Data Bookkeeping Service 3
Providing event metadata in CMS

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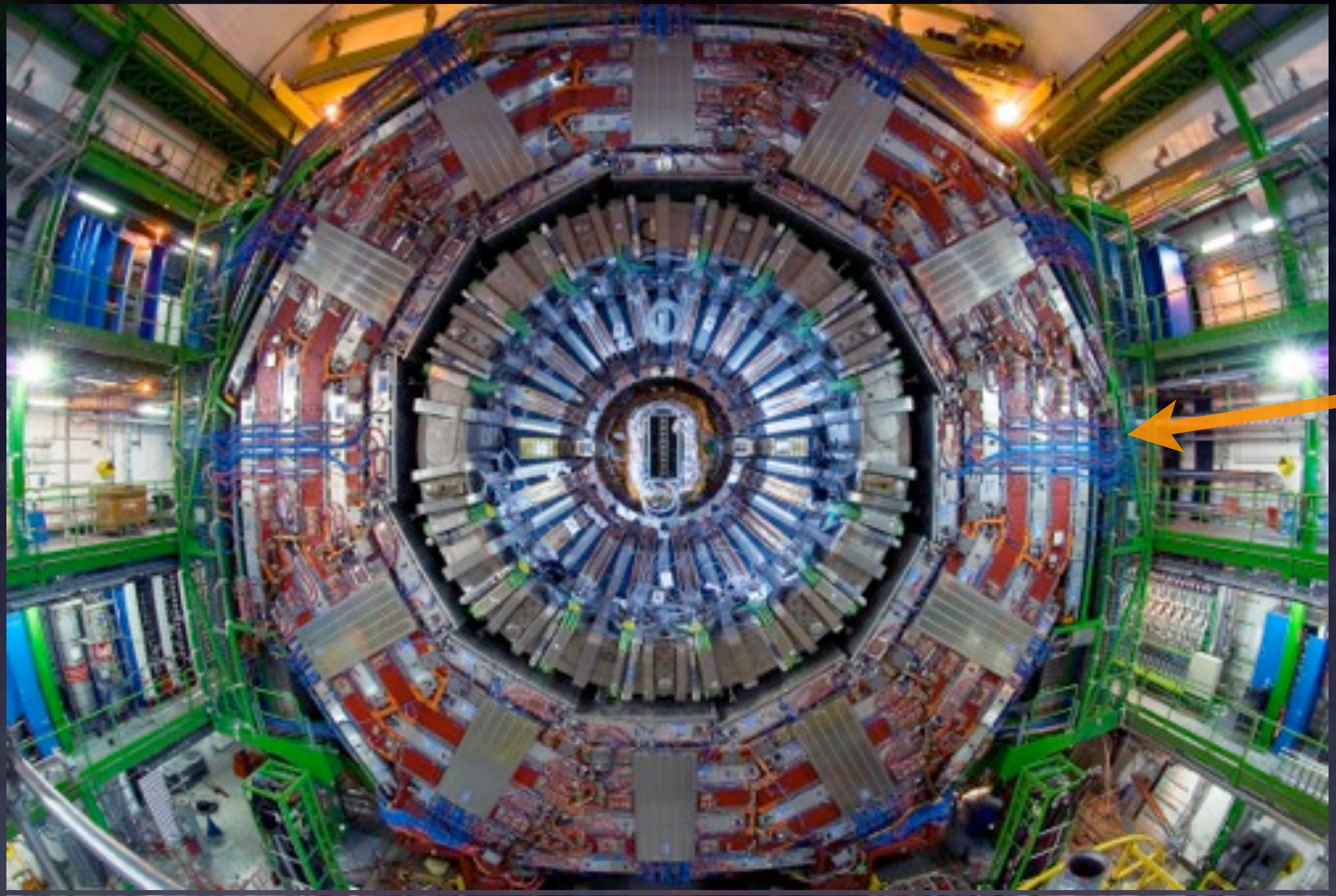
for the CMS Collaboration

