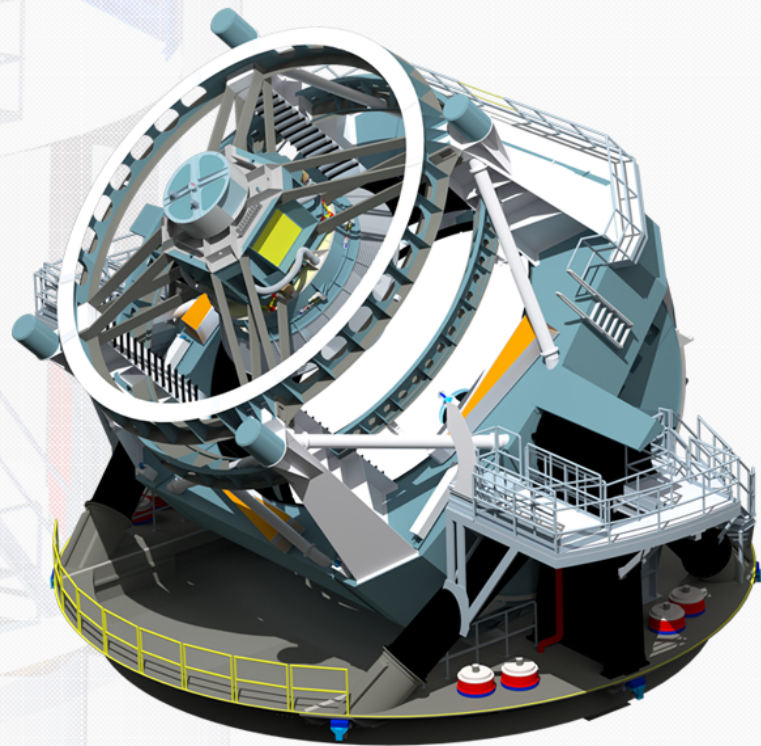


DM Code Structure

Tim Jenness

DM Deputy System Architect

October 6th 2015



DM Boot Camp

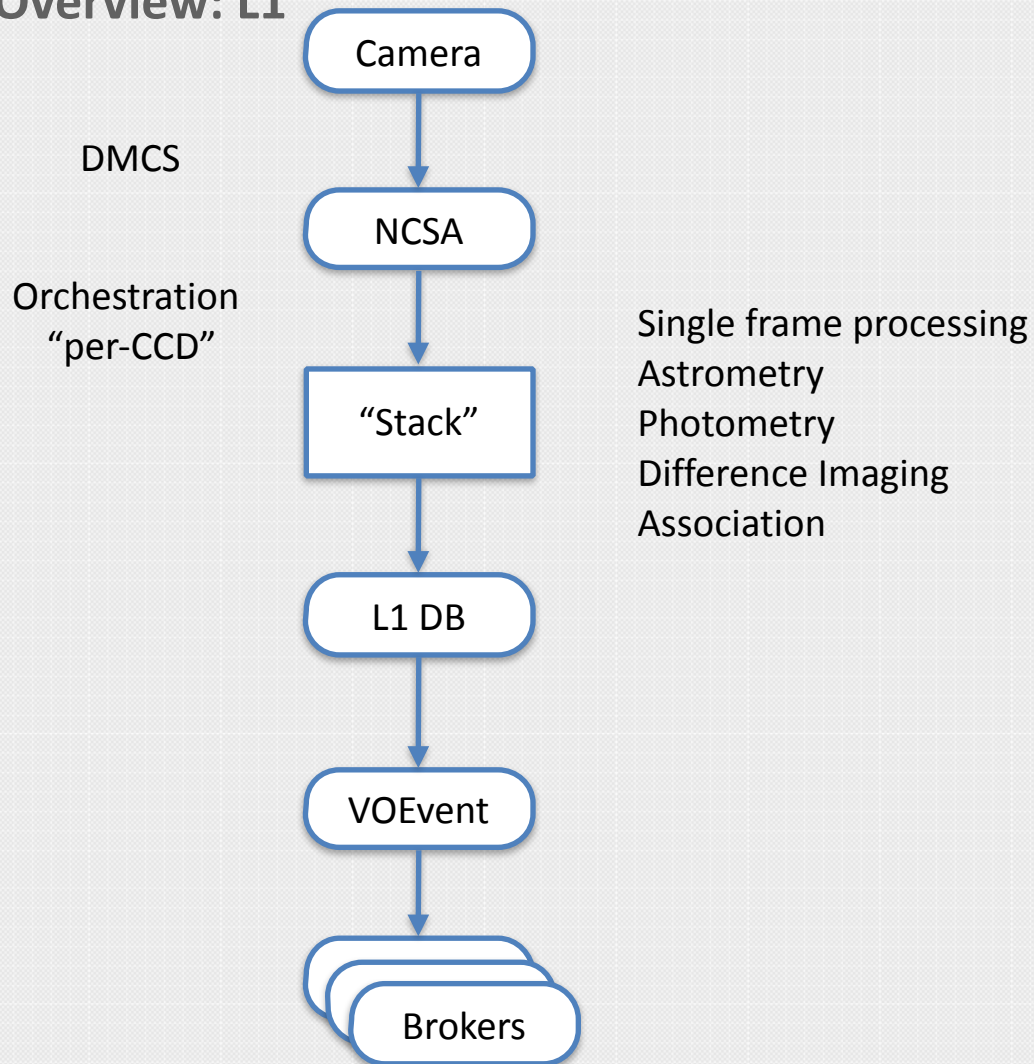
October 6th, 2015 | Tucson, AZ

Overview

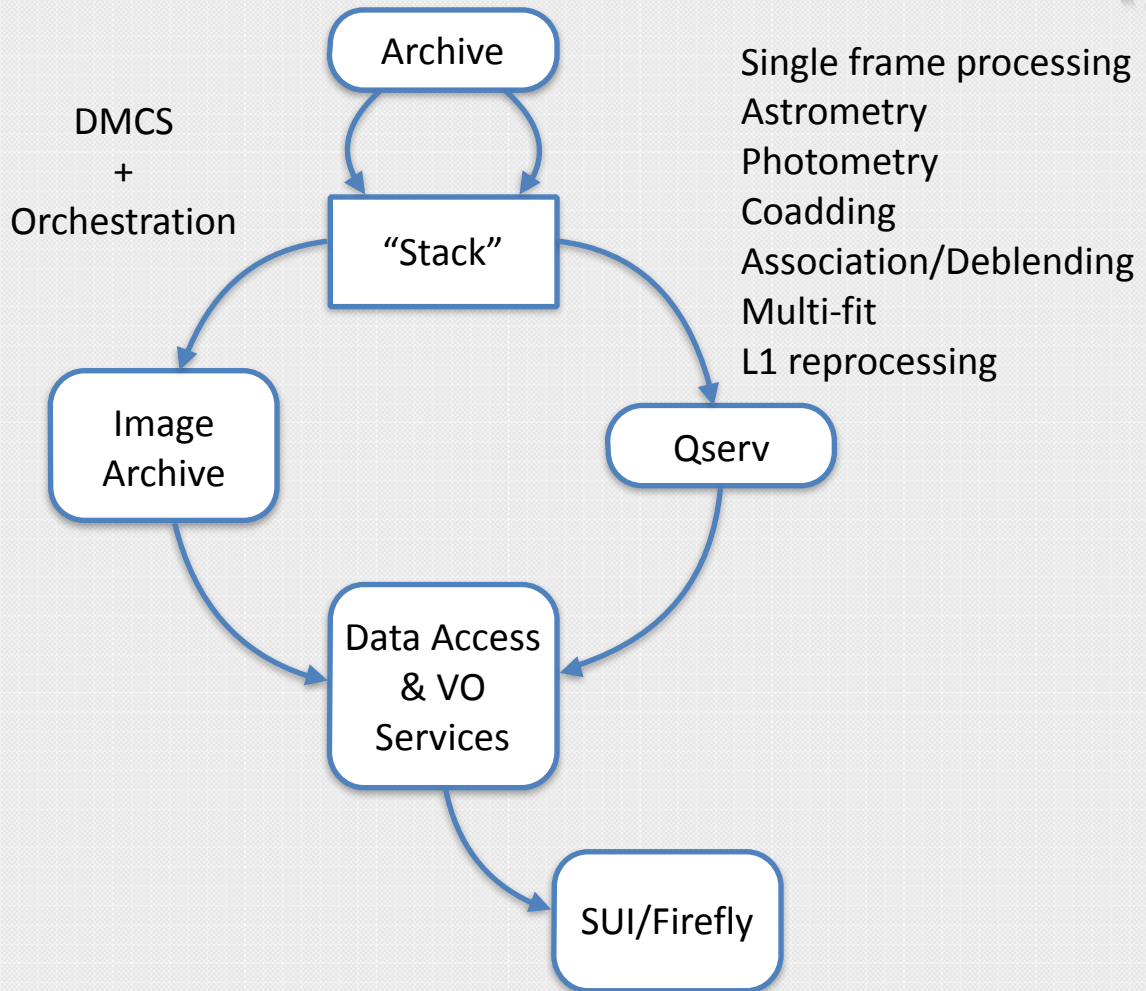


- Combination of C++11 and Python 2.7:
