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The OMERO 5.0.2 documentation is divided into three parts. *About the OMERO Platform* introduces the user-facing client applications and how to get started, as well as detailing where users can access further help and support. System administrators wanting to install an OMERO server can find instructions in the *System Administrator Documentation*. Finally, developers can find more specific and technical information about OMERO in the *Developer Documentation*.

Additional online resources can be found at:

- Downloads
- Features (movie tutorials coming soon)
- Security Vulnerabilities
- OMERO API documentation - OmeroJava API, OmeroPy API, OmeroBlitz / Slice API
- *NEW* User help website
- *NEW* Script sharing service
- *NEW* Partner projects to extend OMERO
- *NEW* Demo server is now available for OMERO 5

OMERO version 5 uses the June 2013 release of the OME-Model.

**Note:** If you are still using OMERO 4.4.x, you can find all the documentation for those releases via our previous versions page.

This documentation is a *work in progress* and many aspects of OMERO are not yet covered. For those already familiar with the documentation, there are summaries of changes available which will be updated as needed:

- What’s new for OMERO users
- What’s new for OMERO sysadmins
- What’s new for OMERO developers

The source code is hosted on Github. To propose changes and fix errors, go to the documentation repository, fork it, edit the file contents and propose your file changes to the OME team using Pull Requests.

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8. [http://www.openmicroscopy.org/site/community/scripts](http://www.openmicroscopy.org/site/community/scripts)
12. [http://www.openmicroscopy.org/site/support/previous/](http://www.openmicroscopy.org/site/support/previous/)
13. [https://github.com/openmicroscopy/ome-documentation/](https://github.com/openmicroscopy/ome-documentation/)
Part I

About the OMERO Platform
OMEReomote Objects (OMERO) is a modern client-server software platform for visualizing, managing, and annotating scientific image data. OMERO lets you import and archive your images, annotate and tag them, record your experimental protocols, and export images in a number of formats. It also allows you to collaborate with colleagues anywhere in the world by creating user groups with different permission levels. OMERO consists of a Java server, several Java client applications, as well as Python and C++ bindings and a Django-based web application.

The OMERO clients are cross-platform. To run on your computer they require Java 1.6 or higher to be installed. This can easily be installed from http://java.com/en if it is not already included in your OS. The OMERO.insight client gets all of its information from a remote OMERO.server — the location of which is specified at login. Since this connection utilises a standard network connection, the client can be run anytime the user is connected to the internet.

This documentation is for the new OMERO 5 Platform. This version is designed to improve our handling of complex multidimensional datasets. It allows you to upload your files in their original format, preserving file names and any nested directory structure in the server repository. For more technical information, please refer to the Developer Documentation.
• About OMERO\(^1\) introduces OMERO for new users, while the Features List\(^2\) provides an overview of the platform features with those that are new for OMERO 5 highlighted (also see What’s new for OMERO 5).

• As OMERO is an open source project with developers and users in many countries, connecting to the community can provide you with a wealth of experience to draw on for help and advice.

• *NEW* Our partners within the OME consortium are working on integrating additional functions and modules with OMERO. See the Partner Projects\(^3\) page for details of the latest extensions which could help OMERO meet your research needs more fully.

• *NEW* You can also extend the functionality of OMERO using OMERO.scripts, our version of plugins. Guides to some of the scripts which ship with OMERO releases are already provided, but you can also check out our Script Sharing\(^4\) page to find extra ones.

• *NEW* Workflow-based user assistance guides are provided on our help website\(^5\). Extended OMERO.web and guides to other OMERO applications will be coming here soon.

2.1 Community support

The Open Microscopy Environment\(^6\) provides a number of resources for both our user and developer communities to assist in use and development of our software. Contributions through our mailing lists and forums are always welcome.

2.1.1 Web

The Open Microscopy Environment website is at http://www.openmicroscopy.org/site. Bio-Formats can be found at http://www.openmicroscopy.org/site/products/bio-formats.

2.1.2 Mailing lists

The following lists are provided:

• ome-users\(^7\) – support with installation and general use or miscellaneous queries, as well as bug reporting

• ome-devel\(^8\) – development discussion and support

Note: You can email these lists without subscribing but posts by non-members will be moderated before going out to all members. We endeavor to approve all genuine posts within 24 hours on working days, but we encourage you to subscribe to take advantage of our active and supportive community.

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\(^1\)[http://www.openmicroscopy.org/site/products/omero/]
\(^2\)[http://www.openmicroscopy.org/site/products/omero/feature-list]
\(^3\)[http://www.openmicroscopy.org/site/products/partner/]
\(^4\)[http://www.openmicroscopy.org/site/community/scripts]
\(^5\)[http://help.openmicroscopy.org/]
\(^6\)[http://www.openmicroscopy.org/site]
\(^7\)[http://lists.openmicroscopy.org.uk/mailman/listinfo/ome-users/]
\(^8\)[http://lists.openmicroscopy.org.uk/mailman/listinfo/ome-devel/]
2.1.3 Forums

Discussion on a number of topics is also available through our forums\(^9\). Forums include:

- OME Announcements\(^10\)
- OMERO\(^11\)
  - User Discussion\(^12\)
  - Installation and Deployment\(^13\)
  - Developer Discussion\(^14\)
- Bio-Formats\(^15\)
  - User Discussion\(^16\)
- OME Data Model\(^17\)
  - User Discussion and Suggestions\(^18\)

2.2 What’s new for OMERO 5

From a user’s perspective, OMERO 5 mostly alters the way import looks in OMERO.insight. Your files are now uploaded on to the OMERO.server in their original format which means you can always export them in this format. We have also introduced checksums to confirm if your file has been correctly uploaded so that you can have confidence that no corruption has occurred on import and your files are safely stored. In combination, these changes mean that you no longer need to store duplicates of your data outside of OMERO, for example if you require the original format for some of your data analysis.

- Importing data guide\(^19\) has been updated to illustrate the new workflow.
- The Command Line Import has also been updated to reflect the new functionality.
- There is a new Getting Started guide\(^20\) for OMERO 5.0.
- OMERO Command Line Interface has been updated to document a new plugin which allows you to list, create, and import tags and tag sets from the command line.

**Note:** OMERO demo server is now available for OMERO 5.

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\(^9\)http://www.openmicroscopy.org/community/

\(^10\)http://www.openmicroscopy.org/community/viewforum.php?f=11


\(^12\)http://www.openmicroscopy.org/community/viewforum.php?f=4

\(^13\)http://www.openmicroscopy.org/community/viewforum.php?f=5

\(^14\)http://www.openmicroscopy.org/community/viewforum.php?f=6

\(^15\)http://www.openmicroscopy.org/community/viewforum.php?f=12

\(^16\)http://www.openmicroscopy.org/community/viewforum.php?f=13

\(^17\)http://www.openmicroscopy.org/community/viewforum.php?f=14

\(^18\)http://www.openmicroscopy.org/community/viewforum.php?f=15

\(^19\)http://help.openmicroscopy.org/importing-data-5.html

\(^20\)http://help.openmicroscopy.org/getting-started-5.html
3.1 OMERO clients overview

Most laboratories use a number of different imaging platforms and thus require tools to manage, visualize and analyze heterogeneous sets of image data recorded in a range of file formats. Ideally a single set of applications, running on a user’s laptop or workstation, could access all sets of data, and provide easy-to-use access to this data.

OMERO ships as a server application called OMERO.server and a series of client applications (known simply as clients): OMERO.web, OMERO.insight, OMERO.editor and OMERO.importer. All run on the major operating systems and provide image visualization, management, and annotation to users from remote locations. With a large number of OMERO.server installations worldwide, OMERO has been shown to be relatively easy to install and get running.

OMERO.insight (.editor, .importer) are desktop applications written in Java and require Java 1.6 (or higher) to be installed on the user’s computer (automatically installed on most up-to-date OS X and Windows XP systems).

Our NEW user assistance help website\(^1\) provides a series of workflow-based guides to performing common actions in the client applications, such as importing and viewing data, exporting images and using the measuring tool.

Our partners within the OME consortium are also producing new clients and modules for OMERO, integrating additional functionality, particularly for more complex image analysis. See the Partner Projects\(^2\) page for more details.

3.1.1 OMERO.web

OMERO.web is a web-based client for users who wish to access their data in the browser. This offers a similar view to the OMERO.insight desktop client. Figures OMERO.web user interface and OMERO.web image viewer present the user interface\(^3\)\(^4\). Developers can use the OMERO.web framework to build customized views.

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4. Snider, et al., JCB (http://jcb.rupress.org/content/195/2/217)
For more information and guides to using OMERO.web, see our help website\(^5\).

### 3.1.2 OMERO.insight

OMERO.insight provides a number of tools for accessing and using data in an OMERO server. The figure *OMERO.insight Image Viewer* presents the OMERO.insight image viewer, whereas figure *OMERO.insight* presents the user interface\(^6\) \(^7\). To find out more, see the OMERO.insight user guides\(^8\).

Among many features, the noteworthy OMERO.insight elements are:

- **DataManager**, a traditional tree-based view of the data hierarchies in an OMERO server. DataManager supports access to all image metadata, annotations, tags.

- **ImageViewer**, for visualization of 5D images (space, channel, time). The ImageViewer makes use of the OMERO server’s Rendering Engine, and provides high-performance viewing of multi-dimensional images on standard workstations (e.g., scrolling through space and time), without requiring installation of high-powered graphics cards. Most importantly, image viewing at remote locations is enabled. Image rendering settings are saved and chosen by user ID.

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6 Dantas, et al., JCB ([http://jcb.rupress.org/content/193/2/307](http://jcb.rupress.org/content/193/2/307))

7 Roscioli, et al., JCB ([http://jcb.rupress.org/content/196/4/435](http://jcb.rupress.org/content/196/4/435))

OMERO Documentation, Release 5.0.2

3.1.3 OMERO.editor

OMERO.editor is an editing tool designed to facilitate recording of experimental metadata, for annotation of images in OMERO, where users can create a “template” (for example, to describe a protocol) and then use this template to create individual “experiment” files, which contain the experimental metadata. A summary of the experiment can be viewed alongside annotated images in OMERO.insight. This workflow makes it easy to reuse protocols, and to build up a detailed description of an experiment by combining several smaller protocols.

The OMERO.editor is part of the OMERO.insight client, but can also run as a stand-alone application. OMERO.editor saves files as XML documents, which makes it possible for them to be read by other software. More information can be found in the OMERO.editor user guide.9

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9http://help.openmicroscopy.org/
10http://help.openmicroscopy.org/editor.html
Note: OMERO.editor is no longer actively developed but is still shipped with OMERO releases.

### 3.1.4 OMERO.importer

The OMERO.importer is part of the OMERO.insight client, but can also run as a stand-alone application. The OMERO.importer allows the import of proprietary image data files from a filesystem accessed from the user’s computer to a running OMERO server. This tool uses a standard file browser to select the image files for import into an OMERO server.

The tool uses Bio-Formats for translation of proprietary file formats in preparation for upload to an OMERO Server. Visit Supported Formats\(^1\) for a detailed list of supported formats.

#### Citation

The screenshots make use of data from the JCB DataViewer\(^2\) under the Creative Commons Attribution-Noncommercial-Share Alike 3.0 Unported License. For more information see Attribution\(^3\).

### 3.2 OMERO Command Line Interface

See also:

\(^1\)http://www.openmicroscopy.org/site/support/bio-formats5/supported-formats.html

\(^2\)http://jcb-dataviewer.rupress.org/

\(^3\)http://www.openmicroscopy.org/site/about/licensing-attribution/attribution
OMERO Command Line Interface System administrator documentation for the Command Line Interface

OMERO Command Line Interface Developer documentation for the Command Line Interface

3.2.1 Overview

The CLI (Command Line Interface) is a set of Python\textsuperscript{14} based system-administration, deployment and advanced user tools. Most of commands work remotely so that the CLI can be used as a client against an OMERO server.

Requirements

Check you have Python\textsuperscript{15} installed by typing:

\begin{verbatim}
$ python --version
Python 2.7.5+
\end{verbatim}

Additionally, Ice\textsuperscript{16} must be installed on your machine:

\begin{verbatim}
$ python -c "import Ice"
\end{verbatim}

The CLI is currently bundled with the OMERO.server. Download the version corresponding to your system from the OMERO downloads\textsuperscript{17} page.

Note: The CLI is bundled with the OMERO.server but that does not imply you must use that directory as a server. You can download the server zip to a number of machines and use the CLI commands from each machine to access an existing OMERO instance.

Once the server is downloaded, the CLI is located under the bin/ directory:

\begin{verbatim}
$ cd OMERO.server
$ bin/omero -h
OMERO Python Shell. Version 4.4.5-ice33
Type "help" for more information, "quit" or Ctrl-D to exit
omero>
\end{verbatim}

Command line help

The CLI is divided into several commands which may themselves contain subcommands. You can investigate the various commands available using the \texttt{-h} or \texttt{--help} option:

\begin{verbatim}
$ bin/omero -h
\end{verbatim}

Again, you can use \texttt{-h} repeatedly to get more details on each of these sub-commands:

\begin{verbatim}
$ bin/omero admin -h
$ bin/omero admin start -h
\end{verbatim}

The \texttt{omero help} command can be used to get info on other commands or options:

\textsuperscript{14}http://python.org
\textsuperscript{15}http://python.org
\textsuperscript{16}http://www.zeroc.com
\textsuperscript{17}http://downloads.openmicroscopy.org/latest/omero5/
$ bin/omero help debug  # debug is an option
$ bin/omero help admin  # same as bin/omero admin -h

Command line workflow

There are three ways to use the command line tools:

1. By explicitly logging in to the server first i.e. by creating a session using the `omero login` command. The connection parameters can be either passed directly in the connection string:

   $ bin/omero login username@servername:4064

   or using the `-s`, `-u` and `-p` options:

   $ bin/omero login -s servername -u username -p 4064

   If no argument can be specified, the interface will ask for the connection credentials:

   $ bin/omero login

   Previously logged in to localhost:4064 as root
   Server: [localhost]
   Username: [root]
   Password:

   During login, a session is created locally on disk and will remain active until you logout or it times out. You can then call the desired command, e.g. the `omero import` command:

   $ bin/omero import image.tiff

2. By passing the session arguments directly to the desired command, e.g.:

   $ bin/omero -s servername -u username -p 4064 import image.tiff

3. By calling the desired command without login arguments. You will be asked to login:

   $ bin/omero import image.tiff

   Server: [servername]
   Username: [username]
   Password:

   Once you are done with your work, you can terminate the current session if you wish using the `omero logout` command:

   $ bin/omero logout

3.2.2 Import images

`omero import` is probably the first command many users will want to use. To import a file `image.tiff`, use:

$ bin/omero import image.tiff
Many options can be passed to the `omero import`. They can be listed using the `-h` option:

```
$ bin/omero import -h
```

### 3.2.3 Manage tags

The `omero tag` subcommands manage the creation, linking and listing of tag annotations. All subcommands can be listed using the `-h` option:

```
$ bin/omero tag -h
```

#### Create tags

To create a new tag annotation, use the `omero tag create` command:

```
$ bin/omero tag create
Please enter a name for this tag: my_tag
Please enter a description for this tag: description of my_tag
```

To create a tag set containing two existing tags of known identifiers 1259 and 1260, use the `omero tag createset` command:

```
$ bin/omero tag createset --tag 1259 1260
Please enter a name for this tag set: my_tag_set
Please enter a description for this tag set: description of my_tag_set
```

For both tags and tag sets, the name and description can be passed using the `--name` and `--desc` options:

```
$ bin/omero tag create --name my_tag --desc 'description of my_tag'
$ bin/omero tag createset --tag 1259 1260 tag_id_2 --name my_tag_set --desc 'description of my_tag_set'
```

#### List tags

To list all the tags owned by the current user, use the `omero tag list` command:

```
$ bin/omero tag list
+-- 1261:'my_tag_set'
    |\   
    | ++ 1259:'my_tag'
    | ++ 1260:'my_tag_2'
    +- 1264:'my_tag_set_2'
    |\   
    | ++ 1260:'my_tag_2'
    | ++ 1263:'my_tag_4'

Orphaned tags:
> 1262:'my_tag_3'
```

To list all the tag sets owned by the current user, use the `omero tag listsets` command:
$ bin/omero tag listsets

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1261</td>
<td>my_tag_set</td>
</tr>
<tr>
<td>1264</td>
<td>my_tag_set_2</td>
</tr>
</tbody>
</table>

Link tags

Tags can be linked to objects on the server using the `omero tag link` command. The object must be specified as `object_type:object_id`. To link the tag of identifier 1260 to the Image of identifier 1000, use:

$ bin/omero tag link Image:1000 1260

3.2.4 Manage sessions

The `omero sessions` commands manage user sessions stored locally on disk. Several sessions can be active simultaneously, but only one will be used for a single invocation of `bin/omero`:

$ bin/omero sessions -h

Multiple sessions

Stored sessions can be listed using the `omero sessions list` command:

$ bin/omero sessions list

<table>
<thead>
<tr>
<th>Server</th>
<th>User</th>
<th>Group</th>
<th>Session</th>
<th>Active</th>
<th>Started</th>
</tr>
</thead>
<tbody>
<tr>
<td>localhost</td>
<td>test</td>
<td>read-annotate-2</td>
<td>22fccb8b-d04c-49ec-9d52-116a163728ca</td>
<td>Logged in</td>
<td>Fri Nov 23 14:55:25 2012</td>
</tr>
<tr>
<td>localhost</td>
<td>root</td>
<td>system</td>
<td>1f800a16-1dc2-407a-8a85-fb44005306be</td>
<td>True</td>
<td>Fri Nov 23 14:55:18 2012</td>
</tr>
</tbody>
</table>

(2 rows)

Sessions keys can then be reused to switch between stored sessions:

$ bin/omero sessions login -k 22fccb8b-d04c-49ec-9d52-116a163728ca
Server: [localhost]
Joined session 1f800a16-1dc2-407a-8a85-fb44005306be (root@localhost:4064).

$ bin/omero sessions list

<table>
<thead>
<tr>
<th>Server</th>
<th>User</th>
<th>Group</th>
<th>Session</th>
<th>Active</th>
<th>Started</th>
</tr>
</thead>
<tbody>
<tr>
<td>localhost</td>
<td>test</td>
<td>read-annotate-2</td>
<td>22fccb8b-d04c-49ec-9d52-116a163728ca</td>
<td>True</td>
<td>Fri Nov 23 14:55:25 2012</td>
</tr>
<tr>
<td>localhost</td>
<td>root</td>
<td>system</td>
<td>1f800a16-1dc2-407a-8a85-fb44005306be</td>
<td>Logged in</td>
<td>Fri Nov 23 14:55:18 2012</td>
</tr>
</tbody>
</table>

(2 rows)

Sessions directory

By default sessions are saved locally on disk under `~/omero/sessions`. The location of the current session file can be retrieved using the `omero sessions file` command:
If you want to use a custom session directory, use the `--session-dir` argument in the `omero sessions` commands:

$ bin/omero login --session-dir=/tmp
$ bin/omero sessions list --session-dir=/tmp
$ bin/omero logout --session-dir=/tmp

### 3.3 The Command Line Import

The Command Line Importer tool (CLI) allows you to import images to an OMERO server from the command line, and is ideally suited for anyone wanting to use a shell-scripted or web-based front-end interface for importing. Based upon the same set of libraries as the standard importer, the command line version supports the same files formats and functions in much the same way. Visit [Supported Formats](http://www.openmicroscopy.org/site/support/bio-formats5/supported-formats.html) for a detailed list of supported formats.

#### 3.3.1 Starting the Command Line Importer

There are three ways to use the importer from the command line:

- `importer-cli` shell script, included for Linux and Macintosh only
- `ome.formats.importer.cli.CommandLineImporter` Java class
- `bin/omero import` command, from a server installation only

Using the importer using the shell script might look like this:

```
./importer-cli -s localhost -u user -w pass path/to/file
```

To use the `ome.formats.importer.cli.CommandLineImporter` class from java on the command line you will also need to include a classpath to the required support jars. Please look inside of the `importer-cli` script for an example of how to do this.

With a server installation, from server directory, execute the following command:

```
bin/omero -s localhost -u user import path/to/file
```

Note that this method will prompt for any mandatory arguments not provided.

The importer can also be used to detect what files *would* be imported:

```
./importer-cli -f /path/to/file
```

or

```
bin/omero import -f /path/to/file
```

will output a list of all the files which would be imported in groups separated by “#” comments. Note that this usage does not require a running server to be available.
3.3.2 Command Line options

The Command Line importer tool takes a number of mandatory and optional arguments to run, as follows:

Usage: importer-cli [OPTION]... [path [path ...]]...
    or: importer-cli [OPTION]... -

Import any number of files into an OMERO instance.
If "-" is the only path, a list of files or directories is read from standard in. Directories will be searched for all valid imports.

Session arguments:
Mandatory arguments for creating a session are 1- either the OMERO server hostname, username and password or 2- the OMERO server hostname and a valid session key.
-s SERVER OMERO server hostname
-u USER OMERO username
-w PASSWORD OMERO password
-k KEY OMERO session key (UUID of an active session)
-p PORT OMERO server port (default: 4064)

Naming arguments:
All naming arguments are optional but only image OR plate values should be set
-n NAME Image name to use
-x DESCRIPTION Image description to use
--plate_name NAME Plate name to use
--plate_description DESCRIPTION Plate description to use

Optional arguments:
-h Display this help and exit
-f Display the used files and exit
-c Continue importing after errors
-l READER_FILE Use the list of readers rather than the default
-d DATASET_ID OMERO dataset ID to import image into
-r SCREEN_ID OMERO screen ID to import plate into
--report Report errors to the OME team
--upload Upload broken files with report
--logs Upload log file with report
--email EMAIL Email for reported errors
--debug LEVEL Turn debug logging on (optional level)
--annotation_ns ANNOTATION_NS Namespace to use for subsequent annotation
--annotation_text ANNOTATION_TEXT Content for a text annotation (requires namespace)
--annotation_link ANNOTATION_LINK Comment annotation ID to link all images to
--no_thumbnails Do not perform thumbnailing after import

Examples:
$ importer-cli -s localhost -u user -w password -d 50 foo.tiff
$ importer-cli -f foo.tiff
$ importer-cli -s localhost -u username -w password -d 50 --debug ALL foo.tiff

For additional information, see:
http://www.openmicroscopy.org/site/support/omero5/users/command-line-import.html
Report bugs to <ome-users@lists.openmicroscopy.org.uk>

These options will also be displayed on the command line by passing no arguments to the importer.

Note:
- Using the --report option sends an automated error report to the QA application. HTTP POST requests are currently used to upload the report. The default parameters (e.g. endpoint URL) may be overridden via an INI-formatted configuration file, which is expected to be located within a config directory relative to the CLI importer (see example below).
- The --email option is the OMERO user’s contact email. Note that errors are not sent to this address.
Sample `config/importer.config` INI file:

```ini
[General]
appTitle = OMERO.importer
appVersionNote =
port = 4064
disableUpgradeCheck = false

[Uploader]
TokenURL = http://qa.openmicroscopy.org.uk/qa/initial/
URL = http://qa.openmicroscopy.org.uk/qa/upload_processing/
BugTrackerURL = http://qa.openmicroscopy.org.uk/qa/upload_processing/
forumURL = http://www.openmicroscopy.org/community/

[UI]
forceFileArchiveOn = false
disableImportHistory = false
```

3.3. The Command Line Import
CHAPTER
FOUR

QUICKSTART SERVER ACCESS

If your institution does not have an existing OMERO.server for you to connect to, you can apply for an account on our demo server. Alternatively, you can create your own using a virtual appliance (a step-by-step guide for how to do this is provided).

4.1 OMERO demo server

Take advantage of the OMERO platform and ask for a free demo account.

To register for a free demo account, please visit the registration page\(^1\).

We will contact you and provide you with a server name, username and password, please be patient as it may take a few days to process your application after we receive it.

If you have already requested a demonstration account:

- your username and password will be emailed to you.

Once you have these, follow the instructions below:

4.1.1 Getting started with your demo account

To log on and try the demo server you have three options:

1. **Using the OMERO.insight client**

Download the OMERO.insight client for your platform, install it and run it as a stand-alone application. You will need to have permissions allowing you to install software on your computer, and you will need to update the client if the demo server is upgraded (we will email you to inform you).

2. **Using OMERO.insight Java Web Start client**

This automatically downloads the current version of the client, ensuring you are not using an out-of-date version, but it requires re-downloading each session.

3. **Using the OMERO.web client**

The web client does not allow you to import data or use the measurement tools.

Using the OMERO.insight client

Download the OMERO.insight client for your platform by clicking on the appropriate link on the downloads page\(^2\).

After download, unzip and install the OMERO.insight client as you would for any other application. Launch OMERO.insight, and you will see the login screen.

Click the **Spanner** icon.

---

\(^1\)http://qa.openmicroscopy.org.uk/registry/demo_account/

\(^2\)http://downloads.openmicroscopy.org/latest/omero5/
In the **Servers** window, click the + icon.

Enter the **Server Address**: demo.openmicroscopy.org

The port will automatically be set to 4064.

Select your network connection speed.

Click **Apply**

Enter the username and password provided.

Click **Login**
Using OMERO.insight Java Web Start client

To use the OMERO.insight Java Web Start client click on the following link:
OMERO.insight Java Web Start

Follow the instructions to download and run it. Log in as described above.

Using the OMERO.web client

To use the OMERO.web client click on the following link:
OMERO.web

The server name is entered automatically, and you enter your demo account username and password as described above.

Please change your password as soon as you have logged in. The easiest way to do this is via: Web Admin

4.1.2 Further guides and help

- Workflow-based user assistance guides are available on our help website. These use screenshots to illustrate how to perform common tasks such as importing and viewing data, and using the measurement tool.
- An overview of some OMERO’s features is available in a short showcase video at: Showcase Video
- If you have any questions, suggestions, comments or proposals, please take advantage of the OME community’s expertise and join our forums or mailing lists:

---

3 http://demo.openmicroscopy.org/webstart/
4 http://demo.openmicroscopy.org/webclient/login
5 http://demo.openmicroscopy.org/webadmin/myaccount/edit/
6 http://help.openmicroscopy.org/
7 http://cvs.openmicroscopy.org.uk/snapshots/movies/omero-4-4/mov/OMERO-Showcase.mov
4.2 OMERO virtual appliance

The OMERO virtual appliance is a quick, easy, and low-cost way to try out OMERO.server on your laptop or desktop. This enables you to make an informed decision about whether committing to an OMERO.server install is right for you.

Virtualization enables canned, ready to run software environments to be created and used, in the form of VM (Virtual Machine), or to be distributed for others to use, in the form of virtual appliances. A Virtual Appliance is essentially a file that describes how to create a new Virtual Machine on demand. The virtualized software environment can contain an entire OS (Operating System), such as Windows or Linux, and any other software that runs in that OS, such as, in this case, OMERO.server and its associated software prerequisites. Once created and started, you can log into the OS and use it as though it were a real machine. One way to think of this is as though you had an entire computer in a window on your desktop.

When using virtualization software, the OS that is running the virtualization software is referred to as the “host OS”. When you use virtualization, the OS running within a virtual machine is referred to as the “guest OS”. This allows us to be explicit about which OS we are working in.

This technology allows the OME Project to distribute a canned, ready-to-run environment containing an OMERO.server, freeing you from having to install the server and prerequisites yourself, and letting you concentrate on evaluating the functionality of the OMERO platform.

**Note:** The virtual hard-drive used by the OMERO virtual appliance is 30GB in size and you should keep track of the amount of this space you have consumed and, if necessary, delete data that is not required. If your data is likely to exceed this space whilst you are evaluating OMERO then it is worthwhile going through the Increasing HD size before you start working with OMERO in earnest.

### 4.2.1 Getting started

To use the virtual appliance you should do the following:

- Install VirtualBox
- Download the OMERO.server virtual appliance
- Import the virtual appliance into VirtualBox to create a virtual machine
- Start the virtual machine

Each of these points is outlined in more detail below.

#### Install VirtualBox

Download VirtualBox from the VirtualBox Downloads page[11] and follow the installation process for your platform. If in doubt, you should download, or upgrade to, the latest version of VirtualBox. Once VirtualBox is installed, run the application. Depending upon your platform and version, the VirtualBox interface should look similar to the following screenshot:

#### Download the OMERO.server virtual appliance

The virtual appliance can be downloaded from the OMERO download page[12] and should have a filename similar to omero-vm-5.0.2.ova.

---

**Import OMERO virtual appliance into VirtualBox**

- Start VirtualBox then select ‘File/Import Appliance’. You will be presented with a dialog box.
- Select and navigate to the location where you downloaded the virtual appliance file.
- Select your OVA file then click **open**.

This process is indicated in the screenshot below.

**Click continue.** You will be presented with a range of options for the VM that will be built from the appliance.

**You can accept the defaults by clicking **Import**.**

You should now see a progress bar as your new virtual machine is built from the appliance. This may take a few minutes depending upon your hardware.
When the import procedure is complete, your new VM should appear in the VirtualBox VM library ready for use.

**Networking**

Our virtual appliance is distributed with VirtualBox’s built-in Host-Only Network Address Translation (NAT) preconfigured. This means that the IP address for the VM is 10.0.2.15 as this is the default VirtualBox Host-Only NAT address. Using this address is the simplest way to distribute a virtual appliance when you do not know the setup of a user’s network.

**Port-forwarding settings**

Your host OS cannot connect directly to 10.0.2.15 but needs to use port-forwarding. This means that you connect to your localhost on a specific port and the communications to and from that port are forwarded to specified ports on the guest VM.

Our virtual appliance should be preconfigured with the correct port-forwarding setting during the import process. However, it is best to double check that these settings are correct:

- Select your VM in the VirtualBox VM Library
- Click on **Settings** then select the **Network** tab
- Click on **Advanced**
- Click on **Port Forwarding**

If the table in the window that appears is empty then port forwarding is not setup. The required port-forwarding settings are as follows:

<table>
<thead>
<tr>
<th>Name</th>
<th>Protocol</th>
<th>Host IP</th>
<th>Host Port</th>
<th>Guest IP</th>
<th>Guest Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>omero-ssl</td>
<td>TCP</td>
<td>127.0.0.1</td>
<td>4064</td>
<td>10.0.2.15</td>
<td>4064</td>
</tr>
<tr>
<td>omero-unsec</td>
<td>TCP</td>
<td>127.0.0.1</td>
<td>4063</td>
<td>10.0.2.15</td>
<td>4063</td>
</tr>
<tr>
<td>omero-web</td>
<td>TCP</td>
<td>127.0.0.1</td>
<td>8080</td>
<td>10.0.2.15</td>
<td>8080</td>
</tr>
<tr>
<td>ssh</td>
<td>TCP</td>
<td>127.0.0.1</td>
<td>2222</td>
<td>10.0.2.15</td>
<td>22</td>
</tr>
</tbody>
</table>

When correctly setup in VirtualBox, your port forwarding settings should look like this:

If you are on Linux or Mac OS X, you can either use our port forwarding setup script or you can set up port forwarding manually.

On Microsoft Windows systems you will have to set up port forwarding manually as the script requires a Bash shell.

The script can be downloaded from the online version of this documentation; see [http://www.openmicroscopy.org/site/support/omero/users/virtual-appliance.html](http://www.openmicroscopy.org/site/support/omero/users/virtual-appliance.html).

After obtaining the script, it can be used in the following manner:
$ bash setup_port_forwarding.sh $VMNAME

where $VMNAME is the name of your VM.

**Note:** By default the scripts create a VM named *omerovm* and the pre-built appliance is named *omero-vm*

Adding port forwarding manually is achieved by editing the port forwarding table shown above. Use the + to add a new row to the table, then click in each cell and type in the required settings.

Now you are ready to start your VM. Select the VM in the VirtualBox VM library then click **start**.
A window should open containing a console for your VM which should now be going through its standard boot process. OMERO.server is automatically started at boot time, meaning that you should be able to interact with OMERO without further setup.

![OMERO Documentation, Release 5.0.2]

Figure 4.6: Booting the virtual appliance

Credentials

There are a number of accounts that are preconfigured in the OMERO virtual appliance. Two of these are OS accounts, for logging into the VM as either the root user or the omero user. There is also a single OMERO.server account which is used to access the OMERO.server software as the OMERO.server root user.

**Virtual Appliance OS credentials**

<table>
<thead>
<tr>
<th>Username</th>
<th>Password</th>
</tr>
</thead>
<tbody>
<tr>
<td>root</td>
<td>[1]</td>
</tr>
<tr>
<td>omero</td>
<td>omero</td>
</tr>
</tbody>
</table>

[1] The omero account is able to run administrative commands via sudo with no password required.

**OMERO.server credentials**

<table>
<thead>
<tr>
<th>Username</th>
<th>Password</th>
</tr>
</thead>
<tbody>
<tr>
<td>root</td>
<td>omero</td>
</tr>
</tbody>
</table>

You can use this administrative account to create as many user level accounts as you require in the usual way.

### 4.2.2 Working with the OMERO.VM

Now that your VM is up and running you have a choice about how to interact with it.

- You can connect to OMERO.web from your host browser. Go to [http://localhost:8080/webclient](http://localhost:8080/webclient).
• You can use OMERO.clients from within your host OS. This will allow you to import data via a GUI and manage that data once imported. To do so, download the OMERO.insight client\(^ {13}\) and follow the instructions below. More information can be found on our help website\(^ {14}\) which provides workflow-based guides to using the OMERO.clients.

• Alternatively, you can interact with the server command line interface by SSH (Secure Shell)'ing into the guest VM or by opening a console within the VM itself. Administrators may need to use one of these methods to restart the server and/or change configuration parameters. In this case, you must have an SSH client installed on your host machine to use to connect to the OMERO.server.

Note: The following examples assume that the OMERO VM is up and running on the same machine that you are working on.

**OMERO.web**

Go directly to http://localhost:8080/webclient to log in with user: “root” / pw: “omero”.

Note: If you receive a 502 nginx error on first attempting to connect to the web app on http://localhost:8080/webclient/ please restart the virtual machine and try again.

**OMERO.insight**

You can run regular OMERO clients on your host machine and connect to the server in the VM. Our example uses OMERO.insight running on Mac OS X to connect to the VM.

  • Download\(^ {15}\) and install OMERO.insight

  • Start OMERO.insight

  • Click the spanner icon situated above the password box to enter the server settings box shown below.

![Figure 4.7: Setting OMERO.insight server address and port number](image)

  • Use the + icon to add a new server entry with the address localhost and the port 4064 then click apply

\(^{13}\)http://downloads.openmicroscopy.org/latest/omero5/
\(^{14}\)http://help.openmicroscopy.org/
\(^{15}\)http://downloads.openmicroscopy.org/latest/omero5/
You can now use the login credentials given above to log into OMERO.insight using the login window shown below (user: "root"/pw: “omero”).

![OMERO.insight login window](image)

**Figure 4.8: OMERO.insight login window**

OMERO.insight should now load up and display the main window. You can now use OMERO.insight to import and manage images on a locally running virtual server just like you would use the standard remote server.

**Note:** A Getting Started guide is available for OMERO.insight on our help website[^1] if you need further assistance to download and install the software.

### Secure Shell

You can log into your VM using SSH, allowing you to use the **OMERO Command Line Interface**. In the following example, we assume that you have an SSH client installed on your host machine and also that your VM is up and running.

You can log into the VM using the above credentials and the following command typed into a terminal:

```
$ ssh omero@localhost -p 2222
```

This invokes the SSH program telling it to login to the localhost on port 2222 using the username *omero*. Remember that earlier you set up port forwarding to forward port 2222 on the host machine to port 22 (the default SSH port) on the guest VM. You should be prompted for a password. Once you have successfully entered your password, you should be greeted by a prompt similar to the following:

```
omero@omerovm:~$
```

There are two potential complications to this method, (1) if you have used a VM before then there could be old SSH fingerprints set up, (2) the first time that you log into the VM you will be asked to confirm that you wish to continue connecting. If you get the following message after you invoke SSH, you need to remove the old fingerprints:

```
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
@ WARNING: REMOTE HOST IDENTIFICATION HAS CHANGED! @
@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@
IT IS POSSIBLE THAT SOMEONE IS DOING SOMETHING NASTY!
Someone could be eavesdropping on you right now (man-in-the-middle attack)!
It is also possible that the RSA host key has just been changed.
The fingerprint for the RSA key sent by the remote host is
Please contact your system administrator.
Add correct host key in /Users/rleigh/.ssh/known_hosts to get rid of this message.
Offending key in /Users/rleigh/.ssh/known_hosts:14
RSA host key for localhost has changed and you have requested strict checking.
Host key verification failed.
```

You can do this using the following command typed into the terminal:

```
$ ssh-keygen -R [localhost]:2222 -f ~/.ssh/known_hosts
```

This should produce output similar to:

```
$ ssh-keygen -R [localhost]:2222 -f ~/.ssh/known_hosts
/Users/rleigh/.ssh/known_hosts updated.
Original contents retained as /Users/rleigh/.ssh/known_hosts.old
```

The first time that you log into the VM you will also be asked to confirm that you wish to connect to this machine by a message similar to the following:

```
$ ssh omero@localhost -p 2222
The authenticity of host '[localhost]:2222 ([127.0.0.1]:2222)' can't be established.
Are you sure you want to continue connecting (yes/no)?
```

You should confirm that you wish to continue connecting, after which you will be prompted for your password as usual:

```
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '[localhost]:2222' (RSA) to the list of known hosts.
```

After which, you should have a prompt indicating that you have a shell open and logged into the VM:

```
omero@localhost's password:
Linux omerovm 2.6.32-5-686 #1 SMP Mon Jun 11 17:24:18 UTC 2012 i686
The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.
Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Thu Apr  5 10:32:18 2012 from 10.0.2.2
```

**Log into the VM directly**

**Note:** Due to the frequent changes in the VirtualBox Guest Additions, key mappings between the host and guest OS do not always work. We recommend using SSH as the primary way of interacting with the Virtual Appliance CLI.

When you start your VM using the VirtualBox GUI, as outlined above, a window will be displayed showing the boot process for the machine as it starts up, just like with a real piece of hardware. Once the boot process has finished you will see a prompt displayed in this window like so:

```
[System startup messages]
Debian GNU/Linux 6.0 omerovm tty1
omerovm login: _
```

You can log into the console of the VM directly using the user account credentials above.
omerovm login: omero
Password: _

There is no GUI on the current OMERO virtual appliance so you will have to use the Bash shell which looks like this:

omerovm:~$_

From here you can interact with OMERO.server via the OMERO Command Line Interface. You will need to login as the ‘omero’ user to access the OMERO CLI (user: “omero” / pw: “omero”). Logout using Ctrl-D.

4.2.3 Known issues

Networking not working

Occasionally, during the boot process, the VirtualBox DHCP server fails to allocate an IP address to the OS in the guest VM. This means that OMERO.clients, such as OMERO.insight, cannot connect to the OMERO.server in the VM.

- **CAUSE:** We believe that this is an intermittent VirtualBox bug that resurfaces across many versions VirtualBox #4038\(^17\) and previously VirtualBox #3655\(^18\).
- **DIAGNOSIS:** Check whether the guest VM has been allocated the reserved host-only NAT IP address. If 10.0.2.15 does not appear in the output from `ifconfig` then this issue has occurred. The easiest way to verify this is to log into the guest VM console and check the output from executing the following command:

  ```
  $ ifconfig
  ```

- **SOLUTION:** An easy, but unreliable, fix is to reboot the guest VM. The preferred fix is to log into the guest VM console and execute the following commands, which will cause the guest OS to release its IP lease before requesting a new lease:

  ```
  $ dhclient -r
  $ dhclient -eth0
  ```

Port conflict when OMERO.server already running in Host OS

If you are already running an instance of the OMERO.server in your host OS then there will be a conflict due to the ports assigned to VirtualBox port-forwarding already being in use.

- **SOLUTION 1:** Turn off the OMERO.server in the host environment by issuing the following command:

  ```
  $ omero admin stop
  ```

- **SOLUTION 2:** Alter the port-forwarding settings for your OMERO.VM as described in the Port-forwarding settings section. For example, increment the host port settings for omero-ssl, omero-unsec, and omero-web.

**Note:** We are assuming that your host OS is not already running services on those ports. You can check whether something is already listening on any of these ports by running the following commands (Mac OS X) which should return the prompt without any further output if there is nothing listening:

  ```
  $ lsof -nP | grep -E ‘(:4063)|{:4064}’
  ```

---

\(^17\)https://www.virtualbox.org/ticket/4038
\(^18\)https://www.virtualbox.org/ticket/3655
VM will not boot because the HDD (Hard Disk Drive) is full

If you fill the virtual HDD used by your VM then the OS may be unable to boot and you will lose access to your OMERO server install. You may also get a “error 28: no space left on device” message. To log into your VM you will need to use the recovery mode. Start the VM and at the Grub screen, use the down arrow followed by return to select the recovery mode entry, e.g.

Debian GNU/Linux, with Linux 2.6.32-5-686 (recovery mode)

as illustrated in this example of the Grub screen:

```
GNU GRUB version 1.98+20100804-14
------------------------------------------------------------------------
| Debian GNU/Linux, with Linux 2.6.32-5-686 |                        |
| Debian GNU/Linux, with Linux 2.6.32-5-686 (recovery mode) |         |
| |                                                                 |
| |                                                                 |
| |                                                                 |
| |                                                                 |
| |                                                                 |
| |                                                                 |
| |                                                                 |
| |                                                                 |
| |                                                                 |
------------------------------------------------------------------------
```

Do not worry if your VM has a kernel number different to 2.6.32-5-686, the important thing is that you select the entry labeled “recovery mode”. At this point, the VM should rapidly boot into the recovery mode and enable you to log in as the omero user. Administrative commands may be run as root by using sudo.

Once you have logged in, you have a number of options but the recommended courses of action are:

1. Delete unnecessary files using standard Linux command line tools like rm to make space for the VM to boot normally, then use your favored OMERO client to login and delete more files. A useful place to start might be by deleting the logs stored in /var/logs.

2. Increase the size of your virtual HDD. If you have filled your existing HDD then it is likely that the volume of data you are storing is too big for the default HDD. You should follow the instructions in the Increasing HD size section to ensure that the size of virtual HDD you have available is suitable for the volumes of data that you are collecting.

4.2.4 Increasing HD size

Image data can become very large and easily fill available hard-drive space. By default, the OMERO virtual appliance is supplied with a 30GB virtual hard-drive. Before using the appliance, consider the volume of data you will be working with whilst evaluating OMERO and whether you need to increase the size of the virtual hard-drive to accommodate it.

The following is a step-by-step guide; be aware that this is not a risk-free procedure and you should backup your VM before proceeding.

Preliminary steps

Acquiring a Ubuntu Linux ISO

Download an Ubuntu Linux ISO\(^\text{19}\). The most up-to-date version is fine.

\(^{19}\)http://www.ubuntu.com/download/desktop
OMERO Documentation, Release 5.0.2

Back up your VM

Before you proceed further, you should create a clone of the omero-vm and subsequently work on the copy so that if something gets broken you can always start again. The easiest way to do this is from the command line.

Note: If you are on Windows then you should navigate to C:\Program Files\Oracle\VirtualBox\ because the VBoxManage tools are not added to your path by default.

Start a shell and, assuming that your VM has the default name of omero-vm, use the following command:

```bash
$ VBoxManage clonevm omero-vm --mode machine --options keepallmacs --name omero-vm-2 --register
```

This will create a copy of your VM called omero-vm-2 which you can make alterations to. This means that you can always return to the original omero-vm if you break anything. From now on only make changes to omero-vm-2.

Extend the HDD

By default, your virtual hard-drive attached to omero-vm-2 is of a type which cannot be extended; so you need to change this by cloning your HDD from the VDMK type to VDI type:

```bash
$ VBoxManage clonehd omero-vm-2-disk1.vmdk omero-vm-2-disk1.vdi --format VDI
```

You now need to increase the size of your virtual HDD. The following command resizes the HDD to 60GB but you should select a size to suit the amount of data you plan to store in OMERO:

```bash
$ VBoxManage modifyhd omero-vm-2-disk1.vdi --resize 60000
```

Add the extended HDD to the VM clone

You now need to tell VirtualBox to use omero-vm-2-disk1.vdi instead of omero-vm-2-disk1.vmdk which is currently attached to the VM. Whilst you are on the Storage tab you will also attach the Ubuntu ISO that you downloaded earlier to your VM. This will allow you to use the tools that ship with Ubuntu to make changes to the filesystem within your VM.

1. Start VirtualBox and select omero-vm-2 in the VM library.
2. Right-click Settings then select the Storage tab.
3. Right-click on omero-vm-2-disk1.vmdk and select Remove attachment.
4. Next to the SATA Controller entry, click the Add Hard Disk icon with a green plus sign. In the pop-up dialog, select Choose existing disk. Now navigate to the location where VirtualBox stores your virtual machines and enter the omero-vm-2 directory. Select the omero-vm-2 disk1.vdi and click open.
5. Add an IDE Controller using the Add Controller icon. Select this new controller then click Add CD/DVD device followed by Choose Disk. Navigate to the location of your Ubuntu ISO, select it and click OK.

The storage for your OMERO VM should now look similar to Virtual Appliance storage settings.

Click OK to return to the VirtualBox VM library. With omero-vm-2 selected, ensure that the storage details match what you expect, e.g. omero-vm-2-disk1.vdi is connected to your SATA Port 0. The size for this disk should also more or less match what you specified earlier with the VBoxManage modifyhd command. The reported numbers do not exactly matchup, e.g. a virtualised HDD of 60GB size will be reported as 58.59GB.

Reallocate space on the VA HDD

Start the omero-vm-2 VM. Ubuntu linux should boot and you should eventually see a welcome screen giving you the option to try Ubuntu or to install it. You can now start the GParted software and resize your partitions.

4.2. OMERO virtual appliance
1. Select try Ubuntu and you should be presented with a graphical desktop.
2. Start the `gparted` tool using the menu option under `System → Administration → GParted Partition Editor`.
3. The GParted GUI will display information similar to `Virtual Appliance HDD in GParted`.
4. Right-click the entry for `/dev/sda5` and select `Swapoff`.
5. Right click `/dev/sda5` and click `Delete` to remove the swap partition.
6. Delete `/dev/sda2` in the same way. This should leave two entries, one for `/dev/sda1` and one for unallocated space.
7. Right-click `/dev/sda1` and select `Resize`. Now drag the right arrow to the right until the entry for `Free space following (MiB)` is about 2000, then click `Resize/Move`.
8. Right click the entry for unallocated space and select `New` from the pop-up menu. Select `linux-swap` from the `File system` drop-down menu then `Add`.

Up until this point you have not actually applied any of your changes to the HDD, you have only specified a list of changes that should be made. You can now go ahead and apply them by selecting the `Edit → Apply All Operations` menu item, then clicking `Apply` in the confirmation dialog box.

When the operations have completed, dismiss the dialog with the `Close` button, close GParted, then shutdown the VM.

**Changing HDD settings inside the VA**

You no longer need the Ubuntu ISO so you can detach it from your VM. Ensure that omero-vm-2 is selected then click `Settings` and select the `Storage` tab. Right-click the `IDE Controller` entry and select `Remove Controller`, then click `OK` to return the VirtualBox VM library.

Start the omero-vm-2 VM and allow it to boot. As root then issue the `df -h` command. Verify that the size of the `/dev/sda1` is approximately what you expect, e.g. if you allocated a 60GB virtual HDD then after size conversions and swap allocation you should end up with `/dev/sda1` reported as being around 56GB.

Within the VM you need to add the UUID of the new swap partition to the `/etc/fstab` file because you deleted the old one and created a new swap meaning that the IDs will no longer match.

```
$ vim /etc/fstab
```
Move your cursor to the entry that looks similar to the following:

```
UUID=SOME-LONG-ALPHA-NUMERIC-STRING none swap sw 0 0
```

then press `i` to enter “insert mode”. Delete the alphanumeric string so that the entry looks similar to the following:

```
UUID= none swap sw 0 0
```

and place your cursor after the equals sign. You can now issue a command from within the VIM editor to insert your new swap UUID into the `fstab` file.

```
[Insert Mode] <CTRL-R> =system('/sbin/blkid -t TYPE=swap | cut -c18-53') <return>
```

Save your file and quit VIM:

```
[Command Mode] :wq <return>
```

Now reboot your VM with

```
$ shutdown -r now
```

Once your VM has rebooted you should now have a working VM with a larger virtual HDD.
Part II

System Administrator Documentation
Note: This documentation is for the new OMERO 5 server. If you are looking to upgrade to 5.x from OMERO 4.x, this is the right documentation to refer to but if you want to continue using OMERO 4, you can find all the documentation for those releases on our previous versions\(^\text{20}\) page.

OMERO 4.4.x will continue to be supported during 2014 but a new release will only be made if a major bug fix is necessary.

\(^{20}\)http://www.openmicroscopy.org/site/support/previous/
CHAPTER
FIVE

SERVER BACKGROUND

5.1 What’s new for OMERO 5

From a sysadmin’s point of view, the introduction of OMERO.fs as part of version 5.0 means that files are now stored on the
server in their original format, preserving file names and directory structures. Therefore, the import process does not duplicate
pixel data and storage requirements are roughly halved in comparison with a 4.4 import including archiving the original files.
Combined with the new file integrity report, you should be confident that once a successful import has taken place, storing
the original files outside of OMERO is no longer necessary as your users can always download their data in its original format if they
need to.

- **OMERO.server upgrade** has been updated to explain the server upgrade process from 4.4.x to OMERO 5, and also to
describe the introduction of password salting support.
- **FS configuration options** has been added to explain the server-side FS workflow for importing files.
- **OMERO.dropbox** has been reworked to clarify the distinction between OMERO.fs and OMERO.dropbox.
- **System Requirements** has been updated to reflect that running OMERO.web on your server now requires Python 2.6.5 or
later.
- **Troubleshooting OMERO** has been updated to guide you through what to do if you are getting search errors, and how to
adjust the **Advanced configuration** to take advantage of improvements to the server indexing system for 5.0.0.
- **Advanced import scenarios** and **In-place import** documentation has been added to explain the new ways of importing data
enabled by the change in server-side workflow.
- **OMERO.insight webstart security and code-signing** has been added to explain the requirement for code-signing the webstart
version of OMERO.insight. Official releases of OMERO.server are code-signed, instructions for using OMERO.insight
webstart with a custom build are included.

5.2 Server overview

The OMERO server system provides storage and processing of image data which conforms to the [OME Specification](http://www.openmicroscopy.org/site/support/ome-model/specifications/).

It can be run on commodity hardware to provide your own storage needs, or run site-wide to provide a large-scale collaborative environment.

Although getting started with the server is relatively straightforward, it does require installing several software systems, and more
advanced usage including backups and integrated logins, needs a knowledgeable system administrator.

You may find the [OMERO clients overview](#) user guide useful before working through the installation and maintenance guides
provided in this section of the documentation.

5.2.1 Developing the server

The server system is composed of several components, each of which runs in a separate process but is co-ordinated centrally.

- **OMERO.blitz** - the data server provides access to metadata stored in a relational database as well as the binary image data
  on disk.

1[^1]
• **OMERO.dropbox** - a filesystem watcher which notifies the server of newly uploaded or modified files and runs a fully automatic import (designed as the first implementation of OMERO.fs referred to in the architecture diagram).

If you are interested in building components for the server, modifying an existing component, or just looking for more background information, there is a section about the server within the Developer Documentation; the best starting point is the OMERO.server overview for developers.

## 5.3 System Requirements

### 5.3.1 Prerequisites overview

Each component of the OMERO platform has a separate set of prerequisites. Where possible, we provide tips on getting started with each of these technologies, but we can only provide free support within limits.

<table>
<thead>
<tr>
<th>Package</th>
<th>OMERO.server</th>
<th>Java</th>
<th>Python</th>
<th>Ice</th>
<th>PostgreSQL</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMERO.importer</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>OMERO.insight</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>OMERO.editor</td>
<td>Required for some functionality</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>OMERO.server</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>OMERO.web</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>OMERO.py</td>
<td>Required for some functionality</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
</tr>
<tr>
<td>OMERO.cpp</td>
<td>Required for some functionality</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
<td>Required</td>
</tr>
</tbody>
</table>
5.3.2 OMERO.server

The system requirements for OMERO.server vary greatly depending on image size and number of users. At a minimum we suggest:

- Mac OS X 10.6 or later; Windows XP or later; Ubuntu 10.04 or later/CentOS 6/Debian Squeeze or other Linux distribution
- Single core 1.33GHz Intel or AMD CPU
- 2GB RAM
- 500MB of hard drive space for OMERO.server distribution
- Java 1.6 or later
- Python 2 (2.6.5 or later - note that this is not the standard version disturbed with Mac OS X 10.6; you may find it easier to upgrade your OS to obtain a later version of Python)
- Hard drive space proportional to the image sizes expected. The drive space should permit proper locking, which is often not the case with remotely mounted shares. See the Unix and Windows binary repository sections for more information.

The recommended OMERO.server specification we suggest for between 25-50 users is:

- Mac OS X 10.6 or later; Windows Server 2008 or later; Ubuntu 12.04 or later/CentOS 6/Debian Wheezy or other Linux distribution
- Quad core 1.33GHz Intel or AMD CPU
- 8GB RAM
- 500MB hard drive space for OMERO.server distribution
- Java 1.6 or later
- Python 2 (2.6.5 or later)
- Hard drive space proportional to the image sizes expected (Likely between 10 and 100TB)

RAM is not going to scale linearly, particularly with the way the JVM works. You are probably going to hit a hard ceiling between 4 and 6GB for JVM size (there is really not much point in having it larger anyway). With a large database and aggressive PostgreSQL caching your RAM usage could be larger but I would surely doubt a large deployment using more than a few GBs of RAM for this purpose, it is just not cost effective.

Summary: Depending on hardware layout 16, 24 or 32GB of RAM would be ideal for your OMERO server. If you have a separate database server more than 16GB of RAM may not be of much benefit to you at all.

CPU is really not something that an OMERO system is almost ever limited by. However, when it is limited it is almost always limited by GHz and not by the CPU count. So you are not going to get a huge OMERO experience performance increase by, for example, throwing 24 cores at the problem.

Summary: Depending on hardware layout 2 x 4, 2 x 6 system core count should be more than enough.

5.3.3 OMERO.insight, OMERO.editor and OMERO.importer

The recommended client specification is:

- Mac OS X 10.6 or later; Windows XP or later; Ubuntu 12.04 or later/CentOS 6/Debian Wheezy or other Linux distribution
- Single core 1.33GHz Intel or AMD CPU
- 2GB RAM
- 100MB hard drive space for OMERO.clients distribution
- Java 1.6 or later

Large imports may require 4GB RAM.
5.3.4 OpenGL versions of OMERO.insight

- NVIDIA 7xxx or later GPU; ATI 4xxx or later GPU
- 2GB RAM

Note: These are suggested requirements based on limited testing. Your mileage may vary. Any OpenGL 1.3 capable card should work.

5.3.5 Client configuration

When performing some operations the clients make use of temporary file storage and log directories. By default these files are stored below the users HOME directory in $HOME/omero/tmp, $HOME/omero/log and $HOME/omero/sessions (resp. $HOME\omero\tmp, $HOME\omero\log and $HOME\omero\sessions). If your home directory is stored on a network, possibly NFS mounted (or similar), then these temporary files are being written and read over the network. This can slow access down. The OMERO_TEMPDIR environment variable may used to set the directory used for temporary files, for example on fast local storage.

5.4 Known Limitations

5.4.1 Windows OS issues

OMERO.web ‘development server’ does not work under Windows XP

The development server included with OMERO.web does not work under Windows XP. This server is included to allow you to easily evaluate and develop the OMERO.web component. As it should not be used in a production environment, while an inconvenience, this should not stop the deployment of a production version of OMERO.web. See OME forum topic\(^2\).

Binary delete

On Windows servers not all binary files corresponding to a delete may be removed from the binary repository. See Binary data for more details.

5.4.2 Mac OS X issues

C++ compilation problems on Mac OS X 10.6 (Snow Leopard)

Under certain circumstances building OmeroCpp can fail with “ld: symbol(s) not found”. You can find further details, a potential solution and make any comments on your experience with the problem on \(^3\).

5.4.3 Ubuntu issues

Importing using desktop clients

Under older Ubuntu installations, the ‘import folder’ option in the desktop clients currently does not work.

5.4.4 Searching

Not finding certain pieces of data in wildcard searches

Sometimes data is missed when certain types of wildcard searches are performed. You can find further details on \(^4\).

\(^2\)http://www.openmicroscopy.org/community/viewtopic.php?f=5&t=640
\(^3\)http://trac.openmicroscopy.org.uk/ome/ticket/3210
\(^4\)http://trac.openmicroscopy.org.uk/ome/ticket/3164
5.4.5 Importing

Import failures when importing many filesets

Starting with OMERO 5, the importer creates an import log for each fileset stored by OMERO.fs. These files are kept open for 30 minutes by logback. If many filesets are imported sequentially, this 30 minute timeout can lead to the server running out of file handles due to the amount of open log files, which are closed at a slower rate than new logs are opened. This problem is most likely to manifest when hundreds of very fast imports occur within a short period of time. This will be addressed in a future release. In the interim, one workaround is to increase the maximum number of open files per process. On Linux, this may be done by setting the `nofile` limit in `/etc/security/limits.conf`, for example:

```
omero soft nofile 10000
omero hard nofile 12000
```

This permits the `omero` user to have 10000 open files per process, which may be increased up to a maximum of 12000 by the user. The username and limits will need adjusting for the specifics of your installation and usage requirements. Note that these settings take effect only for new logins, so the server and the shell or environment the server is started from will require restarting. Run `ulimit -a` as the user running OMERO to verify that the changes have taken effect.

5.4.6 Deleting datasets

If you have a dataset containing any images which are also present in any other datasets, you will not be able to delete it. First, you must remove the shared images by cutting the links.

5.4.7 Changing group permissions

If you have data which has been linked by other users, you cannot make the group that data is in into a private group.

5.4.8 File format support

DeltaVision OMX files (.hdr) not viewable

Some files generated by an OMX system have a pixel type of float and a large dynamic range. While the files import into OMERO they are currently not viewable. This fix would require deep changes to several parts of the code and we have chosen not to make the changes yet. See #3256.

5.4.9 LDAP

Enabling synchronization of LDAP on user login will result in LDAP being treated as the authority on both group membership and also the available groups. Any groups defined in OMERO and not in LDAP will result in users being removed from these groups. The groups will still exist in OMERO but user membership will be treated as being defined by LDAP alone.

5.4. Known Limitations

---

5 http://jira.qos.ch/browse/LOGBACK-244
6 http://trac.openmicroscopy.org.uk/ome/ticket/3256
This chapter contains the instructions to install OMERO.server on UNIX & UNIX-like platforms.

6.1 OMERO.server installation

This section covers the installation of OMERO.server on UNIX and UNIX-like platforms. This includes all BSD, Linux and MacOS X systems. Depending upon which platform you are using, you may find a more specific walk-through listed below.

See also:
OMERO.server Mac OS X installation walk-through with Homebrew Instructions for installing and building OMERO.server on Mac OS X with Homebrew using our special formulas (i.e. from the source code via Homebrew). You do not need to refer to this page to install the prerequisites with Homebrew and then install the server zip from the downloads page.

Monash University also have a guide for installing OMERO on CentOS 6.3 (64-bit)¹ which you may find useful.

6.1.1 Prerequisites

Installation will require:

- a clean, minimal operating system installation
- a “root” level account for which you know the password

Note: If you are unsure of what it means to have a “root” level account, or if you are generally having issues with the various users/passwords described in this install guide, please see Which user account and password do I use where?.

The installation and configuration of the prerequisite applications is largely outside the scope of this document. For Linux distributions, use of the default package manager is recommended. For BSD systems, the ports system provides all the prerequisites. For MacOS X, Homebrew is recommended. This guide provides the package names to install for a number of contemporary systems. However, the names and versions provided vary between releases. Please do check for similar packages if the one documented here is not available for your system as it may be provided under an alternative name. “Debian” refers to Debian and derivative distributions such as Ubuntu. “RedHat” refers to RedHat and related distributions such as CentOS, Fedora and Scientific Linux.

- For Ubuntu you need to enable the universe repository. This should be enabled by default. If not enabled, it may be enabled by editing /etc/apt/sources.list directly, in which case the entries may already exist but are commented out, or by using Synaptic (10.04 and 10.10) or Ubuntu Software Center (11.04 onwards). Update your package lists to ensure that you get the latest packages:

  $ sudo apt-get update

  Install packages by running:

  $ sudo apt-get install

¹https://confluence-vre.its.monash.edu.au/display/CVL/Installing+Omero+on+CentOS+6.3+(64-bit)
$ sudo apt-get install package

where package is the package name to install.

Overview

The following packages are required:

<table>
<thead>
<tr>
<th>Package</th>
<th>Version</th>
<th>Recommended</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice</td>
<td>3.5</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Java</td>
<td>1.7</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>OMEROServer</td>
<td>5.0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Python</td>
<td>2.7</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>PostgreSQL</td>
<td>9.1</td>
<td>8.4</td>
<td></td>
</tr>
</tbody>
</table>

One of the following packages is recommended if you wish to use OMERO.web:

<table>
<thead>
<tr>
<th>Package</th>
<th>Version</th>
<th>Recommended</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apache</td>
<td>2.4</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>Nginx</td>
<td>1.4.7</td>
<td>1.4.2</td>
<td></td>
</tr>
</tbody>
</table>

These packages are required to make full use of OMEROScripts:

<table>
<thead>
<tr>
<th>Package</th>
<th>Version</th>
<th>Recommended</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEncoder</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

The following subsections cover the details for each package, in the order recommended for installation.

Java SE Runtime Environment (JRE)

If possible, install one of the following packages:

<table>
<thead>
<tr>
<th>System</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSD Ports</td>
<td>java/openjdk7</td>
</tr>
<tr>
<td>Debian</td>
<td>openjdk-7-jre</td>
</tr>
<tr>
<td>Homebrew</td>
<td>N/A</td>
</tr>
<tr>
<td>RedHat</td>
<td>java-1.7.0-openjdk</td>
</tr>
</tbody>
</table>

OMERO works with the OpenJDK JRE provided by most systems, or with Oracle Java. Version 6 or later is required. Version 7 or later is recommended (version 6 is end of line and no longer has updates or security support). Your system may already provide a suitable JRE, in which case no extra steps are necessary. Linux distributions usually provide OpenJDK, and older MacOS X versions have Java installed by default. Oracle Java is no longer provided by BSD or Linux distributions for licensing reasons. If your system does not have Java available, for example on newer MacOS X versions, or the provided version is too old, Oracle Java may be downloaded from the Oracle website\(^2\).

Warning: Security

Installing Oracle Java outside the system’s package manager will leave your system without regular distribution-supplied security updates, and so is not recommended.

To check which version of Java is currently available:

```
$ which java
/usr/bin/java
$ java -version
java version "1.7.0_51"
```

\(^2\)http://www.oracle.com/technetwork/java/javase/downloads/index.html
Python 2

Check you have Python (and check its version) by running:

```
$ python --version
Python 2.7.5+
```

**Note:** OMERO does not currently support Python 3; you must use 2.6 or a later 2.x release.

The following Python packages are required:

<table>
<thead>
<tr>
<th>Package</th>
<th>Functionality</th>
<th>Downloads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pillow</td>
<td>OMERO web and Figure Export</td>
<td>Pillow page</td>
</tr>
<tr>
<td>Matplotlib</td>
<td>OMERO web</td>
<td>Matplotlib page</td>
</tr>
<tr>
<td>NumPy (1.2.0 or higher)</td>
<td>Scripting</td>
<td>Numpy/Scipy page</td>
</tr>
<tr>
<td>PyTables (2.1.0 or higher)</td>
<td>OMERO.tables</td>
<td>PyTables page</td>
</tr>
<tr>
<td>scipy.ndimage</td>
<td>Volume Viewer</td>
<td>Numpy/Scipy page</td>
</tr>
</tbody>
</table>

**Note:** Some of these can be ignored if you wish to forego some functionality but we recommend you just install everything. For example, scripting is enabled by default so should not be assumed optional even if you never expect your users to run scripts from the clients.

If possible, install the following packages:

<table>
<thead>
<tr>
<th>System</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSD Ports</td>
<td>lang/python27 graphics/py-pillow math/py-matplotlib math/py-numpy devel/py-tables science/py-scipy python2.7 python-pil python-matplotlib python-numpy python-tables python-scipy python python/pillow python/numpy python/matplotlib</td>
</tr>
<tr>
<td>Debian</td>
<td>python python-pil python-matplotlib python-numpy python-tables python-scipy</td>
</tr>
<tr>
<td>Homebrew</td>
<td>python python/pillow python/numpy python/matplotlib</td>
</tr>
<tr>
<td>RedHat</td>
<td>python python/pillow python/numpy python/matplotlib</td>
</tr>
</tbody>
</table>

Ice

**Note:** OMERO 5.0 supports Ice 3.5, 3.4 and 3.3 on UNIX and UNIX-like platforms. Ice 3.3 support is deprecated and will

---

3http://pillow.readthedocs.org
4Make sure to have libjpeg (http://libjpeg.sourceforge.net/) installed when building Pillow (http://pillow.readthedocs.org).
5https://pypi.python.org/pypi/Pillow
6http://matplotlib.org/
7http://matplotlib.org/
8May already have been installed as a dependency of Matplotlib.
9http://www.scipy.org/Download
10http://www.pytables.org/moin/Downloads
13http://www.scipy.org/Download
14http://pillow.readthedocs.org
15Make sure to have libjpeg (http://libjpeg.sourceforge.net/) installed when building Pillow (http://pillow.readthedocs.org).
16https://pypi.python.org/pypi/Pillow
17http://matplotlib.org/
18http://matplotlib.org/
19May already have been installed as a dependency of Matplotlib.
20http://www.scipy.org/Download
21http://www.pytables.org/moin/Downloads
24http://www.scipy.org/Download
be removed in OMERO 5.1, which will require Ice 3.5 or 3.4. You must install the correct version of OMERO.server (see Downloads\textsuperscript{25}). See “Do I use Ice 3.3 or Ice 3.4?”\textsuperscript{26} in the FAQ. If you have further questions, consult the Forums\textsuperscript{27}.

If possible, install one of the following packages:

<table>
<thead>
<tr>
<th>System</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSD Ports</td>
<td>devel/ice</td>
</tr>
<tr>
<td>Debian</td>
<td>zeroc-ice</td>
</tr>
<tr>
<td>Homebrew</td>
<td>ice</td>
</tr>
<tr>
<td>RedHat</td>
<td>N/A</td>
</tr>
</tbody>
</table>

The Ice version may vary, depending upon the distribution version you are using. The Ice versions in currently supported versions of Debian and Ubuntu\textsuperscript{28} are shown below:

<table>
<thead>
<tr>
<th>Distribution</th>
<th>ZeroC Ice version</th>
<th>OMERO version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Debian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.0</td>
<td>3.4</td>
<td>4.4.x, 5.x.x</td>
</tr>
<tr>
<td>6.0</td>
<td>3.3</td>
<td>4.4.x, 5.0.x</td>
</tr>
<tr>
<td>14.04 (LTS)</td>
<td>3.5</td>
<td>4.4.x, 5.x.x</td>
</tr>
<tr>
<td>Ubuntu</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.10</td>
<td>3.4</td>
<td>4.4.x, 5.x.x</td>
</tr>
<tr>
<td>12.04 (LTS)</td>
<td>3.4</td>
<td>4.4.x, 5.x.x</td>
</tr>
</tbody>
</table>

Using the latest version of Ice is recommended, where possible. If your package manager provides Ice packages, using these is recommended where possible. Distribution-provided packages often have additional bugfixes which are not present in the upstream releases.

If needed, source and binary packages are available from ZeroC\textsuperscript{29}. The latest release is available from the ZeroC website\textsuperscript{30}.

Note: ZeroC\textsuperscript{31} Ice can always be built from source code for specific platforms if a binary package is not available.

**PostgreSQL**

If possible, install the following packages:

<table>
<thead>
<tr>
<th>System</th>
<th>Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSD Ports</td>
<td>databases/postgresql93-client databases/postgresql93-server</td>
</tr>
<tr>
<td>Debian</td>
<td>postgresql</td>
</tr>
<tr>
<td>Homebrew</td>
<td>postgresql92</td>
</tr>
<tr>
<td>RedHat</td>
<td>postgresql postgresql-server</td>
</tr>
</tbody>
</table>

PostgreSQL 8.4 or later is required. See OMERO.server and PostgreSQL for further details.

**OMERO.web**

Please install one of apache (and its fastcgi module) or nginx in order to run OMERO.web.

<table>
<thead>
<tr>
<th>System</th>
<th>Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSD Ports</td>
<td>www/apache24 www/nginx</td>
</tr>
<tr>
<td>Debian</td>
<td>apache2 libapache2-mod-fastcgi nginx</td>
</tr>
<tr>
<td>Homebrew</td>
<td>nginx</td>
</tr>
<tr>
<td>RedHat</td>
<td>httpd mod_fastcgi nginx</td>
</tr>
</tbody>
</table>

**OMERO.scripts**

If you wish to run the “Movie Maker” script, please install mencoder.

\textsuperscript{25}http://downloads.openmicroscopy.org/latest/omero5/  
\textsuperscript{26}http://www.openmicroscopy.org/site/support/faq/omero/do-i-use-ice-3.3-or-ice-3.4  
\textsuperscript{27}http://www.openmicroscopy.org/community/  
\textsuperscript{28}https://wiki.ubuntu.com/Releases  
\textsuperscript{29}http://www.zeroc.com  
\textsuperscript{30}http://zeroc.com/download.html  
\textsuperscript{31}http://www.zeroc.com
## 6.1.2 Installation

Once the above prerequisites have been downloaded, installed and configured appropriately, the OMERO server itself may be installed. You may wish to create a user account solely for the purpose of running the server, and switch to this user for the next steps.

### Server directory

Firstly, a directory needs to be created to contain the server. In this case `~/omero` is used as an example:

```
$ mkdir -p ~/omero
```

Next, change into this directory:

```
$ cd ~/omero
```

### OMERO.server

The release OMERO.server.zip is available from the OMERO downloads page. Download the version matching the version of Ice installed on your system before continuing.

Installing a development version from source is also possible. See the *Installing OMERO from source* section for further details.

Once you have obtained the OMERO.server zip archive, unpack it:

```
$ unzip OMERO.server-5.0.2-ice34-byy.zip
```

If your system does not provide an `unzip` command by default, install one of the following:

<table>
<thead>
<tr>
<th>System</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSD Ports</td>
<td>multimedia/mencoder</td>
</tr>
<tr>
<td>Debian</td>
<td>mencoder</td>
</tr>
<tr>
<td>Homebrew</td>
<td>N/A</td>
</tr>
<tr>
<td>RedHat</td>
<td>mencoder</td>
</tr>
</tbody>
</table>

Optionally, give your OMERO software install a short name to save some typing later, to reflect what you set `OMERO_PREFIX` to in the *Environment variables* section, below:

```
$ ln -s OMERO.server-5.0.2-ice34-byy OMERO.server
```

This will also ease installation of newer versions of the server at a later date, by simply updating the link.

### 6.1.3 Environment variables

If using distribution-provided packages such as Debian or RPM packages, or via the homebrew or macports package manager, it should not be necessary to set any environment variables. However, if using third-party packages for any required components, several variables may require setting in order for them to function correctly.

Please note that the precise details of these environment variables can change as new versions of software are released.

There are several methods for setting environment variables; which is most appropriate will depend upon how the OMERO server is started. Options include:

---

32http://downloads.openmicroscopy.org/latest/omero5/
/etc/security/pam_env.conf Global environment set at login by PAM
/etc/profile or /etc/profile.d/omero Global Bourne shell defaults (also used by derived shells such as bash and zsh)
~/.profile User’s Bourne shell defaults (also used by derived shells)
/etc/bash.bashrc Global bash defaults
~/.bashrc,~/.bash_profile or ~/.bash_login User’s bash configuration.

If OMERO is started as a service using an init script, a global setting should be preferred. If being started by hand using a particular user, a user-specific configuration file may be more appropriate.

The following environment variables may be configured:

LD_LIBRARY_PATH (Linux) or DYLD_LIBRARY_PATH (MacOS X) The Ice and PostgreSQL libraries must be on the library search path. If using the packages provided by your distribution, this will already be the case. If using third-party binary distributions such as the ZeroC Ice package, Oracle Java, or PostgreSQL, the bin directory for each must be added to the path. The OMERO bin directory may also be added to the search path ($OMERO_PREFIX/bin if OMERO_PREFIX has been set).

PATH The search path must include the programs java, python, icegridnode and PostgreSQL commands such as psql. If using the packages provided by your distribution, this will already be the case. If using third-party binary distributions such as Oracle Java, or PostgreSQL, the bin directory for each must be added to the path. The OMERO bin directory may also be added to the search path ($OMERO_PREFIX/bin if OMERO_PREFIX has been set).

PYTHONPATH The Ice python directory must be made available to python. If using the Ice packages provided by your distribution, this will already be the case. If using the ZeroC ice package, add the python directory to the python path.

**Warning:** The OMERO_HOME environment variable is used internally by OMERO. Unless you really know what you are doing, it is strongly recommended that you do not set this variable (see Setting the OMERO_HOME environment variable for details). You can use a different name of your choice instead, indicated by OMERO_PREFIX in this documentation.

After making any needed changes, either source the corresponding file or log back in for them to take effect. Run env to check them.

### 6.1.4 Creating a database

On most systems, a “postgres” user will be created which has admin privileges, while the UNIX root user itself does not have admin privileges. Therefore it is necessary to either become the postgres user, or use sudo as shown below.

For the purposes of this guide, the following dummy data is used:

Username: db_user
Password: db_password
Database: omero_database

**Warning: Security**

These dummy values are examples only and should not be used. For a live or public server install these values should be altered to reflect your security requirements—i.e. use your own choice of username and password instead. These should not be the same username and/or password as your Linux/Mac/Windows root user!

You should also consider restricting access to your server machine, but that is outside the scope of this document.

* Create a non-superuser database user and record the name and password used. You will need to configure OMERO to use this username and password later on.:*

```bash
$ sudo -u postgres createuser -P -D -R -S db_user
Enter password for new role: # db_password
Enter it again: # db_password
```

---

6.1. OMERO.server installation 45
• Create a database for OMERO to reside in:

```bash
$ sudo -u postgres createdb -O db_user omero_database
```

• Add the PL/pgSQL language to your database:

```bash
$ sudo -u postgres createlang plpgsql omero_database
```

**Note:** PostgreSQL 9.0 and later enable PL/pgSQL by default.

• Check to make sure the database has been created, you have PostgreSQL client authentication correctly set up and the database is owned by the `db_user` user.

```bash
$ psql -h localhost -U db_user -l
Password for user db_user:
```

<table>
<thead>
<tr>
<th>Name</th>
<th>Owner</th>
<th>Encoding</th>
</tr>
</thead>
<tbody>
<tr>
<td>omero_database</td>
<td>db_user</td>
<td>UTF8</td>
</tr>
<tr>
<td>postgres</td>
<td>postgres</td>
<td>UTF8</td>
</tr>
<tr>
<td>template0</td>
<td>postgres</td>
<td>UTF8</td>
</tr>
<tr>
<td>template1</td>
<td>postgres</td>
<td>UTF8</td>
</tr>
</tbody>
</table>
(4 rows)

If you have problems, especially with the last step, take a look at *OMERO.server and PostgreSQL* since the authentication mechanism is probably not properly configured.

### 6.1.5 Location for the your OMERO binary repository

• Create a directory for the OMERO binary data repository. `/OMERO` is the default location and should be used unless you explicitly have a reason not to and know what you are doing.

• This is *not* where you want the OMERO application to be installed, it is a *separate* directory which the OMERO.server will use to store binary data.

• You can read more about the *OMERO binary repository*.

```bash
$ sudo mkdir /OMERO
```

• Change the ownership of the directory. `/OMERO` **must** either be owned by the user starting the server (it is currently owned by the system root) or that user **must** have permission to write to the directory. You can find out your username and edit the correct permissions as follows:

```bash
$ whoami
omero
$ sudo chown -R omero /OMERO
```

### 6.1.6 Configuration

• Optionally, review `~/omero/OMERO.server/etc/omero.properties`, which contains all default settings. Do not edit this file—it is for reference only. Any configuration settings you would like to change can be changed in the next step.
• Change any settings that are necessary using `omero config`, including the name and/or password for the ‘db_user’ database user you chose above or the database name if it is not “omero_database”. (Quotes are only necessary if the value could be misinterpreted by the shell. See link [33])

```bash
$ cd ~/omero/OMERO.server
$ bin/omero config set omero.db.name 'omero_database'
$ bin/omero config set omero.db.user 'db_user'
$ bin/omero config set omero.db.pass 'db_password'
```

You can also check the values that have been set using:

```bash
$ cd ~/omero/OMERO.server
$ bin/omero config get
```

• If you have chosen a non-standard `OMERO binary repository` location above, be sure to configure the `omero.data.dir` property. For example, to use `/srv/omero`:

```bash
$ omero config set omero.data.dir /srv/omero
```

• Create the OMERO database initialization script. You will be asked for the version of the script which you would like to generate, where both defaults can be accepted. Finally, you will be asked to enter and confirm password for your newly created OMERO root user. Note that this password is for the root user of the `OMERO.server`, and is not related to the root system user or a PostgreSQL user role.

```bash
$ cd ~/omero/OMERO.server
$ bin/omero db script
```

```
Please enter omero.db.version [OMERO5.0]:
Please enter omero.db.patch [0]:
Please enter password for new OMERO root user: # omero_root_password
Please re-enter password for new OMERO root user: # omero_root_password
Saving to ~/Desktop/omero/OMERO5.0__0.sql
```

**Warning: Security**
For illustrative purposes, the default password for the OMERO root user is shown as `omeroroot_password`. However, you should **not** use these default values for your installation, but use your own choice of password instead. This should **not** be the same password as your Linux/Mac/Windows root user or the database user!

• Initialize your database with the script.

```bash
$ psql -h localhost -U db_user omero_database < OMERO5.0__0.sql
```

At this point you should see some output from PostgreSQL as it installs the schema for new OMERO database.

• Before starting the `OMERO.server`, run the OMERO diagnostics script to check that all of the settings are correct, e.g.

```bash
$ bin/omero admin diagnostics
```

• You can now start the server using:

```bash
$ bin/omero admin start
Creating var/master
Initializing var/log
Creating var/registry
No descriptor given. Using etc/grid/default.xml
```

• Test that you can log in as “root”, either with the OMERO.insight client or on the command-line:

```bash
```

---


6.1. OMERO.server installation
You will be prompted for an OMERO username and password. Use the username and password set when running

$ bin/omero db script

6.1.7 JVM memory settings

To make your server production-ready, you will likely need to increase the JVM memory settings of your application descriptors. This is not done by default since it would prevent starting the server on some sites’ test instance but for production use a setting higher than 512MB is highly recommended.

To increase the JVM memory settings, you need to edit the etc/grid/templates.xml file under the OMERO.server directory.

It is highly recommended to increase the BlitzTemplate default JVM memory settings from -Xmx512M to -Xmx2048M and from XX:MaxPermSize=128m to XX:MaxPermSize=256M in production.

If working with large images generates OutOfMemory exceptions in the var/log/PixelData-0.log file, you may consider increasing the PixelDataTemplate default JVM memory settings to -Xmx1024M.

Once you have modified the templates.xml file, restart the server using:

$ bin/omero admin restart

See also:


Grid configuration  Section of the advanced server configuration documentation describing etc/grid/templates.xml.

6.1.8 OMERO.web and administration

Note: In order to deploy OMERO.web in a production environment such as Apache or IIS please follow the instructions under OMERO.web deployment.

Otherwise, the internal Django webserver can be used for evaluation and development. In this case, we need to turn debugging on, in order that static files can be served by Django:

$ bin/omero config set omero.web.application_server development
$ bin/omero config set omero.web.debug True

and then start by running:

$ bin/omero web start
INFO:__main__:Application Starting...
INFO:root:Processing custom settings for module omeroweb.settings
...
Validating models...

0 errors found
Django version 1.6, using settings 'omeroweb.settings'
Starting development server at http://0.0.0.0:4080/
Quit the server with CONTROL-C.

Once you have deployed and started the server you can use your browser to access the OMERO.web interface:
6.1.9 Enabling movie creation from OMERO.

OMERO has a facility to create AVI/MPEG Movies from images. The page OMERO.movie details how to enable it.

6.1.10 Post-installation items

Backup

One of your first steps after putting your OMERO server into production should be deciding on when and how you are going to backup your database and binary data. Please do not omit this step.

Security

It is also now recommended that you read the Server security and firewalls page to get a good idea as to what you need to do to get OMERO clients speaking to your newly installed OMERO.server in accordance with your institution or company’s security policy.

Advanced configuration

Once you have the base server running, you may want to try enabling some of the advanced features such as OMERO.dropbox or LDAP authentication. If you have *Flex data*, you may want to watch the HCS configuration screencast\(^{34}\). See the Feature list\(^{35}\) for more advanced features you may want to use, and Advanced configuration on how to get the most out of your server.

Update notification

Your OMERO.server installation will check for updates each time it is started from the Open Microscopy Environment update server. If you wish to disable this functionality you should do so now as outlined on the OMERO upgrade checks page.

Troubleshooting

My OMERO install doesn’t work! What do I do now? Examine the Troubleshooting OMERO page and if all else fails post a message to our ume-users\(^{36}\) mailing list discussed on the Community support page.

---

\(^{34}\)http://cvs.openmicroscopy.org.uk/snapshots/movies/omero-4-1/mov/FlexPreview4.1-configuration.mov

\(^{35}\)http://www.openmicroscopy.org/site/products/omero/feature-list

\(^{36}\)http://lists.openmicroscopy.org.uk/mailman/listinfo/ome-users
OMERO diagnostics

If you want help with your server installation, please include the output of the diagnostics command:

$ bin/omero admin diagnostics

OMERO Diagnostics 5.0.2

Commands:  java -version  1.7.0  (/usr/bin/java)
Commands:  python -V     2.7.6  (/usr/bin/python)
Commands:  icegridnode --version 3.5.1 (/usr/bin/icegridnode)
Commands:  icegridadmin --version 3.5.1 (/usr/bin/icegridadmin)
Commands:  psql --version  9.1.13 (/usr/bin/psql)

Server: icegridnode running
Server: Blitz-0 active (pid = 30324, enabled)
Server: DropBox active (pid = 30343, enabled)
Server: FileServer active (pid = 30345, enabled)
Server: Indexer-0 active (pid = 30348, enabled)
Server: MonitorServer active (pid = 30351, enabled)
Server: OMERO.Glacier2 active (pid = 30353, enabled)
Server: OMERO.IceStorm active (pid = 30376, enabled)
Server: PixelData-0 active (pid = 30393, enabled)
Server: Processor-0 active (pid = 30394, enabled)
Server: Tables-0 inactive (disabled)
Server: TestDropBox inactive (enabled)

OMERO: SSL port 4064
OMERO: TCP port 4063

Log dir: /home/omero/OMERO.server-5.0.1-ice35-b21/var/log exists

Log files: Blitz-0.log   3.0 MB  errors=0  warnings=9
Log files: DropBox.log   4.0 KB  errors=0  warnings=1
Log files: FileServer.log 0.0 KB
Log files: Indexer-0.log  10.0 KB  errors=0  warnings=5
Log files: MonitorServer.log 2.0 KB
Log files: OMEROweb.log  642.0 KB  errors=0  warnings=1
Log files: OMEROweb_request.log  0.0 KB
Log files: PixelData-0.log  7.0 KB  errors=0  warnings=4
Log files: Processor-0.log  2.0 KB  errors=0  warnings=1
Log files: Tables-0.log  n/a
Log files: TestDropBox.log  n/a
Log files: master.err   0.0 KB  errors=2  warnings=0
Log files: master.out   0.0 KB
Log files: Total size   3.83 MB

Environment:OMERO_HOME=(unset)
Environment:OMERO_NODE=(unset)
Environment:OMERO_MASTER=(unset)
Environment:OMERO_TEMPDIR=(unset)
Environment:PATH=/usr/local/bin:/usr/bin:/bin
Environment:ICE_HOME=(unset)
Environment:LD_LIBRARY_PATH=(unset)
Environment:DYLD_LIBRARY_PATH=(unset)

OMERO data dir: '/OMERO' Exists? True  Is writable? True
OMERO temp dir: '/home/omero/tmp'  Exists? True  Is writable? True  (Size: 0)
OMERO.web status... DEVELOPMENT: You will have to check status by hand!

6.1. OMERO.server installation
OMERO.server Mac OS X installation walk-through with Homebrew

Overview
This walk-through demonstrates how to install OMERO on a clean Mac OS X 10.7 Lion system using Homebrew. Note that this demonstrates how to install OMERO.server from the source code via Homebrew, in addition to all its prerequisites. The default instructions for UNIX platforms in the OMERO.server installation guide are all you need to install the prerequisites with Homebrew and then install the server zip from the downloads page.

The instructions provided here depend on Homebrew 0.9 or later, including support for the brew tap command. These instructions are implemented in an automated script\(^{37}\) which installs OMERO via Homebrew from a fresh configuration.

Prerequisites

**OS X/Xcode** Install the OS X Developer Tools\(^{38}\). This procedure is regularly tested with the following configuration:

<table>
<thead>
<tr>
<th>Model Identifier</th>
<th>Mac OS X version</th>
<th>Xcode version</th>
</tr>
</thead>
<tbody>
<tr>
<td>MacBookPro8,2 (Intel Core i7, 2.3 GHz, 8 GB RAM)</td>
<td>10.7.5</td>
<td>4.6</td>
</tr>
</tbody>
</table>

*Note:* For Xcode 4.x, make sure that the Command line tools are installed (Preferences → Downloads → Components).

**Java (>=1.6)** You need Java which comes as standard on OS X.

```
$ java -version
java version "1.6.0_33"
Java(TM) SE Runtime Environment (build 1.6.0_33-b03-424-11M3720)
Java HotSpot(TM) 64-Bit Server VM (build 20.8-b03-424, mixed mode)
```

**Homebrew** Follow the installation instructions on the Homebrew wiki\(^{39}\). All requirements for OMERO will be installed to /usr/local.

```
$ ruby -e "$(curl -fsSL https://raw.github.com/mxcl/homebrew/go/install)"
$ brew install git
```

If you are having issues with curl, see the curl (Mac 10.5 only) section under Common issues.

The installation of OMERO via Homebrew depends on two alternate repositories containing extra formulas: https://github.com/Homebrew/homebrew-science for the HDF5 formula and https://github.com/ome/homebrew-alt for all the OME-provided formulas and older versions of Ice.

**Python 2 (>=2.6)** You can install OMERO using either the system-wide Python or the Python provided by Homebrew. For a more thorough description of the latter solution, look at the Homebrew and Python\(^{40}\) page. Note that the automated script linked above tests the OMERO installation using the Homebrew Python.

If using system-wide Python, check it is installed and its version.

```
$ python --version
Python 2.7.3
```

To install the Python provided by Homebrew:

---

\(^{37}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/docs/hudson/OMERO-homebrew-install.sh
\(^{38}\)https://developer.apple.com/technologies/tools/
\(^{39}\)https://github.com/mxcl/homebrew/wiki/installation
\(^{40}\)https://github.com/mxcl/homebrew/wiki/Homebrew-and-Python

---
$ brew install python

Independently of the chosen Python, you can setup and use virtual environments\footnote{http://www.virtualenv.org/en/latest/} to install the OMERO Python dependencies (see \textit{Python dependencies}).

\textbf{Note:} The Homebrew formulas used below provide Python bindings. As described in \textit{Homebrew and Python}\footnote{https://github.com/mxcl/homebrew/wiki/Homebrew-and-Python}, you should NOT be in an active virtual environment when you \texttt{brew install} them.

\section*{OMERO installation}

\textbf{OMERO 5.0.2} If you just want a deployment of the 5.0.2 release of OMERO.server then a simple Homebrew install is sufficient, e.g.

$ brew tap homebrew/science
$ brew tap ome/alt
$ brew install omero

This should install OMERO along with most of the non-Python requirements.

The default version of Ice installed by the OMERO formula is Ice 3.5. To install OMERO with Ice 3.4, use:

$ brew install omero --with-ice34

or to install OMERO with Ice 3.3, use:

$ brew install omero --with-ice33

Additional installation options can be listed using the \texttt{info} command:

$ brew info omero

\textbf{Development server} If you wish to pull OMERO.server from the git repo for development purposes then it is worth setting up OMERO.server manually. First use Homebrew to install the OMERO dependencies:

$ brew tap homebrew/science
$ brew tap ome/alt
$ brew install 'brew deps omero'

The default version of Ice installed by the OMERO formula is Ice 3.5. To install the OMERO dependencies with Ice 3.4, use:

$ brew install 'brew deps omero --with-ice34'

or to install the OMERO dependencies with Ice 3.3, use:

$ brew install 'brew deps omero --with-ice33'

Prepare a place for your OMERO code to live, e.g.
$ mkdir -p ~/code/projects/OMERO
$ cd ~/code/projects/OMERO

If you installed Ice 3.5, you will need to set SLICEPATH to be able to build the server, i.e. `export SLICEPATH=/usr/local/share/Ice-3.5/slice`.

If you want the development version of OMERO.server, you can clone the source code from the project’s GitHub account to build locally:

```bash
$ git clone --recursive git://github.com/openmicroscopy/openmicroscopy
$ cd openmicroscopy && ./build.py
```

**Note:** If you have a GitHub account and you plan to develop code for OMERO, you should make a fork into your own account and then clone this fork to your local development machine, e.g.

```bash
$ git clone --recursive git://github.com/YOURNAMEHERE/openmicroscopy
$ cd openmicroscopy && ./build.py
```

**See also:**
- **Installing OMERO from source** Developer documentation page on how to check out to source code
- **Build System** Developer documentation page on how to build the OMERO.server

**Additional OMERO requirements**

**PostgreSQL** Install PostgreSQL if you do not have another PostgreSQL installation that you can use.

```bash
$ postgres --version  # Check if you have postgres
$ brew install postgresql
```

**Python dependencies** The Python dependencies can be installed in the system-wide Python site-packages, in the Homebrew Python site-packages or within a virtual environment. If you are using the system-wide Python site-packages, you may need to use `sudo` to install the dependencies. If you are using a virtual environment, activate it before calling the Python dependencies installation script.

If you installed OMERO using Homebrew, execute the `omero_python_deps` script:

```bash
$ cd /usr/local
$ bash bin/omero_python_deps
```

If you use a development server, execute the `python_deps.sh` script under `docs/install`:

```bash
$ cd ~/code/projects/OMERO
$ bash docs/install/python_deps.sh
```

If you encounter problems with the installation script, please take a look at **Common issues**.

**Configuration**
Environment variables  Edit your .profile as appropriate. The following are indicators of required entries and correspond to a Homebrew installation of OMERO 5.0.2:

```bash
export PYTHONPATH=$(brew --prefix omero)/lib/python
export PATH=/usr/local/bin:/usr/local/sbin:/usr/local/lib/node_modules:$PATH
```

If you have installed Ice 3.3 or Ice 3.4, you will need to specify the path to Ice Python and dynamic libraries:

```bash
export PYTHONPATH=$(brew --prefix omero)/lib/python:$ICE_HOME/python
export DYLD_LIBRARY_PATH=$ICE_HOME/lib:$DYLD_LIBRARY_PATH
```

where `ICE_HOME` needs to be replaced by `$(brew --prefix zeroc-ice33)` or `$(brew --prefix zeroc-ice34)` depending on your configuration.

Note: If you have a local .bash_profile file, it will override your .profile configuration file.

Note: On Mac OS X Lion, a version of PostgreSQL is already installed. If you get an error like the following:

```
psql: could not connect to server: Permission denied
Is the server running locally and accepting
connections on Unix domain socket "'/var/pgsql_socket/.s.PGSQL.5432"?"?
```

make sure /usr/local/bin is at the beginning of your PATH (see also this post\(^1\)).

Database creation  Start the PostgreSQL server.

\(\)\(^1\)http://nextmarvel.net/blog/2011/09/brew-install-postgresql-on-os-x-lion/

```
$ initdb /usr/local/var/postgres
$ brew services start postgresql
$ pg_ctl -D /usr/local/var/postgres/ -l /usr/local/var/postgres/server.log start
```

Create a user, a database and add the PL/pgSQL language to your database.

```
$ createuser -P -D -R -S db_user
Enter password for new role: # db_password
Enter it again: # db_password
$ createdb -O db_user omero_database
$ createlang plpgsql omero_database
```

Check to make sure the database has been created.

```
$ psql -h localhost -U db_user -l
```

This command should give similar output to the following:

```
<table>
<thead>
<tr>
<th>Name</th>
<th>Owner</th>
<th>Encoding</th>
<th>Collation</th>
<th>Ctype</th>
<th>Access privileges</th>
</tr>
</thead>
<tbody>
<tr>
<td>omero_database</td>
<td>db_user</td>
<td>UTF8</td>
<td>en_GB.UTF-8</td>
<td>en_GB.UTF-8</td>
<td></td>
</tr>
<tr>
<td>postgres</td>
<td>ome</td>
<td>UTF8</td>
<td>en_GB.UTF-8</td>
<td>en_GB.UTF-8</td>
<td></td>
</tr>
<tr>
<td>template0</td>
<td>ome</td>
<td>UTF8</td>
<td>en_GB.UTF-8</td>
<td>en_GB.UTF-8</td>
<td></td>
</tr>
</tbody>
</table>
```

\(^1\)http://nextmarvel.net/blog/2011/09/brew-install-postgresql-on-os-x-lion/
OMERO.server  Now tell OMERO.server about our database.

$ omero config set omero.db.name omero_database
$ omero config set omero.db.user db_user
$ omero config set omero.db.pass db_password

$ omero db script
Please enter omero.db.version [OMERO5.0]:
Please enter omero.db.patch [0]:
Please enter password for new OMERO root user: # root_password
Please re-enter password for new OMERO root user: # root_password
Saving to ~/OMERO5.0__0.sql

Then enter the name of the .sql (see last line above) in the next command, to create the database:

$ psql -h localhost -U db_user omero_database < OMERO5.0__0.sql

Now create a location to store OMERO data, e.g.

$ mkdir -p ~/var/OMERO.data

and tell OMERO.server this location:

$ omero config set omero.data.dir ~/var/OMERO.data

We can inspect the OMERO.server configuration settings using:

$ omero config get

Now start the OMERO.server

$ omero admin start

Now connect to your OMERO.server using OMERO.insight with the following credentials:

U: root
P: root_password

OMERO.web  You can set up the internal development web server

$ omero config set omero.web.application_server development
$ omero config set omero.web.debug True

Then start the webserver with:

$ omero web start
INFO:__main__:Application Starting...
INFO:root:Processing custom settings for module omeroweb.settings
Validating models...

0 errors found
Django version 1.6, using settings 'omeroweb.settings'
Starting development server at http://0.0.0.0:4080/
Quit the server with CONTROL-C.

Common issues

General considerations If you run into problems with Homebrew, you can always run:

```
$ brew update
$ brew doctor
```

Also, please check the Homebrew Bug Fixing Checklist[^44].

Below is a non-exhaustive list of errors/warnings specific to the OMERO installation. Some if not all of them could possibly be avoided by removing any previous OMERO installation artifacts from your system.

curl (Mac 10.5 only)

curl: (60) SSL certificate problem, verify that the CA cert is OK. Details:
error:14090086:SSL routines:SSL3_GET_SERVER_CERTIFICATE:certificate verify failed

Use `export GIT_SSL_NO_VERIFY=1` before running failing brew commands.

Xcode

Warning: Xcode is not installed! Builds may fail!

Install Xcode using Mac App store[^45].

Macports/Fink

Warning: It appears you have MacPorts or Fink installed.

Follow uninstall instructions from the Macports guide[^46].

PostgreSQL

=> Installing postgresql dependency: readline
Error: No such file or directory - /usr/bin/cc

For Xcode 4.3.2 make sure Xcode Command Line Tools are installed (see comment[^47]).

Error: You must `brew link ossp-uuid` before postgresql can be installed

[^46]: http://guide.macports.org/chunked/installing.macports.uninstalling.html
[^47]: https://github.com/mxcl/homebrew/issues/10244#issuecomment-4013781
$ brew cleanup
$ brew link ossp-uuid

### Ice

Error: Failed executing: cd cpp && make M PP_HOME=/Users/sebastien/apps/OMERO.libs/Cellar/mcpp/2.7.2 ... embedded_runpath_prefix=/Users/sebastien/apps/OMERO.libs/Cellar/zeroc-ice33/3.3 install

We have had problems building zeroc-ice33 under MacOS 10.7.3 and 10.6.8 (see #8075). You can try installing zeroc-ice34 (Ice 3.4) instead. If you decide to go with zeroc-ice33, make sure that you do not have DYLD_LIBRARY_PATH set to an existing Ice’s installation lib directory path. In essence your .bash_profile shouldn’t have any OMERO-related environment variables set before executing the installation script.