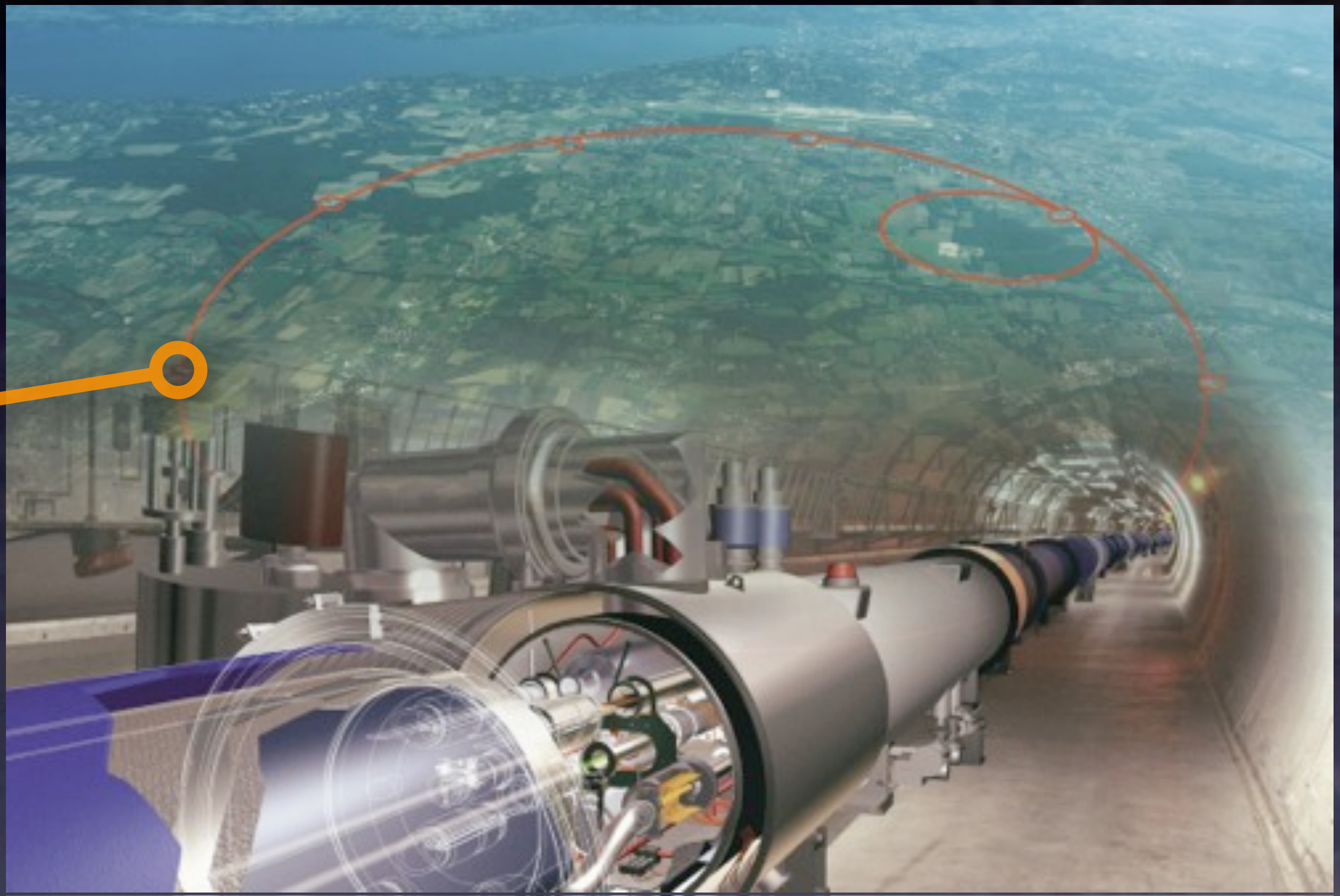
Outline

- Introduction
  - The CMS Experiment
  - The Data Bookkeeping System (DBS 2/3)
- Design of DBS 3
- Dependencies on DBS
- Transition DBS 2 to DBS 3
- Testing of DBS 3

The CMS Experiment

The **C**ompact **M**uon **S**olenoid is a general purpose detector at the Large Hadron Collider at CERN (LHC Point 5)





Huge Data Source:

- Around 200k official datasets
- About 40M official files
- 700 GB ofcl. metadata (DBS 2)

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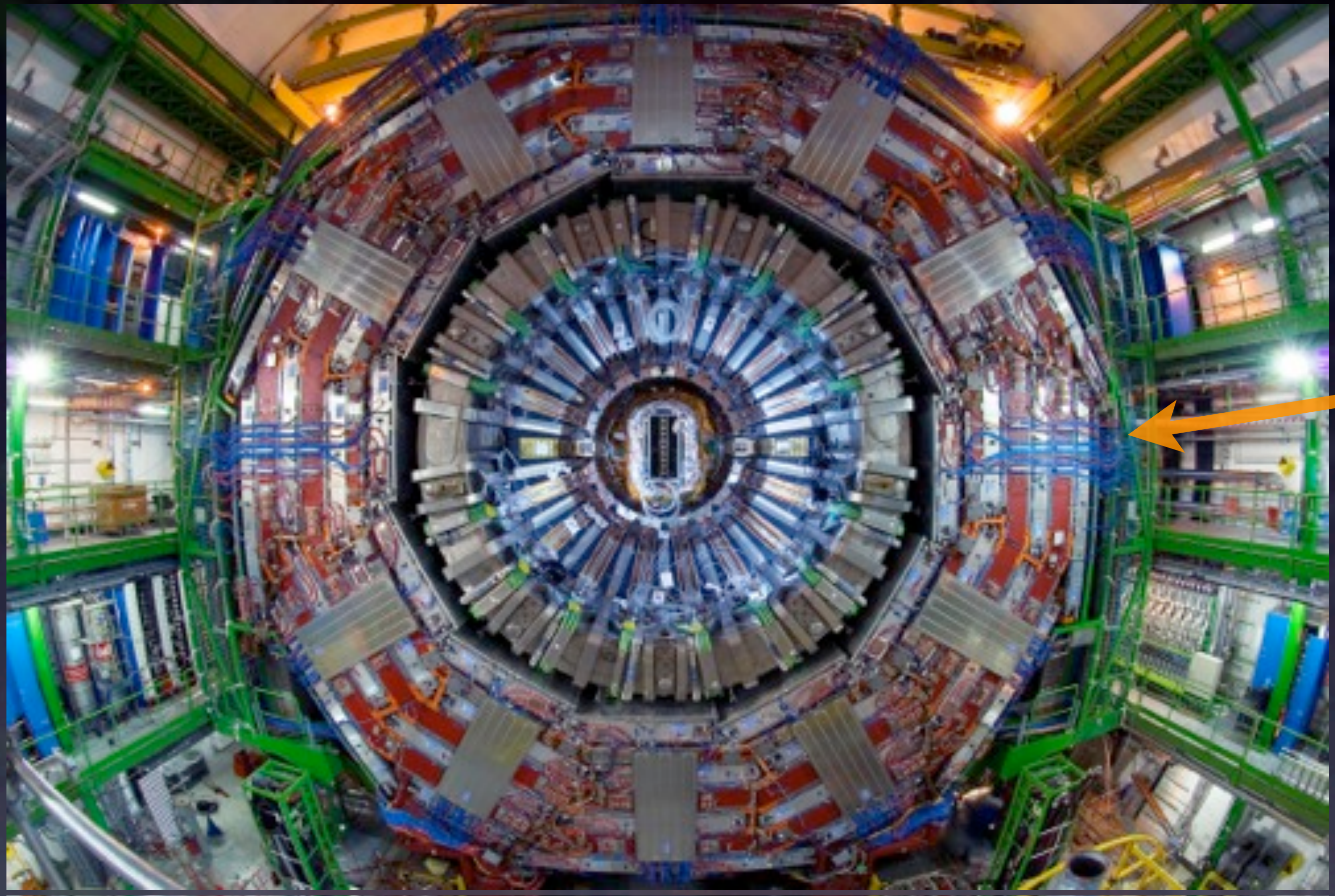
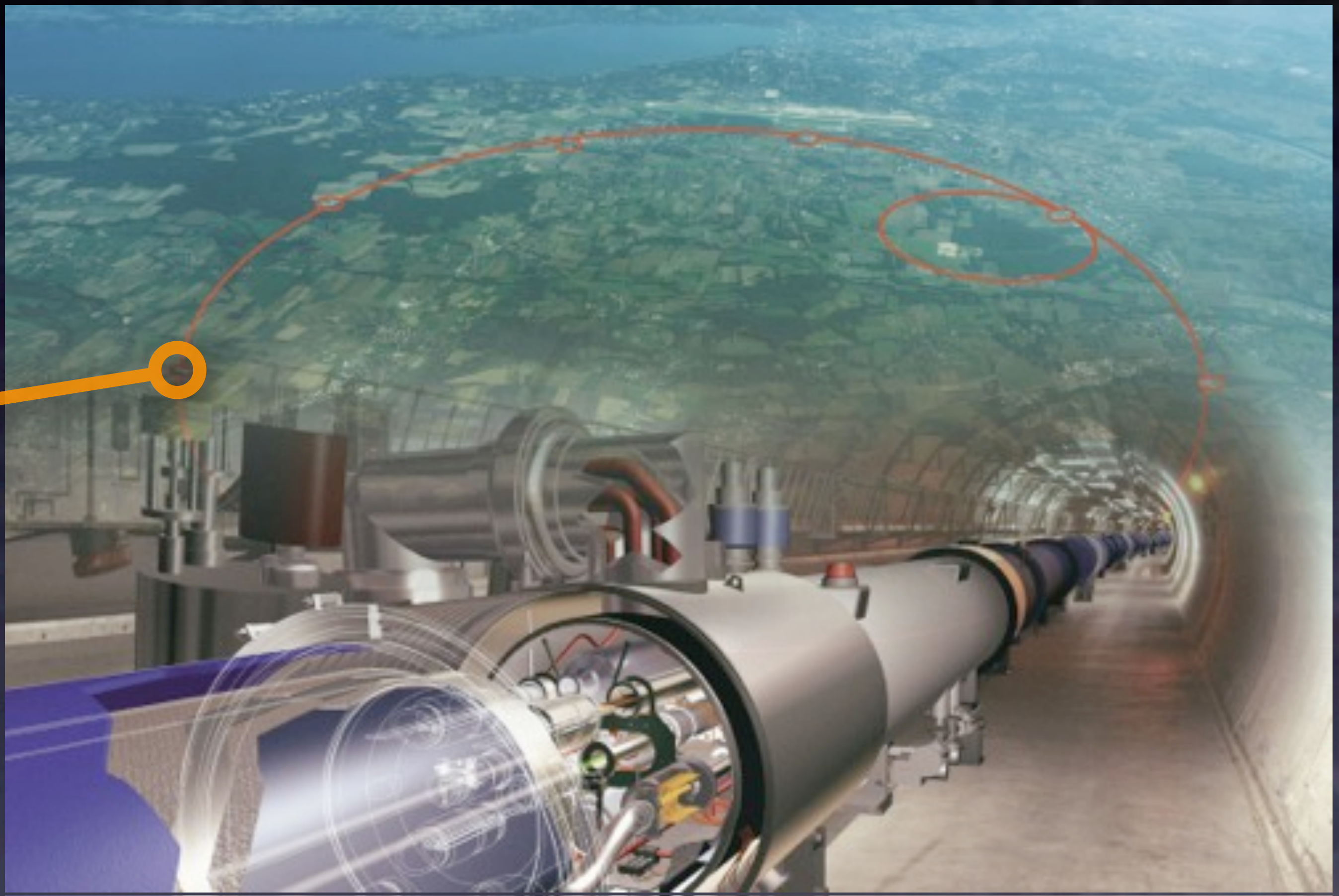