 - C++ used where performance is critical.
 - Prefer to use Python by default.
- Intending to support Python 3 soon.
- GCC 4.8 minimum supported compiler.
- Clang supported.
- Science User Interface uses Java 1.6 server side, Javascript on client side.
- Linux CentOS 6 & 7 and OS X Yosemite and Mavericks are test platforms. No El Capitan support at the moment.
- All LSST code is in an `lsst` namespace.

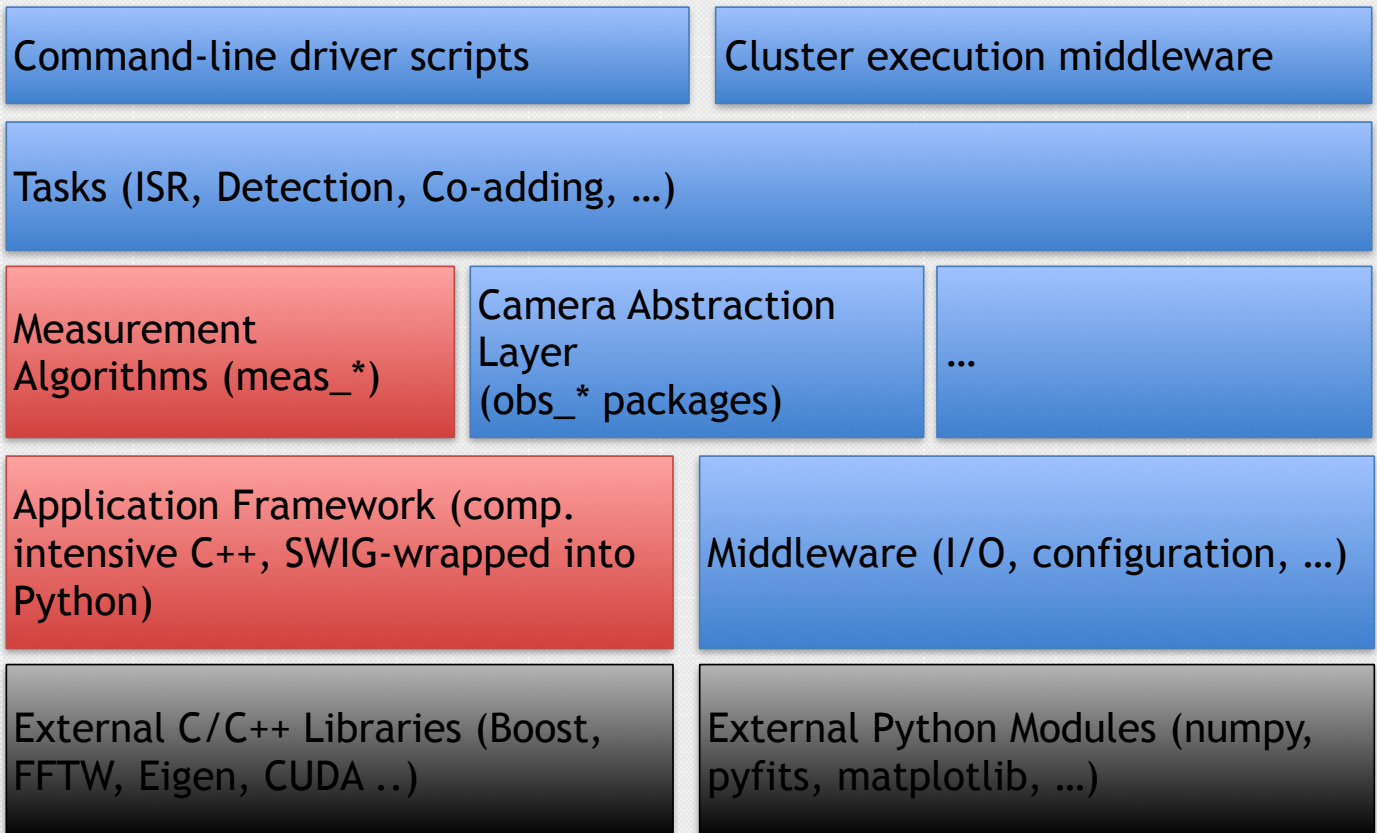
Processing Overview: L1



Processing Overview: L2



Structure of the stack



Red: Mostly C++ (but Python wrapped);
Libraries

Blue: Mostly Python;