### zip

```bash
=> Installing hdf5 dependency: zip
Already downloaded: /Library/Caches/Homebrew/zip-2.1.tar.gz
Error: MD5 mismatch
Expected: 902f831bcefb69c6b635374424acbead
Got: 0d6a55bb7787f98b8d608f323ef5be0
Archive: /Library/Caches/Homebrew/zip-2.1.tar.gz
(To retry an incomplete download, remove the file above.)
```

Manually remove the archived version located under /Library/Caches/Homebrew since the maintainer may have updated the file.

### numexpr (and other Python packages)

If you encounter an issue related to numexpr complaining about NumPy having a too low version number, verify that you have not before installed any Python packages using pip. In the case where pip has been installed before homebrew, uninstall it:

```bash
$ sudo pip uninstall pip
```

After that try running python_deps.sh again. That should install pip via Homebrew and put the Python packages in correct folders.

### gfortran

gfortran currently fails to build on 32-bit 10.6.8 machines (see https://github.com/mxcl/homebrew/issues/17776)

## 6.2 OMERO.server binary repository

### About

The OMERO.server binary data repository is a fundamental piece of server-side functionality. It provides optimized and indexed storage of original file, pixel and thumbnail data, attachments and full text indexes. Its structure is based on OMEIS.

---


### 6.2.1 Layout

The repository is internally laid out as follows:

---

Your repository is not:

- the “database”
- the directory where your OMERO.server binaries are
- the directory where your OMERO.client (OMERO.insight, OMERO.editor or OMERO.importer) binaries are
- your PostgreSQL data directory

### 6.2.2 Locking and remote shares

The OMERO server requires proper locking semantics on all files in the binary repository. In practice, this means that remotely mounted shares such as AFS, CIFS, and NFS can cause issues. If you have experience and/or the time to manage and monitor the locking implementations of your remote filesystem, then using them as for your binary repository should be fine.

If, however, you are seeing errors such as NullPointerExceptions, “Bad file descriptors” and similar in your server log, then you will need to use directly connected disks.

**Warning:** If your binary repository is a remote share and mounting the share fails or is dismounted, OMERO will continue operating using the mount point instead! To prevent this, make the mount point read-only for the OMERO user so that no data can be written to the mount point.

### 6.2.3 Changing your repository location

**Note:** It is strongly recommended that you make all changes to your OMERO binary repository with the server shut down. Changing the omero.data.dir configuration does not move the repository for you, you must do this yourself.

Your repository location can be changed from its /OMERO default by modifying your OMERO.server configuration as follows:

```bash
$ cd OMERO.server
$ bin/omero config set omero.data.dir /mnt/really_big_disk/OMERO
```

The suggested procedure is to shut down your OMERO.server instance, move your repository, change your omero.data.dir and then start the instance back up. For example:

```bash
$ cd OMERO.server
$ bin/omero admin stop
$ mv /OMERO /mnt/really_big_disk
$ bin/omero config set omero.data.dir /mnt/really_big_disk/OMERO
$ bin/omero admin start
```

### 6.2.4 Permissions

Your repository should be owned by the same user that is starting your OMERO.server instance. This is often either yourself (find this out by executing whoami) or a separate omero (or similar) user who is dedicated to running OMERO.server. For example:
In order to be installed, OMERO.server requires a running PostgreSQL instance that is configured to accept connections over TCP. This section explains how to ensure that you have the correct PostgreSQL version and that it is installed and configured correctly.

### 6.3.1 Ensuring you have a valid PostgreSQL version

For OMERO 5.0, PostgreSQL version 8.4 or later is required; version 9.1 or later is recommended. Make sure you are using a supported version. You can check which version of PostgreSQL you have installed with any of the following commands:

```
$ createuser -V
createuser (PostgreSQL) 9.1.4
$ psql -V
psql (PostgreSQL) 9.1.4
$ createdb -V
createdb (PostgreSQL) 9.1.4
```

If your existing PostgreSQL installation is version 8.3 or earlier, you must upgrade to a more up-to-date version. Before upgrading, stop the OMERO server and then perform a full dump of the database using `pg_dump`. See the OMERO.server backup and restore section for further details.

If using a Linux distribution-provided PostgreSQL server, upgrading to a newer version of the distribution will usually make a newer version of PostgreSQL available. If the database was not migrated to the new version automatically, restore your backup after installing, configuring and starting the new version of the database server. If a PostgreSQL server was not provided by your system, EnterpriseDB\(^{50}\) provide an installer.

### 6.3.2 Checking PostgreSQL port listening status

You can check if PostgreSQL is listening on the default port (TCP/5432) by running the following command:

```
$ netstat -an | egrep '5432.*LISTEN'
tcp 0 0 0.0.0.0:5432 0.0.0.0:* LISTEN
tcp 0 0 ::::5432 ::::* LISTEN
```

**Note:** The exact output of this command will vary. The important thing to recognize is whether or not a process is listening on TCP/5432.

If you cannot find a process listening on TCP/5432 you will need to find your `postgresql.conf` file and enable PostgreSQL’s TCP listening mode. The exact location of the `postgresql.conf` file varies between installations.

---

\(^{49}\)http://www.postgresql.org/support/versioning/

\(^{50}\)http://www.enterprisedb.com/
It may be helpful to locate it using the package manager (rpm or dpkg) or by utilizing the find command. Usually, the PostgreSQL data directory (which houses the postgresql.conf file) is located under /var or /usr:

$ sudo find /etc -name 'postgresql.conf'
$ sudo find /usr -name 'postgresql.conf'
$ sudo find /var -name 'postgresql.conf'
/var/lib/postgresql/data/postgresql.conf

**Note:** The PostgreSQL data directory is usually only readable by the user postgres so you will likely have to be root in order to find it.

Once you have found the location of the postgresql.conf file on your particular installation, you will need to enable TCP listening. For PostgreSQL 8.4 and 9.x, the area of the configuration file you are concerned about should look similar to this:

```
#listen_addresses = 'localhost' # what IP address(es) to listen on;
# comma-separated list of addresses;
# defaults to 'localhost', '*' = all

#port = 5432
max_connections = 100
# note: increasing max_connections costs ~400 bytes of shared memory per
# connection slot, plus lock space (see max_locks_per_transaction). You
# might also need to raise shared_buffers to support more connections.
#superuser_reserved_connections = 2
#unix_socket_directory = *
#unix_socket_group = *
#unix_socket_permissions = 0777 # octal
#bonjour_name = * # defaults to the computer name
```

### 6.3.3 PostgreSQL HBA (host based authentication)

OMERO.server must have permission to connect to the database that has been created in your PostgreSQL instance. This is configured in the host based authentication file, pg_hba.conf. Check the configuration by examining the contents of pg_hba.conf. It’s important that at least one line allows connections from the loopback address (127.0.0.1) as follows:

```
# TYPE DATABASE USER CIDR-ADDRESS METHOD
# IPv4 local connections:
host  all  all  127.0.0.1/32  md5
```

**Note:** The other lines that are in your pg_hba.conf are important either for PostgreSQL internal commands to work or for existing applications you may have. **Do not delete them.**

### 6.3.4 Completing configuration

After making any configuration changes to postgresql.conf or pg_hba.conf, reload the server for the changes to take effect.

```
$ sudo service postgresql reload
```

See also:

- **PostgreSQL** Interactive documentation for the current release of PostgreSQL.
- **Connections and Authentication** Section of the PostgreSQL documentation about configuring the server using postgresql.conf.
- **Client Authentication** Chapter of the PostgreSQL documentation about configuring client authentication with pg_hba.conf.
6.4 OMERO.web deployment

OMERO.web is the web application component of the OMERO platform which allows for the management, visualization (in a fully multi-dimensional image viewer) and annotation of images from a web browser. It also includes OMERO.webadmin for managing users and groups.

OMERO.web is an integral part of the OMERO platform and can be deployed with:

- FastCGI using a FastCGI capable web server such as Apache54 (with mod_fastcgi enabled), nginx56 or lighttpd57 (since OMERO 4.2.1)
- The built-in Django lightweight development server (for testing only)

You can find more information about FastCGI and where to get modules or packages for your distribution on the FastCGI website58.

If you need help configuring your firewall rules, see the Server security and firewalls page.

6.4.1 Prerequisites

- OMERO and its prerequisites (see OMERO.server installation).
- Python 2 (2.6 or later)
  - Pillow59 should be available for your distribution
  - Matplotlib60 should be available for your distribution
- A FastCGI capable web server

6.4.2 Configuring OMERO from the command line

Configuration options can be set using the `omero config set` command:

$ bin/omero config set <parameter> <value>

When supplying a value with spaces or multiple elements, use single quotes. The quotes will not be saved as part of the value (see below).

To remove a configuration option (to return to default values where mentioned), simply omit the value:

$ bin/omero config set <parameter>

These options will be stored in a file: `etc/grid/config.xml` which you can read for reference. DO NOT edit this file directly.

You can also review all your settings by using:

$ bin/omero config get

which should return values without quotation marks.

A final useful option of `omero config edit` is:

$ bin/omero config edit

which will allow for editing the configuration in a system-default text editor.

54 http://httpd.apache.org/
55 http://www.fastcgi.com/drupal/
56 http://nginx.org/
57 http://www.lighttpd.net/
58 http://www.fastcgi.com/drupal/node/3
59 http://pillow.readthedocs.org
60 http://matplotlib.org/
6.4.3 Quick Start

Using FastCGI (Unix/Linux)

Once you have installed a FastCGI capable web server, configuration of OMERO.web is quite straightforward.

- Choose between FastCGI TCP (recommended) or FastCGI (advanced):

  $ bin/omero config set omero.web.application_server "fastcgi" / "fastcgi-tcp"

- Place a stanza in your web server configuration file. The location of the file will depend on your system, please refer to your web server’s manual. Apache and nginx configurations can be automatically generated for you by OMERO.web, see Apache configuration or Nginx configuration.

- Start the Django FastCGI workers:

  $ bin/omero web start

  ....
  Copying '/Users/omero/Desktop/omero/lib/python/omeroweb/webstart/static/webstart/img/icon-omero-web.png'
  735 static files copied to '/Users/omero/Desktop/omero/lib/python/omeroweb/static'.
  Starting OMERO.web... [OK]

**Note:** The Django FastCGI workers are managed separately from other OMERO.server processes. You can check their status or stop them using the following commands:

  $ bin/omero web status
  OMERO.web status... [RUNNING] (PID 59217)
  $ bin/omero web stop
  Stopping OMERO.web... [OK]
  Django FastCGI workers (PID 59217) killed.

Apache configuration

To create a site configuration file for inclusion in the main Apache configuration redirect the output of the following command into a file:

  $ bin/omero web config apache

  ...

  ### Stanza for OMERO.web created 2012-07-12 16:44:16.112099
  ###
  FastCGIExternalServer "/usr/local/dev/openmicroscopy/dist/var/omero.fcgi" -host 0.0.0.0:4080
  <Directory "/usr/local/dev/openmicroscopy/dist/var">
    Options -Indexes FollowSymLinks
    Order allow,deny
    Allow from all
  </Directory>

  <Directory "/usr/local/dev/openmicroscopy/dist/lib/python/omeroweb/static">
    Options -Indexes FollowSymLinks
    Order allow,deny
    Allow from all
  </Directory>
Note: The default configuration file installed with mod_fastcgi may be incompatible with OMERO. In particular, the FastCGI-Wrapper option conflicts with FastCGIExternalServer required by OMERO and must be removed or commented out.

**Nginx configuration**

To create a configuration file for a standalone instance of nginx redirect the output of the following command into a file:

```
$ bin/omero web config nginx
```

```bash
# nginx userland template
# this configuration is designed for running nginx as the omero user or similar
# nginx -c etc/nginx.conf
# for inclusion in a system-wide nginx configuration see omero web config nginx --system
#
# pid /usr/local/dev/openmicroscopy/dist/var/pid.nginx;
error_log /usr/local/dev/openmicroscopy/dist/var/log/nginx_error.log;
worker_processes 5;
working_directory /usr/local/dev/openmicroscopy/dist/var;

events {
    worker_connections 1024;
}

http {
    access_log /usr/local/dev/openmicroscopy/dist/var/log/nginx_access.log;
    include /usr/local/dev/openmicroscopy/dist/etc/mime.types;
    default_type application/octet-stream;
    client_body_temp_path /usr/local/dev/openmicroscopy/dist/var/nginx_tmp;
    keepalive_timeout 65;

    server {
        listen 8080;
        server_name _;
        fastcgi_temp_path /usr/local/dev/openmicroscopy/dist/var/nginx_tmp;
        proxy_temp_path /usr/local/dev/openmicroscopy/dist/var/nginx_tmp;

        # weblitz django apps serve static content from here
        location /static {
            alias /usr/local/dev/openmicroscopy/dist/lib/python/omeroweb/static;
        }

        location / {
            if (-f /usr/local/dev/openmicroscopy/dist/var/maintenance.html) {
                error_page 503 /maintenance.html;
                return 503;
            }

            fastcgi_pass 0.0.0.0:4080;
            fastcgi_param PATH_INFO $fastcgi_script_name;
        }
    }
}
```

6.4. OMERO.web deployment
It is also possible to generate a site file for inclusion as part of a system-wide nginx instance:

```bash
$ bin/omero web config nginx --system
```

See also:

*Custom OMERO.web location.*

### Using the lightweight development server

All that is required to use the Django lightweight development server is to set the `omero.web.application_server` configuration option, turn Debugging on and start the server up:

```bash
$ bin/omero config set omero.web.application_server development
$ bin/omero config set omero.web.debug True
$ bin/omero web start
INFO:__main__:Application Starting...
INFO:root:Processing custom settings for module omeroweb.settings
... Validating models...
0 errors found
Django version 1.6, using settings 'omeroweb.settings'
Starting development server at http://0.0.0.0:4080/
Quit the server with CONTROL-C.
```

### 6.4.4 Logging in to OMERO.web

Once you have deployed and started the server, you can use your browser to access OMERO.webadmin or the OMERO.webclient:

- **http://your_host/omero OR, for development server: http://localhost:4080**

**Note:** This starts the server in the foreground. It is your responsibility to place it in the background, if required, and manage its shutdown.
6.4.5 Customizing your OMERO.web installation

**Note:** For clarity, some edge-case/in-development options may not be documented below. For the full list see:

$ bin/omero web -h

OR look in lib/python/omeroweb/settings.py

- A list of servers the Web client can connect to. Default: `[["localhost", 4064, "omero"]].`

  $ bin/omero config set omero.web.server_list '[["prod.example.com", 4064, "prod"], ["dev.example.com", 4064, "dev"]]

- Email server and notification:
  
  - *(REQUIRED)* From: address to be used when sending e-mail. Default: `root@localhost`

    $ bin/omero config set omero.web.server_email "webmaster@example.com"

  

    $ bin/omero config set omero.web.email_host "email.example.com"

  
  - Mail server login username. Default: `'` (Empty string).

    $ bin/omero config set omero.web.email_host_user "username"

  
  - Mail server login password. Default: `'` (Empty string).

    $ bin/omero config set omero.web.email_host_password "password"

  

    $ bin/omero config set omero.web.email_host_port "2255"

  
  - Use TLS when sending e-mail. Default: `False`. 

$ bin/omero config set omero.web.email_use_tls "True"

- **Subject prefix for outgoing e-mail. Default:** "[Django] ".

$ bin/omero config set omero.web.email_subject_prefix "Subject prefix for outgoing e-mail"

- **Controlling displayed scripts:**

  - Since OMERO 4.3.2, OMERO.web has the ability to dynamically display scripts in the script runner menu just like OMERO.insight. Some scripts were not suitable for display initially and are excluded from the menu. You may wish to control which scripts your users can see in OMERO.web using this configuration option. **Default:** `"[/omero/figure_scripts/Movie_Figure.py", "/omero/figure_scripts/Split_View_Figure.py", "/omero/figure_scripts/Thumbnail_Figure.py", "/omero/figure_scripts/ROI_Split_Figure.py", "/omero/export_scripts/Make_Movie.py"]`

  $ bin/omero config set omero.web.scripts_to_ignore '[]'
  $ bin/omero config set omero.web.scripts_to_ignore '="/omero/my_scripts/really_buggy.py", ...']'

- **Customizing index page:**

  - Occasionally, a pre-login custom page may be required for OMERO.web. By creating a custom HTML page and setting `INDEX_TEMPLATE`, it is possible to have an index page that, for example, will serve webstart and link to the webclient under your main domain.

  $ bin/omero config set omero.web.index_template 'webstart/start.html'

  - It is also possible to put the index HTML page in a custom location outside of OMERO.web by adding it to `TEMPLATE_DIRS`

  $ bin/omero config set omero.web.template_dirs '="/path/to/templates_dir"'
  $ bin/omero config set omero.web.index_template 'start.html'

- **Enabling a public user (automatically log in a public user, OMERO 4.4.0 onwards):**

  - First, create a public user. You can use any username and password you wish. If you do not want this user to be able to modify any of the data they see, you should put this user in a Read-Only group and the public data should be owned by another member(s) of this group.

  - Enable the OMERO.web public user functionality, which is disabled (False) by default.

  $ bin/omero config set omero.web.public.enabled True

  - Set a URL filter for which the OMERO.web public user is allowed to navigate. **Default:** `^/(?!webadmin)` (Python regular expression\(^{61}\)). You probably do not want the whole webclient UI to be publicly visible (although you could do this). The idea is that you can create the public pages yourself (see `OMERO.web framework`) since we do not provide public pages. E.g. to allow only URLs that start with ‘/my_web_public’ you would use:

  $ bin/omero config set omero.web.public.url_filter ‘/my_web_public’

Exotic matching techniques can be used but more explicit regular expressions are needed when attempting to filter based on a base URL:

\(^{61}\)http://docs.python.org/2/library/re.html

---

64 http://docs.python.org/2/library/re.html

---

6.4. OMERO.web deployment
If you need more examples of how to configure public url filters, see the Public data in OMERO.web page.

- **Server to authenticate against. Default:** 1 (the first server in `omero.web.server_list`)

  ```bash
  $ bin/omero config set omero.web.public.server_id 1
  ```

- **Username to use during authentication. Default:** Not set. (required if `omero.web.public.enabled=True`)

  ```bash
  $ bin/omero config set omero.web.public.user '__public__'
  ```

- **Password to use during authentication. Default:** Not set. (required if `omero.web.public.enabled=True`)

  ```bash
  $ bin/omero config set omero.web.public.password 'secret'
  ```

- **Administrator e-mail notification:**
  - Admins list of people who get code error notifications. When debug mode is off and a view raises an exception, Django will e-mail these people with the full exception information. Default: `[]` (Empty list).

  ```bash
  $ bin/omero config set omero.webadmins '[["Dave", "dave@example.com"], ["Bob", "bob@example.com"]]
  ```

- **Ping interval:**
  - Since OMERO 4.4.0, OMERO.web now pings the server to keep your session alive when you are logged in and have an active browser window. The duration between these pings can be configured. Default: `60000`. (every 60 seconds)

  ```bash
  $ bin/omero config set omero.web.ping_interval 12000
  ```

- **Debug mode:**
  - A boolean that turns on/off debug mode. Default: `False`.

  ```bash
  $ bin/omero config set omero.web.debug "True"
  ```

- **Cache:**
  - If your deployment requires additional cache store please follow [Django documentation](https://docs.djangoproject.com/en/1.6/topics/cache/) for more details.

- **Custom OMERO.web location:**
  - By default OMERO.web expects to be run from the root URL of the web server. It can be configured to run from a sub-directory, for example `http://example.org/testing/`, as follows:

  ```bash
  $ bin/omero config set omero.web.force_script_name '/testing'
  ```

  - Update your web server configuration. For example, in the nginx configuration replace

  ```bash
  62https://docs.djangoproject.com/en/1.6/topics/cache/
  ```
fastcgi_param PATH_INFO $fastcgi_script_name;

with

fastcgi_split_path_info ^(/testing)(.*)$;
fastcgi_param PATH_INFO $fastcgi_path_info;
fastcgi_param SCRIPT_INFO $fastcgi_script_name;

– If omero.web.force_script_name is set then

$ bin/omero web config nginx

will automatically generate the correct configuration.

• Configuring additional web apps:

  – The OMERO.web framework allows you to add additional Django apps. For an example with installation instructions, see webmobile63

  – Download or clone from the git repository into the /omeroweb/ directory, then run

    $ bin/omero config set omero.web.apps ["<app name>"]

• Customizing webclient login page:

  – You can customize the webclient login page with your own logo. Logo images should ideally be 150 pixels high or less and will appear above the OMERO logo.

  – You will need to host the image somewhere else and link to it with

    $ bin/omero config set omero.web.login_logo "http://www.openmicroscopy.org/site/logo.jpg"

63https://github.com/will-moore/webmobile/
BASIC WINDOWS SERVER INSTALLATION

This chapter contains the instructions to install OMERO.server on Windows platforms.

7.1 OMERO.server installation

See also:
OMERO.server upgrade  Instructions for upgrading your OMERO.server installation.

7.1.1 Limitations

Installation will require an “Administrator” level account for which you know the password. If you are unsure of what it means to have an “Administrator” level account, or if you are generally having issues with the various users/passwords described in this install guide, please see Which user account and password do I use where?.

• Unless you are clear on the differences, you should also open all consoles as an administrator to prevent file permission issues.

• Significant testing has taken place on Windows Server 2008 and we recommend this version.

• OMERO.movie is not supported on Windows at present.

• A reboot is required after installing the prerequisites.

Note: The default user paths on Windows usually contain spaces so you will need to ensure the server installation path has no spaces, C:\OMERO.server for example.

7.1.2 Prerequisites

Note: The installation of these prerequisite applications is largely outside the scope of this document.

Do not mix 32bit (x86) and 64bit (amd64) packages - install either all 32bit or all 64bit. Check your JRE as well.
The following are necessary:

**Java SE Development Kit (JDK)**

Java SE Downloads are available from [http://www.oracle.com/technetwork/java/javase/downloads/index.html](http://www.oracle.com/technetwork/java/javase/downloads/index.html). Java 7 is recommended, Java 6 is supported.

**Ice**

*Note:* OMERO 5.0 supports Ice 3.5, 3.4 and 3.3. Ice 3.3 support is deprecated and will be removed in OMERO 5.1, which will require Ice 3.5 or 3.4. You will need to pick the matching server download for the version of Ice you have installed.

If you are using precompiled packages of Ice and Python (recommended) you should use the versions specified below. In particular since OMERO does not support Python 3 it **will not work with the ZeroC Ice 3.5 package for Windows**. However, Ice 3.5 will work when built against Python 2.7.

Windows installers of Ice 3.4 can be found on the [ZeroC Ice 3.4.2 download page](http://zeroc.com/download_3_4_2.html). Alternatively, you can now download Ice 3.5.1 built against Python 2.7 from our [Ice downloads page](http://downloads.openmicroscopy.org/ice/3.5.1/) (please let us know if you encounter any issues - this has passed initial tests but further testing is needed before we can confidently recommend it over Ice 3.4 for Windows).

If you plan to develop for C++, be sure to read the instructions on the *[OMERO C++ language bindings page](http://www.openmicroscopy.org/omero/cplusplus/bindings.html)*.

**Python 2**

*Note:* OMERO does not currently support Python 3.

Make sure you install the correct Python 2 version for your Ice version:

- If you have installed Ice version 3.4.2 from ZeroC, you need Python version 2.6 which you can download from [Python 2.6.6 release downloads](http://www.python.org/download/releases/2.6.6/).
- If you have downloaded Ice 3.5.1 from our downloads page, you will need to install the [latest Python 2.7 release](http://www.python.org/downloads/windows/) (please let us know if you encounter any issues).

As these are the “vanilla” python distributions (no extra libraries), you will need to install further dependencies, making sure to download the correct version (2.6/2.7, 32/64-bit) for your Python distribution.

**32/64-bit**

OMERO has been extensively tested with 32-bit Python on Windows. 64-bit Python should also work though it has not been tested as thoroughly. You can obtain 64-bit precompiled dependencies from [http://www.lfd.uci.edu/~gohlke/pythonlibs](http://www.lfd.uci.edu/~gohlke/pythonlibs).

**Python for Windows extensions**

Python for Windows extensions (PyWin32) is required. The installer is available from the [PyWin download page](http://sourceforge.net/projects/pywin32/files/pywin32/).

The version you need is: *pywin32-XXX.win32-pyA.B.exe* (or *pywin32-XXX.win-amd64-pyA.B.exe* for 64-bit Python) where XXX should be the latest release number and A and B stand for the Python version, for example *pywin32-218.win32-py2.6.exe*.

---

1 [http://zeroc.com/download_3_4_2.html](http://zeroc.com/download_3_4_2.html)
2 [http://downloads.openmicroscopy.org/ice/3.5.1/](http://downloads.openmicroscopy.org/ice/3.5.1/)
3 [http://www.python.org/download/releases/2.6.6/](http://www.python.org/download/releases/2.6.6/)
Additional libraries

The following are optional depending on what services you require:

<table>
<thead>
<tr>
<th>Package</th>
<th>Functionality</th>
<th>Downloads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pillow</td>
<td>OMERO.web and Figure Export</td>
<td>Pillow page</td>
</tr>
<tr>
<td>Matplotlib</td>
<td>OMERO.web</td>
<td>Matplotlib page</td>
</tr>
<tr>
<td>NumPy (1.2.0 or higher)</td>
<td>Scripting</td>
<td>Numpy/Scipy page</td>
</tr>
<tr>
<td>PyTables (2.1.0 or higher)</td>
<td>OMERO.tables</td>
<td>PyTables page</td>
</tr>
<tr>
<td>scipy.ndimage</td>
<td>Volume Viewer</td>
<td>Numpy/Scipy page</td>
</tr>
</tbody>
</table>

**PostgreSQL (8.4 or higher)**

PostgreSQL has to be installed and configured with PL/pgSQL and to accept TCP connections. PostgreSQL 8.3 and earlier are not supported.

The *One click installer* can be found on the [PostgreSQL Windows download page](http://www.postgresql.org/download/windows). You will need the postgres user’s password later in the install.

- You must install PostgreSQL as a service if you want to follow this document; other PostgreSQL installation environments are supported but are outside the scope of this document.

1. Run the downloaded installer:

2. You may be prompted for permission to continue with a “user account control” dialog. Click yes to continue.

3. The installer will now start.

---

6 [http://pillow.readthedocs.org](http://pillow.readthedocs.org)
7 [https://pypi.python.org/pypi/Pillow](https://pypi.python.org/pypi/Pillow)
8 [http://matplotlib.org/](http://matplotlib.org/)
9 May already have been installed as a dependency of Matplotlib.
10 [http://www.scipy.org/Download](http://www.scipy.org/Download)
14 [http://www.scipy.org/Download](http://www.scipy.org/Download)
15 [http://pillow.readthedocs.org](http://pillow.readthedocs.org)
16 [https://pypi.python.org/pypi/Pillow](https://pypi.python.org/pypi/Pillow)
17 [http://matplotlib.org/](http://matplotlib.org/)
18 May already have been installed as a dependency of Matplotlib.
19 [http://www.scipy.org/Download](http://www.scipy.org/Download)
22 Allows larger volumes to be viewed in the Volume Viewer ([http://www.openmicroscopy.org/site/products/omero/volume-viewer-in-omero.web](http://www.openmicroscopy.org/site/products/omero/volume-viewer-in-omero.web)).
23 [http://www.scipy.org/Download](http://www.scipy.org/Download)
4. Choose the installation directory. The default is fine.

5. Choose the data directory. The default is fine, but if you want to keep the data in a specific location, you may choose an alternative location here.

6. Enter a password for the special “postgres” system account. OMERO does not use this account, but you will need to remember the password for creating the database, below.

7. Enter the port number for PostgreSQL to listen on for incoming connections. The default, 5432, is fine and should not be changed.

8. Select the locale. The default here is fine.

9. PostgreSQL will now be installed and started.
7.1.3 Environment variables

For the prerequisite software to run properly, your PATH and PYTHONPATH environment variables must be configured. This is particularly important for Ice, which does not set the required variables by default.

Update your Windows environment variables: (REQUIRES RESTART!)
1. Locate the *System* control panel page on the Start Menu under *Settings → Control Panel*, open it and navigate to the *Advanced* tab (on Windows Vista the dialog will be visible after clicking the *Change settings* link on the *System* control panel page):

2. Open the *Environment Variables* dialog by clicking on the *Environment Variables...* button of the above dialog:

3. Edit the existing *System* environment variable *Path* and add a new variable pointing to the Ice installation *bin* directory. At the front of the *Path* variable also add a new string pointing to the Python installation directory (e.g. *C:\Python26*). Then add a brand new *System* environment variable called *PYTHONPATH* pointing to the Ice installation *python* location:

*When setting the ENV variables, make sure you write in the correct paths.* You must have entries for:

- python (the first PATH entry, e.g. “C:\Python26;%Sys…”)  
- icebin (the last PATH entry, e.g. “…;C:\Ice-3.4.2\bin;”)  
- PYTHONPATH pointing to the python folder in the ICE installation (e.g. “C:\Ice-3.4.2\python;”)
For 64-bit you will need to use the 64-bit Ice directories, for example “C:\Ice-3.4.2\bin\x64;” and “C:\Ice-3.4.2\python\x64;”.

**Warning:** Remember that the Windows path separator is the semicolon ; and must be appended after every entry. Make sure the first inserted ENV PATH entry (the python path) finishes with a semicolon (eg. “C:\Python26;%SystemRoot%…” ) otherwise you could corrupt other system applications.

4. **Restart your computer.** For environment changes to take effect in background services, a restart is unfortunately necessary. See [http://support.microsoft.com/kb/821761](http://support.microsoft.com/kb/821761) for more information.

### 7.1.4 Creating a database for OMERO

Probably the most important step towards having a working server system is having a properly configured database.

- Create a non-superuser database user (make sure to note down the name and password) using pgAdmin III. You can find pgAdmin III on the Start Menu under **Programs → PostgreSQL 9.1 → pgAdmin III**:
  
  1. Double-click on the **PostgreSQL 9.1** database (or right-click and choose **Connect**) and provide your **postgres** user login password set during the installation, above.
  2. Right-click on **Login Roles** and select **New Login Role…**
3. Create a new role and record the name and password. You will need to configure OMERO to use your username and password by setting the `omero.db.name` and `omero.db.pass` properties.

   **Warning:** For illustrative purposes, the default name and password for the role are `db_user` and `db_password` respectively. However, you should not use these default values for your installation but use your own choice of username and password instead.

- Create an `omero_database` database:
  1. Right-click on `Databases` and select `New Database ...

  2. Create a new database with the `Name omero_database` and `Owner db_user` (this may take a few moments)

- Confirm PL/pgSQL language support in your newly created database
  1. First, go to `File → Options` select the `Browser` tab and activate the `Languages` option:
2. Navigate back to your database, expand the database’s tree view and finally expand the now available Languages item:

3. If the plpgsql language is missing, right-click on the Extensions item and select the New extension... option in the menu. Finally, add the plpgsql extension, accepting all defaults. This will add both the extension and the language. In older PostgreSQL versions without extensions, right-click on the Languages item and select the New language... option in the menu. Finally, add the plpgsql language, accepting all defaults.
7.1. OMERO.server installation

7.1.5 Location for your OMERO binary repository

See also:

OMERO.server binary repository

- Create a directory for the OMERO binary data repository (C:\OMERO is the default location and should be used unless you explicitly have a reason not to and know what you are doing).
This is not where you want the OMERO application to be installed, it is a separate directory that OMERO.server will use to store binary data:

```
C:\mkdir OMERO
```

- Change the ownership of the directory. `C:\OMERO` must either be owned by the user starting the server or that user must
When performing some operations the clients make use of temporary file storage and log directories. By default these files are stored below the user’s home directory (on Windows C:\Users\<username>\) in omero\tmp, omero\log and omero\sessions.

Note: If your home directory is stored on a network (NFS mounted or similar), then file read and write operations occur over the network. This can slow access down. Installing OMERO on a network mapped drive is strongly discouraged.
The OMERO.server also accesses the `omero\tmp` and `omero\log` folders of the user account running the server process. As the server makes heavier use of these folders than the clients, if that user’s home folder is stored on a network the server can be slowed down. To get around this for the OMERO.server you can define an `OMERO_TEMPDIR` environment variable pointing to a temporary directory located on the local file system e.g. `C:\tmp\`. 

Figure 7.13: Add new language

Figure 7.14: New language name
7.1.6 Installation

- Download and extract the OMERO.server zip file, and note its location. Below it is referred to as C:\OMERO.server.

- Optionally, review C:\OMERO.server\etc\omero.properties which contains all default settings.

You will need to open the file with a text editor. Do not edit the file. Any configuration settings you would like to change can be changed in the next step.

- Change any settings that are necessary using bin\omero config, including the name and/or password for the ‘db_user’ database user you chose above or the database name if it is not "omero_database". (Quotes are only necessary if the value could be misinterpreted by the shell. See link\(^\text{25}\)).

```
C:\> cd C:\OMERO.server
C:\OMERO.server\> bin\omero config set omero.db.name omero_database
C:\OMERO.server\> bin\omero config set omero.db.user db_user
C:\OMERO.server\> bin\omero config set omero.db.pass db_password
```

- If you have chosen a non-standard OMERO binary repository location above, be sure to configure the omero.data.dir property.

  When using C:\ style file paths it is necessary to “escape” the backslashes. For example:

```
C:\> bin\omero config set omero.data.dir C:\OMERO
```

- Create the OMERO database initialization script. You will be asked for the version of the script which you would like to generate, where both defaults can be accepted. Finally, you will be asked to enter and confirm password for your newly created OMERO root user.

  Warning: For illustrative purposes, the default password for the OMERO root user is root_password. However, you should not use this default value for your installation but use your own choice of password instead. This should not be the same password as your Linux/Mac/Windows root user!

```
C:\> cd C:\OMERO.server
C:\OMERO.server\> bin\omero db script
Please enter omero.db.version [OMERO5.0]:
Please enter omero.db.patch [0]:
Please enter password for new OMERO root user: # root_password
Please re-enter password for new OMERO root user: # root_password
Saving to C:\OMERO.server\OMERO5.0__0.sql
```

The generated SQL file is found in the folder where you called the “omero db script” command. This could cause a permission denied error in the populate db step if the postgres user cannot access that location. Move the file to a different location or use the -f option.

- Initialize your database with the script.

  1. Launch SQL Shell (psql) from the Start Menu under Programs → PostgreSQL 9.1 → SQL Shell (psql)

```
Server [localhost]:
Database [postgres]: omero_database
Port [5432]:
Username [postgres]: db_user
Password for user db_user:
Welcome to psql 9.1.4, the PostgreSQL interactive terminal.
```

Type: copyright for distribution terms
     h for help with SQL commands
     ? for help with psql commands
     g or terminate with semicolon to execute query
     q to quit

Warning: Console code page (437) differs from Windows code page (1252) 8-bit characters might not work correctly. See psql reference page ‘'Notes for Windows users’’ for details.

2. Execute the following to populate your database (the forward slashes are intentional - if you get a permission denied error it is because the path is wrong, not the slashes):
   
   omero=> \i C:/OMERO.server/OMERO5.0__0.sql
   ...
   ...
   omero=> \q

   • Before starting the OMERO.server, you should run the OMERO diagnostics script so that you check that all of the settings are correct, e.g.

   C:\OMERO.server\> bin\omero admin diagnostics

   The diagnostic tool may say that psql is not found. This should not be a problem but you can fix it by adding its bin folder to the path. For example, C:\Program Files (x86)\PostgreSQL\9.2\bin. Remember to reboot after changing the environment.

   • You can now start the server using:

   C:\OMERO.server> bin\omero admin start
   Creating C:\OMERO.server\var\master
   Creating C:\OMERO.server\var\registry
   No descriptor given. Using etc\grid\windefault.xml
   Installing OMERO.master Windows service.
   Successfully installed OMERO.master Windows service.
   Starting OMERO.master Windows service.
   Waiting on startup. Use CTRL-C to exit
   ...

   If you have chosen a non-default install directory (other than C:\OMERO.server), the output will look like this:

   C:\OMERO.server> bin\omero admin start
   Found default value: C:\OMERO.server\var\master
   Attempting to correct...
   Converting from C:\OMERO.server to C:\OMERO.server
   Changes made: 6
   No descriptor given. Using etc\grid\windefault.xml
   ...

   • If you would like to move the directory again, see bin\winconfig.bat --help, which gets called automatically on an initial install.

   • You can now test that you can log-in as “root”, either with the OMERO.insight client or command-line:

   C:\OMERO.server> bin\omero login
   Server: [localhost]
   Username: [root]
   Password: # root_password

7.1.7 JVM memory settings

To make your server production-ready, you will likely need to increase the JVM memory settings of your application descriptors. This is not done by default since it would prevent starting the server on some sites’ test instance but for production use a setting higher than 512MB is highly recommended.
To increase the JVM memory settings, you need to edit the etc/grid/templates.xml file under the OMERO.server directory.

It is highly recommended to increase the BlitzTemplate default JVM memory settings from -Xmx512M to -Xmx2048M and from XX:MaxPermSize=128m to XX:MaxPermSize=256M in production.

If working with large images generates OutOfMemory exceptions in the varlogPixelData-0.log file, you may consider increasing the PixelDataTemplate default JVM memory settings to -Xmx1024M.

Once you have modified the templates.xml file, restart the server using:

C:\OMERO.server> bin\omero admin restart

See also:

Grid configuration  Section of the advanced server configuration documentation describing etc\grid\templates.xml.

7.1.8 OMERO.web and administration

Note: In order to deploy OMERO.web in a production environment such as Apache or IIS please follow the instructions under OMERO.web deployment.

Otherwise, the internal Django webservice can be used for evaluation and development. In this case, you need to turn debugging on, in order that static files can be served by Django:

C:\OMERO.server> bin\omero config set omero.web.application_server development
C:\OMERO.server> bin\omero config set omero.web.debug True

then start by

c:\OMERO.server> bin\omero web start
INFO:__main__:Application Starting...
INFO:root:Processing custom settings for module omeroweb.settings
...
Validating models...

0 errors found
Django version 1.6, using settings 'omeroweb.settings'
Starting development server at http://0.0.0.0:4080/
Quit the server with CTRL-BREAK.

Note: As OMERO.web 5 is based on Django 1.6, omero.web.session_engine and omero.web.cache_backend should be unset.

C:\omero_dist>bin\omero config set omero.web.session_engine
C:\omero_dist>bin\omero config set omero.web.cache_backend

If your deployment requires additional cache store please follow Django documentation26 for more details.

Once you have deployed and started the server you can use your browser to access the OMERO.web interface:

• http://localhost:4080/

26https://docs.djangoproject.com/en/1.6/topics/cache/
7.1.9 Post-installation items

Backup

One of your first steps after putting your OMERO server into production should be deciding on when and how you are going to backup your database and binary data. Please do not omit this step.

Security

You should read the Server security and firewalls page to get a good idea as to what you need to do to get OMERO clients speaking to your newly installed OMERO server in accordance with your institution or company’s security policy.

Advanced configuration

Once you have the base server running, you may want to try enabling some of the advanced features such as OMERO.dropbox or LDAP authentication. If you have *Flex data*, you may want to watch the HCS configuration screencast\(^{27}\). See the Feature list\(^{28}\) for more advanced features you may want to use, and Advanced configuration on how to get the most out of your server.

Update notification

Your OMERO.server installation will check for updates each time it is started from the Open Microscopy Environment update server. If you wish to disable this functionality you should do so now as outlined on the OMERO upgrade checks page.

Troubleshooting

If you encounter a problem which is not addressed by the Troubleshooting OMERO page, you can post a message to our ome-users\(^{29}\) mailing list as discussed on the Community support page.

Please include the output of the diagnostics command when asking for help with your server installation:

C:\opt\OMERO.server> bin\omero admin diagnostics

================================================================================
OMERO Diagnostics 5.0.2
================================================================================

\(^{27}\)http://cvs.openmicroscopy.org.uk/snapshots/movies/omero-4-1.mov/FlexPreview4.1-configuration.mov

\(^{28}\)http://www.openmicroscopy.org/site/products/omero/feature-list

\(^{29}\)http://lists.openmicroscopy.org.uk/mailman/listinfo/ome-users
Commands: java --version 1.8.0 (C:\Program Files\Java\jdk1.7.0_51\bin\java.EXE -- 2 others)

Commands: python --version 2.7.6 (C:\Python27\python.EXE -- 2 others)

Commands: icegridnode --version 3.5.1 (c:\opt\Ice-3.5.1-win-x64-Release\bin\icegridnode.EXE)

Commands: icegridadmin --version 3.5.1 (c:\opt\Ice-3.5.1-win-x64-Release\bin\icegridadmin.EXE)

Commands: psql --version 9.3.4 (C:\Program Files\PostgreSQL\9.3\bin\psql.EXE)

Server: icegridnode running
Server: Blitz-0 active (pid = 1384, enabled)
Server: DropBox inactive (disabled)
Server: FileServer inactive (disabled)
Server: Indexer-0 active (pid = 3872, enabled)
Server: MonitorServer inactive (disabled)
Server: OMERO.Glacier2 active (pid = 5744, enabled)
Server: OMERO.IceStorm active (pid = 3520, enabled)
Server: PixelData-0 active (pid = 3096, enabled)
Server: Processor-0 inactive (disabled)
Server: Tables-0 inactive (disabled)
Server: TestDropBox inactive (enabled)
Server: OMERO.master active (running as LocalSystem)

OMERO: SSL port 4064
OMERO: TCP port 4063

Log dir: C:\opt\OMERO.server-5.0.1-ice35-b21\var\log exists

Log files:
- Blitz-0.log 38.0 KB
- DropBox.log n/a
- FileServer.log n/a
- Indexer-0.log 64.0 KB errors=0 warnings=2
- MonitorServer.log n/a
- OMEROweb.log n/a
- PixelData-0.log 3.0 KB errors=0 warnings=2
- Processor-0.log n/a
- Tables-0.log n/a
- TestDropBox.log n/a
- master.err 1.0 KB errors=2 warnings=2
- master.out 0.0 KB
- Total size 0.11 MB

Environment:OMERO_HOME=(unset)
Environment:OMERO_NODE=(unset)
Environment:OMERO_MASTER=(unset)
Environment:OMERO_TEMPDIR=(unset)
Environment:PATH=C:\Program Files\PostgreSQL\9.3\bin;C:\Python27;c:\opt\Ice-3.5.1-win-x64-Release\bin;C:\Program Files\Java\jdk1.7.0_51\bin;C:\Windows\system32;C:\Windows;C:\Windows\System32\Wbem;C:\Windows\System32\WindowsPowerShell\v1.0\
Environment:ICE_HOME=c:\opt\Ice-3.5.1-win-x64-Release
Environment:LD_LIBRARY_PATH=(unset)
Environment:DYLD_LIBRARY_PATH=(unset)

OMERO data dir: 'C:\opt\omerodata' Exists? True Is writable? True
OMERO temp dir: 'C:\Users\omero\AppData\Roaming\omero\tmp' Exists? True Is writable? True (Size: 0)
OMERO.web status... [NOT STARTED]
7.2 OMERO.server binary repository

About
The OMERO.server binary data repository is a fundamental piece of server-side functionality. It provides optimized and indexed storage of original file, pixel and thumbnail data, attachments and full text indexes. Its structure is based on OMEIS.

http://www.openmicroscopy.org/site/support/previous/ome-server/system-overview/ome-image-server/

7.2.1 Layout
The repository is internally laid out as follows:

C:\OMERO
C:\OMERO\Pixels <-- Pixel data
C:\OMERO\Files <-- Original file data
C:\OMERO\Thumbnails <-- Thumbnail data
C:\OMERO\FullText <-- Lucene full text search index
C:\OMERO\ManagedRepository <-- OMERO.fs filesets
C:\OMERO\BioFormatsCache <-- Cached Bio-Formats state for rendering

Your repository is not:
- the “database”
- the directory where your OMERO.server binaries are
- the directory where your OMERO.client (OMERO.insight, OMERO.editor or OMERO.importer) binaries are
- your PostgreSQL data directory

7.2.2 Locking and remote shares
The OMERO server requires proper locking semantics on all files in the binary repository. In practice, this means that remotely mounted shares such as AFS, CIFS, and NFS can cause issues. If you have experience and/or the time to manage and monitor the locking implementations of your remote filesystem, then using them as for your binary repository should be fine.

If, however, you are seeing errors such as NullPointerExceptions, “Bad file descriptors” and similar in your server log, then you will need to use directly connected disks.

Warning: If your binary repository is a remote share and mounting the share fails or is dismounted, OMERO will continue operating using the mount point instead! To prevent this, make the mount point read-only for the OMERO user so that no data can be written to the mount point.

7.2.3 Repository Location

Note: It is strongly recommended that you make all changes to your OMERO binary repository with the server shut down. Changing the omero.data.dir configuration does not move the repository for you, you must do this yourself. Remember that C:\ style paths must have backslashes escaped. We strongly discourage the use of network mapped drives as locations for either the binary repository or the OMERO.server installation.

Your repository location can be changed from its C:\OMERO default by modifying your OMERO.server configuration as follows:

C:\> cd C:\OMERO.server
C:\OMERO.server\> bin\omero config set omero.data.dir D:\OMERO
The suggested procedure is to shut down your OMERO.server instance, move your repository, change your `omero.data.dir` and then start the instance back up. For example:

```
C:\> cd C:\OMERO.server
C:\OMERO.server\> bin\omero admin stop
C:\OMERO.server\> move C:\OMERO D:\
C:\OMERO.server\> bin\omero config set omero.data.dir D:\\OMERO
C:\OMERO.server\> bin\omero admin start
```

### 7.2.4 Access Permissions

Your repository should be owned or accessible by the same user that is starting your OMERO.server instance which may be different from the user you use to start OMERO. See [OMERO.server Windows Service](#) for more information.

To modify the access permissions to the binary repository, the OMERO folder properties can be accessed and the permissions settings changed (see [Repository Folder Permissions](#)). Another option (useful for batch permission changes) is the `icacls` (Windows 7)/`cacls` (Windows XP) command line utility. Please note that the new permissions will appear as `Special Permissions` in the Security tab when viewing folder properties. An example invocation allowing the user `omeservice` to read (R) and write (W) from and to the OMERO directory:

```
C:\>icacls OMERO /grant omeservice:RW
processed file: OMERO
Successfully processed 1 files; Failed processing 0 files
```

![Repository Folder Permissions](image)

---

### 7.3 OMERO.server and PostgreSQL

In order to be installed, OMERO.server requires a running PostgreSQL instance that is configured to accept connections over TCP. This section explains how to ensure that you have the correct PostgreSQL version and that it is installed and configured correctly.
For Windows-specific installation instructions, first see Omero.server installation.

7.3.1 Ensuring you have a valid PostgreSQL version

For OMERO 5.0, PostgreSQL 8.4 or higher is required.

If your default PostgreSQL installation is version 8.3 or earlier, you will need to upgrade to a more up-to-date version. We suggest the installer from EnterpriseDB. Versions 8.4, 9.0 and 9.1 are known to work with OMERO 5.0; 9.1 is recommended.

Compatibility matrix

Versions of PostgreSQL which are compatible with OMERO are shown in the table below.

<table>
<thead>
<tr>
<th>PostgreSQL</th>
<th>OMERO 4.1</th>
<th>OMERO 4.2</th>
<th>OMERO 4.3</th>
<th>OMERO 4.4</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.3</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO [4]</td>
</tr>
<tr>
<td>8.4</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
</tr>
</tbody>
</table>

[1] Not suggested; see #4902
[2] Configuration may be necessary; see #5662
[3] Not suggested; see #5861
[4] Unsupported; see #7813

7.3.2 Checking PostgreSQL port listening status

You can check if PostgreSQL is listening on the default port (TCP/5432) by running the following command:

```
C:\> netstat -an | find "5432"
```

Note: The exact output of this command will vary. The important thing to recognize is whether or not a process is listening on TCP/5432.

If you cannot find a process listening on TCP/5432 you will need to find your postgresql.conf file and enable PostgreSQL’s TCP listening mode. The exact location of the postgresql.conf file varies between installations.

Once you have found the location of the postgresql.conf file on your particular installation, you will need to enable TCP listening. For PostgreSQL 8.4 and 9.x, the area of the configuration file you’re concerned about should look similar to this:

```bash
#listen_addresses = 'localhost'  # what IP address(es) to listen on;
                             # comma-separated list of addresses;
                             # defaults to 'localhost', '*' = all
#port = 5432
max_connections = 100
# note: increasing max_connections costs ~400 bytes of shared memory per
# connection slot, plus lock space (see max_locks_per_transaction). You
# might also need to raise shared_buffers to support more connections.
#superuser_reserved_connections = 2
#unix_socket_directory = *
#unix_socket_group = *
```

30http://www.enterprisedb.com/
31http://trac.openmicroscopy.org.uk/ome/ticket/4902
32http://trac.openmicroscopy.org.uk/ome/ticket/5662
33http://trac.openmicroscopy.org.uk/ome/ticket/5861
34http://trac.openmicroscopy.org.uk/ome/ticket/7813

89
7.3.3 PostgreSQL HBA (host based authentication)

OMERO.server must have permission to connect to the database that has been created in your PostgreSQL instance. This is configured in the host based authentication file, pg_hba.conf. Check the configuration by examining the contents of pg_hba.conf. It’s important that at least one line allows connections from the loopback address (127.0.0.1) as follows:

```
# TYPE DATABASE USER CIDR-ADDRESS METHOD
# IPv4 local connections:
host all all 127.0.0.1/32 md5
```

Note: The other lines that are in your pg_hba.conf are important either for PostgreSQL internal commands to work or for existing applications you may have. Do not delete them.

See also:
- PostgreSQL
- Connections and Authentication
- Client Authentication

7.4 OMERO.web deployment

OMERO.web is the web application component of the OMERO platform which allows for the management, visualization (in a fully multi-dimensional image viewer) and annotation of images from a web browser. It also includes OMERO.webadmin for managing users and groups.

OMERO.web is an integral part of the OMERO platform and can be deployed with:

- IIS 5.1, 6.0 or 7.0 on Microsoft Windows (since OMERO 4.2.1)
- FastCGI using a FastCGI capable web server such as Apache (with mod_fastcgi enabled), nginx or lighttpd (since OMERO 4.2.1)
- The built-in Django lightweight development server (for testing only)

You can find more information about FastCGI and where to get modules or packages for your distribution on the FastCGI website.

If you need help configuring your firewall rules, see the Server security and firewalls page.

7.4.1 Prerequisites

- OMERO and its prerequisites (see OMERO.server installation).
- Python 2 (2.6 or later)
  - Pillow should be available for your distribution
  - Matplotlib should be available for your distribution

---

38http://httpd.apache.org/
39http://www.fastcgi.com/drupal/
40http://nginx.org/
41http://www.lighttpd.net/
42http://www.fastcgi.com/drupal/node/3
43http://pillow.readthedocs.org
44http://matplotlib.org/
7.4.2 Configuring OMERO from the command line

Configuration options can be set using the `omero config set` command:

```
C:\omero_dist>bin\omero config set <parameter> <value>
```

When supplying a value with spaces or multiple elements, use **double quotes**. The quotes will not be saved as part of the value (see below). Please use the escape sequence `\"` for nesting double quotes (e.g. `\"[\"foo\", \"bar\"]\}`).

To remove a configuration option (to return to default values where mentioned), simply omit the value:

```
C:\omero_dist>bin\omero config set <parameter>
```

These options will be stored in a file: `etc/grid/config.xml` which you can read for reference. **DO NOT** edit this file directly.

You can also review all your settings by using:

```
C:\omero_dist>bin\omero config get
```

which should return values without quotation marks.

A final useful option of `omero config edit` is:

```
C:\omero_dist>bin\omero config edit
```

which will allow for editing the configuration in a system-default text editor.

7.4.3 Quick start

**Using IIS**

Once you have IIS installed on your system, a straightforward set of steps is required to get the **ISAPI WSGI** handler for **OMERO.web** working with your IIS deployment.

- Choose between FastCGI TCP (recommended) or FastCGI (advanced):

  ```
  C:\omero_dist>bin\omero config set omero.web.application_server "fastcgi" / "fastcgi-tcp"
  ```

- Ensure that the ISAPI for IIS options are installed

- Download and install an **ISAPI WSGI Installer** (we suggest the **Windows Installer**)  

- For extended compatibility with multiple IIS versions ISAPI WSGI uses the IIS 5/6 WMI interface to interact with your IIS deployment. If you are using IIS 7 you must enable the IIS 6 WMI backwards compatibility options, as shown on the figure:

- OMERO.web and ISAPI WSGI are **32-bit** applications on Windows at present. If you are attempting to run OMERO.web on a 64-bit version of Windows, you must enable 32-bit compatibility in the **Advanced Settings... for the Application Pool** assigned to your default **Site**. You can do this in the **IIS Manager** as follows:

- Configure OMERO.web bindings for IIS

---


Note: As OMERO.web 5 is based on Django 1.6, `omero.web.session_engine` and `omero.web.cache_backend` should be unset.

C:\omero_dist>bin\omero web iis

C:\omero_dist>bin\omero config set omero.web.session_engine
C:\omero_dist>bin\omero config set omero.web.cache_backend

If your deployment requires additional cache store please follow Django documentation\(^{47}\) for more details.

\(^{47}\)https://docs.djangoproject.com/en/1.6/topics/cache/
Using the lightweight development server

All that is required to use the Django lightweight development server is to set the `omero.web.application_server` configuration option, turn Debugging on and start the server up:

```
C:\omero_dist>bin\omero config set omero.web.application_server development
C:\omero_dist>bin\omero config set omero.web.debug True
C:\omero_dist>bin\omero web start
INFO:__main__:Application Starting...
INFO:root:Processing custom settings for module omeroweb.settings
... Validating models...
0 errors found
Django version 1.6, using settings 'omeroweb.settings'
Starting development server at http://0.0.0.0:4080/
Quit the server with CTRL-BREAK.
```

7.4.4 Logging in to OMERO.web

Once you have deployed and started the server, you can use your browser to access OMERO.webadmin or the OMERO.webclient:

- **http://your_host/omero** OR, for development server: **http://localhost:4080**

![OMERO.webadmin login](image)

Figure 7.19: OMERO.webadmin login

**Note:** This starts the server in the foreground. It is your responsibility to place it in the background, if required, and manage its shutdown.

7.4.5 Customizing your OMERO.web installation

**Note:** Please use double quotes instead of single quotes and a proper escape sequence to specify options with multiple values.

**Note:** For clarity, some edge-case/in-development options may not be documented below. For the full list see:

```
C:\omero_dist>bin\omero web -h
```

OR look in `lib/python/omeroweb/settings.py`

- A list of servers the Web client can connect to. Default: `[["localhost", 4064, "omero"]].`
C:\omero_dist>bin\omero config set omero.web.server_list "["prod.example.com", 4064, "prod"],

- Email server and notification:
  - (REQUIRED) From: address to be used when sending e-mail. Default: root@localhost
    C:\omero_dist>bin\omero config set omero.web.server_email "webmaster@example.com"
    C:\omero_dist>bin\omero config set omero.web.email_host "email.example.com"
  - Mail server login username. Default: ’’ (Empty string).
    C:\omero_dist>bin\omero config set omero.web.email_host_user "username"
  - Mail server login password. Default: ’’ (Empty string).
    C:\omero_dist>bin\omero config set omero.web.email_host_password "password"
    C:\omero_dist>bin\omero config set omero.web.email_host_port "2255"
  - Use TLS when sending e-mail. Default: False.
    C:\omero_dist>bin\omero config set omero.web.email_use_tls "True"
  - Subject prefix for outgoing e-mail. Default: "[Django] ".
    C:\omero_dist>bin\omero config set omero.web.email_subject_prefix "Subject prefix for outgoing e-mail"

- Controlling displayed scripts:
  - Since OMERO 4.3.2, OMERO.web has the ability to dynamically display scripts in the script run-
  - ner menu just like OMERO.insight. Some scripts were not suitable for display initially and are ex-
  - cluded from the menu. You may wish to control which scripts your users can see in OMERO.web
  - using this configuration option. Default: ’’["omero\figure_scripts\Movie_Figure.py", "omero\figure_scripts\Split_View_Figure.py", "omero\figure_scripts\Thumbnail_Figure.py", "omero\figure_scripts\ROI_Split_Figure.py", "omero\export_scripts\Make_Movie.py"]’
    C:\omero_dist>bin\omero config set omero.web.scripts_to_ignore "[]"  
    C:\omero_dist>bin\omero config set omero.web.scripts_to_ignore "["omero\my_scripts\really_buggy.py", … ]"

- Customizing index page:
  - Occasionally, a pre-login custom page may be required for OMERO.web. By creating a custom HTML page and
  - setting INDEX_TEMPLATE, it is possible to have an index page that, for example, will serve webstart and link to the
  - weclient under your main domain.
    C:\omero_dist>bin\omero config set omero.web.index_template 'webstart\start.html'
It is also possible to put the index HTML page in a custom location outside of OMERO.web by adding it to TEM-PLATE_DIRS

```
C:\omero_dist>bin\omero config set omero.web.template_dirs '["C:\path\to\templates_dir"]'
C:\omero_dist>bin\omero config set omero.web.index_template 'start.html'
```

- Enabling a public user:

  Since OMERO 4.4.0, OMERO.web has the ability to automatically log in a public user.

  * First, create a public user. You can use any username and password you wish. If you do not want this user to be able to modify any of the data they see, you should put this user in a Read-Only group and the public data should be owned by another member(s) of this group. Now you can configure the public user:
    * Enable and disable the OMERO.web public user functionality. Default: False.

      ```
      C:\omero_dist>bin\omero config set omero.web.public.enabled True
      ```

    * Set a URL filter for which the OMERO.web public user is allowed to navigate. Default: ^/(?!webadmin) (Python regular expression). You probably do not want the whole webclient UI to be publicly visible (although you could do this). The idea is that you can create the public pages yourself (see OMERO.web framework since we do not provide public pages. E.g. to allow only URLs that start with '/my_web_public' you would use:

      ```
      C:\omero_dist>bin\omero config set omero.web.public.url_filter '^/my_web_public'
      C:\omero_dist>bin\omero config set omero.web.public.url_filter'^/(my_web_public|webgateway)'
      ```

    Exotic matching techniques can be used but more explicit regular expressions are needed when attempting to filter based on a base URL:

    - 'webtest' matches '/webtest' but also '/webclient/webtest'
    - 'dataset' matches '/webtest/dataset' and also '/webclient/dataset'
    - '/webtest' matches '/webtest...' but also '/webclient/webtest'
    - '^/webtest' matches '/webtest...' but not '/webclient/webtest'

  * Server to authenticate against. Default: 1 (the first server in omero.web.server_list)

    ```
    C:\omero_dist>bin\omero config set omero.web.public.server_id 2
    ```

  * Username to use during authentication. Default: Not set. (required if omero.web.public.enabled=True):

    ```
    C:\omero_dist>bin\omero config set omero.web.public.user '__public__'
    ```

  * Password to use during authentication. Default: Not set. (required if omero.web.public.enabled=True):

    ```
    C:\omero_dist>bin\omero config set omero.web.public.password 'secret'
    ```

- Administrator e-mail notification:

– Admins list of people who get code error notifications. When debug mode is off and a view raises an exception, Django will e-mail these people with the full exception information. Default: [] (Empty list).

```
C:\omero_dist>bin\omero config set omero.webadmins '[["Dave", "dave@example.com"], ["Bob", "bob@example.com"]]
```

* Ping interval:
  – Since OMERO 4.4.0, OMERO.web now pings the server to keep your session alive when you are logged in and have an active browser window. The duration between these pings can be configured. Default: 60000. (every 60 seconds)

```
C:\omero_dist>bin\omero config set omero.web.ping_interval 12000
```

* Debug mode:
  – A boolean that turn on/off debug mode. Default: False.

```
C:\omero_dist>bin\omero config set omero.web.debug "True"
```

* Configuring additional web apps:
  – The OMERO.web framework allows you to add additional Django apps. For an example with installation instructions, see [webmobile](https://github.com/will-moore/webmobile/)
  – Download or clone from the git repository into the /omeroweb/ directory, then run

```
C:\omero_dist>bin\omero config set omero.web.apps '[{"<app name>"}]
```

* Customizing webclient login page:
  – You can customize the webclient login page with your own logo. Logo images should ideally be 150 pixels high or less and will appear above the OMERO logo.
  – You will need to host the image somewhere else and link to it with

```
C:\omero_dist>bin\omero config set omero.web.login_logo 'http://www.openmicroscopy.org/site/logo.jpg'
```

### 7.5 OMERO.server Windows Service

OMERO.server installs a Windows Service to make the startup of the software automatic at Windows boot time.

The `omero admin start` command creates and starts a Windows service. In turn, `omero admin stop` stops and deletes the OMERO Windows service. Therefore, once `omero admin start` succeeds, it is possible to use all the regular Windows utilities, like `sc.exe` or the Services Manager, to stop OMERO.server without having the service removed completely.

If required, the OMERO.server service can be run as a different user (by modifying the *Log On* settings of the Windows service).

#### 7.5.1 Service *Log On* user

**Default Windows Local System user**

When no specific Windows user has been defined using `omero config set`, the OMERO.server starts as the *Local System* user. This user has enough permissions to access data on the local file system. In most circumstances that should allow the OMERO.server service to access data inside the binary repository.

49[https://github.com/will-moore/webmobile/](https://github.com/will-moore/webmobile/)
Custom user

A custom user can be configured to run the OMERO.server service. You can configure the OMERO Windows user by setting `omero.windows.user` and `omero.windows.pass`:

```
C:\OMERO.server\> bin\omero config set omero.windows.user USERNAME
C:\OMERO.server\> bin\omero config set omero.windows.pass PASSWORD
```

**Warning:** Setting `omero.windows.pass` exposes your user password in the OMERO configuration.

The user credentials can also be specified on the command line when running `omero admin start`. The `-u` parameter value is the user name, while the value of `-w` corresponds to the user’s password:

```
C:\OMERO.server\> bin\omero admin start -u omeservice -w password
```

You can verify that a different user has been set as the Log On user for the OMERO.server service by accessing the Windows Services Manager (see Windows Service Log On User Settings).

![Windows Service Log On User Settings](image)

7.5.2 Service startup mode

To start the Services Manager, simply navigate to **Start → All Programs → Accessories → Run** (Windows 7). In the dialog, type `services.msc` and select **OK** (see Run Windows Services Manager).

This will bring up the Windows Services Manager. Here you can see the OMERO.master service running and also stop it. Additionally the Log On tab can be accessed here to configure under which user name the service is started (see OMERO.server binary repository).

It is also possible to change the service start-up type from **Automatic** to **Manual**. The automatic mode guarantees that OMERO.server will start during the Windows boot phase. Manual mode allows the logged in user or administrator to start the service after Windows has finished booting.

7.5. OMERO.server Windows Service
7.5.3 Service events

Windows Event Viewer allows for watching events occurring in the OMERO.server service. To start the viewer, follow the same path as for Windows Services Manager, but this time type in `eventvwr.msc` (see Starting Event viewer).
The status events from OMERO.master will be registered in the *Application* view (though the log output from the server is in the configured directory).

![OMERO.master Events](image)

**Figure 7.24: OMERO.master Events**
8.1 Troubleshooting OMERO

8.1.1 Frequently Asked Questions

If you cannot find what you are looking for here, try the FAQ\(^1\).

8.1.2 Which user account and password do I use where?

Accounts table, including the example usernames and passwords used in the installation guides:

<table>
<thead>
<tr>
<th>Account type</th>
<th>Function</th>
<th>Username</th>
<th>Password</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>Administrator/Root</td>
<td>postgres</td>
<td></td>
</tr>
<tr>
<td>System</td>
<td>(Database) service account</td>
<td>omero_user</td>
<td></td>
</tr>
<tr>
<td>System</td>
<td>(OMERO) service account</td>
<td>postgres</td>
<td></td>
</tr>
<tr>
<td>Database</td>
<td>Database administrator</td>
<td>db_user</td>
<td>db_password</td>
</tr>
<tr>
<td>Database</td>
<td>Database user</td>
<td>root</td>
<td>root_password</td>
</tr>
<tr>
<td>OMERO</td>
<td>OMERO administrator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OMERO</td>
<td>OMERO users</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: These example usernames and passwords are provided to help you follow the installation guide examples. Do not use root_password or db_password; substitute your own passwords.

There are a total of three types of user accounts: system, database and OMERO accounts.

System accounts

These are accounts on your machine or directory server (e.g. LDAP, Active Directory). One account is used for running the OMERO server (either your own or one you created specially for running OMERO, referred to here as “omero_user”). There is also a user called the “administrator-level user” on the Windows installation page and “root-level user” on the UNIX installation page (which includes Mac OS X). A separate “postgres” user is used for running the database server. The “omero_user” account runs the OMERO server, and owns the files uploaded to OMERO. This account must have permission to write to the /OMERO/binary repository. Some operations in the install scripts require the root-level/administrator-level privileges in order to use another account to perform particular actions e.g. the “postgres” user to create a database. However the OMERO.server should never be run as the root-level/administrator-level user or as the system-level “postgres” user.

Database accounts

The PostgreSQL database system contains user and administrative accounts; these are completely separate from the system accounts, above, existing only inside the database. The database administrative user (“postgres”) is the owner of all the database resources, and can create new users internal to the database. A single database account is used at run time by OMERO to talk to your database. Therefore, you must configure the “omero.db.***” values during installation:

\(^1\)http://www.openmicroscopy.org/site/support/faq/
$ bin/omero config set omero.db.user db_user
$ bin/omero config set omero.db.pass db_password

Note: Do not use db_user or db_password here; substitute your own username and password.
A database user may have the same name as an account on your machine, in which case a password might not be necessary.

OMERO accounts

These accounts only exist inside the OMERO system, and are completely separate from both the system and database accounts, above. The first user which you will need to configure is the “root” OMERO user (different from any root-level Unix account). This is done by setting the password in the database script:

$ bin/omero db script
Please enter omero.db.version [OMERO5.0]:
Please enter omero.db.patch [0]:
Please enter password for new OMERO root user: # root_password
Please re-enter password for new OMERO root user: # root_password
Saving to ~/OMERO5.0__0.sql

Other OMERO users can be created via the OMERO.web admin tool. None of the passwords have to be the same, in fact they should be different unless you are using the LDAP plugin.

8.1.3 Server fails to start

1. Check that you are able to successfully connect to your PostgreSQL installation as outlined on the PostgreSQL page for your OS (Windows PostgreSQL page or UNIX/Mac PostgreSQL page).

2. Check the permissions on your omero.data.dir (/OMERO or C:\OMERO by default) as outlined on the OMERO.server installation page for Unix/Mac users, or the OMERO.server binary repository page for Windows users.

3. Are you on a laptop? If you see an error message mentioning “node master couldn’t be reached”\(^2\), you may be suffering from a network address swap. Ice does not like to have its network changed as can happen if the server is running on a laptop on wireless. If you lose connectivity to icegridnode, you may have to kill it manually via kill PID or killall icegridnode (under Unix).

4. If you see an error message mentioning “Freeze::DatabaseException”\(^3\) or “could not lock file: var/registry/__Freeze/lock”\(^4\), your icegrid registry may have become corrupted. This is not a problem, but it will be necessary to stop OMERO and delete the var/master directory (e.g. rm -rf var/master). When restarting OMERO, the registry will be automatically re-created.

8.1.4 Remote clients cannot connect to OMERO installation

The Admin section of OMERO.web appears to work properly and you may or may not have created some users, but no matter what you do remote clients will not speak to OMERO. OMERO.insight gives you an error message similar to the following despite giving the correct username and password:

\(^2\)http://trac.openmicroscopy.org.uk/ome/ticket/7325
\(^3\)http://trac.openmicroscopy.org.uk/ome/ticket/5576
\(^4\)http://trac.openmicroscopy.org.uk/ome/ticket/7325
This is often due to firewall misconfiguration on the machine that runs your OMERO server, affecting the ability of remote clients to locate it. Please see the *Server security and firewalls* page.

### 8.1.5 Server crashes with...

- X11 connection rejected because of wrong authentication
- X connection to localhost:10.0 broken (explicit kill or server shutdown).

OMERO uses image scaling and processing techniques that may be interfered with when used with SSH X11-forwarding. You should disable SSH X11-forwarding in your SSH session by using the `-x` flag as follows before you restart the OMERO.server:

```bash
ssh -x my_server.examples.com
```

### 8.1.6 OutOfMemoryError / PermGen space errors in OMERO.server logs

Out of memory or permanent generation (PermGen) errors can be caused by many things. You may be asking too much of the server. Or you may require an increase in the maximum Java heap or the permanent generation space. This can be done by modifying the IceGrid configuration for your OMERO.server as follows:

- In `etc/grid/templates.xml`:
  ```xml
  <server-template id="BlitzTemplate">
  <parameter name="index"/>
  <parameter name="config" default="default"/>
  <server id="Blitz-${index}" exe="java" activation="always" pwd="${OMERO_HOME}"/>
  <!--
  Debugging options:
  <option>-Xdebug</option>
  <option>-Xrunjdwp:server=y,transport=dt_socket,address=8787,suspend=n</option>
  -->
  <option>-Xmx512M</option>
  <option>-Djava.awt.headless=true</option>
  <option>-Dlog4j.configuration=${OMERO_ETC}log4j.xml</option>
  ...
  
  Replace `-Xmx512M` initially with `-Xmx1024M` or greater as required, (use `-Xmx1024M -XX:MaxPermSize=128m` as an alternative).
  
  Alternatively, if you are finding out of memory errors in one of the other process logs (e.g. Indexer-0.log or PixelData-0.log), look for the entry in `etc/grid/templates.xml` corresponding to that process and change the `-Xmx` option there (e.g. under `<server-template id="IndexerTemplate">` or `<server-template id="PixelDataTemplate">`, respectively).
  
  Furthermore, under certain conditions access of images greater than 4GB can be problematic on 32-bit platforms due to certain bugs within the Java Virtual Machine including [Bug ID: 4724038](http://bugs.sun.com/bugdatabase/view_bug.do?bug_id=4724038). A 64-bit platform for your OMERO.server is **HIGHLY** recommended.

### 8.1.7 Import error when running bin/omero

Traceback (most recent call last):
File "bin/omero", line 67, in ?
  import omero.cli
ImportError: No module named omero.cli

---

If you get any import related errors while running `bin/omero`, the most likely cause is that your PYTHONPATH is not properly set.

- If you installed Ice globally via your package manager, make sure you included ice-python.
- If you installed Ice manually, e.g. under `/opt/Ice-3.5.1` you need to add `/opt/Ice-3.5.1/python` (or similar) to your PYTHONPATH environment variable. See the Ice installation instructions for more information.

### 8.1.8 DropBox fails to start: failed to get session

If the main server starts but DropBox fails with the following entry in `var/log/DropBox.log`,

```
2011-06-07 03:42:56,775 ERROR [ fsclient.DropBox] (MainThread) Failed to get Session:
```

then it may be that the server is taking a relatively long time to start.

A solution to this is to increase the number of retries and/or the period (seconds) between retries in `etc/grid/templates.xml`

```
<property name="omero.fs.maxRetries" value="5"/>
<property name="omero.fs.retryInterval" value="3"/>
```

### 8.1.9 Search does not return expected results

If searching for a specific term does not return the expected results (e.g. searching for the name of a tag does not return the full list of a user’s images annotated with that tag) there are a few things that may have gone wrong.

- Check the server’s log directory for a file named `Indexer-0.log` and monitor its progress (e.g. using `tail` or similar).

  If messages of the format:

  ```
  INFO [ ome.services.fulltext.FullTextIndexer ] (3-thread-2) INDEXED 2 objects in 1 batch(es) [2483 ms.]
  ```

  are periodically being appended to the log file, then your indexer process may be running behind. You can either wait for it to catch up, or try increasing the search batch size in order to speed processing. See the section on the `omero.search.batch` setting for more information.

- If there are no updates to the `Indexer-0.log` file even when new images, tags, files, etc. are added to the server, then it is possible that the Indexer process has become stuck. It is possible to force a restart of the indexer using the IceGrid Tools like so:

  ```
  > bin/omero admin ice
  > omero admin ice
  Ice 3.4.2 Copyright 2003-2011 ZeroC, Inc.
  >>> server list
  Blitz-0
  DropBox
  FileServer
  Indexer-0
  ...
  >>> server stop Indexer-0
  ```

  You do not need to manually re-start the Indexer, as IceGrid will handle the creation of a new Indexer process automatically.

- If the missing search terms are part of a very large text file, it is possible that the file has not been indexed due to exceeding the indexer’s maximum file size limit. See the section on the `omero.search.max_file_size` setting for more information on increasing this limit.

- If none of the above steps have resolved the situation, it is possible that your search index has become corrupt. If this is the case, you will need to re-index your server’s content. See the section on Re-indexing for more information. Keep in
mind that you may also need to adjust the settings for the search batch size, maximum file size, and indexer’s heap size, as
outlined above.

8.1.10 OMERo.web issues

OMERO.web is not accessible from remote computer

To configure the out-of-the-box setup to listen for webadmin and webclient connections on different host run:

c:\omero_dist> bin/omero web start 'host' 'port'

OMERO.web did not start on the production

The user opening OMEROweb.log files needs write permissions to the directory containing the log files. So, be sure you have a
log directory with the correct ownership and the path set in LOGDIR matches the log directory.

- In your /home/omero/omero_dist/var/lib/ directory add the following to your custom_settings.py file:
  
  LOGDIR = '/home/omero/weblog/'

- Check if /home/omero/omero_dist/var/lib/custom_settings.py exists.

- Check who owns the log directory and log files:

  $ ls -al /home/omero/weblog/

  total 49
  drwxr-xr-x  2 apache apache 120 Mar 31 11:29 .
  drwxr-xr-x 10 apache apache 520 Mar 31 11:29 ..
  -rw-r--r--  1 apache apache 23766 Mar 31 11:41 OMEROweb.log
  -rw-r--r--  1 apache apache 23978 Mar 31 11:41 OMEROweb.log.2009-03-31

- or create log and database directories with, for example, apache_user:apache_group ownership:

  mkdir /home/omero/weblog
  chown apache_user:apache_group /home/omero/weblog

OMERO.web piecharts

‘Drive space’ does not generate pie chart or ‘My account’ does not show markup picture and crop the picture options.

Error message says: ‘Piechart could not be displayed. Please check log file to solve the problem’. Please check
var/log/OMEROweb.log for more details. There are a few known possibilities:

- ‘TclError: no display name and no $DISPLAY environment variable’. Turn off the compilation of TCL support in Mat-
 plotlib

- ‘ImportError: No module named Image’. Install Pillow7 (packages should be available for your distribution). Also double
  check if all of the prerequisites were installed from OMERO.web deployment (UNIX instructions or Windows instructions).

6http://matplotlib.org/
7http://pillow.readthedocs.org

8.1. Troubleshooting OMERO
8.1.11 Other issues

Connection problems and TCP window scaling on Linux systems

Later versions of the 2.6 Linux kernel, specifically 2.6.17, have TCP window scaling enabled by default. If you are having initial logins never timeout or problems with connectivity in general you can try turning the feature off as follows:

```
# echo 0 > /proc/sys/net/ipv4/tcp_window_scaling
```

**Server or clients print “WARNING: Prefs file removed in background...”**

Nov 12, 2008 3:02:50 PM java.util.prefs.FileSystemPreferences$7 run
WARNING: Prefs file removed in background /root/.java/.userPrefs/prefs.xml
Nov 12, 2008 3:02:50 PM java.util.prefs.FileSystemPreferences$7 run
WARNING: Prefs file removed in background /usr/lib/jvm/java-1.7.0-icedtea-1.7.0.0/jre/.systemPrefs/prefs.xml

These warnings (also sometimes listed as ERRORS) can be safely ignored, and are solely related to how Java is installed on your system. See [http://bugs.sun.com/bugdatabase/view_bug.do?bug_id=4751177](http://bugs.sun.com/bugdatabase/view_bug.do?bug_id=4751177) or this [ome-users thread](http://lists.openmicroscopy.org.uk/pipermail/ome-users/2009-March/001465.html) on our mailing list for more information.

**Too many open files**

This is caused by the number of opened files exceeding the limit imposed by your operating system. It might be due to OMERO leaking file descriptors; if you are not using the latest version, please upgrade, since a number of bugs which could cause this behavior have been fixed. It is also possible for buggy scripts which do not properly release resources to cause this to occur. To view the current per-process limit, run

```
ulimit -Hn
```

which will show the hard limit for the maximum number of file descriptors (-Sn will show the soft limit). This limit may be increased. On Linux, see `/etc/security/limits.conf` (global PAM per-user limits configuration); it is also possible to increase the limit in the shell with

```
ulimit -n newlimit
```

providing that you are uid 0 (other users can only increase the soft limit up to the hard limit). To view the system limit, run

```
cat /proc/sys/fs/file-max
```

On Mac OS X, the standard ulimit will not work properly. There are several different ways of setting the ulimit, depending upon the version of OS X you are using, but the most common are to edit `sysctl.conf` or `launchd.conf` to raise the limit. However, note that both of these methods change the defaults for every process on the system, not just for a single user or service.

**Increasing the number of available filehandles via ‘ulimit -n’**

ValueError: filedescriptor out of range in select() - this is a known issue in Python versions prior to 2.7.0. See #6201 and [Python Issue #3392](http://bugs.python.org/issue3392) for more details.

---

9[http://trac.openmicroscopy.org.uk/ome/ticket/6201](http://trac.openmicroscopy.org.uk/ome/ticket/6201)
10[http://bugs.python.org/issue3392](http://bugs.python.org/issue3392)
8.2 Server security and firewalls

8.2.1 General

OMERO has been built with security in mind. Various standard security practices have been adhered to during the development of the server and client including:

• Encryption of all passwords between client and server via SSL (Secure Socket Layer)
• Full encryption of all data when requested via SSL
• User and group based access control
• Authentication via LDAP
• Limited visible TCP ports to ease firewalling
• Use of a higher level language (Java or Python) to limit buffer overflows and other security issues associated with native code
• Escaping and bind variable use in all SQL interactions performed via Hibernate

The OMERO team treats the security of all components with care and attention. If you have a security issue to report please do not hesitate to contact us using any one of the mechanisms found on the community page.

8.2.2 Firewall configuration

Securing your OMERO system with so called firewalling or packet filtering can be done quite easily. By default, OMERO clients only need to connect to two TCP ports for communication with your OMERO server: 4063 (unsecured) and 4064 (SSL). These are the IANA assigned ports for the Glacier2 router from ZeroC. Both of these values, however, are completely up to you, see SSL below.

Important OMERO ports:

• TCP/4063
• TCP/4064

If you are using OMERO.web, then you will also need to make your HTTP and HTTPS ports available. These are usually 80 and 443.

Important OMERO.web ports:

• TCP/80
• TCP/443

Example OpenBSD firewall rules

```
block in log on $ext_if from any to <omero_server_ip>
pass in on $ext_if proto tcp from any to <omero_server_ip> port 4063
pass in on $ext_if proto tcp from any to <omero_server_ip> port 4064
pass in on $ext_if proto tcp from any to <omero_server_ip> port 443
pass in on $ext_if proto tcp from any to <omero_server_ip> port 80
```

Example Linux firewall rules

```
11 http://www.openmicroscopy.org/site/community/
12 http://www.iana.org/assignments/service-names-port-numbers/service-names-port-numbers.xml
13 http://www.zeroc.com
```
8.2.3 Passwords

The passwords stored in the password table are salted and hashed, so it is impossible to recover a lost one, instead a new one must be set by an admin.

If the password for the root user is lost, the only way to reset it (in the absence of other admin accounts) is to manually update the password table. The `bin/omero` command can generate the required SQL statement for you:

```
$ bin/omero db password
Please enter password for OMERO root user:
Please re-enter password for OMERO root user:
UPDATE password SET hash = 'PJueOtwuTPHB8Nq/1rFVxg==' WHERE experimenter_id = 0;
```

Current hashed password:

```
$ psql mydatabase -c "select * from password"
+-----------------+--------------------------+
| experimenter_id | hash                     |
|-----------------+--------------------------|
| 0               | Xr4ilOzQ4PCOq3aQ0qbuaQ== |
+(1 row)
```

Change the password using the generated SQL statement:

```
$ psql mydatabase -c "UPDATE password SET hash = 'PJueOtwuTPHB8Nq/1rFVxg==' WHERE experimenter_id = 0;"
UPDATE 1
```

8.2.4 Java key- and truststores.

If your server is connecting to another server over SSL, you may need to configure a truststore and/or a keystore for the Java process. This happens, for example, when your LDAP server uses SSL. See the LDAP plugin for information on how to configure the LDAP URLs. As with all configuration properties, you will need to restart your server after changing them.

To do this, you will need to configure several server properties, similar to the properties you configured during installation (Windows).

- truststore path

```
bin/omero config set omero.security.trustStore /home/user/.keystore
```

A truststore is a database of trusted entities and their associated X.509 certificate chains authenticating the corresponding public keys. The truststore contains the Certificate Authority (CA) certificates and the certificate(s) of the other party to which this entity intends to send encrypted (confidential) data. This file must contain the public key certificates of the CA and the client’s public key certificate.
If you don’t have one you can create it using the following:

```
openssl s_client -connect {{host}}:{{port}} -prexit < /dev/null | openssl x509 -outform PEM | keytool -import -alias ldap -storepass {{password}} -keystore {{truststore}} -noprompt
```

- truststore password

```
bin/omero config set omero.security.trustStorePassword secret
```

- keystore path

```
bin/omero config set omero.security.keyStore /home/user/.mystore
```

A keystore is a database of private keys and their associated X.509 certificate chains authenticating the corresponding public keys.

A keystore is mostly needed if you are doing client-side certificates for authentication against your LDAP server.

- keystore password

```
bin/omero config set omero.security.keyStorePassword secret
```

### 8.2.5 SSL

Especially if you are going to use LDAP authentication to your server, it is important to encrypt the transport channel between clients and the Glacier2 router to keep your passwords safe.

By default, all logins to OMERO occur over SSL using an anonymous handshake. After the initial connection, clients can request to have communication un-encrypted to speed up image loading by clicking on the lock symbol. An unlocked symbol means that non-password related activities (i.e. anything other than login and changing your password) will be unencrypted, and the only critical connection which is passed in the clear is your session id.

Administrators can configure OMERO such that unencrypted connections are not allowed, and the user’s choice will be silently ignored. The SSL and non-SSL ports are configured in the etc/grid/default.xml and windefault.xml files, and as described above, default to 4064 and 4063 respectively, and can be modified with command:

```
$ bin/omero admin ports --help
```

Allows modifying the ports from a standard OMERO install
To have two OMERO’s running on the same machine, several ports must be modified from their default values. Internally, this command uses the omero.install.change_ports module.

Examples:

```bash
bin/omero admin ports --prefix=1            # sets ports to: 14061, 14063, 14064
bin/omero admin ports --prefix=1 --revert  # sets ports back to: 4061, 4063, 4064
bin/omero admin ports --registry=4444 --tcp=5555 --ssl=6666 # sets ports to: 4444 5555 6666
```

Optional Arguments:

In addition to any higher level options

- `-h, --help` show this help message and exit
- `--prefix PREFIX` Adds a prefix to each port ON TOP OF any other settings
- `--registry REGISTRY` Registry port. (default: 4061)
- `--tcp TCP` The tcp port to be used by Glacier2 (default: 4063)
- `--ssl SSL` The ssl port to be used by Glacier2 (default: 4064)
- `--revert` Used to rollback from the given settings to the defaults

See also:

LDAP authentication

8.3 Advanced configuration

Overview

Describes configuration options that not everyone will need, but may be useful for optimizing, customizing, or monitoring your server.

The OMERO server provides several different configuration/extension points that you may want to use.

8.3.1 Configuration properties

The primary form of configuration is via the use of key/value properties, stored in `etc/grid/config.xml` and read on server startup. Backing up and copying these properties is as easy as copying this file to a new server version.

The `etc/omero.properties` file of your distribution defines all the default configuration properties used by the server. Changes made to the file are not recognized by the server. Instead, the `omero config` command is used to change those properties that you would like to customize.

Examples of doing this are on the main Unix and Windows pages, as well as the LDAP installation page.

Here we list some options which you are most likely to want to modify. See `etc/omero.properties` for more details.

`omero.sessions.timeout`

`omero.sessions.timeout` sets the duration of inactivity in milliseconds after which a login is required (default is 600000, or 10 minutes). To change the default, for example, to 1 hour use:

```bash
$ bin/omero config set omero.sessions.timeout 3600000
```

---

14 https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/omero.properties
15 https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/omero.properties
omero.db.poolsize

omero.db.poolsize sets the number of connections to PostgreSQL which will be used by OMERO (default is 10):

$ bin/omero config set omero.db.poolsize 50

Your database installation will need to be configured to accept at least as many, preferably more, connections as the value of “omero.db.poolsize”

omero.search.batch

The search indexer will process events in batches, the size of which is determined by the omero.search.batch setting (default is 50):

$ bin/omero config set omero.search.batch 200

Setting a larger batch size can potentially speed up indexing, but it also places more strain on the indexer heap. If you increase batch size, it may be necessary to also increase heap size (see: OutOfMemoryError / PermGen space errors in OMERO.server logs).

omero.search.max_file_size

The search indexer will not index any text or PDF files larger than omero.search.max_file_size bytes. If a file larger than this is attached, e.g. to an image, the indexer will simply ignore the contents of the file when creating the search index. To allow larger files to be added to the search index you may increase the setting (default is 131072000, or 125 MB):

$ bin/omero config set omero.search.max_file_size 262144000

Note: If you set the max file size to greater than 1/2 the size of the indexer’s heap (256 MB by default), you may encounter Out of Memory errors in the Indexer process or you may cause the search index to become corrupt. Be sure that you also increase the heap size accordingly (see OutOfMemoryError / PermGen space errors in OMERO.server logs).

8.3.2 Grid configuration

In some cases, the configuration properties will not suffice to fully configure your server. In that case, it may be necessary to make use of IceGrid’s XML configuration files. Like the config.xml file mentioned above, these are stored under etc/grid:

default.xml16 is used on Unix systems, windefault.xml17 is used on Windows systems and both make use of templates.xml18.

The default OMERO application descriptor deploys multiple server instances (Blitz-0, FileServer, Indexer-0, PixelData-0…) on a single node. Each server instance is defined by a server-template element in templates.xml19 with its own parameters.

Modifying the application descriptors

When you run omero admin start without any other arguments, it looks up the default application descriptor for your platform:

$ bin/omero admin start
No descriptor given. Using etc/grid/default.xml
Waiting on startup. Use CTRL-C to exit
The “start” and “deploy” command, however, take several other parameters:

```
$ bin/omero admin start --help
usage: bin/omero admin start [-h] [-u USER] [file] [targets [targets ...]]
```

Start icegridnode daemon and waits for required components to come up, i.e. status == 0

If the first argument can be found as a file, it will be deployed as the application descriptor rather than etc/grid/default.xml. All other arguments will be used as targets to enable optional sections of the descriptor

**Positional Arguments:**

- `file` Application descriptor. If not provided, a default will be used
- `targets` Targets within the application descriptor which should be activated.

If a file is passed in as the first argument, then that **application descriptor** as opposed to **default.xml**[20] will be used. You can also modify the default application descriptors in place.

**Note:** The largest issue with using your own application descriptors or modifying the existing ones is that they tend to change between versions, and there is no facility for automatically merging your local changes. You should be prepared to re-make whatever changes you perform directly on the new files.

**Targets**

**Targets** are elements within the application descriptors which can optionally turn on configuration. The target is only applicable until the next invocation of *omero admin start* or *omero admin deploy*

**Note:** You must remember to always apply the targets on each *omero admin* command. If not, the target will not be removed. Therefore, they are often better used for debugging purposes; however, as opposed to alternative application descriptors, using the pre-existing targets should not require any special effort during upgrades.

**Debugging**

```
<properties id="PythonServer">
  <property name="Ice.ImplicitContext" value="Shared"/>
  <!-- Default logging settings for Python servers. -->
  <property name="omero.logging.timedlog" value="False"/>
  <property name="omero.logging.logsize" value="5000000"/>
  <property name="omero.logging.lognum" value="9"/>
  <property name="omero.logging.level" value="20"/>
  <target name="debug">
    <property name="omero.logging.level" value="10"/>
  </target>
</properties>
```

Here, the “debug” target allows increasing the logging output of the Python servers without modifying any files.

**JMX configuration**

```
<server-template id="BlitzTemplate">
  <parameter name="index"/>
  <parameter name="config" default="default"/>
```

[20]https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/grid/default.xml
<parameter name="jmxhost" default=""/>
<parameter name="jmxport" default="3001"/>

...<target name="jmx">
<!-- Be sure to understand the consequences of enabling JMX.
 It allows calling remote methods on your JVM -->
<option>-Dcom.sun.management.jmxremote=${jmxhost}</option>
<option>-Dcom.sun.management.jmxremote.port=${jmxport}</option>
<option>-Dcom.sun.management.jmxremote.authenticate=false</option>
<option>-Dcom.sun.management.jmxremote.ssl=false</option>
</target>

The JMX target activates the monitoring of the Blitz server via JMX. If you need to modify the “jmxport” or “jmxhost” variables, you will need to do so directly in the application descriptor XML.

### 8.3.3 Changing ports / multiple servers on a single host

Since changing all the references to port numbers (4061, 4063, 4064, etc) in the grid configuration can be cumbersome, a `omero admin` command is provided to make the modifications for you. See the SSL section of the Server security and firewalls page for more information.

By modifying the default OMERO ports, it is possible to run multiple OMERO servers on the same physical machine.

```bash
# First server
cd /usr/local/omero-4.2
bin/omero admin ports --prefix=1
bin/omero admin start
# Second server
cd /usr/local/omero-4.3
bin/omero admin ports --prefix=2
bin/omero admin start
```

Clients will need to use the appropriate port (either 14064 or 24064) to connect to OMERO.

### 8.3.4 Extending OMERO

Finally, if configuration does not suffice, there are also options for extending OMERO with your own code. These are described on the development site under Extending OMERO.

### 8.4 LDAP authentication

LDAP\(^{21}\) is an open standard for querying and modifying directory services that is commonly used for authentication, authorization and accounting (AAA). OMERO.server supports the use of an LDAP server to query (but not modify) AAA information for the purposes of automatic user creation.

This allows OMERO users to be automatically created and placed in groups according to your existing institution policies. This can significantly simplify your user administration burden.

The OMERO.server LDAP implementation can handle a number of use cases. For example:

- Allow every “inetOrgPerson” under `omero.ldap.base` to login
- but restrict access based upon an arbitrary LDAP filter, e.g.

```
omero.ldap.user_filter=(memberOf=cn=someGroup,ou=Lab,o=College)
```


### 8.4. LDAP authentication
• and add that user to some number of groups, e.g.

```
omero.ldap.new_user_group=:query:{member=\{dn\}}
```

### 8.4.1 How it works

On login, the username provided is searched for in OMERO. If the name does not exist, then the LDAP plugin is queried for a username matching the system-wide user filter. If such an LDAP entry exists and the password matches, a new user with the given username is created, and the user is added to any groups which match the `new_user_group` setting.

On subsequent logins, the user filter and the password are again checked against the LDAP server, and if there is no longer a match, login is refused. If you would prefer to only have the `user_filter` applied during user creation and not on every login, see *Legacy password providers*.

### 8.4.2 LDAP properties

The LDAP plugin is configured via several configuration properties, all starting with `omero.ldap`. The default values for these properties are set in the file `etc/omero.properties`. An overview of all the properties is outlined in *LDAP configuration overview*.

#### Minimum configuration

The following properties are the minimum requirements for logging in to OMERO using LDAP.

```
omero.ldap.config=true
omero.ldap.urls=ldap://localhost:389
omero.ldap.username=
omero.ldap.password=
omero.ldap.base=ou=example,o=com
```

After having configured your connection, you can turn LDAP on and off between restarts by setting `omero.ldap.config` to false. The `base` property determines where in the LDAP tree searches will begin. No users or groups will be found if they are not under the base provided.

#### User lookup

Two user properties are used to look up users by login name and, if necessary, create new users based on the information in LDAP.

```
omero.ldap.user_filter=(objectClass=person)
omero.ldap.user_mapping=omeName=cn,firstName=givenName,lastName=sn,email=mail
```

The `user_filter` will be AND’ed to the username query, and can contain any valid LDAP filter string. The username query is taken from the LDAP attribute which gets mapped to “omeName” by `omero.ldap.user_mapping`. Here, the “cn” is mapped to “omeName”, so the username query is `(cn=[login name])`. The final query is `(&(objectClass=person)(cn=[login name]))`, which must return a single result to be considered valid.

#### Group lookup

Three group properties are all concerned with what groups a user will be placed in on creation.

```
omero.ldap.group_filter=(objectClass=groupOfNames)
omero.ldap.group_mapping=name=cn
omero.ldap.new_user_group=default
```

8.4. LDAP authentication
The group filter and group mapping work just as the user filter and mapping do, in that the group name query will be AND’d with the group_filter. In this case, the final query would be $(\&(\text{objectClass=groupOfNames})(\text{cn}=[\text{group name}]))$. However, these properties may not be used depending on the value of new_user_group, which can have several different values:

- If not prefixed at all, then the value is simply the name of a group which all users from LDAP should be added to.
- If prefixed with :ou:, then a user’s last organizational unit (OU) will be used as his or her group. For example, the user with the DN “cn=frank,ou=TheLab,ou=LifeSciences,o=TheCollege” will be placed in the group “TheLab”.
- If prefixed with :attribute:, then the rest of the string is taken to be an attribute all of whose values will be taken as group names. For example, omero.ldap.new_user_group=:attribute:memberOf would add a user to all the groups named by memberOf. You can prefix this value with filtered_ to have the group_filter applied to the attribute values, i.e. :filtered_attribute:memberOf will mean that only the values of memberOf which match group_filter will be considered.
- If prefixed with :dn_attribute:, then the rest of the string is taken to be an attribute all of whose values will be taken as group distinguished names. For example, omero.ldap.new_user_group=:dn_attribute:memberOf would add a user to all the groups named by memberOf, where the name of the group is mapped via group_mapping. You can prefix this value with filtered_ to have the group_filter applied to the attribute values, i.e. :filtered_dn_attribute:memberOf will mean that only the values of memberOf which match group_filter will be considered.
- If prefixed with :query:, then the rest of the value is taken as a query to be AND’ed to the group filter. In the query, values from the user such as “@{cn}”, “@{email}”, or “@{dn}” can be used as place holders.
- If prefixed with :bean:, then the rest of the string is the name of a Spring bean which implements the NewUserGroupBean interface. See the developer documentation LDAP plugin design for more info.

**Compound Filters**

Both the user_filter and the group_filter can contain any valid LDAP filter string. These must be a valid filter in themselves. e.g.

```mermaid
groupedFlowchart
  start
  omero.ldap.group_filter=$(\&(\text{objectClass=groupOfNames})(\text{mail}=omero.flag))

This filter is valid and will cause the filter to only match groups that have the mail attribute set to the value omero.flag. When combined with the group_mapping, the final query would be $(\&(\&(\text{objectClass=groupOfNames})(\text{mail}=omero.flag))(\text{cn}=[\text{group name}]))$

This is the same as the query $(\&(\text{objectClass=groupOfNames})(\text{mail}=omero.flag)(\text{cn}=[\text{group name}]))$ but setting group_filter to $(\text{objectClass=groupOfNames})(\text{mail}=omero.flag)$ is not valid as that is not a valid filter on its own.

To restrict the list of groups to just the ones returned by the above query, the following setting is also required to remove unmatched groups:

```mermaid
groupedFlowchart
  start
  omero.ldap.new_user_group=:filtered_dn_attribute:memberOf
```

**8.4.3 LDAP configuration overview**

Like many pieces of OMERO.server configuration, LDAP-specific configuration is done by specifying extra properties during installation. The default values for the LDAP properties are listed in the etc/omero.properties file inside your OMERO installation directory.

**Note:** Please remember that once a change has been made, a server restart will be needed.

Change any settings that are necessary via bin/omero config.

- Enable or disable LDAP (true/false)
bin/omero config set omero.ldap.config true

- LDAP server URL string

bin/omero config set omero.ldap.urls ldap://ldap.example.com:389

Note: A SSL URL above should look like this: ldaps://ldap.example.com:636

- LDAP server bind DN (if required; can be empty)

bin/omero config set omero.ldap.username cn=Manager,dc=example,dc=com

- LDAP server bind password (if required; can be empty)

bin/omero config set omero.ldap.password secret

- LDAP server base search DN

bin/omero config set omero.ldap.base dc=example,dc=com

- The filter applied to all users; can be empty in which case any LDAP user is valid

bin/omero config set omero.ldap.user_filter '(objectClass=inetOrgPerson)'

- LDAP referral options (defaults to “ignore”; available options are “ignore, “follow” or “throw” as per the JNDI referrals documentation\textsuperscript{22})

bin/omero config set omero.ldap.referral follow

8.4.4 LDAP over SSL

If you are connecting to your server over SSL, that is, if your URL is of the form ldaps://ldap.example.com:636 you may need to configure a key and trust store for Java. See the Server security and firewalls page for more information.

