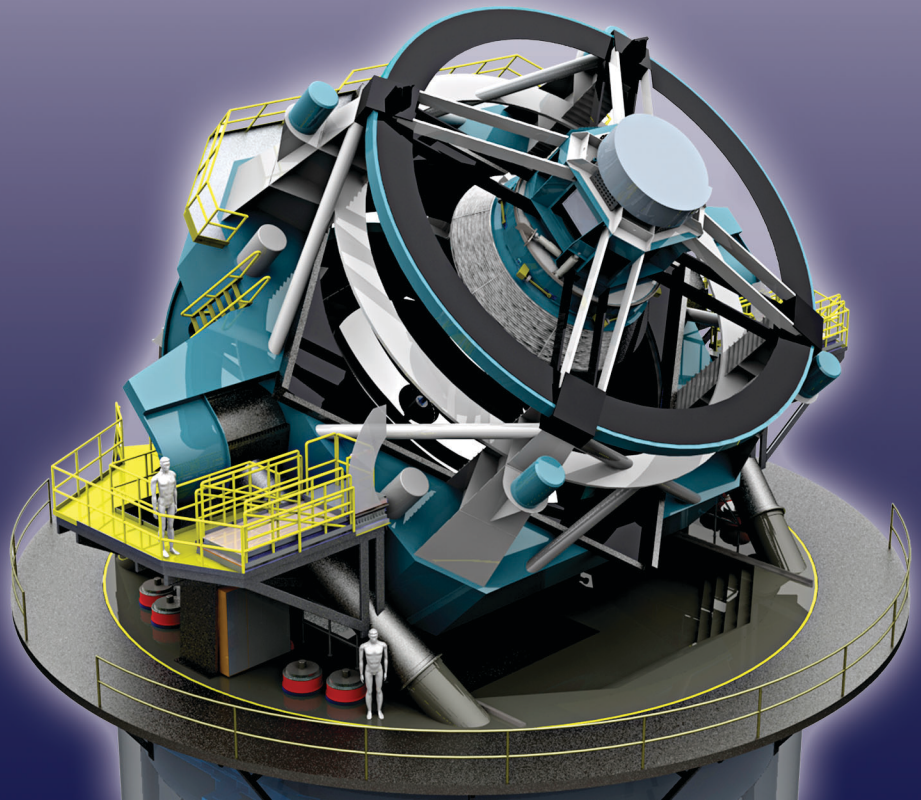
LSST Data Access and VO

Pathfinding through TAP, ADQL and beyond



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IVOA Interop Meeting
Stellenbosch, SA – 05/12/2016

LSST VO Efforts

Large Synoptic Survey Telescope

Current Work with VO

- TAP Service
  - To support QServ and Level 1 Database
- ADQL parser
- All Python!

Future Work

- SIA
- SCS
- Ancillary VO stuff (registries, etc…)

Qserv overview

Qserv is LSST's in-house distributed database

- Based on MySQL(MariaDB) + custom UDFs
- Geospatial partitioning of tables
  - Tables chunks are colocated on worker nodes
    - Including "Level 3" tables aka User Catalogs for join efficiency
  - Uses Shared Scan to perform analytical queries
- ~1-2PB at DR1
- Qserv directly supports Asynchronous (aka batch) queries
  - Likely through an extension of grammar or session variable
    - `CREATE QUERY AS SELECT * FROM Objects WHERE …;`
    - SET QUERY_MODE = 'ASYNC';
    - This could be automatically handled via TAP /async
    - sync queries that trigger shared scan will likely return an error
    - Clearly we need to think about this carefully
- Users will be able to use TAP or directly use database connection
  - Authentication via TAP handled via OpenID.
  - Authentication to Qserv handled via Kerberos or OpenID
    - We are writing OpenID PAM Module, Kerberos PAM already exists
    - Authorization details being worked out

LSST's intended TAP Use Cases

Three core use cases of TAP:

- Client -> Server
  - Python, Java, C++, etc…
  - Astronomy community/VO tools are main users
- Server -> Server
  - Large amounts transferred (~1-5GB+ results)
  - IPAC'S SUIT servers are target users
- Browser/User Agent -> Server
  - Enable highly interactive web applications
  - Enable Level 3 experiments and users to write better web applications and data portals
    - Easily tie in to Authentication system via OpenID and delegation

TAP Implementation: dbserv

- Initial non-TAP PoC written by Jacek Becla
  - JSON response format that is easy to work with
- Moving towards TAP interfaces
  - Led by me
  - Working on ADQL parser
  - We still like JSON though
- Qserv has native support for “async” batch-style queries
  - Slight impedance mismatch with UWS-based recommendations for TAP async
  - Level 1 Database will need more traditional TAP approach through UWS
  - Multiple TAP Services? Not sure.