CERN


CERN

Huge Data Source:

- Around 200k official datasets
- About 40M official files
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- ▸A lot of data to cope with
- ▸A lot of metadata as well
- ▸Need an event data catalog

What is DBS?

- Acronym for the Data Bookkeeping Service
- Event data catalog for the CMS-Experiment at the LHC
- Information used for tracking datasets, data-processing history, associations between runs, files and datasets
- All data-processing in CMS relies on the information stored in DBS
  - Monte Carlo production
  - Data processing of recorded data
  - Physics analysis done by the users

Essential part of the Data Management and Workload Management Systems at CMS

Why DBS 3?

- DBS 2 designed/implemented 2006-2007 prior operation of LHC
  - CMS did not have a standardized service architecture
  - Implementation in JAVA servlets in a Apache Tomcat container
  - XML RPC for client-server communication
  - Some very „thick“ APIs
  - ▸API versioning problems, scalability issues
- CMS computing model evolved since design time of DBS 2
  - Many requests to store additional data not entirely consistent with its original purpose
  - CMS Data Management and Workflow Management group developed a common service and deployment architecture for web services (CMSWEB, RESTful Web services, etc.)

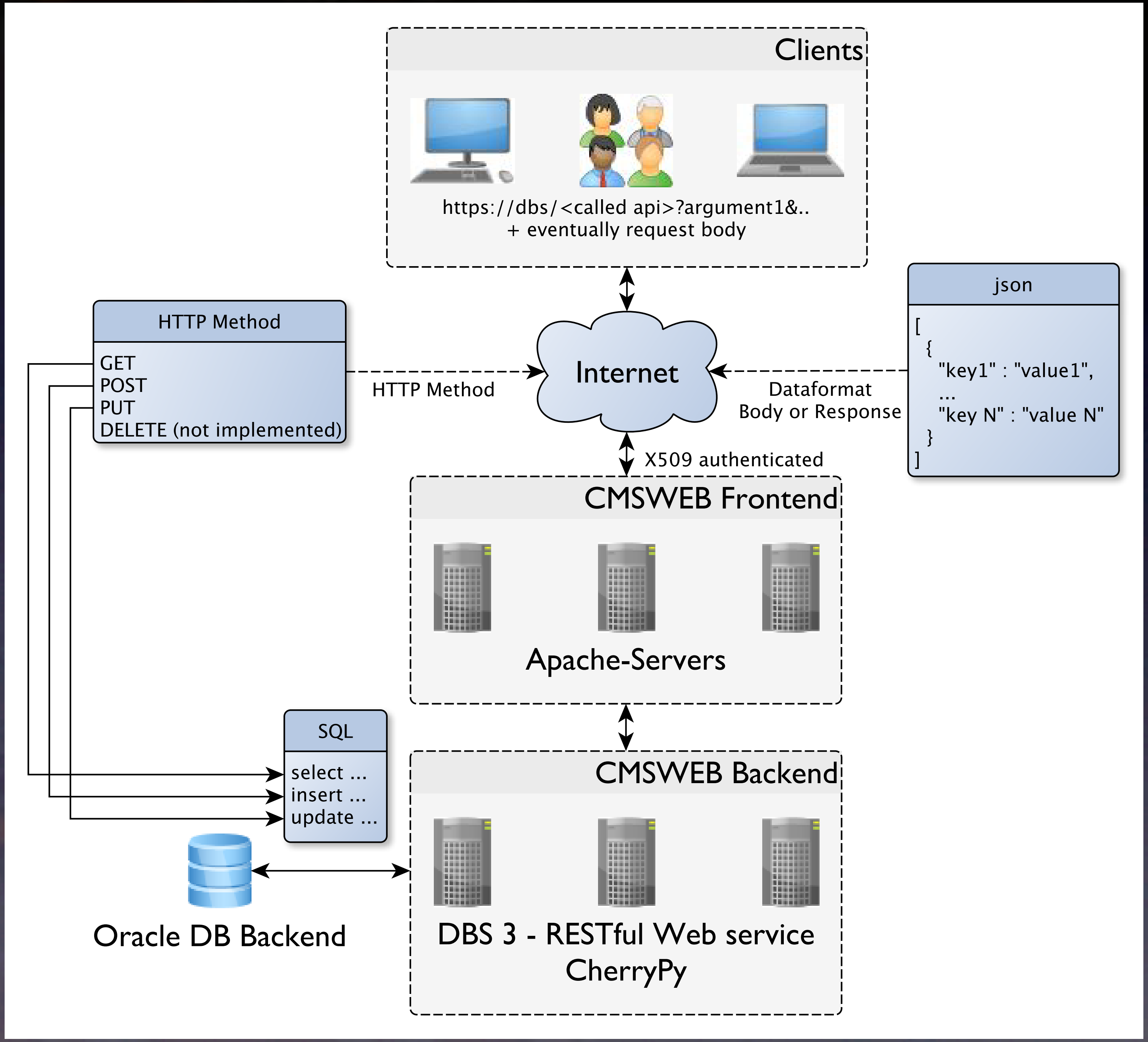
Led to the decision to re-design a new DBS