8.4.5 Synchronizing LDAP on user login

This feature allows for LDAP to be considered the authority on user/group membership. With the following settings enabled each time a user logs in to OMERO their LDAP groups will be read from the LDAP server and reflected in OMERO. Enabling this will result in any bespoke OMERO groups that have been created being removed from the user’s profile. The groups will still exist on the server but the association between user and group will not be reflected unless such a link is made in LDAP.

bin/omero config set omero.ldap.sync_on_login true

8.4.6 Legacy password providers

The primary component of the LDAP plugin is the LdapPasswordProvider, which is responsible for creating users, checking their passwords, and adding them to or removing them from groups. The default password provider is the chainedPassword-

\textsuperscript{22}http://docs.oracle.com/javase/jndi/tutorial/ldap/referral/jndi.html
Provider which first checks LDAP if LDAP is enabled, and then checks JDBC. This can explicitly be enabled by executing the system admin command:

```
bin/omero config set omero.security.password_provider chainedPasswordProvider
```

When the LDAP password provider implementation changes, previous versions can be configured as necessary.

**chainedPasswordProviderNoSalt**

The chainedPasswordProviderNoSalt uses the version of the JDBC password provider without password salting support as available in the OMERO 4.4.x series. To enable it, use:

```
bin/omero config set omero.security.password_provider chainedPasswordProviderNoSalt
```

**chainedPasswordProvider431**

With the 431 password provider, the user filter is only checked on first login and not kept on subsequent logins. This allows for an OMERO admin to change the username of a user in omero to be different than the one kept in LDAP. To enable it, use:

```
bin/omero config set omero.security.password_provider chainedPasswordProvider431
```

See also:

- **OMERO.server installation**  
  Installation guide for OMERO.server under UNIX-based platforms
- **Server security and firewalls**  
  Security pages for OMERO.server
- **LDAP plugin design**  
  Developer documentation on extending the LDAP plugin yourself.
- **What are your LDAP requirements?**

8.5 Installing OMERO.tables

OMERO.tables provide a way to efficiently store large, tabular results within OMERO. If you would like to find out more about the use of the OMERO.tables API, see OMERO.analysis

8.5.1 Requirements

If you would like to help test the Tables API, you will need the following installed:

- HDF5
- NumPy
- PyTables

8.5.2 Unix

PyTables is likely available from the package repository of your Unix-flavor. This includes Mac OS X (homebrew), Debian and Ubuntu (apt-get), CentOS (yum), and SuSE (yast). Here we’ve shown manual instructions using virtualenv.

---

26 http://pytables.github.com/downloads.html
Manually

$ virtualenv $HOME/virtualenv
$ uname -o -p
unknown GNU/Linux
$ gcc --version
gcc-4.8.real (Debian 4.8.1-9) 4.8.1
Copyright (C) 2013 Free Software Foundation, Inc.
This is free software; see the source for copying conditions. There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

$ wget "http://www.hdfgroup.org/ftp/HDF5/current/src/hdf5-1.8.11.tar.gz"
$ tar xzf hdf5-1.8.11.tar.gz
$ cd hdf5-1.8.11
$ ./configure --prefix=$HOME/virtualenv
$ make
$ make install
$ export LD_LIBRARY_PATH=$HOME/virtualenv/lib
$ . $HOME/virtualenv/bin/activate
$ easy_install tables

Checking that it works

After that, the following should succeed:

% python
Python 2.7.5+ (default, Aug 4 2013, 10:07:17)
[GCC 4.8.1] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import tables
>>> tables.test()
=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=-=
PyTables version: 2.4.0
HDF5 version: 1.8.11
NumPy version: 1.7.1
Numexpr version: 2.0.1 (not using Intel's VML/MKL)
Zlib version: 1.2.8 (in Python interpreter)
LZO version: 2.06 (Aug 12 2011)
BZIP2 version: 1.0.6 (6-Sept-2010)
Blosc version: 1.1.3 (2010-11-16)
Python version: 2.7.5+ (default, Aug 4 2013, 10:07:17)
[GCC 4.8.1]
Platform: linux2-x86_64
Byte-ordering: little
Detected cores: 8
...

Once the required Python libraries are installed, starting OMERO will automatically start up the OMERO.tables service; there
should be no need for further configuration or interaction.

8.5.3 Windows

After installing all the Windows prerequisites OMERO.tables should start up during the OMERO.server startup. It can be verified
by looking at the output of omero admin diagnostics:

(...)
Server: Tables-0 active (pid = 3176, enabled)
8.6 OMERO.movie

A short description on how to create movies from OMERO.

8.6.1 Creating a movie from OMERO

OMERO provides a script to make Mpeg or Quicktime movies from any image in the server. These movies are created by a script called makemovie.py, this script has a number of options: these include: selecting a range of Z,T planes, the channels to display. The movie can also show information overlayed over the image: z-section, scale bar and timing.

The resulting movie will then be uploaded to the server by the script and become a file attachment to the source image.

8.6.2 Viewing the movie

The make movie script allows you to save the movie in two different formats, a DivX encoded AVI and Quicktime movie. To view the AVI you may need to install a divX codec from DivX. It should be noted that the DivX avi is normally 1/3 to 1/10 the size of the Quicktime movie.

8.6.3 Installing the make movie script

The make movie script currently uses the mencoder utility to encode the movies, this command should be in the path of the computer (icegrid node) running the script.

You can find windows installs for mencoder at http://sourceforge.net/projects/mplayer-win32/files/

We have Mac OSX installs for mencoder which were originally provided here. Unzip and put the mencoder in the PATH available to the server, e.g. /usr/local/bin/. You may need to restart the server for this to take effect.

There are also macports, rpms and debs for mencoder.

Make movie also uses Pillow and numpy.

8.6.4 Make movie command arguments

A detailed list of the commands accepted by the script are:

- `imageId`: This id of the image to create the movie from
- `output`: The name of the output file, sans the extension
- `zStart`: The starting z-section to create the movie from
- `zEnd`: The final z-section
- `tStart`: The starting timepoint to create the movie
- `tEnd`: The final timepoint.
- `channels`: The list of channels to use in the movie (index, from 0)
- `splitView`: Should we show the split view in the movie (not available yet)
- `showTime`: Show the average time of thequisition of the channels in the frame.

---

27http://www.divx.com/
28http://www.mplayerhq.hu/design7/dload.html
29http://cvs.openmicroscopy.org.uk/snapshots/mencoder/mac/
30http://stefpause.com/apple/mac/mplayer-os-x-10rc1-and-mencoder-binaries/
31http://pillow.readthedocs.org
32http://www.scipy.org/Download
• showPlaneInfo: Show the time and z-section of the current frame.
• fps: The number of frames per second of the movie
• scalebar: The scalebar size in microns, if <=0 will not show scale bar.
• format: The format of the movie to be created currently supports ‘video/mpeg’, ‘video/quicktime’
• overlayColour: The colour of the overlays, scalebar, time, as int(RGB)
• fileAnnotation: The fileAnnotation id of the uploaded movie. (return value from script)

8.6.5 Platform-specific notes

Windows

For Windows, you can download a “MPlayer-rtm-svm-<version>” bundle from http://sourceforge.net/projects/mplayer-win32/33. You will need 7zip34 to open the bundle. Then you will need to add the directory containing "mencoder.exe" to your system path and restart.

8.7 Installing new scripts

OMERO.scripts are the OME version of plugins, allowing you to extend the functionality of OMERO. Official core OMERO.scripts come bundled with every OMERO.server release but you can also add new scripts you have written yourself or found via the new script sharing service35.

8.7.1 Prerequisites

8.7.2 Uploading and managing scripts

OMERO.scripts user guide describes the workflow for developing and uploading scripts as an Admin. Any scripts you add to the lib/scripts/ directory as a server admin will be considered ‘trusted’ and automatically detected by OMERO, allowing them to be run on the server from the clients or command line by any of your users.

Once in the directory, scripts cannot be automatically updated and any additional ones will be lost when you upgrade your server installation. Therefore, we recommend you use a Github repository to manage your scripts. If you are not familiar with using git36, you can use the GitHub app for your OS37 (available for Mac and Windows but not Linux). The basic workflow is:

• fork our omero-user-script38 repository
• clone it in your lib/scripts directory

```
  cd lib/scripts;
  git clone git@github.com:YOURGITUSERNAME/omero-user-scripts.git YOUR_SCRIPTS
```

• save the scripts you want to use into the appropriate sub-directory in your cloned location lib/scripts/YOUR_SCRIPTS

Then when you upgrade your OMERO.server installation, provided your Github repository is up to date with all your latest script versions (i.e. all your local changes are committed), you just need to repeat the git clone step. Those scripts will then be automatically detected by your new server installation and available for use from the clients and command line as before.

33http://sourceforge.net/projects/mplayer-win32/
34http://www.7-zip.org/download.html
35http://www.openmicroscopy.org/site/community/scripts
36http://www.openmicroscopy.org/site/support/contributing/using-git.html
37http://help.github.com/articles/set-up-git
38https://github.com/ome/omero-user-scripts
9.1 Advanced import scenarios

Increasingly users of OMERO are needing to go beyond the traditional "upload via a GUI"-style import model to more powerful methods.

There are a set of requirements for getting data into OMERO which are common to many institutions, some of which may be mutually exclusive.

- Users need to get data off microscopes quickly. This likely includes not waiting for import to complete. Users will often move data immediately, or even save remotely during acquisition.
- Users would like direct access to the binary repository file-system to read original files for analysis.
- Users would like to view and begin working with images ASAP after acquisition

Below we explain which options are available to you, and why there is a trade-off between the above requirements.

9.1.1 Import overview

In OMERO 4 and earlier versions, data was uploaded to the binary repository in an opaque form; starting with OMERO 5, files are uploaded to the repository in their original form using Bio-Formats.

The “OMERO binary repository” (or repo) is the directory belonging to the OMERO user where files are imported:

- The ManagedRepository directory inside of the repo is where files go during import into OMERO 5. Each user receives a top-level directory inside of “ManagedRepository” which fills with timestamped directories as imports accrue.
- Depending on the permissions of this directory, users may or may not be able to see their imported files. Managing the permissions is the responsibility of the system administrator.

In “normal import”, files are copied to the OMERO binary repo via the API and so can work remotely or locally. In “in-place import”, files are “linked” into place.

**Warning:** In-place import is a new, powerful feature - it is critical that you read and understand the documentation before you consider using it.

9.1.2 Traditional import

**Manual import (GUI)**

This is the standard workflow and the one currently used at the University of Dundee. Users dump data to a shared file-system from the acquisition system, and then use the OMERO.insight client from the lab to import.

**Advantages**

- Users can validate that import worked.
- Failed imports can be repeated and/or reported to QA etc.
- Users do not have to wait for import to be scheduled.
- Import destination is known: Project/Dataset etc.

Disadvantages

- Imports can be slow due to the data transfer from file-system to OMERO via the client.
- Users must remember to delete data from the shared file-system to avoid data duplication.
- Users cannot access the OMERO binary repo directly and must download original data via clients for local analysis.

Manual import (CLI)

Another typical workflow is that rather than using the GUI, users perform the same procedure as under “Manual import” but with the command-line (CLI) importer.

Advantages

- With a CLI workflow, it may be easier for users to connect remotely to kick off an import and to leave it running in the background for a long period of time.

Disadvantages

All the same disadvantages apply as under “Manual import (GUI)”.

Cronjob import (manual delete)

For importing via cron, users still dump their data to a shared file-system from the acquisition system. They must have permissions to write to “their” directory which is mapped to a user in OMERO.

A cronjob starts a CLI import, possibly at night. The cronjob could be given admin rights in OMERO to perform an “Import As” for a particular user.

Disadvantages

- If a normal import is used, the cronjob would have to manually delete imported files from their original location to avoid duplication.
- Users cannot work with their data in OMERO until some time after acquisition.
- Failed imports are logged within the managed repository but not yet notified. Logs would probably need to be accessed via a sysadmin/cli. The cronjob could capture stdout and stderr and check for failures.

DropBox import (manual delete)

Similar to the cronjob scenario, DropBox importing requires that users drop their data in “their” directory which has special permissions for writing. The DropBox service monitors those directories for modifications and imports the files on a first-come-first-serve basis.

Advantages

- Users should see their data in OMERO quickly.
Disadvantages

- There is a limitation on the rate of new files in monitored locations.
- There is also a limitation on which file systems can be used. A networked file share cannot be monitored by DropBox.
- Users must manually delete imported files from their DropBox directory to avoid duplication.
- Failed imports are logged within the managed repository but not yet notified. Logs would probably need to be accessed via a sysadmin or through the CLI and searched by the user and file name.

9.1.3 In-place import

The following sections outline in-place based scenarios to help you judge if the functionality may be useful for you.

Common advantages

- All in-place import scenarios provide non-copying benefit. Data that is too large to exist in multiple places, or which is accessed too frequently in its original form to be renamed, remains where it was originally acquired.

Common disadvantages

- Like the DropBox import scenario above, all in-place imports require the user to have access to the user-based directories under the ManagedRepository. See limitations for more details.
- Similarly, all the following scenarios carry the same burden of securing the data externally to OMERO. This is the primary difference between a normal import and an in-place import: backing up OMERO is no longer sufficient to prevent data loss. The original location must also be secured! This means that users must not move or alter data once imported.

In-place manual import (CLI)

The in-place version of a CLI manual import is quite similar to the normal CLI import, with the primary difference being that the data is not transferred from the shared file-system where the data is initially stored after acquisition, but instead is just “linked” into place.

Advantages

- Local filesystem in-place import is faster than traditional importing, due to the lack of a data transfer.

Disadvantages

- Requires proper security setup as explained above.

In-place Cronjob import

Assuming all the restrictions are met, the cronjob-based workflow above can carry out an in-place import by adding the in-place transfer flag. The advantages and disadvantages are as above.

In-place DropBox import (manual delete)

Just as with the in-place cronjob import, using in-place import for DropBox is as straight-forward as passing the in-place flag. The common advantages and disadvantages of in-place import apply.
In-place Dropbox import (automatic delete)

One option that only exists in the in-place scenario is to have files removed from Dropbox automatically after a successful delete. This is achieved by first performing a “hardlink in-place import” from the Dropbox directory to the ManagedRepository and then by deleting the data from Dropbox if and only if the import was successful.

Advantages

- For all successful imports, files will be automatically removed from the Dropbox directories.

Disadvantages

- For failed imports, files will remain in the Dropbox directories until someone manually deletes them.
- This option is only available if the filesystem which Dropbox watches is the same as the file system which the ManagedRepository lives on. This prevents the use of network file systems and similar remote shares.

9.2 In-place import

In-place import is a feature added to OMERO 5.0.0 to allow files which are already present on the server machine to be imported into OMERO without the need to copy them. This requires users to have shell (SSH, etc.) access to the server machine, and so there are a number of limitations to this implementation. Development of this feature is on-going, with improvements planned to enable a more user-friendly experience. This CLI-based stop-gap is being made available at this stage because for some users, in-place import is essential for their use of OMERO.

This feature is designed to allow imaging facilities to import large datasets into OMERO while keeping them safely stored in a secure repository which is read-only for users. Leaving the data in a user’s file system is very dangerous as they may forget they need to keep it or move to a different institution. Under no circumstances should in-place import be used with temporary storage.

**Warning:** The instructions below should help you get started but it is critical that you understand the implications of using this feature. Please do not just copy commands and hope for the best.

9.2.1 Responsibilities

As a data management platform, OMERO assumes that it is in control of your data in order to help prevent data loss. It assumes that data was copied into the server and only a server administrator or authorized OMERO user would have the rights to do anything destructive to that data.

With in-place import, the data either resides completely outside of OMERO or is shared with other users. This means that the critical, possibly sole, copy of your data must be protected outside of OMERO. This is your responsibility for the lifetime of the data.

9.2.2 Limitations

In-place import is only available on the OMERO server system itself. In other words, using SSH or similar, you will need to shell into the server and run the command-line importer directly. If you are uncomfortable with this, you should let someone else handle in-place importing.

Someone wanting to perform an in-place import MUST have:

- a regular OMERO account
- an OS-account with access to `omero bin/omero`
- read access to the location of the data
- **write** access to the ManagedRepository or one of its subdirectories
The above means that it may be useful to create a single OS account (e.g. “import_user”) which multiple users can log into, and then use their own OMERO accounts to import data. Alternatively, each OMERO user can be given an OS account with access rights to the data storage as well as the managed repository.

At the moment in-place import is available only under Posix systems (Unix, Linux, OS X). Support for Windows is forthcoming.

For soft linking with --transfer=ln_s it has been noticed that some plate imports run rather more slowly than usual. Other operations may also be affected. In determining if or how to use in-place import at your high-content screening facility, we thus recommend time profiling with representative data, and alerting us to any significant disappointments.

Also, there is still some data duplication when pyramids are generated. We are hoping to find a work-around for this in the future.

### 9.2.3 Safety tips

Whether you chose to use the hard- or soft-linking option below, you should take steps to secure files which are in-place imported to OMERO. The best option is making them read-only for both the OMERO user and also for the owner of the data. This means the server cannot accidentally modify the files (e.g. if a client mixes up the file IDs and tries to write to the wrong location) and that the files cannot be removed from the system while OMERO is still using them. Files may not be renamed or otherwise altered such that the OMERO server user cannot find them at the expected location.

If possible, all the files should be added to your regular backup process.

### 9.2.4 Getting started

The 5.0.0 command-line import client has a new (hidden) help menu which explains the available options:

```
$ bin/omero import -- --advanced-help
```

ADVANCED OPTIONS:

These options are not intended for general use. Make sure you have read the documentation regarding them. They may change in future releases.

In-place imports:

```
--transfer=ARG File transfer method
```

General options:

- upload # Default
- some.class.Name # Use a class on the CLASSPATH.

Server-side options:

- ln # Use hard-link.
- ln_s # Use soft-link.
- ln_rm # Caution! Hard-link followed by source deletion.

ex. $ bin/omero import -- --transfer=ln_s foo.tiff
$ ./importer-cli --transfer=ln bar.tiff
$ CLASSPATH=mycode.jar ./importer-cli --transfer=com.example.MyTransfer baz.tiff

Background imports:

```
--minutes_wait=ARG Choose how long the importer will wait on server-side processing.
ARG > 0 implies the number of minutes to wait.
ARG = 0 exits immediately. Use a *_completed option to clean up.
ARG < 0 waits indefinitely. This is the default.
```

```
--close_completed Close completed imports.
```
--wait_completed  
Wait for all background imports to complete.

ex. $ bin/omero import -- --minutes_wait=0 file1.tiff file2.tiff file3.tiff
$ ./importer-cli --minutes_wait=0 some_directory/
$ ./importer-cli --wait_completed # Waits on all 3 imports.

Import speed:
-------------

--checksum_algorithm=ARG  
Choose a possibly faster algorithm for detecting file corruption,  
e.g. Adler-32 (fast), CRC-32 (fast), MD5-128,  
Murmur3-32, Murmur3-128, SHA1-160 (slow, default)

ex. $ bin/omero import --checksum_algorithm=CRC-32 foo.tiff
$ ./importer-cli --checksum_algorithm=Murmur3-128 bar.tiff

Report bugs to <ome-users@lists.openmicroscopy.org.uk>

The option for performing an in-place transfer is --transfer. A new extension point, file transfers allow a choice of which mechanism is used to get a file into OMERO.

$ bin/omero import -- --transfer=ln_s my_file.dv

Using session bba923bb-cf0c-4cf0-80c5-a309be523ad8 (root@localhost:4064). Idle timeout: 10.0 min. Curren

The only visible difference here is the line:
Rather than uploading via the OMERO API, the command-line importer makes a call to the system ln command.

### 9.2.5 Transfer options

Previously, OMERO only offered the option of uploading via the API. Files were written in blocks via the RawFileStore interface. With in-place import, several options are provided out of the box as well as the ability to use your own.

#### “ln\_s” - soft-linking

The most flexible option is soft-linking. For each file, it executes `ln -s source target` on the local file system. This works across file system boundaries and leaves a clear record of what file was imported:

```
$ ls -ltra
```

```
total 8
lrwxrwxrwx 1 omero omero 11 Jan 24 10:11 my-file.dv -> /home/demo/my-file.dv
```

Here you can see in the imported file set, a soft-link which belongs to the `omer0` user, but which points to a file in the `/home/demo` directory.

Deleting the imported images in OMERO will delete the **soft link** but not the original file under `/home`. This could come as a surprise to users, since the deletion will effectively free no space.

**Warning:** The deletion of the original files under `/home` (or equivalent) **will lead to a complete loss of the data since no copy is held in OMERO.** Therefore, this method should only be used in conjunction with a properly managed and backed-up data repository. If the files are deleted, there is no way to use OMERO to retrieve them.

#### “ln” - hard-linking

The safest option is hard-linking, though it cannot be used across file systems. For each file, it executes `ln source target`. Attempting to hard link across file system boundaries will lead to an error:

```
...[ main] INFO ome.formats.importer.ImportConfig - OMERO Version: 5.0.0-rc1-DEV-ice35
...[ main] INFO ome.formats.importer.ImportConfig - Bioformats version: 5.0.0-rc1-DEV-ice35
...[ main] INFO formats.importer.cli.CommandLineImporter - Setting transfer to ln
...[ main] INFO ome.formats.importer.ImportCandidates - Depth: 4 Metadata Level: MINIMUM
...[ main] INFO ome.formats.importer.ImportCandidates - 1 file(s) parsed into 1 group(s) with 1 call(s) to setId in 96ms. (98ms total) [0 unknowns]
...[ main] INFO ome.formats.OMEROMetadataStoreClient - Attempting initial SSL connection to localhost:4064
...[ main] INFO ome.formats.OMEROMetadataStoreClient - Insecure connection requested, falling back
...[ main] INFO ome.formats.OMEROMetadataStoreClient - Server: 5.0.0
...[ main] INFO ome.formats.OMEROMetadataStoreClient - Client: 5.0.0-rc1-DEV-ice35
...[ main] INFO ome.formats.OMEROMetadataStoreClient - Java Version: 1.7.0_51
...[ main] INFO ome.formats.OMEROMetadataStoreClient - OS Name: Linux
...[ main] INFO ome.formats.OMEROMetadataStoreClient - OS Arch: amd64
...[ main] INFO ome.formats.OMEROMetadataStoreClient - OS Version: 3.8.0-27-generic
...[ main] INFO ome.formats.importer.cli.LoggingImportMonitor - FILESET UPLOAD PREPARATION
...[ main] INFO ome.formats.importer.ImportConfig - OMERO Version: 5.0.0-rc1-DEV-ice35
...[ main] INFO ome.formats.importer.ImportConfig - Bioformats version: 5.0.0-rc1-DEV-ice35
...[ main] INFO ome.formats.importer.cli.LoggingImportMonitor - FILESET UPLOAD START
```
The safeness of this method comes from the fact that OMERO also has a pointer to the data. Deletion of the original file under /home would leave data in OMERO in place. Again, this could cause a surprise as the space would not be properly freed, but at least there cannot be an accidental loss.

**Warning:** The primary concern with this method is modification of files. If the original data is written by a user, unexpected results could follow in OMERO. See the Safety tips section above for ways around this.

If you are unclear about how hard-linking works, please see the Hard link¹ article on Wikipedia.

### “ln_rm” - moving

Finally, the least favored option is `ln_rm`. It first performs a hard-link like `ln`, but once the import is complete it attempts to delete the original file. This is currently in testing as an option for Dropbox but is unlikely to be of use to general users.

### Your own file transfer

If none of the above options work for you, it is also possible to write your own implementation of the `ome.formats.importer.transfers.FileTransfer` class, likely subclassing `ome.formats.importer.transfers.AbstractFileTransfer` or `ome.formats.importer.transfers.AbstractExecFileTransfer`. If you do so, please let us know how we might improve either the interface or the implementations that we provide.

Once your implementation has been compiled into a jar and placed in the `lib/clients` directory, you can invoke it using:

```bash
$ bin/omero import -- --transfer=example.package.ClassName ...
```

¹http://en.wikipedia.org/wiki/Hard_link
9.2.6 Related advanced options

In addition to the –transfer option in 5.0.0, a number of other advanced options have been added which may be useful for either tweaking import performance or dealing with complicated situations. However, like –transfer, these options should be considered experimental and may change in subsequent releases. Comments and suggestions are very welcome.

Checksums

If you think that calculating the checksums for your large files is consuming too much time, you might want to configure the checksum algorithm used. This can be done with the –checksum_algorithm property. Available options are printed with the –advanced-help option and include Adler-32, CRC-32, MD5-128, Murmur3-32, Murmur3-128, and the default SHA1-160.

DropBox

As described in the scenario “In-place DropBox import (automatic delete)”, DropBox can be configured to use any of the options described above. The configuration property to modify is omero.fs.importArgs:

$ bin/omero config set -- omero.fs.importArgs "--transfer=ln_rm"

This will move files into OMERO rather than leaving a copy in the DropBox directory. For this to work, the two directories will need to be on the same file system. Please read and understand the implications of the ln_rm option.

Warning: Use at your own risk!

9.3 FS configuration options

9.3.1 Background

Users import their image files to the OMERO.fs server. The contents of these files are kept intact by the server and effort is also made to preserve the files’ path and name, so that OMERO.fs can become a trusted repository for the master copy of users’ data. While the default server configuration from etc/omero.properties should typically suffice, omero config set may be used to adjust settings related to file uploads. These settings are explained below.

9.3.2 Template path

When files are uploaded to the repository, a parent directory is created to receive the upload. A multi-file image has all its files stored in the same parent directory, though they may be in different subdirectories of that parent to mirror the original directory structure before upload. The omero.fs.repo.path setting defines the creation of that parent directory.

There is some flexibility in how this parent directory is named. The constraints are:

- The path components must be /-separated, even on Windows systems.
- A path component separator may be written as // with at least one path component listed after it. In this case:
  - The server ensures that the path components preceding the // are owned by the root user.
  - Any newly created path components following the // are owned by the user who owns the images. (This is the case for all newly created path components if no // is used.)
- The path must be unique for each import. It is for this reason that the %time% term expands to a time with millisecond resolution.

---

2https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/omero.properties
9.3.3 Legal file names

Although OMERO.fs attempts to preserve file naming, the server’s operating system or file system is likely to somehow constrain what file names may be stored by OMERO.fs. This is of particular concern when a user may upload from a more permissive system to a server on a less permissive system, or when it is anticipated that the server itself may be migrated to a less permissive system. The server never accepts Unicode control characters in file names.

The omero.fs.repo.path_rules setting defines the combination of restrictions that the server must apply in accepting file uploads. The restrictions are grouped into named sets:

- **Windows required** prohibits names with the characters ",*,/,:<,?,\,|, names beginning with $, the names AUX, CLOCK$, CON, NUL, PRN, COM1 to COM9, LPT1 to LPT9, and anything beginning with one of those names followed by .
- **Windows optional** prohibits names ending with . or a space
- **UNIX required** prohibits names with the character /
- **UNIX optional** prohibits names beginning with . or -

These rules are applied to each separate path component of the file name on the client’s system. So, for instance, an upload of a file /tmp/myfile.tif from a Linux system would satisfy the UNIX required restrictions because neither of the path components tmp and myfile.tif contains a / character.

Applying the “optional” restrictions does not assist OMERO.fs at all; those restrictions are designed to ease manual maintenance of the directory specified by the omero.managed.dir setting, being where the server stores users’ uploaded files.

9.3.4 Checksum algorithm

As the client uploads each file to the server, it calculates a checksum for the file. After the upload is complete the client reports that checksum to the server. The server then calculates the checksum for the corresponding file from its local filesystem and checks that it matches what the client reported. File integrity is thus assured because corruption during transmission or writing would be revealed by a checksum mismatch.

There are various algorithms by which checksums may be calculated. To calculate comparable checksums the client and server use the same algorithm. The server API permits clients to specify the algorithm, but it is expected that they will typically accept the server default set with the omero.checksum.default setting.

The available values, specified in components/model/resources/mappings/acquisition.ome.xml³, are presently:

- Adler-32
- CRC-32
- MD5-128
- Murmur3-32
- Murmur3-128
- SHA1-160

The number that suffixes each of the checksum algorithm names specifies the bit width of the resulting checksum. A larger bit width makes it less likely that different files will have the same checksum by coincidence, but lengthens the checksum hex strings that are reported to the user and stored in the hash column of the original file table in the database.

³https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/model/resources/mappings/acquisition.ome.xml
10.1 OMERO.server backup and restore

10.1.1 Cleaning up your binary repository

The OMERO.server does not remove files from disk until a cleanup task has been run. A script to do this is included in the OMERO.server distribution lib/python/omero/util/cleanse.py which can be used so:

```
$ bin/omero admin cleanse /OMERO
```

This can be performed daily using cron with a script such as:

```sh
#!/bin/bash
USERNAME="root"
PASSWORD="root_password"
BINARY_REPOSITORY="/OMERO"
$OMERO_PREFIX/bin/omero -s localhost -u $USERNAME -w $PASSWORD admin cleanse $BINARY_REPOSITORY
```

10.1.2 Managing OMERO.server log files

Your OMERO.server will produce log files that are rotated when they reach 512MB. These directories will look like:

```
omero_dist $ ls var/log
Blitz-0.log  FileServer.log  MonitorServer.log  Processor-0.log  master.out
DropBox.log  Indexer-0.log  OMEROweb.log  master.err
```

Any files with a .1, .2, .3 etc. suffix may be compressed or deleted.

10.1.3 OMERO.server log file location

The log file directory may also be relocated to different storage by modifying the etc/grid/default.xml file:

```
...<variable name="OMERO_LOGS" value="var/log"/>
...```

10.1.4 Backing up OMERO

Understanding backup sources

OMERO.server has three main backup sources:

1. PostgreSQL database (assumed to be `omero_database`)
2. OMERO.server binary data store (UNIX/Mac information page or Windows information page; assumed to be `/OMERO` or `C:\omero`)
3. OMERO.server configuration

**Note:** The lib/scripts directory should also be backed up, but restoring it may pose issues if any of your users have added their own “official scripts”. A github repository is now available under https://github.com/ome/scripts which provides help for merging your lib/scripts directories.

You should backup (1) and (2) regularly.

**Warning:** Although losing your PostgreSQL database is not as catastrophic for OMERO version 5.0 as it is for 4.4, you still do not want to be in the position of trying to recover your server without a backup of this resource.

You need to back up (3) only before you make changes. You can copy it into `/OMERO/backup` to ensure it is kept safe:

$ `bin/omero config get` > `/OMERO/backup/omero.config`

**Note:** If you have edited `etc/grid/(win)default.xml` directly for any reason then you will also need to copy that file to somewhere safe, such as `/OMERO/backup`.

Backing up your PostgreSQL database

Database backups can be achieved using the PostgreSQL `pg_dump` command. Here is an example backup script that can be placed in `/etc/cron.daily` to perform daily database backups:

```
#!/bin/bash

DATE='date '+%Y-%m-%d_%H:%M:%S-%Z''
OUTPUT_DIRECTORY=/OMERO/backup/database
DATABASE="omero_database"
DATABASE_ADMIN="postgres"

mkdir -p $OUTPUT_DIRECTORY
chown -R $DATABASE_ADMIN $OUTPUT_DIRECTORY
su $DATABASE_ADMIN -c "pg_dump -Fc -f $OUTPUT_DIRECTORY/$DATABASE.$DATE.pg_dump $DATABASE"
```

Other database backup configurations are outside the scope of this document but can be researched on the PostgreSQL website\(^1\) (Chapter 24. Backup and Restore).

**Note:** Regular backups of your PostgreSQL database are crucial; you do not want to be in the position of trying to restore your server without one.

Backing up your binary data store

To simplify backup locations we have, in this document, located all database and configuration backups under `/OMERO`, your **binary data store**. The entire contents of `/OMERO` should be backed up regularly as this will, especially if this document’s

\(^1\)http://www.postgresql.org/docs/9.1/interactive/backup.html
conventions are followed, contain all the relevant data to restore your OMERO.server installation in the unlikely event of a system failure, botched upgrade or user malice.

File system backup is often a very personal and controversial topic amongst systems administrators and as such the OMERO project does not make any explicit recommendations about backup software. In the interest of providing a working example we will use open source rdiff-backup project and like Backing up your PostgreSQL database above, provide a backup script which can be placed in /etc/cron.daily to perform daily /OMERO backups:

```sh
#!/bin/bash
FROM=/OMERO
TO=/mnt/backup_server
rdiff-backup $FROM $TO
```

rdiff-backup can also be used to backup /OMERO to a remote machine:

```sh
#!/bin/bash
FROM=/OMERO
TO=backup_server.example.com::/backup/omero
rdiff-backup $FROM $TO
```

More advanced rdiff-backup configurations are beyond the scope of this document. If you want to know more you are encouraged to read the documentation available on the rdiff-backup website\(^2\).

### 10.1.5 Restoring OMERO

There are three main steps to OMERO.server restoration in the event of a system failure:

1. OMERO.server etc configuration
2. PostgreSQL database (assumed to be omero)
3. OMERO.server binary data store (assumed to be /OMERO)

**Note:** It is important that restoration steps are done in this order unless you are absolutely sure what you are doing.

**Restoring your configuration**

Once you have retrieved an OMERO.server package from the :downloads: downloads <> page that matches the version you originally had installed, all that is required is to restore your backup preferences by running:

```bash
$ bin/omero config load /OMERO/backup/omero.config
```

You should then follow the Reconfiguration steps of install.

**Restoring your PostgreSQL database**

If you have had a PostgreSQL crash and database users are missing from your configuration, you should follow the first two (Create a non-superuser database user and Create a database for OMERO data to reside in) steps of OMERO.server installation. Once you have ensured that the database user and empty database exist, you can restore the pg_dump file as follows:

\(^2\)http://www.nongnu.org/rdiff-backup/docs.html
$ sudo -u postgres pg_restore -Fc -d omero_database omero.2010-06-05_16:27:29-GMT.pg_dump

Restoring your OMERO.server binary data store

All that remains once you have restored your Java preferences and PostgreSQL database is to restore your /OMERO binary data store backup.

See also:
- List of backup software\(^3\) Wikipedia page listing the backup softwares.
- PostgreSQL 9.1 Interactive Manual\(^4\) Chapter 24: Backup and Restore
- rdiff-backup documentation\(^5\) Online documentation of rdiff-backup project

10.2 OMERO.server upgrade

The OME team is committed to providing frequent, project-wide upgrades both with bug fixes and new functionality. We try to make the schedule for these releases as public as possible. You may want to take a look at the roadmap\(^6\) for exactly what will go into a release. We always inform our mailing lists\(^7\) of the development status.

See the full details of OMERO 5.0.2 features in the Announcements\(^8\) forum.

10.2.1 Upgrade check list

- Check Prerequisites
- File limits
- Password salting
- Password usage
- Re-indexing for search
- Troubleshooting
- Upgrade check

Check Prerequisites

Before starting the upgrade, please ensure that you have obtained all the prerequisites for installation, documented for Unix and Windows. In particular, ensure that you are running a suitable version of PostgreSQL to enable successful upgrading of the database.

File limits

You may wish to review the open file limits. Please consult the Import failures when importing many filesets section for further details.

Password salting

With 5.0.0, the default JDBC password provider has been modified to add password salting support. This implies that once a server has been upgraded and deployed, if passwords are modified, you will not be able to easily revert to a configuration without salting. To keep using the legacy password provider without salting support, you will need to configure omero.security.password_provider to use the legacy chainedPasswordProviderNoSalt as described in the Legacy password providers section.

---
\(^3\)https://trac.openmicroscopy.org.uk/ome/roadmap
\(^4\)http://www.openmicroscopy.org/site/community/
\(^5\)http://www.openmicroscopy.org/community/viewforum.php?f=11
**Password usage**

The passwords and logins used here are examples. Please consult the *Which user account and password do I use where?* section for explanation. In particular, make sure to replace the values of `db_user` and `omero_database` with the actual database user and database name for your installation.

**Re-indexing for search**

If you have experienced any issues with search in the past, especially prior to 5.0.1, you could take the opportunity to reindex your full text index. See *Re-indexing* for more information.

**Troubleshooting**

If you encounter errors during an OMERO upgrade, database upgrade, etc. you should retain as much log information as possible and notify the OMERO.server team via the mailing lists available on the community page.

**Upgrade check**

All OMERO products check themselves with the OmeroRegistry for update notifications on startup. If you wish to disable this functionality you should do so now as outlined on the OMERO upgrade checks page.

### 10.2.2 Upgrade steps

For all users, the basic workflow for upgrading your OMERO.server is listed below. Please refer to each section for additional details.

- Perform a database backup
- Copy new binaries
- Upgrade your database
- Merge script changes
- Update your configuration
- Restart your database
- Restore a database backup

**Perform a database backup**

The first thing to do before any upgrade activity is to backup your database.

```
$ pg_dump -h localhost -U db_user -Fc -f before_upgrade.db.dump omero_database
```

**Copy new binaries**

Before copying the new binaries, stop the existing server:

```
$ cd OMERO.server
$ bin/omero web stop
$ bin/omero admin stop
```

Your OMERO configuration is stored using `config.xml` in the `etc/grid` directory under your OMERO.server directory. Assuming you have not made any file changes within your OMERO.server distribution directory, you are safe to follow the following upgrade procedure:

---

9http://www.openmicroscopy.org/site/community/
$ cd ..
$ mv OMERO.server OMERO.server-old
$ unzip OMERO.server-5.0.2-ice3x-byy.zip
$ ln -s OMERO.server-5.0.2-ice3x-byy OMERO.server
$ cp OMERO.server-old/etc/grid/config.xml OMERO.server/etc/grid

Note: ice3x and byy need to be replaced by the appropriate Ice version and build number of OMERO.server.

Upgrade your database

Warning: This section only concerns users upgrading from a 4.4 or earlier server. If upgrading from a 5.0 server, you do not need to upgrade the database.

Run the upgrade script

You must use the same username and password you have defined during OMERO.server installation. The 5.0 upgrade script should execute in a short time.

From a 4.4.x server

$ cd OMERO.server
$ psql -h localhost -U db_user omero_database < sql/psql/OMERO5.0__0/OMERO4.4__0.sql
Password for user db_user:
...
...
status

+                  +                  +
+                  +                  +

YOU HAVE SUCCESSFULLY UPGRADED YOUR DATABASE TO VERSION OMERO 5.0__0+
+                  +                  +

(1 row)

From a 5.0.0-beta1 server

$ cd OMERO.server
$ psql -h localhost -U db_user omero_database < sql/psql/OMERO5.0__0/OMERO5.0DEV__6.sql
Password for user db_user:
...
...
status

+                  +                  +
+                  +                  +

YOU HAVE SUCCESSFULLY UPGRADED YOUR DATABASE TO VERSION OMERO 5.0__0+
+                  +                  +

(1 row)
Optimize an upgraded database (optional)

After you have run the upgrade script, you may want to optimize your database which can both save disk space and speed up access times.

$ psql -h localhost -U db_user omero_database -c 'REINDEX DATABASE ''omero_database'' FORCE;'
$ psql -h localhost -U db_user omero_database -c 'VACUUM FULL VERBOSE ANALYZE;'

Merge script changes

If any new official scripts have been added under lib/scripts or if you have modified any of the existing ones, then you will need to backup your modifications. Doing this, however, is not as simple as copying the directory over since the core developers will have also improved these scripts. In order to facilitate saving your work, we have turned the scripts into a Git submodule which can be found at https://github.com/ome/scripts.

For further information on managing your scripts, refer to Installing new scripts. If you require help, please contact the OME developers.

Update your configuration

Environment variables

If you changed the directory name where the 5.0.2 server code resides, make sure to update any system environment variables. Before restarting the server, make sure your PATH and PYTHONPATH system environment variables are pointing to the new locations.

JVM memory settings

If you modified your memory settings, these changes will be lost and you will need to update the memory settings for the new server. Refer to the JVM memory settings sub-section of the OMERO.server installation section (Unix or Windows) for more information.

Python Imaging Library

Since OMERO 5.0.0, Pillow\(^{10}\) is used as the default imaging library for Python instead of PIL. Refer to the installation page of Pillow\(^{11}\) documentation to install Pillow on your system.

**Warning:** As mentioned in the Pillow installation section, if you installed PIL, you will need to remove it first before installing Pillow.

Changes to OMERO.web URLs

In order to ease deployment and avoid errors for IIS (Windows production deployment) and Apache (notably CentOS/RHEL6) OMERO.web now defaults to being “mounted on /omero”. The new OMERO.web web server stanzas have redirects in them with the notable exception of IIS. Depending on your web server configuration you may need to visit your OMERO.web instance at http://example.com/omero/

As a result of this your web server configuration stanza generated by the previous version of bin/omero web config has to be replaced with the new version. To generate the relevant configuration, please run bin/omero web config <webserver>, update and restart your web server.

\(^{10}\)http://pillow.readthedocs.org
\(^{11}\)http://pillow.readthedocs.org
OMERO Documentation, Release 5.0.2

Changes to OMERO.web config (Windows-only)

Starting with OMERO.web 5.0, the special configuration of "omero.web.cache_backend" is no longer required and may in fact cause issues. Please see the instructions under Using IIS for how to remove the configuration.

Restart your database

- Following a successful database upgrade, you can start the server.

  $ cd OMERO.server
  $ bin/omero admin start

- If anything goes wrong, please send the output of bin/omero admin diagnostics to ome-users@lists.openmicroscopy.org.uk\(^\text{12}\).

- Start OMERO.web with the following command:

  $ bin/omero web start

Restore a database backup

If the upgraded database or the new server version do not work for you, or you otherwise need to rollback to a previous database backup, you may want to restore a database backup. To do so, create a new database,

$ createdb -h localhost -U postgres -O db_user omero_from_backup

restore the previous archive into this new database,

$ pg_restore -Fc -d omero_from_backup before_upgrade.db.dump

and configure your server to use it.

$ bin/omero config set omero.db.name omero_from_backup

See also:

Legacy\(^\text{13}\) Legacy part of the OME website containing upgrade instructions for previous versions of the OMERO server.

10.3 OMERO upgrade checks

On each startup the OMERO server checks for available upgrades via the UpgradeCheck class\(^\text{14}\). An HTTP GET call is made to the URL configured in etc/omero.properties as omero.upgrades.url, currently http://upgrade.openmicroscopy.org.uk by default (note that viewing that link in your browser will redirect you to this page).

Note: If you have been redirected here by clicking on a link to http://upgrade.openmicroscopy.org.uk in an error message or log while trying to run one of the Bio-Formats command line tools, please see the Bio-Formats command line tools documentation\(^\text{15}\) for assistance.

\(^{12}\) ome-users@lists.openmicroscopy.org.uk

\(^{14}\) https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/system/UpgradeCheck.java

\(^{15}\) http://www.openmicroscopy.org/site/support/bio-formats5/users/comlinetools/index.html#version-checker
10.3.1 Actions

Currently the only action taken when an upgrade is necessary is a log statement at WARN level.

```
2011-09-01 12:21:32.070 WARN [ ome.system.UpgradeCheck] ( main) UPGRADE AVAILABLE: Please upgrade to 5.0.2 See http://trac.openmicroscopy.org.uk/omero for the latest version
```

Future versions may also send emails and/or IMs to administrators. In the case of critical upgrades, the server may refuse to start.

10.3.2 Privacy

Currently, the only information which is being transmitted to the server is:

- Java virtual machine version
- Operating system details (architecture, version and name)
- Current server version
- Poll frequency (for determining statistics)
- Your IP address (standard HTTP header information)

\[Note: \] Currently the “poll” property is unused.

If this is a problem for your site, please see Disabling below.

10.3.3 Disabling

If you would prefer to have no checks made, the check can be disabled by setting the omero.upgrades.url property to an empty string:

```
omero.upgrades.url=
```

10.3.4 Developers

To use the UpgradeCheck class from your own code, it is necessary to have common.jar on your classpath. Then,

```
ResourceBundle bundle = ResourceBundle.getBundle("omero");
String version = bundle.getString("omero.version");
String url = bundle.getString("omero.upgrades.url");
ome.system.UpgradeCheck check = new UpgradeCheck(
    url, version, "insight"); // Or "importer", etc.
check.run();
check.isUpgradeNeeded();
// optionally
check.isExceptionThrown();
```

will connect to the server and check your current version against the latest release.

10.3.5 Updating the registry version after a release

```
$ psql -h localhost -U postgres feedback
```

```
feedback=# select * from registry_version;
 id |   version
----+----------
  1 | 5.0.2
```

10.3. OMERO upgrade checks
---+------------
<table>
<thead>
<tr>
<th>1</th>
<th>Beta-4.2.2</th>
</tr>
</thead>
</table>

(1 row)

feedback=# select now();
    now
------------------------
  2011-06-27 16:01:30.749654+01
(1 row)

feedback=# update registry_version set version = 'Beta-4.3.0' where id = 1;
UPDATE 1

See also:

OMERO.server installation  Instructions for installing OMERO.server on UNIX & UNIX-like platforms
OMERO.server installation  Instructions for installing OMERO.server on Windows platforms
OMERO.server upgrade     Instructions for upgrading OMERO.server
Server security and firewalls Description of OMERO security practices

10.4 OMERO Command Line Interface

See also:

OMERO Command Line Interface  User documentation for the Command Line Interface
OMERO Command Line Interface  Developer Documentation for the Command Line Interface

When first beginning to work with the OMERO server, the omero db, omero config, and omero admin commands will be the first you will need.

10.4.1 Database tools

Rather than try to provide the functionality of a RDBM tool like psql, the omero db script command helps to generate SQL scripts for building your database. You can then use those scripts from whatever tool is most comfortable for you:

$ bin/omero db script OMERO4 0 secretpassword
Using OMERO4 for version
Using 0 for patch
Using password from commandline
Saving to /omero/OMERO4__0.sql
$ psql omero < OMERO4__0.sql

10.4.2 Server configuration

The omero config command is responsible for reading/writing user-specific profiles stored under etc/grid/config.xml.
To get the current profile, use the omero config def command:

$ bin/omero config def
default

You can then examine the current profile keys using omero config get and set key-value pairs using omero config set:
$ bin/omero config get

$ bin/omero config set example "my first value"

$ bin/omero config get
example=my first value

You can use the OMERO_CONFIG environment variable to point at a different profile, e.g.:

$ OMERO_CONFIG=another bin/omero config def another

$ OMERO_CONFIG=another bin/omero config get

$ OMERO_CONFIG=another bin/omero config set example "my second value"

$ OMERO_CONFIG=another bin/omero config get
example=my second value

The values set via omero config set override those compiled into the server jars. The default values which are set can be seen in etc/omero.properties. To add several values to a configuration, you can pipe them via standard in using omero config load:

$ grep omero.ldap etc/omero.properties | OMERO_CONFIG=ldap bin/omero config load

$ OMERO_CONFIG=ldap bin/omero config get
omerol.ldap.attributes=objectClass
omerol.ldap.base=ou=example,o=com
omerol.ldap.config=false
omerol.ldap.groups=
omerol.ldap.keyStore=
omerol.ldap.keyStorePassword=
omerol.ldap.new_user_group=default
omerol.ldap.password=
omerol.ldap.protocol=
omerol.ldap.trustStore=
omerol.ldap.trustStorePassword=
omerol.ldap.uris=ldap://localhost:389
omerol.ldap.username=
omerol.ldap.values=person

Each of these values can then be modified to suit your local setup. To remove one of the key-value pairs, pass no second argument:

$ OMERO_CONFIG=ldap bin/omero config set omerol.ldap.trustStore

$ OMERO_CONFIG=ldap bin/omero config set omerol.ldap.trustStorePassword

$ OMERO_CONFIG=ldap bin/omero config set omerol.ldap.keyStore

$ OMERO_CONFIG=ldap bin/omero config set omerol.ldap.keyStorePassword

$ OMERO_CONFIG=ldap bin/omero config get
omerol.ldap.attributes=objectClass
omerol.ldap.base=ou=example,o=com
omerol.ldap.config=false
omerol.ldap.groups=
omerol.ldap.new_user_group=default
omerol.ldap.password=
omerol.ldap.protocol=
omerol.ldap.uris=ldap://localhost:389

10.4. OMERO Command Line Interface
If you will be using a particular profile more frequently you can set it as your default using the `omero config def` command:

```
$ bin/omero config def ldap
```

And finally, if you would like to remove a profile, for example to wipe a given password off of a system, use `omero config drop`:

```
$ bin/omero config drop
```

### 10.4.3 Server administration

#### Server start

Once your database has been properly configured and your config profile is set to use that database, you are ready to start your server using the `omero admin start` command:

```
$ bin/omero admin start
```

#### Server diagnostics

```
$ bin/omero admin diagnostics
```

### 10.4.4 User/group management

The `omero user` and `omero group` commands provide functionalities to add and manage users and groups on your database.

#### User creation

New users can be added to the database using the `omero user add` command:

```
$ bin/omero user add -h
```

During the addition of the new user, you will need to specify the first and last name of the new user and their username as well as the groups the user belongs to. To add John Smith as a member of group 2 identified as jsmith, enter:

```
$ bin/omero user add jsmith John Smith 2
```

Additional parameters such as the email address, institution, middle name etc can be passed as optional arguments to the `omero user add` command.

#### Group creation

New groups can be added to the database using the `omero group add` command:
During the addition of the new group, you need to specify the name of the new group:

$ bin/omero group add newgroup

The permissions of the group are set to private by default. Alternatively you can specify the permissions using --perms or --type optional arguments:

$ bin/omero group add read-only-1 --perms='rwr---'
$ bin/omero group add read-annotate-1 --type=read-annotate

See also:

Permissions overview  Description of the three group permissions levels (private, read-only, read-annotate).

Lists of users/groups on the OMERO server can be queried using the omero user list and omero group list commands:

$ bin/omero user list
$ bin/omero group list

Group management

Users can be added to existing groups using the omero user joingroup or omero group adduser commands. Similarly, users can be removed from existing groups using the omero user leavegroup or omero group removeuser commands:

# Add jsmith to group read-annotate-1
$ bin/omero group adduser jsmith --name=read-annotate-1
# Remove jsmith from group read-annotate-1
$ bin/omero group removeuser jsmith --name=read-annotate-1
# Add jsmith to group read-only-1
$ bin/omero group adduser jsmith --name=read-annotate-1
# Remove jsmith from group read-only-1
$ bin/omero user joingroup read-only-1 --name=jsmith
# Remove jsmith from group read-only-1
$ bin/omero user leavegroup read-only-1 --name=jsmith

By passing the --as-owner option, these commands can also be used to manage group owners

# Add jsmith to the owner list of group read-annotate-1
$ bin/omero group adduser jsmith --name=read-annotate-1 --as-owner
# Remove jsmith from the owner list of group read-annotate-1
$ bin/omero user joingroup read-annotate-1 --name=jsmith --as-owner

Group copy

To create a copy of a group, you must first create a new group using the omero group add command:

$ bin/omero group add read-only-2 --perms='rwr---'

Then you can use the omero group copyusers command to copy all group members from one group to another:
$ bin/omero group copyusers read-only-1 read-only-2

To copy the group owners, use the same command with the \texttt{--as-owner} optional argument:

$ bin/omero group copyusers read-only-1 read-only-2 --as-owner
11.1 Permissions overview

In the 4.4 release of OMERO, the groups and permissions system has been revamped to allow users to share data with more control. Users can now move data between groups that they are a member of.

See also:
OMERO permissions history, querying and usage

11.1.1 Summary

A user may belong to one or more groups, and the data in a group may now at most be shared with users in the same group on the same OMERO server. The degree to which their data is available to other members of the group depends on the permissions settings for that group. Whenever a user logs on to an OMERO server, they are connected under one of their groups. All data they import and any work that is done is assigned to the current group, however now in 4.4 the user can easily copy their data into another group.

11.1.2 Users

**Administrator**  Your OMERO server will have one or more administrators. Each group can be administrated by any of your server administrators. The administrators control all settings for groups.

**Group owner**  Your group may have one or more owners. The group owner has some additional rights within each group than a standard group member, including the ability to add other members to the group.

**Group member**  This is the standard user.

Groups and users must be created by the server administrator. Users can then be added by the administrator or by one of the group owners assigned by the administrator. This would typically be the PI of the lab. The group’s owners or server administrator can also choose the permission level for that group. See the OMERO.insight and OMERO.web admin movies below for more information about groups and how to administrate them in OMERO.

See also:
OMERO.insight Admin update in OMERO 4.4¹  Movie describing the administration tools update under OMERO.insight for OMERO 4.4

OMERO.web Admin update in OMERO 4.4²  Movie describing the administration tools update under OMERO.web for OMERO 4.4

11.1.3 Group permission levels

The various permission levels are:

**Private**  This group is the most restrictive:

- A private *Group owner* can see and control who the group members are and can view their data.
- As a *Group member*, you will only ever be able to see your own data.
• This can be used for general data storage, access and analysis, but has very limited collaboration potential other than for the Group owner to see other group members data.

Potential Use-Cases of Private group:

• This group would be designed so that a PI as Group owner and their student, as a Group member, can access the student’s data. A student might use this as somewhere to store all of their data and from here, the PI and/or student might decide which data could/should be copied into a more collaborative group where additional members would also be able to view the data.
• For an institutional repository type structure where data are being archived, but not necessarily open for general viewing.

Read-only This group is the intermediate option that allows visibility of other users and their data, but minimal ability to annotate their data:

• The Group owner can control group members as above and can perform some annotations on the other group members data.
• Group member can see who other members are and view their data, but he cannot annotate another members’ data at all.

Potential Use-Cases of Read-only group:

• A scientist might move data into a read-only group when they want other group members to access and view their data. Other members can view, while the group owners can annotate and/or add Regions of Interest (ROIs) to the other member’s images.
• For an institutional repository where data are being archived and then available for other users in the institute to view; this could be standard storage of all original data, or for data that is included in publications.

Read-annotate This is the most collaborative group:

• Group member can view other members, their data and can make annotations on those other members’ data.

Potential Use-Cases:

• This could be used by a group of scientists working together with data for a publication.

See also:

OMERO.insight Permissions update in OMERO 4.4^3 Movie describing the permissions update under OMERO.insight in OMERO 4.4
Web Permissions update in OMERO 4.4^4 Movie describing the permissions update under Web in OMERO 4.4

11.1.4 Changing group permissions

It is possible for the Group owner or server Administrator to change the permissions level on a group after it has been created and filled with data, with the following limitations:

• It is not possible to ‘reduce’ permissions to Private. Once links have been created in the database under Read-only or Read-annotate permissions, these cannot be severed. However, it is possible to ‘promote’ a Private group to be a Read-only or Read-annotate group.
• It is possible to toggle permissions of a group between the two collaborative Read-only and Read-annotate groups.

Warning: Please be very careful before downgrading a group’s permission level. If a user has annotated other users’ data and the group is downgraded, any links to annotations that are not permitted by the new permissions level will be lost.

11.1.5 Permissions on your and other users’ data

What can you do with your data?

All OMERO users in all groups can perform all actions to their own data.
The main actions available include, but are not limited to:

• Create projects and/or datasets.
• Import data.
• Delete data.
• Edit names and descriptions of images.
• Change rendering settings on images.
• Annotate images (rate, tag, add attachments and comment).
• De-annotate (remove annotations that you have added).
• Use Regions of Interest (ROIs) (add, import, edit, delete, save and analyze with them).
• Run scripts.
• Move data between groups, if you belong to more than one group.

What can you do with someone else’s data in your group?

Actions available for you on someone else in your group’s data will depend both on the permissions of the group you are working in, and what sort of user you are. See the table below for a quick reference guide to permissions available on other people’s data. Some of these policies may evolve as the permissions functionality matures in response to user feedback. Please let us know any comments or suggestions you have via our mailing lists\(^5\) or through the forums\(^6\).

### 11.1.6 Permissions tables

The following are the permissions valid for users working on data belonging to other group members. These permissions depend on the group permissions and on the type of the user performing the action.

#### Administrator

<table>
<thead>
<tr>
<th>Action</th>
<th>Private</th>
<th>Read-only</th>
<th>Read-annotate</th>
</tr>
</thead>
<tbody>
<tr>
<td>View</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Annotate</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Delete</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Edit</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Move between groups</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Remove annotations</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Mix data</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

#### Group owner

---

\(^5\)http://www.openmicroscopy.org/site/community/mailing-lists

\(^6\)http://www.openmicroscopy.org/community/
<table>
<thead>
<tr>
<th>Action</th>
<th>Private</th>
<th>Read-only</th>
<th>Read-annotate</th>
</tr>
</thead>
<tbody>
<tr>
<td>View</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Annotate</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Delete</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Edit</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Move between groups</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Remove annotations</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Mix data</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

**Group member**

<table>
<thead>
<tr>
<th>Action</th>
<th>Private</th>
<th>Read-only</th>
<th>Read-annotate</th>
</tr>
</thead>
<tbody>
<tr>
<td>View</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Annotate</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Delete</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Edit</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Move between groups</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Remove annotations</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>Mix data</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
</tbody>
</table>

**Key**

**Action**  Action on other users’ data

**Annotate**  Add annotations (rating, tag, attachment, comment ROI) to another users’ data. Also create & save ROIs (save ROIs that you draw on another users’ data).

**Delete**  Delete data such as images or ROIs. ROIs may have been added by others or yourself.

**Edit**  Modify the name or description of other users’ objects such as images.

**Mix data**  Copy, Move or Remove other users’ data to or from your Projects, Datasets or Screens. Copy, Move or Remove your or others’ data to or from others’ Projects, Datasets or Screens.

*Note:* You should always be able to remove annotations (such as tags) that you linked to other users’ data (you own the link). The link can be deleted, but the tag itself will not be deleted.

**Move between groups**  Only the admin has the right to move other users’ data between groups.

*Note:* The admin does not have to be member of the destination group.

**Remove annotations**  Remove annotations made by others on your data.

**Render**  Create your own rendering settings (this will not modify the settings of the owner).

**View**  View other users’ data such as images. View ROIs added by others. Draw ROIs on other users’ data, but they cannot be saved.

### 11.1.7 Issues to be aware of

**ROIs**

- You can never edit (change text or move) other users’ ROI.
- Any ROIs added to other users’ data will not affect ROIs added by the owner.
**Tags and attachments**

- A tag or attachment is ‘owned’ by the person who creates it or uploads it to the server.
- The link between a tag or an attachment is ‘owned’ by the person who annotates an image with that tag or attachment i.e. makes a link between the tag/attachment and the image.
- De-annotation deletes the link between the tag/attachment and image but does not remove/delete the tag or attachment from the system.

**Scripts**

- Although all users can run scripts on other users’ data, the actions within those scripts will be subject to the restrictions of the permissions detailed in the tables above.

### 11.2 OMERO.dropbox

DropBox was originally designed as the first stage of the file system changes referred to as OMERO.fs. It utilizes a file system monitor to find newly uploaded files and run a fully automatic import on those files if possible. This release of OMERO.dropbox runs on the same machine as the OMERO.server and watches designated areas of the local filesystem for new or modified files. If those files are importable, then an automatic import is initiated. OMERO.dropbox is started automatically when the OMERO.server starts and it will run if the prerequisites below are met.

#### 11.2.1 Prerequisites

In addition to the general System Requirements OMERO.dropbox has the following more specific requirements:

- OMERO.dropbox is built on underlying OS file-notification system, and so is only available for specific versions of certain operating systems. OMERO.dropbox will currently function on the following systems:
  - Linux with kernel 2.6.13 and higher.
  - Mac OS 10.6 and later.
- In addition some platforms require further Python packages to be available:
  - Mac OS systems that use a macports install of Python will need to have FSEvents available in the PYTHONPATH. This will require a path of the form /System/Library/Frameworks/Python.framework/Versions/2.X/Extras/lib/python/PyObjC/ to be added, according to the version of Python used.
- The filesystem which OMERO.dropbox watches must be local to the given operating system. Watching a network-attached share (NAS) is strictly *not* supported.

#### 11.2.2 Using DropBox

In its default configuration the monitored area of the file system is a DropBox subdirectory of the OmeroBinaryRepository directory. The system administrator should create DropBox and then under that a directory for each user, using their omero username. The ownership and permissions should be set so that a user can copy files into their DropBox directory:

```
/OMERO/DropBox/amy
 /emily
 /edgar
 /root
 /zak
```
Experimenters can add subdirectories under their named directory for convenience. Copying or moving a file of an importable file type into a named directory or nested subdirectory will initiate an automatic import of that file for that user. Multi-file formats will be imported after the last required file of a set is copied into the directory. Images and plates will be imported into the group the user was last logged into, with images placed into Orphaned images.

Acquisition systems can then be configured to drop a user’s images into a given DropBox.

**Note:** The DropBox system is designed for images filesets to be copied in at normal acquisition rates. Copying numbers of files en masse may result in files failing to import.

### 11.2.3 Log files

The log files `var/log/FileServer.log`, `var/log/MonitorServer.log` and `var/log/DropBox.log` will indicate success or otherwise of start-up of the two components. Once running, `var/log/MonitorServer.log` will log file events seen within designated file areas and `var/log/DropBox.log` will log the progress of any file imports.

### 11.2.4 Advanced use

OMERO.dropbox can be configured in several ways through `etc/grid/templates.xml`. In its default configuration, as detailed above, it monitors the subdirectory `DropBox` of the OMERO data directory for all users.

A number of the properties in `templates.xml` accept a semi-colon separated list of values. This extended configuration allows a site to watch multiple directories, and configure each for a different user, a different type of file, etc. Any value missing from the configuration (e.g. `value="1;;2"`) will be replaced by the default value.

One example alternative configuration would be to watch specific directories for specific users. In the example below two directories are monitored, one for user `amy` and one for `zak`:

```xml
<property name="omero.fs.importUsers" value="amy;zak"/>
<property name="omero.fs.watchDir" value="/home/amy/myData;/home/zak/work/data"/>
```

The remaining properties have been left at their default values for both users.

To limit DropBox to import only files belonging to specific image types the following property can be set,

```xml
<property name="omero.fs.readers" value="/home/amy/my_readers.txt;"/>
```

Here only the image types listed in `my_readers.txt` will be imported for the user `amy` while the system-wide `readers.txt` will be used for `zak`.

For a full description of the properties see below.

**Properties**

Each property takes the form of a single item or a semi-colon separated list of items. Where the item is a list, values within that list should be comma separated.

- **importUsers**
  
  The importUsers is either default for the standard DropBox configuration or a list of OMERO user names. The default is default.

```xml
<property name="omero.fs.importUsers" value="default"/>
```

- **watchDir**
  
  The absolute directory path of interest for each user. The default is empty.
• **eventTypes**

For automatic import Creation and Modification events are monitored. It is also possible to monitor Deletion events though these are not used by DropBox. The default is Creation, Modification.

```
<property name="omero.fs.eventTypes" value="Creation,Modification"/>
```

• **pathMode**

By default existing and newly created subdirectories are monitored. It is possible to restrict monitoring to a single directory ("Flat"), only existing subdirectories ("Recurse"), or all subdirectories ("Follow"). For DropBox to function correctly the mode should be Follow. The default is Follow.

```
<property name="omero.fs.pathMode" value="Follow"/>
```

• **whitelist**

A list of file extensions of interest. An empty list implies all file extensions are monitored. The default is an empty list.

```
<property name="omero.fs.whitelist" value=""/>
```

• **blacklist**

A list of subdirectories to ignore. Not currently supported.

```
<property name="omero.fs.blacklist" value=""/>
```

• **timeout**

This timeout in seconds is used by one-shot monitors. This property is not used by DropBox.

```
property name="omero.fs.timeout" value="0.0"/>
```

• **blockSize**

The number of events that should be propagated to DropBox in one go. Zero implies all events possible. The default is zero.

```
<property name="omero.fs.blockSize" value="0"/>
```

• **ignoreSysFiles**

If this is True events concerning system files, such as filenames beginning with a dot or default new folder names, are ignored. The exact events ignored will be OS-dependent. The default is True.

```
<property name="omero.fs.ignoreSysFiles" value="True"/>
```

• **ignoreDirEvents**

If this is True then the creation and modification of subdirectories is not reported to DropBox. The default is True.

```
<property name="omero.fs.ignoreDirEvents" value="True"/>
```
• **dirImportWait**
  The time in seconds that DropBox should wait after being notified of a file before starting an import on that file. This allows for companion files or filesets to be copied. If a new file is added to a fileset during this wait period DropBox begins waiting again. The default is 60 seconds.
  
  ```xml
  <property name="omero.fs.dirImportWait" value="60"/>
  ```

• **fileBatch**
  The number of files that can be copied in before processing the batch. In cases where there are large numbers of files in a typical file set it may be more efficient to set this value higher. The default is 10.
  
  ```xml
  <property name="omero.fs.fileBatch" value="10"/>
  ```

• **throttleImport**
  The time in seconds that DropBox should wait after initiating an import before initiating a second import. If imports are started too close together connection issues can arise. The default is 10 seconds.
  
  ```xml
  <property name="omero.fs.throttleImport" value="10"/>
  ```

• **readers**
  A file of readers. If this is a valid file then it is used to filter those events that are of interest. Only files corresponding to a reader in the file will be imported. The default is empty.
  
  ```xml
  <property name="omero.fs.readers" value=""/>
  ```

• **importArgs**
  A string of extra arguments supplied to the importer. This could include, for example, an email address to report failed imports to: `--report --email test@example.com`. The default is empty. For details on available extra arguments see *The Command Line Import*.
  
  ```xml
  <property name="omero.fs.importArgs" value=""/>
  ```

**Example**

Here’s a full example of a configuration for two users:

```xml
<property name="omero.fs.importUsers" value="amy;zak"/>
<property name="omero.fs.watchDir" value="/home/amy/myData;/home/zak/work/data"/>
<property name="omero.fs.eventTypes" value="Creation,Modification;Creation,Modification"/>
<property name="omero.fs.pathMode" value="Follow;Follow"/>
<property name="omero.fs.whitelist" value=";"/>
<property name="omero.fs.blacklist" value=";"/>
<property name="omero.fs.timeout" value="0.0;0.0"/>
<property name="omero.fs.blockSize" value="0;0"/>
<property name="omero.fs.ignoreSysFiles" value="True;True"/>
<property name="omero.fs.ignoreDirEvents" value="True;True"/>
<property name="omero.fs.dirImportWait" value="60;60"/>
<property name="omero.fs.fileBatch" value="10;10"/>
<property name="omero.fs.throttleImport" value="10;10"/>
<property name="omero.fs.readers" value="/home/amy/my_readers.txt;"/>
<property name="omero.fs.importArgs" value="--report;--report --email zak@example.com"/>
```
11.3 OMERO.grid

To unify the various components of OMERO, OMERO.grid was developed to monitor and control processes over numerous remote systems. Based on ZeroC’s IceGrid framework, OMERO.grid provides management access, distributed background processing, log handling and several other features.

11.3.1 Terminology

Please notice that ZeroC uses a specific naming scheme for IceGrid elements and actors. A server in the context of this document is not a host computer - it is a process running inside an IceGrid node, servicing incoming requests. A host is a computer on which IceGrid elements get deployed. For more details, see Terminology.

11.3.2 Getting started

Requirements

The normal OMERO installation actually makes use of OMERO.grid internally. If you have followed the instructions under OMERO.server installation (Unix) or OMERO.server installation (Windows), then you will have everything you need to start working with OMERO.grid.

The standard install should also be used to install other hosts in the grid, such as a computation-only host. Some elements can be omitted for a computation-only host such as PostgreSQL, Apache/nginx, etc.

Running OMERO.web and/or starting up the full OMERO.server instance is not required in such a case (only the basic requirements to run omero node are needed, i.e. ZeroC Ice and Python modules for OMERO scripts).

IceGrid Tools

If you would like to explore your IceGrid configuration, use

```
bin/omero admin ice
```

It provides full access to the icegridadmin console described in the ZeroC manual. Specific commands can also be executed:

```
bin/omero admin ice help
bin/omero admin ice application list
bin/omero admin ice application describe OMERO
bin/omero admin ice server list
```

Further, by running java -jar ice-griddgui.jar the GUI provided by ZeroC can be used to administer OMERO.grid. This JAR is provided in the OMERO source code under lib/repository.

See also:

- icegridadmin Command Line Tool
- IceGrid Admin Graphical Tool

OMERO.grid on Windows

Unlike all other supported platforms, the bin\omero script and OMERO.grid are not directly responsible for starting and stopping the OMERO.blitz server and other processes. Instead, that job is delegated to the native Windows service system. A brief explanation is available under OMERO.server Windows Service.

---

11. http://www.zeroc.com
11.3.3 How it works

IceGrid\(^\text{13}\) is a location and activation service, which functions as a central registry to manage all your OMERO server processes. OMERO.grid provides server components which use the registry to communicate with one another. Other than a minimal amount of configuration and starting a single daemon on each host machine, OMERO.grid manages the complexity of all your computing resources.

**Deployment descriptors**

All the resources for a single OMERO site are described by one application descriptor. OMERO ships with several example descriptors under etc/grid\(^\text{14}\). These descriptors describe what processes will be started on what nodes, identified by simple names. For example the default descriptor\(^\text{15}\), used if no other file is specified, defines the master node. As you will see, these files are critical both for the correct functioning of your server as well as its security.

The deployment descriptors provided define which server instances are started on which nodes. The default descriptor configures the master node to start the OMERO.blitz server, the Glacier2 router for firewalling, as well as a single processor - Processor0. The master node is also configured via master.cfg\(^\text{16}\) to host the registry, though this process can be started elsewhere.

**Deployment commands**

The master node must be started first to provide the registry. This is done via the omero admin start command which uses the default descriptor:

```
bin/omero admin start
```

The deploy command looks for any changes to the defined descriptor and restarts only those servers which have modifications:

```
bin/omero admin deploy
```

Both omero admin start and omero admin deploy can optionally take a path to an application descriptor which must be passed on every invocation:

```
bin/omero admin deploy etc/grid/my-site.xml
```

Two other nodes, then, each provide a single processor, Processor1 and Processor2. These are started via:

To start a node identified by NAME, the following command can be used

```
bin/omero node start NAME
```

At this point the node will try and connect to the registry to announce its presence. If a node with the same name is already started, then registration will fail, which is important to prevent unauthorized users.

The configuration of your grid, however, is very much up to you. Based on the example descriptor files (*.xml) and configuration files (*.cfg), it is possible to develop OMERO.grid installations completely tailored to your computing resources.

The whole grid can be shutdown by stopping the master node via: omero admin stop. Each individual node can also be shutdown via: omero node NAME stop on that particular node.

11.3.4 Deployment examples

Two examples will be presented showing the flexibility of OMERO.grid deployment and identifying files whose modification is critical for the deployment to work.

\(^{13}\) http://doc.zeroc.com/display/Ice/IceGrid

\(^{14}\) https://github.com/openmicroscopy/openmicroscopy/tree/develop/etc/grid

\(^{15}\) https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/grid/default.xml

\(^{16}\) https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/master.cfg
Nodes on a single host

The first example will focus on changing the deployed nodes/servers on a single host. It should serve as an introduction to the concepts. Unless used for very specific requirements, this type of deployment doesn’t yield any performance gains.

The first change that you will want to make to your application descriptor is to add additional processors. Take a look at etc/grid/default.xml. There you can define two new nodes - node1 and node2 by simply adding a new XML element below the master node definition:

```xml
<node name="node1">
    <server-instance template="ProcessorTemplate" index="1"/>
</node>

<node name="node2">
    <server-instance template="ProcessorTemplate" index="2"/>
</node>
```

Remember to change the node name and the index number for each subsequent node definition. The node name and the index number do not need to match. In fact, the index number can be completely ignored, except for the fact that it must be unique. The node name, however, is important for properly starting your new processor.

You will need both a configuration file under etc/ with the same name, and unless the node name matches the name of your localhost, you will need to specify it on the command line:

`bin/omero node node1 start`

or with the environment variable OMERO_NODE:

`OMERO_NODE=node1 bin/omero node start`

After starting up both nodes, you can verify that you now have three processors running by looking at the output of omero admin diagnostics.

For more information on using scripts, see the OMERO.scripts advanced topics.

Nodes on multiple hosts

**Warning:** Before attempting this type of deployment, make sure that the hosts can ping each other and that required ports are open and not firewall.

A more complex deployment example is running multiple nodes on networked hosts. Initially, the host’s loopback IP address (127.0.0.1) is used in the grid configuration files.

For this example, let’s presume we have control over two hosts: omero-master (IP address 192.168.0.1/24) and omero-slave (IP address 192.168.0.2/24). The goal is to move the processor server onto another host (omer0-slave) to reduce the load on the host running the master node (omer0-master). The configuration changes required to achieve this are outlined below.

On host omero-master:

- etc/grid/default.xml - remove or comment out from the master node the server-instance using the ProcessorTemplate. Below the master node add an XML element defining a new node:

```xml
<node name="omer0-slave">
    <server-instance template="ProcessorTemplate" index="0" dir="/"
</node>
```

- etc/internal.cfg - change the value of Ice.Default.Locator from 127.0.0.1 to 192.168.0.1

---

17 https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/grid/default.xml
OMERO Documentation, Release 5.0.2

- etc/master.cfg - change all occurrences of 127.0.0.1 to 192.168.0.1

On host omero-slave:

- copy or rename etc/node1.cfg to etc/omero-slave.cfg and change all node1 strings to omero-slave in etc/omero-slave.cfg. Also update the IceGrid.Node.Endpoints value to tcp -h 192.168.0.2
- etc/external.cfg - change the value of Ice.Default.Locator from 127.0.0.1 to 192.168.0.1
- etc/ice.config - add the line Ice.Default.Router=OMERO.Glacier2/router:tcp -p 4063 -h 192.168.0.1

To apply the changes, start the OMERO instance on the omero-master node by using omero admin start. After that, start the omero-slave node by using omero node omero-slave start. Issuing omero admin diagnostics on the master node should show a running processor instance and the omero-slave node should accept job requests from the master node.

11.3.5 Securing grid resources

More than just making sure no malicious code enters your grid, it is critical to prevent unauthorized access via the application descriptors (*.xml) and configuration (*.cfg) as mentioned above.

Firewall

The simplest and most effective way of preventing unauthorized access is to have all OMERO.grid resources behind a firewall. Only the Glacier2 router has a port visible to machines outside the firewall. If this is possible in your configuration, then you can leave the internal endpoints unsecured.

SSL

Though it is probably unnecessary to use transport encryption within a firewall, encryption from clients to the Glacier2 router will often be necessary. For more information on SSL, see SSL.

Permissions Verifier

The IceSSL plugin can be used both for encrypting the channel as well as authenticating users. SSL-based authentication, however, can be difficult to configure especially for within the firewall, and so instead you may want to configure a “permissions verifier” to prevent non-trusted users from accessing a system within your firewall. From etc/master.cfg:18

IceGrid.Registry.AdminPermissionsVerifier=IceGrid/NullPermissionsVerifier
#IceGrid.Registry.AdminCryptPasswords=etc/passwd

Here we have defined a “null” permissions verifier which allows anyone to connect to the registry’s administrative endpoints. One simple way of securing these endpoints is to use the AdminCryptPasswords property, which expects a passwd-formatted file at the given relative or absolute path:

mrmypasswordisomero TN7CjkTVoDnb2
msmypasswordisome jky23t9jXPRRU

where these values come from using openssl:

$ openssl
OpenSSL> passwd
Password:
Verifying - Password:

18https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/master.cfg
Another possibility is to use the OMERO.blitz permissions verifier, so that anyone with a proper OMERO account can access the server.

See Controlling Access to IceGrid Sessions\(^\text{19}\) of the Ice manual for more information.

**Unique node names**

Only a limited number of node names are configured in an application descriptor. For an unauthorized user to fill a slot, they must know the name (which is discoverable with the right code) and be the first to contact the grid saying “I am Node029”, for example. A system administrator need only then be certain that all the node slots are taken up by trusted machines and users.

It is also possible to allow “dynamic registration” in which servers are added to the registry after the fact. In some situations this may be quite useful, but is disabled by default. Before enabling it, be sure to have secured your endpoints via one of the methods outlined above.

**Absolute paths**

Except under Windows, the example application descriptors shipped with OMERO, all use relative paths to make installation easier. Once you are comfortable with configuring OMERO.grid, it would most likely be safer to configure absolute paths. For example, specifying that nodes execute under `/usr/lib/omero` requires that whoever starts the node have access to that directory. Therefore, as long as you control the boxes which can access your endpoints (see Firewall\(^\text{18}\)), then you can be relatively certain that no tampering can occur with the installed binaries.

**11.3.6 Technical information and other tips**

**Processes**

It is important to understand just what processes will be running on your servers. When you run `omero admin start`, `icegridnode` is executed which starts a controlling daemon and deploys the proper descriptor. This configuration is persisted under `var/master` and `var/registry`.

Once the application is loaded, the `icegridnode` daemon process starts up all the servers which are configured in the descriptor. If one of the processes fails, it will be restarted. If restart fails, eventually the server will be “disabled”. On shutdown, the `icegridnode` process also shuts down all the server processes.

**Targets**

In application descriptors, it is possible to surround sections of the description with `<target/>` elements. For example, in `templates.xml\(^\text{20}\)` the section which defines the main OMERO.blitz server includes:

```xml
<server id="Blitz-${index}" exe="${JAVA}" activation="always" pwd="${OMERO_HOME}">
  <target name="debug">
    <option>-Xdebug</option>
    <option>-Xrunjdwp:server=y,transport=dt_socket,address=8787,suspend=y</option>
  </target>
  ...
</server>
```

When the application is deployed, if “debug” is added as a target, then the `-Xdebug`, etc. options will be passed to the Java runtime. This will allow remote connection to your server over the configured port.

Multiple targets can be enabled at the same time:

\(^\text{19}\)http://doc.zeroc.com/display/Ice/Resource+Allocation+using+IceGrid+Sessions#ResourceAllocationusingIceGridSessions-ControllingAccessstoIceGridSessions

\(^\text{20}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/grid/templates.xml
bin/omero admin deploy etc/grid/default.xml debug secure someothertarget

Ice.MessageSizeMax

Ice imposes an upper limit on all method invocations. This limit, Ice.MessageSizeMax, is configured in your application descriptor (e.g. templates.xml\(^{21}\)) and configuration files (e.g. ice.config\(^{22}\)). The setting must be applied to all servers which will be handling the invocation. For example, a call to InteractiveProcessor.execute(omero::RMap inputs) which passes the inputs all the way down to processor.py will need to have a sufficiently large Ice.MessageSizeMax for: the client, the Glacier2 router, the OMERO.blitz server, and the Processor.

The default is currently set to 65536 kilobytes which is 64MB.

Logging

Currently all output from OMERO.grid is stored in $OMERO_PREFIX/var/log/master.out with error messages going to $OMERO_PREFIX/var/log/master.err. Individual services may also create their own log files.

Shortcuts

If the bin/omero script is copied or symlinked to another name, then the script will separate the name on hyphens and execute bin/omero with the second and later parts prepended to the argument list.

For example,

ln -s bin/omero bin/omero-admin
bin/omero-admin start

works identically to:

bin/omero admin start

Symbolic linking

Shortcuts allow the bin/omero script to function as an init.d script when named omero-admin, and need only be copied to /etc/init.d/ to function properly. It will resolve its installation directory, and execute from there unless OMERO_HOME is set.

For example,

ln -s $OMERO_PREFIX/bin/omero /usr/local/bin/omero
omero-admin start

The same works for putting bin/omero on your path:

PATH=$OMERO_PREFIX/bin:$PATH

This means that OMERO.grid can be unpacked anywhere, and as long as the user invoking the commands has the proper permissions on the $OMERO_PREFIX directory, it will function normally.

\(^{21}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/grid/templates.xml

\(^{22}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/ice.config
Running as root

One exception to this rule is that starting OMERO.grid as root may actually delegate to another user, if the “user” attribute is set on the `<server/>` elements in `etc/grid/templates.xml` (this holds only for Unix-based platforms including Apple OS X. See OMERO.grid on Windows for information on changing the server user under Windows).

See also:

OMERO sessions

11.4 Setting the OMERO_HOME environment variable

**Warning:** OMERO_HOME should be considered strictly internal to OMERO and be reserved for development or “power usage”.

11.4.1 Rationale

OMERO_HOME defines the root deployment directory to be used by OMERO command line tools. Setting it allows to switch between different versions of applications or libraries during development.

**Note:** Despite a familiar-sounding name, OMERO_HOME does not denote the server installation directory.

11.4.2 Caveats

As a “power switch”, OMERO_HOME will override the directory layout as detected by the bin/omero family of utilities. This could cause hard-to-detect problems at runtime. Environments hosting multiple OMERO versions would be particularly prone to such side effects, as illustrated below.

```bash
# Installation directory layout:
# /opt
#   +-- OMERO.server-version-4.4.10
#   +-- OMERO.server-version-5.0.0

# OMERO-4 was first installed, and is conveniently referenced through OMERO_HOME
$ echo $OMERO_HOME
> /opt/OMERO.server-version-4.4.10

# Update the configuration for OMERO-4
$ /opt/OMERO.server-version-4.4.10/bin/omero config set omero.db.name 'omero_4_database'
$ /opt/OMERO.server-version-4.4.10/bin/omero config get omero.db.name
> omero_4_database

# Update the configuration for OMERO-5
$ /opt/OMERO.server-version-5.0.0/bin/omero config set omero.db.name 'omero_5_database'
$ /opt/OMERO.server-version-5.0.0/bin/omero config get omero.db.name
> omero_5_database

# Double check the OMERO-4 configuration...
# Using OMERO_HOME has taken precedence over the current directory
# The OMERO-4 server instance has been mistakenly updated to point at
# a version 5 database schema.
# Furthermore, the issue might go unnoticed until the next OMERO-4 restart.
$ /opt/OMERO.server-version-4.4.10/bin/omero config get omero.db.name
> omero_5_database
```

---

[23]https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/grid/templates.xml

11.4. Setting the OMERO_HOME environment variable 158
11.4.3 Recommendations

- If you are using an environment variable to define the server installation root, choose a different name, as represented by `OMERO_PREFIX` in this documentation.
- If you are nevertheless using `OMERO_HOME` in your local environment, it is worth checking for potentially lingering global definitions (e.g. `.bashrc`, `.profile`, `/etc/profile.d`).

See also:

`OMERO.server installation`

11.5 OMERO.insight webstart security and code-signing

Java 1.7 and later includes strict security settings which prevent Java web applications from running unless they are signed with a code-signing certificate. This includes the OMERO.insight webstart client included with OMERO.server.

All current OMERO.server releases are code-signed by the University of Dundee. If you build and distribute your own copies of OMERO and want to use OMERO.insight webstart you can either change the Java security settings for all users, or buy a code-signing certificate and use this to sign the client.

11.5.1 Java configuration settings

Add a security exception in the Java Control Panel (on Windows this can be accessed through the Control Panel, on Mac OS X through System Preferences).

11.5.2 Code-signing your own server

First buy a code-signing certificate from a certificate authority. Note that several types are available, ensure you buy one suitable for signing Java code. If necessary convert it to PKCS #12 format and create a JKS certificate store.

The server can be signed using the `omero_insight_sign.py` script, for example:

```
omero_insight_sign.py <keystore.jks> <alias> OMERO.server-XXX.zip \\
    -kp <keystore-password> -cp <certificate-password> \\
    -ts <timestamping-yes-no> -oz <OMERO.server-XXX-signed.zip>
```

See the script for more information.

---

24https://github.com/openmicroscopy/openmicroscopy/blob/develop/docs/hudson/omero_insight_sign.py
OMERO Documentation, Release 5.0.2

11.5. OMERO.insight webstart security and code-signing

Java Control Panel

- Enable Java content in the browser

Security Level

- Very High

- High (minimum recommended)

- Medium

Java applications identified by a certificate from a trusted authority will be allowed to run.

Exception Site List

Applications launched from the sites listed below will be allowed to run after the appropriate security prompts.

Click Edit Site List... to add items to this list.

Edit Site List...

Restore Security Prompts

Manage Certificates...

OK

Cancel

Apply
Part III

Developer Documentation
The following documentation is for developers wishing to write OMERO client code or extend the OMERO server. Instructions on downloading\(^{25}\), installation and administering OMERO can be found under the *System Administrator Documentation* of the main site.

OMERO is an open source client/server system written in Java for visualizing, managing, and annotating microscope images and metadata. The *OMERO Application Programming Interface* allows clients to be written in *Java*, *Python*, C++ or *MATLAB*. OMERO releases include a Java client OMERO.insight, a Python-based web client OMERO.web and the *OMERO Command Line Interface*, which also uses Python. There is also an ImageJ plugin. OMERO can be extended by modifying these clients or by writing your own in any of the supported languages (see figure). OMERO also supports a *Scripting Service* which allows Python scripts to be run on the server and called from any of the other clients.

OMERO is designed, developed and released by the Open Microscopy Environment\(^{26}\), with contributions from Glencoe Software, Inc.\(^{27}\) OMERO is released under the GNU General Public License (GPL)\(^{28}\) with commercial licenses and customization available from Glencoe Software, Inc.\(^{29}\).

For help with any aspect of OMERO, see details of our *forums and mailing lists*\(^{30}\).

\(^{25}\)http://downloads.openmicroscopy.org/latest/omero5/
\(^{26}\)http://www.openmicroscopy.org/site
\(^{27}\)http://www.glencoesoftware.com/
\(^{28}\)http://www.gnu.org/copyleft/gpl.html
\(^{29}\)http://www.glencoesoftware.com/
\(^{30}\)http://www.openmicroscopy.org/site/community/
12.1 What’s new for OMERO 5

OMERO 5.0 introduces the OMERO.fs (file system) changes needed to stop data duplication on import. Files are now imported and stored in their original format, preserving file names and directory structures, and reducing storage requirements. These changes, coupled with updates to Bio-Formats\(^1\) and the clients, improve the way OMERO handles complex multidimensional datasets.

- *Omero logging* and *Properties* have been updated to explain the new logging configuration in OMERO.fs.
- *Deleting in OMERO* has been updated to explain how OMERO 5 handles deleting multi-file images and image sets and to clarify the finality of deletion.
- *OMERO.fs* has been updated to give an overview of the OMERO.fs project, and further details of the *FS Managed Repository* are being added.
- *OMERO.web* has been upgraded to Django 1.6, requiring Python 2.6.5 or later. This enables more flexibility for developing new web apps and plugins. All the *OMERO.web documentation* has been updated to reflect these changes.
- *Introduction to OMERO.scripts* and *MATLAB and Python* have been updated to reflect that MATLAB and Jython scripts are now supported natively.
- Guidance for getting more involved with OME, and contributing to both OMERO and Bio-Formats, has been moved to our new *Contributing Developer Documentation*\(^2\) section so it is easier to find. It has also been updated to better explain our development processes.
- *OMERO Python language bindings* describes additions to the BlitzGateway API to support Filesets.

12.2 Installing OMERO from source

12.2.1 Code locations

The main repository for OMERO, known as ome.git, is available from:

- https://github.com/openmicroscopy/openmicroscopy
- git://openmicroscopy.org/ome.git

12.2.2 Installing git

In general, see the Git downloads page\(^3\) for installation options.

\(^1\)http://www.openmicroscopy.org/site/support/bio-formats5/
\(^2\)http://www.openmicroscopy.org/site/support/contributing/
\(^3\)http://git-scm.com/download
**Linux**

Most flavors of Linux have git available through the package manager. For example, on Debian or Ubuntu:

```bash
sudo apt-get install git
```

**Mac OS X**

You can install git using [Homebrew](https://github.com/mxcl/homebrew):

```bash
brew install git
```

Or you can use the [binary installer](http://git-scm.com/download).

**Windows**

We recommend using either [msysGit](http://code.google.com/p/msysgit) for a basic git installation, or [Cygwin](http://www.cygwin.com/) for a full-featured Unix-style environment that includes git. You can also use [TortoiseGit](http://code.google.com/p/tortoisegit/) for git shell integration. You may also want to consider installing [VirtualBox](https://www.virtualbox.org/) with a Linux guest OS to make your life easier. Lastly, when using git on Windows, please be aware of the CRLF conversion issue.

### 12.2.3 Git configuration

If you are looking to get started as quickly as possible, the minimum you will need is to have Git installed and then:

```bash
git config --global user.name "Full name"
git config --global user.email YOUR_EMAIL
git clone --recursive https://github.com/openmicroscopy/openmicroscopy
cd openmicroscopy
```

You will not be able to push back to this repository, but you will at least have something you can start looking at.

Git provides a number of options which can make working with it considerably more pleasant. These configuration options are available either globally in `$HOME/.gitconfig` or in the `.git` directory of your repository. The file is in INI-format, but can also be modified using the `git config` command, as illustrated in the examples following.

The most important thing is to update your ‘global’ credentials that are used in your commits. These values are saved in `~/.gitconfig`:

```bash
git config --global user.name "Full name"
git config --global user.email YOUR_EMAIL
```

If you have a PGP key for signing commits and tags, you may want to add it as well:

```bash
git config --global user.signingkey YOUR_PGP_KEY_ID
```

Color and display options make log and diff output much more friendly:

```bash
4https://github.com/mxcl/homebrew/
5http://git-scm.com/download
6http://code.google.com/p/msysgit
7http://www.cygwin.com/
8http://code.google.com/p/tortoisegit/
9https://www.virtualbox.org/
```
git config --global color.ui true
git config --global color.diff auto
git config --global color.graph auto
git config --global color.status auto
git config --global color.branch auto

git config --global core.ui always
git config --global core.editor mate_wait

Aliases provide a way to make shortcuts for longer git commands. One that is often used among the OME team is `graph`:

```
git config --global alias.graph "log --date-order --graph --decorate --oneline"
```

See [Helpful command aliases](http://gitready.com/intermediate/2009/02/06/helpful-command-aliases.html) for more examples.

### 12.2.4 Cloning the source code

Most OME development is currently happening on GitHub, therefore it is highly suggested that you become familiar with how it works, if not create an account for yourself.

Start by cloning the official repository:

```
git clone https://github.com/openmicroscopy/openmicroscopy.git
```

Since the openmicroscopy repository now makes use of submodules, you first need to initialize all the submodules:

```
cd openmicroscopy
git submodule update --init
```

Alternatively, with version 1.6.5 of git and later, you can pass the `--recursive` option to git clone and initialize all submodules:

```
git clone --recursive https://github.com/openmicroscopy/openmicroscopy.git
```

The natural workflow when using GitHub is not just to download someone else’s repository, but also to create a personal working copy. Go to the repository page at [https://github.com/openmicroscopy/openmicroscopy](https://github.com/openmicroscopy/openmicroscopy) and click on “Fork”. This will create a copy of the repository in your own personal space:

[https://github.com/YOURNAME/openmicroscopy](https://github.com/YOURNAME/openmicroscopy)

which can be added to your local repository as another remote:

```
git remote add gh git@github.com:YOURNAME/openmicroscopy.git
```

**Note:** For the SSH transport to work, you will need to follow some of the instructions under [https://github.com/account/ssh](https://github.com/account/ssh)

Depending on which repository you cloned first, either origin/develop or gh/develop will be the “develop” branch of your own fork of openmicroscopy/openmicroscopy. The example below assumes that “gh” is your own personal GitHub repository, and “origin” is the official openmicroscopy repository.

You may even want to remove the “develop” branch from your fork since all branching should happen from the official develop branch. If you’d prefer to keep a copy of “develop” in “gh”, that is fine, but you may then need to keep your develop up-to-date with the official develop.

12.2.5 Installing OMERO

To install the dependencies required to run the OMERO.server on Linux or Mac OS X, take a look at the OMERO.server installation or the OMERO.server Mac OS X installation walk-through with Homebrew sections.

Build System

Overview

The page goes into details about how the build system is configured.

Creating binary distribution

The default ant target ("build-default") will build the OMERO system and copy the necessary components for a binary distribution to the /dist directory. Below is a comparison of what is taken from the build, where it is put, and what role it plays in the distribution.

Note: By default, OMERO C++ language bindings is not built. Use build-all for that.

<table>
<thead>
<tr>
<th>OMERO_SOURCE_PREFIX</th>
<th>OMERO_SOURCE_PREFIX/dist</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>components/blitz/target/blitz.jar</td>
<td>lib/server</td>
<td>Primary Ice servants</td>
</tr>
<tr>
<td>components/blitz/target/server.jar components/tools/OmeroCpp/lib* components/tools/OmeroPy/build/lib lib/repository/&lt;some&gt; etc/ sql/*_sql &lt;javadoc/&gt;</td>
<td>lib/server</td>
<td>Primary server logic</td>
</tr>
<tr>
<td></td>
<td>lib/</td>
<td>Native shared libraries</td>
</tr>
<tr>
<td></td>
<td>lib/python</td>
<td>Python libraries</td>
</tr>
<tr>
<td></td>
<td>lib/client &amp; lib/server etc/ sql/</td>
<td>Libraries needed for the build Configuration</td>
</tr>
<tr>
<td></td>
<td>docs/api</td>
<td>SQL scripts to prepare the database</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Optional) Javadocs produced with “java omero javadoc”</td>
</tr>
</tbody>
</table>

These files are then zipped to OMERO.server-<version>.zip via “java omero release-zip”

Code-signing  The OMERO source tree includes a self-signed certificate for testing OMERO.insight webstart. This is not used by default to avoid problems with double signing official releases. The “release-webstart-signed” target can be used, alternatively see docs/hudson/OMERO.sh and/or OMERO.insight webstart security and code-signing.

Jenkins  The OME project currently uses Jenkins as a continuous integration server available here, so many binary packages can be downloaded without compiling them yourself.

Hudson checks for git changes every 15 minutes and executes:

(cd docs/hudson; python launcher.py)

12https://github.com/openmicroscopy/openmicroscopy/blob/develop/docs/hudson/OMERO.sh
13http://jenkins-ci.org
14http://ci.openmicroscopy.org/
which invokes the “build-all”, “javadoc” “findbugs”, “coverage”, and “release-zip” targets. The Javadocs are always made available here\(^\text{15}\) as well as several build metrics.

**Build tools**

OMERO mostly uses an ant\(^\text{16}\)-based build with dependency management provided by Ivy\(^\text{17}\). Native code is built using SCons\(^\text{18}\) and Python uses the traditional distutils/setuptools tools.

**Structure of the build**  This is an (abbreviated) snapshot of the structure of the filesystem for OMERO:

```
OMERO_SOURCE_PREFIX
|-- build.xml ......................... Top-level build driver
|-- build.py ......................... Python wrapper to handle OS-specific configuration
|-- omero.class ...................... Self-contained Ant launcher
|--etc/ ............................. All configuration
   |-- grid/* .......................... Deployment files
   |   |-- ivysettings.xml
   |   |-- hibernate.properties
   |   |-- local.properties.example
   |   |-- log4j.xml
   |   |-- omero.properties
   |   \-- profiles
   |-- examples ........................ User examples
|--\components

|--<component-name> .................... Each component has this same basic structure.
   |-- build.xml ........................ Main scripts
   |-- ivy.xml .......................... Jar dependencies
   |-- test.xml .......................... Test dependencies
   |-- src .............................. Source code
   |-- resources ........................ Other files of interest
   |-- test .............................. Test source code and test resources
   \-- target ........................... Output of build (deleted on clean)

|-- model ............................. The model component is special in that it produces a jar specific to your database choice: model-psql.jar
   The generated 'ome.model.*' files contain Hibernate annotations for object-relational mapping.

|-- blitz ............................. The blitz component also performs code generation producing artifacts for Java, Python, and C++.
   \ blitz_tools.py ..................... OMERO-specific SCons Environment definition and other build tools.

|--tools ............................. Other server-components with special build needs.
   |--build.xml
   \--<tool-name>
      |--build.xml
      |--ivy.xml
```

\(^{15}\)http://downloads.openmicroscopy.org/latest/omero5/api/
\(^{16}\)http://ant.apache.org
\(^{17}\)http://ant.apache.org.ivy
\(^{18}\)http://scons.org
Note: User examples are explained under Working with OMERO

Each of the components can also be built directly. For example,

```
./build.py -f components/server/build.xml
```

**Code generation** Unfortunately, just the above snapshot of the code repository omits some of the most important code. Many MB of source code is generated both by our own DSLTask as well as by the Ice\(^\text{19}\) slice2java, slice2cpp, and slice2py code generators. These take an intermediate representation of the OME-Model\(^\text{21}\) and generate our OME-Remote Objects. This code is not available in git, but once built, can be found in all the directories named “generated”.

**OmeroTools** Similarly, the ant build alone is not enough to describe all the products which get built. Namely, the builds for the non-Java components stored under components/tools\(^\text{22}\) are a bit more complex. Each tools component installs its artifacts to the tools/target directory which is copied on top of the OMERO_HOME/dist top-level distribution directory. Current tools include:

<table>
<thead>
<tr>
<th>OMERO C++ language bindings</th>
<th>Ant-based builds</th>
<th>Ice-based builds</th>
<th>Scons-based builds</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMERO.web framework</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>OMERO.fs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OMERO Python language bindings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LicenseService</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

**Ant-based builds** Some of the tools also contain Java code which imports files from antlib/resources and then proceeds like the other regular components.

**Ice-based builds** An Ice-based build requires further invocations of slice2* code generation. Currently this

**Scons-based builds** Builds which have C++ targets are based generally on Scons\(^\text{23}\). See OMERO C++ language bindings for more information.

**Comments on Ivy**

- Resolvers are key to how Ivy functions. Currently, the default resolver is called “omero-resolver” and simply looks in our repository (.lib/repository) for the jars which were downloaded from git. Multi-resolvers can be defined (as granular as for an individual jar) in order to pick up the latest version of whatever library from HTTP, SSH, or from the local file system.

- OMERO_HOME/lib/cache: in order to determine the transitive closure of all dependencies, Ivy “resolves” each ivy.xml and stores the resolved ivy.xml in its cache (in our build, ./lib/cache) to speed up other processes. However, when changing the Ivy configuration (.etc/ivyconf.xml) or version number (etc/omero.properties->omero.version) cache can become stale. This should not happen, but currently does. It may be beneficial for the time being to call ant clean from the top-level build which will delete the cache.

---

19https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/dsl  
20http://www.zeroc.com  
21http://www.openmicroscopy.org/site/support/ome-model/ome-xml/  
22https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/tools  
23http://www.scons.org
Comments on build.py

./build.py is a complete replacement for your local ant install. In many cases on and on most OS, you will be fine running ant. If you have any issues (for example OutOfMemory), please use ./build.py instead. *However*, only use one or the other. Do not mix calls between the two.

12.3 Working with OMERO

This page describes various tools and resources useful for working with the OMERO API, as well as some tips on setting up your working environment. It should be useful to client developers working in any of the supported languages. For language specific info, see the following links: OMERO Java language bindings, OMERO Python language bindings, OMERO C++ language bindings, OMERO MATLAB language bindings.

12.3.1 OMERO.clients

The OMERO model is implemented as a relational PostgreSQL database on the OMERO.server and mapped to code-generated model objects used by the clients in the various supported languages (linked above). The OMERO API consists of a number of services for working with these objects and associated binary data. Typically, clients will use various stateless services to query the OMERO model and then use the stateful services for exchange of binary data or image rendering.

A typical client interaction might have an outline such as:

- Log in to OMERO, obtaining connection and ‘service factory’
- Use the stateless ‘Query Service’ or ‘Container Service’ to traverse Projects, Datasets and Images
- Use the stateful ‘Rendering Engine’ or ‘Thumbnail Service’ to view images
- Use the stateful ‘Raw Pixels Service’ or ‘Raw File Store’ to retrieve pixel or file data for analysis
- Create new Annotations or other objects and save them with the stateless ‘Update Service’
- Close stateful services to free resources and close the connection

OMERO.clients use a common ‘gateway’ to communicate with an OMERO.server installation and allow the user to import, display, edit, and manage server data. The OMERO team has developed a suite of clients (see OMERO clients overview), but the open source nature of the OMERO project also allows developers to create their own, customized clients. If you are interested in doing this, further information is available on Developing OMERO clients.

12.3.2 OMERO server

Although most interactions with OMERO can be achieved remotely, you will generally find it easier to have the server installed on your development machine, particularly if you are going to be doing a lot of OMERO development. This gives you local access to the database, binary repository, logs etc. and means you can work ‘off-line’.

Even if the server you are connecting to is remote, you will still want to have the server package available locally, so as to give you the command line tools, Python libraries, etc. It is important that all OMERO server and client libraries you use are the same OMERO version.

You may wish to work with the most recent OMERO release, or alternatively you can use the latest development code. Instructions on how to download or check out the code can be found on the main downloads page. Regular builds of the server are performed by Jenkins including generated Javadocs. See the contributing developer continuous integration documentation for more information.

---

24 http://downloads.openmicroscopy.org/latest/omero5/
25 http://jenkins-ci.org
26 http://www.openmicroscopy.org/site/support/contributing/ci-omero.html
12.3.3 Environment variables

In addition to the install instructions, you might find it useful to set the following variables:

- **OMERO_HOME**: should be set to the directory containing the OMERO distribution or build

  ```
  # E.g. If you built the server yourself
  export OMERO_PREFIX=~/Desktop/OMERO/dist
  # Or you downloaded a release package
  export OMERO_PREFIX=~/Desktop/OMERO.server-Beta-4.2.2
  ```

- Add the /bin/ directory to your PATH - allows you to call the ‘omero’ command from anywhere

  ```
  export PATH=$PATH:$OMERO_PREFIX/bin/
  ```

- For Python developers, set your PYTHONPATH as follows

  ```
  export PYTHONPATH=$PYTHONPATH:$OMERO_PREFIX/lib/python/
  ```

Now checkout the CLI.