ADQL Parser: lacquer

- Prototype: https://github.com/brianv0/lacquer
  - Don't mind the mess right now ☺
- lacquer is based on Facebook's Presto parser, ported to Python
  - ANTLR4+Java to PLY+Python (and LL to LALR)
  - Only added syntax rule is for TOP
  - Another port may be performed to C++ (Flex+Bison) for Qserv native ADQL support
    - i.e. `SET sql_mode = 'ADQL';`
  - Alternatively, clients may rewrite queries instead of relying on TAP or a SQL proxy
    - `curs.execute(sql("SELECT * FROM Objects WHERE 1=CONTAINS(…)"))`
- ADQL validation and query rewriting is decoupled from parsing, multiple backends can be supported
- Our approach is to enforce the majority of ADQL rules a validation stage rather than in the grammar
- Parser is 50% complete, need to finish rewriter framework, then implement ADQL validation and Qserv rewriter, and clean it all up!

Things we *think* we don't like

- Regarding VOTable responses:
  - XML is a machine and human readable document format. BINARY2 isn't human readable, so why use XML at all?
  - No uniform JSON
  - No non-CDATA Binary Format
    - BINARY2 is simple but still requires custom serializers
  - VOTable is not a response format
    - but it appears to be used as one ---->
  - We expect results to regularly exceed 1GB

```
<INFO name="QUERY_STATUS" value="ERROR">
   value out of range in POS=45,91
</INFO>
```

- Personal Pet Peeves:
  - TOP instead of LIMIT syntax
    - Especially if ADQL 2.1 supports OFFSET.
    - REQUEST=doQuery -> unnecessary (and not RESTful)
- Pagination/Framing of /results/result (esp. regarding async)
  - Does TAP return data or files? Is TAP a VOTable interface or a database interface?
  - Somewhat related to VOTable issues
    - And coupled to Response Format
    - VOTable isn't ideal for streaming
  - Again, MAXREC instead of LIMIT and OFFSET

Our solutions to some issues

- For VOTable issues, use “Accept” header liberally and support our three main use cases
  - Maximum Compatibility – VOTable/XML and FITS
    - Consider HDF5 or SQLite?
  - Ease of Use – VOTable-inspired JSON (inside Response container)
    - Incremental/Stream processing in Java, C++, Python via Jackson, yajl, ijson
  - Binary conciseness and cross-language compatibility
    - Protobufs, CapnProto, Thrift, Avro, CBOR, MessagePack, etc…
    - No clear winner, depends on use case
- For ADQL issues, we will comply with the spec as much as possible, but also be more liberal in accepting widely adopted SQL-isms (like LIMIT)
  - TapRegExt for this?
- Similar approach to result pagination
  - We get a single result, but it’s very large!
  - Would like to stream it, but XML isn’t awesome for streaming
  - And we’d like to implement a DBAPI/JDBC-like client interface for TAP, which might also enable good dataframe (pandas) integration

JSON Output


```
{
  "result": {
    "table": {
      "metadata": {
        "elements": [{
          "$type": "field",
          "name": "word",
          "datatype": "text"
        }, {
          "$type": "field",
          "name": "num",
          "datatype": "integer"
        }, {
          "$type": "field",
          "name": "largenum",
          "datatype": "long"
        }, {
          "$type": "field",
          "name": "time",
          "datatype": "text",
          "xtype": "timestamp"
        }, {
          "$type": "field",
          "name": "raw",
          "datatype": "binary"
        }]
      },
      "data": [
        ["hello", 1, "12345678901234", "2015-01-01T12:00Z", "cmF3IGRhdGE="],
        ["world", 1, "98765432101234", "2016-01-01T12:00Z", "bW9yZSByYXcgZGF0YQ=="],
      ]
    }
  }
}
```

More generally:

Client -> Server is the currently the intended use case of the DAL standards.

Should the following use cases be considered when designing DAL standards?

- Server -> Server
- Browser -> Server

Or are these use cases non-goals of the VO DAL?

Moving Forward

- We will continue to implement TAP, ADQL in the near future
  - And critically examine SIA, SCS
- Not sure if we've correctly identified issues or non-issues yet with TAP.
  - TAP/dbserv is very much still a prototype/pathfinder project for us
- We haven't quite scratched the surface of SIA yet.
  - We do have an "imgserv", which is similar in function to SIAP V1
- Hard to find all the current implementations
  - We need Python implementations right now

And two last questions:

- **What does it mean to be a VO site?**
- **What is the estimated manpower (in FTEs) to implement, from scratch, a VO site?**

Prototypes and pathfinding:

- JSON output
  - https://gist.github.com/brianv0/07cf0acd83bde6f450a9
- Pathfinding Binary formats: Protobuf/CapnProto/Thrift versions of VOTable
  - http://gist.github.com/brianv0/be283e3674755d76396e
- Prototype Parser:
  - http://github.com/brianv0/lacquer
  - Development likely moving to /lsst/lacquer soon
- Lacquer output (Derived from a VizieR query)
  - http://gist.github.com/brianv0/c00e7e6a9ec89b28ea6aa7432a8201a7
- Prototype TAP: dbserv
  - http://github.com/lsst/dax_dbserv