Black: External



Package overview

- Orchestration: **ctrl**
- Data Access Framework (aka Butler): **daf**
- pipeline execution support: **pex**
- General application framework: **afw**
- Image Processing: **ip**
- Measuring properties of datasets: **meas**
- Co-addition of images: **coadd**
- Pipeline infrastructure: **pipe**
- Control display tools: **display**
- Camera-specific mappings: **obs**
- Web visualization of catalogs and images: **firefly** (Java)
- Data Access: **dax**
- Full list: <https://confluence.lsstcorp.org/pages/viewpage.action?pageId=9929032>



Middleware: logging

- The **log** package is used for logging.
- C++ and Python interfaces.
- INFO, WARN, DEBUG, TRACE, FATAL levels.
 - **logger.info**("An informational message")
 - **logger.warn**("WARNING message")
- Log levels can be controlled at run time.
- Replaces the **pex_logging** package.
 - Use **log** for new code.
 - **pex_logging** will be removed from the existing codebase.
- Docs: https://lsst-web.ncsa.illinois.edu/doxygen/x_masterDoxyDoc/log.html



Middleware: exceptions

- **pex_exceptions** provides a set of C++ exceptions that can be caught in python code.
- Use native Python exceptions when appropriate.
- Exceptions include:
 - `LogicError`, `DomainError`, `InvalidParameterError`, `LengthError`, `OutOfRangeException`, `RuntimeError`, `RangeError`, `OverflowError`, `UnderflowError`, `NotFoundError`, `MemoryError`, `IoError`, `TypeError`, `TimeoutError`.
- Docs: https://lsst-web.ncsa.illinois.edu/doxygen/x_masterDoxyDoc/pex_exceptions.html

Useful support packages



- **daf_base**
 - Date and time handling:
 - TAI/UTC, MJD/JD/J2000, string conversions.
 - PropertySet/List:
 - simple key/value pairs (e.g. FITS headers).
 - https://lsst-web.ncsa.illinois.edu/doxygen/x_masterDoxyDoc/namespacelsst_1_1daf_1_1base.html
- **ndarray**: C++ n-dimensional arrays compatible with numpy.
 - https://lsst-web.ncsa.illinois.edu/doxygen/x_masterDoxyDoc/ndarray.html
- **geom**: Cartesian and spherical geometry in Python.
 - https://lsst-web.ncsa.illinois.edu/doxygen/x_masterDoxyDoc/namespacelsst_1_1geom.html
- **db**: Database access utilities.



Third-party packages

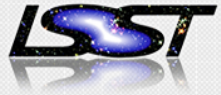
- 3rd party packages are distributed as EUPS-managed packages installable using **eups distrib** or **lsstsw**.
 - They are versioned.
 - LSST packages list them as explicit dependencies.
- **Numpy** and **matplotlib** are presumed to have been installed by other means (but this is checked).
- Some 3rd party packages are not expected to be called directly: e.g. **log4cxx**
- New packages can be requested via the RFC process.
 - Using 3rd party packages is encouraged rather than reimplementing a wheel.
- 3rd party Python packages are currently distributed in this way and not via **pip**.



Third-party packages

- Available packages include:
 - **cfitsio**: Read/write FITS files,
 - **eigen**: linear algebra: matrices, vectors, numerical solvers, and related algorithms,
 - **boost**: general C++ extensions,
 - **wcslib**: World coordinates handling,
 - **fftw**: Fast Fourier transforms,
 - **gsl**: Gnu Scientific Library — mathematical routines such as random number generators, special functions and least-squares fitting,
 - **minuit2**: function minimization.
- Full list: <https://confluence.lsstcorp.org/display/DM/DM+Third+Party+Software>