```
$ omero -h
```

12.3.4 Database access

It is useful to be able to directly query or browse the OMERO PostgreSQL database, which can be achieved with a number of tools. E.g.

- **psql**: This command line tool should already be installed. Depending on your permissions, you may need to connect as the ‘postgres’ user:

  ```
  $ sudo -u postgres psql omero
  Password: # sudo password
  omero=# \d; # give a complete list of tables and views
  omero=# \d annotation; # list all the columns in a particular table
  omero=# select id, discriminator, ns, textValue, file from annotation order by id desc; # query
  ```

- **pgAdmin** is a free, cross platform GUI tool for working with PostgreSQL

12.3.5 OMERO model

You can browse the OMERO model in a number of ways, one of which is by looking at the database itself (see above). Another is via the on-line OMERO model docs.

However, due to the complexity of the OMERO model, it is helpful to have some starting points (follow links below to the docs themselves).

**Note**: Figures to the right show highly simplified outline of various model objects.

---

Projects, datasets and images

Projects and Datasets are many-to-many containers for Images (linked by ProjectDatasetLinks and DatasetImageLinks respectively).

Projects, Datasets, Images and a number of other entities can be linked to Annotations (abstract superclass via specific links (ProjectAnnotationLink, DatasetAnnotationLink etc). Annotation subclasses such as CommentAnnotation, FileAnnotation etc. are stored in a single database table in OMERO (all Annotations have unique ID).

Images

Images in OMERO are made up many entities. These include core image components such as Pixels and Channels, as well as a large number of additional metadata objects such as Instrument (microscope), Objective, Filters, Light Sources, and Detectors. Image pixels data is stored as a single file, numbered by Pixels ID in the OMERO repository under /OMERO/Pixels/ and can be accessed using the Raw Pixels Store.

Note: Some features of the model are due to historical changes and are not exercised in practice. For example, an Image can have multiple sets of Pixels although only 1 is typically used. Also, Logical Channel and Channel can be considered a single entity (as they are now in the OME-model).

12.3.6 Working with the OMERO model objects

For detailed information see OME-Remote Objects and Developing OMERO clients pages.

Objects that you wish to work with on the client must be loaded from OMERO, with the query defining the extent of any data graph that is “fetched”.

The OMERO Application Programming Interface supports 2 principle ways of querying OMERO and retrieving the objects. You can write SQL-like queries using the query service (uses “HQL”) or you can use one of the other services that already has suitable
queries. Using the query service is very flexible but it requires detailed knowledge of the OMERO model (see above) and is susceptible to any change in the model.

For example, to load a specific Project and its linked Datasets you could write a query like this:

```python
queryService = session.getQueryService()
params = omero.sys.Parameters()
params.map = {"pid": rlong(projectId)}
query = "select p from Project p left outer join fetch p.datasetLinks as links left outer join fetch links.child as dataset where p.id=:pid"
project = queryService.findByQuery(query, params)
for dataset in project.linkedDatasetList:
    print dataset.getName().getValue()
```

Or use the Container Service like this:

```python
containerService = session.getContainerService()
project = containerService.loadContainerHierarchy("Project", [projectId], True)
for dataset in project.linkedDatasetList:
    print dataset.getName().getValue()
```

For a list of the available services, see the OMERO Application Programming Interface page.
12.3.7 Examples

HQL examples

HQL is used for Query Service queries (see above). Some examples, coupled with a knowledge of the OMERO model should get you going, along with notes about object loading on the OME-Remote Objects page.

Note: If possible, it is advisable to use an existing API method from one of the other services (as for the container service above).

Although it is possible to place query parameters directly into the string, it is preferable (particularly for type-checking) to use the omero.sys.Parameters object:

```java
queryService.findByQuery("from PixelsType as p where p.value='"%s"' % pType, None)
```

# better to do
params = omero.sys.Parameters()
params.map = {"pType": rstring(pType)}
queryService.findByQuery("from PixelsType as p where p.value=:pType", params)

psql queries

Below are a number of example psql database queries:

# list any images that do not have pixels:
```sql
omero=# select id, name from Image i where i.id not in (select image from Pixels where image is not null) order by i.id desc;
```
```
<table>
<thead>
<tr>
<th>id</th>
<th>name</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>OpenMicroscopy/omero/import/companionFile</td>
</tr>
</tbody>
</table>
```

omero=# \x
Expanded display is on.

```sql
omero=# select id, discriminator, ns, textValue, file from annotation where id=369;
```
```
- [ RECORD 1 ]-+-----------------------------------------------------+-
<table>
<thead>
<tr>
<th>id</th>
<th>discriminator</th>
<th>ns</th>
<th>textValue</th>
<th>file</th>
</tr>
</thead>
<tbody>
<tr>
<td>369</td>
<td>/type/OriginalFile/</td>
<td>openmicroscopy.org/omero/import/companionFile</td>
<td>570</td>
<td></td>
</tr>
</tbody>
</table>
```

omero=# \x
Expanded display is off.

```sql
omero=# select * from joboriginalfilelink where parent = 7;
```
```
<table>
<thead>
<tr>
<th>id</th>
<th>permissions</th>
<th>version</th>
<th>child</th>
<th>creation_id</th>
<th>external_id</th>
<th>group_id</th>
<th>owner_id</th>
<th>update_id</th>
<th>parent</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>-103</td>
<td></td>
<td>110</td>
<td>891</td>
<td></td>
<td>208</td>
<td>207</td>
<td>891</td>
<td>7</td>
</tr>
<tr>
<td>17</td>
<td>-103</td>
<td></td>
<td>113</td>
<td>926</td>
<td></td>
<td>208</td>
<td>207</td>
<td>926</td>
<td>7</td>
</tr>
</tbody>
</table>
```

(2 rows)

omero=# select id, name, path, owner_id, group_id, ome_perms(permissions) from originalfile where id in
OMERO Documentation, Release 5.0.2

id | name | path | owner_id | group_id | ome_perms
-----+-------------------+--------------------------------------------------------------+----------+----------+-----------
113 | stdout | /Users/will/omero/tmp/omero_will/75270/processuLq8fd.dir/out | 207 | 208 | -rw----
110 | imagesFromRois.py | ScriptName061ea79c-f98c-447b-b720-d17003d6a72f | 0 | 0 | -rw----
(2 rows)

# find all annotations on Image ID=2
omero=# select * from annotation where id in (select child from imageannotationlink where parent = 2) ;

# trouble-shooting postgres
omero=# select * from pg_stat_activity ;

bin/omero hql
You can use the omero omero hql command to query a remote OMERO database, entering your login details when requested.

Note: Because you will be querying the database under a particular login, the entries returned will be subject to the permissions of that login.

bin/omero hql -q --limit=10 "select name from OriginalFile where id=4106"
bin/omero hql -q --limit=10 "select id, textValue, file from Annotation a order by a.id desc"
bin/omero hql -q --limit=100 "select id, owner.id, started, userAgent from Session where closed is null"

12.4 Running and writing tests

The following guidelines apply to tests in both the Java and Python test components. However, some of the presented options apply to only one or the other.

12.4.1 Running unit tests

The unit testing framework is fairly simple. Only methods which contain logic written within OMERO are tested. This means that framework functionality like remoting or the Hibernate layer is not tested. This is a part of integration testing (see below).

You can run the unit tests for any component from its directory by entering:

```
./build.py -f components/<component>/build.xml test
```

The same can be done for all components using:

```
./build.py test-unit
```

Note that for tests written in Python the package pytest must be installed, see Writing Python tests.

12.4.2 Running integration tests

Integration testing is a bit more complex because of the reliance on a database, which is not easily mockable. All Hibernate-related classes are tested in integration mode.

The tests require a fast computer. Running all the integration tests places several restrictions on the environment:

- There must be a running OMERO database.
- An OMERO.server instance must be running.
Integration tests assume that:

- **ICE_CONFIG** has been properly set. The contents of the etc/ice.config file should be enough to configure a running server for integration testing. This means that code creating a client connection as outlined in developers/GettingStarted/AdvancedClientDevelopment.html should execute without errors.

- An OMERO.server instance is running on the host and port specified in the ICE_CONFIG file.

If any of the tests fail with a user authentication exception (or omero.client throws an exception), a new ice.config file can be created and pointed to by the ICE_CONFIG environment variable. Most likely the first settings that will have to be put there will be omero.user and omero.pass.

### Running all tests

To run all the integration tests, use

```bash
./build.py test-integration
```

### Component tests

Running an integration test suite for an individual component can be done explicitly via:

```bash
./build.py -f components/<component>/build.xml integration
```

Results are placed in components/<component>/target/reports.

### Individual test groups

To run individual OmeroJava test groups (or comma-separated sets of groups) of tests, the `-DGROUPS` parameter can be used together with the `test` target

```bash
./build.py -f components/tools/OmeroJava/build.xml test -DGROUPS=integration
```

### Individual tests

Alternatively, you can run individual tests which you may currently be working on. This can be done by using the `test` option. For example:

```bash
./build.py -f components/tools/OmeroJava/build.xml test -DTEST=integration/AdminTest
./build.py -f components/tools/OmeroPy/build.xml test -DTEST=test/integration/test_admin.py
```

### Individual test class methods

Individual OmeroJava test class methods (or a comma-separated list of methods) can be run using the `-DMETHODS` parameter together with the `test` target. The test method must be provided in the fully qualified name form (package.class.method).

```bash
./build.py -f components/tools/OmeroJava/build.xml test -DMETHODS=integration.chgrp.AnnotationMoveTest.testMoveTaggedImage
```

---

Using markers in OmeroPy tests

Tests under OmeroPy can be included or excluded according to markers defined in the tests. This can be done by using the `-DMARK` option. For example:

```
./build.py -f components/tools/OmeroPy/build.xml integration -DMARK=long_running
```

See Writing Python tests for more information on this.

Failing tests

The `test.with.fail` ant property is set to `false` by default, which prevents test failures from failing the build. However, it can instead be set to `true` to allow test failures to fail the build. For example:

```
./build.py -Dtest.with.fail=true integration
```

Some components might provide individual targets for specific tests (e.g. OmeroJava provides the `broken` target for running broken tests). The `build.xml` file is the reference in each component.

12.4.3 Writing Java tests

For more information on writing tests in general see [http://testng.org](http://testng.org). For a test to be an “integration” test, place it in the “integration” TestNG group. If a test is temporarily broken, add it to the “broken” group:

```java
@Test(groups = {"integration", "broken"})
public void testMyStuff() {
}
```

Tests should be of the Acceptance Test form. The ticket number for which a test is being written should be added in the TestNG annotation:

```java
@Test(groups = "ticket:60")
```

This works at either the method level (see SetsAndLinksTest.java\(^42\)) or the class level (see UniqueResultTest.java\(^43\)).

OmeroJava

The tests under `components/tools/OmeroJava/test\(^44\)` will be the starting point for most Java-client developers coming to OMERO. An example skeleton for an integration test looks similar to

```java
@Test(groups = "integration")
public class MyTest {
    omero.client client;

    @BeforeClass
    protected void setup() throws Exception {
        client = new omero.client();
        client.createSession();
    }
}
```

---

\(^42\)[https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/model/test/ome/model/utests/SetsAndLinksTest.java](https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/model/test/ome/model/utests/SetsAndLinksTest.java)


Using Eclipse to run tests

To facilitate importing OMERO components into Eclipse, there are `.project` and `.classpath-template` files stored in each component directory (e.g. `common's.classpath` and `common's.project`).

There are also top-level `.classpath` and `.project` files which allow for importing all components as a single project, but this approach requires more memory and does not clearly differentiate the classpaths, and so can lead to confusion.

Before importing any component as a project into Eclipse, a successful build has to have taken place:

```
./build.py
```

This is for two reasons. Firstly, the Eclipse projects are not configured to perform the code generation needed. The `build.py` command creates the directory:

```
<component>/target
```

which will be missing from any Eclipse project you open before building the source.

Secondly, Ivy is used to copy all the jar dependencies from `OMERO_SOURCE_PREFIX/lib/repository` to `<component>/target/libs`, which is then used in the Eclipse `.classpath` files.

If Eclipse ever gets out of sync after the first build, `./build.py build-eclipse` can be used to quickly synchronize.

TestNG plugin

A prerequisite of running unit and integration tests in the Eclipse UI is having the TestNG plug-in installed and working (help available on the TestNG site\(^{47}\)).

Unit tests

Running the unit tests under Eclipse requires no extra settings and is as easy as navigating to the package or class context menu `Run As` or `Debug As`, then selecting `TestNG`.

Integration tests

Integration tests require the `ICE_CONFIG` environment variable to be available for the Eclipse-controlled JVM. This can be done by editing Debug/Run configurations in Eclipse. After navigating to the Debug (or Run) Configurations window, the `Environment` tab needs to be selected. After clicking `New`, `ICE_CONFIG` can be defined as a path to the `ice.config` file. This setting needs to be defined per package, class or method.

\(^{45}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/classpath-template

\(^{46}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/project

\(^{47}\)http://testng.org/doc/eclipse.html
Debugging a running OMERO instance

By using the “debug” target from templates.xml, it is possible to have OMERO listen on port 8787 for a debugging connection.

```
bin/omero admin stop
bin/omero admin start debug
```

Then in Eclipse, you can create a new “Debug” configuration by clicking on Remote Java Application, and setting the port to 8787. These values are arbitrary and can be changed locally.

Keep in mind:

- The server will not start up until you have connected with Eclipse. This is due to the “suspend=y” clause in templates.xml. If you would like the server to start without you connecting, use “suspend=n”.
- If you take too much time examining your threads, your calls may throw timeout exceptions.

12.4.4 Writing Python tests

To write and run Python tests you first need to install pytest:

```
pip install pytest
```

For more information on writing tests in general see http://pytest.org.

OmeroPy

Similar to the OmeroJava tests, the tests under components/tools/OmeroPy/test will be the starting point for most Python-client developers coming to OMERO. Integration tests should be placed under components/tools/OmeroPy/test/integration. The file names must begin with `test_` for the tests to be found by pytest.

```python
import omero

class TestExample(object):
    def setup_method(self, method):
        client = new omero.client()
        client.createSession()

    def teardown_method(self, method):
        client.closeSession()

    def testSimple():
        ec = client.getSession().getAdminService().getEventContext()
        assert ec, "No EventContext!"
```

Running tests directly

When writing tests it can be more convenient, flexible and powerful to run the tests from components/tools/OmeroPy using setup.py. Since Python is interpreted, tests can be written and then run without having to rebuild or restart the server. A few basic examples are shown below.

Run a single test file:

---

48 https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/tools/OmeroPy/test
49 https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/tools/OmeroPy/test/integration
50 https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/tools/OmeroPy
cd components/tools/OmeroPy
./setup.py test -s test/integration/test_admin.py

The `-k` option will run all integration tests containing the given string in their names. For example, to run all the tests under test/integration with `permissions` in their names:

./setup.py test -s test/integration -k permissions

This option can also be used to run a named test within a test module:

./setup.py test -s test/integration/test_admin.py -k testGetGroup

The `-m` option will run integration tests depending on the markers they are decorated with. For example, to run all integration tests excluding those decorated with the marker `long_running`:

./setup.py test -s test/integration -m "not long_running"

For more help with `setup.py` see:

./setup.py --help test

To make use of the more advanced options available in `pytest` that are not accessible using `setup.py`, the script `py.test` can be used directly. For example, to run the tests in a single package allowing standard output to be shown on the console:

`py.test test/integration/test_admin.py -s`

For a full list of options see:

`py.test --help`

and [http://pytest.org/latest/usage.html](http://pytest.org/latest/usage.html) for more help in running tests.
13.1 OMERO Python language bindings

MOVIE: introduction to Blitz Gateway\(^1\)

In addition to the auto-generated Python libraries of the core OMERO Application Programming Interface, we have developed a more user-friendly Python module ‘Blitz Gateway’ that facilitates several aspects of working with the Python API, such as connection handling, object graph traversal and lazy loading.

This page gives you a large number of code samples to get you started. Then we describe a bit more about Blitz Gateway documentation.

The Python libraries are part of the server build and can be found under OMERO_HOME/lib/python. These include the core omero.model objects and services as well as the Blitz Gateway code (at OMERO_HOME/lib/python/omero/gateway/__init__.py).

To use OmeroPy, you will need to download the libraries (E.g. as part of the server package) and setup your PYTHONPATH to include them:

```bash
export OMERO_PREFIX=/Desktop/OMERO.server-5.0.2-ice3x-byy # for example
export PYTHONPATH=$PYTHONPATH:$OMERO_PREFIX/lib/python
```

You will also need Ice libraries as described in the OMERO.server installation and an OMERO server to connect to, which must be the same major version, i.e. 5.0.x.

All the code examples below can be found at examples/Training/python\(^2\).

Start by downloading the first example below: examples/Training/python/Connect_To_OMERO.py\(^3\) and edit the USERNAME and PASSWORD variables according to your log-in.

Then you can run the example:

```
$ python Connect_To_OMERO.py
```

If all goes well, you should be connected to your OMERO server and see some details of your session printed out.

All the following code examples can be downloaded and run in the same way, and they will use the USERNAME and PASSWORD from the file you just edited. However, you will need to edit some other parameters, usually IDs from Projects, Datasets, Images etc. You can use the OMERO.insight or OMERO.web client to choose suitable data IDs before editing and running the code samples.

### 13.1.1 Code samples

**Connect to OMERO**

\(^1\)http://cvs.openmicroscopy.org.uk/snapshots/movies/omero-4-3/mov/BlitzGatewayIntro-4.3.mov

\(^2\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/examples/Training/python

\(^3\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/Training/python/Connect_To_OMERO.py
# These values will be imported by all the other training scripts.
HOST = 'localhost'
PORT = 4064
USERNAME = 'username'
PASSWORD = 'passwd'

from omero.gateway import BlitzGateway

if __name__ == '__main__':
    ###
    NB: This block is only run when calling this file directly
    and not when imported.
    ###

# Connect to the Python Blitz Gateway
# ==============================================================
# Make a simple connection to OMERO, printing details of the
# connection. See OmeroPy/Gateway for more info
conn = BlitzGateway(USERNAME, PASSWORD, host=HOST, port=PORT)
connected = conn.connect()

# Check if you are connected.
# ==============================================================
if not connected:
    import sys
    sys.stderr.write("Error: Connection not available, please check your user name and password.\n")
    sys.exit(1)

# Using secure connection.
# ==============================================================
# By default, once we have logged in, data transfer is not encrypted (faster)
# To use a secure connection, call setSecure(True):

# conn.setSecure(True) # <-------- Uncomment this

# Current session details
# ==============================================================
# By default, you will have logged into your 'current' group in OMERO. This
# can be changed by switching group in the OMERO.insight or OMERO.web clients.

user = conn.getUser()
print "Current user:"
print " ID ": user.getId()
print " Username ": user.getName()
print " Full Name ": user.getFullName()

print "Member of:
for g in conn.getGroupsMemberOf():
    print " ID ": g.getName(), " Name ": g.getId()
group = conn.getGroupFromContext()
print "Current group: ", group.getName()

print "Other Members of current group:"
for exp in conn.listColleagues():
    print "   ID:", exp.getId(), exp.getOmeName(), " Name:", exp.getFullName()

print "Owner of:"
for g in conn.listOwnedGroups():
    print "   ID:", g.getName(), " Name:", g.getId()

# New in OMERO 5
print "Admins:"
for exp in conn.getAdministrators():
    print "   ID:", exp.getId(), exp.getOmeName(), " Name:", exp.getFullName()

# The 'context' of our current session
cctx = conn.getEventContext()
print cctx  # for more info

# Close connection:
# =================================================================
# When you are done, close the session to free up server resources.
conn._closeSession()

Read data

- Create a connection

conn = BlitzGateway(USERNAME, PASSWORD, host=HOST, port=PORT)
conn.connect()

- Configuration

imageId = 1
datasetId = 2
plateId = -1  # Don't need to set this

def print_obj(obj, indent=0):
    """
    Helper method to display info about OMERO objects.
    Not all objects will have a "name" or owner field.
    """
    print """"%s Name:""""%s (owner="%s")"""" % (\
        """"%s"""", obj_OMERO_CLASS,\
        obj.getId(),\
        obj.getName(),\
        obj.getOwnerOmeName())
• List all Projects available to me, and their Datasets and Images:

```python
# The only_owned=True parameter limits the Projects which are returned.
# If the parameter is omitted or the value is False, then all Projects
# visible in the current group are returned.
print "\nList Projects:
"
print "=" * 50
my_expId = conn.getUser().getId()
for project in conn.listProjects(my_expId):
    print_obj(project)
    for dataset in project.listChildren():
        print_obj(dataset, 2)
        for image in dataset.listChildren():
            print_obj(image, 4)
```

• Retrieve the datasets owned by the user currently logged in:

```python
# Here we create an omero.sys.ParametersI instance which we
# can use to filter the results that are returned. If we did
# not pass the params argument to getObjects, then all Datasets
# in the current group would be returned.
print "\nList Datasets:
"
print "=" * 50
params = omero.sys.ParametersI()
params.exp(conn.getUser().getId())  # only show current user’s Datasets

datasets = conn.getObjects("Dataset", params=params)
for dataset in datasets:
    print_obj(dataset)
```

• Retrieve the images contained in a dataset:

```python
print "\nDataset:%s" % datasetId
print "=" * 50
dataset = conn.getObject("Dataset", datasetId)
print "\nImages in Dataset:%s", dataset.getName()
for image in dataset.listChildren():
    print_obj(image)
```

• Retrieve an image by Image ID:

```python
image = conn.getObject("Image", imageId)
print "\nImage:%s" % imageId
print "=" * 50
print image.getName(), image.getDescription()
# Retrieve information about an image.
print " X:\", image.getSizeX()
print " Y:\", image.getSizeY()
print " Z:\", image.getSizeZ()
print " C:\", image.getSizeC()
print " T:\", image.getSizeT()
# render the first timepoint, mid z section
z = image.getSizeZ() / 2
t = 0
renderedImage = image.renderImage(z, t)
```
# renderedImage.show()  # popup (use for debug only)
# renderedImage.save("test.jpg")  # save in the current folder

• Retrieve Screening data:

```python
print "\nList Screens:
print "=" * 50
for screen in conn.getObjects("Screen"):  
  print_obj(screen)
  for plate in screen.listChildren():  
    print_obj(plate, 2)
    plateId = plate.getId()
```

• Retrieve Wells and Images within a Plate:

```python
if plateId >= 0:
  print "\nPlate:%s" % plateId
  print "=" * 50
  plate = conn.getObject("Plate", plateId)
  print "\nNumber of fields:", plate.getNumberOfFields()
  print "\nGrid size:", plate.getGridSize()
  print "\nWells in Plate:", plate.getName()
  for well in plate.listChildren():
    index = well.countWellSample()
    print " " Well: ", well.row, well.column, " Fields:", index
    for index in xrange(0, index):
      print " " Image: ",
      well.getImage(index).getName(),
      well.getImage(index).getId()
```

• Close connection:

```python
# When you are done, close the session to free up server resources.
conn._closeSession()
```

Groups and permissions

• Create a connection

```python
conn = Blitz Gateway(USERNAME, PASSWORD, host=HOST, port=PORT)
conn.connect()
```

• Configuration

```python
imageId = 1
```

• We are logged in to our ‘default’ group

```python
group = conn.getGroupFromContext()
print "Current group: ", group.getName()
```

• Each group has defined Permissions set
group_perms = group.getDetails().getPermissions()
perm_string = str(group_perms)
permission_names = {'rw----':'PRIVATE',
                   'rwx---':'READ-ONLY',
                   'rwr---':'READ-ONLY',
                   'rwxr--':'READ-ANNOTATE',
                   'rwxrw-':'READ-WRITE'}  # Not exposed in 4.4.0 clients
print "Permissions: $s (%s)" % (permission_names[perm_string], perm_string)

• By default, any query applies to ALL data that we can access in our Current group.
This will be determined by group permissions. E.g. in Read-Only or Read-Annotate groups, this will include other users’ data
See Permissions overview.

projects = conn.listProjects()  # may include other users’ data
for p in projects:
    print p.getName(), "Owner: ", p.getDetails().getOwner().getFullName()

image = conn.getObject("Image", imageId)  # Will return None if Image is not in current group
print "Image: ", image

• In OMERO-4.4, we added ‘cross-group’ querying, use ‘-1’

conn.SERVICE_OPTS.setOmeroGroup('-1')
image = conn.getObject("Image", imageId)  # Will query across all my groups
print "Image: ", image,
if image is not None:
    print "Group: ", image.getDetails().getGroup().getName(),
    print image.details.group.id.val  # access groupId without loading group

• To query only a single group (not necessarily your ‘current’ group)

groupId = image.details.group.id.val
conn.SERVICE_OPTS.setOmeroGroup(groupId)  # This is how we ‘switch group’ in webclient
projects = conn.listProjects()
image = conn.getObject("Image", imageId)
print "Image: ", image,

• Close connection:

# When you are done, close the session to free up server resources.
conn._closeSession()

Raw data access

• Create a connection

c = BlitzGateway(USERNAME, PASSWORD, host=HOST, port=PORT)
c.conn.connect()

• Configuration

imageId = 27544
• Retrieve a given plane

```python
# Use the pixelswrapper to retrieve the plane as
# a 2D numpy array. See [http://www.scipy.org/Tentative_NumPy_Tutorial]
# Numpy array can be used for various analysis routines

image = conn.getObject("Image", imageId)
sizeZ = image.getSizeZ()
sizeC = image.getSizeC()
sizeT = image.getSizeT()
z, t, c = 0, 0, 0  # first plane of the image
pixels = image.getPrimaryPixels()
planes = pixels.getPlane(z, c, t)  # get a numpy array.
print "plane at zct":", z, c, t

planes = pixels.getPlane(z, c, t)
print "plane at zct":", z, c, t

# first plane of the image

image = conn.getObject("Image", imageId)
sizeZ = image.getSizeZ()
sizeC = image.getSizeC()
sizeT = image.getSizeT()
z, t, c = 0, 0, 0  # first plane of the image
pixels = image.getPrimaryPixels()
planes = pixels.getPlane(z, c, t)  # get a numpy array.
print "plane at zct":", z, c, t

planes = pixels.getPlane(z, c, t)
print "plane at zct":", z, c, t
```

• Retrieve a given stack

```python
# Get a Z-stack of tiles. Using getTiles or getPlanes (see below) returns
# a generator of data (not all the data in hand) The RawPixelsStore is
# only opened once (not closed after each plane) Alternative is to use
# getPlane() or getTile() multiple times - slightly slower.
c, t = 0, 0  # First channel and timepoint
tile = (50, 50, 10, 10)  # x, y, width, height of tile

zctList = [(z, c, t, tile) for z in range(sizeZ)]
print "Z stack of tiles:
planes = pixels.getTiles(zctList)
for i, p in enumerate(planes):
    print "Tile":", zctList[i], "min":", p.min(),
    "max":", p.max(), "sum":", p.sum()
```

• Retrieve a given hypercube

```python
zctList = []
for z in range(sizeZ / 2, sizeZ):  # get the top half of the Z-stack
    for c in range(sizeC):
        for t in range(sizeT):  # all time-points
            zctList.append((z, c, t))
print "Hyper stack of planes:
planes = pixels.getPlanes(zctList)
for i, p in enumerate(planes):
    print "plane zct":", zctList[i], "min":", p.min(), "max":", p.max()
```

• Close connection:

```python
# When you are done, close the session to free up server resources.
conn._closeSession()
```

Write data

• Create a connection
conn = BlitzGateway(USERNAME, PASSWORD, host=HOST, port=PORT)
conn.connect()

- Configuration

projectId = 2
#Specify a local file. E.g. could be result of some analysis
fileToUpload = "README.txt"  # This file should already exist

- Create a new Dataset

datasetObj = omero.model.DatasetI()
datasetObj.setName(rstring("New Dataset"))
datasetObj = conn.getUpdateService().saveAndReturnObject(datasetObj)
datasetId = datasetObj.getId().getValue()
print "New dataset, Id:" datasetId

- Link to Project

project = conn.getObject("Project", projectId)
if project is None:
    import sys
    sys.stderr.write("Error: Object does not exist.\n")
    sys.exit(1)
link = omero.model.ProjectDatasetLinkI()
link.setParent(omero.model.ProjectI(project.getId(), False))
link.setChild(datasetObj)
conn.getUpdateService().saveObject(link)

- How to create a file annotation and link to a Dataset

dataset = conn.getObject("Dataset", datasetId)
# create the original file and file annotation (uploads the file etc.)
namespace = "imperial.training.demo"
print \"Creating an OriginalFile and FileAnnotation"
fileAnn = conn.createFileAnnfromLocalFile(fileToUpload, mimetype="text/plain", ns=namespace, desc=None)
print \"Attaching FileAnnotation to Dataset: " File ID", fileAnn.getId(), ",", fileAnn.getFile().getName()
dataset.linkAnnotation(fileAnn)  # link it to dataset.

- Download a file annotation linked to a Dataset

# make a location to download the file. "download" folder.
path = os.path.join(os.path.dirname(__file__), "download")
if not os.path.exists(path):
    os.makedirs(path)

# Go through all the annotations on the Dataset. Download any file annotations we find.
print \"\nAnnotations on Dataset:" dataset.getName()
for ann in dataset.listAnnotations():
    if isinstance(ann, omero.gateway.FileAnnotationWrapper):
        print \"File ID":", ann.getFlie().getId(), ann.getFile().getName(), \"Size":", ann.getFile().getSize()

file_path = os.path.join(path, ann.getFile().getName())
```python
f = open(str(file_path), 'w')
print('\nDownloading file to', file_path, '...')
try:
    for chunk in ann.getFileInChunks():
        f.write(chunk)
finally:
    f.close()
    print('File downloaded!')

• Load all the file annotations with a given namespace

nsToInclude = [namespace]
sToExclude = []
metadataService = conn.getMetadataService()
annotations = metadataService.loadSpecifiedAnnotations('omero.model.FileAnnotation', nsToInclude, nsToExclude)
for ann in annotations:
    print(ann.getId().getValue(), ann.file.name.val)

• Get first annotation with specified namespace

ann = dataset.getAnnotation(namespace)
print('Found Annotation with namespace:', ann.getNs())

• Close connection:

    # When you are done, close the session to free up server resources.
    conn._closeSession()

OMERO tables

• Create a connection

conn = BlitzGateway(USERNAME, PASSWORD, host=HOST, port=PORT)
conn.connect()

• Configuration

datasetId = 33

• Create a name for the Original File (should be unique)

    from random import random
tablename = "TablesDemo:%s" % str(random())

    col1 = omero.grid.LongColumn('Uid', 'testLong', [])
    col2 = omero.grid.StringColumn('MyStringColumnInit', '', 64, [])

columns = [col1, col2]

• Create and initialize a new table.
```
repositoryId = 1

```
repositoryId = 1

table = conn.c.sf.sharedResources().newTable(repositoryId, tablename)
table.initialize(columns)
```

• Add data to the table.

```
ids = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
strings = ['one', 'two', 'three', 'four', 'five', 'six', 'seven', 'eight', 'nine', 'ten']
data1 = omero.grid.LongColumn('Uid', 'test Long', ids)
data2 = omero.grid.StringColumn('MyStringColumn', '', 64, strings)
data = [data1, data2]
table.addData(data)
table.close()  # when we are done, close.
```

• Get the table as an original file...

```
orig_file = table.getOriginalFile()
orig_file_id = orig_file.id.val
# ...so you can attach this data to an object. E.g. Dataset
fileAnn = omero.model.FileAnnotationI()
fileAnn.setFile(omero.model.OriginalFileI(orig_file_id, False))  # use unloaded OriginalFileI
fileAnn = conn.getUpdateService().saveAndReturnObject(fileAnn)
link = omero.model.DatasetAnnotationLinkI()
link.setParent(omero.model.DatasetI(datasetId, False))
link.setChild(omero.model.FileAnnotationI(fileAnn.id.val, False))
conn.getUpdateService().saveAndReturnObject(link)
```

• Table API

See also:

```
javadoc
```

```
openTable = conn.c.sf.sharedResources().openTable(orig_file)
```

```
print "Table Columns:"
for col in openTable.getHeaders():
    print "  ", col.name
```

```
rowCount = openTable.getNumberOfRows()
print "Row count:", rowCount
```

• Get data from every column of the specified rows

```
rowCount = openTable.getNumberOfRows()
print "Row count:", rowCount
```

```
rowNumbers = [3, 5, 7]
print "\nGet All Data for rows: ", rowNumbers
data = openTable.readCoordinates(range(rowCount))
for col in data.columns:
    print "Data for Column: ", col.name
    for v in col.values:
        print "  ", v
```

• Get data from specified columns of specified rows

```
4http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/grid/Table.html
```

```
rowNumbers = [3, 5, 7]
print "\nGet All Data for rows: ", rowNumbers
data = openTable.readCoordinates(range(rowCount))
for col in data.columns:
    print "Data for Column: ", col.name
    for v in col.values:
        print "  ", v
```
colNumbers = [1]
start = 3
stop = 7
print "\nGet Data for cols: ", colNumbers,
    " and between rows: ", start, "-", stop

data = openTable.read(colNumbers, start, stop)
for col in data.columns:
    print "Data for Column: ", col.name
    for v in col.values:
        print " \t", v

• Query the table for rows where the ‘Uid’ is in a particular range

queryRows = openTable.getWhereList(\"(Uid > 2) & (Uid <= 8)\",\n    variables={}, start=0, stop=rowCount, step=0)
data = openTable.readCoordinates(queryRows)
for col in data.columns:
    print "Query Results for Column: ", col.name
    for v in col.values:
        print " \t", v
openTable.close() # we’re done

• In future, to get the table back from Original File

orig_table_file = conn.getObject(\"OriginalFile\", attributes=\{"name": tablename\}) # if name is unique
savedTable = conn.c.sf.sharedResources().openTable(orig_table_file._obj)
print "Opened table with row-count: ", savedTable.getRowCount()

• Close connection:

# When you are done, close the session to free up server resources.
conn._closeSession()

ROIs

• Create a connection

conn = BlitzGateway(USERNAME, PASSWORD, host=HOST, port=PORT)
conn.connect()
updateService = conn.getUpdateService()

• Configuration

imageId = 27544

• Create ROI.

# We are using the core Python API and omero.model objects here, since ROIs are
# not yet supported in the Python Blitz Gateway.
#
# In this example, we create an ROI with a rectangular shape and attach it to an
# image.
x = 50
y = 200
width = 100
height = 50
image = conn.getObject("Image", imageId)
theZ = image.getSizeZ() / 2
theT = 0

print "Adding a rectangle at theZ: $s, theT: $s, X: $s, Y: $s, width: $s, height: $s" % 
     (theZ, theT, x, y, width, height)

roi = omero.model.RoiI()
roi.setImage(image._obj)  # use the omero.model.ImageI that underlies the 'image' wrapper
rect = omero.model.RectI()
rect.x = rdouble(x)
rect.y = rdouble(y)
rect.width = rdouble(width)
rect.height = rdouble(height)
rect.theZ = rint(theZ)
rect.theT = rint(theT)
rect.textValue = rstring("test-Rectangle")
roi.addShape(rect)

ellipse = omero.model.EllipseI()
ellipse.cx = rdouble(y)
ellipse.cy = rdouble(x)
ellipse.rx = rdouble(width)
ellipse.ry = rdouble(height)
ellipse.theZ = rint(theZ)
ellipse.theT = rint(theT)
ellipse.textValue = rstring("test-Ellipse")
roi.addShape(ellipse)

r = updateService.saveAndReturnObject(roi)

for roi in result.rois:
    print "ROI: ID: ", roi.getId().getValue()
    for s in roi.copyShapes():
        shape = {}
        shape['id'] = s.getId().getValue()
        shape['theT'] = s.getTheT().getValue()
        shape['theZ'] = s.getTheZ().getValue()
        if s.getTextValue():
            shape['textValue'] = s.getTextValue().getValue()
        if type(s) == omero.model.RectI:
            shape['type'] = 'Rectangle'
            shape['x'] = s.getX().getValue()
            shape['y'] = s.getY().getValue()
shape['width'] = s.getWidth().getValue()
shape['height'] = s.getHeight().getValue()
elif type(s) == omero.model.EllipseI:
    shape['type'] = 'Ellipse'
    shape['cx'] = s.getCx().getValue()
    shape['cy'] = s.getCy().getValue()
    shape['rx'] = s.getRx().getValue()
    shape['ry'] = s.getRy().getValue()
elif type(s) == omero.model.PointI:
    shape['type'] = 'Point'
    shape['cx'] = s.getCx().getValue()
    shape['cy'] = s.getCy().getValue()
elif type(s) == omero.model.LineI:
    shape['type'] = 'Line'
    shape['x1'] = s.getX1().getValue()
    shape['x2'] = s.getX2().getValue()
    shape['y1'] = s.getY1().getValue()
    shape['y2'] = s.getY2().getValue()
elif type(s) in (omeo.model.MaskI, omero.model.LabelI, omero.model.PolygonI):
    print type(s), " Not supported by this code"
    # Do some processing here, or just print:
    print "Shape:",
    for key, value in shape.items():
        print " ", key, value,
    print ""

• Remove shape from ROI

result = roiService.findByImage(imageId, None)
for roi in result.rois:
    for s in roi.copyShapes():
        # Find and remove the Shape we added above
        if s.getTextValue() and s.getTextValue().getValue() == "test-Ellipse":
            print "Removing Shape from ROI..."
            roi.removeShape(s)
            roi = updateService.saveAndReturnObject(roi)

• Close connection:

# When you are done, close the session to free up server resources.
conn._closeSession()

Delete data

• Create a connection

conn = BlitzGateway(USERNAME, PASSWORD, host=HOST, port=PORT)
conn.connect()

• Configuration

projectId = 507          # NB: This will be deleted!

• Load the Project
project = conn.getObject("Project", projectId)
if project is None:
    import sys
    sys.stderr.write("Error: Object does not exist.\n")
    sys.exit(1)

print "Project: ", project.getName()

• Delete Project

# You can delete a number of objects of the same type at the same
# time. In this case ‘Project’. Use deleteChildren=True if you are
# deleting a Project and you want to delete Datasets and Images.
obj_ids = [projectId]
deleteChildren = False
handle = conn.deleteObjects("Project", obj_ids,
    deleteAnns=True, deleteChildren=deleteChildren)

• Retrieve callback and wait until delete completes

# This is not necessary for the Delete to complete. Can be used
# if you want to know when delete is finished or if there were any errors
cb = omero.callbacks.CmdCallbackI(conn.c, handle)
print "Deleting, please wait."
while not cb.block(500):
    print ".",
    err = isinstance(cb.getResponse(), omero.cmd.ERR)
    print "Error?", err
    if err:
        print cb.getResponse()
    cb.close(True)  # close handle too

• Close connection:

# When you are done, close the session to free up server resources.
conn._closeSession()

Render Images

• Create a connection

conn = BlitzGateway(USERNAME, PASSWORD, host=HOST, port=PORT)
conn.connect()

• Configuration

imageId = 27544

• Get thumbnail

# Thumbnail is created using the current rendering settings on the image
image = conn.getObject("Image", imageId)
img_data = image.getThumbnail()
renderedThumb = Image.open(StringIO(img_data))
#renderedThumb.show()  # shows a pop-up
renderedThumb.save("thumbnail.jpg")

• Get current settings

print "Channel rendering settings:
for ch in image.getChannels():
    print "Name: ", ch.getLabel()  # if no name, get emission wavelength or index
    print "Color: ", ch.getColor().getHtml()
    print "Active: ", ch.isActive()
    print "Levels:" , ch.getWindowStart(), "-", ch.getWindowEnd()
print "isGreyscaleRenderingModel: ", image.isGreyscaleRenderingModel()

• Render each channel as a separate greyscale image

image.setGreyscaleRenderingModel()
sizeC = image.getSizeC()
z = image.getSizeZ() / 2
for c in range(1, sizeC + 1):  # Channel index starts at 1
    channels = [c]  # Turn on a single channel at a time
    image setActiveChannels(channels)
    renderedImage = image.renderImage(z, t)

    #renderedImage.show()  # popup (use for debug only)
    renderedImage.save("channel%s.jpg" % c)  # save in the current folder

• Turn 3 channels on, setting their colours

image.setColorRenderingModel()
channels = [1, 2, 3]
colorList = ["F00", None, "FFFF00"]  # do not change colour of 2nd channel
image.setActiveChannels(channels, colors=colorList)
image.setProjection("intmax")  # max intensity projection ‘intmean’ for mean-intensity
renderedImage = image.renderImage(z, t)  # z and t are ignored for projections

    #renderedImage.show()
renderedImage.save("all_channels.jpg")
image.setProjection("normal")  # turn off projection

• Turn 2 channels on, setting levels of the first one

channels = [1, 2]
rangeList = [[100.0, 120.2], [None, None]]
image.setActiveChannels(channels, windows=rangeList)
renderedImage = image.renderImage(z, t, compression=0.5)  # default compression is 0.9

    #renderedImage.show()
renderedImage.save("two_channels.jpg")

• Save the current rendering settings

image.saveDefaults()

• Close connection:

    # When you are done, close the session to free up server resources.
    conn._closeSession()
Create Image

- Create a connection

```python
cconn = BlitzGateway(USERNAME, PASSWORD, host=HOST, port=PORT)
cconn.connect()
```

- Configuration

```python
imageId = 27544 # This image must have at least 2 channels
```

- Create an image from scratch

```python
# This example demonstrates the usage of the convenience method
# createImageFromNumpySeq() Here we create a multi-dimensional image from a
# hard-coded array of data.

from numpy import array, int8

sizeX, sizeY, sizeZ, sizeC, sizeT = 5, 4, 1, 2, 1
plane1 = array([[0, 1, 2, 3, 4], [5, 6, 7, 8, 9], [0, 1, 2, 3, 4], [5, 6, 7, 8, 9]], dtype=int8)
plane2 = array([[5, 6, 7, 8, 9], [0, 1, 2, 3, 4], [5, 6, 7, 8, 9], [0, 1, 2, 3, 4]], dtype=int8)
planes = [plane1, plane2]

def planeGen():
    """generator will yield planes""
    for p in planes:
        yield p

desc = "Image created from a hard-coded arrays"
i = cconn.createImageFromNumpySeq(planeGen(), "numpy image",
    sizeZ, sizeC, sizeT, description=desc, dataset=None)
```

- Create an Image from an existing image

```python
# We are going to create a new image by passing the method a 'generator' of 2D
# planes This will come from an existing image, by taking the average of 2 channels.
zctList = []
image = cconn.getObject('Image', imageId)
sizeZ, sizeC, sizeT = image.getSizeZ(), image.getSizeC(), image.getSizeT()
dataset = image.getParent()
pixels = image.getPrimaryPixels()
newSizeC = 1

def planeGen():
    """set up a generator of 2D numpy arrays."
    
    for z in range(sizeZ): # all Z sections
        channel0 = pixels.getPlane(z, 0, t)
        channel1 = pixels.getPlane(z, 1, t)
```

The createImage method below expects planes in the order specified here (for z.. for c.. for t..)

```python
for z in range(sizeZ):
    for c in range(newSizeC):
        for t in range(sizeT): # all time-points
            channel10 = pixels.getPlane(z, 0, t)
            channel11 = pixels.getPlane(z, 1, t)
```
Here we can manipulate the data in many different ways. As an example we are doing "average"
newPlane = (channel0 + channel1) / 2  # average of 2 channels
print "newPlane for z,t:", z, t, newPlane.dtype, newPlane.min(), newPlane.max()
yield newPlane

desc = "Image created from Image ID: %s by averaging Channel 1 and Channel 2" % imageId
i = conn.createImageFromNumpySeq(planeGen(), "new image",
    sizeZ, newSizeC, sizeT, description=desc, dataset=dataset)

• Close connection:

    # When you are done, close the session to free up server resources.
    conn._closeSession()

Filessets - New in OMERO 5

• Create a connection

    conn = BlitzGateway(USERNAME, PASSWORD, host=HOST, port=PORT)
    conn.connect()

• Configuration

    imageId = 101

• Get the ‘Fileset’ for an Image

    # A Fileset is a collection of the original files imported to
    # create an image or set of images in OMERO.
    image = conn.getObject("Image", imageId)
    fileset = image.getFileset()  # will be None for pre-FS images
    fsId = fileset.getId()
    # List all images that are in this fileset
    for fsImage in fileset.copyImages():
        print fsImage.getId(), fsImage.getName()
    # List original imported files
    for origFile in fileset.listFiles():
        name = origFile.getName()
        path = origFile.getPath()
        print path, name

• Get Original Imported Files directly from the image

    # this will include pre-FS data IF images were archived on import
    print image.countImportedImageFiles()
    # specifically count Fileset files
    fileCount = image.countFilesetFiles()
    # list files
    if fileCount > 0:
        for origFile in image.getImportedImageFiles():
            name = origFile.getName()
            path = origFile.getPath()
            print path, name
• Can get the Fileset using conn.getObject()

```
fileset = conn.getObject("Fileset", fsId)
```

• Close connection:

```
# When you are done, close the session to free up server resources.
conn._closeSession()
```

## Python OMERO.scripts

It is relatively straightforward to take the code samples above and re-use them in OMERO.scripts. This allows the code to be run on the OMERO server and called from either the OMERO.insight client or OMERO.web by any users of the server. See [OMERO.scripts user guide](http://downloads.openmicroscopy.org/latest/omero5/api/epydoc/omero.scripts.html).

### 13.2 Blitz Gateway documentation

The epydoc-generated documentation of methods provided by OMERO Gateway is available showing [wrapper classes](http://downloads.openmicroscopy.org/latest/omero5/api/epydoc/omero.gateway-module.html).

Specifically, the API for the ‘conn’ connection wrapper created above is [here](http://downloads.openmicroscopy.org/latest/omero5/api/epydoc/omero.gateway._BlitzGateway-class.html).

When working with [OMERO model objects](http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/model.html) (omero.model.Image etc) the Gateway will wrap these objects in classes such as [omero.gateway.ImageWrapper](http://downloads.openmicroscopy.org/latest/omero5/api/epydoc/omero.gateway._ImageWrapper-class.html) to handle object loading and hierarchy traversal. For example:

```python
>>> for p in conn.listProjects():       # Initially we just load Projects
...    print p.getName()              ...
...    for dataset in p.listChildren():  # lazy-loading of Datasets here
...        print "$ ".*, dataset.getName()
...
TestProject
Aurora-B
tiff stacks
test
siRNAi
CENP
survivin
```

#### 13.2.1 Access to the OMERO API services

If you need access to API methods that are not provided by the gateway library, you can get hold of the [OMERO Application Programming Interface](http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/ServiceFactory.html).

**Note:** These services will always work with omero.model objects and not the gateway wrapper objects.

The gateway handles creation and reuse of the API services, so that new ones are not created unnecessarily. Services can be accessed using the methods of the underlying [Service Factory](http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/ServiceFactory.html) with the Gateway handling reuse as needed. Stateless services (those retrieved with get… methods E.g. `getQueryService()` are always reused for each call, E.g. `blitzon.getQueryService()` whereas stateful services E.g. `createRenderingEngine()` may be created each time.

---

Not all methods of the service factory are currently supported in the gateway. You can get an idea of the currently supported services by looking at the source code under the `_createProxies` method.

Example: ContainerService can load Projects and Datasets in a single call to server (no lazy loading)

```python
cs = conn.getContainerService()
projects = cs.loadContainerHierarchy("Project", None, None)
for p in projects:
    print p.getName().getValue()  # need to 'unwrap' rstring
    for d in p.linkedDatasetList():
        print d.getName().getValue()
```

13.2.2 Stateful services, reconnection, error handling etc

The Blitz gateway was designed for use in the OMERO.web framework and it is not expected that stateful services will be maintained on the client for significant time. There is various error-handling functionality in the Blitz gateway that will close existing services and recreate them in order to maintain a working connection. If this happens then any stateful services that you have on the client-side will become stale. We will attempt to document this a little better in due course, but our general advice is to create, use and close the stateful services in the shortest practicable time.

13.2.3 Overwriting and extending omero.gateway classes

When working with `omero.gateway` or wrapper classes such as `omero.gateway.ImageWrapper` you might want to add your own functionality or customize an existing one. NB: Note the call to `omero.gateway.refreshWrappers()` to ensure that your subclasses are returned by calls to `getObjects()` For example:

```python
class MyBlitzGateway (omero.gateway.BlitzGateway):
    def __init__(self, *args, **kwargs):
        super(MyBlitzGateway, self).__init__(*args, **kwargs)

        # do something, e.g. add new field...
        self.new_field = 'foo'

    def connect (self, *args, **kwargs):
        rv = super(MyBlitzGateway, self).connect(*args,**kwargs)

        if rv:
            # do something, e.g. modify new field...
            self.new_field = 'bla'

        return rv

omero.gateway.BlitzGateway = MyBlitzGateway

class MyBlitzObjectWrapper (object):

    @annotation_counter = None

    def countAnnotations (self):
        
        Count on annotations linked to the object and set the value on the custom field 'annotation_counter'.

        @return     Counter
        ```
```

---

13http://downloads.openmicroscopy.org/latest/omero5/api/epydoc/omero.gateway._BlitzGateway-class.html

13.2. Blitz Gateway documentation
if self.annotation_counter is not None:
    return self.annotation_counter
else:
    container = self._conn.getContainerService()
    m = container.getCollectionCount(self._obj.__class__.__name__,
                                      type(self._obj).ANNOTATIONLINKS,
                                      [self._oid], None)
    if m[self._oid] > 0:
        self.annotation_counter = m[self._oid]
        return self.annotation_counter
    else:
        return None

class ImageWrapper (MyBlitzObjectWrapper, omero.gateway.ImageWrapper):
    ""
    omero_model_ImageI class wrapper overwrite omero.gateway.ImageWrapper
    and extends MyBlitzObjectWrapper.
    ""
    
def __prepare__(self, **kwargs):
        if kwargs.has_key('annotation_counter'):
            self.annotation_counter = kwargs['annotation_counter']

ero.gateway.ImageWrapper = ImageWrapper

# IMPORTANT to update the map of wrappers for 'Image' etc. returned by getObjects("Image")
nero.gateway.refreshWrappers()

This page provides some background information on the OMERO Python client `gateway` (omero.gateway module) and describes work to improve the API, beginning with the OMERO 4.3 release.

The Blitz Gateway is a Python client-side library that facilitates working with the OMERO API, handling connection to the server, loading of data objects and providing convenience methods to access the data. It was originally designed as part of the OMERO.web framework framework, to provide connection and data retrieval services to various web clients. However, we have now decided to encourage its use for all access to the OMERO Python API.

13.2.4 Wrapper objects

The Gateway consists of a number of wrapper objects:

Connection wrapper

The BlitzGateway class (see API of development code\(^{15}\)) is a wrapper for the OMERO client and session objects. It provides various methods for connecting to the OMERO server, querying the status or context of the current connection and as a starting point for retrieving data objects from OMERO.

from omero.gateway import *

conn = BlitzGateway("username", "password", host="localhost", port=4064)
conn.connect()

for p in conn.listProjects():
    print p.name

Model object wrappers

OMERO model objects, E.g. omero.model.Project, omero.model.Pixels etc (see full list\(^{16}\)) are code-generated and mapped to the OMERO database schema. They are language agnostic and their data is in the form of omero.rtypes as described:  

\(^{15}\)http://downloads.openmicroscopy.org/latest/omero5/api/epydoc/omero.gateway.BlitzGateway-class.html

\(^{16}\)http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/model.html
To facilitate work in Python, particularly in web page templates, these Python model objects are wrapped in Blitz Object Wrappers. This hides the use of rtypes.

```python
import omero
from omero.model import *
from omero.rtypes import *
p = omero.model.ProjectI()
p.name = rstring("My Project")  # attributes are all rtypes
print p.getName().getValue()  # getValue() to unwrap the rtype
print p.name.val  # short-hand
```

These wrappers also have a reference to the BlitzGateway connection wrapper, so they can make calls to the server and load more data when needed (lazy loading).

E.g.

```python
# connect as above
for p in conn.listProjects():
    print p.name
    for dataset in p.listChildren():  # lazy loading of datasets, wrapped in DatasetWrapper
        print "Dataset", d.name
```

### Wrapper coverage

The OMERO data model has a large number of objects, not all of which are used by the OMERO.web framework framework. For this reason, the Blitz gateway (which was originally built for OMERO.web framework) has not yet been extended to wrap every omero.model object with a specific Blitz Object Wrapper. The current list of object wrappers can be found in the omero.gateway module API17. As more functionality is provided by the Blitz Gateway, the coverage of object wrappers will increase accordingly.

## 13.3 OMERO Command Line Interface

See also:

**OMERO Command Line Interface** User documentation on the Command Line Interface

**OMERO Command Line Interface** System Administrator documentation for the Command Line Interface

13.3.1 Extensions

Plugins can be written and put in the `lib/python/omero/plugins` directory. On execution, all plugins in that directory are registered with the CLI. Alternatively, the “–path” argument can be used to point to other plugin files or directories.

Thread-safety

The `omero.cli.CLI` should be considered thread-unsafe. A single connection object is accessible from all plugins via `self.ctx.conn(args)`, and it is assumed that changes to this object will only take place in the current thread. The CLI instance itself, however, can be passed between multiple threads, as long as only one accesses it sequentially, possibly via locking.

See also:

* Extending OMERO  Other extensions to OMERO

The following should be considered a design document. A portion of the functionality is included in the milestone OMERO-Beta4\(^{18}\) and later releases, but more functionality will continually be added. If you would like to request a particular function, please open a ticket.

13.3.2 Design plans

General notes:

- `bin/omero` will find its installation. Therefore, to install OMERO it is only necessary to unpack the bundle, and put `bin/omero` somewhere on your path.
- Any command can be produced by symlinking `bin/omero` to a file of the form “omero-command-arg1-arg2”. This is useful under `/etc/rc.d` to have a startup script.
- All commands respond to `omero help`.

13.4 OMERO Java language bindings

Using the Ice Java mapping\(^{19}\) from ZeroC\(^{20}\), OMERO provides access to your data within an OMERO.blitz server from Java code.

13.4.1 Using the `omero_client.jar`

The `omero_client.jar` is a combination of all necessary Java OMERO class as well as the Ice classes needed to write a complete Java client for OMERO.blitz.

The library is placed under OMERO_HOME/dist/lib/client by the build. To use OMERO Java language bindings, setup you will need to setup your CLASSPATH:

```bash
CLASSPATH=path/omero_client.jar
javac mycode
```

13.4.2 Extended classpath

To access all the functionality available in omero_client.jar or to use the importer, you will need more jar files. To see all the current requirements, take a look at the builds on jenkins\(^{21}\), or alternatively examine the dependencies in the ivy.xml files (e.g. components/insight/ivy.xml\(^{22}\))

---

\(^{18}\)http://trac.openmicroscopy.org.uk/ome/milestone/OMERO-Beta4

\(^{19}\)http://doc.zeroc.com/display/Ice/Hello+World+Application

\(^{20}\)http://www.zeroc.com

\(^{21}\)http://ci.openmicroscopy.org/

\(^{22}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/insight/ivy.xml
13.4.3 Connect to OMERO

- **Connect to the server.** Remember to close the session.

```java
client client = new client(hostName, port);
ServiceFactoryPrx entry = client.createSession(userName, password);
// if you want to have the data transfer encrypted then you can
// use the entry variable otherwise use the following
client unsecureClient = client.createClient(false);
ServiceFactoryPrx entryUnencrypted = unsecureClient.getSession();

//Retrieve the user id.
long userId = entryUnencrypted.getAdminService().getEventContext().userId;
long groupId = entryUnencrypted.getAdminService().getEventContext().groupId;

- **Close connection. IMPORTANT**

```java
client.closeSession();
//if unsecure client exists.
if (unsecureClient != null) unsecureClient.closeSession();
```

13.4.4 Read data

The IContainer service provides method to load the data management hierarchy in OMERO. A list of examples follows, indicating how to load Project, Dataset, Screen, etc.

- **Retrieve the projects** owned by the user currently logged in.

```java
If a Project contains Datasets, the Datasets will automatically be loaded.

IContainerPrx proxy = entryUnencrypted.getContainerService();
ParametersI param = new ParametersI();
long userId = entryUnencrypted.getAdminService().getEventContext().userId;
param.exp(omero.rtypes.rlong(userId));
param.leaves(); //indicate to load the images
//param.noLeaves(); //no images loaded, this is the default value.
List<IObject> results = proxy.loadContainerHierarchy(
    Project.class.getName(), new ArrayList<Long>(), param);
//You can directly interact with the IObject or the Pojos object.
//Follow interaction with the Pojos.
Iterator<IObject> i = results.iterator();
ProjectData project;
Set<DatasetData> datasets;
Iterator<DatasetData> j;
DatasetData dataset;
while (i.hasNext()) {
    project = new ProjectData((Project) i.next());
    datasets = project.getDatasets();
    j = datasets.iterator();
    while (j.hasNext()) {
        dataset = j.next();
        //Do something here
        //If images loaded.
        //dataset.getImages();
    }
}
```

- **Retrieve the Datasets** owned by the user currently logged in.
IContainerPrx proxy = entryUnencrypted.getContainerService();
ParametersI param = new ParametersI();
long userId = entryUnencrypted.getAdminService().getEventContext().userId;
param.exp(omero.rtypes.rlong(userId));

//indicate to load the images
param.leaves();
List<IObject> results = proxy.loadContainerHierarchy(Dataset.class.getName(), new ArrayList<Long>(), param);
//You can directly interact with the IObject or the Pojos object.
//Follow interaction with the Pojos.
Iterator<IObject> i = results.iterator();
DatasetData dataset;
Iterator<ImageData> j;
ImageData image;
while (i.hasNext()) {
    dataset = new DatasetData((Dataset) i.next());
    images = dataset.getImages();
    j = images.iterator();
    while (j.hasNext()) {
        image = j.next();
        //Do something
    }
}

• **Retrieve the Images** contained in a Dataset.

IContainerPrx proxy = entryUnencrypted.getContainerService();
ParametersI param = new ParametersI();
param.leaves(); //indicate to load the images
List<IObject> results = proxy.loadContainerHierarchy(Dataset.class.getName(), Arrays.asList(datasetId), param);
//You can directly interact with the IObject or the Pojos object.
//Follow interaction with the Pojos.
DatasetData dataset = new DatasetData((Dataset) results.get(0));
Set<ImageData> images = dataset.getImages();
Iterator<ImageData> j = images.iterator();
ImageData image;
while (j.hasNext()) {
    image = j.next();
    //Do something
}

• **Retrieve an Image** if the identifier is known.

IContainerPrx proxy = entryUnencrypted.getContainerService();
List<Image> results = proxy.getImages(Image.class.getName(), Arrays.asList(imageId), new ParametersI());
if (results.size() == 0) return;
//You can directly interact with the IObject or the Pojos object.
//Follow interaction with the Pojos.
ImageData image = new ImageData(results.get(0));

• **Access information about the image** for example to draw it.

The model is as follows: Image-Pixels i.e. to access valuable data about the image you need to use the pixels object. We now only support one set of pixels per image (it used to be more!).

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PixelsData pixels = image.getDefaultPixels();
int sizeZ = pixels.getSizeZ(); // The number of z-sections.
int sizeT = pixels.getSizeT(); // The number of timepoints.
int sizeC = pixels.getSizeC(); // The number of channels.
int sizeX = pixels.getSizeX(); // The number of pixels along the X-axis.
int sizeY = pixels.getSizeY(); // The number of pixels along the Y-axis.

- **Retrieve Screening data** owned by the user currently logged in.

Note that the wells are not loaded.

IContainerPrx proxy = entryUnencrypted.getContainerService();
ParametersI param = new ParametersI();
long userId = entryUnencrypted.getAdminService().getEventContext().userId;
param.exp(omero.rtypes.rlong(userId));
List<IObject> results = proxy.loadContainerHierarchy(Screen.class.getName(), new ArrayList(), param);
// You can directly interact with the IObject or the Pojos object.
// Follow interaction with the Pojos.
Iterator<IObject> i = results.iterator();
ScreenData screen;
Set<PlateData> plates;
Iterator<PlateData> j;
PlateData plate;
while (i.hasNext()) {
    screen = new ScreenData((Screen) i.next());
    plates = screen.getPlates();
    j = plates.iterator();
    while (j.hasNext()) {
        plate = j.next();
    }
}

- **Retrieve Wells within a Plate.**

Given a plate ID, load the wells. You will have to use the findAllByQuery method from the IQuery service.

IQueryPrx proxy = entryUnencrypted.getQueryService();
StringBuilder sb = new StringBuilder();
ParametersI param = new ParametersI();
param.addLong("plateID", plateId);
sb.append("select well from Well as well ");
sb.append("left outer join fetch well.plate as pt ");
sb.append("left outer join fetch well.wellSamples as ws ");
sb.append("left outer join fetch ws.plateAcquisition as pa ");
sb.append("left outer join fetch ws.image as img ");
sb.append("left outer join fetch img.pixels as pix ");
sb.append("left outer join fetch pix.pixelsType as pt ");
sb.append("where well.plate.id = :plateID");
if (plateAcquisitionId > 0) {
    sb.append(" and pa.id = :acquisitionID");
    param.addLong("acquisitionID", plateAcquisitionId);
}
List<IObject> results = proxy.findAllByQuery(sb.toString(), param);
Iterator<IObject> i = results.iterator();
WellData well;
while (i.hasNext()) {
    well = new WellData((Well) i.next());
    // Do something
}
13.4.5 Raw data access

- Retrieve a given plane.

This is useful when you need the pixels intensity.

```
// To retrieve the image, see above.
PixelsData pixels = image.getDefaultPixels();
int sizeZ = pixels.getSizeZ();
int sizeT = pixels.getSizeT();
int sizeC = pixels.getSizeC();
long pixelsId = pixels.getId();
RawPixelsStorePrx store = entryUnencrypted.createRawPixelsStore();
store.setPixelsId(pixelsId, false);
for (int z = 0; z < sizeZ; z++) {
    for (int t = 0; t < sizeT; t++) {
        for (int c = 0; c < sizeC; c++) {
            byte[] plane = store.getPlane(z, c, t);
            // Do something
        }
    }
}
store.close();
```

- Retrieve a given tile.

```
// To retrieve the image, see above.
PixelsData pixels = image.getDefaultPixels();
int sizeZ = pixels.getSizeZ();
int sizeT = pixels.getSizeT();
int sizeC = pixels.getSizeC();
long pixelsId = pixels.getId();
RawPixelsStorePrx store = entryUnencrypted.createRawPixelsStore();
store.setPixelsId(pixelsId, false);
// tile is the top-left corner
int x = 0;
int y = 0;
int width = pixels.getSizeX()/2;
int height = pixels.getSizeY()/2;
for (int z = 0; z < sizeZ; z++) {
    for (int t = 0; t < sizeT; t++) {
        for (int c = 0; c < sizeC; c++) {
            byte[] plane = store.getTile(z, c, t, x, y, width, height);
            // Do something
        }
    }
}
store.close();
```

- Retrieve a given stack.

This is useful when you need the pixels intensity.

```
// To retrieve the image, see above.
PixelsData pixels = image.getDefaultPixels();
int sizeT = pixels.getSizeT();
int sizeC = pixels.getSizeC();
long pixelsId = pixels.getId();
RawPixelsStorePrx store = entryUnencrypted.createRawPixelsStore();
store.setPixelsId(pixelsId, false);
for (int t = 0; t < sizeT; t++) {
    for (int c = 0; c < sizeC; c++) {
```
byte[] plane = store.getStack(c, t);
    // Do something
}
store.close();

• **Retrieve a given hypercube.**

This is useful when you need the pixels intensity.

    //To retrieve the image, see above.
    PixelsData pixels = image.getDefaultPixels();
    long pixelsId = pixels.getId();
    RawPixelsStorePrx store = entryUnencrypted.createRawPixelsStore();
    store.setPixelsId(pixelsId, false);
    // offset values in each dimension XYZCT
    List<Integer> offset = new ArrayList<Integer>();
    offset.add(0);
    offset.add(0);
    offset.add(0);
    offset.add(0);
    offset.add(0);
    List<Integer> size = new ArrayList<Integer>;
    size.add(pixels.getSizeX());
    size.add(pixels.getSizeY());
    size.add(pixels.getSizeZ());
    size.add(pixels.getSizeC());
    size.add(pixels.getSizeT());
    // indicate the step in each direction, step = 1,
    // will return values at index 0, 1, 2.
    // step = 2, values at index 0, 2, 4 etc.
    List<Integer> step = new ArrayList<Integer>;
    step.add(1);
    step.add(1);
    step.add(1);
    step.add(1);
    step.add(1);
    byte[] values = store.getHypercube(offset, size, step);
    // Do something
    store.close();

### 13.4.6 Write data

• **Create a dataset and link it to an existing project.**

    //Using IObject directly
    Dataset dataset = new DatasetI();
    dataset.setName(omero.rtypes.rstring("new Name 1"));
    dataset.setDescription(omero.rtypes.rstring("new description 1"));

    //Using pojo object
    DatasetData datasetData = new DatasetData();
    datasetData.setName("new Name 2");
    datasetData.setDescription("new description 2");
    ProjectDatasetLink link = new ProjectDatasetLinkI();
    link.setChild(dataset);
    link.setParent(new ProjectI(projectId, false));
IObject r = entryUnencrypted.getUpdateService().saveAndReturnObject(link);

//With pojo
link = new ProjectDatasetLinkI();
link.setChild(datasetData.asDataset());
link.setParent(new ProjectI(projectId, false));
r = entryUnencrypted.getUpdateService().saveAndReturnObject(link);

• Create a tag (tag annotation) and link it to an existing project.

//Using the IObject.
TagAnnotation tag = new TagAnnotationI();
tag.setTextValue(omero.rtypes.rstring("new tag 1"));
tag.setDescription(omero.rtypes.rstring("new tag 1"));

//Using the Pojo
TagAnnotationData tagData = new TagAnnotationData("new tag 2");
tagData.setTagDescription("new tag 2");

//link project and annotation
ProjectAnnotationLink link = new ProjectAnnotationLinkI();
link.setChild(tag);
link.setParent(new ProjectI(projectId, false));

IObject r = entryUnencrypted.getUpdateService().saveAndReturnObject(link);

//With pojo
link = new ProjectAnnotationLinkI();
link.setChild(tagData.asAnnotation());
link.setParent(new ProjectI(projectId, false));
r = entryUnencrypted.getUpdateService().saveAndReturnObject(link);

• Create a file annotation and link to an image.

To attach a file to an object e.g. an image, few objects need to be created:

1. an OriginalFile
2. a FileAnnotation
3. a link between the Image and the FileAnnotation.

// To retrieve the image see above.
int INC = 262144;
File file = new File(fileToUpload);
String name = file.getName();
String absolutePath = file.getAbsolutePath();
String path = absolutePath.substring(0,
    absolutePath.length()-name.length());

IUpdatePrx iUpdate = entryUnencrypted.getUpdateService(); // service used to write object
// create the original file object.
OriginalFile originalFile = new OriginalFileI();
originalFile.setName(omero.rtypes.rstring(name));
originalFile.setPath(omero.rtypes.rstring(path));
originalFile.setSize(omero.rtypes.rlong(file.length()));
originalFile.setSha1(omero.rtypes.rstring(generatedSha1));
originalFile.setMimetype(omero.rtypes.rstring(fileMimeType)); // or "application/octet-stream"
// now we save the originalFile object
originalFile = (OriginalFile) iUpdate.saveAndReturnObject(originalFile);

// Initialize the service to load the raw data
OMERO Documentation, Release 5.0.2

RawFileStorePrx rawFileStore = entryUnencrypted.createRawFileStore();
rawFileStore.setFileId(originalFile.getId().getValue());

FileInputStream stream = new FileInputStream(file);
long pos = 0;
int rlen;
byte[] buf = new byte[INC];
ByteBuffer bbuf;
while ((rlen = stream.read(buf)) > 0) {
    rawFileStore.write(buf, pos, rlen);
    pos += rlen;
    bbuf = ByteBuffer.wrap(buf);
    bbuf.limit(rlen);
}
stream.close();

originalFile = rawFileStore.save();
// Important to close the service
rawFileStore.close();

//now we have an original File in the database and raw data uploaded.
// We now need to link the Original file to the image using
// the File annotation object. This is the way to do it.
FileAnnotation fa = new FileAnnotationI();
fa.setFile(originalFile);
fa.setDescription(omero.rtypes.rstring(description));
fa.setNs(omero.rtypes.rstring(NAME_SPACE_TO_SET)); // The name space you have set to identify the file and

// save the file annotation.
fa = (FileAnnotation) iUpdate.saveAndReturnObject(fa);

// now link the image and the annotation
ImageAnnotationLink link = new ImageAnnotationLinkI();
link.setChild(fa);
l其所asParent(image.asImage());
// save the link back to the server.
link = (ImageAnnotationLink) iUpdate.saveAndReturnObject(link);
// To attach to a Dataset use DatasetAnnotationLink;

• Load all the annotations with a given namespace linked to images.

long userId = entryUnencrypted.getAdminService().getEventContext().userId;
List<String> nsToInclude = new ArrayList<String>();
nsToInclude.add(NAME_SPACE_TO_SET);
List<String> nsToExclude = new ArrayList<String>();
ParametersI param = new ParametersI();
param.exp(omero.rtypes.rlong(userId)); //load the annotation for a given user.
IMetadataPrx proxy = entryUnencrypted.getMetadataService();
// retrieve the annotations linked to images, for datasets use: omero.model.Dataset.class
List<Annotation> annotations = proxy.loadSpecifiedAnnotations(FileAnnotation.class.getName(), nsToInclude, nsToExclude, param);
//Do something with annotations.

• Read the attachment.

First load the annotations, cf. above.

Iterator<Annotation> j = annotations.iterator();
Annotation annotation;
FileAnnotationData fa;
RawFileStorePrx store = entryUnencrypted.createRawFileStore();
i int index = 0;
File file = new File(downloadFileName); //This file should be there.
FileOutputStream stream = new FileOutputStream(file);
OriginalFile of;
while (j.hasNext()) {
    annotation = j.next();
    if (annotation instanceof FileAnnotation && index == 0) { //read the first one.
        fa = new FileAnnotationData((FileAnnotation) annotation);
        //The id of the original file
        of = getOriginalFile(fa.getFileID());
        store.setFileId(fa.getFileID());
        int offset = 0;
        long size = of.getSize().getValue();
        //name of the file
        //of.getName().getValue();
        try {
            for (offset = 0; (offset+INC) < size;) {
                stream.write(store.read(offset, INC));
                offset += INC;
            }
        } finally {
            stream.write(store.read(offset, (int) (size-offset)));
            stream.close();
        }
    } break;
}
store.close();

13.4.7 How to use OMERO tables

- Create a table.

In the following example, we create a table with 2 columns.

```java
/**
 * Creates a number of empty rows.
 * @param rows The number of rows.
 * @return See above.
 */
private Column[] createColumns(int rows)
{
    Column[] newColumns = new Column[2];
    newColumns[0] = new LongColumn("Uid", ",", new long[rows]);
    return newColumns;
}
```

int rows = 1;
String name = UUID.randomUUID().toString();
Column[] columns = createColumns(rows);

//create a new table.
TablePrx table = entryUnencrypted.sharedResources().newTable(1, name);

//initialize the table
table.initialize(columns);
//add data to the table.
rows = 2;
Column[] newRow = createColumns(rows);
LongColumn uids = (LongColumn) newRow[0];
LongColumn myLongs = (LongColumn) newRow[1];
for (int i = 0; i < rows; i++) {
    uids.values[i] = i;
    myLongs.values[i] = i;
}

table.addData(newRow);
OriginalFile file = table.getOriginalFile(); // if you need to interact with the table

- Read the contents of the table.

file = new OriginalFileI(file.getId(), false);
table = entryUnencrypted.sharedResources().openTable(file);

//read headers
Column[] cols = table.getHeaders();
for (int i = 0; i < cols.length; i++) {
    String colName = cols[i].name;
}

// Depending on size of table, you may only want to read some blocks.
long[] columnsToRead = new long[cols.length];
for (int i = 0; i < cols.length; i++) {
    columnsToRead[i] = i;
}

// The number of columns we wish to read.
long[] rowSubset = new long[(int) (table.getNumberOfRows()-1)];
for (int j = 0; j < rowSubset.length; j++) {
    rowSubset[j] = j;
}
Data data = table.slice(columnsToRead, rowSubset); // read the data.
cols = data.columns;
for (int j = 0; j < cols.length; j++) {
    Column c = cols[j];
}
table.close();

13.4.8 ROIs

To learn about the model see developers/roi.html. Note that annotation can be linked to ROI.

- Create ROI.

In this example, we create an ROI with a rectangular shape and attach it to an image.

//to retrieve the image see above.
Roi roi = new RoiI();
roi.setImage(image);
Rect rect;
rect = new RectI();
rect.setX(omero.rtypes.rdouble(10));
rect.setY(omero.rtypes.rdouble(10));
rect.setWidth(omero.rtypes.rdouble(10));
rect.setHeight(omero.rtypes.rdouble(10));
rect.setTheZ(omero.rtypes.rint(0));

http://www.openmicroscopy.org/site/support/ome-model/developers/roi.html
rect.setTheT(omero.rtypes.rint(0));

//Add the shape
roi.addShape(rect);

//Create an ellipse.
EllipseI ellipse = new EllipseI();
ellipse.setCx(omero.rtypes.rdouble(10));
ellipse.setCy(omero.rtypes.rdouble(10));
ellipse.setRx(omero.rtypes.rdouble(10));
ellipse.setRy(omero.rtypes.rdouble(10));
ellipse.setTheZ(omero.rtypes.rint(0));
ellipse.setTheT(omero.rtypes.rint(0));
ellipse.setTextValue(omero.rtypes.rstring("ellipse text"));

//Add the shape
roi.addShape(ellipse);

//Save ROI and shape
roi = (Roi) entryUnencrypted.getUpdateService().saveAndReturnObject(roi);

//now check that the shape has been added.
ROIData roiData = newROIData(roi);
//Retrieve the shape on plane (z, t) = (0, 0)
List<ShapeData> shapes = roiData.getShapes(0, 0);
Iterator<ShapeData> i = shapes.iterator();
while (i.hasNext()) {
    ShapeData shape = i.next();
    //plane info
    int z = shape.getZ();
    int t = shape.getT();
    long id = shape.getId();
    if (shape instanceof RectangleData) {
        RectangleData rectData = (RectangleData) shape;
        //Handle rectangle
    } else if (shape instanceof EllipseData) {
        EllipseData ellipseData = (EllipseData) shape;
        //Handle ellipse
    } else if (shape instanceof LineData) {
        LineData lineData = (LineData) shape;
        //Handle line
    } else if (shape instanceof PointData) {
        PointData pointData = (PointData) shape;
        //Handle point
    }
}

• Retrieve ROIs linked to an Image.

// Retrieve the roi linked to an image
RoiResult r = entryUnencrypted.getRoiService().findByImage(image.getId().getValue(), new RoiOptions());
if (r == null) return;
List<Roi> rois = r.rois;
List<Shape> list;
Iterator<Roi> j = rois.iterator();
while (j.hasNext()) {
    roi = j.next();
    list = roi.copyShapes();
    //Do something
}

• Remove a shape from ROI.
// Retrieve the roi linked to an image
RoiResult r = entryUnencrypted.getRoiService().findByImage(image.getId().getValue(), new RoiOptions());
List<Roi> rois = r.rois;
List<Shape> list;
Iterator<Roi> j = rois.iterator();
while (j.hasNext()) {
    roi = j.next();
    list = roi.copyShapes();
    // remove the first shape.
    if (list.size() > 0) {
        roi.removeShape(list.get(0));
        //update the roi.
        entryUnencrypted.getUpdateService().saveAndReturnObject(roi);
    }
}

13.4.9 Delete data

It is possible to delete Projects, datasets, images, ROIs etc. and objects linked to them depending on the specified options (see Deleting in OMERO).

- Delete Image.

In the following example, we create an image and delete it.

```java
//First create an image.
Image img = new Image();
img.setName(omero.rtypes.rstring("image1"));
img.setDescription(omero.rtypes.rstring("descriptionImage1"));
img.setAcquisitionDate(omero.rtypes.rtime(1000000));
img = (Image) entryUnencrypted.getUpdateService().saveAndReturnObject(img);
DeleteCommand[] cmds = new DeleteCommand[1];
//Command to delete the image.
cmds[0] = new DeleteCommand("/Image", img.getId().getValue(), null);
DeleteHandlePrx handle = entryUnencrypted.getDeleteService().queueDelete(cmds);

//If you want to interact with call-back and handle.
DeleteCallbackI cb = new DeleteCallbackI(client, handle);
DeleteReport[] reports = handle.report();
for (int i = 0; i < reports.length; i++) {
    DeleteReport report = reports[i];
    String error = report.error;
}
```

13.4.10 Render Images

- Initialize the rendering engine and render an image.

```java
//See above how to load the image.
PixelsData pixels = image.getDefaultPixels();
long pixelsId = pixels.getId();
RenderingEnginePrx proxy = entryUnencrypted.createRenderingEngine();
proxy.lookupPixels(pixelsId);
if (!proxy.lookupRenderingDef(pixelsId)) {
    proxy.resetDefaults();
    proxy.lookupRenderingDef(pixelsId);
}
```
proxy.load();
// Now can interact with the rendering engine.
proxy.setActive(0, Boolean.valueOf(false));
// to render the image uncompressed
PlaneDef pDef = new PlaneDef();
pDef.z = 0;
pDef.t = 0;
pDef.slice = omero.romio.XY.value;
// render the data uncompressed.
int[] uncompressed = proxy.renderAsPackedInt(pDef);
byte[] compressed = proxy.renderCompressed(pDef);

//Create a buffered image
ByteArrayInputStream stream = new ByteArrayInputStream(compressed);
BufferedImage image = ImageIO.read(stream);

// Close
proxy.close();

• Retrieve thumbnails.

//See above how to load the image.
PixelsData pixels = image.getDefaultPixels();
ThumbnailStorePrx store = entryUnencrypted.createThumbnailStore();
PixelsData pixels = image.getDefaultPixels();
Map<Long, byte[]> map = store.getThumbnailByLongestSideSet(
    omero.rtypes.rint(96), Arrays.asList(pixels.getId()));
//Convert the byte array
Entry entry;
Iterator i = map.entrySet().iterator();
ByteArrayInputStream stream;
//Create a buffered image to display
Map<Long, BufferedImage> results = new HashMap<Long, BufferedImage>();
while (i.hasNext()) {
    entry = (Entry) i.next();
    stream = new ByteArrayInputStream((byte[]) entry.getValue());
    results.put((Long) entry.getKey(), ImageIO.read(stream));
}

13.4.11 Create Image

The following example shows how to create an Image from an Image already in OMERO. Similar approach can be applied when uploading an image.

//See above how to load an image.
PixelsData pixels = image.getDefaultPixels();
int sizeZ = pixels.getSizeZ();
int sizeT = pixels.getSizeT();
int sizeC = pixels.getSizeC();
int sizeX = pixels.getSizeX();
int sizeY = pixels.getSizeY();
long pixelsId = pixels.getId();

//Read the pixels from the source image.
RawPixelsStorePrx store = entryUnencrypted.createRawPixelsStore();
store.setPixelsId(pixelsId, false);
List<byte[]> planes = new ArrayList<byte[]>();
for (int z = 0; z < sizeZ; z++) {
    for (int t = 0; t < sizeT; t++) {
        planes.add(store.getPlane(z, 0, t));
    }
}

// Better to close to free space.
store.close();

// Now we are going to create the new image.
IPixelsPrx proxy = entryUnencrypted.getPixelsService();

// Search for PixelsType object matching the source image.
List<IObject> l = proxy.getAllEnumerations(PixelsType.class.getName());
Iterator<IObject> i = l.iterator();
PixelsType type = null;
String original = pixels.getPixelType();
while (i.hasNext()) {
    PixelsType o = (PixelsType) i.next();
    String value = o.getValue().getValue();
    if (value.equals(original)) {
        type = o;
        break;
    }
}
if (type == null)
    throw new Exception("Pixels Type not valid.");

// Create new image.
String name = "newImageFrom"+image.getId();
RLong idNew = proxy.createImage(sizeX, sizeY, sizeZ, sizeT, Arrays.asList(0), type, name,
                   "From Image ID: "+image.getId());
if (idNew == null)
    throw new Exception("New image could not be created.");
ImageData newImage = loadImage(idNew.getValue());

// Link the new image and the dataset hosting the source image.
DatasetImageLink link = new DatasetImageLinkI();
link.setParent(new DatasetI(datasetId, false));
link.setChild(new ImageI(newImage.getId(), false));
entryUnencrypted.getUpdateService().saveAndReturnObject(link);

// Write the data.
store = entryUnencrypted.createRawPixelsStore();
store.setPixelsId(newImage.getDefaultPixels().getId(), false);
int index = 0;
for (int z = 0; z < sizeZ; z++) {
    for (int t = 0; t < sizeT; t++) {
        store.setPlane(planes.get(index++), z, 0, t);
    }
}

// Save the data.
store.save();
store.close();

13.4.12 Further information

For the details behind writing, configuring, and executing a client, please see Working with OMERO.

See also:

13.4. OMERO Java language bindings
13.5 OMERO MATLAB language bindings

See Developing OMERO clients and OME-Remote Objects, for an introduction to Object.

13.5.1 Installing the OMERO.matlab toolbox

- Download the latest released version from the download page.[25]
- Unzip the directory anywhere on your system.
- In MATLAB, move to the newly unzipped directory and run loadOmero;
- The MATLAB files are now on your path, and the necessary jars are on your java classpath. You can change directories and still have access to OMERO.

Once OMERO.matlab is installed, the typical workflow is:
1. Creating a connection
2. Keeping your session alive
3. Creating an unencrypted session (optional)
4. Do some work (load objects, work with them, upload to the server…)
5. Closing your connection
6. Unloading OMERO (optional)

As a quickstart example, the following lines create a secure connection to a server, read a series of images and close the connection:

```matlab
client = loadOmero(servername, port);
session = client.createSession(user, password);
client.enableKeepAlive(60);
images = getImages(session, ids);
client.closeSession();
```

Examples of usage of the OMERO.matlab toolbox are provided in the training examples[26] directory.

13.5.2 Configuring the OMERO.matlab connection

Creating a connection

As described under Working with OMERO, there are several ways to configure your connection to an OMERO server. OMERO.matlab comes with a few conveniences for making this work.

If you run client = loadOmero(); (i.e. loadOmero with an output argument), then OMERO.matlab will try to configure the omero.client object for you. First, it checks the ICE_CONFIG environment variable. If set, it will let the omero.client constructor initialize itself. Otherwise, it looks for the file ice.config in the current directory. The OMERO.matlab toolbox comes with a default ice.config file pointing at localhost. To use this configuration file, you should replace localhost by your server address.

Alternatively, you can pass the same parameters to loadOmero; that you would pass to omero.client:

```matlab
>> omero_client_1 = loadOmero('localhost');
>> omero_client_2 = omero.client('localhost');
```

[26]https://github.com/openmicroscopy/openmicroscopy/tree/develop/examples/Training/matlab
Or, if you want a session created directly, the following are equivalent:

```matlab
>> [client1, session1] = loadOmero('localhost');
>> client2 = loadOmero('localhost');
>> session2 = client2.createSession()
```

### Keeping your session alive

For executing any long running task, you will need a background thread which keeps your session alive. If you are familiar with MATLAB Timers you can use `omeroKeepAlive.m` directly or modify it to your liking.

```matlab
>> [c, s] = loadOmero;
>> t = omeroKeepAlive(c); % Create a 60-second timer and starts it
>> ...
>> delete(t); % Disable the keep-alive
```

Alternatively, you can use the Java-based `enableKeepAlive` method, but it is not configurable from within MATLAB:

```matlab
c.enableKeepAlive(60); % Call session.keepAlive() every 60 seconds
c.closeSession(); % Close session to end the keep-alive
```

### Creating an unencrypted session

Once a session has been created, if you want to speed up the data transfer, you can create and use an unencrypted session as:

```matlab
unsecureClient = client.createClient(false);
sessionUnencrypted = unsecureClient.getSession();
```

### Closing your connection

When you are done with OMERO, it is critical that you close your connection to save resources:

```matlab
client.closeSession();
clear client1;
clear session1;
```

If you created an unencrypted session, you will need to close the unsecure session as well:

```matlab
client.closeSession();
unsecureClient.closeSession();
```

### Unloading OMERO

Then if you would like, you can unload OMERO as well:

```matlab
unloadOmero();
```

You may see the following warning when unloading OMERO:

---

27https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/omeroKeepAlive.m
>> unloadOmero()
Warning: Objects of omero/client class exist - not clearing java
> In javaclasspath>doclear at 377
   In javaclasspath>local_javapath at 194
   In javaclasspath at 105
   In javarmpath at 48
   In unloadOmero at 75

While unloading OMERO, found java objects left in workspace.
Please remove with 'clear <name>' and then run 'unloadOmero'
again. Printing all objects...

Name    Size  Bytes  Class       Attributes
 c      1x1       omero.client

Closing session(s) for 1 found client(s): c

This means that there is still an OMERO.matlab object in your workspace. If not listed, use whos to find such objects, and clear to remove them. After that, run unloadOmero() again:

>> clear c
>> unloadOmero()

**Warning:** You should also unload OMERO before installing a new version of OMERO.matlab or calling loadOmero again.

If you need to create another session without unloading/loading OMERO again, use the omero.client object directly:

>> [c, s] = loadOmero(arg1, arg2);
>> c = omero.client(arg3, arg4);
>> s = c.createSession();

### 13.5.3 Reading data

The IContainer service provides methods to load the data management hierarchy in OMERO – projects, datasets… A list of examples follows indicating how to load projects, datasets, screens…

- **Projects**

The projects owned by the user currently logged in can be retrieved using the getProjects function:

```
projects = getProjects(session)
```

If the project identifiers are known, they can be specified as:

```
projects = getProjects(session, ids)
```

If the projects contain datasets, the datasets will automatically be loaded:

---

28https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/io/getProjects.m
for j = 1 : numel(projects)  
datasetsList = projects(j).linkedDatasetList;  
for i = 0:datasetsList.size()-1,  
d = datasetsList.get(i);  
end  
end

If the datasets contain images, the images will automatically be loaded:

imageList = projects(1).linkedDatasetList.get(0).linkedImageList;

To avoid loading the whole graph (projects, datasets, images), pass false as a second optional argument. Only datasets will be loaded:

unloadedProjects = getProjects(session, ids, false)

• Datasets

The datasets owned by the user currently logged in can be retrieved using the getDatasets\(^{29}\) function:

datasets = getDatasets(session)

If the dataset identifiers are known, they can be specified as:

datasets = getDatasets(session, ids)

If the datasets contain images, the images will automatically be loaded:

imageList = datasets(1).linkedImageList;

To avoid loading the images, pass false as a second optional argument:

unloadedDatasets = getDatasets(session, ids, false)

• Images

All the images owned by the user currently logged in can be retrieved using the getImages\(^{30}\) function:

images = getImages(session)

If the image identifiers are known, they can be specified as:

images = getImages(session, ids)

All the images contained in a subset of datasets of known identifiers datasetsIds can be returned using:

datasetImages = getImages(session, ‘dataset’, datasetsIds)

All the images contained in all the datasets under a subset of projects of known identifiers projectIds can be returned using:

\(^{29}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/io/getDatasets.m  
\(^{30}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/io/getImages.m
The `getImages` function retrieves images for a project:

```java
projectImages = getImages(session, 'project', projectIds)
```

The **Image-Pixels** model implies you need to use the **Pixels** objects to access valuable data about the Image:

```java
pixels = image.getPrimaryPixels();
sizeZ = pixels.getSizeZ().getValue(); % The number of z-sections.
sizeT = pixels.getSizeT().getValue(); % The number of timepoints.
sizeC = pixels.getSizeC().getValue(); % The number of channels.
sizeX = pixels.getSizeX().getValue(); % The number of pixels along the X-axis.
sizeY = pixels.getSizeY().getValue(); % The number of pixels along the Y-axis.
```

**Screens**

The screens owned by the user currently logged in can be retrieved using the `getScreens` function:

```java
screens = getScreens(session)
```

If the screen identifiers are known, they can be specified as:

```java
screens = getScreens(session, ids)
```

Note that the wells are not loaded. The plate objects can be accessed using:

```java
for j = 1 : numel(screens),
    platesList = screens(j).linkedPlateList;
    for i = 0:platesList.size()-1,
        plate = platesList.get(i);
        plateAcquisitionList = plate.copyPlateAcquisitions();
        for k = 0:plateAcquisitionList.size()-1,
            pa = plateAcquisitionList.get(i);
        end
    end
end
```

**Plates**

The plates owned by the user currently logged in can be retrieved using the `getPlates` function:

```java
plates = getPlates(session)
```

If the plate identifiers are known, they can be specified as:

```java
plates = getPlates(session, ids)
```

**Wells**

Given a plate identifier, the wells can be loaded using the `findAllByQuery` method:

```java
wellList = session.getQueryService().findAllByQuery(
    ['select well from Well as well '...
    'left outer join fetch well.plate as pt '...
    'left outer join fetch well.wellSamples as ws '...
    'left outer join fetch ws.plateAcquisition as pa '...
    'left outer join fetch ws.image as img '...
```

---

32. https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/io/getPlates.m
'left outer join fetch img.pixels as pix '...
'left outer join fetch pix.pixelsType as pt '...
'where well.plate.id = ', num2str(plateId), [']);

for j = 0:wellList.size()-1,
    well = wellList.get(j);
    wellsSampleList = well.copyWellSamples();
    well.getId().getValue()
    for i = 0:wellsSampleList.size()-1,
        ws = wellsSampleList.get(i);
        ws.getId().getValue()
        pa = ws.getPlateAcquisition();
    end
end

13.5.4 Raw data access

You can retrieve data, plane by plane or retrieve a stack.

• Plane
The plane of an input image at coordinates (z, c, t) can be retrieved using the getPlane\(^{33}\) function:

plane = getPlane(session, image, z, c, t);

Alternatively, the image identifier can be passed to the function:

plane = getPlane(session, imageID, z, c, t);

• Tile
The tile of an input image at coordinates (z, c, t) originated at (x, y) and of dimensions (w, h) can be retrieved using the getTile\(^{34}\) function:

tile = getTile(session, image, z, c, t, x, y, w, h);

Alternatively, the image identifier can be passed to the function:

tile = getTile(session, imageID, z, c, t, x, y, w, h);

• Stack
The stack of an input image at coordinates (c, t) can be retrieved using the getStack\(^{35}\) function:

stack = getStack(session, image, c, t);

Alternatively, the image identifier can be passed to the function:

stack = getStack(session, imageID, c, t);

• Hypercube
This is useful when you need the Pixels intensity.