Design Goals

- Re-design with respect to the evolved processing model in CMS
- Spin-off any services outside the project scope (i.e. Web GUI)
  - Web GUI provided by Data Aggregation Service DAS
- Simplified and lightweight APIs
- Optimized DB schema
- Logical data-processing history (provenance, parentage)
  - No split and merge steps in processing history
    Since they have no impact on the data content

Implementation of prototypes using various architectures and technology led to the current DBS 3 design and implementations

Design of DBS 3



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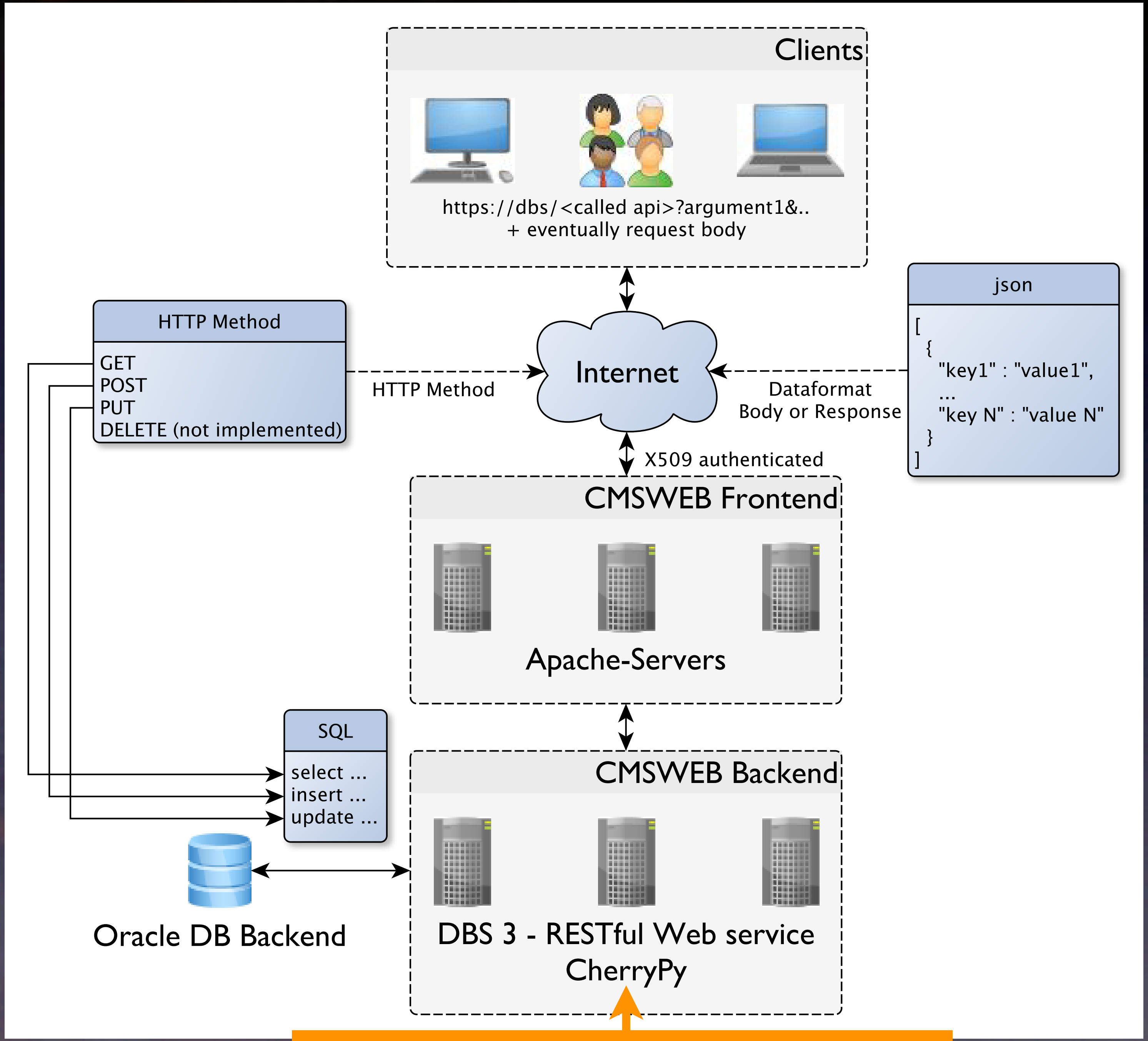
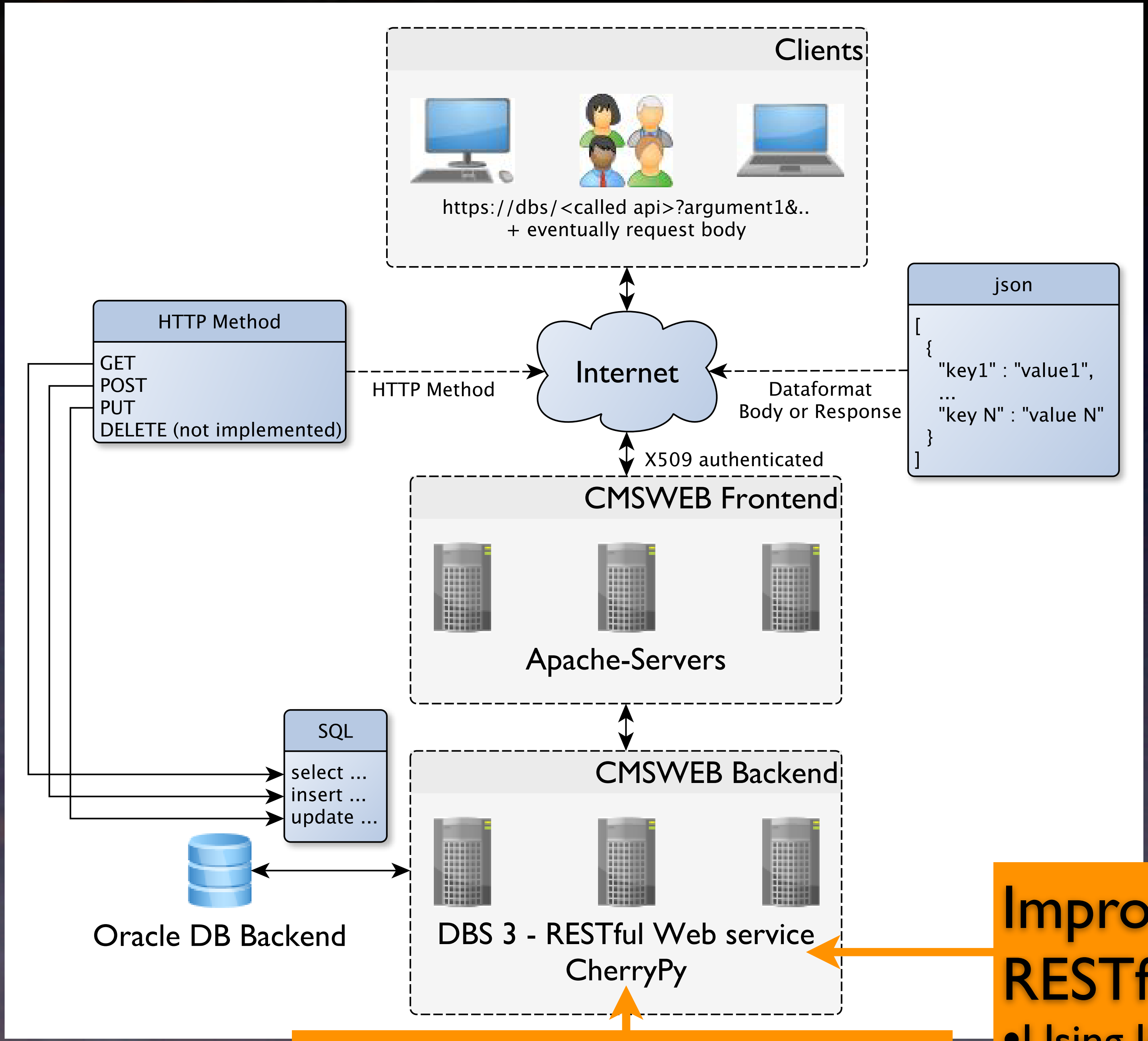