Structure of a package



<i>bin</i>	Executables (includes python scripts)
<i>doc</i>	Documentation
<i>examples</i>	Python and C++ example code
<i>include</i>	C++ include files
<i>lib</i>	Compiled shared libraries (empty on check out)
<i>python</i>	Python code and Swig interface files
<i>src</i>	C++ source code
<i>tests</i>	Test code (Python and C++)
<i>ups</i>	EUPS configuration (dependencies, environment variables)

See: <https://github.com/lsst/templates> for a detailed example



Building a package: Scons

- SCons is used to build LSST software.
 - <http://scons.org>
 - A “Software Construction tool”
 - Written entirely in Python.
- To build and test a package:
 - `setup -k -r .` — to ensure the tests use the newly-built code.
 - `scons -j 4 opt=3` — for a parallelized build.
- This will build the C++ (including the shared libraries) and Python code, build the examples, run the tests and build the documentation (currently using doxygen).
- `scons -j4 python` will just build the python code.
- `SConstruct` file used by `scons` to configure the build.
- `SConscript` files are used for subsidiary configuration in subdirs.

LSST extensions: sconUtils



- Scons does not know anything about LSST software conventions.
- sconUtils adds all the LSST-specific knowledge:
 - EUPS version and dependency tracking.
 - Compiler detection (clang vs gcc and how to add C++11 support).
 - Swig interface building.
 - How to run tests.
- Simplest possible **SConstruct** file:

```
# -*- python -*-  
from lsst.sconUtils import scripts  
scripts.BasicSConstruct("meas_base")
```

for a package laid out in the standard form with no special features.

Python code



- Lives in the `python/lsst` directory.
- If your package is named `something_else` the code will be located in `python/lsst/something/else`.
- Each sub-directory (`lsst` and below) must have an `__init__.py` file that must contain at least:

```
import pkgutil, lsstimport
__path__ = pkgutil.extend_path(__path__, __name__)
```

- This is required to ensure that all the packages can be found when spread across the filesystem with EUPS using PYTHONPATH sharing the same `lsst` namespace.

Python/C++ Interfaces: SWIG



- Simplified Wrapper and Interface Generator
 - <http://www.swig.org>
- Parses a C++ header file and generates the Python wrapper code.
- Interface is defined in “.i” files that live in the `python/lsst/` tree.
 - `meas_base.i` files are in `python/lsst/meas/base/`
- Swig generates `.py` file and shared library. For `meas_base` `baseLib.i` generates `baseLib.py` and `_baseLib.so`.
 - The other `.i` files are included by `baseLib.i`.
 - The `SConscript` file in the same directory tells `scons` that only `baseLib` is relevant
 - Look in the `_wrap.cc` file to see what Swig has generated.

3rd Party Package Structure



- 3rd Party packages are wrappers around the standard distribution files.
- EUPS, via **eupspkg**, knows how to build different styles of distro: Python setup.py, autoconf, cmake.

<i>ups</i>	EUPS configuration, including dependencies, and special build instructions.
<i>upstream</i>	Upstream unmodified distribution tar file.
<i>patches</i>	Patches to be applied to the distribution before building it.

Testing



- Each package has associated unit tests
- Python tests use `unittest`.
 - `assertEqual`, `assertLess` etc.
 - Only use `assertTrue` if you are really testing truth.
- C++ tests use `boost`.
- Aim for new code to come with associated unit tests.
 - Code coverage is less than ideal at present but aiming to begin gathering metrics on this.
 - Integration tests are used to test the stack as a whole.
- Python tests will soon be run via a standard python test environment such as `nose` or `py.test`.
 - This gives us significantly better test output handling in the Jenkins continuous integration system.

Documentation



- Currently the `doc` directory contains doxygen format files with a root document page in either `mainpage.dox` or `main.dox`.
- Doxygen format used for method and class descriptions inline.
- Currently investigating migrating to ReST and numpydoc format and aiming to integrate into ReadTheDocs.



Those “ups” configuration files

- **ups** directory teaches EUPS and sconUtils how the package relates to other packages and how to configure it when it is “setup”.
- **.table** file lists dependencies and environment variables that EUPS should set.
- **.cfg** file contains configuration information for sconUtils that might be needed from packages depending on this package.
- **eupspkg.cfg.sh** provides overrides and additional information to allow **eupspkg** to build a package.

Coding Standards



- Python coding standard: <https://confluence.lsstcorp.org/display/LDMDG/Python+Coding+Standard>
 - Considering recasting standard as a delta relative to PEP8
- C++ coding standard: <https://confluence.lsstcorp.org/pages/viewpage.action?pageId=16908666>