\(^{33}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/image/getPlane.m
\(^{34}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/image/getTile.m
\(^{35}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/image/getStack.m
% Create the store to load the stack. No access via the gateway
store = session.createRawPixelsStore();
% Indicate the pixels set you are working on
store.setPixelsId(pixelsId, false);

% Offset values in each dimension XYZCT
offset = java.util.ArrayList;
offset.add(java.lang.Integer(0));
offset.add(java.lang.Integer(0));
offset.add(java.lang.Integer(0));
offset.add(java.lang.Integer(0));
offset.add(java.lang.Integer(0));

size = java.util.ArrayList;
size.add(java.lang.Integer(sizeX));
size.add(java.lang.Integer(sizeY));
size.add(java.lang.Integer(sizeZ));
size.add(java.lang.Integer(sizeC));
size.add(java.lang.Integer(sizeT));

% Indicate the step in each direction,
% step = 1, will return values at index 0, 1, 2.
% step = 2, values at index 0, 2, 4...
step = java.util.ArrayList;
step.add(java.lang.Integer(1));
step.add(java.lang.Integer(1));
step.add(java.lang.Integer(1));
step.add(java.lang.Integer(1));
step.add(java.lang.Integer(1));

% Retrieve the data
store.getHypercube(offset, size, step);
% Close the store
store.close();

13.5.5 Annotations

The following table lists all OMERO.matlab functions used to manipulate annotations from OMERO:

<table>
<thead>
<tr>
<th>Tag</th>
<th>File</th>
<th>Comment</th>
<th>XML</th>
</tr>
</thead>
<tbody>
<tr>
<td>Get by identifier</td>
<td>getTagAnnotations</td>
<td>getFileAnnotations</td>
<td>getCommentAnnotations</td>
</tr>
<tr>
<td>Linked to images</td>
<td>getImageTagAnnotations</td>
<td>getImageFileAnnotations</td>
<td>getImageCommentAnnotations</td>
</tr>
<tr>
<td>Linked to datasets</td>
<td>getDatasetTagAnnotations</td>
<td>getDatasetFileAnnotations</td>
<td>getDatasetCommentAnnotations</td>
</tr>
<tr>
<td>Linked to projects</td>
<td>getProjectTagAnnotations</td>
<td>getProjectFileAnnotations</td>
<td>getProjectCommentAnnotations</td>
</tr>
<tr>
<td>Linked to screens</td>
<td>getScreenTagAnnotations</td>
<td>getScreenFileAnnotations</td>
<td>getScreenCommentAnnotations</td>
</tr>
<tr>
<td>Linked to plates</td>
<td>getPlateTagAnnotations</td>
<td>getPlateFileAnnotations</td>
<td>getPlateCommentAnnotations</td>
</tr>
<tr>
<td>Write</td>
<td>writeTagAnnotation</td>
<td>writeFileAnnotation</td>
<td>writeCommentAnnotation</td>
</tr>
</tbody>
</table>

---

36https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getTagAnnotations.m
37https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getFileAnnotations.m
38https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getCommentAnnotations.m
39https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getXmlAnnotations.m
40https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getImageTagAnnotations.m
41https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getImageFileAnnotations.m
42https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getImageCommentAnnotations.m
43https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getImageXmlAnnotations.m
44https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getDatasetTagAnnotations.m
45https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getDatasetFileAnnotations.m
46https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getDatasetCommentAnnotations.m
47https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getDatasetXmlAnnotations.m
48https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getProjectTagAnnotations.m
49https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getProjectFileAnnotations.m
50https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getProjectCommentAnnotations.m
51https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getProjectXmlAnnotations.m
52https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getScreenTagAnnotations.m
53https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getScreenFileAnnotations.m
54https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getScreenCommentAnnotations.m
55https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getScreenXmlAnnotations.m
56https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getPlateTagAnnotations.m
57https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getPlateFileAnnotations.m
58https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getPlateCommentAnnotations.m
59https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getPlateXmlAnnotations.m

13.5. OMERO MATLAB language bindings 221
• Reading annotations

If the identifier of the annotation of a given type is known, the annotation can be retrieved from the server using the corresponding function, e.g. for tags using the `getTagAnnotations` function:

```matlab
tagAnnotations = getTagAnnotations(session, tagIds);
```

Alternatively, the annotations of a given type linked to a given object can be retrieved using the corresponding function, e.g. to retrieve all tags linked to images `getImageTagAnnotations` function:

```matlab
tagAnnotations = getImageTagAnnotations(session, imageIds);
```

Annotations can be filtered by namespace. To include only annotations with a given namespace `ns`, use the `include` parameter/key value:

```matlab
tagAnnotations = getImageTagAnnotations(session, imageIds, 'include', ns);
```

To exclude all annotations with a given namespace `ns`, use the `exclude` parameter/key value:

```matlab
tagAnnotations = getImageTagAnnotations(session, imageIds, 'exclude', ns);
```
tagAnnotations = getImageTagAnnotations(session, imageIds, 'exclude', ns);

By default, only the annotations owned by the session owner are returned. To specify the owner of the annotations, use the owner parameter/key value pair. For instance to return all tag annotations owned by user 5:

tagAnnotations = getImageTagAnnotations(session, imageIds, 'owner', 5);

To retrieve all annotations independently of their owner, use -1 as the owner identifier:

tagAnnotations = getImageTagAnnotations(session, imageIds, 'owner', -1);

• Reading file annotations

The content of a file annotation can be downloaded to local disk using the `getFileAnnotationContent` function. If the file annotation has been retrieved from the server as `fileAnnotation`, then the content of its `OriginalFile` can be downloaded under `target_file` using:

`getFileAnnotationContent(session, fileAnnotation, target_file);`

Alternatively, if only the identifier of the file annotation `faId` is known:

`getFileAnnotationContent(session, faId, target_file);`

• Writing annotations

New annotations can be created using the corresponding `write*Annotation` function (see table above). Existing annotations can be linked to existing objects on the server using the `linkAnnotation` function.

For example, to create a new tag annotation `tag_name` and attach it to the image `image_id`:

`tagAnnotation = writeTagAnnotation(session, tag_name);`  
`link = linkAnnotation(session, tagAnnotation, 'Image', image_id);`

To create a file annotations from the content of a `local_file_path` and attach it to the image `image_id`:

`fileAnnotation = writeFileAnnotation(session, local_file_path);`  
`link = linkAnnotation(session, fileAnnotation, 'Image', image_id);`

For existing file annotations, it is possible to replace the content of the original file without having to recreate a new file annotation using the `updateFileAnnotation` function. If the file annotation has been retrieved from the server as `fileAnnotation`, then the content of its `OriginalFile` can be replaced by the content of `local_file_path` using:

`updateFileAnnotation(session, fileAnnotation, local_file_path);`

13.5.6 Writing data

• Create a Dataset and link it to an existing project.

94 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/getFileAnnotationContent.m  
95 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/linkAnnotation.m  
96 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/annotations/updateFileAnnotation.m
dataset = omero.model.DatasetI;
dataset.setName(omero.rtypes.rstring(char('name dataset')));
dataset.setDescription(omero.rtypes.rstring(char('description dataset')));

% Link Dataset and Project
link = omero.model.ProjectDatasetLinkI;
link.setChild(dataset);
link.setParent(omero.model.ProjectI(projectId, false));

session.getUpdateService().saveAndReturnObject(link);

13.5.7 How to use OMERO tables

• Create a table. In the following example, a table is created with 2 columns.

name = char(java.util.UUID.randomUUID());
columns = javaArray('omero.grid.Column', 2)
columns(1) = omero.grid.LongColumn('Uid', 'testLong', []);
valuesString = javaArray('java.lang.String', 1);
columns(2) = omero.grid.StringColumn('MyStringColumn', '', 64, valuesString);

% Create a new table.
table = session.sharedResources().newTable(1, name);

% Initialize the table
table.initialize(columns); % Add data to the table.
data = javaArray('omero.grid.Column', 2);
data(1) = omero.grid.LongColumn('Uid', 'test Long', [2]);
valuesString = javaArray('java.lang.String', 1);
valuesString(1) = java.lang.String('add');
data(2) = omero.grid.StringColumn('MyStringColumn', '', 64, valuesString);
table.addData(data);

% Read the contents of the table.
of = omero.model.OriginalFileI(file.getId(), false);
tablePrx = session.sharedResources().openTable(of);

% Read headers
headers = tablePrx.getHeaders();
for i=1:size(headers, 1),
    headers(i).name; % name of the header
    % Do something
end

% Depending on the size of table, you may only want to read some blocks.
cols = [0:size(headers, 1)-1]; % The number of columns you wish to read.
rows = [0:tablePrx.getNumberOfRows()-1]; % The number of rows you wish to read.
data = tablePrx.slice(cols, rows); % Read the data.
c = data.columns;
for i=1:size(c),
    column = c(i);
    % Do something
end
tablePrx.close(); % Important to close when done.
13.5.8 ROIs

To learn about the model, see the developers guide to the ROI model[^97]. Note that annotations can be linked to ROI.

- Creating ROI

This example creates a ROI with two shapes, a rectangle and an ellipse, and attaches it to an image:

```matlab
% First create a rectangular shape.
rectangle = createRectangle(0, 0, 10, 20);
% Indicate on which plane to attach the shape
setShapeCoordinates(rectangle, 0, 0, 0);

% First create an ellipse shape.
ellipse = createEllipse(0, 0, 10, 20);
% Indicate on which plane to attach the shape
setShapeCoordinates(ellipse, 0, 0, 0);

% Create the roi.
roi = omero.model.RoiI;
% Attach the shapes to the roi, several shapes can be added.
roi.addShape(rectangle);
roi.addShape(ellipse);

% Link the roi and the image.
roi.setImage(omero.model.ImageI(imageId, false));
% Save
iUpdate = session.getUpdateService();
roi = iUpdate.saveAndReturnObject(roi);
% Check that the shape has been added.
numShapes = roi.sizeOfShapes;
for ns = 1:numShapes
    shape = roi.getShape(ns-1);
end
```

See also:

ROI utility functions[^98] OMERO.matlab functions for creating and managing Shape and ROI objects.

- Retrieving ROIs linked to an image

```matlab
service = session.getRoiService();
roiResult = service.findByImage(imageId, []);
rois = roiResult.rois;
n = rois.size;
shapeType = '';
for thisROI = 1:n
    roi = rois.get(thisROI-1);
    numShapes = roi.sizeOfShapes;
    for ns = 1:numShapes
        shape = roi.getShape(ns-1);
        if (isa(shape, 'omero.model.Rect'))
            rectangle = shape;
            rectangle.getX().getValue()
        elseif (isa(shape, 'omero.model.Ellipse'))
            ellipse = shape;
            ellipse.getCx().getValue()
        elseif (isa(shape, 'omero.model.Point'))
            point = shape;
            point.getX().getValue();
        elseif (isa(shape, 'omero.model.Line'))
            line = shape;
            line.getX1().getValue();
    end
end
```

[^97]: http://www.openmicroscopy.org/site/support/ome-model/developers/roi.html
[^98]: OMERO.MATLAB language bindings
• Removing a shape from ROI

```java
// Retrieve the roi linked to an image
service = session.getRoiService();
roiResult = service.findByImage(imageId, []);
for thisROI = 1:n
    roi = rois.get(thisROI - 1);
    numShapes = roi.sizeOfShapes;
    for ns = 1:numShapes
        shape = roi.getShape(ns - 1);
        % Remove the shape
        roi.removeShape(shape);
    end
% Update the roi.
    roi = iUpdate.saveAndReturnObject(roi);
end
```

13.5.9 Deleting data

It is possible to delete projects, datasets, images, ROIs… and objects linked to them depending on the specified options (see Deleting in OMERO). For example, images of known identifiers can be deleted from the server using the `deleteImages` function:

```java
deleteImages(session, imageIds);
```

See also:

- `deleteProjects`
- `deleteDatasets`
- `deleteScreens`
- `deletePlates` Utility functions to delete objects

13.5.10 Rendering images

The `RenderImages.m` example script shows how to initialize the rendering engine and render an image.

13.5.11 Creating Image

The `CreateImage.m` example script shows how to create an image in OMERO. A similar approach can be applied when uploading an image. To upload individual planes onto the server, the data must be converted into a byte (int8) array first. If the Pixels object has been created, this conversion can done using the `toByteArray` function.

13.6 OMERO C++ language bindings

Using the Ice C++ language mapping from ZeroC, OMERO provides native access to your data from C++ code. The `build-cpp` build target produces a platform-dependent shared library which can be linked to your application.

**Binaries are not provided**, therefore it will be necessary for you to compile your own.

---

99 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/delete/deleteImages.m
100 https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/Training/matlab/deleteProjects.m
101 https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/Training/matlab/deleteDatasets.m
102 https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/Training/matlab/deleteScreens.m
103 https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/Training/matlab/deletePlates.m
104 https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/Training/matlab/CreateImage.m
105 https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/Training/matlab/CreateImage.m
106 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroM/src/helper/toByteArray.m
107 http://doc.zeroc.com/display/IceHelloWorldApplication
108 http://www.zeroc.com
13.6.1 Prerequisites

- The OMERO source code
- A C++ compiler
  - GCC is recommended for Linux and MacOS X
  - Visual Studio or the Platform SDK for Windows
- The ZeroC Ice libraries, headers and slice definitions

13.6.2 Restrictions

Ice 3.3 and Ice 3.4 will only build with GCC versions older than 4.6 (they contain broken headers which newer GCC versions will not parse). GCC 4.4 is tested and recommended.

Ice 3.5 will build with any GCC version up to 4.8, the latest stable version; later versions may work, but are untested.

The version of GCC and/or Ice provided on your system should be compatible, but if you are restricted to a particular version of GCC or Ice, you may need to obtain or build a compatible version of Ice or GCC, respectively.

13.6.3 Preparing to build

Begin by following the instructions under Installing OMERO from source on acquiring the source code. Be sure that the git branch you are using matches the version of your server!

Set the ICE_HOME environment variable for your installation. This location varies depending upon the installation location and Ice version in use. Some possible locations for the 3.5.0 version of Ice follow. Note these are just examples; you need to adjust them for the Ice installation path and version in use.

- Ice built from source and installed into /opt:
  ```
  export ICE_HOME=/opt/Ice-3.5.0
  ```
- Ice installed on Linux using RPM packages:
  ```
  export ICE_HOME=/usr/share/Ice-3.5.0
  ```
- MacOS with homebrew:
  ```
  export ICE_HOME=/usr/local/Cellar/ice/3.5.0
  ```
- Windows using Visual Studio:
  ```
  set ICE_HOME=C:\Ice-3.5.0
  ```

Users of a package manager will also need to set ICE_HOME if the Ice paths are not automatically detected correctly. The slice2xxx tools generally don’t pick up the location of the slice definitions by default if this is unset.

**Note:** If the Ice headers and libraries are not present on the standard search paths, these will need to be specified using the CPPPATH and LIBPATH environment variables (see below).

Windows users building with Visual Studio will also need to run the Visual Studio environment setup scripts:

```
C:\Documents and Settings\USER>c:\Program Files (x86)\Microsoft Visual Studio 9.0\VC\vcvarsall.bat
Setting environment for using Microsoft Visual Studio 2008 x86 tools.
```

or otherwise guarantee that the your environment is properly configured. For the 64bit build, be sure to use the right setup, namely *Start→Microsoft Visual Studio 2008→Visual Studio Tools→Visual Studio +2008 Command Prompt.*
13.6.4 Building the library

To build the C++ dynamic library:

```
cd omero
./build.py
./build.py build-cpp
```

or

```
./build.py build-all
```

If you would like to build the C++ tests, you can run:

```
./build.py test-compile-all
./build.py test-unit
```

or to test only C++:

```
./build.py -f components/tools/OmeroCpp/build.xml test
```

**Note:** If you would like to work on just the C++ code without worrying about the rest of the build, you can install `scons` and use it directly. Alternatively, you can use the `scons` version which comes with the OMERO source code:

```
cd components/tools/OmeroCpp && python ../../../target/scons/scons.py test
```

This does require having run the top-level build (`build.py`) at least once.

**Note:** If the build fails with errors such as

```
Checking for C++ header file Ice/Ice.h... no
Fatal Error: Ice/Ice.h not found
```

this can be caused by the Ice headers not being installed or not being on the search path. However, also check components/tools/OmeroCpp/config.log. If this contains error messages such as

```
/usr/include/Ice/ProxyHandle.h:176:13: error: ‘upCast’ was not declared in this scope, and no declarations were found by argument-dependent lookup at the point of instantiation
```

this is caused by the Ice headers being buggy, and newer versions of GCC rejecting the invalid code. To compile in this situation, add `-fpermissive` to `CXXFLAGS` to allow the invalid code to be accepted, but do note that this may also mask other problems so should not be used unless strictly needed.

13.6.5 Further build configuration

The C++ bindings use `scons`\(^{109}\) as a build system. `scons` provides several hooks into its operation. The following environment variables as defined in `components/blitz/blitz_tools.py`\(^{110}\) are considered:

**ARCH** Either x86 or x64. x64 will be used by default on a 64-bit machine, otherwise x86

---

\(109\)http://www.scons.org

\(110\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/blitz/blitz_tools.py
CPPPATH directories to be searched for include files, for example

    -I/opt/Ice-3.5.0/include

A : or ; separator character is used to separate directories, depending on the platform.

CXXFLAGS standard make-like CXXFLAGS variable

CXX compiler executable. Useful with ccache\(^{111}\).

LIBPATH directories to be searched for libraries, for example

    -L/opt/Ice-3.5.0/lib

Directories are separated by : or ; as with CPPPATH.

ICE_HOME your Ice installation. The contained include directory will be added to your CPPPATH, but the contained lib
directory will not be added to your LIBPATH since this may not contain the needed 32- or 64-bit libraries; this will need
setting with the correct value for your system.

J specifies the number of concurrent build tasks as with make.

RELEASE debug or Os (i.e. optimize for size). debug is used by default.

VERBOSE show the actual build commands rather than the pretty “Compiling XYZ…” statements.

Zip files containing the C++ header files, the libraries, and source code are placed under OMERO_HOME/target with other zip
artifacts.

Note: If you are using make, you can unpack the main zip (e.g. OMERO.cpp-<version>-64dbg.zip) to some directory
(OMERO_DIST) and follow the instructions below to get started. For help with other build systems, please contact the mailing
list.

### 13.6.6 Using the library

To use OMERO C++ language bindings it is necessary to point your compiler and linker at the mentioned directories above. A
simple GNU make Makefile might look like this:

```
# MAKEFILE:
#
# Where the OMERO distribution was installed
OMERO_DIST?=/opt/omero

# Where the Ice lib/ and include/ directories are to be found
ICE_HOME?=/usr

INCLUDES=-I$(OMERO_DIST)/include -I$(ICE_HOME)/include

LIBS=-L$(OMERO_DIST)/lib -L$(ICE_HOME)/lib -L$(ICE_HOME)/lib64 \ 
    -lIce -lIceUtil -lGlacier2 -lomero_client -lstdc++

LIBPATH=$(LD_LIBRARY_PATH):$(ICE_HOME)/lib:$ICE_HOME/lib64:$(OMERO_DIST)/lib

.PHONY: clean run

yourcode.o: yourcode.cpp
    $(CXX) $(CXXFLAGS) -c -o $@ $(INCLUDES)

yourcode: yourcode.o
    $(CXX) -o $@ $^ $(LIBS)

run: yourcode
    LD_LIBRARY_PATH="$(LIBPATH)" ./yourcode --Ice.Config=../etc/ice.config
```

\(^{111}\)http://ccache.samba.org/
13.6.7 A trivial example: `yourcode.cpp`

And a simple example file might looking something like the following:

```cpp
// // yourcode.cpp:
//
// Domain
#include <omero/client.h>
#include <omero/api/IAdmin.h>
// Std
#include <iostream>
#include <cassert>
#include <vector>
#include <time.h>
#include <map>

using namespace std;

/*
* Pass "--Ice.Config=your_config_file" to the executable, or
* set the ICE_CONFIG environment variable.
*/

int main(int argc, char* argv[])
{
    omero::client_ptr omero = new omero::client(argc, argv);
    omero::API::ServiceFactoryPrx sf = omero->createSession();
    sf->closeOnDestroy();

    // IAdmin is responsible for all user/group creation, password changing, etc.
    omero::API::IAdminPrx admin = sf->getAdminService();

    // Who you are logged in as.
    cout << admin->getEventContext()->userName << endl;

    // These two services are used for database access
    omero::API::IQueryPrx query = sf->getQueryService();
    omero::API::IUpdatePrx update = sf->getUpdateService();

    return 0;
}
```

This code does not do much. It creates a server session, loads a few services, and prints the user’s name. For serious examples, see Working with OMERO.

13.6.8 Compiling and running your code

Therefore, to compile and run `yourcode`, you will need to download the two files above (`Makefile` and `yourcode.cpp`) and then from the shell:

```bash
make OMERO_DIST=dist yourcode
LD_LIBRARY_PATH=dist/lib ./yourcode --Ice.Config=dist/etc/ice.config
```
where you have edited `dist/etc/ice.config` to contain the values:

```plaintext
omero.host=localhost
omero.user=your_name
omero.pass=your_password
```

Alternatively, you can pass these on the command-line:

```bash
LD_LIBRARY_PATH=dist/lib ./yourcode omero.host=localhost --omero.user=foo --omero.pass=bar
```

### 13.6.9 Notes for Mac users

This example explains how to build on Linux only. For doing the same on Mac OS X, change all instances of `LD_LIBRARY_PATH` to `DYLD_LIBRARY_PATH`.

### 13.6.10 Notes for Visual Studio users

The SConstruct build file in *OMERO C++ language bindings* defines a target `msproj` which can be used to generate an MS Visual Studio project and solution. There is also a similarly named `ant` target:

```bash
build -f components\tools\OmeroCpp\build.xml msproj
```

**Note:** It may be necessary to specify `/Zm1000` as an additional compiler setting.

### 13.6.11 Further information

For the details behind writing, configuring, and executing a client, please see *Working with OMERO*.

**See also:**

Ice\(^{112}\), *OMERO.grid, OMERO Application Programming Interface, Build System, #1596\(^{113}\)* which added 64bit support

---

\(^{112}\)http://www.zeroc.com

\(^{113}\)http://trac.openmicroscopy.org.uk/ome/ticket/1596
CHAPTER
FOURTEEN

ANALYSIS

14.1 Local analysis

If you are interested in running your analysis locally and storing the results to the server, then your first step is to become familiar with the developer documentation.

• The Working with OMERO guide provides numerous examples in each language with explanations and tries to be a starting point for anyone who wants to write code which talks to the OMERO server.

• Most of the OMERO Application Programming Interface is covered by the Javadocs\(^1\).

• Each of the languages has extra information on its own page:
  – OMERO C++ language bindings
  – OMERO Java language bindings
  – OMERO MATLAB language bindings
  – OMERO Python language bindings

Once you have your local analysis working, you can push it onto the server for background processing using the OMERO scripting service.

14.2 Storing external data in OMERO

There are several options for storing external or schema-less data in OMERO, including StructuredAnnotations for small quantities of data, or extending the OME model, but this risks interoperability issues. (See Extending Omero).

For larger volumes of data, or data which needs to be queried, OMERO.tables provides a unified solution for the storage of columnar data from various sources, such as automated analysis results or script-based processing, and makes them available within OMERO.

14.2.1 Third-party analysis and OMERO.tables

Support has been added for some third-party analysis data, which gets converted in OMERO into a common format. These formats include:

• MIAS data, measurements, and overlays
• InCell data and measurements
• Flex data with Acapella results (screencast\(^2\)). In the Flex case, additional configuration may be necessary for accessing both the raw data and the analysis results. Watch the configuration screencast\(^3\) for more information.

The analysis results which are parsed out of the formats listed above are converted to HDF by the OMERO.tables API. This facility can then be used by clients to visualize the parsed measurements, and in the case of regions of interest, see their location overlaid on the associated image:

\(^1\)http://downloads.openmicroscopy.org/latest/omero5/api/
\(^2\)http://cvs.openmicroscopy.org.uk/snapshots/movies/omero-4-1/mov/FlexPreview4.1-import.mov
\(^3\)http://cvs.openmicroscopy.org.uk/snapshots/movies/omero-4-1/mov/FlexPreview4.1-configuration.mov
14.2.2 Other high-content screening (HCS) data

In addition to the Flex, Mias, and InCell 100 file formats, BD Pathway, Olympus ScanR, and native OME-XML/TIFF files can all be imported as HCS data, though without support for any external analysis data which may be attached. If you are interested in having other analysis formats supported, contact either the open source community or Glencoe Software, Inc.\(^4\) depending on your needs.

14.3 OMERO.tables

The OMERO.tables API unifies the storage of columnar data from various sources, such as automated analysis results or script-based processing, and makes them available within OMERO.

Large and small volumes of tabular data can be stored via named columns, and retrieved in bulk or via paging. A limited query language provides basic filtering and selecting.

For installation instructions, see Installing OMERO.tables

14.3.1 The interface

The slice definition file\(^5\) for the OMERO.tables API primarily defines two service interfaces and a type hierarchy.

**class omero.grid.Table**  The central service for dealing with tabular data, described below.

**class omero.grid.Tables**  An internal service used for managing table services, and can be ignored for almost all purposes.

**class omero.grid.Column**  The base class for column types which permit returning arrays of columnar values (Ice\(^6\) doesn’t provide an Any type, so it is necessary to group values of the same type). All columns in a table must have the same number of rows.

---

\(^4\)http://www.glencoesoftware.com/

\(^5\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/blitz/resources/omero/Tables.ice

\(^6\)http://www.zeroc.com
Single value columns

These columns store a single value in each row.

```python
class omero.grid.FileColumn (name, description[, values])
class omero.grid.ImageColumn (name, description[, values])
class omero.grid.RoiColumn (name, description[, values])
class omero.grid.WellColumn (name, description[, values])
class omero.grid.PlateColumn (name, description[, values])
```

Id-based \((long)\) columns which reference `omeo.model.File`, `Image`, `Roi`, `Well` and `Plate` instances respectively.

```python
class omero.grid.BoolColumn (name, description[, values])
    A value column with `bool` (non-null) values.

class omero.grid.LongColumn (name, description[, values])
    A value column with `long` (non-null, 64-bit) values.

class omero.grid.DoubleColumn (name, description[, values])
    A value column with `double` (non-null, 64-bit) values.
```

Parameters:

- `name (string)` – The name of the column, each column in a table must have a unique name.
- `description (string)` – The column description, may be empty.
- `values ([])` – A list of values (one value per row) used to initialize a column (optional).

Values:

A class member holding the list of values stored in the column.

```python
class omero.grid.StringColumn (name, description, size[, values])
    A value column which holds strings
```

Parameters:

- `name (string)` – The column name.
- `description (string)` – The column description.
- `size (long)` – The maximum string length that can be stored in this column, \(>= 1\)
- `values (string[])` – A list of strings (optional).

Array value columns

These columns store an array in each row.

```python
class omero.grid.FloatArrayColumn (name, description, size[, values])
    A value column with fixed-width arrays of `float` (32 bit) values.

class omero.grid.DoubleArrayColumn (name, description, size[, values])
    A value column with fixed-width arrays of `double` (64 bit) values.

class omero.grid.LongArrayColumn (name, description, size[, values])
    A value column with fixed-width arrays of `long` (64 bit) values.
```

Parameters:

- `name (string)` – The column name.
- `description (string)` – The column description.
- `size (long)` – The width of the array, \(>= 1\)
- `values ([],[])` – A list of arrays, each of length `size` (optional).

**Warning**: The OMERO.tables service currently does limited validation of string and array lengths. When adding or modifying data it is essential that the `size` parameter of a column matches that of the underlying table.
Warning: Array value columns should be considered experimental for now.

Main methods

class omero.grid.Data

  Holds the data retrieved from a table, also used to update a table.

  lastModification
     The timestamp of the last update to the table.

  rowNumbers
     The row indicies of the values retrieved from the table.

  columns
     A list of columns

class omero.grid.Table

  The main interface to the Tables service.

  getHeaders()
     Returns An empty list of columns describing the table. Fill in the values of these columns to add a new row to the table.

  getNumberOfRows()
     Returns The number of rows in the table.

  readCoordinates(rowNumbers)
     Read a set of entire rows in the table.

     Parameters rowNumbers (long[]) – A list of row indicies to be retrieved from the table.

     Returns The requested rows as a Data object.

  read(colNumbers, start, stop)
     Read a subset of columns and rows from a table.

     Parameters

     • colNumber (long[]) – A list of column indicies to be retrieved from the table.

     • start (long) – The index of the first row to retrieve.

     • stop (long) – The index of the last+1 row to retrieve (uses similar semantics to range()).

     Returns The requested columns and rows as a Data object.

Note: start=0, stop=0 currently returns the first row instead of empty as would be expected using the normal Python range semantics. This may change in future.

  getWhereList(condition, variables, start, stop, step)
     Run a query on a table, see Query language.

     Parameters

     • condition (string) – The query string

     • variables – A mapping of strings and variable values to be substituted into condition. This can often be left empty.

     • start (long) – The index of the first row to consider.

     • stop (long) – The index of the last+1 row to consider.

     • step (long) – The stepping interval between the start and stop rows to consider, using the same semantics as range(). Set to 0 to disable stepping.

     Returns A list of row indices matching the condition which can be passed as the first parameter of readCoordinates() or read().
Note: variables seems to add unnecessary complexity, should it be removed?

initialize \((columns)\)

Initialize a new table. Any column values are ignored, use \(addData()\) to add these values.

*Parameters* \(columns\) \((Column[f])\) – A list of columns whose names and types are used to setup the table.

\(addData\) \((columns)\)

Append one or more full rows to the table.

*Parameters* \(columns\) \((Column[f])\) – A list of columns, such as those returned by \(getHeaders()\), whose values are the rows to be added to the table.

\(update\) \((data)\)

Modify one or more columns and/or rows in a table.

*Parameters* \(data\) \((Data)\) – A \(Data\) object previously obtained using \(read()\) or \(readCoordinates()\) with column values to be updated.

You may find the *Python and Java* annotated code samples helpful, in addition to the *examples* and documentation on the API\(^7\). These are only an introduction to using OMERO.tables and do not show its full potential, see *Going forward* for some inspiration.

14.3.2 Examples

- **Hello World**: examples/OmeroTables/first.py\(^8\)
- **Creating a Measurement Table**: examples/OmeroTables/MeasurementTable.java\(^9\)
- **Querying a Table**: examples/OmeroTables/FindMeasurements.java\(^10\)

14.3.3 The implementation

Currently, each table is backed by a single HDF table. Since PyTables (and HDF in the general case) do not support concurrent access, OMERO.tables provides a global locking mechanism which permits multiple views of the same data. Each OMERO.tables file (registered as an *OriginalFile* in the database), is composed of a single HDF table with any number of certain limited column types.

14.3.4 Query language

The query language mentioned above is *currently* the PyTables condition syntax\(^11\). Columns are referenced by name. The following operators are supported:

- **Logical operators**: \&\&, |, ~
- **Comparison operators**: <, <=, ==, !=, >=, >
- **Unary arithmetic operators**: -
- **Binary arithmetic operators**: +, -, *, /, **, %

and the following functions:

- where\((bool, number1, number2)\): number — number1 if the bool condition is true, number2 otherwise.
- \{sin, cos, tan\}\((float|complex)\): float|complex — trigonometric sine, cosine or tangent.
- \{arcsin, arccos, arctan\}\((float|complex)\): float|complex — trigonometric inverse sine, cosine or tangent.
- arctan2\((float1, float2)\): float — trigonometric inverse tangent of float1/float2.
- \{sinh, cosh, tanh\}\((float|complex)\): float|complex — hyperbolic sine, cosine or tangent.

---

\(^7\)[http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/grid/Table.html](http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/grid/Table.html)

\(^8\)[https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroTables/first.py](https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroTables/first.py)

\(^9\)[https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroTables/MeasurementTable.java](https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroTables/MeasurementTable.java)

\(^10\)[https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroTables/FindMeasurements.java](https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroTables/FindMeasurements.java)

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• \{arcsinh, arccosh, arctanh\}(float|complex): float|complex — hyperbolic inverse sine, cosine or tangent.
• \{log, log10, log1p\}(float|complex): float|complex — natural, base-10 and log(1+x) logarithms.
• \{exp, expm1\}(float|complex): float|complex — exponential and exponential minus one.
• sqrt(float|complex): float|complex — square root.
• \{real, imag\}(complex): float — real or imaginary part of complex.
• complex(float, float): complex — complex from real and imaginary parts.

for example, if \texttt{id} is the name of a \texttt{LongColumn}

```
table.getWhereList(condition='(id>x)', variables={'x': omero.rtypes.rint(5)},
                    start=2, stop=10, step=3)
```

will extract a subset of rows (2, 5, 8) as indicated by \texttt{start}, \texttt{stop} and \texttt{step}, substitute 5 in place of \texttt{x} in the \texttt{condition}, and evaluate \texttt{condition} so as to return the indices of rows where column \texttt{id} is greater than 5.

### 14.3.5 Going forward

The Tables API itself provides little more than a remotely accessible store, think of it as a server for Excel-like spreadsheets. We are currently looking into the facilities that can be built on top of it, and are very open to suggestions. For example, the \texttt{IRoi} interface\(^1\) has been extended to filter ROIs by a given measurement. This allows seeing only those results from a particular analysis run. The following example shows how to set up such a measurement and retrieve its results:

\texttt{iroi.py}\(^2\)

For an example of production code that parses out such measurements, see \texttt{populate_roi.py}\(^3\).

The \texttt{IRoi} interface has been integrated into OMERO.insight, allowing for the visualization and export of OMERO.tables:

We are also looking into a NoSQL-style storage mechanism for OMERO, either as an alternative back-end to OMERO.tables or as an additional key-value type store. Any suggestions or ideas would be very welcome.

See also:

- PyTables\(^4\) Software on which OMERO.tables is built.
- Condition Syntax\(^5\) The PyTables condition syntax.
- Tables.ice\(^6\) The API definition for OMERO.tables
- The Tables test suite\(^7\) The testsuite for OMERO.tables

**Installing OMERO.tables** Installation requirements for install OMERO.tables

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\(^1\)http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/IRoi.html

\(^2\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroTables/iroi.py

\(^3\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroPy/src/omero/util/populate_roi.py

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Figure 14.1: Choice between multiple measurements
CHAPTER
FIFTEEN

SCRIPTS - PLUGINS FOR OMERO

15.1 Introduction to OMERO.scripts

OMERO.scripts are the OME version of plugins, allowing you to extend the functionality of your OMERO installation.

The OMERO scripting service allows scripts to be uploaded to the server so that image processing and analysis, and other functionality, can be carried out there rather than on your local machine. Scripts are generally written in Python, but other languages are also supported, like Jython. MATLAB scripts are supported natively as well as via a Python wrapper as described in MATLAB and Python.

Scripts can be run from the OMERO clients, using a UI generated from the script and the results should also be handled where relevant e.g. allowing users to view OMERO Images or Datasets created by the script, or download files or images.

![Figure 15.1: Scripts menu in OMERO.insight](image)

15.1.1 Finding scripts

Core scripts\(^1\) are bundled with every OMERO.server release and automatically available to all users. You can find additional scripts via the new script sharing\(^2\) page.

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\(^1\)https://github.com/ome/scripts
\(^2\)http://www.openmicroscopy.org/site/community/scripts
15.1.2 Installing and running scripts

The easiest way to make use of scripts is for someone with admin rights to upload them to the OMERO.server as described in the OMERO.scripts user guide. Once a script has been added under the lib/scripts directory, you can run them from the OMERO clients or the command line.

15.1.3 Writing scripts

OMERO.scripts user guide describes the workflows for developing and running your own scripts. You should use the Guidelines for writing OMERO.scripts to ensure your script interacts with the OMERO clients in a usable way.

If you are a biologist with no previous coding experience, you may find the Python for Biologists\footnote{http://pythonforbiologists.com/index.php/introduction-to-python-for-biologists/} free online course helpful.
15.1.4 Managing scripts

To keep your scripts up to date, we recommend you use a Github repository to manage your scripts. If you are not familiar with using git\(^4\), you can use the GitHub app for your OS\(^5\) (available for Mac and Windows but not Linux). The basic workflow is:

- fork our omero-user-script\(^6\) repository
- clone it in your lib/scripts directory

```bash
cd lib/scripts;
git clone git@github.com:YOURGITUSERNAME/omero-user-scripts.git YOUR_SCRIPTS
```

- save the scripts you want to use into the appropriate sub-directory in your cloned location lib/scripts/YOUR_SCRIPTS

Your new scripts will then show up in the script menu in the clients, alongside the core ‘omero’ scripts which are shipped with each release. This means you should try to pick unique names to avoid future clashes e.g. Custom_Scripts/Search_Scripts/original_metadata_search.py:

![Figure 15.4: Custom scripts in OMERO.web menu](image)

The OME developers use Github to co-ordinate all our development work so joining the network will help you access help and support, and see what other people are doing with scripts. Cloning our repository also means you have an example script to get you started with developing your own.

15.1.5 Contributing back to the community

If you have modified one of the core scripts or developed your own that you would like to contribute back to the community, please get in touch. We can either add your repository to the list on the script sharing\(^7\) page so people can find it, or if the script is likely to have wide appeal, we can look into adding it to the core scripts that are distributed with an OMERO release.

See also:

OMERO.scripts user guide, Guidelines for writing OMERO.scripts, OMERO.scripts advanced topics and MATLAB and Python

15.2 OMERO.scripts user guide

OMERO.blitz provides a service to run scripts on the server. The scripts are then passed on to a grid of processors called OMERO.grid that executes the script and returns the result to the server which in turn passes the result onto the caller. All scripts are of the form:

\(^4\)http://www.openmicroscopy.org/site/support/contributing/using-git.html
\(^5\)http://help.github.com/articles/set-up-git
\(^6\)https://github.com/ome/omero-user-scripts
\(^7\)http://www.openmicroscopy.org/site/community/scripts
# import the omero package and the omero.scripts package.
import omero, omero.scripts as script

This method creates the client script object, with name SCRIPTNAME and SCRIPTDESCRIPTION.
The script then supplies a number of variables that are both inputs and outputs to the
script. The types allowed are defined in the script package, with the qualifier after the
variable of in, out or inout depending on whether the variable if for input, output or input
and output.

client = script.client("SCRIPTNAME", "SCRIPTDESCRIPTION",
    script.TYPE("VARIABLENAME").[in()|out()|inout()], ..., )

# create a session on the server.
client.createSession()

# All variables are stored in a map accessed by getInput and setOutput via the client object.
VARIABLENAME = client.getInput("VARIABLENAME");
client.setOutput("VARIABLENAME", value);

This is a guide to getting started with the scripting service, without going into the ‘behind the scenes’ details. More technical
details can be found on the OMERO.scripts advanced topics page. In addition to this guide, you may find the following pages
useful for more information on using the OMERO Python API: Working with OMERO, OMERO Python language bindings.

15.2.1 Sample scripts

Below are two sample scripts. You can find the core scripts that are distributed with the OMERO.server under the scripts reposi-
tory\(^8\) or download them from OMERO.insight (from the bottom-left of any run-script dialog), or use the script sharing\(^9\) page to
find scripts written by other users.

Ping script

This script echoes the input parameters as outputs.

```python
import omero, omero.scripts as script
client = script.client("ping.py", "simple ping script",
    script.Long("a"), script.String("b"))
client.createSession()

keys = client.getInputKeys()
print "Keys found:"
print keys
for key in keys:
    client.setOutput(key, client.getInput(key))
```

Accessing an Image and Channels on the server

This example shows usage of the Python Blitz Gateway to access an Image, using its ID. We then list the Channel names and the
script returns them as outputs.

```python
import omero, omero.scripts as scripts
from omero.gateway import BlitzGateway
from omero.rtypes import wrap

# Define the script name & description, and a single ‘required’ parameter
```

---

\(^8\)https://github.com/ome/scripts

\(^9\)http://www.openmicroscopy.org/site/community/scripts
OMERO Documentation, Release 5.0.2

```
client = scripts.client("Get_Channels.py", "Get channel names for an image",
                  scripts.Long("imageId", optional=False))

    # get the Image Id from the parameters.
imageId = client.getInput("imageId", unwrap=True)    # unwrap the rtype

    # Use the Python Blitz Gateway for convenience
conn = BlitzGateway(client_obj=client)

    # get the Image, print its name
image = conn.getObject("Image", imageId)
print image.getName()

# Print each channel ‘label’ (Name or Excitation wavelength)
for i, ch in enumerate(image.getChannels()):
    print ch.getLabel()
    # Return as output. Key is string, value is rtype
    client.setOutput("Channel%s" % i, wrap(str(ch.getLabel())))

# Cleanup
client.closeSession()
```

15.2.2 Script writing as ‘Admin’

The basic steps in a script-writing workflow are:

- Write a script using your favorite text editor, save locally
- Use command line (or OMERO.insight) to upload script to server
- Use command line (or OMERO.insight or web clients) to run script on the server (results will be displayed)
- Edit script and replace copy on server and run again, etc.

Working with scripts is far more straightforward if you have admin access to your OMERO.server installation - this is the preferred workflow. It is possible to work with scripts as a regular user (see OMERO.scripts advanced topics) but the software you would be required to install means it is easier to install a server on your local machine so you have admin rights.

It is assumed that scripts written by a server admin are “trusted” to run on the server without causing any disruption or security risks. Once uploaded these scripts are available to all regular users of the server alongside the official scripts included in each OMERO release.

Download / Edit script

The easiest way to get started is to take an existing script and edit it for your needs. An example created for the purpose of this tutorial can be found at Edit_Descriptions.py. You should organize your scripts on your local machine in a way that makes sense to users, since your local file paths will be mimicked on the server and used to organize script menus in OMERO.insight (see screen-shot above).

```
# Save the script to a suitable location. The tutorial will use this location:
# Desktop/scripts/demo_tutorial/Edit_Descriptions.py
```

The action of this script (editing Image descriptions) is trivial but it demonstrates a number of features that you may find useful, including conventions for inputs and outputs to improve interaction with OMERO.insight (as discussed on the Guidelines for writing OMERO.scripts).

The script is well documented and should get you started. A few points to note:

Since the OMERO 4.3 release, if you are using the ‘Blitz Gateway’, you can get a connection wrapper like this:

10https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/ScriptingService/Edit_Descriptions.py
from omero.gateway import BlitzGateway

conn = BlitzGateway(client_obj=client)
# now you can do E.g. conn.getObject("Image", imageId) etc.

Alternatively, if you are working directly with the OMERO services, you can get a service factory like this:

session = client.getSession()
# now you can do E.g. session.getQueryService() etc.

More example scripts

Several official scripts are included in the release of OMERO and can be found under the lib/scripts/omero/ directory of the server package. Any script can also be download from the OMERO.insight client (bottom-left of the run-script dialog).

**Warning:** If you wish to edit the official scripts that are part of the OMERO release, you should be prepared to apply the same changes to future releases of these scripts from OMERO. If you think that your changes should be included as part of future released scripts, please let us know.

Upload script

You can use the command line, OMERO.insight or the server file system to upload scripts. The `script` command line tool is discussed in more detail below.

You may find it useful to add the OMERO.server/bin/ folder to your PATH so you can call `bin/omero` commands when working in the scripts folder. E.g:

```bash
export PATH=$PATH:/Users/will/Desktop/OMERO.server-5.0.2/bin/

Upload the script we saved earlier, specifying it as ‘official’ (trusted to run on the server processor). You will need to log in the first time you use the `omero script` command. The new script ID will be printed out:

```bash
$ cd Desktop/scripts/
$ omero script upload demo_tutorial/Edit_Descriptions.py --official
Previously logged in to localhost:4064 as root
Server: [localhost] # hit 'enter' to accept default login details
Username: [root]
Password:
Created session 09fcf689-cc85-409d-91ac-f9865dbfd650 (root@localhost:4064). Idle timeout: 10.0 min. Current group: system
Uploaded official script as original file #301

You can add, remove and edit scripts directly in the OMERO_HOME/lib/scripts/omero/ folder. Any changes made here will be detected by OMERO. Official scripts are uniquely identified on the OMERO server by their ‘path’ and ‘name’.

Any folders in the script path are created on the server under /lib/scripts/ E.g. the above example will be stored at /lib/scripts/examples/Edit_Descriptions.py

The ID of the script is printed after upload and can also be determined by listing scripts (see below).

Run script

You can run the script from OMERO.insight by browsing the scripts (see screen-shot above). A UI will be generated from the chosen script and the currently selected images or datasets will be populated if the script supports this (see Guidelines for writing OMERO.scripts).

Or launch the script from the command line, specifying the script ID. You will be asked to provide input for any non-optional parameters that do not have default values specified. Any stdout and stderr will be displayed as well as any outputs that the script has returned.
OMERO Documentation, Release 5.0.2

wjm:examples will$ omero script launch 301 # script ID
Using session 1202acc0-4424-4fa2-84fe-7c9e069d3563 (root@localhost:4064). Idle timeout: 10.0 min. Current group: system
Enter value for "IDs": 1201
Job 1464 ready
Waiting....
Callback received: FINISHED

*** start stdout ***
* {'IDs': [1201L], 'Data_Type': 'Dataset'}
* Processing Images from Dataset: LSM - .mdb
* Editing images with this description:
* No description specified
* Editing image ID: 15651 Name: sample files.mdb [XY-ch-02]
* Editing image ID: 15652 Name: sample files.mdb [XY-ch-03]
* Editing image ID: 15653 Name: sample files.mdb [XY-ch]
* Editing image ID: 15654 Name: sample files.mdb [XYT]
* Editing image ID: 15655 Name: sample files.mdb [XYZ-ch-20x]
* Editing image ID: 15656 Name: sample files.mdb [XYZ-ch-zoom]
* Editing image ID: 15658 Name: sample files.mdb [XYZ-ch0]
* Editing image ID: 15657 Name: sample files.mdb [XYZ-ch]

*** end stdout ***

*** out parameters ***
* Message=8 Images edited
*** done ***

Parameter values can also be specified in the command.

# simply specify the required parameters that don’t have defaults
$ omero script launch 301 IDs=1201

# can also specify additional parameters
$ omero script launch 301 Data_Type='Image' IDs=15652,15653 New_Description="Adding description from script to Image"

Edit and replace

Edit the script and upload it to replace the previous copy, specifying the ID of the file to replace.

$ omero script replace 301 examples/Edit_Descriptions.py

Finally, you can upload and run your scripts from OMERO.insight.

Other script commands

Start by printing help for the script command:

$ omero script -h
usage: /Users/will/Documents/workspace/Omero/dist/bin/omero script [-h] <subcommand> ...

Support for launching, uploading and otherwise managing OMERO.scripts

Optional Arguments:
  In addition to any higher level options

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-h, --help  show this help message and exit

Subcommands:
Use /Users/will/Documents/workspace/Omero/dist/bin/omero script <subcommand> -h for more information.

<subcommand>
  demo  Runs a short demo of the scripting system
  list  List files for user or group
  cat   Prints a script to standard out
  edit  Opens a script in $EDITOR and saves it back to the server
  params  Print the parameters for a given script
  launch  Launch a script with parameters
  disable  Makes script non-executable by setting the mimetype
  enable  Makes a script executable (sets mimetype to text/x-python)
  jobs  List current jobs for user or group
  serve  Start a usermode processor for scripts
  upload  Upload a script
  replace  Replace an existing script with a new value
  run  Run a script with the OMERO libraries loaded and current login

To list scripts on the server:

$ omero script list
Using session 09fcf689-cc85-409d-91ac-f9865d8fd650 (root@localhost:4064). Idle timeout: 10.0 min. Current group: system

id | Official scripts
-----+---------------------------------------------
201 | /omero/analysis_scripts/flim-omero.py
1 | /omero/analysis_scripts/FLIM.py
202 | /omero/export_scripts/Batch_Image_Export.py
203 | /omero/export_scripts/Make_Movie.py
204 | /omero/figure_scripts/Movie_Figure.py
205 | /omero/figure_scripts/Movie_ROI_Figure.py
206 | /omero/figure_scripts/ROI_Split_Figure.py
207 | /omero/figure_scripts/Split_View_Figure.py
208 | /omero/figure_scripts/Thumbnail_Figure.py
8 | /omero/import_scripts/Populate_ROI.py
9 | /omero/setup_scripts/FLIM_initialise.py
209 | /omero/util_scripts/Channel_Offsets.py
210 | /omero/util_scripts/Combine_Images.py
211 | /omero/util_scripts/Images_From_ROIs.py
(14 rows)

If you want to know the parameters for a particular script you can use the params command. This prints out the details of the script, including the inputs.

$ wjm:examples will$ omero script params 301
Using session 1202acc0-4424-4fa2-84fe-7c9e069d3563 (root@localhost:4064). Idle timeout: 10.0 min. Current group: system

id: 301
name: Edit_Descriptions.py
version: 
authors: 
institutions: 
description: Edits the descriptions of multiple Images, either specified via Image IDs or by the Dataset IDs. See http://www.openmicroscopy.org/site/support/omero4/developers/scripts/user-guide.html for the tutorial.
namespaces:
stdout: text/plain
stderr: text/plain
inputs:
  New_Description - The new description to set for each Image in the Dataset

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Optional: True
Type: ::omero::RString
Min:
Max:
Values:
IDs - List of Dataset IDs or Image IDs
Optional: False
Type: ::omero::RList
Subtype: ::omero::RLong
Min:
Max:
Values:
Data_Type - The data you want to work with.
Optional: False
Type: ::omero::RString
Min:
Max:
Values: Dataset, Image
outputs:

15.2.3 Debugging scripts

The stderr and stdout from running a script should always be returned to you, either when running scripts from the command line, via OMERO.insight or using the scripts API. This should allow you to debug any problems you have.

You can also look at the output from the script in the OriginalFile directory, commonly stored in /OMERO/File/. The script file when executed is uploaded as a new OriginalFile, and the standard error, standard out are saved as the next two OriginalFiles after that. These files can be opened in a text editor to examine contents.

15.3 Guidelines for writing OMERO.scripts

These guidelines for writing OMERO scripts are designed to improve the interaction of the scripts with OMERO clients so that they can:

• generate a nice, usable UI for the script
• handle the script results appropriately

If you want instructions on how to get started with OMERO scripts, see the link above or the OMERO.scripts user guide.

Most of the points below are implemented in the example Edit_Descriptions.py\textsuperscript{11}.

15.3.1 Script naming and file path

• Script Name should be in the form ‘Script_Name.py’. OMERO.insight will replace underscores with spaces in the script selection menu.
• File paths - OMERO.insight will use the parent folder to build a scripts menu, capitalising and removing underscores. For example, a script uploaded from /omero/export_scripts/Batch_Image_Export.py will be displayed in OMERO.insight under “Export Scripts”.
• Script Descriptions should give a brief summary of what the script does. If a longer description or instructions for using the script are desired, it is suggested that a URL is included. The description will be displayed in the script UI and any URLs will be ‘clickable’ to launch a browser.

\textsuperscript{11}https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/ScriptingService/Edit_Descriptions.py
15.3.2 Parameters

• Parameter Names should be in the form ‘Parameter_Name’. Underscores will be replaced by spaces in the UI generated in OMERO.insight.

• Where applicable, Parameters should be supplied with a list of options. For example:

```
scripts.String("Algorithm", values=[rstring('Maximum_Intensity'), rstring('Mean_Intensity')])
```

• Where possible, parameters should be supplied with default values. These will be used to populate fields in the OMERO.insight script UI and will be used by default when launching the script from the command line.

```
scripts.String("Folder_Name", description="Name of folder to store images", default='Batch_Image_Export')
```

• Where applicable, Parameters should have min and max values, E.g:
scripts.Int("Size_Z", description="Number of Z planes in new image", min=1),

### 15.3.3 Parameter grouping / ordering

Parameters are not ordered by default. They can be ordered and grouped by adding a “grouping” attribute, which is a string, where ‘groups’ are separated by a ‘.’. E.g. “01.A”. Parameters will be ordered by the lexicographic sorting of this string and groups indicated in the UI. In most cases this will simply be a common indentation of parameters in the same group. In addition, if the ‘parent’ parameter of a group is a boolean, then un-checking the check-box in the UI will disable the child parameters. For example a UI generated from the code below will have a ‘Show Scalebar’ option. If this is un-checked, then the Size and Colour parameters will be disabled and will not be passed to the script.

scripts.Bool("Show_Scalebar", grouping="10", default=True),
scripts.Int("Scalebar_Size", grouping="10.1"),
scripts.String("Scalebar_Colour", grouping="10.2"),

### 15.3.4 Pick selected Images, Datasets or Projects from OMERO clients

Both OMERO.insight and OMERO.web recognize and populate a pair of fields named ‘Data_Type’ (string) and ‘IDs’ (Long list) with the objects currently selected in the client UI when the script is launched. You should specify the ‘Data_Type’ options that your script should accept. E.g.

dataTypes = [rstring('Dataset'), rstring('Image')]

client = scripts.client('Thumbnail_Figure.py', "Export a figure of thumbnails",
    scripts.String("Data_Type", optional=False, grouping="01", values=dataTypes, default="Dataset"),
    scripts.List("IDs", optional=False, grouping="02").ofType(rlong(0)))

### 15.3.5 Script outputs

- Scripts may return a short message to report success or failure. This should use the key: ‘Message’ in the output map. This will be displayed in OMERO.insight when the script completes.

    client.setOutput("Message", rstring("Script generated new Image"))

- Scripts that generate an Image should return the Image object. OMERO.insight will provide a link to view the Image. The key that is used (“Image” in this example) is not important for this to work, but ‘image’ should be an omero.model.ImageI object.

    client.setOutput("Image", robject(image))

- Scripts that generate a File Annotation or Original File should return these objects. OMERO.insight will give users the option of downloading the File, and may also allow viewing of the file if it is of a suitable type. This should be set as the mimetype of the File Annotation (E.g. ‘plain/text’, ‘image/jpeg’ etc). In this example, fileAnnotation should be an omero.model.FileAnnotationI object, but could also be an omero.model.OriginalFileI object.

    client.setOutput("File_Annotation", robject(fileAnnotation))

---

**15.3. Guidelines for writing OMERO.scripts**
15.3.6 More tips

- Use the `unwrap()` function from omero.rtypes to unwrap rtypes from the script parameters since this function will iteratively unwrap lists, maps etc.

```python
from omero.rtypes import *
scriptParams = {}
for key in client.getInputKeys():
    if client.getInput(key):
        scriptParams[key] = unwrap(client.getInput(key))

print scriptParams  # stdout will be returned - useful for bug fixing etc.
```

15.4 MATLAB and Python

MATLAB functionality can be mixed into Python scripts via the Python package Mlabwrap\(^\text{12}\).

15.4.1 Installing Mlabwrap

To install MlabWrap follow the installation guide at http://www.scipy.org/MlabWrap and make sure that the paths are set for the environment variables:

```
LD_LIBRARY_PATH=$MATLABROOT/bin/Platform
MLABRAW_CMD_STR=$MATLABROOT/bin/matlab
```

15.4.2 Example MATLAB scripts

Below are some sample scripts showing MATLAB being launched from OMERO.scripts. MATLAB functions can also call the OMERO Java language bindings interface to access the server from the MATLAB functions.

Calling a simple MATLAB function

```python
import omero, omero.scripts as script
# import mlabwrap to launch matlab.
from mlabwrap import matlab;
client = script.client("rand.py", "Get matrix of random numbers drawn from a uniform distribution", script.Long("x").inout(), script.Long("y").inout())
client.createSession()
x = client.getInput("x").val
y = client.getInput("y").val

# call the matlab rand function via mlabwrap will automatically launch matlab
# if it is not already running on the system and call the rand method.
val = matlab.rand(x,y);
print val
```

Using the OMERO interface inside MATLAB

This example shows the MATLAB script being called, passed to the client object and accessing the same client instance as the script.

\(^\text{12}\)http://mlabwrap.sourceforge.net
import omero, omero.scripts as script
# import mlabwrap to launch matlab.
from mlabwrap import matlab;

client = script.client("projection.py", "Call the matlab projection code",
                     script.String("iceConfig").in(), script.String("user").in(),
                     script.String("password"),
                     script.Long("pixelsId").inout(), script.String("method").inout()
                     script.Long("stack").inout())

client.createSession()

iceConfig = client.getInput("pixelsId").val
user = client.getInput("pixelsId").val
password = client.getInput("pixelsId").val
method = client.getInput("method").val
stack = client.getInput("stack").val;

image = matlab.performProjection(iceConfig, username, password, pixelsId, stack, method);

The MATLAB projection method

function performProjection(iceConfig, username, password, pixelsId, zSection, method)

omerojavaService = createOmeroJavaService(iceConfig, username, password);
pixels = getPixels(omerojavaService, pixelsId);
stack = getPlaneStack(omerojavaService, pixelsId, zSection);
projectedImage = ProjectionOnStack(stack, method);

function [resultImage] = ProjectionOnStack(imageStack,type)

[zSections, X, Y] = size(imageStack);

if(strcmp(type,'mean') || strcmp(type, 'sum'))
    resultImage = squeeze(sum(imageStack));
    if(strcmp(type,'mean'))
        resultImage = resultImage./zSections;
    end
end
if(strcmp(type,'max'))
    resultImage = squeeze(max(imageStack,[],1));
end

15.5 OMERO.scripts advanced topics

15.5.1 Regular user (non-admin) workflow

If you are using a server for which you do not have admin access, you must upload scripts as ‘user’ scripts, which are not trusted to run on the server machine. The OMERO scripting service will still execute these scripts in a similar manner to official ‘trusted’ scripts but behind the scenes it uses the client machine to execute the script. This means that any package imports required by the script should be available on the client machine.

The first step is to connect to the server and set up the processor on the client (see diagram, below).

- You need to download ‘Ice’ from ZeroC and set the environment variables, as described in the server installation page (see *Unix* and *Windows* versions).
You also need the OMERO server download. Go to the OMERO downloads page and get the appropriate server package (version must be OMERO 4.2 or later and match the server you are connecting to). Unzip the package in a suitable location.

In a command line terminal, change into the unzipped OMERO package, connect to the server and start user processor. For example for host: openmicroscopy.org.uk and user: will

```bash
$ cd Desktop/OMERO.server-Beta-4.2/
$ bin/omero -s openmicroscopy.org.uk -u will script serve user
$ password: .....
```

If you want to run scripts belonging to another user in the same collaborative group you need to set up your local user processor to accept scripts from that user. First, find the ID of the user, then start the user processor and give it the user’s ID:

```bash
$ cd Desktop/OMERO.server-Beta-4.2/
$ bin/omero -s openmicroscopy.org.uk -u will user list
$ bin/omero -s openmicroscopy.org.uk -u will script serve user=5
```

From this point on, the user and admin workflows are the same, except for a couple of options that are not available to regular users. Also see below.

**Note:** Because non-official scripts do not have a unique path name, you will be able to run the upload command multiple times on the same file. This will create multiple copies of a file in OMERO and then you will have to choose the most recent one (highest ID) if you want to run the latest script. It is best to avoid this and use the ‘replace’ command as for official scripts.

**To list user scripts:**

```bash
$ omero -s openmicroscopy -u will script list user # lists user scripts
id   | Scripts for user
-----+---------------------------------------------------------------------------------------------
151   | examples/HelloWorld.py
251   | examples/Edit_Descriptions.py
```

You can list scripts belonging to another user that are available for you (e.g. you are both in the same collaborative group) by using the user ID as described above:

---

13http://www.openmicroscopy.org/site/products/omero/downloads
User scripts can be run from OMERO.insight. They will be found under ‘User Scripts’ in the scripts menu. Remember, for user scripts you will need to have the User-Processor running.

### 15.5.2 The iScript service

The OMERO.blitz server provides a service called iScript\(^{14}\) that includes methods to upload, delete, query and run scripts. To access these methods a session needs to be created and the script service started. However, you may find it more convenient to use the command line `bin/omero script` or the OMERO.insight client to work with scripts as described on the OMERO.scripts user guide.

### 15.5.3 Scripting service API

The recommended way of working with the scripting service is via the command line as described on the OMERO.scripts user guide page. The information on this page is only useful if you want to access the Scripting service from your own client-side Python code.

OMERO clients can upload, edit, list and run scripts on the OMERO server using the Scripting Service API. These methods (discussed below) are implemented in `examples/ScriptingService/adminWorkflow.py\(^{15}\)`. This sample script allows these functions to be called from the command line and can be used as an example for writing your own clients.

Most functions of the `adminWorkflow.py` script are also implemented in the OMERO CLI described on the OMERO.scripts user guide, which is the preferred way of accessing the scripting service for script writers.

Having downloaded `examples/ScriptingService/adminWorkflow.py\(^{16}\)`, you can get some instructions for using the script by typing:

```
$ python adminWorkflow.py help
```

To upload ‘official’ scripts, use the `uploadOfficialScript` method of the scripting service or use the upload command from `adminWorkflow.py` (you can omit password and enter it later if you do not want it showing in your console):

```
$ python adminWorkflow.py -s server -u username -p password -f script/file/to/upload.py upload
```

Official scripts must have unique paths. Therefore, the `uploadOfficialScript` method will not allow you to overwrite and existing script. However, the `adminWorkflow.py` upload command will automatically use `scriptService.editScript()` if the file exists. If you want to change this behavior, edit the `adminWorkflow.py` script accordingly.

To get the official scripts available to run, use the `getScripts()` method, which returns a list of Original Files (scripts). This code will produce a list of scripts like the one above.

```python
scripts = scriptService.getScripts()
for s in scripts:
    print s.id.val, s.path.val + s.name.val
```

This can be called from `adminWorkflow.py` with this command:

```
$ python adminWorkflow.py -s server -u username -p password list
```

---


\(^{15}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/ScriptingService/adminWorkflow.py

\(^{16}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/ScriptingService/adminWorkflow.py
The script can then be run, using the script ID and passing the script a map of the input parameters. The adminWorkflow.py script has a `run` command that can be used to identify a script by its ID or path/name and run it. The `run` command will ask for parameter inputs at the command line.

```
$ python adminWorkflow.py -s localhost -u root -p omero -f scriptID run
```

or

```
$ python adminWorkflow.py -s localhost -u root -p omero -f omero/figure_scripts/Roi_Figure.py run
```

You can combine the latter form of this command with the ‘upload’ option to upload and run a script at once, useful for script writing and testing.

```
$ python adminWorkflow.py -s localhost -u root -p omero -f omero/figure_scripts/Roi_Figure.py upload run
```

Alternatively, you could edit adminWorkflow.py to ‘hard-code’ a set of input parameters for a particular script (this strategy is used by examples/ScriptingService/runHelloWorld.py). The code below shows a more complex example parameter map. This strategy might save you time if you want to be able to rapidly run and re-run a script you are working on. Of course, it is also possible to run scripts from OMERO.insight!

```python
cNamesMap = omero.rtypes.rmap({'0': omero.rtypes.rstring("DAPI"),
                            '1': omero.rtypes.rstring("GFP"),
                            '2': omero.rtypes.rstring("Red"),
                            '3': omero.rtypes.rstring("ACA")})
blue = omero.rtypes.rstring('Blue')
red = omero.rtypes.rstring('Red')
mrgdColoursMap = omero.rtypes.rmap({'0': blue, '1': blue, '3': red})
map = {
    "Image_IDS": omero.rtypes.rlist(imageIds),
    "Channel_Names": cNamesMap,
    "Split_Indexes": omero.rtypes.rlist([omero.rtypes.rlong(1), omero.rtypes.rlong(2)]),
    "Split_Panels_Grey": omero.rtypes.rbool(True),
    "Merged_Colours": mrgdColoursMap,
    "Merged_Names": omero.rtypes.rbool(True),
    "Width": omero.rtypes.rint(200),
    "Height": omero.rtypes.rint(200),
    "Image_Labels": omero.rtypes.rstring("Datasets"),
    "Algorithm": omero.rtypes.rstring("Mean_Intensity"),
    "Stepping": omero.rtypes.rint(1),
    "Scalebar": omero.rtypes.rint(10), # will be ignored since no pixelsize set
    "Format": omero.rtypes.rstring("PNG"),
    "Figure_Name": omero.rtypes.rstring("splitViewTest"),
    "Overlay_Colour": omero.rtypes.rstring("Red"),
    "ROI_Zoom": omero.rtypes.rfloat(3),
    "ROI_Label": omero.rtypes.rstring("fakeTest"), # won’t be found - but should still work
}
```

The results returned from running the script can be queried for script outputs, including stdout and stderr. The following code queries the results for an output named ‘Message’ (also displayed by OMERO.insight)

```python
print results.keys()
if 'Message' in results:
    print results['Output_Message'].getValue()
if 'stdout' in results:
    origFile = results['stdout'].getValue()
    print "Script generated StdOut in file": origFile.getId().getValue()
if 'stderr' in results:
```

---

17https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/ScriptingService/runHelloWorld.py
```
origFile = results[‘stderr’].getValue()
print "Script generated StdErr in file:", origFile.getId().getValue()
```

This code has been extended in adminWorkflow.py to display any StdErr and StdOut generated by the script when it is run.
16.1 OMERO.web framework

OMERO.web is a framework for building web applications for OMERO. It uses Django to generate HTML pages from data retrieved from the OMERO server. OMERO.web acts as a Python client of the OMERO server using the OMERO API, as well as being a web server itself (see ‘infrastructure’ info below). It uses Django ‘apps’ to provide modular web tools, such as the webclient (working with image data) and webadmin (administrator management). This modular framework makes it possible to extend OMERO.web with your own apps.

One of the apps, WebGateway, provides utility methods for accessing data and rendering images, as well as handling the connection to OMERO server.

MOVIE introduction to OmeroWeb

OMERO.web is a framework for building web applications for OMERO. It uses Django to generate HTML pages from data retrieved from the OMERO server. OMERO.web acts as a Python client of the OMERO server using the OMERO API, as well as being a web server itself (see ‘infrastructure’ info below). It uses Django ‘apps’ to provide modular web tools, such as the webclient (working with image data) and webadmin (administrator management). This modular framework makes it possible to extend OMERO.web with your own apps.

One of the apps, WebGateway, provides utility methods for accessing data and rendering images, as well as handling the connection to OMERO server.

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1 http://cvs.openmicroscopy.org.uk/snapshots/movies/omero-4-3/mov/OmeroWebIntro-4.3.mov
2 https://www.djangoproject.com/
16.1.1 OMERO.web infrastructure

OMERO Python API

The OMERO.web framework is all based on the OMERO Python API, using the Blitz Gateway (see OMERO Python language bindings). The OMERO.web framework provides functionality for creating and retrieving connections to OMERO (see example below & Writing OMERO.web views for more details).

Web gateway

The webgateway is a Django app that provides utility functionality for the other web components. This includes a full image viewer, as well as methods for rendering images etc. You can browse the webgateway URLs, or see the WebGateway page for more info.

Web apps

The OMERO.web framework consists of several Django apps denoted by folders named ‘web....’. These include webgateway & webtest, as discussed above, as well as released tools (webadmin, webclient) and other apps in development:

- webclient: Main web client for viewing images, annotating etc. More information available under OMERO.web.
- webadmin: For administration of user and group settings.
- webgateway: A web services interface, providing rendered images and data. See WebGateway.
- webtest: A sample app for testing, that can also be used as a basis for creating your own app.

16.1.2 Getting started

The preferred workflow for extending OMERO.web is to create a new Django app. Django apps provide a nice way for you to keep all your code in one place and make it much easier to port your app to new OMERO releases or share it with other users. To get started, see Creating an app. Further documentation on editing the core OMERO.web code is at Editing OMERO.web. If you want to have a quick look at some example code, see below...

Quick example - webtest

This tiny example gives you a feel for how the OMERO.web framework gets data from OMERO and displays it on a web page. You can find this and other examples in the ‘webtest’ app. Also, see the OMERO.web demo movie.

Note: Some details of this code have changed in the OMERO 4.4 release - see below.

There are 3 parts to each page: url, view and template. For example, this code below is for generating an HTML page of a Dataset (see screen-shot). If you have OMERO.web running, you can view the page under http://servername.example.org/webtest/dataset/<datasetId>.

- url goes in omeroweb/webtest/urls.py This maps the URL 'webtest/dataset/<datasetId>' to the View function ‘dataset’, passing it the datasetId.

```python
url(r'^dataset/(\d+)/$', views.dataset),
```

- View function, in omeroweb/webtest/views.py. NB: @login_required decorator retrieves connection to OMERO as ‘conn’ passed in args to method. See Writing OMERO.web views for more details.

---

4 http://cvs.openmicroscopy.org.uk/snapshots/movies/omero-4-3/mov/OmeroWebIntro-4.3.mov
from omeroweb.webclient.decorators import login_required
# handles login (or redirects). Was @isUserConnected before OMERO 4.4
@login_required()
def dataset(request, datasetId, conn=None, **kwargs):
    ds = conn.getObject("Dataset", datasetId)
    # generate html from template
    return render_to_response('webtest/dataset.html', {'dataset': ds})

• Template: The template web page, in omeroweb/webtest/templates/webtest/dataset.html

    <html><body>
    <h1>{{ dataset.getName }}</h1>
    {% for i in dataset.listChildren %}
        <div style="float:left; padding:10px">
            <img src="{% url 'webgateway.views.render_thumbnail' i.id %}" />
            <br />
            {{ i.getName }}
        </div>
    {% endfor %}
    </body></html>

• Next: Get started by Creating an app....
16.2 Creating an app

The Django web site has a very good tutorial\(^5\) to get you familiar with the Django framework. The more you know about Django, the easier you will find it working with the OmeroWeb framework. One major feature of Django that we do not use in OmeroWeb is the Django database mapping, since all data comes from the OMERO server and is saved back there. You will notice that the models.py files in each app are empty.

**Note:** Since OMERO 5.0, the web framework uses Django 1.6 instead of Django 1.3. One important change is the syntax of the url template tag\(^6\), which now requires quotes, and will need to be updated for OMERO 4.4 web apps moving to OMERO 5.0.

16.2.1 Getting set up

You will need to have an OMERO server running that you can connect to. This will typically be on your own machine, although it does not necessarily have to be. If you want to connect to another server (not localhost) you can edit the server list as described on the OMERO.web deployment page (see Unix or Windows version) and choose that server when you log in. That page also describes how to set debug to ‘True’ which is important when developing with OMERO.web and you should also be using the Django ‘development’ server.

```
$ bin/omero web start
INFO:__main__:Application Starting...
INFO:root:Processing custom settings for module omeroweb.settings
...  
Validating models...

0 errors found
Django version 1.6, using settings 'omeroweb.settings'
Starting development server at http://0.0.0.0:4080/
Quit the server with CONTROL-C.
```

**Note:** Port number is 4080

You should make sure that you can access the webclient and webadmin on your local machine before starting to develop your own code. Be sure to use the correct port number, E.g:

- [http://localhost:4080/webclient/\(^7\)](http://localhost:4080/webclient/)

When you edit and save your app, Django will automatically detect this and you only need to refresh your browser to see the changes. You can see this in the OMERO.web intro movie\(^8\).

If you want to run OMERO.web from source code, see Editing OMERO.web.

You can place your app anywhere on your PYTHONPATH, as long as it can be imported by OMERO.web.

**Note:** OMERO 5 uses Django 1.6 which has a different project layout from OMERO 4.4. If you are upgrading your app from 4.4.x you may need to update some import statements. E.g. from omeroweb import webgateway will become import webgateway.

16.2.2 Creating an app

We suggest you use github (as we do) since it is much easier for us to help you with any problems you have if we can see your code. The steps below describe how to create a stand-alone git repository for your app, similar to webtagging\(^9\). If you do not want to use github, simply ignore the github steps below.

---

\(^5\)https://docs.djangoproject.com/en/dev/intro/tutorial01/
\(^6\)https://docs.djangoproject.com/en/dev/ref/templates/builtins/#std:templatetag-url
\(^7\)http://localhost:4080/webclient/
\(^8\)http://cvs.openmicroscopy.org.uk/snapshots/movies/omero-4-3/mov/OmeroWebIntro-4.3.mov
\(^9\)https://github.com/dpwrussell/webtagging

---
The steps below describe setting up a new app. You should choose an appropriate name for your app and use it in place of `<your-app>` in the examples below:

**Create and checkout a new github repository OR manually create a new directory**

- Login to your github account homepage (E.g. https://github.com/<your-name>/) and click “New repository”
- Enter the name of `<your-app>`, add description and choose to add README.
- Checkout your new repository (into a new directory)

  ```
  $ git clone git@github.com:<your-name>/<your-app>.git
  ```

- OR: If you haven’t used git to create your app directory above, then

  ```
  $ mkdir <your-app>
  ```

**Add your app location to your PYTHONPATH**

If your app is not in a directory that is already on your PYTHONPATH then you need to add it:

```
$ export PYTHONPATH=$PYTHONPATH:/path/to/your-app
```

**Add the essential files to your app**

- Create an empty file `<your-app>/__init__.py` (NB: both double underscores)
- Create urls.py

  ```
  from django.conf.urls.defaults import *
  from omeroweb.<your-app> import views
  urlpatterns = patterns('django.views.generic.simple',
  # index 'home page' of the <your-app> app
  url( r'^$' , views.index, name='<your-app>_index' ),
  )
  ```

- Create views.py

  ```
  from django.http import HttpResponse
  
  def index(request):
  ""
  Just a place-holder while we get started
  ""
  return HttpResponse("Welcome to your app home-page!")
  ```

**Add your app to OMERO.web**

This will add your app to the INSTALLED_APPS, so that URLs are registered etc.
$ bin/omero config set omero.web.apps '"<your-app>"'

**Note:** For releases before 4.4, you need to ‘register’ your app with Django manually by adding it to the `INSTALLED_APPS` list in `omeroweb/settings.py` following the pattern of existing apps there. You also need to edit `omeroweb/urls.py` to add your app’s `urls.py` file to the list of “urlpatterns”. Again, you should be able to follow the existing examples there. You can also specify at this point the URL under which your app will be found.

Now you can view the home-page we created above (NB: you will need to restart the OMERO web server for the config settings to take effect)

$ bin/omero web stop
$ bin/omero web start


**Commit your code and push to github**

$ git status (see new files, plus .pyc files)
$ echo ".pyc" > .gitignore       # ignore .pyc files
$ echo ".gitignore" >> .gitignore  # ALSO ignore .gitignore

$ git add .
$ git commit -m "Initial commit of bare-bones OMERO.web app"
$ git push origin master

**Connect to OMERO: example**

We have got our new app working, but it is not connecting to OMERO yet. Let us create a simple “stack preview” for an Image with multiple Z-sections. We are going to display the image name and 5 planes evenly spaced across the Z-stack. You should be able to add the appropriate code to `urls.py`, `views.py` that you created above, and add a template under `/omeroweb/<your-app>/templates/<your-app>/`

**Note:** note that `/<your-app>/` appears twice in that path (need an extra folder under templates). This example can be found in webtest.

- **urls.py**

```python
url(r'^stack_preview/(?P<imageId>[0-9]+)/$', views.stack_preview, name="<your-app>_stack_preview" ),
```

- **views.py** Here we are using the `@login_required` decorator to retrieve a connection to OMERO from the session key in the HTTP request (or provide a login page and redirect here). ‘conn’ is passed to the method arguments. NB: Note a couple of new imports to add at the top of your page.

```python
from omeroweb.webclient.decorators import login_required
from django.shortcuts import render_to_response

@login_required()
def stack_preview (request, imageId, conn=None, **kwargs):
    """ Shows a subset of Z-planes for an image ""
```
OMERO Documentation, Release 5.0.2

image = conn.getObject(”Image”, imageId)
# Get Image from OMERO
image_name = image.getName()
sizeZ = image.getSizeZ()
# get the Z size
# 5 Z-planes
z_indexes = [0, int(sizeZ*0.25),
int(sizeZ*0.5), int(sizeZ*0.75), sizeZ-1]
return render_to_response(’webtest/stack_preview.html’,
{’imageId’:imageId,
’image_name’:image_name,
’z_indexes’:z_indexes})

• <your-app>/templates/<your-app>/stack_preview.html
<html>
<head>
<title>Stack Preview</title>
</head>
<body>
<h1>{{ image_name }}</h1>
{% for z in z_indexes %}
<img src=”{% url ’webgateway.views.render_image’ imageId z 0 %}”
style=”max-width: 200px; max-height:200px”/>
{% endfor %}
</body>
</html>

Viewing the page at http://localhost:4080/<your-app>/stack_preview/<image-id>/ should give you the image name and 5 planes
from the Z stack. You will notice that we are using webgateway to handle the image rendering using a URL auto-generated by
Django - see WebGateway.
Resources for writing your own code
The webtest app has a number of examples. If you go to the webtest homepage E.g. http://localhost:8000/webtest you will see an
introduction to some of them. This page tries to ﬁnd random image and dataset from your OMERO server to use in the webtest
examples.
Extending templates
We provide several HTML templates in webgateway/templates/webgateway/base. This is a nice way of giving users the feeling
that they have not left the webclient, if you are providing additional functionality for webclient users. You may choose not to
use this if you are building a ‘stand-alone’ web application. In either case, it is good practice to create your own templates with
common components (links, logout etc), so you can make changes to all your pages at once. See Writing page templates in
OMERO.web for more info.
App settings
You can add settings to your app that allow conﬁguration via the command line in the same way as for the base OMERO.web
in omeroweb/settings.py. The list of CUSTOM_SETTINGS_MAPPINGS in omeroweb/settings.py code is a good source for
examples of the diﬀerent data types and parsers you can use.
For example, if you want to create a user-deﬁned setting yourapp.foo, that contains a dictionary of key-value pairs, you can add
to CUSTOM_SETTINGS_MAPPINGS in yourapp/settings.py:
import json
CUSTOM_SETTINGS_MAPPINGS = {

16.2. Creating an app

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"omero.web.yourapp.foo": {"FOO": {'key": "val"'}, json.loads}
}

From somewhere else in your app, you can then access the settings:

```python
from yourapp import settings
print settings.FOO
```

Users can then configure this on the command line as follows:

```bash
$ bin/omero config set omero.web.yourapp.foo '{"userkey": "userval"}'
```

**OMERO.web top links**

You can configure settings ‘top_links’ to add a link to the list of links at the top of the webclient main pages.

- **Name your url in urls.py** (optional). Preferably we use url names to refer to urls. For example, the homepage of your app might be named like this in urls.py.

  ```python
  url(r'^$', views.index, name='webmobile_index'),
  ```

- **Update configuration** Use the OMERO command line interface to add the link or links to the appropriate list. NB: Since there is not currently an option to add to web settings lists, you will need to include the full list of links when you configure the list.

To add a single link, using the format ["Label", “URL_name”], you can follow this example:

```bash
$ bin/omero config set omero.web.ui.top_links '[["Mobile", "webmobile_index"]]
```

Multiple links can be added in the same way. You can also create external links by specifying the full URL instead of the ‘URL_name’. For example:

```bash
$ bin/omero config set omero.web.ui.top_links '[["Mobile", "webmobile_index"], ["OME", "https://www.openmicroscopy.org"]]
```

**OMERO.web plugins (OMERO 4.4)**

If you want to display content from your app within the webclient UI, please see **Webclient Plugins**.

### 16.3 Webclient Plugins

The webclient UI can be configured to include content from other web apps. This allows you to extend the webclient UI with your own functionality. This is used by the **webtagging app**\(^\text{12}\) and there are also some examples in the webtest app.

Currently you can add content in the following locations:

- **Center Panel** Adding a panel to the center of the webclient will display a drop-down menu to the top right of the center panel, allowing users to choose your plugin.

- **Right Panel** You can add additional tabs to the right panel. These will be available in the main webclient page as well as history and search result pages.

\(^\text{12}\)http://www.openmicroscopy.org/site/products/partner/omero.webtagging
16.3.1 Overview

To begin with, you need to prepare your plugin pages in your own app, with their own URLs, views and templates. Then you can display these pages within the webclient UI, using the plugin framework.

The webclient plugins work by adding some custom JavaScript snippets into the main pages of the webclient and adding HTML elements to specified locations in the webclient. These snippets of JavaScript can be used to load content into these HTML elements. Usually you will want to do this dynamically, to display data based on the currently selected objects (although this is optional). Helpers can be used to respond to changes in the selected objects and the selected tab, so you can load or refresh your plugin only when necessary.

16.3.2 App URLs

To display content based on currently selected data, such as Projects, Datasets and Images, your app pages will need to have these defined in their URLs. For example:

# Webtagging: Tag images within the selected dataset
url( r'^auto_tag/dataset/(?P<datasetId>[0-9]+)/$', views.auto_tag ),

# Webtest: Show a panel of ROI thumbnails for an image
url( r'^image_rois/(?P<imageId>[0-9]+)/$', views.image_rois ),

These URLs should simply display the content that you want to show in the webclient. NB: when these pages load in the webclient, they will have all the webclient CSS and JavaScript (such as jQuery) available so you do not need to include these in your page. Furthermore, it is important not to overwrite CSS or JavaScript in the webclient (for example by including jQuery).

16.3.3 Configuring the plugin

Choose an element ID

You will need to specify an ID for the `<div>` element that is added to the webclient, so that you can refer to this element in the JavaScript. For example, “image_roi_tab” or “auto_tag_panel”.

Create a JavaScript file

This will contain the JavaScript snippet that is injected into the main webclient page `<head>` when the page is generated. This is added using Django’s templates, so it should be placed within your app’s `/templates/<app-name>/` directory and named `.html`, e.g. `/templates/<app-name>/webclient_plugins/right_plugin_rois.html`. All the JavaScript should be within `<script>` and `</script>` tags. Your plugin initialization should happen after the page has loaded, so you use the jQuery on-ready function.

You use custom jQuery functions, called ‘omeroweb_right_plugin’ or ‘omeroweb_center_plugin’, to initialize the webclient plugin. These will handle all the selection change events. You simply need to specify how the panel is loaded, based on the selected object(s) and what objects are supported. The plugin will be disabled when non-supported objects are selected.

Below is a simple example of their usage. More detailed documentation available in the plugin options section below.

Center Panel Plugin

```javascript
$(function() {
    // Initialise the center panel plugin, on our specified element
    $('#auto_tag_panel').omeroweb_center_plugin({

        // To support single item selection, we can specify the types like this.
        // Tab will only be enabled when a single dataset is selected
        supported_obj_types: ['dataset'],

        load_plugin_content: function(selected, dtype, oid){
```
// since we currently limit our dtype to 'dataset', oid will be dataset ID  
// Use the 'index' of your app as base for your URL  
var auto_tag_url = '{% url 'webtagging_index' %}auto_tag/dataset/' + oid + '/';  
$(this).load(auto_tag_url);
});
});
</script>

Right Tab Plugin

<script>
$(function() {

  // Initialise the right tab plugin, on our specified tab element  
  $('*#image_roi_tab').omeroweb_right_plugin(

    // Tab will only be enabled when a single image is selected  
    supported_obj_types: ['image'],

    // This will get called when tab is displayed or selected objects change  
    load_plugin_content: function(selected, obj_dtype, obj_id) {

      // since we only support single images, the obj_id will be an image ID  
      // Generate url based on a template-generated url  
      var url = '{% url 'webtest_index' %}image_rois/' + obj_id + '/';

      // Simply load the tab  
      $(this).load(url);
    },
  });
});
</script>

16.3.4 Plugin installation

Now you need to add your plugin to the appropriate plugin list, stating the displayed name of the plugin, the path/to/js_snippet.html and the ID of the plugin element. Plugin lists are:

- omero.web.ui.center_plugins
- omero.web.ui.right_plugins

Use the OMERO command line interface to add the plugin to the appropriate list.

Note: Since there is not currently an option to add to web settings lists, you will need to include the full list of plugins when you configure the plugin list.

The OMERO.webclient does not include any center plugins by default, so if you only want to add a single plugin to the center, you can simply do:

```bash
$ bin/omero config set omero.web.ui.center_plugins  
  '[["Auto Tag", "webtagging/auto_tag_init.js.html", "auto_tag_panel"]]
```

The right_plugins list includes the Acquisition tab and Preview tab by default. If you want to keep these and add your plugin to the list, you will need to list all three. For example, to add the webtest ROI plugin:
$ bin/omero config set omero.web.ui.right_plugins
  '[["Acquisition", "webclient/data/includes/right_plugin.acquisition.js.html", "metadata_tab"],
   [["Preview", "webclient/data/includes/right_plugin.preview.js.html", "preview_tab"],
   [["ROIs", "webtest/webclient_plugins/right_plugin.rois.js.html", "image_roi_tab"]]]'

**Restart Web**

Stop and restart your web server, then refresh the webclient UI. You should see your plugin appear in the webclient UI in the specified location. You should only be able to select the plugin from the drop-down menu or tab if the supported data type is selected, e.g. ‘image’. When you select your plugin, the load content method you specified above will be called and you should see your plugin loaded.

**Refreshing content**

If you now edit the `views.py` or HTML template for your plugin and want to refresh the plugin within the webclient, all you need to do is to select a different object (e.g. dataset, image etc). If you select an object that is not supported by your plugin, then nothing will be displayed, and for the right-tab plugin, the tab selection will change to the first tab.

### 16.3.5 Plugin options

- **supported_obj_types**: If your plugin displays data from single objects, such as a single Image or Dataset, you can specify that here, using a list of types:

  ```python
  supported_obj_types: ['dataset', 'image'],
  ```

  This will ensure that the plugin is only enabled when a single Dataset or Image is selected. To support multiple objects, see 'tab_enabled'.

- **plugin_enabled**: This function allows you to specify whether a plugin is enabled or not when specified objects are selected. It is only used if you have NOT defined ‘supported_obj_types’. The function is passed a single argument:

  - selected: This is a list of the selected objects e.g. `[[‘id’: ‘image-123’], [‘id’: ‘image-456’]]`

  The function should return true if the plugin should be enabled. For example, if you want the center plugin to support multiple images, or a single dataset:

  ```python
  plugin_enabled: function(selected){
    if (selected.length == 0) return false;
    var dtype = selected[0][‘id’].split(‘-’)[0];
    if (selected.length > 1) {
      return (dtype == ‘image’);
    } else {
      return ($.inArray(dtype, [‘image’, ‘dataset’]) > -1);
    }
  }
  ```

- **load_plugin_content / load_tab_content**: This function will be called when the plugin/tab content needs to be refreshed, either because the plugin is displayed for the first time, or because the selected object changes. The function will be passed 3 arguments:

  - selected: This is a list of the selected objects e.g. `[[‘id’: ‘image-123’], [‘id’: ‘image-456’]]`

  - obj_dtype: This is the data-type of the first selected object, e.g. ‘image’

  - obj_id: This is the ID of the first selected object, e.g. 123
16.3.6 OMERO 4.4.x backwards compatibility

If an OMERO 5 plugin also needs to work for OMERO 4.4.x installations, there are three things to consider:

URLs in templates

The `url` tag has changed in Django 1.6 from `{% url myview %}` to `{% url 'myview' %}`. In order for your OMERO 4.4.x install to understand the new syntax, it is simply a matter of adding `{% load url from future %}` to the top of the template file. By using the new-style syntax and the `{% load url from future %}` line the template will be valid in both OMERO 4.4.x and OMERO 5. The `{% load url from future %}` line does no harm when used on Django 1.6.

URL imports

The import statement required to get the URL and patterns objects in the plugin’s `urls.py` has changed as well. The following import can be used to import from the correct place depending on which Django version is present.

```python
import django
if django.VERSION < (1, 6):
    from django.conf.urls.defaults import *
else:
    from django.conf.urls import *
```

Plugin settings

In OMERO 4.4.x (with the older Django) it was possible to manipulate settings in the plugin’s `settings.py` like so:

```python
from django.conf import settings

# We can directly manipulate the settings
# E.g. add plugins to CENTER_PLUGINS list
settings.CENTER_PLUGINS.append(
    ["Auto Tag", "webtagging/auto_tag_init.js.html", "auto_tag_panel"]
)
```

This is no longer possible in OMERO 5 with Django 1.6 and it is necessary to use `omero config set` to change this setting as documented here: Plugin Installation.

In order to preserve the old functionality on OMERO 4.4.x servers, the plugin’s `settings.py` can be changed to:

```python
import django

if django.VERSION < (1, 6):
    from django.conf import settings

    # We can directly manipulate the settings
    # E.g. add plugins to CENTER_PLUGINS list
    settings.CENTER_PLUGINS.append(
        ["Auto Tag", "webtagging/auto_tag_init.js.html", "auto_tag_panel"]
    )
```

This will only take effect on OMERO 4.4.x servers so remember to document that with OMERO 5 the config will need to be modified by the person doing the installation.

---

13https://docs.djangoproject.com/en/dev/releases/1.5/#overview
# 16.4 Editing OMERO.web

If you need to make changes to OMERO.web itself, then you will want to check out the OMERO source code. You can directly edit and run the OMERO.web code. This means that you benefit from the convenience of editing, saving and refreshing your browser without any build step.

However, you will still need to build OMERO (or download the release build) and set up your PYTHONPATH as described in the install documentation in order that you have the various dependencies such as Django.

You will then have 2 copies of the OMERO.web code - source code under components/tools/OmeroWeb/omeroweb and the server build under dist/lib/python/omeroweb.

To set up and run OMERO.web from the source code, you need to follow a few steps (commands are shown below):

- Set OMERO_HOME, so that OMERO.web knows where to find config, write logs etc.

  **Warning:** You should not set OMERO_HOME on production servers.

  The examples below assume a developer environment, making appropriate use of OMERO internals. See Setting the OMERO_HOME environment variable for details.

  - Make sure that the Django libraries that are under the build: dist/lib/python/django are on your PYTHONPATH.
  - Make sure the OmeroWeb folder: components/tools/OmeroWeb is on your PYTHONPATH.
  - Remove the built omeroweb folder, otherwise this will get used instead of the source omeroweb

  **Note:** You have to do this again if you build the server

- From the source omeroweb/ folder, manually run the Django development server

  ```
  # Example path to build target or downloaded directory
  $ export OMERO_HOME = ~/Desktop/OMERO/dist
  
  # Make sure the Django code etc can be imported
  $ export PYTHONPATH=$OMERO_HOME/lib/python/:$OMERO_HOME/..components/tools/OmeroWeb:$PYTHONPATH
  $ cd $OMERO_HOME
  # need to remove the built omeroweb code so it doesn’t get imported
  $ rm -rf lib/python/omeroweb/
  
  $ cd ..components/tools/OmeroWeb
  $ python omeroweb/manage.py runserver
  Validating models...
  0 errors found
  December 05, 2013 - 13:39:26
  Django version 1.6, using settings 'omeroweb.settings'
  Starting development server at http://127.0.0.1:8000/
  Quit the server with CONTROL-C.
  
  **Note:** Default port number is 8000. To specify port, use E.g: $ python manage.py runserver 0.0.0.0:4080
  ```

# 16.5 WebGateway

WebGateway is a Django app within the OMERO.web framework. It provides a web API for rendering images and accessing data on the OMERO server via URLs.

**Note:** The OMERO.web client also supports URLs linking to specified data in OMERO. See the OMERO.web user guides\[^14\] for more details.

\[^14\]http://help.openmicroscopy.org/
16.5.1 Web services

This list of URLs below may be incomplete or out of date. For a complete list of URLs, see the latest API, [latest API](http://downloads.openmicroscopy.org/latest/omero5/api/epydoc/omeroweb.webgateway.urls-module.html) and try the URLs out for yourself!

The HTTP request will need to include login details for creating or using a current server connection. This will be true for any request made after logging in to the server, e.g. login using webclient or webadmin login pages then go to web-gateway/... or if you have logged in to a server at [http://ome.example.com/webclient](http://ome.example.com/webclient) then go to, for example, [http://ome.example.com/webgateway/render_image/<imageid>/<z>/<t>/](http://ome.example.com/webgateway/render_image/<imageid>/<z>/<t>)/

![Rendered thumbnail](https://example.com/rendered_thumbnail.png)

### URLs from within OMERO web

Images rendered within OMERO web templates should use Django’s `{% url %}` tag to generate URLs for webgateway, passing in the ID of the image. This is shown for each of the URLs below:

#### Image viewer

- Provides a full image viewer, with controls for scrolling Z and T, editing rendering settings etc.

  ```python
  webgateway/img_detail/<imageid>/
  {% url 'webgateway.views.full_viewer' image_id %}
  ```

#### Images

- Returns a jpeg of the specified plane with current rendering settings

  ```python
  webgateway/render_image/<imageid>/<z>/<t>/
  {% url 'webgateway.views.render_image' image_id theZ theT %}
  ```

  From OMERO 4.4.4, omitting Z and T will use the default values:

  ```python
  webgateway/render_image/<imageid>/
  {% url 'webgateway.views.render_image' image_id %}
  ```

- Makes a jpeg laying out each active channel in a separate panel

  ```python
  webgateway/render_split_channel/<imageId>/<z>/<t>/
  {% url 'webgateway.views.render_split_channel' image_id theZ theT %}
  ```

- Plots the intensity of a row of pixels in an image. w is line width

  ```python
  webgateway/render_row_plot/<imageId>/<z>/<t>/<y>/<w>
  {% url 'webgateway.views.render_row_plot' image_id theZ theT yPos width %}
  ```

Figure 16.1: Rendered thumbnail
• Plots the intensity of a column of pixels in an image.

    webgateway/render_col_plot/<imageId>/<z>/<t>/<x>/<w>/
    {% url 'webgateway.views.render_col_plot' image_id theZ theT xPos width %}

• Returns a jpeg of a thumbnail for an image. w and h are optional (default is 75). Specify just one to retain aspect ratio

    webgateway/render_thumbnail/<imageId>/<w>/<h>
    {% url 'webgateway.views.render_thumbnail' image_id 100 %} # size 100
    {% url 'webgateway.views.render_thumbnail' image_id %} # default size

Rendering settings

If no rendering settings are specified (as above), then the current rendering settings will be used. To apply different settings to images returned by the render_image and render_split_channels URLs, parameters can be specified in the request. N.B. These settings are only applied to the rendered image and will not be saved unless specified.

Individual parameters are:

• Channels on/off. E.g. For a 4 channel image, to turn on all channels except 2:

    ?c=1,-2,3,4
    # From OMERO 4.4.4 you can simply specify the active channels
    ?c=3 # only Channel 3 is active
    ?c=3,4 # Channels 3 and 4 are active

• Channel colour. E.g. To set the colours for channels 1 to red and 2 to green and 3 to blue:

    ?c=1|FF0000,2|00FF00,3|0000FF

• Rendering levels. E.g. To set the cut-in and cut-out values for a 3 Channel image.

    ?c=1|400:505,2|463:2409,3|620:3879
    ?c=-1|400:505,2|463:2409,3|620:3879 # First channel inactive "-1"
    ?c=2|463:2409,3|620:3879 # OMERO 4.4.4 only: inactive channels can be omitted

• Z-projection. Maximum intensity, Mean intensity or None (normal)

    ?p=intmax
    ?p=intmean
    ?p=normal

• Rendering ‘Mode’: greyscale or colour.

    ?m=g # greyscale (only the first active channel will be shown in grey)
    ?m=c # colour

• Parameters can be combined, E.g.

    webgateway/render_image/2602/10/0/?c=1|100:505|0000FF,2|463:2409|0000FF,3|620:3879|FF0000,-4|447:4
JSON methods

• List of projects: webgateway/proj/list/

```json
[{ "description": "", "id": 269, "name": "Aurora"},
 { "description": "", "id": 269, "name": "Drugs"} ]
```

• Project info: webgateway/proj/<projectId>/detail/

```json
{"description": "", "type": "Project", "id": 269, "name": "CenpA"}
```

• List of Datasets in a Project: webgateway/proj/<projectId>/children/

```json
[ { "child_count": 9, "description": "", "type": "Dataset", "id": 270,
  "name": "Control"}, ]
```

• Dataset, same as for Project: webgateway/dataset/<datasetId>/detail/

• Details of Images in the dataset: webgateway/dataset/<datasetId>/children/

• Lots of metadata for the image. See below: webgateway/imgData/<imageId>/

Saving etc

• webgateway/saveImgRDef/<imageId>/

• webgateway/resetImgRDef/<imageId>/

• webgateway/compatImgRDef/<imageId>/

• webgateway/copyImgRDef/

ImgData

The following is sample JSON data generated by /webgateway/imgData/<imageId>/

```json
{
  "split_channel": {
    "c": { "width": 1448, "gridy": 2, "border": 2, "gridx": 3, "height": 966},
    "g": { "width": 966, "gridy": 2, "border": 2, "gridx": 2, "height": 966 }
  },
  "rdefs": { "defaultT": 0, "model": "color",
    "projection": "normal", "defaultZ": 15},
  "pixel_range": [-32768, 32767],
  "channels": [{
    "color": "0000FF", "active": true, 
    "window": { "max": 449.0, "end": 314, "start": 70, "min": 51.0},
    "emissionWave": "DAPI",
    "label": "DAPI"},
    {"color": "00FF00", "active": true,
    "window": { "max": 7226.0, "end": 1564, "start": 396, "min": 37.0},
    "emissionWave": "FITC",
    "label": "FITC" }],
  "meta": {
    "projectDescription": "", 
    "datasetName": "survivin",
    "projectId": 2,
    "imageDescription": "",
    "imageTimestamp": 1277977808.0,
```

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"imageId": 12,
"imageAuthor": "Will Moore",
"imageName": "CSFV-siRNAi02_R3D_D3D.dv",
"datasetDescription": "",
"projectName": "siRNAi",
"datasetId": 3
}
"id": 12,
"pixel_size": {"y": 0.0663, "x": 0.0663, "z": 0.2},
"size": {
    "width": 480,
    "c": 4,
    "z": 31,
    "t": 1,
    "height": 480
}
}

16.6 Embedding OMERO.web viewport to your website

Insert the following: **WARNING**: Please note that you are giving plain password and everyone can read from your HTML source code!

```html
<div id="omeroviewport"><iframe width="850" height="600" ... id="omeroviewport" name="omeroviewport"></iframe></div>
```

16.6.1 Launching OMERO.web viewer

Use the following code to reference the scripts.

```html
<script type="text/javascript">

    function openPopup(url) {
        owindow = window.open(url, 'anew', config='height=600,width=850,left=50,top=50,toolbar=no,menubar=no,scrollbars=yes,resizable=yes,location=no,directories=no,status=no');
        if(!owindow.closed) owindow.focus();
        return false;
    }

</script>
```

Then in `<BODY>` insert the following:

```html
<a href="#" onclick="return openPopup('http://localhost:8000/webclient/img_detail/IMAGE_ID/')">Open viewer</a>
```

16.6.2 Embedding OMERO.web viewport to the template in OMERO.web

This website will show you how to easily embed the viewport to the new template with the use of the jQuery JavaScript library. Use the following code to reference the stylesheets and scripts.

```html
<link rel="stylesheet" href="/appmedia/webgateway/css/jquery-plugin-gs_slider.css" type="text/css" media="screen" />
<link rel="stylesheet" href="/appmedia/webgateway/css/weblitz-viewport.css" type="text/css" media="screen" />
<script type="text/javascript" src="/appmedia/omero/web/javascript/jquery_1.3.2.js"></script>
```
Then create the small java script which allows you to view particular image defined by `image_id`. Please note that if you also need to modify the name of your application /my_app you are running in.

```javascript
$(document).ready(function() {
    var viewport = $.WeblitzViewport($("#viewport"), "/MYAPP" );
    viewport.load(image_id);
});
</script>

Then in `<BODY>` insert the following:

```html
<div class="miniview" id="viewport"></div>
```

## 16.7 Writing OMERO.web views

This page contains info on how to write your own views.py code, including documentation on the webclient/views.py and webgateway/views.py code. In general, these notes refer to the 4.4 and later release of OMERO, since the OMERO.web framework will be cleaned up substantially in this release. We note some points below where these changes will break existing code.

Although we aim to provide some useful notes and examples here, you will find the best source of examples is the code itself.

### 16.7.1 @Decorators

Decorators in Python are functions that ‘wrap’ other functions to provide additional functionality. They are added above a method using the @ notation. We use them in the OMERO.web framework to handle common tasks such as login (getting connection to OMERO server) etc.