Re-designed/implemented in Python (CherryPy)

Design of DBS 3



Improved scalability by RESTful design

- Using lightweight APIs (Amdahl's law of scaling limits)
- Stateless client server communication

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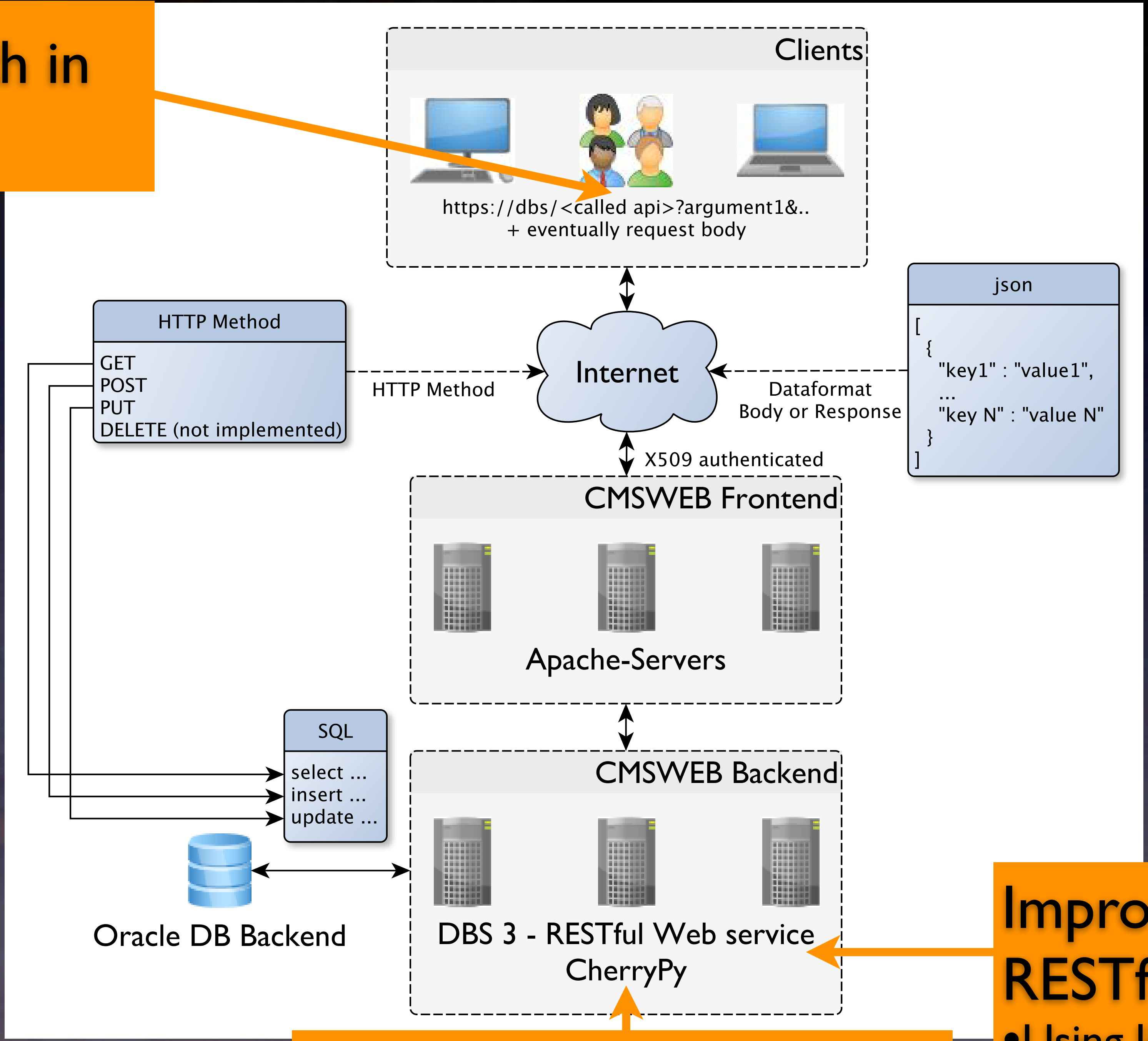
Design of DBS 3

API chosen by path in URI



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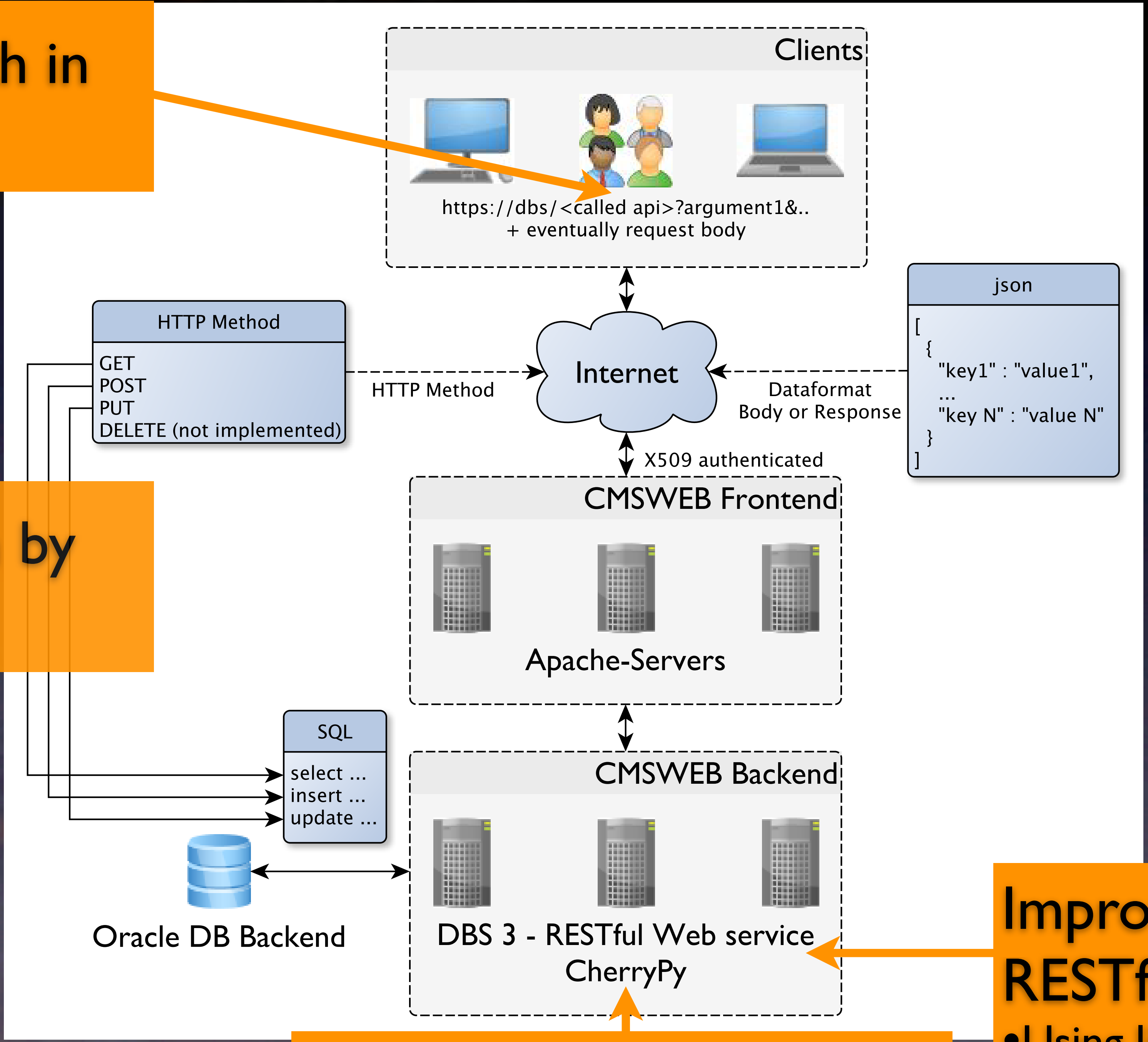

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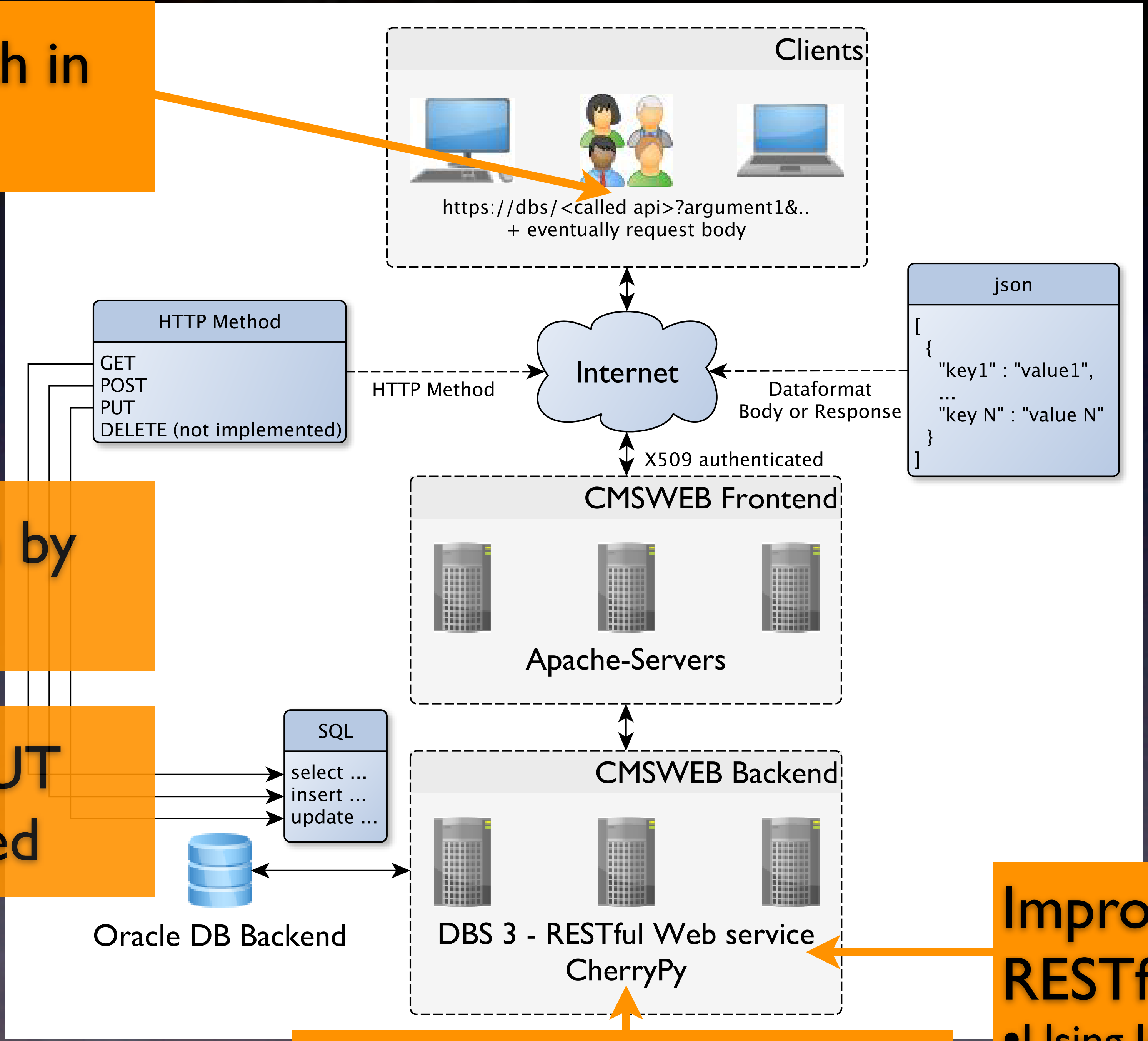