```
@login_required()
```

**Note:** Before 4.4, this was called @isUserConnected and had similar functionality.

The login_required decorator uses parameters in the ‘request’ object to retrieve an existing connection to OMERO. In the case where the user is not logged in, they are redirected to a login page. Upon login, they will be redirected back to the page that they originally tried to view. The method that is wrapped by this decorator will be passed a ‘conn’ Blitz Gateway connection to OMERO.

**Note:** login_required is a class-based decorator with several methods that can be overwritten to customize its functionality (see below). This means that the decorator **MUST** be instantiated when used with the @ notation, i.e.:

```
@login_required()    NOT    @login_required    # this will give you strange error messages
```

A simple example of @login_required() usage (in webtest/views.py). Note the Blitz Gateway connection “conn” retrieved by @login_required() is passed to the function via the optional parameter `conn=None`.

---

16https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroWeb/omero/webclient/views.py
from omeroweb.decorators import login_required

@login_required()
def dataset(request, datasetId, conn=None, **kwargs):
    ds = conn.getObject("Dataset", datasetId)
    return render_to_response('webtest/dataset.html', {'dataset': ds})

Figure 16.2: Logic flow for retrieving Blitz Gateway connection from HTTP request.

**login_required logic**

The login_required decorator has some complex connection handling code, to retrieve or create connections to OMERO. Although it is not necessary to study the code itself, you may find it useful to understand the logic that is used (see Flow Diagram). As mentioned above, we start with a HTTP request (top left) and either a connection is returned (bottom left) OR we are redirected to login page (right).

*Note:* Options to configure a “public user” are described on the OMERO.web configuration page (see Unix or Windows version).

### Extending login_required

The base login_required class can be found in omeroweb/decorators.py. It has a number of methods that can be overwritten to customize or extend its functionality. Again, it is best to look at an example of this. See webclient/decorators.py to see how the base omeroweb.decorators.login_required has been extended to configure the conn connection upon login, handle login failure differently etc.

#### 16.7.2 Style guides

Tips on good practice in views.py methods and their corresponding URLs.

- Include any required arguments in the function parameter list. Although many views.py methods use the `**kwargs` parameter to accept additional arguments, it is best not to use this for arguments that are absolutely required by the method.
- Specify default parameters where possible. This makes it easier to reuse the method in other ways.
- Use keyword arguments in URL regular expressions. This makes them less brittle to changes in parameter ordering in the views.
- Similarly, use keyword arguments for URLs in templates.
and reverse function:

```python
>>> from django.core.urlresolvers import reverse
>>> reverse('url_name', kwargs={'object_id': 1})
```

### 16.7.3 OMERO.web error handling

Django comes with some nice error handling functionality. We have customized this and also provided some client-side error handling in JavaScript to deal with errors in AJAX requests. This JavaScript can be found in the ..?...js code which should be included in all pages that require this functionality. Errors are handled as follows:

- **404** Simply display a 404 message to the user
- **403** This is ‘permission denied’ which probably means the user needs to login to the server (e.g. session may have timed out). The page is refreshed which will redirect the user to login page.
- **500** Server error. We display a feedback form for the user to submit details of the error to our QA system - POSTs to “qa.openmicroscopy.org.uk:80”. This URL is configurable in settings.py.

In general, you should not have to write your own error handling code in views.py or client side. The default behavior is as follows:

#### With Debug: True (during development)

Django will return an HTML page describing the error, with various parameters, stack trace etc. If the request was AJAX, and you have our JavaScript code on your page then the error will be handled as described (see above). NB: With Debug True, 500 errors will be returned as HTML pages by Django but these will not be rendered as HTML in our feedback form. You can use developer tools on your browser (e.g. Firebug on Firefox) to see various errors and open the request in a new tab to display the full debug info as HTML.

#### With Debug: False (in production)

Django will use its internal error handling to produce standard 404, 500 error pages. We have customized this behavior to display our own error pages. The 500 error page allows you to submit the error as feedback to our QA system. If the request is AJAX, we return the stack trace is displayed in a dialog which also allows the error to be submitted to QA.

#### Custom error handling

If you want to handle certain exceptions in particular ways you should use appropriate try/except statements.

This is only advised for trivial errors, where you can give the user a simple message, e.g. “No Objects selected, Please try again”, or if the error is well understood and you can recover from the error in a reasonable way.

For ‘unexpected’ server errors, it is best to allow the exception to be handled by Django since this will provide a lot more info to the user (request details etc.) and format HTML (both with Debug True or False).

If you still want to handle the exception yourself, you can provide stack trace alongside a message for the user. If the request is ajax, do not return HTML, since the response text will be displayed in a dialog box for the user (not rendered as HTML).

```python
try:
    # something bad happens
except:
    # log the stack trace
    logger.error(traceback.format_exc())
    # message AND stack trace
    err_msg = "Something bad happened! \n \n%s" % traceback.format_exc()
    if request.is_ajax():
```
You can use these templates in a number of ways, but there are 2 general scenarios that are detailed below:

- You want a page header to look like the webclient, but you do not need any data or connection to an OMERO server.
- You want a page that looks and behaves like it is part of the webclient application, including data from the OMERO server.

### 16.8.1 Django templates

We use Django templates for the OMERO.web pages. See docs here: [https://docs.djangoproject.com/en/dev/ref/templates/](https://docs.djangoproject.com/en/dev/ref/templates/) and [template inheritance](https://docs.djangoproject.com/en/dev/topics/templates/#template-inheritance). We have designed a number of OMERO.web base templates that you can extend. The base templates live in the ‘webgateway’ app under omeroweb/webgateway/templates/webgateway/base. You can use these to make pages that do not require an OMERO login (e.g. public home page) etc.

If you want your pages to extend the webclient application, you can use templates from omeroweb/webclient/templates/webclient/base.

These templates are described in more detail below.

### 16.8.2 Getting Started

Within your [OMERO web app](https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/tools/OmeroWeb/omeroweb/webclient/templates/webclient/base), create a new page template and add this line at the top:

---

17[https://docs.djangoproject.com/en/dev/topics/templates/#template-inheritance](https://docs.djangoproject.com/en/dev/topics/templates/#template-inheritance)

Now add the page content in a ‘content’ block like this:

{% block content %}
    Your page content goes here
{% endblock %}

You can now save this template and view the page. It should look something like the screen-shot above. You could add a ‘title’ block to set the page <title>

{% block title %}
    My OMERO web app page
{% endblock %}

Additional blocks can be used to customize the page further. See below for more details.

### 16.8.3 Using Webclient templates

Webclient templates can be used in exactly the same way, for example try using this at the top of the page you created above:

{% extends "webclient/base/base_container.html" %}

However, this template will need various pieces of data to be in the page context that Django uses to render the page. You will need to use the @login_required() and @render_response() decorators on your views.py methods in order to retrieve this info and pass it to the template. See Writing OMERO.web views for more details.

If you have used the ‘content’ block on this page (as described above) you will see that your page content fills the whole area under the header. However, if you want to use the same 3 column layout as the webclient, you can replace your ‘content’ block with:

{% block left %}
    Left column content
{% endblock %}

{% block center %}
    Center content
{% endblock %}

{% block right %}
    Right column content
{% endblock %}

This should give you something like the screen-shot below.

### 16.8.4 Extending templates

You should aim to create a small number of your own base templates, extending the OMERO.web webgateway or webclient templates as required. If you extend all of your own pages from a small number of your own base templates, then you will find it easier to change things in future. For example, any changes in our ‘webgateway’ templates will only require you to edit your own base templates.

Here is a full list of the templates under omeroweb/webgateway/templates/webgateway/base with more details below:

- **base_html.html** - This provides the base <html> template with blocks for ‘link’ (for CSS) ‘title’ ‘script’ and ‘body’. It is extended by every other template. Usage: {% extends "webgateway/base/base_html.html" %}
• base_frame.html - This adds jQuery and jQuery-ui libraries to a blank page. Used for popup windows etc. Usage: {% extends "webgateway/base/base_frame.html" %}

• base_header.html - This also extends base_html.html adding all the header and footer components that are used by the webclient. See screen-shot above. More details below.

• base_main.html - This adds jQuery and jQuery-ui libraries to the base_header.html template. Used for popup windows etc. Usage: {% extends "webgateway/base/base_main.html" %}

• container2.html, container3.html - These templates extend the base_header.html template, adding a 2 or 3 column layout in the main body of the page. container3.html is used by the webclient for the base_container example above.

Webtest examples

You can find examples of how to extend the base templates in the webtest application. The location of these depends on your OMERO version:

• 4.4.0 - 4.4.4 - Look under omeroweb/webtest/templates/webtest/common. View live at <your-server-name>/webtest/common/base_header/

• After 4.4.4 - Look under omeroweb/webtest/templates/webtest/webgateway. View live at <your-server-name>/webtest/webgateway_templates/base_header/>

The link is to an example that extends base_header.html and contains links to all the other webtest examples. These pages indicate the names of the various template “blocks” that have been used to add content to different parts of the page (also see below for block names).

16.8.5 Content blocks

These blocks can be used to add content to specific points in the page.

Note: It is important to consider using {{ block.super }} if you want to include the content from the parent template. This is critical for the “link” and “script” blocks, which are used to add <link> and <script> elements to the head of the page. If you forget to use " " {{ block.super }} " " then you will remove all the CSS and JavaScript links required by the parent template.

See base_header.html\(^\text{19}\) for full template details.

• link: Used to add CSS with <link> blocks to the page head. E.g:

16.9 Public data in OMERO.web

Since OMERO 4.4, the OMERO.web framework has supported auto-login for a single username / password. This means that any “public” visitors to certain OMERO.web pages will be automatically logged in and will be able to access and data that is available to the defined ‘public user’.

Here is how to go about setting this up on your OMERO.web install:

- Create a group with read-only permissions (name can be anything e.g. “public-data”). We use read-only permissions so that the public user will not be able to modify, delete or annotate data belonging to other members.
- Create a member of this group, noting the username and password (we will enter these below). Again, the First Name, Last Name, username and password can be anything you like.
- Enable the public user and set their username and password:

  ```bash
  $ bin/omero config set omero.web.public.enabled True
  $ bin/omero config set omero.web.public.user '<username>'
  $ bin/omero config set omero.web.public.password '<password>'
  ```

- Set a URL filter for which the OMERO.web public user is allowed to navigate. Default: ‘^/(?!webadmin)’ (Python regular expression). You probably do not want the whole webclient UI to be publicly visible (although you could do this).

  The idea is that you can create the public pages yourself since we do not provide them. For example, to allow only URLs that start with '/my_web_public' you would use:

  ```bash
  $ bin/omero config set omero.web.public.url_filter '/my_web_public'
  ```
To enable public access to view images in a public group in the webclient while still preventing data manipulation, use the following command:

```bash
$ bin/omero config set omero.web.public.url_filter '^(?!webadmin|webclient/action/\w+|webclient/annotate_(file|tags|comment))'
```

If you simply want to enable the image viewer, making sure all data stays secure you would use:

```bash
$ bin/omero config set omero.web.public.url_filter '/webgateway'
```

Then you can access public images via the following link `http://your_host/webgateway/img_detail/IMAGE_ID/`. Please remember that public images must be in a public group where public user can access them.

Exotic matching techniques can be used but more explicit regular expressions are needed when attempting to filter based on a base URL:

- `webtest` matches `/webtest` but also `/webclient/webtest`
- `dataset` matches `/webtest/dataset` and also `/webclient/dataset`
- `/webtest` matches `/webtest...` but also `/webclient/webtest`
- `/webtest` matches `/webtest...` but not `/webclient/webtest`

Set a server to connect to. Default: 1 (the first server in omero.web.server_list)

```bash
$ bin/omero config set omero.web.public.server_id 1
```

If you wish to mix public and restricted access to the system, the user can always access the login page using the following link `http://your_host/webclient/login/`. 
17.1 Architecture

17.1.1 Logical view

OMERO.insight is logically organized in two layers. The Agents layer contains the logic to manage user interaction. It contains coarse grained components which we call agents, that are each responsible for a specific aspect of the application’s functionality:

- The Data Manager provides the user with the GUI functionality to access their data, metadata and visualize large image sets.
- The Viewer is a tool to visualize and tune 5D images.
- The Measurement Tool is a tool to perform basic measurement.

Note: If you want to add a new agent, go to How to build an agent.

These agents are internally organized according to the MVC (Model-View-Controller\(^1\)) pattern, PAC (Presentation-Abstraction-Control\(^2\)) pattern, or a combination of the two. They rely on the services provided by the bottom layer, the Container, to accomplish their tasks.

The Container layer manages the agents life-cycle and provides them with services to:

- Communicate without having to know each other (Event bus).
- Access the OMERO Server (data management and image services).
- Transform entries in configuration files into objects and then access them (Configuration).
- Log messages (log service) and notify the user (user notification service) of runtime errors.
- Cache data (cache service).
- Provide a common top level window to plug their GUI’s (Taskbar).

17.1.2 Initialization of Agents

Agents let the container create them and then manage their life-cycle. This is achieved through the use of a common interface, Agent, that all agents have to implement and by requiring every agent to have a public no-arguments constructor. The Agent interface plays the role of a Separated Interface (Fow\(^3\)), decoupling the container from knowledge of concrete agents. This way, new agents can be plugged in.

At start-up the container finds out which are the agents’ implementation classes from its configuration file, instantiates every agent by reflection (using the no-arguments constructor) and then reads each agent’s configuration file (Fow\(^4\)). The configuration entries in this file are turned into objects and collected into a map-like object, which is then passed to the agent. This map object also contains pointers to the container’s services. We can think of this object as a Registry (Fow\(^5\)).

---

\(^1\)http://en.wikipedia.org/wiki/Model-view-controller
\(^2\)http://en.wikipedia.org/wiki/Presentation-abstraction-control
\(^3\)http://martinfowler.com/books
\(^4\)http://martinfowler.com/books
\(^5\)http://martinfowler.com/books
There is one Registry containing pointers to the container’s services for each agent, so configuration entries are private to each agent - container’s services are shared among all agents though. Agents access the Registry object through the Registry interface.

The life-cycle of an agent is as follow:
17.1.3 Interaction among Agents

Interactions among agents are event-driven. Agents communicate by using a shared Event bus provided by the container. The event bus is an event propagation mechanism loosely based on the Publisher-Subscriber pattern and can be regarded as a time-ordered event queue - if event A is posted on the bus before event B, then event A is also delivered before event B.

17.1.4 Process view

All agents run synchronously within the Swing dispatching thread. All container’s services are called within Swing event handlers and thus run within the Swing dispatching thread. To see how to retrieve data from an OMERO server, go to the Retrieve data from server page.

See also:
Organization, Event bus

17.2 Configuration

The container provides a flexible and extensible configuration mechanism. Each agent has its own configuration file which is parsed at start-up by the container. The configuration entries in this file are turned into objects and collected into a map-like object, which is then passed to the agent. This map object also contains pointers to the container’s services. Thus, we can think of this object as a Registry. There is one Registry for each agent, so configuration entries are private to each agent - container’s services are shared among all agents though. The container also has its own configuration file and Registry.

The container maintains a set of predefined bindings that are used to convert a configuration entry into an object - such as a String, Integer, Font, IconFactory, etc. However, agents can specify custom handlers for converting a configuration entry into an object.

17.2.1 Structure

Configuration files are XML files which declares only two elements:

---

http://en.wikipedia.org/wiki/Publish/subscribe
The `entry` and `structuredEntry` elements are used to specify name-value pairs in the actual configuration files. Both elements have a required name attribute whose content is used as a key for accessing the entry value from within the application. In the case of the `entry` element, the value is a string – this element can thus be used for “classic” name-value style, such as:

```
<entry name="ITEM">The item’s value</entry>
```

On the other hand, the value of `structuredEntry` can be made up by any arbitrary sequence of tags.

In both cases (`entry` and `structuredEntry`), the entry value is returned to the application as an object and the type attribute dictates how the entry value is turned into an object. Only “string”, “integer”, “float”, “double” and “boolean” may be used for the type attribute within the `entry` element, whose content is parsed into a `String`, `Integer`, `Float`, `Double` or `Boolean` object according to the content of the type attribute – if this attribute is missing, then “string” is assumed. For example, say you write the following into an agent’s configuration file:

```
<entry name="/some/name" type="boolean">true</entry>
```

This will make a `Boolean` object (set to hold `true`) available to the agent – the key for accessing the object will be the string “/some/name”.

Things work similarly for the `structuredEntry` element. In this case, the content of the type attribute can be specified to be the fully qualified name of the class that will handle the transformation of the entry value into an object. This is provided so that agents may specify custom handlers for custom configuration entries. For example, an agent’s configuration file could contain the entry:

```
<structuredEntry name="/some/name" type="some.pkg.SomeHandler">
  <tag_1>aValue</tag_1>
  <tag_2>anotherValue</tag_2>
</structuredEntry>
```

In this case, an instance of `some.pkg.SomeHandler` will be created to transform the contents of the entry (that is `tag_1` and `tag_2`) into a custom object. Obviously enough, the tags contained within a `structuredEntry` have to be exactly the tags that the handler expects.

If no type attribute is specified, then it is assumed `type = "map"`, which results in the entry’s contents being parsed into a `Map` object. Each child tag is assumed to be a simple tag with a string content, like in the following example:
Each child tag's name is a key in the map and the tag's content is its value – the above would generate the map: \( (\text{key}_1, \text{value}_1), (\text{key}_2, \text{value}_2) \).

Some predefined structured entries are supplied by the container for common cases (icons and font entries) and for use by the container only (OMERO and agents entries). Here's an excerpt from the container's configuration file:

```xml
<container>
  <services>
    <structuredEntry name="/services/OMERODS" type="OMERODS">
      <port>1099</port>
    </structuredEntry>
  </services>
  <agents>
    <structuredEntry name="/agents" type="agents">
      <agent>
        <name>Viewer</name>
        <!-- The class tag specifies the FQN of the agent’s class. -->
        <class>org.openmiscroscopy.shoola.agents.viewer.Viewer</class>
        <!-- The config tag specifies the name of the agent's configuration file. -->
        <config>viewer.xml</config>
      </agent>
    </structuredEntry>
  </agents>
  <resources>
    <iconFactories>
      <!-- This entry can be used in agents' configuration files as well. -->
      <structuredEntry name="/resources/icons/DefaultFactory" type="icons">
        <!-- The location tag specifies the FQN of the package that contains the icon files. -->
        <location>org.openmicroscopy.shoola.env.ui.graphx</location>
      </structuredEntry>
    </iconFactories>
    <fonts>
      <!-- This entry can be used in agents' configuration files as well. -->
      <structuredEntry name="/resources/fonts/Titles" type="font">
        <family>SansSerif</family>
        <size>12</size>
        <style>bold</style>
      </structuredEntry>
    </fonts>
  </resources>
</container>
```

The configuration parser only takes the `entry` and `structuredEntry` tags into account and ignores all the others. It may be useful to group sets of related entries together, as shown above.

The classes that encompass the machinery for parsing configuration files and building registries are depicted by the following UML class diagram.
The Entry abstract class sits at the base of a hierarchy of classes that represent entries in configuration files. It represents a name-value pair, where the name is the content of the name attribute of a configuration entry (which is stored by the name field) and the value is the object representing the entry’s content. As the logic for building an object from the entry’s content depends on what is specified by the type attribute, this class declares an abstract getValue method which subclasses implement to return the desired object – we use polymorphism to avoid conditional logic. So we have subclasses (StringEntry, IntegerEntry, IconFactoryEntry, etc.) to handle the content of an entry tag (either entry or structuredEntry) in correspondence of each predefined value of the type attribute (“string”, “integer”, “icons”, and so on). Given an entry tag, the createEntryFor static method (which can be considered a Factory Method) creates a concrete Entry object to handle the conversion of that tag’s content into an object. Subclasses of Entry implement the setContent method to grab the tag’s content, which is then used for building the object returned by the implementation of getValue().

The Registry Interface declares the operations to be used to access configuration entries and container’s services.

The RegistryImpl class implements the Registry interface. It maintains a map of Entry objects, which are keyed by their name attribute and represent entries in the configuration file. It also maintains references to the container’s services into member fields – as services are accessed frequently, this ensures O(1) access time.

The Parser class is in charge of parsing a configuration file, extracting entries (only entry and structuredEntry tags are taken into account), obtain an Entry object to represent each of those entries and add these objects to a given RegistryImpl object.

### 17.2.2 Dynamics

How a configuration file is parsed and the corresponding Registry is built:

A RegistryImpl object is created with an empty map. Then a Parser object is created passing the path to the configuration file and the RegistryImpl object. At this point parse() is invoked on the Parser object. The configuration file is read (the XML parsing is handled by built-in JAXP libraries) and, for each configuration entry (that is, either entry or structuredEntry tag), createEntryFor() is called to obtain a concrete Entry object, which will handle the conversion of the tag’s content into an object. This Entry object is then added to the map kept by the RegistryImpl object.

In order to find out which class is in charge of handling a given tag, the Entry class maintains a map, contentHandlers, whose keys are the predefined values used for the type attribute (“string”, “integer”, “icons”, etc.) and values are the fully qualified

---

**Figure 17.3: OMERO.insight configuration**

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---

**Figure 17.3: OMERO.insight configuration**
names of the handler classes. Given a tag, `createEntryFor()` uses the content of the type attribute (or “string” if this attribute is missing) to look up the class name in the map and then creates an instance by reflection - all `Entry`'s subclasses are supposed to have a no-args constructor. If the class name is not found in the map, then the content of the type attribute is assumed to be a valid fully qualified name of an `Entry`'s subclass. This allows for agents to specify custom handlers – as long as the handler extends `Entry` and has a public no-args constructor.

Notice that the `RegistryImpl` object adds the couple `(e.getName(), e)` to its map. Because the `Entry` class takes care of setting the name field to the content of the name attribute within the entry tag, the application code can subsequently access `e` by specifying the value of the name attribute to `lookup()`. The above outlined process is repeated for each configuration file so that the configuration entries of each agent (and the container) are kept in separate objects – a `RegistryImpl` is created every time. Because every agent is then provided with its own `RegistryImpl` object, the configuration entries are private to each agent. However, the container configures all `RegistryImpl` objects with the same references to its services.

See also:

**Directory contents**

### 17.3 Contributing to OMERO.insight

**Note:** See the [Contributing Developer] documentation for more information about contributing to OME projects in general.

#### 17.3.1 Getting started with OMERO.insight

Getting started with OMERO.insight entails that you have an `OMERO.server` already deployed.

[Contributing Developer]: http://www.openmicroscopy.org/site/support/contributing/
17.3.2 Installing from source

Since January 2011, the OMERO.insight code base is part of the OMERO code base. See Installing OMERO from source, to check out code using http://git.openmicroscopy.org.

Requirements

- Install a Java 6 or Java 7 Development Kit (JDK), available from Java SE Downloads and required for both the OMERO server and client code. Set the JAVA_HOME environment variable to your JDK installation.

Running code

It is helpful to set up the project in Eclipse. Because the OMERO Java and Python source files are encoded in UTF-8, ensure that the encoding in Eclipse (Preferences → General → Workspace → Text file encoding) is also set to UTF-8.

Build system

Ant

The compilation, testing, launch, and delivery of the application are automated by means of an Ant build file, located under the build directory (See Directory contents). Move to the build directory and, from the command line, enter:

```
java build
```

This will display the available targets to compile, run, test, and create a distribution bundle. Use the target you wish, for example:

```
java build all
```

Because all the tools needed to build the software are already included in the build directory, you do not need to have Ant on your machine. If you wish to use Ant instead, you can still do it by using the build.xml file under the build directory. However, there are some dependencies to satisfy before; these are clearly documented in the build.xml file itself.

Jenkins

The OME project currently uses Jenkins (formerly known as hudson) as a continuous integration server available here. OMERO.insight is built as part of the “OMERO” jobs. See the contributing developer continuous integration documentation for full details.

17.4 Directory contents

The repository of the software artifacts is organized as follows:

- **build**: This directory contains the tools to compile, run, test, and deliver the application.
- **config**: Various configuration files required by the application to run.
- **docgen**: Documentation artifacts that are used to build actual documents. These are organized in two sub-directories: javadoc and xdocs. The former only contains resources (like CSS files) to generate programmer’s documentation – the actual documentation contents are obtained from the source code. The latter contains both resources (like stylesheets and

---

9http://www.eclipse.org
10http://ant.apache.org/
11http://jenkins-ci.org
12http://ci.openmicroscopy.org/
13http://www.openmicroscopy.org/site/support/contributing//ci-omero.html
DHTML code) to generate all other kinds of documentation (like design and users documents) and the actual documentation contents in the form of XML/HTML files.

- **launch**: Launcher scripts and installation instructions bundled with the default application distribution file. Its sub-dirs contain further resources to build platform-specific distributions.
- **SRC**: Contains the application source files.
- **TEST**: The test code.
- **README**: The README file.

## 17.5 Event bus

Interactions among agents are event-driven. Agents communicate by using a shared event bus provided by the container. The event bus is an event propagation mechanism loosely based on the **Publisher-Subscriber** pattern and can be regarded as a time-ordered event queue - if event A is posted on the bus before event B, then event A is also delivered before event B.

Events are fired by creating an instance of a subclass of *AgentEvent* and by posting it on the event bus. Agents interested in receiving notification of *AgentEvent* occurrences implement the *AgentEventListener* interface and register with the event bus. This interface has a callback method, *eventFired*, that the event bus invokes in order to dispatch an event. A listener typically registers interest only for some given events - by specifying a list of *AgentEvent* subclasses when registering with the event bus. The event bus will then take care of event de-multiplexing - an event is eventually dispatched to a listener only if the listener registered for that kind of event.

### 17.5.1 Structure

Figure 17.5: OMERO.insight event bus

---

EventBus

- Defines how client classes access the event bus service.
- A client object (subscriber) makes/cancels a subscription by calling `register()`/`remove()`.
- A client object (publisher) fires an event by calling `postEvent()`.

AgentEvent

- Ancestor of all classes that represent events.
- Source field is meant to be a reference to the publisher that fired the event.
- An event is "published" by adding its class to the events package within the agents package.

AgentEventListener

- Represents a subscriber to the event bus.
- Defines a callback method, `eventFired`, that the event bus invokes in order to dispatch an event.

EventBusListener

- Concrete implementation of the event bus.
- Maintains a de-multiplex table to keep track of what events have to be dispatched to which subscribers.

17.5.2 In action

- When a subscriber invokes the register or remove method, the de-multiplex table is updated accordingly and then the event bus returns to idle.
- When a publisher invokes `postEvent()`, the event bus enters into its dispatching loop and delivers the event to all subscribers in the event notification list.
- Time-ordered event queue - if event A is posted on the bus before event B, then event A is also delivered before event B.
- Dispatching loop runs within same thread that runs the agents (Swing dispatching thread).

17.6 Event

17.6.1 Structure

We devise two common categories of events:

- Events that serve as a notification of state change. Usually events posted by agent to notify other agents of a change in its internal state.
- Events that represent invocation requests and completion of asynchronous operations between agents and some services.

In the first category fall those events that an agent posts on the event bus to notify other agents of a change in its internal state. Events in the second category are meant to support asynchronous communication between agents and internal engine. The `AgentEvent` class, which represents the generic event type, is sub-classed in order to create a hierarchy that represents the above categories. Thus, on one hand we have an abstract `StateChangeEvent` class from which agents derive concrete classes to represent state change notifications. On the other hand, the `RequestEvent` and `ResponseEvent` abstract classes are sub-classed by the container in order to define, respectively, how to request the asynchronous execution of an operation and how to represent its completion. We use the Asynchronous Completion Token pattern to dispatch processing actions in response to the completion of asynchronous operations.

StateChangeEvent

- Ancestor of all classes that represent state change notifications.
- Its state field can be used to carry all state-change information.

RequestEvent

- Abstractly represents a request to execute an asynchronous operation.
A concrete subclass encapsulates the actual request.

Knows how and which processing action to dispatch upon completion of the asynchronous operation.

CompletionHandler

- Represents a processing action.
- Allows for all processing action to be treated uniformly.

ResponseEvent

- Abstractly represents the completion of an asynchronous operation.
- A concrete subclass encapsulates the result of the operation, if any.
- Knows the RequestEvent object that originated it.
- Knows how to activate the de-multiplexing of a completion event to the processing action.

17.6.2 In action

Follow a concrete example:

```java
//Somewhere in the Data Manager
//Request to View an image

EventRequest req = new ViewImage((ImageData) image, null)
//Request the execution of the view call.
eventBus.postEvent(req);
```
A concrete `RequestEvent` encapsulates a request to execute an asynchronous operation. Asynchrony involves a separation in space and time between invocation and processing of the result of an operation: we request the execution of the operation at some point in time within a given call stack (say in method `X` we make a new request and we post it on the event bus). Then, at a later point in time and within another call stack (event `Fired` method), we receive a notification that the execution has completed and we have to handle this completion event - which mainly boils down to doing something with the result, if any, of the operation. Recall that the `ResponseEvent` class is used for representing a completion event and a concrete subclass carries the result of the operation, if any. After the operation has completed, a concrete `ResponseEvent` is put on the event bus so that the object which initially made the request (often an agent, but, in this context, we will refer to it as the initiator, which is obviously required to implement the `AgentEventListener` interface and register with the event bus) can be notified that execution has completed and possibly handle the result. Thus, at some point in time the initiator’s `eventFired` method is called passing in the response object.

Now the initiator has to find out which processing action has to be dispatched to handle the response. Moreover, the processing action often needs to know about the original invocation context - unfortunately, we cannot relinquish the original call stack (method `X` is gone). The solution is to require that a response be linked to the original request and that the initiator link a request to a completion handler (which encapsulates the processing action) before posting it on the event bus (this explains the fancy arrangement of the `RequestEvent`, `ResponseEvent` and `CompletionHandler`).

This way de-multiplexing matters are made very easy for the initiator. Upon reception of a completion event notification, all what the initiator has to do is to ask the response object to start the de-multiplexing process - by calling the complete method.
This method calls handleCompletion() on the original request, passing in the response object. In turn, handleCompletion() calls the handle method on its completion handler, passing in both the request and the response. The right processing action has been dispatched to handle the response. Also, notice that the completion handler is linked to the request in the original invocation context, which makes it possible to provide the handler with all the needed information from the invocation context. Moreover, both the original request and the corresponding response are made available to the completion handler. This is enough to provide the completion handler with a suitable execution context - all the needed information from the original call stack is now available to the processing action.

17.7 How to build an agent

An agent is created and managed by the container. Building an agent is done in two steps:

- write the agent code
- declare the agent in the container.xml file located in the config directory

The agent intercepts the events posted on the event bus.

Note: When a new version of the software is delivered, make sure you keep the container.xml shipped with the application and add the new agent entry to it.

17.7.1 Writing code

The following example creates a concrete agent MyBrowserAgent:

- Create a myBrowser package in the agents package.
- Create a class MyBrowserAgent, this class MUST implement the Agent interface to be initialized and the AgentListener to interact with other agents.

```java
public class MyBrowserAgent
    implements Agent, AgentEventListener
{

    /** Reference to the registry. */
    private static Registry registry;

    //no-arguments constructor required for initialization
    public MyBrowserAgent() {}

    //Follow methods required by the Agent Interface

    //No-op implementation in general
    public void activate()
    {
        //this method will be invoked during the activation by the container
    }

    //invoked before shutting down the application
    public boolean canTerminate() { return true; }

    //not yet implemented: invoked when shutting down the application
    public Map<String, Set> hasDataToSave() { return null; }

    //invoked while shutting down the application
    public void terminate() {}

    public void setContext(Registry ctx)
    {
        //Must be a reference to the Agent Registry to access services.
        registry = ctx;
    }
}
```
//register the events the agent listens to e.g. BrowseImage
EventBus bus = registry.getEventBus();
bus.register(this, BrowseImage.class);
}

public void eventFired(AgentEvent e)
{
    if (e instanceof BrowseImage) {
        //Do something
        browseImage((BrowseImage) e);
    }
}

Where to create the BrowseImage event

- Create a myBrowser package in the agents.events package.
- Create a BrowseImage event in the myBrowser package.

public class BrowseImage
    extends RequestEvent
{

    /** The id of the image to browse. */
    private long imageID;

    /**
     * Creates a new instance.
     * @param imageID The id of image to view.
     */
    public BrowseImage(long imageID)
    {
        if (imageID < 0)
            throw new IllegalArgumentException("ImageID not valid.");
        this.imageID = imageID;
    }

    /**
     * Returns the ID of the image to browse.
     * @return See above.
     */
    public long getImageID() { return imageID; }

}

Listening to the BrowseImage event

To listen to events posted on the event bus, the agent MUST implement the AgentEventListener Interface and register the events to listen to.

- Register BrowseImage in the setContext(Registry) method of the Agent interface.
• **Listen to** `BrowseImage` **in the** `eventFired(AgentEvent)` **method of the** `AgentListener` **interface.**

For example, when clicking on an image in the Data Manager, the following event is posted:

```java
EventBus bus = registry.getEventBus();
bus.post(new BrowseImage(imageID));
```

The `MyBrowserAgent` handles the event

```java
public void eventFired(AgentEvent e) {
    if (e instanceof BrowseImage) {
        // Do something
        browseImage((BrowseImage) e);
    }
}
```

**Creating an agent's view**

See *How to build an agent's view*

### 17.7.2 Declaring the agent

The `MyBrowserAgent` needs to be declared in the `container.xml`.

- **Open the** `container.xml` **located in the config folder (see Directory contents).**
- **Add the following:**

```xml
<agents>
    <structuredEntry name="/agents" type="agents">
        <!-- NOTE FOR DEVELOPERS
        Add an agent tag for each of your Agents.
        The name tag specifies the human-readable name of the Agent.
        The active tag specifies if the agent is turned on or off.
        Set to true to turn the agent on, false otherwise.
        The class tag specifies the FQN of the Agent class.
        The config tag specifies the name of the Agent's configuration file within the config directory.
        -->
        <agent>
            <name>My Browser</name>
            <active>true</active>
            <class>org.openmicroscopy.shoola.agents.mybrowser.MyBrowserAgent</class>
            <config>mybrowser.xml</config>
        </agent>
    </structuredEntry>
</agents>
```

- **Create a** `mybrowser.xml` **and add it to the config directory:**

```xml
<?xml version="1.0" encoding="utf-8"?>
<agent name="My Browser">
    <resources>
        <iconFactories>
            <!-- This entry is turned into an instance of:
                 org.openmicroscopy.shoola.env.config.IconFactory
            -->
        </iconFactories>
    </resources>
</agent>
```
This object can then be used to retrieve any image file within the directory pointed by the location tag. -->

<structuredEntry name="/resources/icons/Factory" type = "icons">
<!-- The location tag specifies the FQN of the package that contains the icon files. -->
<location>org.openmicroscopy.shoola.agents.myBrowser.graphx</location>
</structuredEntry>
</iconFactories>
<fonts>
<!-- This entry is turned into an instance of java.awt.Font. -->
<structuredEntry name="/resources/fonts/Titles" type="font">
<fam ily>SansSerif</family>
<size>12</size>
<style>bold</style>
</structuredEntry>
</fonts>
</resources>
</agent>

The file mybrowser.xml allows the agent to define specific parameters.

See also:
Organization, Retrieve data from server

17.8 How to build an agent’s view

This section explains how a view of the agent is created. All our agents follow the same approach. To see the code while reading the notes, go to components/insight/SRC/org/openmicroscopy/shoola/agents/treeviewer/view.

Using the previous example MyBrowserAgent (see How to build an agent):

1. Create a view package in the mybrowser package.

2. Create the following classes MyBrowser (interface), MyBrowserComponent, MyBrowserModel, MyBrowserControl, and MyBrowserUI. If you browse the source code, you will notice that we usually have a class used as a toolbar and a class used as a status bar. Both classes are initialized by the BrowserUI. For clarity, they have been omitted in the following diagram.

3. Create a MyBrowserFactory. This class keeps track of the MyBrowser instances created and not yet discarded. A component is only created if none of the tracked ones is displaying the data, otherwise the existing component is recycled.

17.8.1 Typical life-cycle of an agent view

The object is first created using the MyBrowserFactory

//Somewhere in the MyBrowserFactory code

/** The sole instance. */
private static final MyBrowserFactory singleton = new MyBrowserFactory();

/**
* Returns a viewer to display the specified images.
* @param images The <code>ImageData</code> objects.
*
public static MyBrowser getViewer(Set<ImageData> images)
MyBrowserModel model = new MyBrowserModel(images);
return singleton.getViewer(model);

/**

 Figure 17.8: OMERO.insight agent view

 The diagram shows how an Agent View is organised.

 Defines the functionalities of the MyBrowser. Provides a
top-level window to host data.

 <<interface>>
 MyBrowser
 +activate()
 +discard()
 +getUI(): JFrame

 Regarded as the Model

 back ref

 MyBrowserControl

 The MyBrowser's Controller

 MyBrowserModel

 Tracks state changes and knows how to initiate data retrievals. Also knows how to store and manipulate results

 MyBrowserComponent

 Component hub, embeds the component's MVC triad. It manages the component's state machine and fires state change
notifications as appropriate, but delegates actual functionality to the MVC sub-components.

 MyBrowserUI

 The MyBrowser's View. Extends Top Window (i.e. JFrame)
* Creates or recycles a viewer component for the specified 
* <code>model</code>. 
* 
* @param model The component’s Model. 
* @return A {@link MyBrowser} for the specified <code>model</code>. 
*/
private MyBrowser getViewer(MyBrowserModel model)
{
    Iterator v = viewers.iterator();
    MyBrowserComponent comp;
    while (v.hasNext()) {
        comp = (MyBrowserComponent) v.next();
        if (model.isSameDisplay(comp.getModel())) {
            comp.refresh(); //refresh the view.
            return comp;
        }
    }
    comp = new MyBrowserComponent(model);
    comp.initialize();
    comp.addChangeListener(this);
    viewers.add(comp);
    return comp;
}

After creation, the object is in the MyBrowser#NEW state and is waiting for the MyBrowser#activate() method to be called. Such a call usually triggers loading of the objects on the server. The object is now in the MyBrowser#LOADING state. After all the data have been retrieved, the object is in the MyBrowser#READY state and the data display is built and set on screen.

When the user quits the window, the MyBrowser#discard() method is invoked and the object transitions to the MyBrowser#DISCARDED state. At which point, all clients should de-reference the component to allow for garbage collection.

17.9 Retrieve data from server

To retrieve data stored in an OMERO server, Agents can either:

- directly access a Data service (container service) through their Registry (in which case, the call happens in the Swing dispatching thread, so it is not possible to give user feedback by showing a progress bar for example):

  OmeroDataService service = registry.getDataService();
  service.getServerName()

- or retrieve data asynchronously using a Data Services View

17.9.1 Data services view

Usage

A data services view is a logical grouping of data and operations that serve a specific purpose, for example to support dataset browsing by providing easy access to datasets, thumbnails, tags, etc. A data services view is defined by an interface that extends DataServiceView and consists of a collection of asynchronous calls that operate on (possibly) large portions of a data model in the background.

Agents obtain a reference to a given view through their registry by specifying the view’s defining interface as follows (note the required cast on the returned reference):

  XxxView view = (XxxView) registry.getDataServicesView(XxxView.class);
XxxView is obviously a made up name for one of the sub-interfaces of DataServiceView contained in this package. All calls are carried out asynchronously with respect to the caller’s thread and return a CallHandle object which can be used to cancel execution. This object is then typically linked to a button so that the user can cancel the task, like in the following example:
final CallHandle handle = view.loadSomeDataInTheBg(observer);

//The above call returns immediately, so we don't have to wait.
//While the task is carried out, we allow the user to change
//her mind and cancel the task:

cancelButton.addActionListener(new ActionListener() {
    public void actionPerformed(ActionEvent e) {
        handle.cancel();
    }
});

The observer argument to the above call is an instance of AgentEventListener (in env.event). Normally all calls within a view allow to specify this argument, which is used to provide the caller with feedback on the progress of the task and with its eventual outcome.

Specifically, as the computation proceeds in the background, DSCallFeedbackEvents (in env.data.events) are delivered to the observer. These event objects have a status field which contains a textual description of the activity currently being carried out within the computation and a progress indicator which is set to the percentage of the work done so far. So the indicator will be 0 for the first feedback event and, if the computation runs to completion, 100 for the last feedback event, which will always have its status field set to null – note that a null status is also possible for the previous events if no description was available at the time the event was fired. Moreover, any partial result that the computation makes available will be packed into the feedback event.

It is important to keep in mind that the computation may not run to completion – either because of an exception within the computation or because the agent cancels execution – CallHandle.cancel() (in env.data.views). In both cases, the feedback notification will not run to completion either. However, in any case a final DSCallOutcomeEvent (in env.data.events) is delivered to the observer to notify of the computation outcome – the event’s methods can be used to find out the actual outcome and retrieve any result or exception. Every call documents what is the returned object and what are the possible exceptions so that the caller can later cast the returned value or exception as appropriate.

Here is the code for a prototypical observer:

```java
public void eventFired(AgentEvent ae) {
    if (AE instanceof DSCallFeedbackEvent) { //Progress notification.
        update((DSCallFeedbackEvent) AE); //Inform the user.
    } else { //Outcome notification.
        DSCallOutcomeEvent oe = (DSCallOutcomeEvent) AE;
        switch (oe.getState()) {
            case DSCallOutcomeEvent.CANCELLED: //The user cancelled.
                handleCancellation();
                break;
            case DSCallOutcomeEvent.ERROR: //The call threw an exception.
                handleException(oe.getException());
                break;
            case DSCallOutcomeEvent.NO_RESULT: //The call returned no value.
                handleNullResult();
                break;
            case DSCallOutcomeEvent.HAS_RESULT: //The call returned a value.
                handleResult(oe.getResult());
        }
    }
}
```

Because the logic is likely to be common to most of the observers, the DSCallAdapter (in env.data.events) class factors it out to provide a more convenient way to write observers. Back to our previous example, the observer could look something like the following:

```java
observer = new DSCallAdapter() {
    public void update(DSCallFeedbackEvent fe) { //Received some feedback.
        ...
    }
};
```
```java
String status = fe.getStatus();
int percDone = fe.getPercentDone();
if (status == null)
    status = (percDone == 100) ? "Done" : ""; //Else
statusBar.setText(status); //A JLabel object part of the UI.
progressBar.setValue(percDone); //A JProgressBar object part of the UI.
}

public void onEnd() { //Called right before any of the handleXXX methods.
    progressBar.setVisible(false); //Because the computation has finished.
}

public void handleResult(Object result) { //Computation returned a result.
    //We have a non-null return value. Cast it to what
    //loadSomeDataInTheBg() declared to return.
    SomeData data = (SomeData) result;
    //Update model, UI, etc.
}

public void handleCancellation() { //Computation was cancelled.
    UserNotifier un = registry.getUserNotifier();
    un.notifyInfo("Data Loading", "SomeData task cancelled.");
}

public void handleException(Throwable exc) { //An error occurred.
    UserNotifier UN = registry.getUserNotifier();
    un.notifyError("Data Loading Failure", "Couldn’t retrieve SomeData.", exc);
}
```

Note that the observer's code in the example above works just like any other Swing listener. In fact, all events are delivered sequentially and within the Swing event dispatching thread. This means the observer can run synchronously with respect to the UI and will not need to worry about concurrency issues — as long as it runs within Swing. Finally, also note that subsequent feedback events imply computation progress and the DSCallOutcomeEvent is always the last event to be delivered in order of time.

The xxxLoader classes in agents.treeviewer are a good place to look at and see how to use data services view.

Execution

The next diagram analyzes a concrete call to a view to exemplify the pattern followed by all asynchronous calls in the various views. The call is mapped onto a command, the command is transferred to a processor for asynchronous execution, a handle to the call is returned to the invoker.

Initialization

The DataTypesFactory (in env.data.views) needs to be initialized before any concrete BatchCallTree (in env.data.views) is created. The reason for this is that BatchCallTree's constructor needs to cache a reference to the registry so that concrete subclasses can access it later. The DataTypesFactory takes care of this initialization task during the container's start-up procedure by calling DataTypesFactory.initialize(Container). Any data service view should be created in env.data.views and declared in DataTypesFactory.makeNew(Class). The method returns an implementation of the corresponding view.

See also:

Directory contents

17.10 Organization

The source code is organized as follows. All classes share a common base namespace:
Two main packages sit under the shoola directory:

- **agents**: All the classes related to concrete agents.
- **env**: All the classes that make up the runtime environment, that is the container.

The **agents** package is further broken down into:

- events
- dataBrowser
- editor
- imviewer
- measurement
- metadata
- treeviewer
- util

These packages contain the code for the Data Browser, Data Manager, Editor, Viewer, and Measurement agents. The events package contains the events that are used by all these agents.
The `env` package is also broken down into further sub-packages:

- **config**: Registry-related classes.
- **data**: Defines the client’s side interface and implementation of the Remote Facade that we use to access the OMERO server.
- **event**: The event bus classes.
- **init**: Classes to perform initialization tasks at start-up.
- **log**: Adapter classes to wrap log4j\(^{16}\).
- **cache**: Adapter classes to wrap ehcache\(^{17}\).
- **rnd**: The image data provider.
- **ui**: The top frame window and the user notification widgets.

**Note**: Two extra packages are part of the project for convenience reason only:

- **svc**: Provides general services e.g. transport service using HTTP.
- **util**: Collection of classes that be used outside the OMERO structure

### 17.11 Taskbar

The container provides a top-level window, the taskbar, to let users control some of the container’s tasks like the connection to the remote service or quitting the application. The taskbar contains a menu bar and several toolbars. Agents can add their own entries to the menu bar and to the toolbars in order to trigger agent-specific actions, or can ignore the taskbar altogether. For example, agents that are UIs typically add an entry to the Window menu and to the Quick-launch toolbar (this should be done during the agent’s linking phase) for top-level windows that the user can bring up. Some utility classes provide agents with functionality to link their top-level windows to the taskbar and to manage the display of those windows on screen.

#### 17.11.1 Structure and dynamics

The following diagram shows the classes that provide the taskbar service and their relationships:

The following diagram shows how some utility classes that can be used to link windows to the TaskBar and to manage their display on screen:

The following diagram shows how the display state of a top window is managed by the TopWindowManager:

#### 17.11.2 How to

Agents can use the taskbar directly to add entries to the various menus and toolbars. After retrieving the TaskBar from the Registry, the `addXXX` and `removeXXX` are available to do the job.

Agents can add entries to any of the menus within the menu bar – File, Connect, Tasks, Window, Help. Two toolbars, Tasks and Quick-Launch, are also provided for agents to plug in their buttons. Buttons in the Tasks toolbar are usually shortcuts to entries in the Tasks menu. Similarly, buttons in the Quick-Launch toolbar are usually shortcuts to entries in the Window menu.

However, some utility classes provide agents with built-in functionality to link their top-level windows to the taskbar and to manage the display of those windows on screen.

The `TopWindow` class extends JFrame to provide the base functionality for windows that are to be linked to the TaskBar by means of one quick-launch button and a menu entry in the Window menu. The constructor of this class automatically adds a button to the Quick-Launch toolbar and an entry in the Window menu – subclasses use the `configureXXX` methods to specify icons, names, and tool tips. These are display-trigger buttons that cause the window to be shown on screen. This class uses the `TopWindowManager` to control mouse clicks on these buttons as well as to manage the display state of the window.

\(^{16}\)http://logging.apache.org/log4j/

\(^{17}\)http://ehcache.org/
This diagram shows the classes that provide the taskbar services and their relationships. The taskbar is a top-level window that contains a menu bar and a series of toolbars. The customer brings this window up after initialization for the user to control some of the container's tasks – like the connection to remote services or quitting the application.

Agents that have a UI typically add an entry to the window menu and to the quick-launch toolbar (during the linking phase) for top-level windows that the user can bring up.

Figure 17.11: Taskbar structure

- how this display state is managed is specified by the TopWindowManager state machine, which is represented in one of the previous diagrams.

Here is an example of a window that inherits from TopWindow:

```java
class MainWindow extends TopWindow {
    // Member fields omitted.

    // Specifies names, icons, and tool tips for the quick-launch button and the
    // window menu entry in the taskbar.
    private void configureDisplayButtons() {
        configureQuickLaunchBtn(icons.getIcon("agent.png"),
                               "Display the main window.");
        configureWinMenuEntry("Example Agent", icons.getIcon("agent.png"));
    }

    // Builds and lays out this window.
    private void buildGUI() { /* Omitted. */ }
}
```

17.11. Taskbar
// Creates a new instance.
MainWindow(Registry config) {
    // We have to specify the title of the window to the superclass
    // constructor and pass a reference to the TaskBar, which we get
    // from the Registry.
    super("Example Agent", config.getTaskBar());

    configureDisplayButtons();
    buildGUI();
}

The TopWindowGroup class links a group of windows to the TaskBar and manages their display on screen. Rather than adding...
a quick-launch button in the Quick-Launch toolbar and an entry in the window menu for each window in the group, the constructor of this class adds a drop-down button (a button that triggers the display of a popup menu) to the Quick-Launch toolbar and a sub-menu to the Window menu. These menus contain an entry for each window in the group and are populated/depopulated via the add/remove methods. All those menu entries are display-trigger buttons that cause the corresponding window to be shown on screen. This class uses the TopWindowManager to control mouse clicks on these buttons as well as to manage the display state of each window in the group.

The following UIManager class provides an example of how to use the TopWindowGroup class. This example class creates and controls an instance of MainWindow (which we have already seen in the previous example) as well as AuxiliaryWindow instances. This latter class is just a window which contains two buttons and its code is omitted. UIManager delegates to the TopWindowGroup class the linkage of AuxiliaryWindow's to the TaskBar as well as the management of their display state.

Follows the code:

```java
class UIManager {
    //Inherits from TopWindow, so it is automatically linked to the TaskBar.
    //Contains a button that we listen to. When a mouse click occurs we call
    //createAuxWin().
```
private MainWindow mainWindow;

//Manages all the AuxiliaryWindow's that we have created and not destroyed yet.
private TopWindowGroup auxWinGroup;

//Counts how many AuxiliaryWindow's that we have created so far.
private int auxWinCount;

//Cached reference to access the icons.
private IconFactory icons;

//Creates a new instance.
UIManager(Registry config)
{
    auxWinCount = 0;
    icons = (IconFactory) config.lookup("/resources/icons/MyFactory");
    mainWindow = new MainWindow(config);

    //The MainWindow contains a button (not shown in the previous example)
    //which we listen to in order to trigger the creation of new
    //AuxiliaryWindow's.
    mainWindow.openAuxiliary.addActionListener(new ActionListener() {
        public void actionPerformed(ActionEvent ae) { createAuxWin(); }
    });

    //We now create the window group. The text we pass will be displayed by
    //the sub-menu within the Window menu along with the icon, which will also
    //be the icon displayed by the drop-down button in the Quick-Launch
    //toolbar.
    auxWinGroup = new TopWindowGroup("Aux Win",
        icons.getIcon("edu_languages.png"),
        config.getTaskBar());
}

//Creates an AuxiliaryWindow and adds it to the auxWinGroup.
//Every AuxiliaryWindow contains two buttons, one labeled "Close" and the other
//"Dispose". We listen to mouse clicks on these buttons in order to hide the
//window when the "Close" button is clicked and to remove the window (and dispose
//of it) from the auxWinGroup when the "Dispose" button is clicked.
private void createAuxWin()
{
    String title = "Aux Window " + (++auxWinCount);
    final AuxiliaryWindow aw = new AuxiliaryWindow(title);

    //Attach listeners and specify actions.
    aw.close.addActionListener(new ActionListener() {
        public void actionPerformed(ActionEvent ae) { aw.setVisible(false); }
    });
    aw.dispose.addActionListener(new ActionListener() {
        public void actionPerformed(ActionEvent e) {
            //Remove from group and dispose.
            auxWinGroup.remove(aw, true);
        }
    });

    //Add to the group. An entry will be added both to the Window sub-menu
    //and to the popup menu triggered by the drop-down button in the
    //Quick-Launch toolbar. We set the display text of those entries to be
//the same as the window's title, but we don't specify any icon.
auxWinGroup.add(aw, title, null);

//Bring the window up.
aw.open();

//Releases all UI resources currently in use and returns them to the OS.
void disposeUI()
{
  mainWindow.dispose();
  auxWinGroup.removeAll(true); //Empty group and dispose of all windows.
}
OMERO can be extended by modifying these clients or by writing your own in any of the supported languages.

## 18.1 Developing OMERO clients

Note:

- If you are only interested in using our OMERO clients, please see the OMERO clients overview section, which will point you to user guides, demo videos, and download sites.
- This page is intended for developers already familiar with client/server programming. If you are not, your best starting point is to read the Hello World\(^1\) chapter of the Ice manual (or more). A deeper understanding of Ice might not be necessary, but certainly understanding the Ice basics will make reading this guide much easier.

For developers, there are many examples listed below, all of which are stored under: examples\(^2\) and buildable/Runnable via scons\(^3\):

```bash
cd omero-src
./build.py build-all
cd omero-src/examples
python ../target/scons/scons.py
```

Other examples (in Python) can be found here.

### 18.1.1 Introduction

A Blitz client is any application which uses the OMERO Application Programming Interface to talk to the OMERO.blitz server in any of the supported languages, like Python, C++, Java, or Matlab. A general understanding of the OMERO.server overview may make what is happening behind the scenes more transparent, but is not necessary. The points below outline all that an application writer is expected to know with links to further information where necessary.

### 18.1.2 Distributed computing

The first hurdle when beginning to work with OMERO is to realize that building distributed-object systems is different from both building standalone clients and writing web applications in frameworks like mod_perl, django, or Ruby on Rails. The remoting framework used by OMERO is Ice\(^4\) from ZeroC. Ice is comparable to CORBA in many ways, but is typically easier to use. For ZeroC’s comparison of Ice to CORBA, see iceVsCorba.html\(^5\).

A good first step is to be aware of the difference between remote and local invocations. Any invocation on a proxy (`<class_name>Prx`, described below) will result in a call over the network with all the costs that entails. The often-cited

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\(^{1}\)http://doc.zeroc.com/display/Ice/Hello+World+Application  
\(^{2}\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/examples  
\(^{3}\)http://www.scons.org  
\(^{4}\)http://www.zeroc.com  
\(^{5}\)http://zeroc.com/iceVsCorba.html
all apply, and the developer must be aware of concurrency and latency issues, as well as complete loss of connectivity, all of which we will discuss below.

### 18.1.3 Objects

Before we can begin talking about what you can do with OMERO (the remote method calls available in the OMERO Application Programming Interface), it is helpful to first know what the objects are that we will be distributing. These are the only types that can pass through the API.

#### “Slice” mapping language

Ice provides an interface definition language (IDL) for defining class hierarchies for passing data in a binary format. Similar to WSDL in web services or CORBA’s IDL, slice provides a way to specify how types can pass between different programming languages. For just that reason, several constructs not available in all the supported languages are omitted:

- multiple inheritance (C++ and Python)
- nullable primitive wrappers (e.g. Java’s java.lang.Integer)
- interfaces (Java)
- HashSet types
- iterator types

#### Primitives

Slice defines the usual primitives – `long`, `string`, `bool`, as well as `int`, `double`, and `float` – which map into each language as would be expected. Aliases like `Ice::Long` are available for C++ to handle both 32 and 64 bit architectures.

A simple struct can then be built out of any combination of these types. From `components/blitz/resources/omero/System.ice`:

```c
// The EventContext is all the information the server knows about a // given method call, including user, read/write status, etc. class EventContext
{
    long userId;
    string userName;
    ...
    bool isAdmin;
    ...
}
```

#### Sequences, dictionaries, enums, and constants

Other than the “user-defined classes” which we will get to below, slice provides only four built-in building blocks for creating a type hierarchy.

- **Sequences. & Dictionaries**: Most of the sequences and dictionaries in use by the OMERO Application Programming Interface are defined in `components/blitz/resources/omero/Collections.ice`. Each sequence or dictionary must be defined before it can be used in any class. By default a sequence will map to an array of the given type in Java or a vector in C++, but these mappings can be changed via metadata. (In most cases, a `List` is used in the Java mapping).

- **Constants**: Most of the enumerations for OMERO Application Programming Interface are defined in components/blitz/resources/omero/Constants.ice. These are values which can be defined once and then referenced in each of the supported programming languages. The only real surprise when working with enumerations is that in Java each constant is mapped to an interface with a single `public final static` field named “value”.

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6[^6]

7[^7]

8[^8]

9[^9]

10[^10]

[^8]: https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/blitz/resources/omero/System.ice
[^9]: https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/blitz/resources/omero/Constants.ice
[^10]: https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/blitz/resources/omero/Constants.ice
```cpp
#include <iostream>
#include <omero/Constants.h>
using namespace omero::constants;

int main() {
    std::cout << "By default, no method call can pass more than ";
    std::cout << MESSAGESIZEMAX << " kb" << std::endl;
    std::cout << "By default, client.createSession() will wait ";
    std::cout << (CONNECTTIMEOUT / 1000) << " seconds for a connection" << std::endl;
}
```

Example: examples/OmeroClients/constants.cpp

```cpp
sz=omero.constants.MESSAGESIZEMAX.value;
to=omero.constants.CONNECTTIMEOUT.value/1000;
disp(sprintf('By default, no method call can pass more than %d kb',sz));
disp(sprintf('By default, client.createSession() will wait %d seconds for a connection', to));
```

Example: examples/OmeroClients/constants.m

```cpp
from omero.constants import *
print "By default, no method call can pass more than %s kb" % MESSAGESIZEMAX
print "By default, client.createSession() will wait %s seconds for a connection" % (CONNECTTIMEOUT/1000)
```

Example: examples/OmeroClients/constants.py

```java
import static omero.rtypes.*;
public class constants {
    public static void main(String[] args) {
        System.out.println(String.format("By default, no method call can pass more than %s kb", omero.constants.MESSAGESIZEMAX.value));
        System.out.println(String.format("By default, client.createSession() will wait %s seconds for a connection", omero.constants.CONNECTTIMEOUT.value/1000));
    }
}
```

Example: examples/OmeroClients/constants.java

- ** Enums.** Finally, enumerations which are less used through *OMERO Application Programming Interface*, but which can be useful for simplifying working with constants.

```cpp
#include <iostream>
#include <omero/Constants.h>
using namespace omero::constants::projection;

int main() {
    std::cout << "IProjection takes arguments of the form: ";
    std::cout << MAXIMUMINTENSITY;
    std::cout << std::endl;
}
```

Example: examples/OmeroClients/enumerations.cpp

11https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/constants.cpp
12https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/constants.m
13https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/constants.py
14https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/constants.java
15https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/enumerations.cpp
v=omero.constants.projection.ProjectionType.MAXIMUMINTENSITY.value();
disp(sprintf('IProjection takes arguments of the form: $s', v));

Example: examples/OmeroClients/enumerations.m\(^{16}\)

```matlab
import omero
import omero_Constants_ice
print "IProjection takes arguments of the form: $s" % omero.constants.projection.ProjectionType.MAXIMUMINTENSITY;
```

Example: examples/OmeroClients/enumerations.py\(^{17}\)

```python
public class enumerations {
    public static void main(String[] args) {
        System.out.println(String.format("IProjection takes arguments of the form: %s", omero.constants.projection.ProjectionType.MAXIMUMINTENSITY));
    }
}
```

Example: examples/OmeroClients/enumerations.java\(^{18}\)

RTypes

In Java, the Ice primitives map to non-nullable primitives. And in fact, for the still nullable types java.lang.String as well as all collections and arrays, Ice goes so far as to send an empty string ("") or collection([]) rather than null.

However, the database and OMERO support nullable values and so OMERO.blitz defines a hierarchy of types which wraps the primitives: RTypes\(^{19}\). Since Ice allows references to be nulled, as opposed to primitives, it is possible to send null strings, integers, etc.

```c
#include <omero/RTypesI.h>
using namespace omero::rtypes;
int main() {
    omero::RStringPtr s = rstring("value");
    omero::RBoolPtr b = rbool(true);
    omero::RLongPtr l = rlong(1);
    omero::RIntPtr i = rint(1);
}
```

Example: examples/OmeroClients/primitives.cpp\(^{20}\)

```cpp
import omero.rtypes;

a = rtypes.rstring('value');
b = rtypes.rbool(true);
l = rtypes.rlong(1);
i = rtypes.rint(1);
```

Example: examples/OmeroClients/primitives.m\(^{21}\)

---

\(^{16}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/enumerations.m

\(^{17}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/enumerations.py

\(^{18}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/enumerations.java

\(^{19}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/blitz/resources/omero/RTypes.ice

\(^{20}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/primitives.cpp

\(^{21}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/primitives.m
from omero.rtypes import *
s = rstring("value")
b = rbool(True)
l = rlong(1)
i = rint(1)

Example: examples/OmeroClients/primitives.py

import static omero.rtypes. *

public class primitives {
    public static void main(String[] args) {
        omero.RString a = rstring("value");
        omero.RBool b = rbool(true);
        omero.RLong l = rlong(1l);
        omero.RInt i = rint(1);
    }
}

Example: examples/OmeroClients/primitives.java

The same works for collections. The RCollection subclass of RType holds a sequence of any other RType.

#include <omero/RTypesI.h>
using namespace omero::rtypes;

int main() {
    // Sets and Lists may be interpreted differently on the server
    omero::RListPtr l = rlist(); // rstring("a"), rstring("b")
    omero::RSetPtr s = rset(); // rint(1), rint(2));
    // No-varargs (#1242)
}

Example: examples/OmeroClients/rcollection.cpp

% Sets and Lists may be interpreted differently on the server
ja = javaArray('omero.RString',2);
ja(1) = omero.rtypes.rstring('a');
ja(2) = omero.rtypes.rstring('b');
list = omero.rtypes.rlist(ja)
ja = javaArray('omero.RInt',2);
ja(1) = omero.rtypes.rint(1);
ja(2) = omero.rtypes.rint(2);
set = omero.rtypes.rset(ja)

Example: examples/OmeroClients/rcollection.m

import omero
from omero.rtypes import *
% Sets and Lists may be interpreted differently on the server
list = rlist(rstring("a"), rstring("b"));
set = rset(rint(1), rint(2));

Example: examples/OmeroClients/rcollection.py

---

22https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/primitives.py
23https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/primitives.java
24https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/rcollection.cpp
25https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/rcollection.m
26https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/rcollection.py
import static omero.rtypes.*;
public class rcollection {
    public static void main(String[] args) {
        // Sets and Lists may be interpreted differently on the server
        omero.RList list = rlist(rstring("a"), rstring("b"));
        omero.RSet set = rset(rint(1), rint(2));
    }
}

Example: examples/OmeroClients/rcollection.java

A further benefit of the RTypes is that they support polymorphism. The original OMERO Application Programming Interface was designed strictly for Java, in which the java.lang.Object type or collections of java.lang.Object could be passed. This is not possible with Ice, since there is no any type as there is in CORBA.

Instead, omero.RType is the abstract superclass of our “remote type” hierarchy, and any method which takes an “RType” can take any subclass of “RType”.

To allow other types discussed later to also take part in the polymorphism, it is necessary to include RType wrappers for them. This is the category that omero::RObject and omero::RMap fall into.

omero::RTime and omero::RClass fall into a different category. They are identical to omero::RLong and omero::RString, respectively, but are provided as type safe variants.

OMERO model objects

With these components – rtypes, primitives, constants, etc. – it is possible to define the core nouns of OME, the OME-Remote Objects. The OMERO OME-Remote Objects is a translation of the OME XML specification into objects for use by the server, built out of RTypes, sequences and dictionaries, and Details.

Details

The omero.model.Details object contains security and other internal information which does not contain any domain value. Attempting to set any values which are not permitted, will result in a SecurityViolation, for example trying to change the details.owner to the current user.

#include <omero/model/ImageI.h>
#include <omero/model/PermissionsI.h>
using namespace omero::model;

int main() {
    ImagePtr image = new ImageI();
    DetailsPtr details = image->getDetails();
    PermissionsPtr p = new PermissionsI();
    p->setUserRead(true);
    assert(p->isUserRead());
    details->setPermissions(p);
    // Available when returned from server
    // Possibly modifiable
    details->getOwner();
    details->setGroup(new ExperimenterGroupI(1L, false));
    // Available when returned from server
    // Not modifiable
    details->getCreationEvent();
    details->getUpdateEvent();
}

Example: examples/OmeroClients/details.cpp

27https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/rcollection.java
28http://www.openmicroscopy.org/site/support/ome-model/ome-xml/
29https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/details.cpp
image = omero.model.ImageI();
details_ = image.getDetails();
p = omero.model.PermissionsI();
p.setUserRead(true);
assert( p.isUserRead() );
details_.setPermissions( p );
% Available when returned from server
% Possibly modifiable
details_.getOwner();
details_.setGroup( omero.model.ExperimenterGroupI(1, false) );
% Available when returned from server
% Not modifiable
details_.getCreationEvent();
details_.getUpdateEvent();

Example: examples/OmeroClients/details.m

import omero
import omero.clients
image = omero.model.ImageI()
details = image.getDetails()
p = omero.model.PermissionsI()
p.setUserRead(True)
assert p.isUserRead()
details.setPermissions(p)
% Available when returned from server
% Possibly modifiable
details.getOwner()
details.setGroup( omero.model.ExperimenterGroupI(1L, False))
% Available when returned from server
% Not modifiable
details.getCreationEvent()
details.getUpdateEvent()

Example: examples/OmeroClients/details.py

import omero.model.Image;
import omero.model.ImageI;
import omero.model.Details;
import omero.model.Permissions;
import omero.model.PermissionsI;
import omero.model.ExperimenterGroupI;
public class details {
    public static void main(String args[]) {
        Image image = new ImageI();
        Details details = image.getDetails();
        Permissions p = new PermissionsI();
p.setUserRead(true);
        assert p.isUserRead();
details.setPermissions(p);
        // Available when returned from server
        // Possibly modifiable
details.getOwner();
details.setGroup(new ExperimenterGroupI(1L, false));
        // Available when returned from server
        // Not modifiable
details.getCreationEvent();
details.getUpdateEvent();
    }

30https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/details.m
31https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/details.py
ObjectFactory and casting

In the previous examples, you may have noticed how there are two classes for each type: Image and ImageI. Classes defined in slice are by default data objects, more like C++’s structs than anything else. As soon as a class defines a method, however, it becomes an abstract entity and requires application writers to provide a concrete implementation (hence the “I”). All OMERO classes define methods, but OMERO takes care of providing the implementations for you via code generation. For each slice-defined and Ice-generated class omero.model.Something, there is an OMERO-generated class omero.model.SomethingI which can be instantiated.

```
#include <omero/model/ImageI.h>
#include <omero/model/DatasetI.h>
using namespace omero::model;
int main() {
    ImagePtr image = new ImageI();
    DatasetPtr dataset = new DatasetI(1L, false);
    image->linkDataset(dataset);
}
```

Example: examples/OmeroClients/constructors.cpp

```
import omero.model.*;
image = ImageI();
dataset = DatasetI(1, false);
image.linkDataset(dataset)
```

Example: examples/OmeroClients/constructors.m

```
import omero
import omero.clients
image = omero.model.ImageI()
dataset = omero.model.DatasetI(long(1), False)
image.linkDataset(dataset)
```

Example: examples/OmeroClients/constructors.py

```
import java.util.Iterator;
import omero.model.Image;
import omero.model.ImageI;
import omero.model.Dataset;
import omero.model.DatasetI;
import omero.model.DatasetImageLink;
import omero.model.DatasetImageLinkI;
public class constructors {
    public static void main(String args[]) {
        Image image = new ImageI();
        Dataset dataset = new DatasetI(1L, false);
        image.linkDataset(dataset);
    }
}
```
When OME-Remote Objects instances are serialized over the wire and arrive in the client, the Ice runtime must determine which constructor to call. It consults with the ObjectFactory, also provided by OMERO, to create the new classes. If you would like to have your own classes or subclasses created on deserialization, see the Advanced topics section below.

Such concrete implementations provide features which are not available in the solely Ice-based versions. When you would like to use these features, it is necessary to down-cast to the OMERO-based type.

For example, objects in each language binding provide a “more natural” form of iteration for that language.

```c++
#include <omero/model/ImageI.h>
#include <omero/model/DatasetI.h>
#include <omero/model/DatasetImageLinkI.h>
using namespace omero::model;
int main() {
    ImageIPtr image = new ImageI();
    DatasetIPtr dataset = new DatasetI();
    DatasetImageLinkPtr link = dataset->linkImage(image);
    omero::model::ImageDatasetLinksSeq seq = image->copyDatasetLinks();
    ImageDatasetLinksSeq::iterator beg = seq.begin();
    while(beg != seq.end()) {
        beg++;
    }
}
```

Example: examples/OmeroClients/constructors.java

Example: examples/OmeroClients/iterators.cpp

```cpp
import omero.model.*;
image = ImageI();
dataset = DatasetI();
link = dataset.linkImage(image);
it = image.iterateDatasetLinks();
while it.hasNext()
    it.next().getChild().getName();
end
```

Example: examples/OmeroClients/iterators.m

```cpp
import omero
from omero.model.ImageI import ImageI
from omero.model.DatasetI import DatasetI
from omero.model.DatasetImageLinkI import DatasetImageLinkI
image = ImageI()
dataset = DatasetI()
link = dataset.linkImage(image)
for link in image.iterateDatasetLinks():
    link.getChild().getName();
```

Example: examples/OmeroClients/iterators.py
import omero.model.ImageI;
import omero.model.Dataset;
import omero.model.DatasetI;
import omero.model.DatasetImageLink;
import omero.model.DatasetImageLinkI;
import java.util.*;

public class iterators {
    public static void main(String args[]) {
        ImageI image = new ImageI();
        Dataset dataset = new DatasetI();
        DatasetImageLink link = dataset.linkImage(image);
        Iterator<DatasetImageLinkI> it = image.iterateDatasetLinks();
        while (it.hasNext()) {
            it.next().getChild().getName();
        }
    }
}

Example: examples/OmeroClients/iterators.java

Also, each concrete implementation provides static constants of various forms.

#include <omero/model/ImageI.h>
#include <iostream>

int main() {
    std::cout << omero::model::ImageI::NAME << std::endl;
    std::cout << omero::model::ImageI::DATASETLINKS << std::endl;
}

Example: examples/OmeroClients/staticfields.cpp

disp(omero.model.ImageI::NAME);
disp(omero.model.ImageI::DATASETLINKS);

Example: examples/OmeroClients/staticfields.m

import omero
from omero.model.ImageI import ImageI as ImageI
print ImageI::NAME
print ImageI::DATASETLINKS

Example: examples/OmeroClients/staticfields.py

import omero.model.ImageI;
public class staticfields {
    public static void main(String[] args) {
        System.out.println(ImageI.NAME);
        System.out.println(ImageI.DATASETLINKS);
    }
}

Example: examples/OmeroClients/staticfields.java

---

18.1. Developing OMERO clients
Visibility and loadedness

In the constructor example above, a constructor with two arguments was used to create the Dataset instance linked to the new Image. The Dataset instance so created is considered “unloaded”.

Objects and collections can be created unloaded as a pointer to an actual instance or they may be returned unloaded from the server when they are not actively accessed in a query. Because of the interconnectedness of the OME-Remote Objects, loading one object could conceivably require downloading a large part of the database if there were not some way to “snip-off” sections.

```cpp
#include <omero/model/ImageI.h>
#include <omero/model/DatasetI.h>
#include <omero/ClientErrors.h>
using namespace omero::model;

int main() {
    ImagePtr image = new ImageI(); // A loaded object by default
    assert(image->isLoaded());
    image->unload(); // can then be unloaded
    assert(! image->isLoaded());
    image = new ImageI( 1L, false ); // Creates an unloaded "proxy"
    assert(! image->isLoaded());
    image->getId(); // Ok
    try {
        image->getName(); // No data access is allowed other than id.
    } catch (const omero::ClientError& ce) {
        // Ok.
    }
}
```

Example: examples/OmeroClients/unloaded.cpp

```cpp
image = omero.model.ImageI(); // A loaded object by default
assert(image.isLoaded());
image.unload(); // can then be unloaded
assert(~ image.isLoaded() );
image = omero.model.ImageI( 1L, false );
assert(~ image.isLoaded() ); // Creates an unloaded "proxy"
image.getId(); // Ok.
try {
    image.getName(); // No data access is allowed other than id.
} catch ME {
    pass
}
```

Example: examples/OmeroClients/unloaded.m

```cpp
import omero
import omero.clients
image = omero.model.ImageI() # A loaded object by default
assert image.isLoaded() # can then be unloaded
image.unload()
assert( not image.isLoaded() ) # Creates an unloaded "proxy"
image = omero.model.ImageI( 1L, False ) # Ok
assert( not image.isLoaded() )
image.getId()
try:
    image.getName() # No data access is allowed other than id.
except:
    pass
```

45https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/unloaded.cpp
46https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/unloaded.m
Example: examples/OmeroClients/unloaded.py

```python
import omero.model.ImageI;
public class unloaded {
    public static void main(String args[]) {
        ImageI image = new ImageI(); // A loaded object by default
        assert image.isLoaded(); // can then be unloaded
        image.unload();
        assert ! image.isLoaded(); // Creates an unloaded "proxy"
        image = new ImageI(1L, false);
        assert ! image.isLoaded();
        try {
            image.getId();
        } catch (Exception e) {
            // Ok.
        }
    }
}
```

Example: examples/OmeroClients/unloaded.java

When saving objects that have unloaded instances in their graph, the server will automatically fill in the values. So, if your `Dataset` contains a collection of `Image`s, all of which are unloaded, then they will be reloaded before saving, based on the id. If, however, you had tried to set a value on one of the `Images`, you will get an exception.

To prevent errors when working with unloaded objects, all the `OME-Remote Objects` classes are marked as protected in the slice definitions which causes the implementations in each language to try to hide the fields. In Python, an underscore is prefixed to all the variables. (In the Python case, we have also tried to “strengthen” the hiding of the fields, by overriding `__setattr__`. This is not full proof, but only so much can be done to hide values in Python.)

## Collections

Just as an entire object can be unloaded, any collection field can also be unloaded. However, as mentioned above, since it is not possible to send a null collection over the wire with Ice and working with RTypes can be inefficient, all the `OME-Remote Objects` collections are hidden behind several methods.

```c
#include <omero/model/DatasetI.h>
#include <omero/model/DatasetImageLinkI.h>
#include <omero/model/EventI.h>
#include <omero/model/ImageI.h>
#include <omero/model/PixelsI.h>
using namespace omero::model;
int main(int argc, char* argv[]) {
    ImagePtr image = new ImageI(1, true);
    image->getDetails()->setUpdateEvent(new EventI(1L, false));
    // On creation, all collections are
    // initialized to empty, and can be added
    // to.
    assert(image->sizeOfDatasetLinks() == 0);
    DatasetPtr dataset = new DatasetI(1L, false);
    DatasetImageLinkPtr link = image->linkDataset(dataset);
    assert(image->sizeOfDatasetLinks() == 1);
    // If you want to work with this collection,
    // you’ll need to get a copy.
    ImageDatasetLinksSeq links = image->copyDatasetLinks();
    // When you are done working with it, you can
    // unload the datasets, assuming the changes
```
// have been persisted to the server.
image->unloadDatasetLinks();
assert(image->sizeOfDatasetLinks() < 0);
try {
    image->linkDataset( new DatasetI() );
} catch (...) {
    // Can’t access an unloaded collection
}

// The reload...() method allows one instance
// to take over a collection from another, if it
// has been properly initialized on the server.
// sameImage will have its collection unloaded.
ImagePtr sameImage = new ImageI(1L, true);
sameImage->getDetails()->setUpdateEvent( new EventI(1L, false) );
sameImage->linkDataset( new DatasetI(1L, false) );
image->reloadDatasetLinks( sameImage );
assert(image->sizeOfDatasetLinks() == 1);
assert(sameImage->sizeOfDatasetLinks() < 0);
// If you would like to remove all the member
// elements from a collection, don’t unload it
// but "clear" it.
image->clearDatasetLinks();
// Saving this to the database will remove
// all dataset links!
// Finally, all collections can be unloaded
// to use an instance as a single row in the database.
image->unloadCollections();
// Ordered collections have slightly different methods.
image = new ImageI(1L, true);
image->addPixels( new PixelsI() );
image->getPixels(0);
image->getPrimaryPixels(); // Same thing
image->removePixels( image->getPixels(0) );
}

Example: examples/OmeroClients/collectionmethods.cpp

import omero.model.*;
image = ImageI(1, true);
image.getDetails().setUpdateEvent( EventI(1, false) );
% On creation, all collections are
% initialized to empty, and can be added
% to.
assert(image.sizeOfDatasetLinks() == 0);
dataset = DatasetI(1, false);
link = image.linkDataset(dataset);
assert(image.sizeOfDatasetLinks() == 1);
% If you want to work with this collection,
% you’ll need to get a copy.
links = image.copyDatasetLinks();
% When you are done working with it, you can
% unload the datasets, assuming the changes
% have been persisted to the server.
image.unloadDatasetLinks();
assert(image.sizeOfDatasetLinks() < 0);
try
    image.linkDataset( DatasetI() );
catch ME
    % Can’t access an unloaded collection
end
% The reload...() method allows one instance
% to take over a collection from another, if it
% has been properly initialized on the server.
% sameImage will have its collection unloaded.
sameImage = ImageI(1, true);
sameImage.getDetails().setUpdateEvent( EventI(1, false) );
sameImage.linkDataset( DatasetI(1, false) );
image.reloadDatasetLinks( sameImage );
assert(image.sizeOfDatasetLinks() == 1);
assert(sameImage.sizeOfDatasetLinks() < 0);
% If you would like to remove all the member
% elements from a collection, don’t unload it
% but "clear" it.
image.clearDatasetLinks();
% Saving this to the database will remove
% all dataset links!
% Finally, all collections can be unloaded
% to use an instance as a single row in the database.
image.unloadCollections();
% Ordered collections have slightly different methods.
image = ImageI(1, true);
image.addPixels( PixelsI() );
image.getPixels(0);
image.getPrimaryPixels(); % Same thing
image.removePixels( image.getPixels(0) );

Example: examples/OmeroClients/collectionmethods.m

```matlab
import omero
import omero.clients
ImageI = omero.model.ImageI
DatasetI = omero.model.DatasetI
EventI = omero.model.EventI
PixelsI = omero.model.PixelsI
image = ImageI(long(1), True)
image.getDetails().setUpdateEvent( EventI(1L, False) )
# On creation, all collections are
# initialized to empty, and can be added
# to.
assert image.sizeOfDatasetLinks() == 0
dataset = DatasetI(long(1), False)
link = image.linkDataset(dataset)
assert image.sizeOfDatasetLinks() == 1
# If you want to work with this collection,
# you’ll need to get a copy.
links = image.copyDatasetLinks()
# When you are done working with it, you can
# unload the datasets, assuming the changes
# have been persisted to the server.
image.unloadDatasetLinks()
assert image.sizeOfDatasetLinks() < 0
try:
    image.linkDataset( DatasetI() )
except:
    # Can’t access an unloaded collection
    pass
# The reload...() method allows one instance
# to take over a collection from another, if it
# has been properly initialized on the server.
# sameImage will have its collection unloaded.
sameImage = ImageI(1L, True)
sameImage.getDetails().setUpdateEvent( EventI(1L, False) )
```

50https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/collectionmethods.m
Example: examples/OmeroClients/collectionmethods.py

```java
import omero.model.Dataset;
import omero.model.DatasetI;
import omero.model.DatasetImageLink;
import omero.model.DatasetImageLinkI;
import omero.model.EventI;
import omero.model.Image;
import omero.model.ImageI;
import omero.model.Pixels;
import omero.model.PixelsI;
import java.util.*;

public class collectionmethods {
    public static void main(String args[]) {
        Image image = new ImageI(1, true);
        image.getDetails().setUpdateEvent( new EventI(1L, false) );
        // On creation, all collections are
        // initialized to empty, and can be added
        // to.
        assert image.sizeOfDatasetLinks() == 0;
        Dataset dataset = new DatasetI(1L, false);
        DatasetImageLink link = image.linkDataset(dataset);
        assert image.sizeOfDatasetLinks() == 1;
        // If you want to work with this collection,
        // you’ll need to get a copy.
        List<DatasetImageLink> links = image.copyDatasetLinks();
        // When you are done working with it, you can
        // unload the datasets, assuming the changes
        // have been persisted to the server.
        image.unloadDatasetLinks();
        assert image.sizeOfDatasetLinks() < 0;
        try {
            image.linkDataset( new DatasetI() );
        } catch (Exception e) {
            // Can’t access an unloaded collection
        }
        // The reload...() method allows one instance
        // to take over a collection from another, if it
        // has been properly initialized on the server.
        // sameImage will have its collection unloaded.
        Image sameImage = new ImageI(1L, true);
    }
}
```

51https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/collectionmethods.py
OMERO Documentation, Release 5.0.2

```java
sameImage.getDetails().setUpdateEvent( new EventI(1L, false) );
sameImage.linkDataset( new DatasetI(1L, false) );
image.reloadDatasetLinks( sameImage );
assert image.sizeOfDatasetLinks() == 1;
assert sameImage.sizeOfDatasetLinks() < 0;
// If you would like to remove all the member
// elements from a collection, don’t unload it
// but “clear” it.
image.clearDatasetLinks();
// Saving this to the database will remove
// all dataset links!
// Finally, all collections can be unloaded
// to use an instance as a single row in the database.
image.unloadCollections();
// Ordered collections have slightly different methods.
image = new ImageI(1L, true);
image.addPixels( new PixelsI() );
image.getPixels(0);
image.getPrimaryPixels(); // Same thing
image.removePixels( image.getPixels(0) );
```

Example: examples/OmeroClients/collectionmethods.java

These methods prevent clients from accessing the collections directly, and any improper access will lead to an omero.ClientError.

## Interfaces

As mentioned above, one of the Java features which is missing from the slice definition language is the ability to have concrete classes implement multiple interfaces. Much of the OME-Remote Objects in the RMI-based types (ome.model) was based on the use of interfaces.

- **IObject** is the root interface for all object types. **Methods**: getId(), getDetails(),...
- **IEnum** is an enumeration value. **Methods**: getValue()
- **ILink** is a link between two other types. **Methods**: getParent(), getChild()
- **IMutable** is an instance for changes will be persisted. **Methods**: getVersion()

Instead, the Ice-based types (ome.model) all subclass from the same concrete type – omero.model.IObject – and it has several methods defined for testing which of the ome.model interfaces are implemented by any type.

Use of such methods is naturally less object-oriented and requires if/then blocks, but within the confines of the mapping language is a next-best option.

```
No cpp example
```

```java
import omero.model.*;
o = EventI();
assert( ~ o.isMutable() );
o = ExperimenterI();
assert( o.isMutable() );
asert( o.isGlobal() );
```

---

52. https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/collectionmethods.java
assert( o.isAnnotated() );
o = GroupExperimenterMapI();
assert( o.isLink() );
someObject = ExperimenterI();
% Some method call and you no longer know what someObject is
if (~ someObject.isMutable() )
  % No need to update
elseif (someObject.isAnnotated())
  % deleteAnnotations(someObject);
end

Example: examples/OmeroClients/interfaces.m\textsuperscript{57}

\begin{verbatim}
import omero
from omero.model_EventI import EventI
from omero_model_ExperimenterI import ExperimenterI
from omero_model_GroupExperimenterMapI import GroupExperimenterMapI
assert ( not EventI().isMutable() )
assert ExperimenterI().isMutable()
assert ExperimenterI().isGlobal()
assert ExperimenterI().isAnnotated()
assert GroupExperimenterMapI().isLink()
\end{verbatim}

Example: examples/OmeroClients/interfaces.py\textsuperscript{58}

\begin{verbatim}
import omero.model.IObject;
import omero.model.EventI;
import omero.model.ExperimenterI;
import omero.model.GroupExperimenterMapI;
public class interfaces {
    public static void main(String args[]) {
        assert ! new EventI().isMutable();
        assert new ExperimenterI().isMutable();
        assert new ExperimenterI().isGlobal();
        assert new ExperimenterI().isAnnotated();
        assert new GroupExperimenterMapI().isLink();
        IObject someObject = new ExperimenterI();
        // Some method call and you no longer know what someObject is
        if ( ! someObject.isMutable() ) {
            // No need to update
        } else if (someObject.isAnnotated()) {
            // deleteAnnotations(someObject);
        }
    }
}
\end{verbatim}

Example: examples/OmeroClients/interfaces.java\textsuperscript{59}

Improvement of this situation by adding abstract classes is planned. However, the entire functionality will not be achievable because of single inheritance.

**Language-specific behavior**

**Smart pointers (C++ only)**

An important consideration when working with C++ is that the **OME-Remote Objects** classes themselves have no copy-constructors and no assignment operator (operator=), and so cannot be allocated on the stack. Combined with smart pointers this effectively

\textsuperscript{57}https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/interfaces.m
\textsuperscript{58}https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/interfaces.py
\textsuperscript{59}https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/interfaces.java
prevents memory leaks.

The code generated types must be allocated on the heap with new and used in combination with the smart pointer typedefs which handle calling the destructor when the reference count hits zero.

```cpp
#include <omero/model/ImageI.h>
using namespace omero::model;
int main()
{
    // ImageI image(); // ERROR
    // ImageI image = new ImageI(); // ERROR
    ImageIPtr image1 = new ImageI(); // OK
    ImageIPtr image2(new ImageI()); // OK
    // image1 pointer takes value of image2
    // image1's content is garbage collected
    image1 = image2;
    //
    // Careful with boolean contexts
    //
    if (image1 && image1 == 1) {
        // Means non-null
        // This object can be dereferenced
    }
    ImageIPtr nullImage; // No assignment
    if ( !nullImage && nullImage == 0) {
        // Dereferencing nullImage here would throw an exception:
        // nullImage->getId(); // IceUtil::NullHandleException!
    }
}
```

Example: examples/OmeroClients/smartpointers.cpp

```
# No m example

# No py example

# No java example
```

**Warning:** As shown in the example, using a smart pointer instance in a boolean or integer/long context, returns 1 for true (i.e. non-null) or 0 for false (i.e. null). Be especially careful with the RTypes.

For more information, see 6.14.6 Smart Pointers for Classes in the Ice manual, which also describes the Ice.GC.Interval parameter which determines how often garbage collection runs in C++ to reap objects. This is necessary with the OME-Remote Objects since there are inherently cycles in the object graph.

Another point type which may be of use is omero::client_ptr. It also performs reference counting and will call client.closeSession() once the reference count hits zero. Without client_ptr, your code will need to be surrounded by a try/catch block. Otherwise, 1) sessions will be left open on the server, and 2) your client may hang on exit.

```cpp
#include <omero/client.h>
int main(int argc, char* argv[])
{
    // Duplicating the argument list. ticket:1246
    Ice::StringSeq argv1 = Ice::argsToStringSeq(argc, argv);
    Ice::StringSeq argv2(argv1);
```

---

60https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/smartpointers.cpp
61http://doc.zeroc.com/display/Ice/Smart+Pointers+for+Classes
Ice::InitializationData id1, id2;
id1.properties = Ice::createProperties(args1);
id2.properties = Ice::createProperties(args2);
// Either
omero::client client(id1);
try {
    // Do something like
    // client.createSession();
} catch (...) {
    client.closeSession();
}
// Or
//
{
    omero::client_ptr client = new omero::client(id2);
    // Do something like
    // client->createSession();
} // Client was destroyed via RAII

Example: examples/OmeroClients/clientpointer.cpp

# No m example

# No py example

# No java example

__getattr__ and __setattr__ (Python only)

Like smart pointers for OMERO C++ language bindings, the OMERO Python language bindings SDK defines __getattr__ and __setattr__ methods for all OME-Remote Objects classes. Rather than explicitly calling the getFoo() and setFoo() methods, field-like access can be used. (It should be noted, however, that the accessors will perform marginally faster.)

# No cpp example

# No m example

```python
import omero
import omero.clients
from omero.rtypes import *
i = omero.model.ImageI()
#
# Without __getattr__ and __setattr__
#
i.setName(rstring("name"))
assert i.getName().getValue() == "name"
#
# With __getattr__ and __setattr__
```

https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/clientpointer.cpp

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# i = omero.model.ImageI()
i.name = rstring("name")
assert i.name.val == "name"
#
# Collections, however, cannot be accessed
# via the special methods due to the dangers
# outlined above
#
try:
    i.datasetLinks[0]
except AttributeError, ae:
    pass

Example: examples/OmeroClients/getsetattr.py

# No java example

Method inspection and code completion (Matlab & Python)

Ice generates a number of internal (private) methods which are not intended for general consumption. Unfortunately, Matlab’s code-completion as well as Python’s `dir` method return these methods, which can lead to confusion. In general, the API user can ignore any method beginning with an underscore or with `ice_`. For example,

```python
>>> for i in dir(omero.model.ImageI):
...     if i.startswith("_") or i.startswith("ice_"):
...         print i
...     (snip)
_op_addAllDatasetImageLinkSet
_op_addAllImageAnnotationLinkSet
_op_addAllPixelsSet
_op_addAllRoiSet
_op_addAllWellSampleSet
... ice_id
ice_ids
ice_isA
ice_ping
ice_postUnmarshal
ice_preMarshal
ice_staticId
ice_type
```

18.1.4 Services overview

After discussing the many types and how to create them, the next obvious question is what one can actually do with them. For that, we have to look at what services are provided by `OMERO.blitz`, how they are obtained, used, and cleaned up.

OMERO client configuration

The first step in accessing the `OMERO Application Programming Interface` and therefore the first thing to plan when writing an OMERO client is the proper configuration of an `omero.client` instance. The omero.client (or in C++ omero::client) class tries to wrap together and simplify as much of working with Ice as possible. Where it can, it imports or `<#includes>` types for you,

63https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/getattr.py

18.1. Developing OMERO clients

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creates an Ice::Communicator and registers an ObjectFactory. Typically, the only work on the client developers part is to properly configure the omero.client object and then login.

In the simplest case, configuration requires only the server host, username, and password with which you want to login. But as you can see below, there are various ways to configure your client, and this is really only the beginning.