API chosen by path in URI

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GET, POST and PUT methods supported

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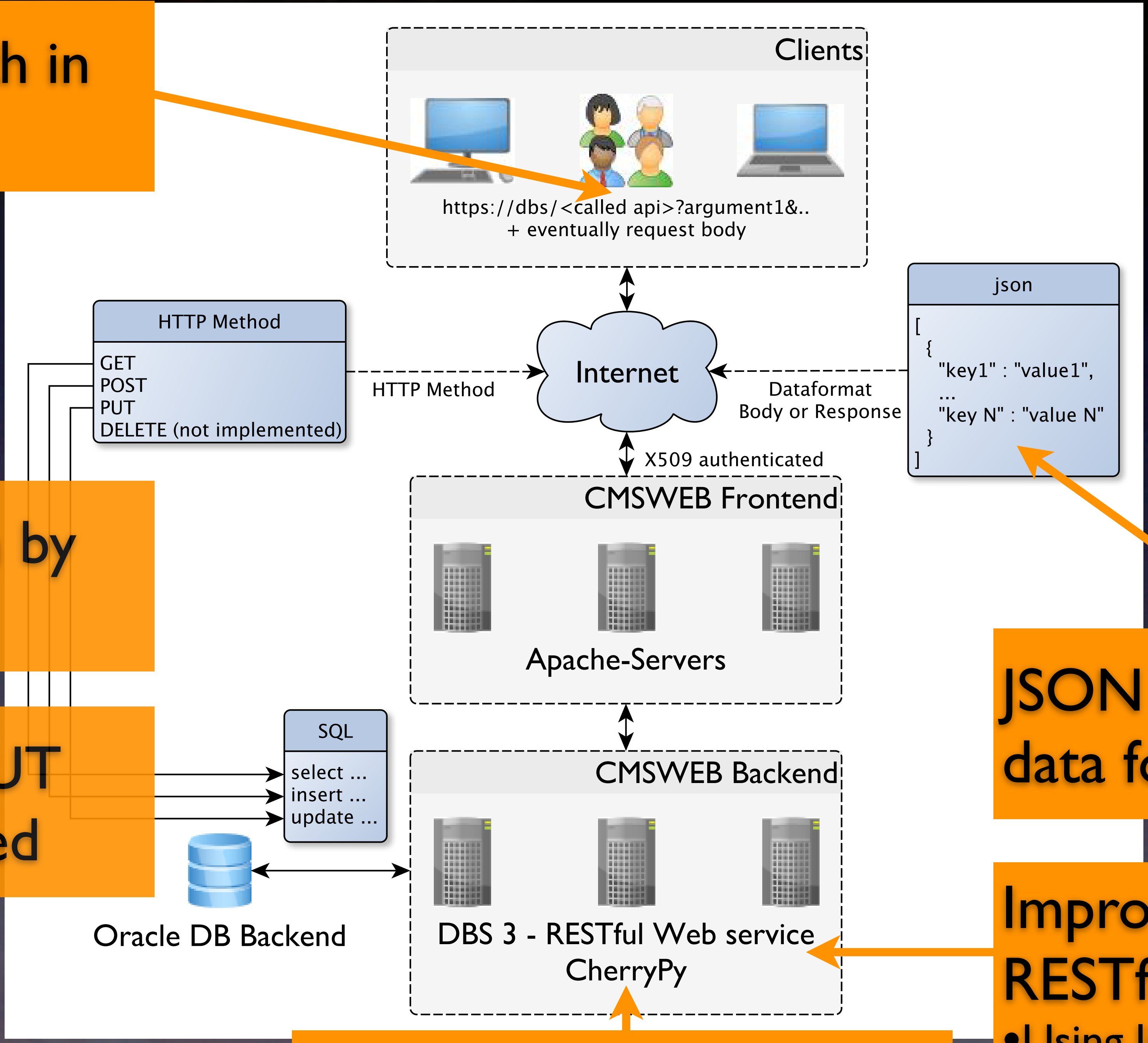