```cpp
#include <omero/client.h>
#include <iostream>
int main(int argc, char* argv[]) {
    // All configuration in file pointed to by
    // --Ice.Config=file.config
    // No username, password entered
    try {
        omero::client client1(argc, argv);
        client1.createSession();
        client1.closeSession();
    } catch (const Glacier2::PermissionDeniedException& pd) {
        // Bad password?
    } catch (const Ice::ConnectionRefusedException& cre) {
        // Bad address or port?
    }
    // Most basic configuration.
    // Uses default port 4064
    // createSession needs username and password
    try {
        omero::client client2("localhost");
        client2.createSession("root", "ome");
        client2.closeSession();
    } catch (const Glacier2::PermissionDeniedException& pd) {
        // Bad password?
    } catch (const Ice::ConnectionRefusedException& cre) {
        // Bad address or port?
    }
    // Configuration with port information
    try {
        omero::client client3("localhost", 24063);
        client3.createSession("root", "ome");
        client3.closeSession();
    } catch (const Glacier2::PermissionDeniedException& pd) {
        // Bad password?
    } catch (const Ice::ConnectionRefusedException& cre) {
        // Bad address or port?
    }
    // Advanced configuration in C++ takes place
    // via an InitializationData instance.
    try {
        Ice::InitializationData data;
        data.properties = Ice::createProperties();
        data.properties->setProperty("omero.host", "localhost");
        omero::client client4(data);
        client4.createSession("root", "ome");
        client4.closeSession();
    } catch (const Glacier2::PermissionDeniedException& pd) {
        // Bad password?
    } catch (const Ice::ConnectionRefusedException& cre) {
        // Bad address or port?
    }
    // std::map to be added (ticket:1278)
    try {
        Ice::InitializationData data;
        data.properties = Ice::createProperties();
        data.properties->setProperty("omero.host", "localhost");
        data.properties->setProperty("omero.user", "root");
        data.properties->setProperty("omero.pass", "ome");
        omero::client client5(data);
    }
```
// Again, no username or password needed
// since present in the data. But they *can*
// be overridden.
client5.createSession();
client5.closeSession();
} catch (const Glacier2::PermissionDeniedException& pd) {
  // Bad password?
} catch (const Ice::ConnectionRefusedException& cre) {
  // Bad address or port?
}   

Example: examples/OmeroClients/configuration.cpp

% All configuration in file pointed to by
% --Ice.Config=file.config
% No username, password entered
args = javaArray('java.lang.String',1);
args(1) = java.lang.String('--Ice.Config=ice.config');
client1 = omero.client(args);
client1.createSession();
client1.closeSession();
% Most basic configuration.
% Uses default port 4064
% createSession needs username and password
client2 = omero.client('localhost');
client2.createSession('root', 'ome');
client2.closeSession();
% Configuration with port information
client3 = omero.client('localhost', 10463);
client3.createSession('root', 'ome');
client3.closeSession();
% Advanced configuration can also be done
% via an InitializationData instance.
data = Ice.InitializationData();
data.properties = Ice.Util.createProperties();
data.properties.setProperty('omero.host', 'localhost');
client4 = omero.client(data);
client4.createSession('root', 'ome');
client4.closeSession();
% Or alternatively via a java.util.Map instance
map = java.util.HashMap();
map.put('omero.host', 'localhost');
map.put('omero.user', 'root');
map.put('omero.pass', 'ome');
client5 = omero.client(map);
% Again, no username or password needed
% since present in the map. But they *can*
% be overridden.
client5.createSession();
client5.closeSession();

Example: examples/OmeroClients/configuration.m

import omero
import Ice
# All configuration in file pointed to by
# --Ice.Config=file.config or ICE_CONFIG
# environment variable;

64https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/configuration.cpp
65https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/configuration.m
# No username, password entered

try:
    client1 = omero.client()
    client1.createSession()
    client1.closeSession()
except Ice.ConnectionRefusedException:
    pass # Bad address or port?

# Most basic configuration.
# Uses default port 4064.
# `createSession` needs username and password

try:
    client2 = omero.client("localhost")
    client2.createSession("root","ome")
    client2.closeSession()
except Ice.ConnectionRefusedException:
    pass # Bad address or port?

# Configuration with port information

try:
    client3 = omero.client("localhost", 24064)
    client3.createSession("root","ome")
    client3.closeSession()
except Ice.ConnectionRefusedException:
    pass # Bad address or port?

# Advanced configuration can also be done
# via an `Ice.InitializationData` instance.

data = Ice.InitializationData()
data.properties = Ice.createProperties()
data.properties.setProperty("omero.host", "localhost")

try:
    client4 = omero.client(data)
    client4.createSession("root","ome")
    client4.closeSession()
except Ice.ConnectionRefusedException:
    pass # Bad address or port?

# Or alternatively via a dict instance
m = {
    "omero.host":"localhost",
    "omero.user":"root",
    "omero.pass":"ome"
}

client5 = omero.client(m)

# Again, no username or password needed
# since present in the map. But they *can* # be overridden.

try:
    client5.createSession()
    client5.closeSession()
except Ice.ConnectionRefusedException:
    pass # Bad address or port?

Example: examples/OmeroClients/configuration.py

```java
public class configuration {
    public static void main(String[] args) throws Exception {
        // All configuration in file pointed to by
        // --Ice.Config=file.config
        // No username, password entered
        omero.client client1 = new omero.client(args);
        try {
            client1.createSession();
        } catch (Ice.ConnectionRefusedException cre) {
            // Bad address or port?
        } finally {
```

---

66 https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/configuration.py
client1.closeSession();
}
// Most basic configuration.
// Uses default port 4064
// createSession needs username and password
omer0.client client2 = new omero.client("localhost");
try {
    client2.createSession("root", "ome");
} catch (Ice.ConnectionRefusedException cre) {
    // Bad address or port?
} finally {
    client2.closeSession();
}
// Configuration with port information
omer0.client client3 = new omer0.client("localhost", 24064);
try {
    client3.createSession("root", "ome");
} catch (Ice.ConnectionRefusedException cre) {
    // Bad address or port?
} finally {
    client3.closeSession();
}
// Advanced configuration can also be done
// via an InitializationData instance.
Ice.InitializationData data = new Ice.InitializationData();
data.properties = Ice.Util.createProperties();
data.properties.setProperty("omero.host", "localhost");
omer0.client client4 = new omer0.client(data);
try {
    client4.createSession("root", "ome");
} catch (Ice.ConnectionRefusedException cre) {
    // Bad address or port?
} finally {
    client4.closeSession();
}
// Or alternatively via a java.util.Map instance
java.util.Map<String, String> map = new java.util.HashMap<String, String>();
map.put("omero.host", "localhost");
map.put("omero.user", "root");
map.put("omero.pass", "ome");
omer0.client client5 = new omer0.client(map);
// Again, no username or password needed
// since present in the map. But they *can*
// be overridden.
try {
    client5.createSession();
} catch (Ice.ConnectionRefusedException cre) {
    // Bad address or port?
} finally {
    client5.closeSession();
}

Example: examples/OmeroClients/configuration.java

To find out more about using the Ice.Config file for configuration, see etc/ice.config.

67https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/configuration.java
68https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/ice.config
What is a ServiceFactory?

In each of the examples above, the result of configuration was the ability to call `createSession` which returns a `ServiceFactoryPrx`.

The ServiceFactory is the clients representation of the user’s *server-side session*, which multiple clients can connect to it simultaneously. A `ServiceFactoryPrx` object is acquired on login via the `createSession` method, and persists until either it is closed or a timeout is encountered unless additional clients attach to it. This is done via `client.joinSession(String uuid)`. In that case, the session is not finally closed until its reference count drops to zero.

It produces services!

Once a client has been configured properly, and has an active in ServiceFactory in hand, it is time to start accessing services.

The collection of all services provided by OMERO is known as the *OMERO Application Programming Interface*. Each service is defined in a slice file under `components/blitz/resources/omero`\(^{69}\). The central definitions are in `components/blitz/resources/omero/API.ice`\(^{70}\), along with the definition of ServiceFactory itself:

```java
interface ServiceFactory extends Glacier2::Session
{
    // Central OMERO.blitz stateless services.
    IAdmin* getAdminService() throws ServerError;
    IConfig* getConfigService() throws ServerError;

    // Central OMERO.blitz stateful services.
    Gateway* createGateway() throws ServerError;
}
```

In the definition above, the return values look like C/C++ pointers, which in Ice’s definition language represents return-by-proxy. When a client calls, `serviceFactory.getAdminService()` it will receive an `IAdminPrx`. Any call on that object is a remote invocation.

Stateless vs. stateful

Most methods on the ServiceFactory return either a stateless or a stateful service factory. Stateless services are those returned by calls to “getSomeNameService()”. They implement `omero.api.ServiceInterface` but not its subinterface `omero.api.StatefulServiceInterface`. Stateless services are for all intents and purposes singletons, though the implementation may vary.

Stateful services are returned by calls to “createSomething()” and implement `omero.api.StatefulServiceInterface`. Each maintains a state machine with varying rules on initialization and usage. It is important to guarantee that calls are ordered as described in the documentation for each stateful service. It is also important to always close stateful services to free up server resources. If you fail to manually call `StatefulServiceInterfacePrx.close()`, it will be called for you on session close/timeout.

What are timeouts?

The following code has a resource leak:

```java
import omero, sys
c = omero.client()
s = c.createSession()
sys.exit(0)
```

Although the client will not suffer any consequences, this snippet leaves a *session* open on the server. If the server failed to eventually reap such sessions, they would eventually consume all available memory. To get around this, the server implements

---

69 https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/blitz/resources/omero
70 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/blitz/resources/omero/API.ice
It is the clients responsibility to periodically contact the server to keep the session alive. Since threading policies vary in applications, no strict guideline is available on how to do this. Almost any API method will suffice to tell the server that the client is still active. Important is that the call happens within every timeout window.

# No cpp example

# No m example

```python
import time
import omero
import threading
IDLETIME = 5

import omero.client()
import omero.createSession()
import omero.createRenderingEngine()

class KeepAlive(threading.Thread):
    def run(self):
        self.stop = False
        while not self.stop:
            time.sleep(IDLETIME)
            print "calling keep alive"
            # Currently, passing a null or empty array to keepAllAlive
            # would suffice. For future-proofing, however, it makes sense
            # to pass stateful services.
            try:
                s.keepAllAlive([re])
            except:
                c.closeSession()

keepAlive = KeepAlive()
keepAlive.start()
time.sleep(IDLETIME * 2)
keepAlive.stop = True
```

Example: examples/OmeroClients/timeout.py

```python
import omero.*;
import omero.api.*;
import omero.model.*;
import omero.sys.*;

public class timeout {
    static int IDLETIME = 5;
    static client c;
    static ServiceFactoryPrx s;

    public static void main(String[] args) throws Exception {
        final int idletime = args.length > 1 ? Integer.parseInt(args[0]) : IDLETIME;
        c = new client(args);
        s = c.createSession();
        System.out.println(s.getAdminService().getEventContext().sessionUuid);
        final RenderingEnginePrx re = s.createRenderingEngine(); // for keep alive

        class Run extends Thread {
            public boolean stop = false;
            public void run() {
                while (!stop) {
                    try {
                        Thread.sleep(idletime*1000L);
                    } catch (Exception e) {
                        // ok
                    }
                }
            }

            public static void main(String[] args) {
                new Run();
            }
        }
    }
}
```

71https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/timeout.py
System.out.println(System.currentTimeMillis() + " calling keep alive");
try {
    // Currently, passing a null or empty array to keepAllAlive
    // would suffice. For future-proofing, however, it makes sense
    // to pass stateful services.
    s.keepAllAlive(new ServiceInterfacePrx[]{re});
} catch (Exception e) {
    c.closeSession();
    throw new RuntimeException(e);
}

final Run run = new Run();

class Stop extends Thread {
    public void run() {
        run.stop = true;
    }
}
Runtime.getRuntime().addShutdownHook(new Stop());
run.start();

Example: examples/OmeroClients/timeout.java

Exceptions

Probably the most critical thing to realize is that any call on a proxy, which includes ServiceFactoryPrx or any of the *Prx service classes is a remote invocation on the server. Therefore proper exception handling is critical. The definition of the various exceptions is outlined on the Exception handling page and so will not be repeated here. However, how are these sensibly used?

One easy rule is that every omero.client object which you successfully call createSession() on must have closeSession() called on it before you exit.

omero.client client = new omero.client();
client.createSession();
try {
    // do whatever you want
} finally {
    client.closeSession();
}

Obviously, the work you do in your client will be much more complicated, and may be under layers of application code. But when designing where active omero.client objects are kept, be sure that your clean-up code takes care of them.

18.1.5 IQuery

Now that we have a good idea of the basics, it might be interesting to start asking the server what it has got. The most powerful way of doing this is by using IQuery and the Hibernate Query Language (HQL).

#include <omero/api/IQuery.h>
#include <omero/client.h>
#include <omero/RTypesI.h>
#include <omero/sys/ParametersI.h>
using namespace omero::rtypes;

72https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/timeout.java
int main(int argc, char* argv[]) {
  std::string query_string = "select i from Image i where i.id = :id and name like :namedParameter";
  omero::sys::ParametersIPtr p = new omero::sys::ParametersI();
  p->add("id", rlong(1L));
  p->add("namedParameter", rstring("cell%mit%"));
  omero::api::IObjectList results = q->findAllByQuery(query_string, p);
}

Example: examples/OmeroClients/queries.cpp

[client, sf] = loadOmero;
try
  q = sf.getQueryService();
  query_string = 'select i from Image i where i.id = :id and name like :namedParameter';
  p = omero.sys.ParametersI();
  p.add('id', omero.rtypes.rlong(1L));
  p.add('namedParameter', omero.rtypes.rstring('cell%mit%'));
  results = q.findAllByQuery(query_string, p) % java.util.List
catch ME
  client.closeSession();
end

Example: examples/OmeroClients/queries.m

import sys
import omero
from omero.rtypes import *
from omero.sys_ParametersI import ParametersI
client = omero.client(sys.argv)
try:
    sf = client.createSession()
    q = sf.getQueryService()
    query_string = "select i from Image i where i.id = :id and name like :namedParameter";
    p = ParametersI()
    p.addId(1L)
    p.add("namedParameter", rstring("cell%mit%"));
    results = q.findAllByQuery(query_string, p)
finally:
    client.closeSession()

Example: examples/OmeroClients/queries.py

import java.util.List;
import static omero.rtypes.*;
import omero.api.ServiceFactoryPrx;
import omero.api.IQueryPrx;
import omero.model.IObject;
import omero.model.ImageI;
import omero.model.PixelsI;
import omero.sys.ParametersI;
public class queries {
  public static void main(String args[]) throws Exception {
    omero.client client = new omero.client(args);
    try {
ServiceFactoryPrx sf = client.createSession();
IQueryPrx q = sf.getQueryService();
String query_string = "select i from Image i where i.id = :id and name like :namedParameter";
ParametersI p = new ParametersI();
p.add("id", rlong(1L));
p.add("namedParameter", rstring("cell\mit\%"));
List<IObject> results = q.findAllByQuery(query_string, p);
} finally {
    client.closeSession();
}
}

Example: examples/OmeroClients/queries.java

The query_string is an example of HQL. It looks a lot like SQL, but works with objects and fields rather than tables and columns (though in OMERO these are usually named the same). The Parameters object allow for setting named parameters (:id) in the query to allow for re-use, and is the only other argument need to IQueryPrx.findAllByQuery() to get a list of IObject instances back. They are guaranteed to be of type omero::model::Image, but you may have to cast them to make full use of that information.

18.1.6 IUpdate

After you have successfully read objects, an obvious thing to do is create your own. Below is a simple example of creating an image object:

```cpp
#include <IceUtil/Time.h>
#include <omero/api/IUpdate.h>
#include <omero/client.h>
#include <omero/RTypesI.h>
#include <omero/model/ImageI.h>
using namespace omero::rtypes;
int main(int argc, char* argv[]) {
    omero::client_ptr client = new omero::client(argc, argv);
    omero::model::ImagePtr i = new omero::model::ImageI();
    i->setName( rstring("name") );
    i->setAcquisitionDate( rtime(IceUtil::Time::now().toMilliSeconds()) );
    omero::api::ServiceFactoryPrx sf = client->createSession();
    omero::api::IUpdatePrx u = sf->getUpdateService();
    i = omero::model::ImagePtr::dynamicCast( u->saveAndReturnObject( i ) );
}
```

Example: examples/OmeroClients/updates.cpp

[client,sf] = loadOmero;
try
    i = omero.model.ImageI();
    i.setName(omero.rtypes.rstring('name'));
    i.setAcquisitionDate(omero.rtypes.rtime(java.lang.System.currentTimeMillis()));
    u = sf.getUpdateService();
    i = u.saveAndReturnObject( i );
    disp(i.getId().getValue());
catch ME
    disp(ME);
    client.closeSession();
end

76 https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/queries.java
77 https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/updates.cpp
Example: examples/OmeroClients/updates.m

```matlab
import sys
import time
import omero
import omero.clients
from omero.rtypes import *

client = omero.client(sys.argv)
try:
    i = omero.model.ImageI()
    i.name = rstring("name")
    i.acquisitionDate = rtime(time.time() * 1000)
    sf = client.createSession()
    u = sf.getUpdateService()
    i = u.saveAndReturnObject(i)
finally:
    client.closeSession()
```

Example: examples/OmeroClients/updates.py

```python
import java.util.List;
import static omero.rtypes.*;
import omero.api.ServiceFactoryPrx;
import omero.api.IUpdatePrx;
import omero.model.ImageI;
import omero.model.Image;

public class updates {
    public static void main(String args[]) throws Exception {
        omero.client client = new omero.client(args);
        try {
            Image i = new ImageI();
            i.setName(rstring("name"));
            i.setAcquisitionDate(rtime(System.currentTimeMillis()));
            ServiceFactoryPrx sf = client.createSession();
            IUpdatePrx u = sf.getUpdateService();
            i = (Image) u.saveAndReturnObject(i);
        } finally {
            client.closeSession();
        }
    }
}
```

Example: examples/OmeroClients/updates.java

18.1.7 Examples

To tie together some of the topics which we have outlined above, we would like to eventually have several more or less complete application examples which you can use to get started. For the moment, there is just one simpler example TreeList, but more will certainly be added. Let us know any ideas you may have.

**TreeList**

# No cpp example
function projects = AllProjects(query, username)
q = ['select p from Project p join fetch p.datasetLinks dil ',
     'join fetch dil.child where p.details.owner.omeName = :name'];
p = omero.sys.ParametersI();
p.add('name', omero.rtypes.rstring(username));
projects = query.findAllByQuery(q, p);

Example: examples/TreeList/AllProjects.m
81

import omero
from omero.rtypes import *
from omero.sys_ParametersI import ParametersI
def getProjects(query_prx, username):
    return query_prx.findAllByQuery(
        "select p from Project p join fetch p.datasetLinks dil join fetch dil.child where p.details.owner.omeName = :name",
        ParametersI().add("name", rstring(username)))

Example: examples/TreeList/AllProjects.py
82

import java.util.List;
import omero.model.Project;
import omero.api.IQueryPrx;
import omero.sys.ParametersI;
import static omero.rtypes.*;
public class AllProjects {
    public static List<Project> getProjects(IQueryPrx query, String username) throws Exception {
        List rv = query.findAllByQuery("select p from Project p join fetch p.datasetLinks dil join fetch dil.child where p.details.owner.omeName = :name",
                                  new ParametersI().add("name", rstring(username)));
        return (List<Project>) rv;
    }
}

Example: examples/TreeList/AllProjects.java
83

# No cpp example

function PrintProjects(projects)
if (projects.size()==0)
    return;
end;
for i=0:projects.size()-1,
    project = projects.get(i);
    disp(project.getName().getValue());
    links = project.copyDatasetLinks();
    if (links.size()==0)
        return
    end
    for j=0:links.size()-1,
        pdl = links.get(j);
        dataset = pdl.getChild();
        disp(sprintf(' %s', char(dataset.getName().getValue())));
    end
end

81https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/TreeList/AllProjects.m
82https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/TreeList/AllProjects.py
83https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/TreeList/AllProjects.java
Example: examples/TreeList/PrintProjects.m\(^84\)

```python
def print_(projects):
    for project in projects:
        print project.getName().val
        for pdl in project.copyDatasetLinks():
            dataset = pdl.getChild()
            print " " + dataset.getName().val
```

Example: examples/TreeList/PrintProjects.py\(^85\)

```python
import java.util.List;
import omero.model.Project;
import omero.model.ProjectDatasetLink;
import omero.model.Dataset;

public class PrintProjects {
    public static void print(List<Project> projects) {
        for (Project project : projects) {
            System.out.print(project.getName().getValue());
            for (ProjectDatasetLink pdl : project.copyDatasetLinks()) {
                Dataset dataset = pdl.getChild();
                System.out.println(" " + dataset.getName().getValue());
            }
        }
    }
}
```

Example: examples/TreeList/PrintProjects.java\(^86\)

```c
#include <omero/client.h>
#include <Usage.h>
#include <AllProjects.h>
#include <PrintProjects.h>

int main(int argc, char* argv[]) {
    std::string host, port, user, pass;
    try {
        host = argv[0];
        port = argv[1];
        user = argv[2];
        pass = argv[3];
    } catch (…) {
        Usage::usage();
    }
    omero::client client(argc, argv);
    int rc = 0;
    try {
        omero::api::ServiceFactoryPrx factory = client.createSession(user, pass);
        std::vector<omero::model::ProjectPtr> projects = AllProjects::getProjects(factory->getQueryService(), user);
        PrintProjects::print(projects);
    } catch (…) {
        client.closeSession();
    }
    return rc;
}
```

Example: examples/TreeList/Main.cpp\(^87\)

---

\(^84\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/TreeList/PrintProjects.m
\(^85\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/TreeList/PrintProjects.py
\(^86\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/TreeList/PrintProjects.java
\(^87\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/TreeList/Main.cpp
function Main(varargin)
    try
        host = varargin{1};
        port = varargin{2};
        user = varargin{3};
        pass = varargin{4};
    catch ME
        Usage
    end
    client = omero.client(host, port);
    factory = client.createSession(user, pass);
    projects = AllProjects(factory.getQueryService(), user);
    PrintProjects(projects);
    client.closeSession();
end

Example: examples/TreeList/Main.m

import sys
import omero
import Usage, AllProjects, PrintProjects
if __name__ == "__main__":
    try:
        host = sys.argv[1]
        port = sys.argv[2]
        user = sys.argv[3]
        pasw = sys.argv[4]
    except:
        Usage.usage()
    client = omero.client(sys.argv)
    try:
        factory = client.createSession(user, pasw)
        projects = AllProjects.getProjects(factory.getQueryService(), user)
        PrintProjects.print_(projects)
    finally:
        client.closeSession()

Example: examples/TreeList/Main.py

import omero.api.ServiceFactoryPrx;
import omero.model.Project;
import java.util.List;
public class Main {
    public static void main(String args[]) throws Exception{
        String host = null, port = null, user = null, pass = null;
        try {
            host = args[0];
            port = args[1];
            user = args[2];
            pass = args[3];
        } catch (Exception e) {
            Usage.usage();
        }
        omero.client client = new omero.client(args);
        try {
            ServiceFactoryPrx factory = client.createSession(user, pass);
            List<Project> projects = AllProjects.getProjects(factory.getQueryService(), user);
            PrintProjects.print_(projects);
        } finally {
            client.closeSession();
        }
}

88https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/TreeList/Main.m
89https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/TreeList/Main.py
18.1.8 Advanced topics

Sudo

If you are familiar with the admin user concept in OMERO, you might wonder if it is possible for administrative users to perform tasks for regular users. Under Unix-based systems this is commonly known as “sudo” functionality. Although not (yet) as straightforward, it is possible to create sessions for other users and carry out actions on their behalf.

```cpp
#include <iostream>
#include <omero/api/IAdmin.h>
#include <omero/api/ISession.h>
#include <omero/client.h>
#include <omero/model/Session.h>

int main(int argc, char* argv[]) {
    Ice::StringSeq args1 = Ice::argsToStringSeq(argc, argv);
    Ice::StringSeq args2(args1); // Copies
    // ticket:1246
    Ice::InitializationData id1;
    id1.properties = Ice::createProperties(args1);
    Ice::InitializationData id2;
    id2.properties = Ice::createProperties(args2);
    omero::client_ptr client = new omero::client(id1);
    omero::client_ptr sudoClient = new omero::client(id2);
    omero::api::ServiceFactoryPrx sf = client->createSession();
    omero::api::ISessionPrx sessionSvc = sf->getSessionService();
    omero::sys::PrincipalPtr p = new omero::sys::Principal();
    p->name = "root"; // Can change to any user
    p->group = "user";
    omero::model::SessionPtr sudoSession = sessionSvc->createSessionWithTimeout( p, 3*60*1000L ); // 3 minutes to live
    omero::api::ServiceFactoryPrx sudoSf = sudoClient->joinSession( sudoSession->getUuid()->getValue() );
    omero::api::IAdminPrx sudoAdminSvc = sudoSf->getAdminService();
    std::cout << sudoAdminSvc->getEventContext()->userName;
}
```

Example: examples/OmeroClients/sudo.cpp

```cpp
client = omero.client();
sudoClient = omero.client();
try
    sf = client.createSession('root','ome');
    sessionSvc = sf.getSessionService();
    p = omero.sys.Principal();
    p.name = 'root'; % Can change to any user
    p.group = 'user';
    p.eventType = 'User';
    sudoSession = sessionSvc.createSessionWithTimeout( p, 3*60*1000 ); % 3 minutes to live
    sudoSf = sudoClient.joinSession( sudoSession.getUuid().getValue() );
    sudoAdminSvc = sudoSf.getAdminService();
    disp(sudoAdmin.Svc.getEventContext().userName);
catch ME
```

---

*[90](https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/TreeList/Main.java)

*[91](https://github.com/openmicroscopy/openmicroscopy/blob/develop/examples/OmeroClients/sudo.cpp)
sudoClient.closeSession();
client.closeSession();
end

Example: examples/OmeroClients/sudo.m

import sys
import omero
args = list(sys.argv)
client = omero.client(args)
sudoClient = omero.client(args)
try:
sf = client.createSession("root","ome")
sessionSvc = sf.getSessionService()
p = omero.sys.Principal()
p.name = "root" # Can change to any user
p.group = "user"
p.eventType = "User"
sudoSession = sessionSvc.createSessionWithTimeout( p, 3*60*1000L ) # 3 minutes to live
sudoSf = sudoClient.joinSession( sudoSession.getUuid().getValue() )
sudoAdminSvc = sudoSf.getAdminService()
print sudoAdminSvc.getEventContext().userName
finally:
sudoClient.closeSession()
client.closeSession()

Example: examples/OmeroClients/sudo.py

import java.util.List;
import omero.api.IAdminPrx;
import omero.api.ISessionPrx;
import omero.api.ServiceFactoryPrx;
import omero.model.Session;
import omero.sys.Principal;
public class sudo {
    public static void main(String args[]) throws Exception {
        omero.client client = new omero.client(args);
        omero.client sudoClient = new omero.client(args);
        try {
            ServiceFactoryPrx sf = client.createSession("root","ome");
            ISessionPrx sessionSvc = sf.getSessionService();
            Principal p = new Principal();
p.name = "root"; // Can change to any user
p.group = "user"
p.eventType = "User"
            Session sudoSession = sessionSvc.createSessionWithTimeout( p, 3*60*1000L ); // 3 minutes to live
            ServiceFactoryPrx sudoSf = sudoClient.joinSession( sudoSession.getUuid().getValue() );
            IAdminPrx sudoAdminSvc = sudoSf.getAdminService();
            System.out.println( sudoAdminSvc.getEventContext().userName );
        } finally {
            sudoClient.closeSession();
            client.closeSession();
        }
    }
}

Example: examples/OmeroClients/sudo.java

18.1. Developing OMERO clients
Proposed

Like the complete examples above, there are several topics which need to be covered in more detail:

- how to detect client/server version mismatches
- how to make asynchronous methods
- how to use client callbacks
- how to make use of your own ObjectFactory

18.1.9 Planned improvements and known issues

Topics to be added

Obviously, this introduction is still not exhaustive by any means. Some topics which we would like to see added here in the near future include:

- more examples of working with the OME-Remote Objects
- examples of all services
- security and ownership
- performance

Code generation

Although not directly relevant to writing a client, it is important to note that much of the code for OMERO Python language bindings, OMERO C++ language bindings, and OMERO Java language bindings is code generated by the BlitzBuild. Therefore, many of the imported and included files in the examples above cannot be found in github\(^5\).

We plan to include packages of the generated source code in future releases. Until then, it is possible to find our latest builds on jenkins\(^6\) or to build them locally, although some of the generated files are later overwritten by hand-written versions:

- model is located in components/tools/OmeroCpp/src/omero/model/
- OmeroPy is located in components/tools/OmeroPy/src/

Lazy loading and caching

Separate method calls will often return one and the same object, say Dataset#123. Your application, however, will not necessarily recognize them as the same entity unless you explicitly check the id value. A client-side caching mechanism would allow duplicate objects to be handled transparently, and would eventually facilitate lazy loading.

Helper classes

Several types are harder to use than they need be. omero.sys.Parameters, for example, is a class for which native implementations are quite helpful. We have provided omero.sys.ParametersI in all supported languages, and will most likely support more over time:

Other

- Superclasses need to be introduced where possible to replace the ome.model.* interfaces
- Annotation-link-loading can behave strangely if AnnotationLink.child is not loaded.

\(^{5}\)https://github.com/openmicroscopy/openmicroscopy
\(^{6}\)http://ci.openmicroscopy.org/
18.2 OMERO Application Programming Interface

All interaction with the OMERO server takes place via several API services available from a ServiceFactory. A service factory is obtained from the client connection e.g. Python:

```python
client = omero.client("localhost")
session = client.createSession("username", "password")  # this is the service factory
adminService = session.getAdminService()  # now we can get/create services
```

- The Service factory API\(^{97}\) has methods for creating Stateless and Stateful services (see below).
  - Stateless services are obtained using “get…” methods e.g. `getQueryService()`
  - Stateful services are obtained using “create…” methods e.g. `createRenderingEngine()`

- Services will provide access to omero.model.objects. You will then need the API for these objects\(^{98}\), e.g. Dataset, Image, Pixels etc.

18.2.1 Services list

The `ome.api`\(^{99}\) package in the common component defines the central “verbs” of the OMERO system. All external interactions with the system should happen with these verbs, or services. Each OMERO service belongs to a particular service level with each level calling only on services from lower levels.

Service Level 1 (direct database and Hibernate connections)

- AdminService: src\(^{100}\), API\(^{101}\) for working with Experimenters, Groups and the current Context (switching groups etc).
- ConfigService: src\(^{102}\), API\(^{103}\) for getting and setting config parameters.
- ContainerService: API\(^{104}\) for loading Project, Dataset and Image hierarchies.
- DeleteService: API\(^{105}\) for deleting objects asynchronously (delete queue).
- LdapService: src\(^{106}\), API\(^{107}\) for communicating with LDAP servers.
- MetadataService: API\(^{108}\) for working with Annotations.
- PixelsService: API\(^{109}\) for pixels stats and creating Images with existing or new Pixels.
- ProjectionService API\(^{110}\)
- QueryService: src\(^{111}\), API\(^{112}\) for custom SQL-like queries.
- RenderingSettingsService API\(^{113}\) for copying, pasting & resetting rendering settings.
- RepositoryInfo API\(^{114}\) disk space stats.
- RoiService API\(^{115}\) working with ROIs.

\(^{98}\)[http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/model.html]
\(^{99}\)[https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/common/src/ome/api]
\(^{100}\)[https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/IAdmin.java]
\(^{101}\)[http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/IAdmin.html]
\(^{102}\)[https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/IConfig.java]
\(^{103}\)[http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/IConfig.html]
\(^{104}\)[http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/IContainer.html]
\(^{105}\)[http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/IDelete.html]
\(^{106}\)[https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/ILdap.java]
\(^{107}\)[http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/ILdap.html]
\(^{110}\)[http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/IProjection.html]
\(^{111}\)[https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/IQuery.java]
\(^{112}\)[http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/IQuery.html]
\(^{113}\)[http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/IRenderingSettings.html]
\(^{114}\)[http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/IRepositoryInfo.html]
\(^{115}\)[http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/IRoi.html]
• ScriptService API\textsuperscript{116} for uploading and launching Python scripts.
• SessionService API\textsuperscript{117} for creating and working with OMERO sessions.
• ShareService API\textsuperscript{118} for queries based on time.
• TimelineService API\textsuperscript{119} for enumerations.
• UpdateService: src\textsuperscript{121}, API\textsuperscript{122} for saving and deleting omero.model objects.

Service Level 2

• IContainer\textsuperscript{123}
• ITypes\textsuperscript{124}

Stateful/Binary Services

• RawFileStore: src\textsuperscript{125}, API\textsuperscript{126}
• RawPixelsStore: src\textsuperscript{127}, API\textsuperscript{128}
• RenderingEngine: src\textsuperscript{129}, API\textsuperscript{130} (see OMERO rendering engine for more)
• ThumbnailStore: src\textsuperscript{131}, API\textsuperscript{132}
• IScale\textsuperscript{133}

A complete list of service APIs can be found here\textsuperscript{134} and some examples of API use in Python are provided. Java or C++ code can use the same API in a very similar manner.

18.2.2 Discussion

Reads and writes

IQuery and IUpdate are the basic building blocks for the rest of the (non-binary) API. IQuery is based on QuerySources and QueryParameters which are explained under Queries. The goal of this design is to make wildly separate definitions of queries (templates, db-stored, Java code, C# code, …) runnable on the server.

IUpdate takes any graph composed of IObject\textsuperscript{135} objects and checks them for dirtiness. All changes to the graph are stored in the database if the user calling IUpdate has the proper permissions, otherwise an exception is thrown.

Dirty checks follow the Three Commandments:

1. Any IObject-valued field with an unloaded set to true is treated as a place holder (proxy) and is re-loaded from the database.
2. Any collection-valued field with a null value is re-loaded from the database.

\textsuperscript{116}\url{http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/IScript.html}
\textsuperscript{117}\url{http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/ISession.html}
\textsuperscript{118}\url{http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/IShare.html}
\textsuperscript{119}\url{http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/ITimeline.html}
\textsuperscript{120}\url{http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/ITypes.html}
\textsuperscript{121}\url{https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/IUpdate.java}
\textsuperscript{122}\url{http://downloads.openmicroscopy.org/latest/omero5/api/ome/api/IUpdate.html}
\textsuperscript{123}\url{https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/IContainer.java}
\textsuperscript{124}\url{https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/ITypes.java}
\textsuperscript{125}\url{https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/RawFileStore.java}
\textsuperscript{126}\url{http://downloads.openmicroscopy.org/latest/omero5/api/ome/api/RawFileStore.html}
\textsuperscript{127}\url{https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/RawPixelsStore.java}
\textsuperscript{128}\url{http://downloads.openmicroscopy.org/latest/omero5/api/ome/api/RawPixelsStore.html}
\textsuperscript{129}\url{https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/omeis/providers/re/RenderingEngine.java}
\textsuperscript{130}\url{http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api/RenderingEngine.html}
\textsuperscript{131}\url{https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/ThumbnailStore.java}
\textsuperscript{132}\url{http://downloads.openmicroscopy.org/latest/omero5/api/ome/api/ThumbnailStore.html}
\textsuperscript{133}\url{https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/model/src/ome/model/IScale.java}
\textsuperscript{134}\url{http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/api.html}
\textsuperscript{135}\url{https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/model/src/ome/model/IObject.java}
3. Any collection-valued field with the FILTERED flag is assumed to be dirty and is loaded from the database, with the future option of examining the filtered collection for any new and updated values and applying them to the real collection. (Deletions cannot happen this way since it would be unclear if the object was filtered or deleted.)

**Administration**

The **IAdmin** interface defines all the actions necessary to administer the *Server security and firewalls*. It is explained further on the **OMERO admin interface** page.

**Pojos**

Certain operations, like those dealing with data management and viewing, happen more frequently than others (like defining microscopes). Those have been collected in the **IContainer** interface. **IContainer** simplifies a few very common queries, and there is a related package ("pojos.") for working with the returned graphs. OMERO.insight works almost exclusively with the **IContainer** interface for its non-binary needs.

### 18.2.3 Examples

```java
// Saving a simple change
Dataset d = iQuery.get( Dataset.class, 1L );
d.setName( "test" );
iUpdate.saveObject( d );

// Creating a new object
Dataset d = new Dataset();
d.setName( "test" ); // not-null fields must be filled in
iUpdate.saveObject( d );

// Retrieving a graph
Set<Dataset> ds = iQuery.findAllByQuery( "from Dataset d left outer join d.images where d.name = 'test'" );
```

### 18.2.4 Stateless versus stateful services

A stateless service has no client-noticeable lifecycle and all instances can be treated equally. A new stateful service, on the other hand, will be created for each client-side proxy (see the **ServiceFactory.create** methods). Once obtained, a stateful service proxy can only be used by a single user. After task completion, the service should be closed (proxy.close()) to free up server resources.

**18.2.5 How to write a service**

A tutorial is available at How To create a service. In general, if a properly annotated service is placed in any JAR of the OMERO EAR file (see **Build System** for more) then the service will be deployed to the server. In the case of **OMERO.blitz**, the service must be properly defined under **components/blitz/resources**.

**18.2.6 OMERO annotations for validation**

The server-side implementation of these interfaces makes use of ((JDK5)) **Structured annotations** and an **AOP** interceptor to validate all method parameters. Calls to **pojos.findContainerHierarchies** are first caught by a method interceptor, which checks for annotations on the parameters and, if available, performs the necessary checks. The interceptor also makes proactive checks. For a range of parameter types (such as Java Collections) it requires that annotations exist and will refuse to proceed if not implemented.

---

136 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/IAdmin.java
137 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/IContainer.java
138 https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/blitz/resources
An API call of the form:

```
pojos.findContainerHierarches(Class, Set, Map)
```

is implemented as

```
pojos.findContainerHierarchies(@NotNull Class, @NotNull @Validate(Integer.class) Set, Map)
```

See also:

*Queries, OMERO rendering engine, Exception handling*

## 18.3 OMERO admin interface

The one central interface for administering the OMERO security system is `IAdmin`. Though several of the methods are restricted to system users (root and other administrators), many are also for general use. The `@javax.ejb.security.RolesAllowed` annotations on the `LocalAdmin` class define who can use which methods.

### 18.3.1 Actions available through IAdmin and IUpdate

A couple of the methods in the `IAdmin` interface are also available implicitly through `IUpdate`, the main interface for updating the database. This duplication is mainly useful for large scale changes, such as changing the permissions to an entire object graph.

- `changePermissions`
- `changeGroup`

The following shows how these methods can be equivalently used:

```
// setup
ServiceFactory sf = new ServiceFactory();
IAdmin iAdmin = sf.getAdminService();
IUpdate iUpdate = sf.getUpdateService();
Image myImg = ...; //

// using IAdmin -- let's change the group of myImg
// and then make it group private.
iAdmin.changeGroup(myImg, new ExperimenterGroup(3L, false));
iAdmin.changePermissions(myImg, new Permissions(Permissions.GROUP_PRIVATE));

// and do the same using Details and IUpdate
myImg.getDetails().setPermissions( new Permissions(Permissions.GROUP_PRIVATE));
myImg.getDetails().setGroup( new ExperimenterGroup(3L, false));
iUpdate.saveObject( myImg );
```

The benefit of the second method is the batching of changes into a single call. The benefit of the first is at most explicitness. Note, however, that changing any of the values of Details which are not also changeable through `IAdmin` will result in a `SecurityViolation`.

### 18.3.2 Actions only available through IAdmin

The rest of the write methods provided by `IAdmin` are disallowed for `IUpdate` and will throw `SecurityViolations`. This includes adding users, groups, user/group maps, events, enums, or similar. ( Enums here are a special case, because they are created not through `IAdmin` but through `ITypes`). A system administrator may be able to use `IUpdate` to create these “System-Types” but using `IAdmin` is safer, cleaner, and guaranteed to work in the future.

The password methods and `synchronizeLoginCache` are also special cases in that they have no equivalent in any other API.

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139[https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/api/local/LocalAdmin.java](https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/api/local/LocalAdmin.java)
18.3.3 Similarities between IAdmin and IQuery

All of the read methods provided by IAdmin are also available from IQuery, that is, the IAdmin (currently) provide no special context or security privileges. However, having all of the methods in one interface reduces code duplication, which is especially useful when you want the entire user/group graph as provided by getExperimenter/getGroup/lookupExperimenter/lookupGroup.

See also:
OMERO Application Programming Interface

18.4 Deleting in OMERO

Deleting data in OMERO is complex due to the highly linked nature of data in the database. For example, an Image has links to Datasets, Comments, Tags, Instrument, Acquisition metadata etc. If the image is deleted, some of this other data should remain and some should be deleted with the image (since it has no other relevance).

In the 4.2.1 release of OMERO, an improved deleting service was introduced to fix several problems or requirements related to the delete functionality (see #2615 for tickets):

- Need a better way to define what gets deleted when certain data gets deleted (e.g. Image case above)
- Need to be able to configure this definition, since different users have different needs
- Deleting large amounts of data (e.g. Plate of HCS data) was too memory-intensive (data was loaded from the database during delete)
- Poor logging of deletes
- Large deletes (e.g. screen data) take time: Clients need to be able to keep working while deletes run ‘in the background’
- Binary data (pixels, thumbnails, files etc) was not removed at delete time - required sysadmin to clean up later

Future releases will continue this work (see #2911).

18.4.1 Finality of deletion

Import in OMERO 5.x uploads the image and companion files intact and stores them within subdirectories of the directory configured by the value of omero.managed.dir, typically ManagedRepository. The files relating to a specific fileset are stored together on the server’s filesystem and they are read by Bio-Formats when images are viewed in OMERO clients. If any of a fileset’s files, or the corresponding entries for them in the database, are deleted, then the fileset may no longer be readable. If all the fileset’s files are deleted, the fileset will certainly be unreadable, and there is no ‘undo’ that will bring it back.

18.4.2 Delete behavior (technical)

Configuring what gets deleted is done using an XML file. The technical specification of delete behavior can be found components/server/resources/ome/services/spec.xml

Delete Image

The general delete behavior for deleting an Image is to remove every piece of data from the database that was added when the image was imported, removing pixel data and thumbnails from disk. In addition, the following data is deleted:

- Comments on the image
- Rating of the image
- ROIs for this image (see below)
- Image Rendering settings for yourself and other users

Optional - In OMERO.web and OMERO.insight, you will be asked whether you also want to delete:

140http://trac.openmicroscopy.org.uk/ome/ticket/2615
141http://trac.openmicroscopy.org.uk/ome/ticket/2911
142https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/spec.xml
• Files attached to the image (if not linked elsewhere). In that case, the binary data will be removed from disk too.

• Your own tags on the image (if not used elsewhere)

The same option is available when deleting dataset, project, plate, screen.

**Delete Dataset or Project**

When deleting a Project or Dataset, you have the option to also delete tags and annotations (as for Image above). You also can choose whether to ‘delete contents’. This will delete any Datasets (or Images) that are contained in the Project (or Dataset). However, Datasets and Images will not get deleted if they are also contained in other Projects or Datasets respectively.

If a user decides to delete/keep the annotations (see **Optional** above) when deleting a Project (or Dataset) and its contents, the rule associated to the annotation will be apply to all objects.

**Delete Screen, Plate or Plate Acquisition**

When deleting a Screen, you have the option to also delete tags and annotations. You also can choose whether to ‘delete contents’. This will delete any Plates that are contained in the Screen. However, Plates will not get deleted if they are also contained in other Screen.

When deleting a Plate, you have the option to also delete tags and annotations but **NOT** the option to ‘delete contents’.

If the Plate has Plate Acquisitions, you can delete one or more Plate Acquisition at once.

**Delete Tag/Attachment**

You can delete a Tag/Attachment, and it will be removed from all images. However you cannot delete a Tag/Attachment if it has been used by another user in the same collaborative group. This is to prevent potential loss of significant amount of annotation effort by other users. You will need to get the other users to first remove your Tag/Attachment where they have used it, before you can delete it.

**Known Issue:** if the owner of the Tag/Attachment is also an owner of the group (e.g. PI), they will be able to delete their Tag/Attachment, even if others have used it.

**Delete multi-file Images and Image sets**

An Image, or a set of Images, may come from a single file or a set of dependent files. For instance, a single Leica LIF file may contain many Images, as may a Zeiss mdb file with lsm files. On the other hand, some file formats, like Deltavision with log file, or the original ICS file format, use multiple files to represent a single Image. At import time, these groups of related files and Images are organized into Filesets: a Fileset is a set of files that encode a set of Images. The simplest case where there is one file per Image still has a corresponding Fileset.

Even if many Images come from the same file, they may be separately selected and viewed in client software. However, at least at present, a Fileset may not be partially deleted: either all the files and Images from it are deleted, or none are. So, for instance, the Images from the same Leica LIF file may be deleted only all at once, and the Deltavision log file is not deleted separately from the main file. The same applies to high-content screening data: a Plate with its Wells and Images are all stored in one Fileset and may be deleted only together.

Each Fileset has a corresponding directory on the server in which, perhaps in subdirectories, all its files are stored. All the file paths for an Image’s Fileset can be accessed from the tool-bar at the top of the right-hand panel.

**Delete in collaborative group**

Some more discussion of delete issues in a collaborative group, where your data are linked to data of other users, can be found on the **Permissions overview** page.

• A user cannot remove Images from another user’s Dataset, or remove Datasets (or Plates) from Projects (or Screens).

• A user cannot delete anything that belongs to another user.
Group owner rights

An owner of the group, usually a PI, can delete anything that belongs to other members of the group.

Edge cases

These are ‘known issues’ that may cause problems for some users (not for most). These will be resolved in future depending on priority.

- Annotations of annotations are not deleted, e.g. a Tag is not deleted if a Tag Set is deleted (only true if directly using the API).
- Other users’ ROIs (and associated measurements) are deleted from images.
- Multiply-linked objects are unlinked and not deleted, e.g. Project p1 contains two Datasets d1 and d2, Project p2 contains Dataset d1. If the Project p1 is deleted, the Dataset d1 is only unlinked from p1 and not completely deleted.

Binary data

When Images, Plates or File Annotations have been successfully deleted from the database the corresponding binary data is deleted from the binary repository (see Unix and Windows versions). It is possible that some files may not be successfully deleted if they are locked for any reason. This is a known problem on Windows servers. In this case, the undeleted files can be removed manually via bin/omero admin cleanse

18.5 OMERO Import Library

The Import Library is a re-usable framework for building import clients. Several are provided by the OMERO team directly:

- the integrated importer
- The Command Line Import tool

18.5.1 Components

The primary classes which make up the Import Library are:

- ImportLibrary.java which is the main driver
- ImportCandidates.java takes file paths and determines the proper files to import
- ImportConfig.java, an extensible mechanism for storing the properties used during import
- ImportEvent.java, the various events raised during import to IObserver and IObservable implementations
- OMEROMetadataStoreClient.java, the low-level connection to the server
- OMEROWrapper.java, the OMERO adapter for the Bio-Formats ImageReaders class
- In OMERO.insight, the main entry point is the importImage method of OMEROGateway.java
- In the CLI, the main entry point is the CommandLineImporter.java class

18.5. OMERO Import Library
18.5.2 Earlier Import Workflow

Prior to OMERO 5.0, the import workflow was very much client-side. Using the ImportLibrary a client would determine the import candidates and then import the image. The import phase would comprise copying the pixel data to the OMERO data directory, writing the metadata into the database, and optionally copying the original file to the OMERO data directory for archiving.

18.5.3 FS Managed Repository Import Workflow

From 5.0 the workflow has changed. The client still determines the import candidates but the client-side import process simply uploads the original files to the OMERO data directory and then uses the ManagedRepository service to initiate a server-side import. On the server the import is then completed by writing the metadata into the database. After import, pixel data is accessed directly from the original files using Bio-Formats. This means that data files are no longer duplicated and any nested directory structure is preserved. It also allows OMERO to take advantage of pre-generated pyramids available in some formats e.g. SVS.

For full details of the import workflow see FS Managed Repository.

18.5.4 Example

The CommandLineImporter.java class shows a straightforward import. An ErrorHandler instance is passed both to the ImportCandidates constructor (since errors can occur while parsing a directory) and to the ImportLibrary. This and other handlers receive ImportEvents which notify listeners of the state of the current import.

18.6 TempFileManager

Class to be used by Working with OMERO and server components to allow a uniform creation of temporary files and folders with a best-effort guarantee of deleting the resources on exit. The manager searches three locations in order, taking the first which allows lockable write-access (See #1653\(^\text{151}\)):

- The environment property setting OMERO_TEMPDIR
- The user’s home directory, for example specified in Java via System.getProperty("user.home")
- The system temp directory, in Java System.getProperty("java.io.tmpdir") and in Python temp-file.gettempdir()

18.6.1 Creating temporary files

For the user “ralph”,

```python
from omero.util.temp_files import create_path
path = create_path("omero",".tmp")
```

or

```python
import omero.util.TempFileManager
File file = TempFileManager.create_path("omero",".tmp")
```

both produce a file under the directory:

```
/tmp/omero_ralph/$PID/omero$RANDOM.tmp
```

where $PID is the current process id and $RANDOM is some random sequence of alphanumeric characters.

\(^{151}\text{http://trac.openmicroscopy.org.uk/ome/ticket/1653}\)
18.6.2 Removing files

If `remove_path` is called on the return value of `create_path`, then the temporary resources will be cleaned up immediately. Otherwise, when the Java or Python process exits, they will be deleted. This is achieved in Java through `Run-time#addShutdownHook(Thread)` and in Python via `atexit.register()`.

18.6.3 Creating directories

If an entire directory with a unique directory is needed, pass “true” as the “folder” argument of the `create_path` method:

```python
create_path("omero", ".tmp", folder = True)
```

and

```python
TempFileManager.create_path("omero", ".tmp", true);
```

**Note:** All contents of the generated directory will be deleted.

**See also:**

[#1534](http://trac.openmicroscopy.org.uk/ome/ticket/1534)

18.7 Exception handling

18.7.1 Client exceptions

The exceptions which can be received by a client due to a remote call on the OMERO server are all defined in `components/blitz/resources/omero/ServerErrors.ice` (included below). This file contains two separate hierarchies rooted at `Ice::Exception` and `omero::ServerError`.

For a better understanding of how to handle exceptions, please read both of the `*.ice` files carefully, and see *Working with OMERO* for examples of exception handling.

```
/*
* Copyright 2007 Glencoe Software, Inc. All rights reserved.
* Use is subject to license terms supplied in LICENSE.txt
*/
#ifndef OMERO_SERVERERRORS_ICE
#define OMERO_SERVERERRORS_ICE
#include <Glacier2/Session.ice>
/**
 * Exceptions thrown by OMERO server components. Exceptions thrown client side
 * are available defined in each language binding separately, but will usually
 * subclass from "ClientError"
 * including examples of what a appropriate try/catch block would look like.
 */
typedef struct _OMERO_ServerErrors_ICE_{
/**
 * All exceptions that are thrown by a remote call (any call on a "Prx instance)
 * will be either a subclass of [Ice::UserException] or [Ice::LocalException].
 */
```

152 http://trac.openmicroscopy.org.uk/ome/ticket/1534

153 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/blitz/resources/omero/ServerErrors.ice
* from the Ice manual shows the entire exception hierarchy. The exceptions described in
* this file will subclass from [Ice::UserException]. Other Ice-runtime exceptions subclass
* from [Ice::LocalException].
* </p>
* <pre>
* OMERO Specific:
* ===============
* ServerError (root server exception)
* |__ InternalException (server bug)
* |__ ResourceError (non-recoverable)
* |  \ NoProcessorAvailable
* |__ ConcurrencyException (recoverable)
* |  \ ConcurrentModification (data was changed)
* |  \ OptimisticLockException (changed data conflicts)
* |  \ LockTimeout (took too long to acquire lock)
* |  \ TryAgain (some processing required before server is ready)
* |  \ TooManyUsersException
* |  \ DatabaseBusyException
* |__ ApiUsageException (misuse of services)
* |  \ OverUsageException (too much)
* |  \ QueryException (bad query string)
* |  \ ValidationException (bad data)
* |__ SecurityViolation (some no-no)
* |  \ GroupSecurityViolation
* |  \ PermissionMismatchGroupSecurityViolation
* |  \ ReadOnlyGroupSecurityViolation
* |__ SessionException
* |  \ RemovedSessionException (accessing a non-extant session)
* |  \ SessionTimeoutException (session timed out; not yet removed)
* |  \ ShutdownInProgress (session on this server will most likely be destroyed)
* </pre>
* <p>
* However, in addition to [Ice::LocalException] subclasses, the Ice runtime also
* defines subclasses of [Ice::UserException]. In some cases, OMERO subclasses
* from these exceptions. The subclasses shown below are not exhaustive, but show those
* which an application’s exception handler may want to deal with.
* </p>
* <pre>
* Ice::Exception (root of all Ice exceptions)
* |__ Ice::UserException (super class of all application exceptions)
* |  |__ Glacier2::CannotCreateSessionException (1 of 2 exceptions throwable by createSession)
* |  |  \ omero::AuthenticationException (bad login)
* |  |  \ omero::ExpiredCredentialException (old password)
* |  |  \ omero::WrappedCreateSessionException (any other server error during createSession)
* |  |  \ omero::licenses::NoAvailableLicensesException (see tools/licenses/resources/omero/LicensesAPI.ice)
* |  \ Glacier2::PermissionDeniedException (other of 2 exceptions throwable by createSession)
* |  \ Ice::LocalException (should generally be considered fatal. See exceptions below)
* </pre>
 EXCEPTIONS ( Glacier2 ) ---------------------

* createSession() is a two-phase process. First, a PermissionsVerifier is called which must return true; then a SessionManager is called to create the session (ServiceFactory). If the PermissionsVerifier returns false, then PermissionDeniedException will be thrown. This, however, cannot be
* subclassed and so string parsing must be used. */

/* Thrown when the information provided omero.createSession() or more
   * specifically Glacier2.RouterPrx.createSession() is incorrect. This
   * does -not- subclass from the omero.ServerError class because the
   * Ice Glacier2::SessionManager interface can only throw CCSEs. */

exception AuthenticationException extends Glacier2::CannotCreateSessionException {
    
};

/* Thrown when the password for a user has expired. Use: ISession.changeExpiredCredentials()
   * and login as guest. This does -not- subclass from the omero.ServerError class because the
   * Ice Glacier2::SessionManager interface can only throw CCSEs. */

exception ExpiredCredentialException extends Glacier2::CannotCreateSessionException {
    
};

/* Thrown when any other server exception causes the session creation to fail.
   * Since working with the static information of Ice exceptions is not as easy
   * as with classes, here we use booleans to represent what has gone wrong. */

exception WrappedCreateSessionException extends Glacier2::CannotCreateSessionException {
    bool concurrency;
    long backOFF; /* Only used if ConcurrencyException */
    string type; /* Ice static type information */
};

// OTHER SERVER EXCEPTIONS ------------------------------

/* Programmer error. Ideally should not be thrown. */

exception InternalException extends ServerError {
    
};

// RESOURCE

/* Unrecoverable error. The resource being accessed is not available. */

exception ResourceError extends ServerError {
    
};

/* A script cannot be executed because no matching processor
   * was found. */

exception NoProcessorAvailable extends ResourceError {
    
    /**
     * Number of processors that responded to the inquiry.
     * If 1 or more, then the given script was not acceptable
     * (e.g. non-official) and a specialized processor may need
     * to be started.
     **/
    int processorCount;
}

// CONCURRENCY

/* Recoverable error caused by simultaneous access of some form. */

exception ConcurrencyException extends ServerError {
long backOff; /* Backoff in milliseconds */
};
/**
 * Currently unused.
 */
exception ConcurrentModification extends ConcurrencyException {
};
/**
 * Too many simultaneous database users. This implies that a
 * connection to the database could not be acquired, no data
 * was saved or modified. Clients may want to wait the given
 * backOff period, and retry.
 */
exception DatabaseBusyException extends ConcurrencyException {
};
/**
 * Conflicting changes to the same piece of data.
 */
exception OptimisticLockException extends ConcurrencyException {
};
/**
 * Lock cannot be acquired and has timed out.
 */
exception LockTimeout extends ConcurrencyException {
    int seconds; /* Informational field on how long timeout was */
};
/**
 * Background processing needed before server is ready
 */
exception TryAgain extends ConcurrencyException {
};
exception MissingPyramidException extends ConcurrencyException {
    long pixelsID;
};
// API USAGE
exception ApiUsageException extends ServerError {
};
exception OverUsageException extends ApiUsageException {
};
/**
 * 
 */
exception QueryException extends ApiUsageException {
};
exception ValidationException extends ApiUsageException {
};
// SECURITY
exception SecurityViolation extends ServerError {
};
exception GroupSecurityViolation extends SecurityViolation {
};
exception PermissionMismatchGroupSecurityViolation extends SecurityViolation {
};
18.7.2 Server exceptions

Due to the strict API boundary enforced by Ice, the client and server exception hierarchies, though related, are distinct. The discussion below is possibly of interest for server developers only. Client developers should refer to the information and examples under Working with OMERO.

Interceptor

Exception handling in the OMERO is centralized in an Aspect-oriented programming interceptor (source code\textsuperscript{154}). All exceptions thrown by code are caught in a \texttt{try \{} catch (Throwable t) \{} block. Exceptions which do not subclass \texttt{ome.conditions.RootException}\textsuperscript{155} are wrapped in an \texttt{ome.conditions.InternalException}\textsuperscript{156}.

The only exceptions to this are any interceptors which may be run before the exception handler is run. The order of interceptors is defined in \texttt{services.xml}\textsuperscript{157}.

Hierarchy

The current exception hierarchy (package \texttt{ome.conditions}\textsuperscript{158}) used is as follows:

- \texttt{RootException}
  - \texttt{InternalException} - should not reach the client; Bug! Contact administrator e.g. NullPointerException, assertion failed, etc.
  - \texttt{ResourceError} - fatal error in server, e.g. OutOfMemory, disk space full, the database is in illegal state, etc.
  - \texttt{DataAccessException}
    - \texttt{SecurityViolation} - do not do that! E.g. edit locked project, create new user.
    - \texttt{OptimisticLockException} - re-load and compare e.g. “someone else has already updated this project”
    - \texttt{ApiUsageException} - something wrong with how you did things e.g. IllegalStateException, object uninitialized, etc.
    - \texttt{ValidationException} - something wrong with what you sent; sends list of fields, etc.; edit and retry, e.g. no ”?” in image names.

\textsuperscript{154}https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/services/util/ServiceHandler.java
\textsuperscript{155}https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/model/src/ome/conditions/RootException.java
\textsuperscript{156}https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/model/src/ome/conditions/InternalException.java
\textsuperscript{157}https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/services.xml
\textsuperscript{158}https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/model/src/ome/conditions
where the colors indicate:

Abstract
FixAndRetryConditions
RetryConditions
NoRecourseConditions

Any other exception which reaches the client should be considered an `OutOfServiceException`, meaning that something is (hopefully only) temporarily wrong with the server, e.g. no connection, server down, server restarting. But since this cannot be caught since the server cannot be reached, there is no way to guarantee that a real `OutOfServiceException` is thrown.

18.7.3 Moving forward

`FixAndRetryConditions` need to have information about what should be fixed, like a `Validation` object which lists fields with error messages. A `RetryCondition` could have a back-off value to prevent too frequent retries.

Questions

- What data should be available in the exceptions?
- What other logic do we want on our exceptions, keeping in mind they will have to be re-implemented in all target languages?

18.8 Omero logging

All OMERO components written in Java use the SLF4J\(^{159}\) logging facade, typically backed by Logback\(^{160}\); all components written in python use the built-in logging module.

**Warning:** Refrain from calling `logging.basicConfig()` anywhere in your module except in if __name__ == "__main__" blocks.

18.8.1 Java clients

Java clients log to $HOME/omero/log. The number of files and their size are limited.

`logback-cli.xml`\(^{161}\) controls the output for the command line importer: all logging goes to standard err, while useful output (pixel ids, or used files) goes to standard out. It is contained within the blitz.jar itself. Therefore, to modify the settings use `-Dlogback.configurationFile=/path/to/logback.xml` or similar.

OMERO.insight logging is configured via `logback.xml` which is available in the config/ directory of any OMERO.insight install.

18.8.2 Java servers

Java server components are configured by passing `-Dlogback.configurationFile=etc/logback.xml` to each Java process. `Entry.java`\(^{162}\) guarantees that the `logback.xml`\(^{163}\) file is read periodically so that changes to your logging configuration do not require a restart.

By default, the output from logback is sent to: var/log/<servername>.log. Once files reach a size of 500MB, they are rolled over to <servername>.log.1, <servername>.log.2, etc. Once the files have rolled over, you can safely delete or compress (bzip2, gzip, zip) them. Alternatively, once you are comfortable with the stability of your server, you can either reduce logging or the number and size of the files kept. **Note:** if something goes wrong with your server installation, the log files can be very useful in tracking down issues.

\(^{159}\)http://www.slf4j.org/
\(^{160}\)http://logback.qos.ch/
\(^{161}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/logback-cli.xml
\(^{162}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/blitz/src/ome/services/blitz/Entry.java
\(^{163}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/logback.xml
In addition, each import process logs to a file under the managed repository which matches the timestamped fileset directory’s name. For example, if an imported fileset is uploaded to `/OMERO/ManagedRepository/userA_1/2013-06/17/12-00-00.000`, then the log file can be found under `/OMERO/ManagedRepository/userA_1/2013-06/17/12-00-00.000.log`.

### 18.8.3 Python servers

Python servers are configured by a call to `omero.util.configure_server_logging(props)`. The property values are taken from the configuration file passed to the server via `icegridnode`. For example, the config file for Processor-0 can be found in `var/master/servers/Processor-0/config/config`. These values come from the `templates.xml`.

All the “omero.logging.*” properties can be overwritten in your `default.xml` file (or on Windows, `etc/grid/windefault.xml`). See the “Profile” properties block for how to configure for your site.

Similar to logback, logging is configured to be written to `var/log/<servername>.log` and to maintain 9 backups of at most 500MB.

### 18.8.4 stdout and stderr

Though all components try to avoid it, some output will still go to stdout/stderr. On non-Windows systems, all of this output will be sent to the `var/log/master.out` and `var/log/master.err` files.

### 18.8.5 Windows stdout and stderr

On Windows, the state of stdout and stderr is somewhat different. No information will be written to master.out, master.err, or similar files. Instead, what logging is produced will go to the Windows Event Viewer, but finding error situations can be considerably more challenging (See #1449 for more information).

---

164 https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/grid/templates.xml
165 https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/grid/default.xml
166 https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/grid/windefault.xml
167 http://trac.openmicroscopy.org.uk/ome/ticket/1449
19.1 OME-Remote Objects

OMERO is based on the OME data model which can appear overly complex for new users. However, the core entities you need for getting started are much simpler.

Images in OMERO are organized into a many-to-many container hierarchy: “Project” -> “Dataset” -> “Image”. These containers (and various other objects) can be annotated to link various types of data. Annotation types include Comment (string), Tag (short string), Boolean, Long, Xml, File attachment etc.

Images are represented as Pixels with 5 dimensions: X, Y, Z, Channel, Time.

At the core of the work on the Open Microscopy Environment\(^1\) is the definition of a vocabulary for working with microscopic data. This vocabulary has a representation in the XML specification\(^2\), in the database (the data model), and in code. This last representation is the object model with which we will concern ourselves here.

Because of its complexity, the object model is generated from a central definition\(^3\) using our own code-generator\(^4\). It relies on no libraries and can be used in both the server and the RMI clients. OMERO.blitz uses a second mapping\(^5\) to generate OMERO Java language bindings, OMERO Python language bindings, and OMERO C++ language bindings classes, which can be mapped\(^6\) back and forth to the server object model. This document discusses only the server object-model and how it is used internally.

---

1. \[\text{http://www.openmicroscopy.org/site}\]
2. \[\text{http://www.openmicroscopy.org/site/support/ome-model/ome-xml/}\]
3. \[\text{https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/model}\]
4. \[\text{https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/dsl}\]
5. \[\text{https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/blitz/resources/templates}\]
6. \[\text{https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/blitz/src/omero/util/IceMapper.java}\]
Instances of the object model have no direct interaction with the database, rather the mapping is handled externally by the O/R framework, Hibernate\(^7\). That means, by and large, generated classes are data objects, composed only of getter and setter fields for fields representing columns in the database, and contain no business logic. However, to make working with the model easier, and perhaps more powerful, there are several features which we have built-in.

**Note:** The discussion here of object types is still relevant but uses the ome.model.* objects for examples. These are server internal types which may lead to some confusion. Clients work with omero.model.* objects. This documentation will eventually be updated to reflect both hierarchies.*\(^\*\)

### 19.1.1 OME type language

The OME-Remote Objects has two general parts: first, the long studied and well-established core model and second, the user-specified portion. It is vital that there is a central definition of both parts of the object model. To allow users to easily define new types, we need a simple domain specific language (or little language) which can be mapped to Hibernate mapping files. See an example at:

- components/model/resources/mappings/acquisition.ome.xml\(^8\)

From this DSL, various artifacts can be generated: XML Schema, Java classes, SQL for generating tables, etc. The ultimate goal is to have no exceptions in the model.

![Diagram](https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/model/resources/mappings/acquisition.ome.xml)

Conceptually, the XSD files under the components/specification source directory are the starting point for all code generation. Currently however, the files under components/model/resources/mappings\(^9\) are hand-written based on the XSD files.

The ant-task created from the components/dsl/src\(^10\) Java files is then used to turn the mapping files into generated Java code under the file: model/target/generated/src directory. These classes are all within the ome.model package. A few hand-written Java classes can also be found in components/model/src/ome/model/internal\(^11\).

The build-schema target takes the generate ome.model classes as input and generates the sql/psql\(^12\) scripts which get used on omero db script to generate a working OMERO database. Files named like “OMEROVERSION__PATCH.sql” are hand-written update scripts.

The primary consumer of the ome.model classes at runtime is the components/server\(^13\) component.

The above classes are considered the internal server code, and are the only objects which can take part in Hibernate transactions.

---

\(^7\)http://www.hibernate.org
\(^8\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/model/resources/mappings/acquisition.ome.xml
\(^9\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/model/resources/mappings
\(^10\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/dsl/src
\(^11\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/model/src/ome/model/internal
\(^12\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/sql/psql
\(^13\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/server
External to the server code is the “blitz” layer. These classes are in the omero.model package. They are generated by another call to the DSL ant task in order to generate the Java, Python, C++, and Ice files under file: components/blitz/generated.

The generated Ice files along with the hand-written Ice files from components/blitz/resources/omero\textsuperscript{14} are then run through the slice2cpp, slice2java, and slice2py command-line utilities in order to generate source code in each of these languages. Clients pass in instances of these omero.model (or in the case of C++, omero::model) objects. These are transformed to ome.model objects, and then persisted to the database.

If we take a concrete example, a C++ client might create an Image via new omero::model::ImageI(). The “I” suffix represents an “implementation” in the Ice naming scheme and this subclasses from omero::model::Image. This can be remotely passed to the server which will be deserialized as an omero.model.ImageI object. This will then get converted to an ome.model.core.Image, which can finally be persisted to the database.

**Keywords**

Some words are not allowed as properties/fields of OMERO types. These include:

- id
- version
- details
- … any SQL keyword

**Properties**

Mutable, annotated, global.

19.1.2 Improving generated data objects

**Constructors**

Two special constructors are generated for each model object. One is for creating proxy instances, and the other is for filling all NOT-NULL fields:

```java
Pixels p_proxy = new Pixels(Long, boolean);
Pixels p_filled = new Pixels(ome.model.core.Image, ome.model.enums.PixelsType,
    java.lang.Integer, java.lang.Integer, java.lang.Integer, java.lang.Integer,
    java.lang.String, ome.model.enums.DimensionOrder, ome.model.core.PixelsDimensions);
```

The first should almost always be used as: new Pixels(5L, false). Passing in an argument of true would imply that this object is actually loaded, and therefore the server would attempt to null all the fields on your object. See below for a discussion on loadedness.

In the special case of Enumerations, a constructor is generated which takes the value field for the enumeration:

```java
Format file_format = new Format("text/plain");
```

Further, this is the only example of a managed object which will be loaded by the server without its id. This allows applications to record only the string "text/plain" and not need to know the actual id value for "text/plain".

**Details**

Each table in the database has several columns handling low-level matters such as security, ownership, and provenance. To hide some of these details in the object model, each IOBJECT instance contains an ome.model.internal.Details instance.

Details works something like unix’s stat:

\footnote{https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/blitz/resources/omero}
though it can also store arbitrary other attributes (meta-metadata, so to speak) about our model instances. See *Dynamic methods* below for more information.

The main methods on Details are:

```java
Permissions Details.getPermissions();
List Details.getUpdates();
Event Details.getCreationEvent();
EventDetails.getUpdatEvent();
Experimenter Details.getOwner();
ExperimenterGroup Details.getGroup();
ExternalInfo getExternalInfo();
```

though some of the methods will return `null`, if that column is not available for the given object. See *Interfaces* below for more information.

Consumers of the API are encouraged to pass around Details instances rather than specifying particulars, like:

```java
if (securitySystem.allowLoad(Project.class, project.getDetails())) {} // and not
if (project.getDetails().getPermissions().isGranted(USER,READ) && project.getDetails().getOwner().getId(myId)) {…}
```

This should hopefully save a good deal of re-coding if we move to true ACL rather than the current filesystem-like access control. Because it is a field on every type, Details is also on the list of keywords in the type language (above).

### Interfaces

To help work with the generated objects, several interfaces are added to their “implements” clause:

<table>
<thead>
<tr>
<th>Property</th>
<th>Applies_to</th>
<th>Interface</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>owner</td>
<td>! global</td>
<td>! global</td>
<td>need sudo</td>
</tr>
<tr>
<td>group</td>
<td>! global</td>
<td>! immutable</td>
<td>need sudo</td>
</tr>
<tr>
<td>version</td>
<td>! immutable</td>
<td>! global</td>
<td></td>
</tr>
<tr>
<td>creationEvent</td>
<td>! global</td>
<td>! global &amp;! immutable</td>
<td></td>
</tr>
<tr>
<td>updateEvent</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>permissions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>externalInfo</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>name</td>
<td></td>
<td>Named</td>
<td></td>
</tr>
<tr>
<td>description</td>
<td></td>
<td>Described</td>
<td></td>
</tr>
<tr>
<td>linkedAnnotationList</td>
<td></td>
<td>IAnnotated</td>
<td></td>
</tr>
</tbody>
</table>
For example, `ome.model.meta.Experimenter` is a “global” type, therefore it has no `Details.owner` field. In order to create this type of object, you will either need to have admin privileges, or in some cases, use the `ome.api.IAdmin` interface directly (in the case of enums, you will need to use the `ome.api.ITypes` interface).

**Inheritance**

Inheritance is supported in the object model. The superclass relationships can be defined simply in the mapping files. One example is the annotation hierarchy in `components/model/resources/mappings/annotations.ome.xml`. Hibernate supports this polymorphism, and will search all subclasses when a super class is returned. However, due to Hibernate’s use of bytecode-generated proxies, testing for class equality is not always straightforward.

Hibernate uses CGLIB and Javassist and similar bytecode generation to perform much of its magic. For these bytecode generated objects, the `getClass()` method returns something of the form “`ome.model.core.Image_$$_javassist`” which cannot be passed back into Hibernate. Instead, we must first parse that class String with `Utils#trueClass()`.

**Model report objects**

To support the Collection Counts requirement in which users would like to know how many objects are in a collection by owner, it was necessary to add read-only `Map<String, Long>` fields to all objects with links. See the Collection counts page for more information.

**Dynamic methods**

Finally, because not all programming fits into the static programming frame, the object model provides several methods for working dynamically with all IObject subclasses.

**fieldSet / putAt / retrieve**

Each model class contains a public final static String for each field in that class (superclass fields are omitted.) A copy of all these fields is available through `fieldSet()`. This field identifier can be used in combination with the `putAt` and `retrieve` methods to store arbitrary data a class instance. Calls to `putAt/retrieve` with a string found in `fieldSet` delegate to the traditional getters/setters. Otherwise, the value is stored in lazily-initialized Map (if no data is stored, the map is null).

**acceptFilter**

An automation of calls to `putAt / retrieve` can be achieved by implementing an `ome.util.Filter`. A Filter is a VisitorPattern-like interface which not only visits every field of an object, but also has the chance to replace the field value with an arbitrary other value. Much of the internal functionality in OMERO is achieved through filters.

**Limitations**

- The filter methods override all standard checks such as `IObject#isLoaded` and so null-pointer exceptions etc. may be thrown.
- The types stored in the dynamic map currently do not propagate to the `OMERO.blitz` model objects, since not all `java.lang.Object` can be converted.

**19.1.3 Entity lifecycle**

These additions make certain operations on the model objects easier and cleaner, but they do not save the developer from understanding how each object interacts with Hibernate. Each object has a defined lifecycle and it is important to know both the origin (client, server, or backend) as well as its current state to understand what will and can happen with it.

---

States

Each instance can be found in one of several states. Quickly, they are:

**transient** The entity has been created ("new Image()") and not yet shown to the backend.

**persistent** The entity has been stored in the database and has a non-null ID (IObject.getId()). Here Hibernate differentiates between detached, managed, and deleted entities. Detached entities do not take part in lazy-loading or dirty detection like managed entities do. They can, however, be re-attached (made “managed”). Deleted entities cannot take part in most of the ORM activities, and exceptions will be thrown if they are encountered.

**unloaded (a reference, or proxy)** To solve the common problem of lazy loading exceptions found in many Hibernate applications, we have introduced the concept of unloaded proxy objects which are objects with all fields nulled other than the id. Attempts to get or set any other property will result in an exception. The backend detects these proxies and restores their value before operating on the graph. There are two related states for collections — null which is completely unloaded and filtered in which certain items have been removed (more on this below).
Identity, references, and versions

Critical for understanding these states is understanding the concepts of identity and versioning as it relates to ORM. Every object has an id field that if created by the backend will not be null. However, every table does not have a primary key field – subclasses contain a foreign key link to their superclass. Therefore all objects without an id are assumed to be non-persistent (i.e. transient).

Though the id cannot be the sole decider of equality since there are issues with the Java definition of equals() and hashCode(), we often perform lookups based on the class and id of an instance. Here again caution must be taken not to unintentionally use a possibly bytecode-generated subclass. See the discussion under Inheritance above.

Class/id-based lookup is in fact so useful that it is possible to take a model object and call obj.unload() to have a “reference” – essentially a placeholder for a model object that contains only an id. Calls to any accessor other than get/setId will throw an exception. An object can be tested for loadedness with obj.isLoaded().

A client can use unloaded instances to inform the backend that a certain information is not available and should be filled in server-side. For example, a user can do the following:

```java
Project p = new Project();
Dataset d = new Dataset( new Long(1), false); // this means create an already unloaded instance
p.linkDataset(d);
iUpdate.saveObject(p);
```

The server, in turn, also uses references to replace backend proxies that would otherwise through LazyInitializationExceptions on serialization. Clients, therefore, must code with the expectation that the leaves in an object graph may be unloaded. Extending a query with “outer join fetch” will cause these objects to be loaded as well. For example:

```sql
select p from Project p left outer join fetch p.datasetLinks as links left outer join fetch links.child as dataset
```

but eventually in the complex OME metadata graph, it is certain that something will remain unloaded.

Versions are the last piece to understanding object identity. Two entities with the same id should not be considered equal if they have differing versions. On each write operation, the version of an entity is incremented. This allows us to perform optimistic locking so that two users do not simultaneously edit the same object. That works so:

1. User A and User B retrieve Object X id=1, version=0.
2. User A edits Object X and saves it. Version is incremented to 1.
3. User B edits Object X and tries to save it. The SQL generated is: UPDATE table SET value = newvalue WHERE id = 1 and version = 0; which updates no rows.
4. The fact that no rows were altered is seen by the backend and an OptimisticLockException is thrown.

Identity and versioning make working with the object model difficult sometimes, but guarantee that our data is never corrupted.

Note: There is one exception to this discussed below under Links. See that section or #1649 for more information.

19.1.4 Working with the object model

With these states in mind, it is possible to start looking at how to actually use model objects. From the point of view of the server, everything is either an assertion of an object graph (a “write”) or a request for an object graph (a “read”), whether they are coming from an RMI client, an OMERO.blitz client, or even being generated internally.

Writing

Creating new objects is as simple as instantiating objects and linking them together. If all NOT-NULL fields are not filled, then a ValidationException will be thrown by the server:

http://trac.openmicroscopy.org.uk/ome/ticket/1649
IUpdate update = new ServiceFactory().getUpdateService();
Image i = new Image();
try {
    update.saveObject(i);
    catch (ValidationException ve) {
        // not ok.
    }
i.setName("image");
return update.saveAndReturnObject(i); // ok.

Otherwise, the returned value will be the Image with its id field filled. This works on arbitrarily complex graphs of objects:

Image i = new Image("image-name"); // This constructor exists because "name" is the only required field.
Dataset d = new Dataset("dataset-name");
TagAnnotation tag = new TagAnnotation();
tag.setTextValue("some-tag");
i.linkDataset(d);
i.linkAnnotation(tag);
update.saveAndReturnObject(i);

Reading

Reading is a similarly straightforward operation. From a simple id based lookup, iQuery.get(Experimenter.class, 1L) to a search for an arbitrarily complex graph:

Image i = iQuery.findByQuery("select i from Image i +
    "join fetch i.datasetLinks as dlinks +
    "join fetch i.annotationLinks as alinks +
    "join fetch i.details.owner as owner +
    "join fetch owner.details.creationEvent +
    "where i.id = :id", new Parameters().addId(1L));

In the return graph, you are guaranteed that any two instances of the same class with the same id are the same object. For example:

Image i = ...; // From query
Dataset d = i.linkedDatasetList().get(0);
Image i2 = d.linkedImageList().get(0);
if (i.getId().equals(i2.getId())) {
    assert i == i2 : "Instances must be referentially equal"
}

Reading and writing

Complications arise when you try to mix objects from different read operations because of the difference in equality. In all but the most straightforward applications, references to IObject instances from different return graphs will start to intermingle. For example, when a user logs in, you might query for all Projects belonging to the user:

List<Project> projects = iQuery.findAllByQuery("select p from Project p where p.details.owner.omeName =
Project p = projects.get(0);
Long id = p.getId();

Later you might query for Datasets, and be returned some of the same Projects again within the same graph. You have now possibly got two versions of the Project with a given id within your application. And if one of those Projects has a new Dataset reference, then Hibernate would not know whether the object should be removed or not.
Project oldProject = ...; // Acquired from first query
// Do some other work
Dataset dataset = iQuery.findByQuery("select d from Dataset d +
    "join fetch d.projectsLinks links "+
    "join fetch links.parent "+
    "where d.id = :id", new Parameters().addId(5L));
Project newProject = dataset.linkedProjectList().get(0);
assert newProject.getId().equals(oldProject.getId()) : "same object"
assert newProject.sizeOfDatasetLinks() == oldProject.sizeOfDatasetLinks() :
    "if this is false, then saving oldProject is a problem";

Without optimistic locks, return oldProject, trying to save oldProject would cause whatever Datasets were missing from it to be removed from newProject as well. Instead, an OptimisticLockException is thrown if a user tries to change an older reference to an entity. Similar problems also arise in multi-user settings, when two users try to access the same object, but it is not purely due to multiple users or even multiple threads, but simply due to stale state.

Note: There is an issue with multiple users in which a SecurityViolation is thrown instead of an OptimisticLockException. See #164918 for more information.

Various techniques to help to manage these duplications are:

- Copy all data to your own model.
- Return unloaded objects wherever possible.
- Be very careful about the operations you commit and about the order they take place in.
- Use a ClientSession.

Lazy loading

An issue related to identity is lazy loading. When an object graph is requested, Hibernate only loads the objects which are directly requested. All others are replaced with proxy objects. Within the Hibernate session, these objects are “active” and if accessed, they will be automatically loaded. This is taken care of by the first-level cache, and is also the reason that referential equality is guaranteed within the Hibernate session. Outside of the session however, the proxies can no longer be loaded and so they cannot be serialized to the client.

Instead, as the return value passes through OMERO’s AOP layer, they get disconnected. Single-valued fields are replaced by an unloaded version:

```java
OriginalFile ofile = ...; // Object to test
if ( ! Hibernate.isInitialized( ofile.getFormat() ) ) {
    ofile.setFormat( new Format( ofile.getFormat().getId(), false) );
}
```

Multi-valued fields, or collections, are simply nulled. In this case, the sizeOfXXX method will return a value less than zero:

```java
Dataset d = ...; // Dataset obtained from a query. Didn’t request Projects
assert d.sizeOfProjects() < 0 : “Projects should not be loaded”;
```

This is why it is necessary to specify all “join fetch” clauses for instances which are required on the client-side. See ProxyCleanupFilter19 for the implementation.

Collections

More than just the nulling during serialization, collections pose several interesting problems.

For example, a collection may be filtered on retrieval:

```java
Dataset d = iQuery.findByQuery("select d from Dataset d "+" 
+"join fetch d.projectLinks links "+" 
+"where links.parent.id > 2000", null);
```

Some `ProjectDatasetLink` instances have been filtered from the `projectLinks` collection. If the client decides to save this collection back, there is no way to know that it is incomplete, and Hibernate will remove the missing Projects from the Dataset. It is the developer’s responsibility to know what state a collection is in. In the case of links, discussed below, one solution is to use the link objects directly, even if they are largely hidden with the API, but the problem remains for 1-N collections.

**Links**

A special form of links model the many-to-many relationship between two other objects. A Project can contain any number of Datasets, and a Dataset can be in any number of Projects. This is achieved by `ProjectDatasetLinks`, which have a Project “parent” and a Dataset “child” (the parent/child terms are somewhat arbitrary but are intended to fit roughly with the users’ expectations for those types).

It is possible to both add and remove a link directly:

```java
ProjectDatasetLink link = new ProjectDatasetLink();
link.setParent( someProject );
link.setChild( someDataset );
link = update.saveAndReturnObject( link );
```

// someDataset is now included in someProject

```java
update.deleteObject(link);
// or update.deleteObject(new ProjectDatasetLink(link.getId(), false)); // a proxy
```

// Now they the Dataset is not included,
// __unless__ there was already another link.

However, it is also possible to have the links managed for you:

```java
someProject.linkDataset( someDataset ); // This creates the link
update.saveObject( someProject ); // Notices added link, and saves it

someProject.unlinkDataset( someDataset );
update.saveObject( someProject ); // Notices removal, and deletes it
```

The difficulty with this approach is that `unlinkDataset()` will fail if the `someDataset` which you are trying to remove is not referentially equal. That is:

```java
someProject.linkDataset( someDataset );
someProject.unlinkDataset( someDataset );
update.saveObject( someProject ); // Notices removal, and deletes it
```

```java
updatedProject.unlinkDataset( someDataset );
update.saveObject( updatedProject ); // will no __nothing__ !
```

does not work since `someDataset` is not included in `updatedProject`, but rather `updatedDataset` with the same id is. Therefore, it would be necessary to do something along the following lines of:

```java
updatedProject = ...; // As before
for (Dataset updatedDataset : updatedProject.linkedDatasetList() ) {
    if (updatedDataset.getId().equals( someDataset.getId() )) {
        updatedProject.unlinkDataset( updatedDataset );
    }
```
The unlink method in this case, removes the link from both the Project.datasetLinks collection as well as from the Dataset.projectLinks collection. Hibernate notices that both collections are in agreement, and deletes the ProjectDatasetLink (this is achieved via the “delete-orphan” annotation in Hibernate). If only one side of the collection has had its link removed, an exception will be thrown.

**Synchronization**

Another important point is that the model objects are in no way synchronized. All synchronization must occur within application code.

### 19.1.5 Future topics

- **Validation**: Since the accessor methods themselves are largely logic-less, the work of validating the objects has been offset to validation objects and the Hibernate system. For each given object, a validation method can be specified which will check instance fields (TODO: the null-policy should be configurable based on whether or not the object is currently in a session). Validation is intended to verify the specification constraints which cannot (easily and/or quickly) be verified by the database.
  - **Versioning/Locking**
  - **ObjectFactory** for wrapping model objects from *OMERO.blitz*
  - **Links to external models**
  - **Client cache**
  - **Document collection methods**
  - **Add info on the ILink interface to the section above.**

- In addition to the extended functionality of the new object model, there are some changes to the actual structure, the specification, that are needed.
  - `image_id ==> pixel_id` where appropriate
  - `plane_info`
  - `ACL` (getting ownership in each table not MEX)
  - one table; one class
  - cleaning up container relationships (project, category, screen, etc.)
  - replace ST definition (“ST is immutable”) with locking mechanism
  - possibly versioning
19.2 Available transformations

<table>
<thead>
<tr>
<th>Available transforms</th>
<th>Direction</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003-FC-to-2007-06.xsl</td>
<td>upgrade</td>
<td>excellent</td>
</tr>
<tr>
<td>2003-FC-to-2008-09.xsl</td>
<td>upgrade</td>
<td>excellent</td>
</tr>
<tr>
<td>2007-06-to-2008-02.xsl</td>
<td>upgrade</td>
<td>excellent</td>
</tr>
<tr>
<td>2007-06-to-2008-09.xsl</td>
<td>upgrade</td>
<td>excellent</td>
</tr>
<tr>
<td>2008-02-to-2008-09.xsl</td>
<td>upgrade</td>
<td>excellent</td>
</tr>
<tr>
<td>2008-09-to-2009-09.xsl</td>
<td>upgrade</td>
<td>excellent</td>
</tr>
<tr>
<td>2009-09-to-2010-04.xsl</td>
<td>upgrade</td>
<td>excellent</td>
</tr>
<tr>
<td>2010-04-to-2010-06.xsl</td>
<td>upgrade</td>
<td>excellent</td>
</tr>
<tr>
<td>2010-06-to-2011-06.xsl</td>
<td>upgrade</td>
<td>excellent</td>
</tr>
<tr>
<td>2011-06-to-2012-06.xsl</td>
<td>upgrade</td>
<td>excellent</td>
</tr>
<tr>
<td>2012-06-to-2013-06.xsl</td>
<td>upgrade</td>
<td>excellent</td>
</tr>
<tr>
<td>2010-06-to-2003-FC.xsl</td>
<td>downgrade</td>
<td>poor (very lossy)</td>
</tr>
<tr>
<td>2010-06-to-2008-02.xsl</td>
<td>downgrade</td>
<td>fair (lossy)</td>
</tr>
<tr>
<td>2011-06-to-2010-06.xsl</td>
<td>downgrade</td>
<td>good</td>
</tr>
<tr>
<td>2012-06-to-2011-06.xsl</td>
<td>downgrade</td>
<td>good</td>
</tr>
<tr>
<td>2013-06-to-2012-06.xsl</td>
<td>downgrade</td>
<td>good</td>
</tr>
</tbody>
</table>

19.2.1 Quality of transformations

<table>
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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>/2003-FC/</td>
<td></td>
<td>excellent</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>/2007-06/</td>
<td>poor</td>
<td>—</td>
<td>excellent</td>
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<tr>
<td>/2008-02/</td>
<td>poor</td>
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<tr>
<td>/2008-09/</td>
<td>poor</td>
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<tr>
<td>/2009-09/</td>
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<tr>
<td>/2010-04/</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
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<td>fair</td>
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<td>—</td>
<td></td>
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<tr>
<td>/2010-06/</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
<td>—</td>
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</tr>
<tr>
<td>/2011-06/</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
<td>good</td>
<td>—</td>
<td>—</td>
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<tr>
<td>/2012-06/</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
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<td>fair</td>
<td>fair</td>
<td>fair</td>
<td>good</td>
<td>good</td>
<td>—</td>
</tr>
<tr>
<td>/2013-06/</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
<td>fair</td>
<td>good</td>
<td>good</td>
<td>good</td>
</tr>
</tbody>
</table>

19.2.2 Key to quality

- **poor** (very lossy) - the bare minimum of metadata is preserved to allow image display, all other metadata is lost
- **fair** (lossy) - a portion of the metadata is preserved, at least enough to display the image and some other data, it will be far from complete however
- **good** - most information is preserved, it may be possible to do a better job but could be difficult for technical reasons or require custom code not just a transform
- **excellent** - as much information as possible is preserved, some values can still be lost if there are completely incompatible with the new schema

19.2.3 Matrix of transformation paths

This shows the sequence of transformations used to convert one version of the schema to another version.

19.3 Structured annotations

Structured annotations permit the attachment of data and metadata outside the OMERO data model to certain types within the model. The annotations are designed for individualized use by both sites and tools. Annotations can be attached to multiple instances simultaneously to quickly annotated all entities in a view. Each annotation has a “name” which can be interpreted as a “namespace” by tools, which can filter out all unknown namespaces. Further, to prevent users from overwriting or editing important information, annotations are immutable, but editing can be simulated via copy and delete.
### 19.3.1 Annotated and annotating types

Each type which can be annotated implements `ome.model.IAnnotated`. Currently, these are:

- **Project**
- **Dataset**
- **Image**
- **Pixels**
- **OriginalFile**
- **PlaneInfo**
- **Roi**
- **Channel**
- **Annotation** and all annotation subtypes in order to form hierarchies
- **ScreenPlateWell**: Screen, ScreenAcquisition, Plate, Well, WellSample, Reagent
- **...**

#### Annotation hierarchy

Though they largely are all String or numeric values, a hierarchy of annotations makes differentiating between just what interpretation should be given to the annotation. This may eventually include validation of the input string and/or file.
Annotation (A*) ........................ A name field and a description
ListAnnotation ........................ Uses AnnotationAnnotation links to form a list of annotations
BasicAnnotation (A*) .................... Literal or "primitive" values
BooleanAnnotation ..................... A simple true/false flag
TimeStampAnnotation .................. A date/time
TermAnnotation ........................ A term used in an ontology
NumericAnnotation (A*) ................ Floating point and integer values
DoubleAnnotation
LongAnnotation
TextAnnotation (A*) .................... A single text field
CommentAnnotation .................... A user comment
TagAnnotation ........................ Interpreted as a Web 2.0 "tag" on an object, tags on tags form tag bundles
XmlAnnotation ........................ An xml snippet attached to some object
MapAnnotation ........................ A set of key-value pairs
TypeAnnotation (A*) .................... Links some entity to another (possibly to be replaced by <any/>)
FileAnnotation ........................ Uses the Format field on OriginalFile to specify type

A* = abstract

See also:

Schema documentation for Structured Annotations\textsuperscript{20}  Section of the auto-generated schema documentation describing the structured annotations

19.3.2 Names and namespaces

Since arbitrary blobs or clobes can be attached to an entity, it is necessary for clients to have some way to differentiate what it can parse. In many cases, the name might be a simple reminder for a user to find the file s/he has annotated. Applications, however, will most likely want to define a namespace, like \texttt{http://name-of-application-provider.com/name-of-application/file-type/version}. Queries can then be produced which search for the proper namespace or match on a part of the name space:

\begin{verbatim}
  iQuery.findAllByQuery("select annotation from FileAnnotation where "+
  "name like 'http://name-of-application-provider.com/name-of-application/\%\'");
\end{verbatim}

Tags will most likely begin without a namespace. As a tag gets escalated to a common vocabulary, it might make sense to add a possibly site-specific namespace with more well-defined semantics.

19.3.3 Descriptions

Unlike the previous, ImageAnnotation and DatasetAnnotation types, the new structured annotations do not have a description field. The single description field was limited for multi-user scenarios, and can be fully replaced by TextAnnotations attached to another annotation.

\begin{verbatim}
  FileAnnotation fileAnnotation = ...;
  TextAnnotation description = ...;
  fileAnnotation.linkAnnotation(description);
\end{verbatim}

19.3.4 Immutability

The actual content value of an annotation – the text, long, double, file value, etc – is immutable. Links to and from the annotation, however, can be modified.

Currently the namespace field of annotations is mutable. See \#878\textsuperscript{21} for discussion.

\textsuperscript{21}http://trac.openmicroscopy.org.uk/ome/ticket/878
19.3.5 Examples

Basics

```java
import ome.model.IAnnotated;
import ome.model.annotations.FileAnnotation;
import ome.model.annotations.TagAnnotation;
import ome.model.core.OriginalFile;
import ome.model.display.Roi;

List<Annotation> list = iAnnotated.linkedAnnotationList();
// do something with list
```

Attaching a tag

```java
TagAnnotation tag = new TagAnnotation();
tag.setTextValue("interesting");

Roi roi = …; // Some region of interest
ILink link = roi.linkAnnotation(tag);

iUpdate.saveObject(link);
```

Attaching a file

```java
// or attach something new
OriginalFile myOriginalFile = new OriginalFile();
myOriginalFile.setName("output.pdf");
// upload PDF

FileAnnotation annotation = new FileAnnotation();
annotation.setName("http://example.com/myClient/analysisOutput");
annotation.setFile(myOriginalFile);

ILink link = iAnnotated.linkAnnotation(annotation)
link = iUpdate.saveAndReturnObject(link);
```

All write changes are intended to occur through the IUpdate interface, whereas searching should be significantly easier through ome.api.Search than IQuery.

See also:

*Extending OMERO*
20.1 OMERO search

Beginning with 3.0-Beta3, the OMERO server will use Lucene\(^1\) to index all string and timestamp information in the database, as well as all OriginalFiles which can be parsed to simple text (see File parsers for more information). The index is stored under /OMERO/FullText (or the FullText subdirectory of your \(\${\text{omero.data.dir}}\)), and can be searched with Google-like queries.

20.1.1 Field names

Each row in the database becomes a single Lucene Document parsed into the several Fields. A field is referenced by prefixing a search term with the field name followed by a colon. For example, name:myImage searches for myImage anywhere in the name field.

\(^1\)http://lucene.apache.org
Field | Comments
--- | ---
*<field name>* | Any unprefixed field searches the combination of all fields together i.e. a search for *cell AND name:myImage* gets translated to *combined_fields:cell AND name:myImage*. Each string, timestamp, or Details field of the entity also gets its own Field entry, like the name field above.
details.owner.omeName | Login name of the owner of the object
details.owner.firstName | First name of the owner of the object
details.owner.lastName | Last name of the owner of the object
details.group.name | Group name of the owning group of the object
details.creationEvent.id | Id of the Event of this objects creation
details.creationEvent.time | When that Event took place
details.updateEvent.id | Id of the Event of this objects last modification
details.updateEvent.time | When that Event took place
details.permissions | Permissions in the form rw-rw-rw-.
tag | Contents from a TagAnnotation.
annotation | Contents from any annotations, including TagAnnotation and any TextAnnotation on another TextAnnotation (a.k.a. a description)
annotation.ns | Namespace (if present) for any annotations on an object
annotation.type | Short type name, e.g. TextAnnotation or FileAnnotation for any annotations on an object
file.name | For FileAnnotations and objects they are attached to, the name of the OriginalFile
file.format | For FileAnnotations and objects they are attached to, the format of the OriginalFile
file.path | For FileAnnotations and objects they are attached to, the path of the OriginalFile
file.sha1 | For FileAnnotations and objects they are attached to, the sha1 of the OriginalFile
file.contents | For FileAnnotations and objects they are attached to as well as the OriginalFile itself, the file contents themselves if their Format is configured with the File parsers.
Internal, combined_fields | The default field prefix.
_hibernate_class | Used by Hibernate Search to record the entity type. The class value, e.g. ome.model.core.Image is also entered in combined_fields. Unimportant for the casual users.
id | The primary key of the entity. Unimportant for the casual user

### 20.1.2 Queries

Search queries are very similar to Google searches. When search terms are entered without a prefix (“name:”), then the default field will be used which combines all available fields. Otherwise, a prefix can be added to restrict the search.

### 20.1.3 Indexing

Successful searching depends on understanding how the text is indexed. The default analyzer used is the FullTextAnalyzer².

1. Desktop/image_GFP-H2B_1.dv ---> "desktop", "image", "gfp", "h2b", "1", "dv"
3. Desktop/image_GFP_01-H2B.dv ---> "desktop", "image", "gfp", "01", "h2b", "dv"

Assuming these entries above for Image.name:

- searching for **GFP-H2B** returns 1 and 2.
- searching for **“GFP H2B”** also returns 1 and 2.

²https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/services/fulltext/FullTextAnalyzer.java
• searching for **GFP H2B** returns 1, 2, and 3, since the two terms are joined by an **OR**.

### 20.1.4 Information for developers and system administrators

#### Scheduling indexing

Indexing is not driven by the user, but happens automatically in the background. Automatic indexing occurs at the frequency defined in `etc/omero.properties`:

```plaintext
omero.search.cron=0,30 * * * * ?
omero.search.batch=100
```

which implies every thirty seconds of every hour, day, month, year, etc. During each iteration, 100 EventLogs will be loaded from the database and processed. Upon successful completion, the persistent count in the configuration table, will be incremented.

```sql
omero3=# select value from configuration where name = 'PersistentEventLogLoader.current_id';
  value
---------
  30983
(1 row)
```

If you have more than one `PersistentEventLogLoader.*` value in your database, then you have run indexing with multiple versions of the server. This is fine. To allow a new server version to force an update, the configuration key may be changed. For example,

```
PersistentEventLogLoader.current_id
```

became

```
PersistentEventLogLoader.v2.current_id
```

in r2460.

Once an entity is indexed, it is possible to start writing querying against the server via `IQuery.findAllByFullText()`.

Use `new Parameters(new Filter().owner())` and `.group()` to restrict your search. Or alternatively use the `oma.api.Search` interface (below).

#### Re-indexing

There are a few reasons that you may need to re-index your database, e.g. if the index has become corrupt or you would like to have large files, that were previously skipped, added to the index (see `omero.search.max_file_size`). Under most circumstances, you should be able to re-index the database while the server is still running.

If you need to make any adjustments to the server configuration or the process heap size, first shut the server down and make these changes before restarting the server. Then, with the server running, using the following steps to initiate a re-indexing

- Disable the search indexer process and stop any currently running indexer processes:

  ```
  > bin/omero admin ice server disable Indexer-0
  > bin/omero admin ice server stop Indexer-0
  ```

- Remove the existing search Indexes by deleting the contents of the `FullText` subdirectory of your `${omero.data.dir}`

- Reset the indexer’s progress counter in the database
substituting in your local omero database's user and name

- Re-enable/restart the indexer process (the Ice grid will handle automatically restarting the process as soon as it is re-enabled)

```
> bin/omero admin ice server enable Indexer-0
```

Depending on the size of your database, it may take the indexer some time to finish re-indexing. During this time, your OMERO server will remain available for use, however the search functionality will be degraded until the re-indexing is finished.

It is also possible to re-index the database with the server off-line. First, shutdown the OMERO server as normal and make any adjustments to the configuration that need to be made. Clear the contents of the FullText directory, then run

```
> bin/omero admin reindex --full
```

Re-indexing the database in off-line mode will use a 1 GB heap by default (as opposed to the default 256MB heap for the indexer process in the running server). You can further adjust the size of the heap by passing an alternate value in the JAVA_OPTS variable on the command line

```
> JAVA_OPTS="-Xmx2056MB" bin/omero admin reindex --full
```

You may also want to increase the omero.search.batch size to take advantage of the larger heap. The combination of a larger heap and batch size should enable the re-index to complete sooner in off-line mode than it might in the context of a running server.

Alternatively, you can re-index a specific class of objects in off-line mode, followed by a later re-index with the server running. Start by shutting down the server and clearing the contents of the FullText directory. Then reindex a specific class of object with

```
> bin/omero admin reindex --class ome.model.core.Image
```

Multiple classes can be re-indexed together by appending extra --class ... arguments on the command-line. Once this limited re-indexing is completed, you can restart the server and search capabilities will be available in a limited fashion. If you would then like to re-index the remaining objects in the system, follow the steps for the on-line reindexing above, skipping the step that involves clearing the FullText directory.

```
ome.api.IQuery
```

The current IQuery implementation restricts searches to a single class at a time.

- findAllByFullText(Image.class, "metaphase") – Images which contain or are annotated with “metaphase”
- findAllByFullText(Image.class, "annotation:metaphase") – Images which are annotated with “metaphase”
- findAllByFullText(Image.class, "tag:metaphase") – Images which are tagged with “metaphase” (specialization of the previous)
- findAllByFullText(Image.class, "file.contents:metaphase") – Images which have files attached containing “metaphase”
- findAllByFullText(OriginalFile.class, "file.contents:metaphase") – File containing “metaphase”

```
ome.api.Search
```

The Search API offers a number of different queries along with various filters and settings which are all maintained on the server.

20.1. OMERO search

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The matrix below shows which combinations of parameters and queries are supported (S), will throw an exception (X), and which will simply silently be ignored (I).

<table>
<thead>
<tr>
<th>Query Method, Parameters</th>
<th>byFullText/SomeMustNone</th>
<th>byGroupForTags/byTagsForGroup</th>
<th>byAnnotatedWith</th>
</tr>
</thead>
<tbody>
<tr>
<td>annotated between</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>annotated by</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>annotated with</td>
<td>S</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>created between</td>
<td>S</td>
<td>S</td>
<td>S</td>
</tr>
<tr>
<td>modified between</td>
<td>S</td>
<td>I (Immutable)</td>
<td>S</td>
</tr>
<tr>
<td>owned by</td>
<td>X</td>
<td>I</td>
<td>X</td>
</tr>
<tr>
<td>all types</td>
<td>X</td>
<td>I</td>
<td>X</td>
</tr>
<tr>
<td>1 type</td>
<td>S</td>
<td>I</td>
<td>S</td>
</tr>
<tr>
<td>N types</td>
<td>X</td>
<td>I</td>
<td>X</td>
</tr>
<tr>
<td>only ids</td>
<td>S</td>
<td>I</td>
<td>S</td>
</tr>
<tr>
<td>Ordering / Fetches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>orderBy</td>
<td>S</td>
<td>I</td>
<td>S</td>
</tr>
<tr>
<td>fetchAnnotations</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>setProjections</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>currentMetdata</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>setProjections</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Leading wildcard searches

Leading wildcard searches are disallowed by default. "?omething" or "*hatever", for example, would both throw exceptions. They can be run by using:

```java
Search search = serviceFactory.createSearchService();
search.setAllowLeadingWildcards(true);
```

There is a performance penalty, however. In addition, wildcard searches get expanded on the server to boolean queries. For example, assuming "ACELL", "BCELL", and "CCELL" are all terms in your index, then the query:

```
*CELL
```

gets expanded to:

```
ACELL OR BCELL OR CCELL
```

If there are more than "omero.search.maxclause" terms in the expansion (default is 4096), then an exception will be thrown. This requires the user to enter a more refined search, but not because there are too many results, only because there is not enough room in memory to search on all terms at once.

Extension points

Two extension points are currently available for searching. The first are the File parsers mentioned above. By configuring the map of Formats (roughly mime-types) of files to parser instances, extracting information from attached binary files can be made quick and straightforward.

---

3. Any fetchAnnotation() argument to byFullText() or related queries, returns all annotations.
4. byAnnotatedWith() does not accept a fetchAnnotation() argument of Annotation.class.
5. setProjections may need to be removed if Lucene cannot handle OMERO's security requirements.
6. Not yet implemented.
7. Any fetchAnnotation() argument to byFullText() or related queries, returns all annotations.
8. byAnnotatedWith() does not accept a fetchAnnotation() argument of Annotation.class.
9. setProjections may need to be removed if Lucene cannot handle OMERO's security requirements.
10. Not yet implemented.
Similarly, Search bridges provide a mechanism for parsing all metadata entering the system. One built-in bridge (the Full-TextBridge\textsuperscript{11}) parses out the fields mentioned above, but by creating your own bridge it is possible to extract more information specific to your site.

See also:

Structured annotations, Search bridges, File parsers, Query Parser Syntax\textsuperscript{12},

**Luke**\textsuperscript{13} a Java application which you can download and point at your /OMERO/FullText directory to get a better feeling for Lucene queries.

## 20.2 File parsers

File parsers extract text from various file types and provide it as a Reader to the FullTextBridge for use during search indexing. Plain text formats can use the default fileParser bean, but any specialized format, such as PDF or RTF requires special libraries and special registration.

### 20.2.1 Configuration

Currently, configuration takes places solely in service-ome.api.Search.xml\textsuperscript{14}. Eventually, it should be able to replace file parsers at configuration or even runtime.

### 20.2.2 Available parsers

<table>
<thead>
<tr>
<th>File type</th>
<th>Parser</th>
</tr>
</thead>
<tbody>
<tr>
<td>application/pdf</td>
<td><a href="http://pdfbox.apache.org">http://pdfbox.apache.org</a> (internal)</td>
</tr>
<tr>
<td>text/xml</td>
<td>(internal)</td>
</tr>
<tr>
<td>text/plain</td>
<td>(internal)</td>
</tr>
<tr>
<td>text/csv</td>
<td>(internal)</td>
</tr>
</tbody>
</table>

The base class for File parsers are FileParser.java\textsuperscript{15}

See also:

OMERO search

## 20.3 Search bridges

A “bridge” is the mapping between your metadata and how it is stored in the Lucene\textsuperscript{16} index. **OMERO search** uses one internal bridge to parse all of your metadata for later searching. If, however, there is more metadata that you would like to add to the index, you can implement the org.hibernate.search.bridge.FieldBridge interface yourself, or subclass the helper class components/server/src/ome/services/fulltext/BridgeHelper.java\textsuperscript{17}

### 20.3.1 Example

Assume you wanted to be able to search for a project based on the name of all images contained in that project. In the set method,

```java
public void set(final String name, final Object value,
                 final Document document, final Field.Store store,
                 final Field.Index index, final Float boost) {
```

\textsuperscript{11}https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/services/fulltext/FullTextBridge.java

\textsuperscript{12}http://lucene.apache.org/core/3_6_0/queryparsersyntax.html

\textsuperscript{13}https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/service-ome.api.Search.xml

\textsuperscript{14}https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/services/fulltext/FileParser.java

\textsuperscript{15}http://lucene.apache.org

\textsuperscript{16}https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/services/fulltext/BridgeHelper.java
you would need to add a field to the Document for each Image.

```java
Project p = (Project) value;
List<Image> images = getImages(p);
for (Image image : images) {
    add(document, "image_name", image.getName(), store, index, boost);
}
```

## 20.3.2 Configuration

Custom bridges are configured in etc/omero.properties but can be overridden via the standard configuration mechanisms. The `omero.search.bridges` property defines a comma-separated list of bridge classes which will be passed to `components/server/src/ome/services/fulltext/FullTextBridge.java`.

See Java deployment for how to have your bridge classes included on the server’s classpath if it doesn’t get built by the Build System.

### 20.3.3 Available bridges

See `components/server/src/ome/services/fulltext/bridges` for a list of provided (example) bridges.

### 20.3.4 Re-indexing

BridgeHelper provides two methods – `reindex(IObject)` and `reindexAll(List<IObject>)` – for keeping the indexes for objects in sync.

For example, if the `image.name` above were to be changed, the index for the Project would be stale until the Project itself were re-indexed. Custom bridges can call `reindex(Project)` while indexing the image to have the Project re-indexed from the backlog. Before any new changes are processed, the backlog is always first cleared. One caveat: while processing the backlog, no new objects can be added to it.

For bridge writers, this means concretely that implementations should check for all related types and index them in groups, rather than relying on transitivity. For example,

```java
if (value instanceof Project) {
    final Project p = (Project) value;
    handleProject(p, document, store, index, boost);

    for (final ProjectDatasetLink pdl : p.unmodifiableDatasetLinks()) {
        final Dataset d = pdl.child();
        reindex.add(d);
        handleDataset(d, document, store, index, boost);

        for (final DatasetImageLink dil : d.unmodifiableImageLinks()) {
            final Image i = dil.child();
            reindex.add(i);
            handleImage(document, store, index, two_step_boost, i);
        }
    }
} else if (value instanceof Dataset) {
    final Dataset d = (Dataset) value;
    handleDataset(d, document, store, index, boost);

    for (final ProjectDatasetLink pdl : d.unmodifiableProjectLinks()) {
        final Project p = pdl.parent();
        reindex.add(p);
```

---

18[https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/services/fulltext/FullTextBridge.java](https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/services/fulltext/FullTextBridge.java)
handleProject(p, document, store, index, two_step_boost);
}

for (final DatasetImageLink dil : d.unmodifiableImageLinks()) {
    final Image i = dil.child();
    reindex.add(i);
    handleImage(document, store, index, two_step_boost, i);
}

} else if (value instanceof Image) {
    final Image i = (Image) value;
    handleImage(document, store, index, two_step_boost, i);

    for (final DatasetImageLink dil : i.unmodifiableDatasetLinks()) {
        final Dataset d = dil.parent();
        reindex.add(d);
        handleDataset(d, document, store, index, boost);
        for (final ProjectDatasetLink pdl : d
            .unmodifiableProjectLinks()) {
            final Project p = pdl.parent();
            reindex.add(p);
            handleProject(p, document, store, index, boost);
        }
    }
}

// Handle re-indexing
// if (reindex.size() > 0) {
//    reindexAll(reindex);
//}

In which case, regardless of whether an Image, Dataset, or Project is indexed, all related objects are simultaneously added to the backlog, which will be processed in the next cycle, but their indexing will not add any new values to the backlog.

See #955\textsuperscript{20} and #1102\textsuperscript{21}

See also:

\textit{OMERO search}

\textsuperscript{20}http://trac.openmicroscopy.org.uk/ome/ticket/955
\textsuperscript{21}http://trac.openmicroscopy.org.uk/ome/ticket/1102
21.1 Password Provider

A **Password Provider** is an implementation of the Java interface `ome.security.auth.PasswordProvider`\(^1\). Several implementations exist currently:

- `ome.security.auth.JdbcPasswordProvider`\(^2\) is the most common provider, and uses the “password” table for storing passwords hashed using MD5 and salt per user.
- `ome.security.auth.FilePasswordProvider`\(^3\) is rarely used, but in some scenarios may be useful since it permits setting usernames and passwords in a plain text file.
- `ome.security.auth.LdapPasswordProvider`\(^4\) is a highly configurable provider which provides READ-ONLY access to an LDAP server and can create users and groups on the fly. See [LDAP plugin design](https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/services/messages/LoginAttemptMessage.java) for more information.

The “chainedPasswordProvider” (`ome.security.auth.PasswordProviders`\(^5\)) is configured for use by default in `etc/omero.properties`\(^6\) under `omero.security.password_provider`. It first checks with the `LdapPasswordProvider` and then falls back to the `JdbcPasswordProvider`.

To write your own provider, you can either subclass from `ome.security.auth.ConfigurablePasswordProvider`\(^7\) as the providers above do, or write your own implementation from scratch. You will need to define your object in a Spring XML file matching the pattern `ome/services/db-*.xml`. See [Extending OMERO](https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/omero.properties) more for information.

### 21.1.1 Things to keep in mind

- All the existing implementations take care to publish a `LoginAttemptMessage`\(^8\) so that any `LoginAttemptListener` implementation can properly react to failed logins. Your implementation should probably do the same.

- When dealing with chains of password providers, an implementation can safely return null from `checkPassword` to say “I don’t know anything about this”. This is only important if you configure your own chained password provider with your new implementation as one of the elements.

21.2 LoginAttemptListener

All the **Password Provider** implementations provided by default publish a “LoginAttemptMessage”\(^9\)” every time they check a password value. This permits any `org.springframework.context.ApplicationListener<LoginAttemptMessage>` to react to the login. Only one implementation is active by default (as of 4.2.1): `ome.security.auth.LoginAttemptListener`\(^10\) which throttles logins after a given number of failed attempts. Configuration for this listener is available in `etc/omero.properties`\(^11\):
A more sophisticated listener would lock the user’s account until an administrator intervenes. This is the goal of #3139.

### 21.3 LDAP plugin design

Once configured, **LDAP authentication** allows sysadmins to control OMERO’s user and group creation via an external, locally-maintained LDAP server. Due to the flexibility of LDAP, each instance may have a number of requirements that cannot be supported out of the box. Below, we discuss the design of the LDAP plugin as well as how it can be extended for local use.

#### 21.3.1 Simple walkthrough

The LDAP plugin follows these steps:

1. Sysadmin configures properties mapping users and groups from LDAP to OMERO.
2. Once LDAP is enabled, any OMERO user who has a non-null dn in the password table will have their password checked against LDAP and **not** against OMERO (changing the password via OMERO is **not** supported). This functionality is provided by the **Password Provider**.
3. If there is no OMERO user for a given name, the LDAP plugin will use `omero.ldap.user_filter` and `omero.ldap.user_mapping` to look for a valid user:
   - (a) The `user_mapping` property is of the form: `omeName=<ldap attribute>;firstName=<ldapAttribute>;…`
   - (b) For looking up new users, the plugin will only use the `omeName` attribute. For example, if a user tries to login with “emma” and the `user_mapping` starts with `omeName=cn;` then the LDAP search will be for `(cn=emma)`.
   - (c) The `(cn=emma)` LDAP filter is then added to the value of `omero.ldap.user_filter`. For example, if the `user filter` is `(objectClass=inetOrgPerson)`, the full query for the new user will be: `(&(objectClass=inetOrgPerson)(cn=emma))`
4. If the search returns a single LDAP user, then an OMERO user will be created with all properties mapped according to `omero.ldap.user_mapping`.
5. Then the user will be placed in groups according to the value of `omero.ldap.new_user_group`, which are created if necessary. Details of the various options can be found under **LDAP authentication**. Each option is handled by a different `NewUserGroupBean` implementation.

#### 21.3.2 NewUserGroupBean.java

The interface described for the “:bean:” new_user_group prefix, is `ome.security.auth.NewUserGroupBean`\(^{13}\). It defines a single method: `groups(..., AttributeSet set)` which returns a list of `ExperimenterGroup ids` (`List<Long>`) which the user should be added to.

Other prefix handlers also implement the interface as examples. In the same package are:

- **:attribute:** - `AttributeNewUserGroupBean.java`\(^{14}\)
- **:ou:** - `OrgUnitNewUserGroupBean`\(^{15}\)
- **:query:** - `QueryNewUserGroupBean`\(^{16}\)

See also:

**OMERO.server installation** Instructions for installing OMERO.server on UNIX and UNIX-like platforms

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\(^{12}\)[http://trac.openmicroscopy.org.uk/ome/ticket/3139]


\(^{15}\)[https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/auth/OrgUnitNewUserGroupBean.java]

OMERO roles

There are two areas where roles are used. The first is in service-level security (deciding who can make what calls) and the second is in object-level security (who can read and edit individual objects). Both of these sets of roles are composed of “ExperimenterGroups”.

21.4.1 Setting roles

An Experimenter is given a role by being a member of an ExperimenterGroup (specifically, this means that there exists a GroupExperimenterMap where child == the experimenter id and parent == the experimenter group id). Creating a GroupExperimenterMap is generally done transparently by IAdmin service. Instead, administrators call:

- IAdmin.createUser(user)
- IAdmin.createGroup(group)
- IAdmin.addGroups(user, group, group, …)
- IAdmin.removeGroups(user, group, group, …)
- IAdmin.createSystemUser(user)

21.4.2 Service-level

The two main roles that are distinguished at the service-level are “system” and “user” groups. These groups are created during installation and must not be configured by administrators. All users added through IAdmin.createUser(user) are automatically added to the “user” group, and all users added through IAdmin.createSystemUser(user) are added to both “system” and “user” groups.

During login, a user is checked against all groups for membership in “user” or “system”, and no special action needs to be taken by the user or client developer.

Note: Although currently all methods in the session beans are labelled as @RolesAllowed("user") or @RolesAllowed("system"), there is nothing stopping a developer from writing a service method which accepts another role, as long as that role has been created in the ExperimenterGroup table.

21.4.3 Object-level

Object-level security is more complicated. When execution reaches the EventHandler, a second login takes place to authorize the user with the OMERO security system. This second authorization process takes into account the group that (can be) passed into the client ServiceFactory\(\text{Login}\) (Login(String, String, String, String). If a user has not set the group name or the default “user” group has been set, then the default group for that user will be used (a user is not allowed to use the “user” group for object updates). If the group is set to “system”, then the “system” group will be used, and a user is granted admin privileges for object updates. This means that a user could be authorized to call a method by being in the “system” group, but if the “system” group is not specified, SecurityViolations will most likely be thrown.

21.4.4 Special privileges for PIs

There is one other special, implicit role which is group leader. The user listed as “owner” for a group is considered the group leader, also known as the PI (principal investigator) of that group. For all objects that are assigned to that group, the PI has near-admin access. Objects which are set to unreadable (“-wu-wu-wu”) will still be visible to the PI. The same objects can also be updated regardless of the permissions set.
21.5 OMERO security system

The OMERO security system is intended to be as transparent as possible while permitting users to configure the visibility of their data. For the user, this means that with no special actions, data and metadata created will be readable by both members of the same group and by other users, but will be writable by no one, comparable to a umask of 755 on Unix. For the developer, transparency means that there is little or no code that must be written to prevent security violations, and simple mechanisms for allowing restricted operations when the time comes.

Other links which may be of use:

- OMERO admin interface
- OMERO roles
- Permissions overview
- OMERO permissions history, querying and usage

21.5.1 Concepts

Several concepts and/or components from our and other code bases play a role in OMERO security:

**Hibernate Listeners and Events**\(^{17}\) listeners and events are the two extension points provided by Hibernate for responding to and influencing internal actions. Essentially any method on the `org.hibernate.Session` interface has a corresponding event, and almost the same is true for the interceptor. Additionally interceptors can change the state of the objects before `INSERT` and `UPDATE`, and after `SELECT`.

**Hibernate Filters**\(^{18}\) filters are a mechanism for injecting SQL clauses into the `SELECT` statements generated by Hibernate. Similar to listeners and events for write actions, filters allow us to extend Hibernate functionality with our own logic.

**Handler/Interceptor** as outlined in *Aspect-oriented programming*, OMERO makes extensive use of method interceptors to relieve the developer of some coding burden. Transactions, session management, and, naturally, security are handled largely by our interceptors (or “handlers”).

**Events** Every write action produces an Event in the database. This database contains several *EventLogs* which specify exactly what was created or altered during that specific event.

21.5.2 Participants

Now, with the concepts cleared up, we can take a look at all of the concrete source artifacts (“participants”) which are important for security.

**Top-level and build**

- **omero.properties**\(^{19}\) contains login and connection information for the database and OMERO.
- **local.properties.example**\(^{20}\) contains the default root password. This can be overridden with your own `etc/local.properties` file.
- **hibernate.properties**\(^{21}\) contains default connection information for the database, this includes the user name and if necessary the user password. These values can be overridden in `local.properties`.
- **omero.properties**\(^{22}\) contains a default user group, event type, and connection information for logging in from the client side, if no Login or Server is specified to ServiceFactory. These values can be overridden in `local.properties`.
- **mapping.vm**\(^{23}\) specifies the default permissions that all objects will have after construction, as well as attaches the security filter to all classes and collections.
- **data.vm**\(^{24}\) used by DSLTask to generate psql-footer.sql which is used to bootstrap the database security system (root et al).
- **common/build.xml**\(^{25}\) contains an ant target (adduser) which will create a user and empty password from the command line. This target can also be called from the top-level (java omero adduser).
Client and common

the server uses the information in /etc/local.properties to create a Login object. If no Login, Server, or Properties is provided to the ServiceFactory constructor, the empty properties defined in ome/config.xml is used.

IAdmin.java main interface for administering accounts and privileges. See OMERODocumentation for more.

ITypes.java only related to security by necessity. The security system disallows the creation of certain “System-Types”. Enumerations are one of these. ITypes, however, provides a createEnumeration method with general access.

GraphHolder.java all model objects (implementations of IObject have a never-null GraphHolder instance available. This graph holder is responsible for various OMERO and Hibernate internal processes. One of these is the exchange of Tokens. For the server, the existence of a special token within the GraphHolder grants certain privileges to that IObject. This logic is encapsulated within the SecuritySystem.

Details.java contains all the fields necessary to perform access control, such as owner, group, and permissions.

Permissions.java representation of rights and roles. For more information, see Permissions overview.

Token.java an extremely simple class (“public class Token { }”) which is only significant when it is equivalent (“==” to a privileged Token stored within the SecuritySystem.

IEnum.java the only non-access control related types which are considered “System-Types” are enumerations. IEnum is a marker interface for all enumerations and creation of IEnum implementations can only be performed through ITypes.

SecurityViolation.java the exception thrown by the OMERO security system at the first hint of misdoings.

Principal.java an Omero-specific implementation of the java.security.Principal interface. Carries in addition to the typical name field, information about the user group, the event type, and the session umasks.

meta.ome.xml

JBoss-only

ServiceFactory.java Login.java Server.java

Server side

AdminImpl.java CurrentDetails.java SecureAction.java SecuritySystem.java BasicSecuritySystem.javaACLEventListener.java EventHandler.java MergeEventListener.java OmeroInterceptor.java SessionHandler.java SecurityFilter.java EventLogListener.java EventListenersFactoryBean.java LocalAdmin.java sec-system.xml services.xml

References:

https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/services.xml
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/sec-system.xml
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/hibernate.xml
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/api/local/LocalAdmin.java
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/OmeroInterceptor.java
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/MergeEventListener.java
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/EventHandler.java
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/BasicSecuritySystem.java
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/CurrentDetails.java
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/ACLEventListener.java
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/EventLogListener.java
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/api/local/LocalAdmin.java
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/hibernate.xml
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/sec-system.xml
https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/services.xml

27 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/model/resources/mappings/meta.ome.xml
28 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/config.xml
29 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/tools/hibernate/SessionHandler.java
30 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/CurrentDetails.java
33 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/ACLEventListener.java
34 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/EventLogListener.java
35 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/MergeEventListener.java
36 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/OmeroInterceptor.java
37 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/EventHandler.java
38 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/BasicSecuritySystem.java
39 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/ACLEventListener.java
40 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/EventLogListener.java
43 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/ACLEventListener.java
44 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/EventLogListener.java
45 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/MergeEventListener.java
46 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/OmeroInterceptor.java
47 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/EventHandler.java
49 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/ACLEventListener.java
50 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/EventLogListener.java
51 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/MergeEventListener.java
52 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/OmeroInterceptor.java
53 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/api/local/LocalAdmin.java
54 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/hibernate.xml
55 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/sec-system.xml
56 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/services.xml

21.5. OMERO security system
21.5.3 End-to-end

Build system

Security starts with the build system and installation. During the generation of the model (by the DSLTask), a sql script is created called "data.sql". After ddl.sql creates the database, data.sql bootstraps the security system by creating the initial (root) experimenter, and event, and then creates the “system” group and the “user” group. It then creates a password table and sets the root password to “ome”. (It also creates all of the enumeration values, but that is unimportant for security).

Note: The password table is not mapped into Hibernate, and is only accessible via the OMERO admin interface.

Client-side

To begin the runtime security process, a user logs in by providing a Login and/or a Server instance to ServiceFactory. These types are immutable and their values remain constant for the lifetime of the ServiceFactory. The user can also set the umask property on ServiceFactory._. This value is mutable and can be set at anytime.

The values are converted to java.util.Properties which are merged with the properties from the *.properties files from /etc to create the client OmeroContext (also known as the “application context”). The context contains a Principal and user credentials (password etc.) which are associated with the thread before each method execution in a specialized TargetSource. Finally, these objects are serialized to the application server along with the method arguments.

Application server

The application server first performs one query (most likely SQL) to check that the credentials match those for the given user name. A second query is executed to retrieve all roles/groups for the given user. If the roles returned are allowed to invoke the desired method, invocation continues with the queried user and roles stored in the InvocationContext.

Server code

Execution then passes to OMERO code, specifically to the interceptors and lifecycle methods defined on our session beans. This intercepting code checks the passed Principal for OMERO-specific information. If this information is available, it is passed into the SecuritySystem through the login method. Finally, execution is returned to the actual bean which can either delegate to OMERO services or perform logic themselves.

Interceptors

All calls to the delegates (and in the future all calls on the session beans) are also caught intercepted by Spring-configured interceptors. These guarantee that the system is always in a valid and secure state. In stack order they are:

- the service handler, which handles logging and checks all arguments against ServiceInterface annotations;
- the proxy handler, which after execution, removes all uninitialized Hibernate objects to prevent exceptions (special logic allows this to happen See unloaded objects);
- the transaction handler, which binds a transaction to the thread,
- the session handler, which uses the now prepared transaction to initialize either a new or a cached (in the case of stateful session beans) session and also bind it to the thread;
- and finally, the event handler, which performs what one might actually consider login. It instantiates Experimenter, ExperimenterGroup, and Event objects from Hibernate and gives them a special Token so that they can authenticate themselves later to the SecuritySystem and turns session read security on for the entirety of execution below its frame.
Services

Finally execution has reached the OMERO services and can begin to perform logic. Because of these layers, almost no special logic (other than eviction and not calling write methods from within read methods, see #223\(^{57}\)) needs to be considered. There are, however, a few special cases.

**IQuery** (within the application server), for example will always return a graph of active Hibernate objects. Changes to them will be persisted to the database on flush.

**IUpdate**, on the other hand, does contain some logic for easing persistence, though this will eventually be ported to the Hibernate event system. This includes pre-saving the newly created event and the work of UpdateFilter like reloading objects unloaded by the proxy handler (above).

Finally, **IAdmin** is special in that it and it alone access the non-Hibernate password data store and even access application server APIs (like JMX) in order to make authentication and authorization function properly.

Hibernate

Once execution has left this service layer, it enters the world of Hibernate ORM. Here we cannot actively change functionality but only provide callbacks like the OmeroInterceptor and EventListeners. The OmeroInterceptor instance registered with the Hibernate SessionFactory (via Spring) is allowed for calling back to the often mentioned SecuritySystem to determine what objects can be saved and which deleted. It also properly sets the, for a user mostly unimportant, Details object. The EventListeners are more comprehensive than the OmeroInterceptor and can influence almost every phase of the Hibernate lifecycle, specifically every method on the Session interface.

The event listeners which implement AbstractSaveEventListener (i.e. MergeEventListener, SaveOrUpdateEventListener, etc.) are responsible for reloading unloaded objects (and will hopefully take this functionality fully from IUpdate) and provide special handling for enums and other system types. There are also event listeners which are the equivalent of database triggers (pre-update, post-delete, etc.) and these are used for generating our audit log.

So much for write activities. Select queries are, as mentioned above, secured through the use of Hibernate filters which add join and where clauses dynamically to queries. For example an HQL query of the form:

```sql
select i from Image i
```

would be filtered so that the current user does not receive references to any objects with reduced visibility:

```sql
select i from Image i where ( current_user = :root OR i.permissions = :readable )
```

The actual clauses added are much more complex and are added for each joined entity type (i.e. table) which appears in a query.

```sql
select i from Image i join i.defaultPixels p
```

would contain the “( current_user = :root …)” clause twice.

Currently, subqueries are an issue in that the clauses do not get added to them. This may cause consternation for some particular queries.

Security system

All of this is supported by an implementation of the SecuritySystem interface which encapsulates all logic regarding security. It also hides as much as it can, and if not specifically needed should be ignored. However, before you attempt to manually check security, by all means use the security system, and for that, it may need to be acquired from the server-side OmeroContext. Currently, there is no client-side security system. See #234\(^{58}\).

The OMERO security system and its current only implementation BasicSecuritySystem? are somewhat inert and expect well-defined and trusted (see #235\(^{59}\)) methods to invoke callbacks during the proper Hibernate phase.

\(^{57}\)http://trac.openmicroscopy.org.uk/ome/ticket/223

\(^{58}\)http://trac.openmicroscopy.org.uk/ome/ticket/234

\(^{59}\)http://trac.openmicroscopy.org.uk/ome/ticket/235
21.5.4 Logging in (client-side)

When using the client library and the ServiceFactory, logging in is trivial. One need only set several System properties or place them in an omero.properties file somewhere on the classpath. Internally, Spring takes the System properties and creates an `ome.system.Principal` instance. This is then passed to the server on each invocation of a proxy obtained from JNDI.

21.5.5 Logging in (server-side)

Much of this infrastructure is not available to server-side code (no ome/client/spring.xml, no ServiceFactory, etc.). As such, the Principal needs to be manually created and provided to the server-side `SecuritySystem.java`.

Basically it amounts to this:

```java
Principal p = new Principal( omeroUserName, omeroGroupName, omeroEventTypeValue );
securitySystem.login( p );
```

This must be run otherwise the `EventHandler` will throw a security exception.

---

**Note:** The code above is being run in a secure context (i.e. you are root). Please be careful.

---

21.6 OMERO permissions history, querying and usage

21.6.1 Introduction

The OMERO permissions model has had a significant overhaul from version 4.1.x to 4.4.x. Users and groups have existed in OMERO since well before the initial 4.1.x releases and numerous permissions levels were possible in the 4.1.x series but it was largely assumed that an Experimenter belonged to a single Group and that the permissions of that Group were private.

The OMERO permissions system received its first significant update in 4.2.0 with the introduction of multiple group support throughout the platform and group permissions levels.

In a 4.1.x object graph Group containment was not enforced i.e. two linked objects (such as a Project and Dataset) could in theory be members of two distinct Groups. All objects continued to carry their permissions and those permissions were persisted in the database.

**Things to note about 4.2.x permissions**

- Objects could not be moved between groups easily.
- It was not possible to reduce the permissions level of a group.
- The delete service (introduced in OMERO 4.2.1) was made aware of the permissions system.
- ‘Default Group’ switching was required to make queries in different permissions contexts.

**Note:** Queries span only one group at a time. Inserts and updates as other users must be done by creating a session as that user.

See also:

OMERO 4.2.0 Server Permissions

Database upgrade from 4.1 to 4.2

Deleting in OMERO

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60 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/system/Principal.java
63 http://www.openmicroscopy.org/site/support/previous/omero420/server/permissions
64 http://www.openmicroscopy.org/site/support/previous/omero420/server/db-upgrade-41-to-42

21.6. OMERO permissions history, querying and usage 391
Changes for OMERO 4.4.x

The second major OMERO permissions system innovations were performed in 4.4.0:

- Cross group querying was reintroduced.
- Change group was enabled, allowing the movement of graphs of objects between groups.
- Permissions level reduction was made possible for read-annotate to read-only transitions.

A thorough user interface review resulted in the following features being made available in the UI:

- single group browsing and user-switching (available since 4.4.0)
- browsing data across multiple groups (available since 4.4.6 and refined in 4.4.7)

The concept of a ‘Default or Primary Group’ was deprecated.

Note: Queries, inserts and updates span any or all groups and any user via options flags.

21.6.2 Working with the OMERO 5.0.2 permissions system

Example environment

- OMERO 5.0.2 server
- IPython shell initiated by running omero shell --login

Group membership

<table>
<thead>
<tr>
<th>User</th>
<th>private-1</th>
<th>read-only-1</th>
<th>read-write-1</th>
<th>read-annotate-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>user-2</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>user-3</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Simple inserts and queries

While the ‘Default Group’ is essentially a deprecated concept, a user must be logged into one to provide a default context. It is still possible to change this default group but it is no longer required to make queries in other permissions contexts.

All remote calls to an OMERO server, since well before version 4.1.x, have the option of taking an Ice context object. Through this object, and manipulations thereof, we can affect our query context. What follows is a series of examples exploring inserts and queries using contexts that span a single group at a time.

Retrieving a user’s event context and group membership

```python
# Session that has already been created for user-2
session = client.getSession()

# Retrieve the services we are going to use
admin_service = session.getAdminService()

ec = admin_service.getEventContext()
print(ec)
groups = [admin_service.getGroup(v) for v in ec.memberOfGroups]
for group in groups:
    print('Group name: %s' % group.name.val)
```

Example output:
Here you can see and validate that, when logged in as user-2, we are a member of both the private-1 and read-only-1 groups. Membership of the user group is required in order to login. This group essentially acts as a role, letting the OMERO security system know whether or not the user is active.

### Inserting and querying data from specific groups

For the purposes of this example, we will prepare a single Project in both the private-1 and read-only-1 groups and then perform various queries on those Projects.

```python
# Session that has already been created for user-2
session = client.getSession()

# Project object instantiation
private_project = ProjectI()
private_project.name = rstring('private-1 project')
read_only_project = ProjectI()
read_only_project.name = rstring('read-only-1 project')
```
admin_service = session.getAdminService()
query_service = session.getQueryService()

# Groups we are going to write data into
private_group = admin_service.lookupGroup('private-1')
read_only_group = admin_service.lookupGroup('read-only-1')

# Save and return our two projects, setting the context correctly for each
ctx = {'omeo.group': str(private_group.id.val)}
private_project = update_service.saveAndReturnObject(private_project, ctx)
ctx = {'omeo.group': str(read_only_group.id.val)}
read_only_project = update_service.saveAndReturnObject(read_only_project, ctx)

private_project_id = private_project.id.val
read_only_project_id = read_only_project.id.val
print 'Created Project:%d in group private-1' % (private_project_id)
print 'Created Project:%d in group read-only-1' % (read_only_project_id)

# Query for the private project we created using private-1
# You will notice that this returns the Project as we have specified
# the group that the Project is in within the context passed to the
# query service.
ctx = {'omeo.group': str(private_group.id.val)}
params = ParametersI()
params.addId(private_project_id)
projects = query_service.findAllByQuery('select p from Project as p ' \
     'where p.id = :id', params, ctx)
print 'Found %d Project(s) with ID %d in group private-1' % (len(projects), private_project_id)

# Query for the private project we created using read-only-1
# You will notice that this does not return the Project as we have **NOT**
# specified the group that the Project is in within the context passed to the
# query service.
ctx = {'omeo.group': str(read_only_group.id.val)}
params = ParametersI()
params.addId(private_project_id)
projects = query_service.findAllByQuery('select p from Project as p ' \
     'where p.id = :id', params, ctx)
print 'Found %d Project(s) with ID %d in group read-only-1' % (len(projects), private_project_id)

# Use the OMERO 4.3.x introduced delete service to clean up the Projects
# we have just created.
handle = session.submit(Delete('/Project', private_project_id, None))
try:
    callback = CmdCallbackI(client, handle)
    callback.loop(10, 1000)  # Loop a maximum of ten times each 1000ms
finally:
    # Safely ensure that the Handle to the delete request is cleaned up,
    # otherwise there is the possibility of resource leaks server side that
    # will only be cleaned up periodically.
    handle.close()
handle = session.submit(Delete('/Project', read_only_project_id, None))
try:
    callback = CmdCallbackI(client, handle)
    callback.loop(10, 1000)  # Loop a maximum of ten times each 1000ms
finally:
handle.close()

Example output:

Created Project:113 in group private-1
Created Project:114 in group read-only-1
Found 1 Project(s) with ID 113 in group private-1
Found 0 Project(s) with ID 113 in group read-only-1

Advanced queries

In OMERO 4.4.0, cross group querying was reintroduced. Again, we make use of the Ice context object. Through this object, and manipulations thereof, we can expand our query context to span all groups via the use of -1. What follows is a series of example queries using contexts that span all groups.

Querying data across groups

```python
# Session that has already been created for user-2
session = client.getSession()

# Project object instantiation
private_project = ProjectI()
private_project.name = rstring('private-1 project')
read_only_project = ProjectI()
read_only_project.name = rstring('read-only-1 project')

# Retrieve the services we are going to use
update_service = session.getUpdateService()
admin_service = session.getAdminService()
query_service = session.getQueryService()

# Groups we are going to write data into
private_group = admin_service.lookupGroup('private-1')
read_only_group = admin_service.lookupGroup('read-only-1')

# Save and return our two projects, setting the context correctly for each.
# ALL interactions with the update service where NEW objects are concerned
# must be passed an explicit context and NOT '-1'. Otherwise the server
# has no idea which set of owners to assign to the object when persisted.
ctx = {'omero.group': str(private_group.id.val)}
private_project = update_service.saveAndReturnObject(private_project, ctx)
ctx = {'omero.group': str(read_only_group.id.val)}
read_only_project = update_service.saveAndReturnObject(read_only_project, ctx)

private_project_id = private_project.id.val
read_only_project_id = read_only_project.id.val
print 'Created Project:%d in group private-1' % (private_project_id)
print 'Created Project:%d in group read-only-1' % (read_only_project_id)
```

# Query for the private project we created using private-1

#
# You will notice that this returns both Projects as we have specified
# `-1’ in the context passed to the query service.
ctx = {'omero.group': '-1'}
params = ParametersI()
params.addIds([private_project_id, read_only_project_id])
projects = query_service.findAllByQuery('select p from Project as p 
  where p.id in (:ids)', params, ctx)

print 'Found %d Project(s) % (len(projects))

# Use the OMERO 4.3.x introduced delete service to clean up the Projects
# we have just created. The delete service uses ‘-1’ by default for all its
# internal queries. We are also introducing the ‘DoAll’ command, which
# allows for the aggregation of ‘Delete’ commands.
deleterquests = [
  Delete('/Project', private_project_id, None),
  Delete('/Project', read_only_project_id, None)
]
handle = session.submit(DoAll(deleterquests))

try:
callback = CmdCallbackI(client, handle)
callback.loop(10, 1000)  # Loop a maximum of ten times each 1000ms

finally:
  # Safely ensure that the Handle to the delete request is cleaned up,
  # otherwise there is the possibility of resource leaks server side that
  # will only be cleaned up periodically.
  handle.close()

Example output:
Created Project:117 in group private-1
Created Project:118 in group read-only-1
Found 2 Project(s)

Querying data across users in the same group

Through the use of an omero.sys.ParametersI filter, restricting a query to a given user is possible. For the purposes of these examples, we will assume that both user-2 and user-3 have a single project each in the read-only-1 group.

#!/python
from omero.model import *
from omero.rtypes import *
from omero.sys import ParametersI

# Session that has already been created for user-2
session = client.getSession()

# Retrieve the services we are going to use
admin_service = session.getAdminService()
query_service = session.getQueryService()

# Groups we are going to query
read_only_group = admin_service.lookupGroup('read-only-1')

# Users we are going to query
user_2 = admin_service.lookupExperimenter('user-2')
user_3 = admin_service.lookupExperimenter('user-3')
# Print the members of ‘read-only-1’

```python
print('Members of "read-only-1" (experimenter_id, username): %r' % 
    [(v.id.val, v.omeName.val) for v in read_only_group.linkedExperimenterList()])
```

# Query for all projects

```python
ctx = {'omero.group': str(read_only_group.id.val)}
projects = query_service.findAllByQuery(
    'select p from Project as p', None, ctx)
print('All projects in "read-only-1" (project_id, owner_id): %r' % 
    [(v.id.val, v.details.owner.id.val) for v in projects])
```

# Query for projects owned by ‘user-2’

```python
ctx = {'omero.group': str(read_only_group.id.val)}
params = ParametersI()
params.addId(user_2.id.val)
projects = query_service.findAllByQuery(
    'select p from Project as p' \ 
    'where p.details.owner.id = :id', params, ctx)
print('Projects owned by "user-2" in "read-only-1" (project_id, owner_id): %r' % 
    [(v.id.val, v.details.owner.id.val) for v in projects])
```

# Query for projects owned by ‘user-3’

```python
ctx = {'omero.group': str(read_only_group.id.val)}
params = ParametersI()
params.addId(user_3.id.val)
projects = query_service.findAllByQuery(
    'select p from Project as p' \ 
    'where p.details.owner.id = :id', params, ctx)
print('Projects owned by "user-3" in "read-only-1" (project_id, owner_id): %r' % 
    [(v.id.val, v.details.owner.id.val) for v in projects])
```

Example output:

Members of "read-only-1" (experimenter_id, username): [(10L, 'user-2'), (9L, 'user-3')]
All projects in "read-only-1" (project_id, owner_id): [(4L, 10L), (7L, 9L)]
Projects owned by "user-2" in "read-only-1" (project_id, owner_id): [(4L, 10L)]
Projects owned by "user-3" in "read-only-1" (project_id, owner_id): [(7L, 9L)]

### Utilizing the Permissions object

Every object that is retrieved from the server via the query service, regardless of the context used, has a fully functional `omero.model.PermissionsI` object. This object contains various methods to allow the caller to interrogate the operations that are possible by the current user on the object:

- `canAnnotate()`
- `canDelete()`
- `canEdit()`
- `canLink()`

---

65 [http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/model/Permissions.html#canAnnotate](http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/model/Permissions.html#canAnnotate)
66 [http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/model/Permissions.html#canDelete](http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/model/Permissions.html#canDelete)
67 [http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/model/Permissions.html#canEdit](http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/model/Permissions.html#canEdit)
68 [http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/model/Permissions.html#canLink](http://downloads.openmicroscopy.org/latest/omero5/api/slice2html/omero/model/Permissions.html#canLink)
21.6.3 Troubleshooting permissions issues

Data disappears after a change of the primary group of a user

As outlined above, changes were made so that by default queries do not span multiple groups and the ‘Primary or Default Group’ is essentially a deprecated concept. If you have multiple groups and you are attempting to make queries by switching the ‘Active Group’ via the `setSecurityContext()` method of an active session (`omero.cmd.SessionPrx`), those queries will be scoped only to that group. If you want your queries to act more like they did in 4.1.x, setting `omero.group=-1` will achieve that.

However, the reasons we made these changes have more to them than just API usage and the OMERO client history of only showing the data from one group at a time. Changing the ‘Active Group’ is both expensive because of the atomicity requirements the server enforces and can create dangerous concurrency situations. This is further complicated by the addition of the change group and delete background processes since 4.1.x. Manipulating a session’s ‘Primary or Default Group’ during these tasks can have drastic effects. Changing the ‘Active Group’ is forbidden if there are any stateful services (`omero.api.RenderingPrx` for example) currently open.

In short, in OMERO 5.0.2 you absolutely **should not** be switching the ‘Primary or Default Group’ of the user, or the ‘Active Group’ of a session, as a means to achieve cross group querying.

Listing other users’ data in read-only groups

In order to list other users’ data associated with read-only groups of which you are a member, you can also use the context object and set the `omero.group` to -1. In addition, you can add a filter to the query to only select the other users’ data. You can do this either by using the `omero.sys.ParametersI` object’s `exp()` method when using the `IContainer` service, or by an explicit query when using `IQuery` service.

Is the default group the primary group when not specifying the context?

The value of the `groupId` property of the `omero.sys.EventContext` is the “Active Group” for the created session. It can be modified as described above with the restrictions outlined. Unless the session has been created by means other than `createSession()` on an `omero.client` object, this will be the user’s “Primary or Default Group.” A user’s ‘Primary or Default Group’ is the first group in the collection that describes the relation `Experimenter <--> ExperimenterGroup`. It can be set by the `setDefaultGroup()` method on the `IAdmin` service.

What about when importing data without specifying the context object?

Exactly as outlined above. Import does nothing different or special. If you want the operating context of an import to be different from the default you must specify it as such.

Specifying the group context as -1 when deleting data

There is no need to do this. Complete graphs cannot span multiple groups and queries are only (unless otherwise filtered) restricted at the group level and not at the level of the user. Furthermore, the delete service always internally performs all its queries in the `omero.group=-1` context unless another more explicit one is specified.
22.1 OMERO.server overview

22.1.1 OMERO sequence narrative

Trying to understand all of what goes on with the server can be a bit complicated. This short narrative tries to touch on the most critical aspects.

- A request reaches the server over one of the two remoting protocols: RMI or ICE. First, the Principal\(^1\) is examined for a valid session which was created via ISession.createSession(String username, String password)\(^2\).

- These values are checked against the experimenter, experimentergroup and password tables. A valid login consists of a user name which is to be found in the omename column of experimenter. This row from experimenter must also be contained in the “user” experimenter group which is done via the mapping table groupexperimentermap (see this SQL template\(^3\) for how root and the intial groups are setup).

- If the server is configured for LDAP Authentication, an Experimenter may be created when ISessions attempts to check the password via IAdmin.checkPassword()\(^4\).

- If authentication occurs, the request is passed to an EJB\(^5\) interceptor which checks whether or not the authenticated user is authorized for that service method. Methods are labelled either @RolesAllowed("user"), @RolesAllowed("system"), or @PermitAll. All users are a member of “user”, but only administrators will be able to run “system” methods.

- If authorization occurs, the request finally reaches a container-managed stateful or stateless service. The service will prepare the OMERO runtime for the particular user – checking method parameters, creating a new event, initializing the security system, etc. – and pass execution onto the method implementation. This is done using references acquired (or injected) from the Spring application context.

- The actual service implementation (from ome.logic\(^6\) or ome.services\(^7\)) will be either read-only (IQuery\(^8\)-based) or a read-write (IUpdate\(^8\)-based).

- In the case of a read-only action, the implementation asks the database layer for the needed object graph, transforms them where necessary, and returns the values to the remoting subsystem. On the client-side, the returned graph can be mapped to an internal model via the ((OMERO Model Mapping model wrapper)).

- In the case of a read-write action, the change to the database is first passed to a validation layer for extensive checking. Then the graph is passed to the database layer which prepares the SQL, including an audit trail of the changes made to the database.

- After execution, the OMERO runtime is reset, the method call is logged, and either the successful results are returned or an exception is thrown.

\(^1\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/system/Principal.java
\(^2\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/ISession.java
\(^3\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/dsl/resources/ome/dsl/psql-footer.vm
\(^4\)http://www.oracle.com/technetwork/java/javaee/ejb/index.html
\(^5\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/server/src/ome/logic
\(^6\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/common/src/ome/api/IQuery.java
\(^7\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/server/src/ome/services
\(^8\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/IUpdate.java
22.1.2 Technologies

It is fairly easy to work with the server without understanding all of its layers. The API is clearly outlined in the ome.api package and the client proxies work almost as if the calls were being made from within the same virtual machine. The only current caveat is that objects returned between two different calls will not be referentially (i.e. obj1 == obj2) equivalent. We are working on removing this restriction.

To understand the full technology stack, however, there are several concepts which are of importance:

- A layered architecture ensures that components only “talk to” the minimum necessary number of other components. This reduces the complexity of the entire system. Ensuring a loose-coupling of various components is facilitated by dependency injection. Dependency injection is the process of allowing a managing component to place a needed resource in a component’s hand. Code for lookup or creation of resources, in turn, is unneeded, and explicit implementation details do not need to be hard-coded.

- Object-relational mapping (ORM) is the process of mapping relational tables to object-oriented classes. Currently OMERO uses Hibernate\(^9\) to provide this functionality. ORM allows the developer to work in a known environment, here the type-safe world of Java, rather than writing difficult to debug sql.

- Aspect-oriented programming, a somewhat new and misunderstood technology, is perhaps the last technology which should be mentioned. Various pieces of code (“aspects”) are inserted at various moments (“joinpoints”) of execution. Collecting logic into aspects, whether logging, transactions, security etc., also reduces the overall complexity of the code.

22.1.3 Server design

The server logic resides in the components/server\(^10\) component.

Topics

- Exception handling
- OME-Remote Objects
- Server security and firewalls

See also:
OMERO.grid

22.2 Extending OMERO

Overview

Despite all the effort put into building OMERO, it will never satisfy the requirements of every group. Where we have seen it useful to do so, we have created extension points which can be used by third-party developers to extend, improve, and adapt OMERO. We outline most of these options below as well as some of their trade-offs. We are also always interested to hear about other possible extension points. Please contact the ome-devel mailing list\(^4\) with any such suggestions.

22.2.1 Other starting points

Clients

To write your own clients or scripts against the OMERO API, see the Working with OMERO page. Though writing your own client is a form of extending OMERO, the topics that follow are for extending the server and do not cover clients. For information specific to OMERO.insight, please see the client documentation:

---

\(^{9}\)http://lists.openmicroscopy.org.uk/mailman/listinfo/ome-devel/
\(^{10}\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/server
Figure 22.1: Server Architecture

- *How to build an agent*
- *How to build an agent’s view*
- *Retrieve data from server*

**List of extension points**

To get a feeling for what type of extension points are available, you might want to take a look at the following pages. Many of them will point you back to this page for packaging and deploying your new code.

- *File parsers* - write Java file parsers to further extend search
- *LoginAttemptListener* - write a Java handler for failed login attempts
- *OMERO Command Line Interface* - write drop in Python extensions for the command-line
Figure 22.2: Server Design

- **Introduction to OMERO.scripts** - write python scripts to process data server-side
- **LDAP plugin design** - write a Java authentication plugin
- **Password Provider** - write a Java password backend
- **Search bridges** - write Java Lucene parsers to extend search
22.2.2 Main topics

Model

The OME Data Model and its OMERO representation, the OME-Remote Objects, intentionally draw lines between what metadata can be supported and what cannot. Though we are always examining new fields for inclusion, it is not possible to represent everyone’s model within OME.

Structured annotations

The primary extension point for including external data are the Structured annotations (SAs). SAs are designed as email-like attachments which can be associated with various core metadata types. In general, they should link to information outside of the OME model, i.e. information which OMERO clients and servers do not understand. URLs can point to external data sources, or XML in a non-OME namespace can be attached.

The primary drawbacks are that the attachments are opaque and cannot be used in a fine-grain manner.

Code generation

Since it is prohibitive to model full objects with the SAs, one alternative is to add types directly to the generated code. By adding a file named `*.ome.xml` to `components/model/resources/mappings` and running a full-build, it is possible to have new objects generated in all OMERO.blitz languages. Supported fields include:

- boolean
- string
- long
- double
- timestamp
- links to any other `ome.model.*` object, including enumerations

For example:

```xml
<types>
  <!-- "named" and "described" are short-cuts to generate the fields "name" and "description" -->
  <type id="ome.model.myextensions.Example" named="true" described="true">
    <required name="valueA" type="boolean"/> <!-- This is NONNULL -->
    <optional name="valueB" type="long"/>     <!-- This is nullable -->
    <onemany name="images" type="ome.model.core.Image"/> <!-- A set of images -->
  </type>
</types>
```

Collections of primitive values like `<onemany name="values" type="long"/>` are not supported. Please see the existing mapping files for more examples of what can be done.

The primary drawback of code-generating your own types is isolation and maintenance. Firstly, your installation becomes isolated from the rest of the OME ecosystem. New types are not understood by other servers and clients, and cannot be exported or shared. Secondly, you will need to maintain your own server and client builds of the system, since the provided binary builds would not have your new types.

Measurement results

For storing large quantities of only partially structured data, such as tabular/CSV data with no pre-defined columns, neither the SAs nor the code-generation extensions are ideal. SAs cannot easily be aggregated, and code-generation would generate too many types. This is particularly clear in the storage and management of HCS analysis results.

To solve this problem, we provide the OMERO.tables API for storing tabular data indexed via Roi, Well, or Image id.
Services

Traditionally, services were added via Java interfaces in the `components/common/src/ome/api` package. The creation of such “core” services is described under *How To create a service*. However, with the introduction of *OMERO.blitz*, it is also possible to write blitz-only services which are defined by a slice definition under `components/blitz/resources/omero`.

A core service is required when server internal code should also make use of the interface. Since this is very rarely the case for third-party developers wanting to extend OMERO, only the creation of blitz services will be discussed here.

Add a slice definition

The easiest possible service definition in slice is:

```
module example {
  interface NewService {
    void doSomething();
  };
}
```

This should be added to any existing or a new `.ice` file under the `blitz/resources/omero` directory. After the next ant build, stubs will be created for all the *OMERO.blitz* languages, i.e. *OMERO Java language bindings*, *OMERO Python language bindings*, and *OMERO C++ language bindings*.

**Note:** Once you have gotten your code working, it is most re-usable if you can put it all in a single directory under `tools/`. These components also have their `resources/*.ice` files turned into code, and they can produce their own artifacts which you can distribute without modifying the main code base.

Warning: exceptions

You will need to think carefully about what exceptions to handle. Ice (especially *OMERO C++ language bindings*) does not handle exceptions well that are not strictly defined. In general, if you would like to add your own exception type, feel free to do so, but either 1) subclass `omero::ServerError` or 2) add to the appropriate `throws` clauses. And regardless, if you are accessing any internal OMERO API, add `omero::ServerError` to your `throws` clause.

See *Exception handling* for more information.

Java implementation using _Disp

To implement your service, create a class subclassing “example._NewServiceDisp” class which was code-generated. In this example, the class would be named “NewServiceI” by convention. If this service needs to make use of any of the internal API, it should do so via dependency injection. For example, to use IQuery add either:

```java
void setLocalQuery(LocalQuery query) {
  this.query = query;
}
```

or

```java
NewServiceI(LocalQuery query) {
  this.query = query;
}
```

The next step “Java Configuration” will take care of how those objects get injected.

---

12 https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/common/src/ome/api
13 https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/blitz/resources/omero
Java implementation using _Tie

Rather than subclassing the _Disp object, it is also possible to implement the _Tie interface for your new service. This allows wrapping and testing your implementation more easily at the cost of a little indirection. You can see how such an object is configured in blitz-servantDefinitions14.

Java configuration

Configuration in the Java servers takes place via Spring15. One or more files matching a pattern like ome/services/blitz-*\.xml should be added to your application.

```xml
<?xml version="1.0" encoding="UTF-8"?>
<!DOCTYPE beans PUBLIC "-//SPRING//DTD BEAN//EN" "http://www.springframework.org/dtd/spring-beans.dtd">
<beans>
  <bean class="NewServiceI">
    <description>
      This is a simple bean definition in Spring. The description is not necessary.
    </description>
    <constructor-arg ref="internal-ome.api.IQuery"/>
  </bean>
</beans>
```

The three patterns which are available are:

- ome/services/blitz-*\.xml - highest-level objects which have access to all the other defined objects.
- ome/services/services-*\.xml - internal server objects which do not have access to blitz-*\.xml objects.
- ome/services/db-*\.xml - base connection and security objects. These will be included in background java process like the index and pixeldata handlers.

Note: Password Provider and similar should be included at this level.

See components/blitz/resources/ome/services16 and components/server/resources/ome/services17 for all the available objects.

Java deployment

Finally, these resources should all be added to OMERO_DIST/lib/server/extensions.jar:

- the code generated classes
- your NewServiceI.class file and any related classes
- your ome/service/blitz-*\.xml file (or other XML)

Future topics

Information on:

- implementation, configuration, and deploy in other OMERO.blitz languages
- Subclassing from existing servant implementation
- Using AMD to reduce server contention

will be provided in the future or upon request.

---

14https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/blitz/resources/ome/services/blitz-servantDefinitions.xml#L36
15http://spring.io
16https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/blitz/resources/ome/services
17https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/server/resources/ome/services
Non-service beans

In addition to writing your own services, the instructions above can be used to package any Spring-bean into the OMERO server. For example:

```java
//
// MyLoginAttemptListener.java
//
import ome.services.messages.LoginAttemptMessage;
import org.springframework.context.ApplicationListener;

/**
 * Trivial listener for login attempts.
 */
public class MyLoginAttemptListener implements ApplicationListener<LoginAttemptMessage> {
    public void onApplicationEvent(LoginAttemptMessage lam) {
        if (lam.success != null && !lam.success) {
            // Do something
        }
    }
}
```

```xml
<beans>
    <bean class="MyLoginAttemptListener" class="MyLoginAttemptListener">
        <description>
            This listener will be added to the Spring runtime and listen for all LoginAttemptMessages.
        </description>
    </bean>
</beans>
```

Putting `MyLoginAttemptListener.class` and `ome/services/blitz-myLoginListener.xml` into `lib/server/extensions.jar` is enough to activate your code:

```bash
~/example $ ls -l
MyLoginListener.class
MyLoginListener.java
lib

~/example $ jar cvf lib/server/extensions.jar MyLoginListener.class ome/services/blitz-myLoginListener.xml
added manifest
adding: MyLoginListener.class(in = 0) (out = 0)(stored 0%)
adding: ome/services/blitz-myLoginListener.xml(in = 0) (out = 0)(stored 0%)
```
Servers

With the OMERO.grid infrastructure, it is possible to have your own processes managed by the OMERO infrastructure. For example, at some sites, Nginx\(^\text{18}\) is started to host OMERO.web framework. Better integration is possible however, if your server also uses the Ice\(^\text{19}\) remoting framework.

One way or the other, to have your server started, monitored, and eventually shutdown by OMERO.grid, you will need to add it to the “application descriptor” for your site. When using:

```
bin/omero admin start
```

the application descriptor used is etc/grid/default.xml\(^\text{20}\). The `<application>` element contains various `<node>`s. Each node is a single daemon process that can start and stop other processes. Inside the nodes, you can either directly add a `<server>` element, or in order to reuse your description, you can use a `<server-instance>` which must refer to a `<server-template>`.

To clarify with an example, if you have a simple application which should watch for newly created Images and send you an email:

```
mail_on_import.py
```

you could add this in either of the following ways:

### Server element

```
<node name="my-emailer-node"> <!-- this could also be an existing node, but it must be unique -->
  <server id="my-emailer-server" exe="/home/josh/mail_on_import.py" activation="always">
    <env>${PYTHONPATH}</env>
    <!-- The adapter name must also be unique -->
    <adapter name="MyAdapter" register-process="true" endpoints="tcp"/>
  </server>
</node>
```

### Server-template and server-instance elements

```
<server-template id="emailer-template"> <!-- must also be unique -->
  <property name="user"/>
  <server id="emailer-server-${user}" exe="/home/${user}/mail_on_import.py" activation="always">
    <env>${PYTHONPATH}</env>
    <adapter name="MyAdapter" register-process="true" endpoints="tcp"/>
  </server>
</server-template>
<node name="our-emailer-node">
  <server-instance id="emailer-template" user="ann">
    <server-instance id="emailer-template" user="ann">
  </node>
```

See also:
[ome-devel] model description driven code generation\(^\text{21}\)

### 22.3 OMERO.blitz

The OMERO.blitz server is responsible for providing secure access to data and metadata via user sessions (OMERO sessions), and cleaning up all resources when they are no longer being used. Various server capabilities are accessed via a multitude of services collectively known as the OMERO Application Programming Interface.

---
\(^\text{18}\)http://wiki.nginx.org/Main
\(^\text{19}\)http://www.zeroc.com
\(^\text{20}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/grid/default.xml
22.3.1 Metadata

Metadata stored in an object-relational database is mapped into the OMERO OME-Remote Objects via Hibernate\(^\text{22}\). Hibernate Query Language (HQL) calls can be made against the server and have all ownership information automatically taken into account.

22.3.2 Image data

The binary image data can either be accessed in its raw form via the RawPixelsStore service, or can be rendered by the OMERO.server image rendering service.

22.4 OMERO.fs

OMERO.fs is a series of on-going changes designed to improve the way an OMERO.server interacts with existing directories of acquired image data. It currently consists of two components:

OMERO.dropbox is designed for watching a directory and kicking off an automatic import. The configuration of the DropBox system is covered on the OMERO.dropbox system administrator’s page.

OMERO.fs Managed Repository is designed to store original data in an unaltered form without requiring the data duplication that was carried out by a pre-5.0 import. The changes to the import system mean that an OMERO.fs server stores the original files in the ManagedRepository, preserving file names and any nested directory structure. This improves the way OMERO deals with High Content Screening (HCS) and other complex heterogeneous data types, reducing storage requirements and using Bio-Formats to recognize ‘filesets’ (groups of files which correspond to multi-dimensional images and accompanying information) so they can be treated as single entities within the OMERO clients.

22.4.1 FS Managed Repository

The OMERO 5 release introduces OMERO.fs, a new way of storing files in the OMERO binary repository and thus a new method of importing images to the server.

In previous versions of OMERO the import process was very much client-centered. When importing an image the client pushed pixel data, metadata and, optionally, original image files to the OMERO server. With the advent of OMERO 5, OMERO.fs allows the pixels to be accessed directly from the original image files. This means that much of the import process can now take place on the server once the original image files have been uploaded.

This page looks at the implications for the developer writing import clients. A broad description of the import workflow is followed by some of the model changes needed to facilitate this workflow. The current API sequence is then introduced before looking at server-side classes and sequence. Finally, the configuration required for OMERO.fs is specified.

Import overview

The broad import workflow comprises selecting a file or set of files to be imported client-side. Using Bio-Formats on the client this selection is resolved into a number of import candidates. Here an import candidate is a file or set of files that represents a single image, a multi-image set or a plate. Each import candidate, which may be one file or several files, is then treated as Fileset for import. The import of each Fileset is then undertaken by the client in two stages: upload and server-side import.

A Fileset is uploaded to the server into a location determined by the server, multiple Filesets may be uploaded in parallel by a client. A checksum is calculated before upload by the client and after upload by the server. If these checksums match then the client triggers a server-side import. The client can then move on to doing other work and leave the import to complete on the server.

Once the Fileset is on the server and an import has been initiated by the client all processing then takes place on the server. The server then uses Bio-Formats to extract and store the metadata, calculate the minimum and maximum pixel values and do other import processing.

\(^\text{22}\)http://www.hibernate.org
Model description

See acquisition.ome.xml

- ome.model.fs.Fileset
  - Represents a group of files which are considered to belong together.
  - There is the possibility that a single client fileset will be one or more datasets in Bio-Formats. We need to decide to either model this or to use a special reader (DirectoryReader?) on the server.
  - Also links to multiple ome.model.jobs.Job instances.
  - In development: links to the plate and image objects which are created during import.
- ome.model.jobs.Job subclasses
  - Each one represents some action which takes place server-side on the Fileset.
  - For the standard sequence described above, the first will always be an UploadJob which contains version info from the client. If the files were not uploaded however, this may not be the case. Then a MetadataImportJob follows, which is the basic import.
  - Other jobs may be necessary for regular usage (PixelDataJob, IndexingJob, etc.). Later jobs may also be added like a re-parse job with another FilesetVersionInfo instance, a re-check of the sha1s to look for corruption, or an archive job.
  - For job definitions, see jobs.ome.xml
- ome.model.fs.FilesetEntry
  - Link from a Fileset to exactly one ome.model.core.OriginalFile
  - Critically, it also contains the original absolute client path of that file.
- ome.model.fs.FilesetVersionInfo
  - In development: A snapshot of process information along with software versions. Most important for knowing how files were parsed, therefore when using importPaths, a “synthetic” version info might be created to say that these were just uploaded blindly.

API sequence

- Choose which files to import by either:
  - ImportLibrary and friends (Java only)
  - listing all files (not directories) manually.

- Choose a ManagedRepositoryPrx from SharedResourcesPrx.repositories().

- Call either:
  - ImportLibrary.importImage() which calls ManagedRepositoryPrx.importFilesets(Fileset, ImportSettings), or
  - directly use ManagedRepositoryPrx.importPaths(StringSet).

- Receive an ImportProcessPrx.

- For each FileEntry in the FileSet or each path in the StringSet (in order), call ImportProcessPrx.getUploader() and receive a RawFileStorePrx.

- Upload the file via RawFileStorePrx.write() while reading the files locally to write, be sure to calculate the checksum.

- Pass a list of checksums (in order) to ImportProcessPrx.verifyUpload(StringSet). If the hashes match, receive a HandlePrx. Otherwise an exception is thrown.

At this point, the client should be able to disconnect and the rest of the import should happen independently.

- Create an CmdCallbackI that wraps the HandlePrx and wait for successful completion.
At this point, the main metadata import is finished, but background processing may still be occurring. Handles for the background processing will also be returned.

Server-side classes/concepts

AbstractRepositoryI and all of its subclasses are implementations of the InternalRepository API. These objects are for internal use only and should never be accessible by the clients. Each instance is initialized with a directory which the servant attempts to "acquire" (i.e. grab a lock file). Once it does so, it is the serving repository.

Each internal repository provides a public view which in turn provides the Repository API. All method calls assume Unix-style strings, which are guaranteed by CheckedPath, a loose wrapper around java.io.File. CheckedPath objects along with the active Ice.Current instance are passed to the RepositoryDao interface, which provides database access for all repositories. Access to raw IO is provided by the RepoRawFileStoreI servant, which wraps a RawFileBean.

The ManagedRepository implementation is responsible for import and enforces further constraints (beyond those of CheckedPath) on where and what files are created. Most importantly, the omero.fs.repo.path template value is expanded and pre-pended to all uploads. A further responsibility of the ManagedRepository is to maintain a list of all currently running ManagedImportProcessI, each of which is held in the ProcessContainer. These ManagedImportProcessI instances further wrap RepoRawFileStoreI instances with a subclass, ManagedRawFileStoreI.

Server-side sequence

NB: Server-side ImportLibrary is no longer being used. That logic is currently moved to ManagedImportRequestI. This may not be the best location. Further, several other layers might also be collapsible, like OMEROMetadataStore which is currently accessible as a “hidden” service MetadataStorePrx. Here, “hidden” means that it’s not directly retrievable from ServiceFactoryPrx.

- ManagedRepositoryI.importPaths()
  - re-uses ImportContainer.fillData() to create an ImportSettings and a Fileset and then calls importFileset(Fileset, ImportSettings)

- ManagedRepositoryI.importFileset()
  - determines an ImportLocation calling PublicRepositoryI.makeDir() where necessary.
  - createImportProcess creates a ManagedImportProcessI, registers it, and returns it.
  - After this, the repository is only responsible for periodically having the ping and eventually the shutdown method called, via ProcessContainer.

- ManagedImportProcessI.getUploader()
  - creates a new RepositoryRawFileStoreI for each file in the paths/fileset.
  - Once close() is called on this instance, closeCalled(int i) will be called on the import process and the instance will be removed.
  - If getUploader() is called again, then a new file store will be created.

- ManagedImportProcessI.verifyUpload()
  - If all hashes match, then a ManagedImportRequestI instance is created and submitted to omero.cmd.SessionI.submit_async() for background processing. The client can wait for the returned omero.cmd.HandlePrx to finish by using a CmdCallbackI.
  - At this point, the ImportProcessPrx can be closed as well as the entire client and the import would still continue. Only if HandlePrx.cancel() is called, will the import be aborted.
  - QUESTION: How to handle rollback at this point?

- ManagedImportRequestI.init (within transaction)
  - Registry.getInternalServiceFactory() grabs a ServiceFactoryPrx without the need for an omero.client instance.
  - OMEROWrapper and a OMEROMetadataStoreClient are created with this connection.
  - Some other basic configuration takes place.
• ManagedImportRequest.step() (N times, each within same transaction as init())
  – NB: it may later make more sense for this bit to happen in a separate process.
  – At the moment, 5 steps are hard-coded. Each performing roughly the same amount of work. Some of these may later be done in the background.
    * importMetadata() calls store.saveToDB(), which calls MetadataStorePrx.saveToDb(), a remote call. This could possibly be inlined.
    * generateThumbnails() calls store.resetDefaultsAndGenerateThumbnails(), another remote call, which could also be inlined.
    * pixelData() calls store.setPixelsParams(), updatePixels(), and populateMinMax(). Min/Max especially should be backgrounded.
    * Finally, store.launchProcessing() is called, which should remain, but could also be inlined. The returned script processes could be returned in the ImportResponse.
    * Return appropriate values.
  – notifyObservers() currently does nothing, since this was client-side functionality in ImportLibrary. This needs to be replaced!
• ManagedImportRequest.buildResponse() (N times, outside the transaction)
  – Only step 4 does anything, storing the pixels in a ImportResponse
• ManagedImportRequest.getResponse() (1 time, regardless of exception or not)
  – Performs cleanup, then returns the ImportResponse assuming that no call to helper.cancel() has been made. At this point, ImportLibrary.importImage() returns successfully.

Configuration properties

• omero.data.dir - singleton property (i.e. once globally) which points to the legacy repository location for OMERO. For OMERO to run on multiple systems, the contents of this directory must be on a shared volume.

• omero.managed.dir - singleton property point to the default ManagedRepository. In an OMERO install in which there is only one Blitz server, this will be the only repository. Need not be located under omero.data.dir but is by default.

• omero.fs.repo.path - the template which determines the path that will be created inside of a managed repository. It is this value which makes the ManagedRepository “managed”.

• omero.repo.dir - value passed to all non-legacy, standalone repositories. This is not actively used, but would allow hosting repositories on multiple physical systems without the need for a shared volume. For example, after running bin/omero admin start on the main machine, it would be possible to launch nodes on various machines via bin/omero node start fs-B,bin/omero node start fs-C, etc. Each of these would pass a different omero.repo.dir value to its process.

See also:
FS configuration options

22.5 OMERO.processor

The Processor is a python process-launcher which can be run on any Unix system to execute scripts for a user. This makes use of the scripting service functionality. As many processor nodes can be started as physical computers are available.

• Source code: components/tools/OmeroPy/src/omero/processor.py
  
• Documentation: OMERO.grid

---

23https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/tools/OmeroPy/src/omero/processor.py
22.6 OMERO.server image rendering

A major requirement for any image data application is the ability to display images. In most applications, this is achieved by reading pixel data from a filesystem and then mapping the pixel data to the 256 grey level available on most computer display monitors. It is common in some experiments to record and display multiple channels at once. Typically three, four, or even five separate images must be mapped, and then presented as a color image for painting on a monitor. Because these operations can require many thousands of operations and must be displayed rapidly to support the display of time-lapse movies, most image display software applications use a high-speed graphics CPU and dedicated hardware for image rendering and display. This requirement limits the deployment of these applications to high-powered workstations.

OMERO.server includes an image server, a software application that delivers rendered images to a client. This ensures that client applications can display image data. The OMERO Rendering Engine (OMERO-RE) has been designed to minimize the amount of data transferred to the client and thus removes the requirement for a specific graphics CPU, allowing high-performance image viewing on standard laptop computers. The OMERO-RE achieves this by limiting data transfer times by being close to the data, using highly efficient network transfer protocols, utilizing modern multi-processor and multi-core machines to provide the data to clients in a format that is as efficient to display as possible. OMERO-RE is multi-threaded and can use multi-core servers to simultaneously render individual channels before assembly into a final color image ready for transfer to the client. The use of the RE is not mandatory. If a client needs to have the full pixel data, it can. This OriginalPixels facility is used for client-side analysis, like that performed in the OMERO.insight measurement tool.

Transfer of image data even after rendering can limit performance, especially when accessing data remotely on connections with limited bandwidth (e.g. domestic ADSL). Therefore the OMERO-RE contains a compression service with an API that allows a client adjustable compression providing minimal image artefacts and a 20-fold range of data size to the client.

The OMERO Rendering Engine is accessed by OMERO client applications written in Java, C++, or Python via a binary protocol (ICE) provided by ZeroC24.

22.7 Clustering

Clustering an OMERO instance consists of starting multiple OMERO.blitz servers with each allocating user sessions based on some criteria. There are at least two reasons you may want to cluster the OMERO server: availability and throughput.

22.7.1 Availability

Having the ability to have two servers up at the same time implies that even if you have to restart one of the servers, there should be no down-time. Currently, OMERO sessions are sticky to a cluster node and so it is not possible shutdown a node at any time. All new sessions can be redirected to the server which is to be left turned on however, then when all active sessions have completed, the chosen server can be shutdown.

22.7.2 Throughput

The other main reason to have other servers running is to service more user sessions simultaneously. Out of the box, each OMERO.blitz process is configured for 400MB of memory. When dealing with memory intensive operations like rendering, each added server can make a positive difference. This is only a part of the story, since much of the bottleneck is not the server itself but other shared resources, like the database or the filesystem, and so to further extend throughput, you will need to parallelize these.

22.7.3 Installation

If you are using the default OMERO.grid application descriptor25 quickly enabling clustering is as simple as executing:

```
bin/omero config set omero.cluster.redirector configRedirector
bin/omero node backup start
```

24http://www.zeroc.com
25https://github.com/openmicroscopy/openmicroscopy/blob/develop/etc/grid/default.xml
This starts a second node, named “backup”, which contains a second OMERO.blitz server, “Blitz-1”. By default, this newly created server will not be used until sessions are manually redirected to it.

See also:

Scaling Omero

### 22.8 Collection counts

The IContainer interface has always provided a method for returning the count of some collection types via `getDetails().getCounts()`. Previous to 3.0-Beta3, the counting process was fairly time intensive, and has been removed.

In its place, the 3.0-Beta3 server has database views for all link collections. These are accessed through HQL directly, such as:

```java
Long self = iAdmin.getEventContext().getCurrentUserId();
Image i = iQuery.findByQuery(
    "select i from Image i left outer join fetch i.annotationLinksCountPerOwner", null);
Map<Long, Long> countsPerOwner = i.getAnnotationLinksCountPerOwner();

// Map may be null if not fetched.
if (countsPerOwner != null) {
    // countOfAnnotationsForImageByUser
    Long count = countsPerOwner.get(self);
    if (count != null) {
        // do something
    }
}
```

Values written to the map will not be persisted to the database, since they are continually re-generated.

#### 22.8.1 Pojo options

The PojoOptions configuration of what elements are counted has been removed from the API. Instead, the returned map contains all values for all users, and can be summed to acquire the total count.

#### 22.8.2 Restrictions

Currently a Hibernate bug (waiting to be filed) prevents retrieving the counts on any other than the top-level object (“select this”).

#### 22.8.3 Instructions

Starting with OMERO3A__3, the views.sql script is automatically executed when initializing your database. If you have an older database, upgrade it to the latest version, and apply the `views.sql` manually.

#### 22.9 How To create a service

26https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/IContainer.java
Overview

These instructions are for core developers only and may be slightly out of date. They will eventually be revised, but if you are looking for general instructions on extending OMERO with a service, see Extending OMERO. If you would indeed like to create a core service, please contact the ome-devel mailing list.

To fulfill #306, r905 provides all the classes and modifications needed to create a new stateless service (where this varies from stateful services is also detailed). In brief, a service provider must create an interface, an implementation of that interface, a Spring configuration file, as well as modify the server configuration and the central service factory. (These last two points stand to change with #314).

Note: With the creation of OMERO.blitz, there are several other locations which need to be modified. These are also listed below.

22.9.1 Files to create

components/common/src/ome/api/IConfig.java: the interface which will be made available to client and server alike (which is why all interfaces must be located in the /common component). Only serializable and client-available types should enter or exit the API. Must subclass `ome.api.ServiceInterface`.

components/server/src/ome/logic/ConfigImpl.java: the implementation which will usually subclass AbstractLevel{1,2}Service or AbstractBean (See more below on super-classes) This is class obviously requires the most work, both to fulfill the interface’s contract and to provide all the metadata (annotations) necessary to properly deploy the service.

components/server/resources/ome/services/service-ome.api.IConfig.xml: a Spring configuration file, which can “inject” any value available in the server (Omero) context into the implementation. Two short definitions are the minimum. (Currently not definable with annotations.) As explained in the file, the name of the file is not required and in fact the two definitions can be added to any of the files which fall within the lookup definition in the server’s beanRefContext.xml file (see below).

components/blitz/src/ome/services/blitz/impl/ConfigI.java: a Ice “servant” implementation which can use on of several methods for delegating to the ome.api.IConfig interface, but all of which support throttling.

22.9.2 Files to edit (not strictly necessary, see #314)

components/common/src/ome/system/ServiceFactory.java: our central API factory, needs an additional method for looking up the new interface (get<interface name>Service())

components/server/resources/ome/services/server Spring configurations, which makes the use of JNDI and JAAS significantly simpler.

components/blitz/resources/omero/API.ice: a ZeroC slice definition file, which provides cross-language mappings. Add the same service method to ServiceFactoryI as to ServiceFactory.java.

components/blitz/resources/ome/services/blitz-servantDefinitions.xml: a Spring configuration, which defines a mapping between Ice servants and Java services.

---

27 http://trac.openmicroscopy.org.uk/ome/ticket/306
28 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/api/IConfig.java
29 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/logic/ConfigImpl.java
30 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/service-ome.api.IConfig.xml
31 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/
33 http://trac.openmicroscopy.org.uk/ome/ticket/314
34 http://spring.io
35 http://trac.openmicroscopy.org.uk/ome/ticket/306
36 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/beanRefContext.xml
37 http://spring.io
38 http://trac.openmicroscopy.org.uk/ome/ticket/314
39 http://www.zeroc.com
40 http://www.zeroc.com
41 http://spring.io
42
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22.9. How To create a service
components/blitz/resources/omero/Constants.ice\(^{48}\) (blitz) a ZeroC\(^{49}\) slice definition file, which provides constants needed for looking up services, etc.

components/blitz/src/ome/services/blitz/impl/ServiceFactoryI.java\(^{50}\) (blitz) the central session in a blitz. Should always be edited parallel to ServiceFactory.java. Also optional in that MyServicePrxHelper.uncheckedCast(serviceFactoryI.getName(String)) can be used instead.

### 22.9.3 Files involved

components/server/resources/beanRefContext.xml\(^{51}\)

components/blitz/resources/beanRefContext.xml\(^{52}\) Singleton definitions\(^{53}\) which allow for the static location of the active context. These do not need to be edited, but in the case of the server beanRefContext.xml\(^{54}\), it does define which files will be used to create the new context (of importance is the line `classpath*:ome/services/service-*-*.xml`). blitz’s beanRefContext.xml defines the pattern `classpath*:ome/services/blitz-*-*.xml` to allow for blitz-specific configuration.

### 22.9.4 And do not forget the tests

components/server/test/ome/server/itests/ConfigTest.java\(^{55}\) tests only the implementation without a container.

  blitz: Currently, testing blitz is outside the scope of this document.

### 22.9.5 Things to be aware of

**Local APIs**

Several services implement a server-side subclass of the `ome.api` interface rather than the interface itself. These interfaces are typically in `ome.api.local`. Such local interfaces can provide methods that should not be made available to clients, but which are needed within the server. Though not currently used, the `@Local()` annotation on the implementation can list the local interface for future use. See `UpdateImpl`\(^{57}\) for an example.

**Stateful services**

Currently all stateful services are in their own component (components/rendering and components/romio) but their interface will still need to be under components/common for them to be accessible to clients. To be done.

### 22.10 OMERO sessions

Beginning with OMERO-3.0-Beta3, the OMERO server has unified the handling of login sessions among both the JBoss and the OMERO.blitz servers. Previously JBoss logins were handled via the standard JAAS\(^{61}\) mechanisms, using a modified `DatabaseLoginModule`. This proved problematic for several reasons:

1. Exceptions thrown during login could not easily be caught or specified.
2. Passwords were sent in the clear on every invocation.
3. SQL queries on every invocation caused significant overhead.

\(^{48}\)http://www.zeroc.com

\(^{51}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/beanRefContext.xml

\(^{53}\)http://docs.spring.io/spring/docs/2.x/reference/beans.html#beans-factory-scopes-singleton

\(^{54}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/beanRefContext.xml

\(^{56}\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/server/src/ome/api/local

\(^{57}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/logic/UpdateImpl.java

\(^{58}\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/rendering

\(^{59}\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/romio

\(^{60}\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/common

\(^{61}\)http://www.oracle.com/technetwork/java/javase/tech/index-jsp-136007.html
Blitz did not suffer from these problems, but the login functionality was largely outside of the core server code and sessions were more volatile: a loss of an Ice connection caused all resources to be lost. With OMERO sessions, both login systems have been brought together and simplified.

In short:

- Sessions are a replacement for the standard JavaEE security infrastructure.
- Sessions unify the Blitz and RMI session handling, making working with Java RMI more like Blitz (since the JavaEE interaction is essentially “conversationless”).
- Sessions provide the ability (especially in Blitz) to quit a session and rejoin it later as long as it has not timed out, possibly useful for moving from one machine to another.
- Sessions provide the ability to share the same space. Two users/clients attached to the same session would experience the same life-cycle.
- Sessions provide a scratch space to which any data can be written for and by job/script executions.
- Sessions act as a global cache (in memory or on disk) to speed up various server tasks, including login. With further extensions like http://terracotta.org/, sessions could serve as a “distributed” cache.
- Sessions prevent sending passwords in plain text or any other form. After that, all session interactions take place via a shared secret key.

22.10.1 Design

All services other than ISession, assume that a user is logging in with a username equal to session uuid. Whereas previously one logged in with:

```java
ome.system.Principal p = new ome.system.Principal("josh","user","User");
```

behind the scenes, now the “josh” value is replaced by the UUID of a ome.model.meta.Session instance.

The session is acquired by a call to:

```java
ome.api.ISession.createSession(Principal principal, String credentials);
```

and carries information related to the current user’s session.

```java
Session session;
session.getUuid(); // Unique identifier; functions as a temporary password. DO NOT SHARE IT.
session.getTimeToIdle(); // Number of milliseconds which the user can idle without session timeout
session.getTimeToLive(); // Total number of milliseconds for which the session can live
session.getStarted(); // Start of session
session.getClosed(); // if != null, then session is closed
```

These properties cannot be modified.

Other properties are for use by clients:

```java
session.getMessage(); // General purpose message statement
session.getAgent(); // Can be used to specify which program the user is using
session.getDefaultEventType(); // Default event type (the third argument "User" to Principal above)
session.getDefaultPermissions(); // String representation of umask (e.g. "rw----")
```

After changing a property on the session returned by `createSession()` it is possible to save them to the server via:

```java
ome.api.ISession.updateSession(Session);
```

Finally, when finished, to conserve resources it is possible to destroy the session via:
OMERO Documentation, Release 5.0.2

OMERO.blitz Session Creation and Destruction

22.10. OMERO sessions
```java
client = omero.client()

servicefactory = client.createSession()

iadmin = servicefactory.getAdminService()

olduuid = iadmin.getEventContext().sessionUuid

// lose connection

client = omero.client()

servicefactory = client.createSession(omero.sys.Principal(), olduuid)

// now reattached
```

## 22.10.2 Existing sessions

In `OMERO.blitz`, once the connection to a `ServiceFactoryPrx` (a Glacier2 Session subclass) was lost, it was not possible to reconnect to any of the services created using that connection. Now it is possible to reacquire the session if it is still active, by passing the previous session UUID as your password (User principal is ignored).

```java
client = omero.client()

servicefactory = client.createSession()

iadmin = servicefactory.getAdminService()

olduuid = iadmin.getEventContext().sessionUuid

// lose connection

client = omero.client()

servicefactory = client.createSession(omero.sys.Principal(), olduuid)

// now reattached
```

## 22.10.3 Backwards compatibility

In the short-term, there is no need for any change to client code to make use of the new sessions.

`ome.system.ServiceFactory` has been modified to automatically acquire a session before the first service call is made. Eventually, clients will want to make use of the session API and catch session exceptions to have a finer control of the client lifecycle.

Similarly, no changes are needed in `OMERO.blitz` client code since Glacier2 sessions now delegate to `OMERO sessions`. Clients can access the ISession service when necessary. Exceptions thrown are still Ice-based.

See also:

*Server security and firewalls*

## 22.11 Aspect-oriented programming

Aspect-oriented programming is, among other things, the attempt to define and centralize cross-cutting concerns. In other words, it is not much more than the tried-and-true principle of modularization. Having possibly unseen aspects operating on a given class however, can complicate an initial examination of the code. Therefore, it is important to be aware of what portions of the OMERO code base are “advised” and where to find the advisors (in the case of OMERO solely interceptors).

In Spring\(^{62}\), advisors are declared in the bean definition files (under `components/server/resources/ome/services\(^{63}\), `services.xml`\(^{64}\), `hibernate.xml`\(^{65}\), and others.

In these configuration files, various Spring beans (shared objects) are defined with names like “proxyHandler”, “eventHandler”, “serviceHandler”, and “transactionHandler”. Each of these is a method interceptor which is passed execution before the actual logic is reached. The interceptor can inspect or replace the return value, but can also stop the method execution from ever taking place.

Unlikely with AspectJ\(^{66}\), the AOP implementation used by OMERO only allows for the advising of interfaces. Simply creating a new service implementation via “new QueryImpl()” will not produce an advised object, which in turn will not function properly, if at all. Instead, advised objects can only be acquired from the Spring context.

By and large, only the *API service methods* are advised in OMERO.

\(^{62}\)http://spring.io

\(^{63}\)https://github.com/openmicroscopy/openmicroscopy/tree/develop/components/server/resources/ome/services

\(^{64}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/services.xml

\(^{65}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/hibernate.xml

\(^{66}\)http://eclipse.org/aspectj/
22.11.1 Why?

Often, when implementing or adding code, it becomes clear just how many requirements are placed by libraries, the application server, and existing code on any new code. This can include transaction handling, session handling, security checks, object validation, logging etc. As a code-base grows, these dependencies slow development and make code unmanageable. AOP tries to reduce these dependencies by defining each of these concerns in a single place.

As a quick example, in OMERO transactions and exceptions are handled through method interceptors. Rather than writing:

```java
void method1(){
    try {
        Transaction tx = new Transaction();
        tx.begin();
        // your code goes here
        tx.commit();
    } catch (TxException e) {
        tx.rollback();
    } catch (OtherException e) {
    }
}
```

you just write:

```java
void method1(){
    // your code goes here
}
```

See also:

Aspect Oriented Programming\(^{67}\) Chapter of the Spring documentation
AOP Alliance\(^{68}\) Joint project defining interfaces for various AOP implementations
AspectJ\(^{69}\) The arguable leader in Java/AOP development. Not used in Omero, but a good starting point.
Aspect-oriented programming\(^{70}\) Wikipedia page on AOP

22.12 OmeroContext

The entire OMERO application (on a single JVM) resides in a single `ome.system.OmeroContext`. Each call belongs additionally to a single `org.hibernate.Session` (which can span over multiple calls) and to a single `ome.model.meta.Event` (which is restricted to a single task).

The container for all OMERO applications is the `OmeroContext` (components/common/src/ome/system/OmeroContext.java\(^{71}\)). Based on the Spring\(^{72}\) configuration backing the context, it can be one of `client`, `internal`, or `managed`. The use of a `ServiceFactory` simplifies this usage for the client.

22.12.1 Hibernate sessions

A Hibernate `Session` comprises a Unit-of-Work\(^{73}\) which translates for OMERO’s `OME-Remote Objects` model to a relational database. It keeps references to all Database-backed objects so that within a single session, object-identity stays constant and object changes can be persisted.

\(^{67}\)https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/src/ome/system/OmeroContext.java
\(^{68}\)http://spring.io
\(^{69}\)http://www.martinfowler.com/eaaCatalog/unitOfWork.html
A session can span multiple calls by being disconnected from the underlying database transaction, and then reconnected to a new transaction on the next call (see components/server/src/ome/tools/hibernate/SessionHandler.java\textsuperscript{74} for the implementation). For information about Events see *OMERO events and provenance*.

\textsuperscript{74}https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/tools/hibernate/SessionHandler.java
22.13 OMERO events and provenance

22.13.1 What is an event?

As described under OmeroContext, each method call takes place within a single application context (always the same), session, and event. Of these, only event is guaranteed to be unique for every task*. The components/server/src/ome/security/basic/EventHandler.java is responsible for creating new events.

22.13.2 Events as audit log

On each Database-update (INSERT/UPDATE/DELETE), an EventLog is created by a HibernateInterceptor which is then saved to the database at the end of the method call (in UpdateImpl).

22.13.3 Relationship to ModuleExecutions

The OMERO Event plays a similar role to the ModuleExecution in the OME 2 system. They both contain time of create/update/deletion, status, and type information. Event, however, has lost its ACL/permissions role. These values have been moved to embedded values represented by the Details object. Event also is not linked to all the created SemanticTypes as was ModuleExecution, and so cannot fully represent the provenance data needed by the AnalysisEngine. At such time as the AnalysisEngine is ported to Java, the ModuleExecution object will have to be added.

* Here we say “task” and not method call, because all method calls to a single stateful service instance belong to the same event. This is the nature of a stateful service. Logically, however, it is a single action.

See also:

Hibernate events

22.14 Properties

As of milestone OMERO-Beta4 (Milestone 800), client usage of these properties has significantly changed. Please see the sysadmin documentation for how to configure your server installation.

Under the etc/ directory in both the source and the binary distributions, several files are provided which help to configure OMERO server:

<table>
<thead>
<tr>
<th>File</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>etc/omero.properties</td>
<td>Our central configuration file with all defaults.</td>
</tr>
<tr>
<td>etc/hibernate.properties</td>
<td>Required by Hibernate since some properties are only configurable</td>
</tr>
<tr>
<td>etc/logback.xml</td>
<td>Log configuration</td>
</tr>
<tr>
<td>etc/local.properties.example</td>
<td>The properties that you will most likely want to change.</td>
</tr>
<tr>
<td>etc/local.properties</td>
<td>This file can be copied to etc/local.properties to being, or alternatively you can run &quot;java omero setup&quot;</td>
</tr>
<tr>
<td></td>
<td>(Name will change to &quot;...default&quot;)</td>
</tr>
<tr>
<td>etc/local.properties</td>
<td>Local overrides for other properties (used by build only)</td>
</tr>
</tbody>
</table>

During the build, these files get stored in the blitz.jar and are read-only. On creation of an OmeroContext, the lookup for properties is (first wins):

- Properties passed into the constructor (if none, then the default properties in config.xml)
- System.properties set via “java -Dproperty=value”

---

75 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/src/ome/security/basic/EventHandler.java
77 http://trac.openmicroscopy.org.uk/ome/milestone/OMERO-Beta4
78 http://trac.openmicroscopy.org.uk/ome/ticket/800
79 https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/common/resources/ome/config.xml
• Configuration files in order listed.

This ordering is defined for the various components via “placeholder configurers” in:

• components/server/resources/ome/services/services.xml

Once configured at start, all values declared in one of the mentioned ways can be used in Spring configurations via the syntax:

```xml
<bean id="...">
  <property name="mySetter" value="${property.name}"/>
</bean>
```

### 22.15 Queries

![Diagram](image)

Figure 22.3: omero.services.query

#### 22.15.1 Introduction

The ome.services.queries package is intended to allow for the easy definition of queries by both developers and clients. Due to the fragility of HQL defined queries, a framework allowing for easy definition, multiple formats (Velocity templates, Database values, class files), and transparent lookup is critical.

Lookup happens among all QuerySources that are registered with the QueryFactory instance present in OMERO services. The first non-null Query instance returned by a QuerySource for a given String id is used.

Queries implement the HibernateCallback interface and are passed directly into a HibernateTemplate instance. Therefore, care should be taken as to which QuerySources are registered with the QueryFactory.

---

80[https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/services.xml](https://github.com/openmicroscopy/openmicroscopy/blob/develop/components/server/resources/ome/services/services.xml)
22.15.2 Parameters

Critical for using queries is the specification of named parameters, number of results to return, offset of the first result to return etc. These features are offered by the ome.parameters package. The ome.parameters.Parameters class is the starting point for building new parameters (although the ome.parameters.Filter object is used by some methods).

To specify parameters, instantiate a Parameters object either with or without a Filter object argument. The version with Filter object is useful for specifying the number of results to be returned and whether or not a java.util.Collection or a ome.model.IObject instance will be returned. For example,

```java
Parameters p = new Parameters( new Filter().unique() );
```

will specify that the given query should return a single instance. An exception will be thrown if more than one result is found.

```java
Parameters p = new Parameters( new Filter().unique().page(0,1) );
```

However, this will guarantee that only one result will be returned, since more than 1 result (“maxResults”) will be ignored. Here, an ordering of the results might make sense.

Once a Parameters instance is available, named parameters can be added using any of the add…() methods. These parameters will be dynamically bound during query preparation. For example, a query of the form:

```java
select e from Experimenter e where omeName = :name
```

has one named parameter “name”, which can be specified by the call:

```java
parameters.addString("name","<myNamHere>");
```

Positional parameters of the form

```java
select e from Experimenter where omeName = ?
```

are not supported.

22.15.3 Adding queries

Subclassing query

Other than by defining String queries via new QueryDef() TBD, the easiest way to create queries is to subclass ome.services.query.Query. The only non-optional requirements on the Query implementor are then to define the (possibly optional) named parameters to the Query, and to override the “buildQuery” (which must call one and only one of “setQuery()” or “setCriteria()”)

Other than that, the Query implementor can enable filters on the Hibernate session (an attempt is made to clean up after the Query runs), and in general use any of the Hibernate session methods.

22.15.4 Defining a QuerySource

A more involved but perhaps more rewarding method would be to implement QuerySource and configure QueryFactory to lookup query ids also in your QuerySource. This would allow you to write Velocity (or Freemarker/Ruby/Python/Groovy…) QuerySources which use some form of templating or scripting to generate HQL queries.
22.16 OMERO throttling

Throttling consists of reducing the total number of resources that one user or group can consume at a given time. The throttling service is a new component of OMERO.blitz which should ensure a more fair usage.

For example, each blitz server has a pre-defined maximum number of server threads. Any calls beyond this number must wait on a currently executing call to finish. Before throttling, a single user could consume all the available threads and all other users would have to wait.

With throttling, all invocations are placed on configurable on a queue which is worked on my any number of configurable slots. Each site can configure the number and type of slots based on which throttling strategy has been chosen.

22.16.1 Planning

Planned for milestone:3.0-Beta4, the infrastructure for throttling was committed to milestone 3.0-Beta3.1\(^\text{[81]}\) with the in-thread strategy, which uses the calling thread for execution. This provides the same semantics as the current blitz server.

Other strategies include:

- a per-session strategy
- a per-user strategy
- a per-group strategy

each of which allows the session, user, or group a fair slice of execution, but no more. Within each strategy, the order of operation is guaranteed not to change once the execution reaches the server. However, there is nothing the server can do to prevent re-ordering if two calls are made by the client simultaneously.

More advanced strategies are possible based on total consumed resources over some window, or even a service-level agreement (SLA) or Quality of Service (QoS)-style planning. All strategies must guarantee a proper method ordering.

It is also intended that the throttling service provide limits to memory usage, database hits within a single transaction, and total execution time.

22.16.2 Terminology

- **Slots** - are the number of available executions that a single session, user, or group can perform simultaneously on a single machine. (If the server is clustered, there will be the given number of slots per hosts)

- **Hard** and **soft** limits - hard limits throw an OverUsageException and require some form of compensation on the clients. Soft limits, on the other hand, simply slow down, or throttle, execution to give other operations a chance to succeed.

- **Strictness** - when a strategy is configured as strict, then once a session, user, or group has reached its limits, the hard or soft limit will be enforced even if no one else is using the server. A non-strict policy will "borrow" someone else’s slot for the duration of one execution.

See also:

Scaling Omero

22.17 OMERO rendering engine

22.17.1 Description

The rendering component provides for the efficient rendering of raw pixels based on per-user display settings. A user can change settings and see them take effect in real time. Changes can also be persisted to the database and then viewed from another machine or even client.

---

\(^\text{[81]}\)http://trac.openmicroscopy.org.uk/ome/milestone/3.0-Beta3.1
22.17.2 Server-port

The rendering engine has been ported to also now sit on the server-side, though equally usable from any Java setting.

22.17.3 Optimizations

Here we have a listing of the various rendering engine optimizations that have taken place over time:

- Packed Integers (#449\[82\])
- Region Based Rendering (#450\[83\])
- Removal of RGB Rendering Model (#452\[84\])

22.17.4 Compression

With r1744 and r1748, the rendering engine now supports compression. (#6\[85\])

22.17.5 Design

The following diagrams describe the original design of the Rendering Engine. Designed initially for the client-side, much of this information needs to be updated. Textual explanations are included as notes in each diagram.

22.18 Scaling Omero

There are several ways that OMERO, or any server system, can scale. Optimizing your system for more than one of these factors is non-trivial, but we try to lay out some guidelines below for what has worked, what almost certainly will not work, and what – under the right circumstances – might be optimal.

22.18.1 Concurrent invocations

The bottlenecks for concurrent invocations are:

- database connections
- server threads
- the router

Database connections

Database servers, in general, have a maximum number of allowed connections. In postgres, the default max_connections is 100, though in many cases this will be significantly lower due to the available shared memory (SHMMAX). If OMERO were to use direct connections to the database, after max_connections invocations, all further attempts to connect to the server would fail with “too many connection” exceptions. Instead, OMERO uses a connection pool in front of Postgres, which manages many more simultaneous attempts to connect to the database.

With the default max_connection set to 64, it is possible to execute 500 queries simultaneously without database exceptions. Instead, one receives server exceptions.

\[82\]http://trac.openmicroscopy.org.uk/ome/ticket/449

\[83\]http://trac.openmicroscopy.org.uk/ome/ticket/450

\[84\]http://trac.openmicroscopy.org.uk/ome/ticket/452

\[85\]http://trac.openmicroscopy.org.uk/ome/ticket/6
Server threads

In OMERO.blitz, too many (500+ on the default configuration) simultaneous invocations will result in ConnectionLost exceptions. We are currently working on ways to extend the number of single invocations on one server, but a simpler solution is to start another OMERO.blitz server.

22.18.2 Total throughput

The bottlenecks for throughput are:

- maximum message size
- server memory
- IO
- network

See also:

OMERO.server and PostgreSQL
Instructions about OMERO.server and PostgreSQL under UNIX & UNIX-like platforms.

OMERO.server and PostgreSQL
Instructions about OMERO.server and PostgreSQL under Windows platforms.

OMERO.grid

#906

http://trac.openmicroscopy.org.uk/ome/ticket/906
22.19 SqlAction

Internal server interface used to wrap all calls which speak JDBC directly. This allows special logic to be introduced where necessary for each RDBM.

Calls which use Hibernate for the cross-database conversion can use the `org.hibernate.Session` interface.
An OME image can aggregate more than one set of pixels – an example would be an OME image that is linked both to the original image data acquired from the microscope (this is one set of pixels) and the deconvolved data (yet another pixel set). In order to visualize a given pixel set within an image, we need both a rendering context to hold all sort of visualization options and algorithms that, taking into account the context information, transform the raw data into an image that can be displayed on screen.

```java
// QuantumManager
- waves5k; QuantumStrategy
  int Strategies(quantumDef ImageState)
  getStrategyDef(int id); QuantumStrategy

// CodomainChain
- intervalStart; int
- intervalEnd; int
- LUT; int
- subLUT(); void
- execLUT(map<DBx>
- remapLUT(map<DBx>
- transform<DBx>

// CodomainChain

// QuantumManager

// RenderingStrategy

// Renderer

// PlaneDef

// PlaneDef

// DataSink

// getPlane2D(id; PlaneDef with)
```
Here are the key players in the quantization process — the process by which we limit the input pixel intensity values to a discrete set of values.

**QuantumStrategy**
- `globalMin`: Comparable
- `globalMax`: Comparable
- `windowStart`: Comparable
- `windowEnd`: Comparable

- `setIdentity()`: void
- `setWindowStart(start)`, `setWindowEnd(end)`: void
- `quantize()`: void
- `onWindowChange()`: void

**QuantumFactory**
- `getStrategy(q: QuantumDef)`: void

**Intensity-Transform**
- `computeStrategy()`: void
- `intensityTransform()`: void

**Value-Mapper**
- `getValueMapper()`: void

**Mapping-context**
- `#map-params`: 1

**Subclasses**
- Work on explicit pixel types (uint8, float32, etc.)
- Taking into account the pixel type, transform the intensity value passed to `quantize()` by delegating to the configured quantum map.
- Encapsulate a calculation strategy for the quantization process, i.e., LUTs and approximation.
- Implement `onWindowChange()` to get notified when the window interval changes.

Implementing classes (ExponentialMap, LogarithmicMap, PolynomialMap) transform values according to a given curve \( y(k) = f(k) \).

Coefficient \( k \) selects a curve in the family.
After quantization, we can apply a series of transformations that operate on the codomain (sub-interval of [0, 255]) of the initial quantum map to enhance the image. These are referred to as enhancements in the spatial domain. Here are the key classes that are involved in the process:

- **CodomainChain**
  - intvalEnd: int
  - int LUT: int
  - buildLUT: void
  - void updateMap(mapCB, int)
  - removeMap(mapCB, int)
  - transform(mapCB, int)

Each transformation is applied to the map and the result is stored in the LUT. The LUT is then used to compose the final image.

**CodomainMapContext**
- InteralStart: int
- InternalEnd: int
- setCodomainStart: void
- buildContext: void
- getCodomainMap: void
- copy: void
- equals: boolean (F/F)

This class manages the codomain map and provides methods to set and build the map context. It also allows for copying and checking equality of the map context.

**QuantumDef**
- family: int
- coefficient: double
- pixelType: double
- pixels: int
- pixelEnd: int
- colDef: int
- colResolution: int
- setResolution: void
- setActive: boolean

This class defines the parameters for the quantization process:
- Family: the type of quantization (linear, exponential, logarithmic, etc.)
- Coefficient: a parameter that affects the quantization
- PixelType: the type of image data (e.g., 8-bit, 16-bit)
- Pixels: the number of pixels in the quantization
- PixelEnd: the end index of the pixel data
- ColDef: the column definition
- ColResolution: the column resolution
- SetResolution: sets the resolution
- SetActive: sets the active status

**ChannelBindings**
- inputStart: Comparable
- inputEnd: Comparable
- active: boolean

This class defines the input and output channels for the rendering process.

**SpatialDomainEnhancement**
- def: (FIFO)

This class enhances the spatial domain by applying filters or transformations to the image. The enhancement is defined as a FIFO (first-in, first-out) structure.

**Wave-Rendering**
- localParams: void
- [one for each wavelength]

This class handles the wave rendering process, where each wavelength is rendered separately and combined to form the final image.

**OMERO Documentation, Release 5.0.2**

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22.19. SqlAction

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22.19. SqlAction

This diagram shows a concrete example of a rendering strategy in action.

The `rgbStrategy` object is an instance of `RGBStrategy`, a sub-class of `RenderStrategy`. What is depicted here is the implementation of the `renderWave` method. Specifically, we illustrate how an X-Y plane is rendered (in this diagram we assume that the plane definition is set to X-Y).

Now we use the Java3D API to create a `BufferedImage` from rendered `DataBuf` and return the new `BufferedImage`.

Next, we repeat the process for any other active wavelength. After that, the `DataBuf` object is ready to be processed by Java3D to produce the RGG image to display.

Here's how we compute `rVal`, `gVal`, and `bVal` (one computed the same way):

```
color = colorBuf.getElem(R_BAND, sizeX*12*2+1);  // rVal
rVal = color[(rVal << 8)] + rVal / 255;
```

Note how we add to the previous red value. This way we can compose by number of wavelengths into an RGG image.
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