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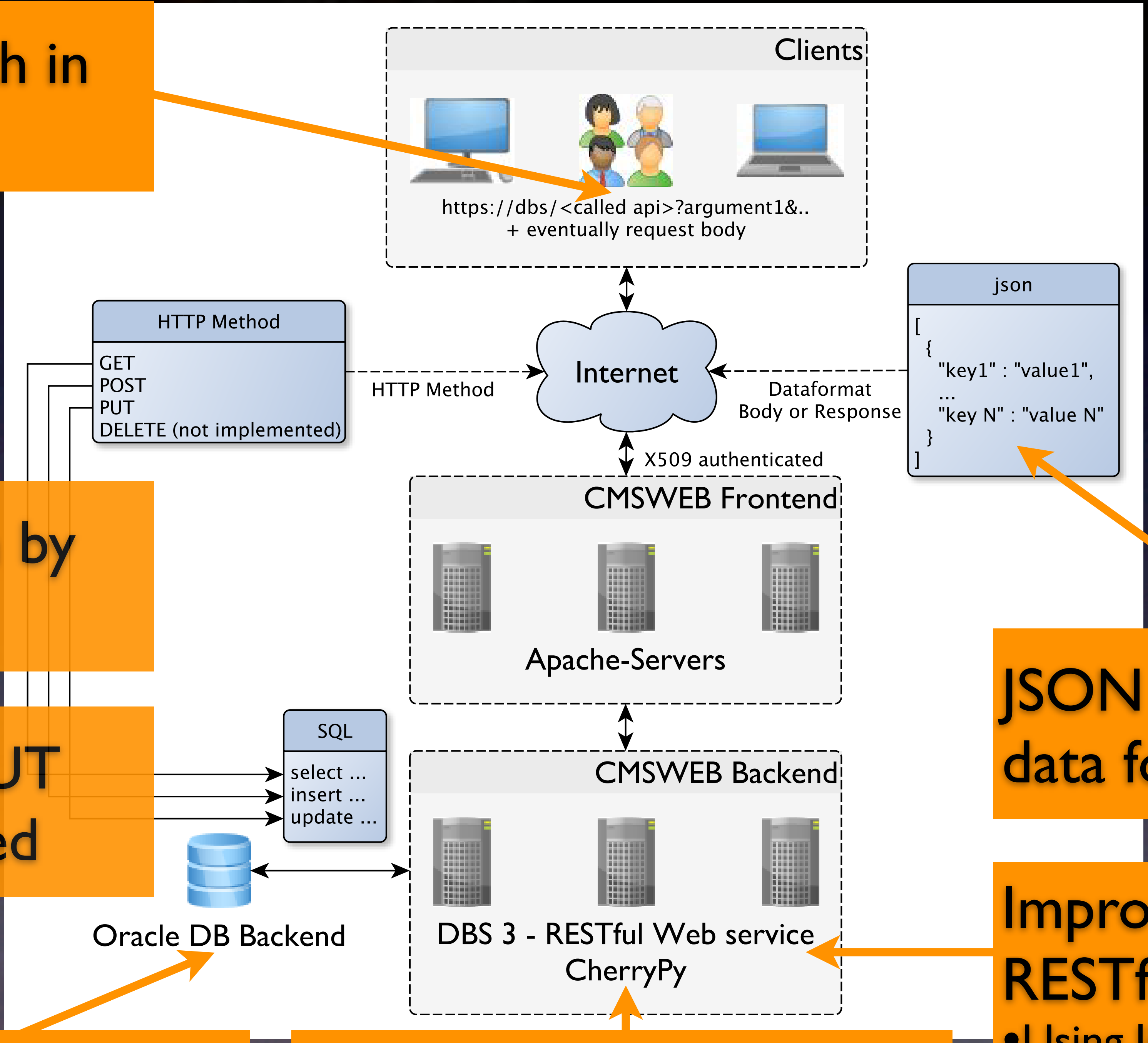

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Oracle DB backend for persistent storage

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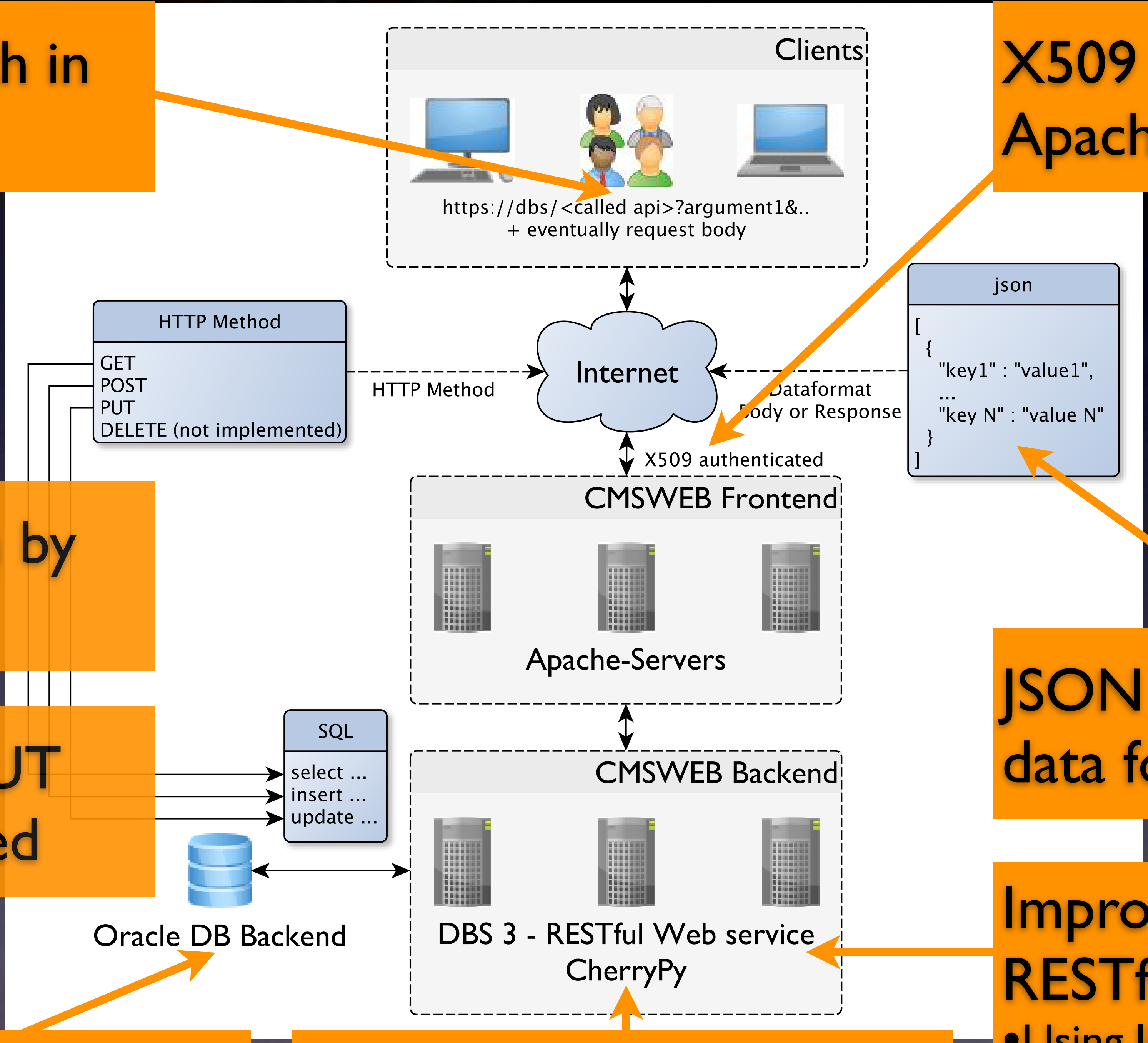
Design of DBS 3

API chosen by path in URI

X509 authenticated by Apache HTTP frontend



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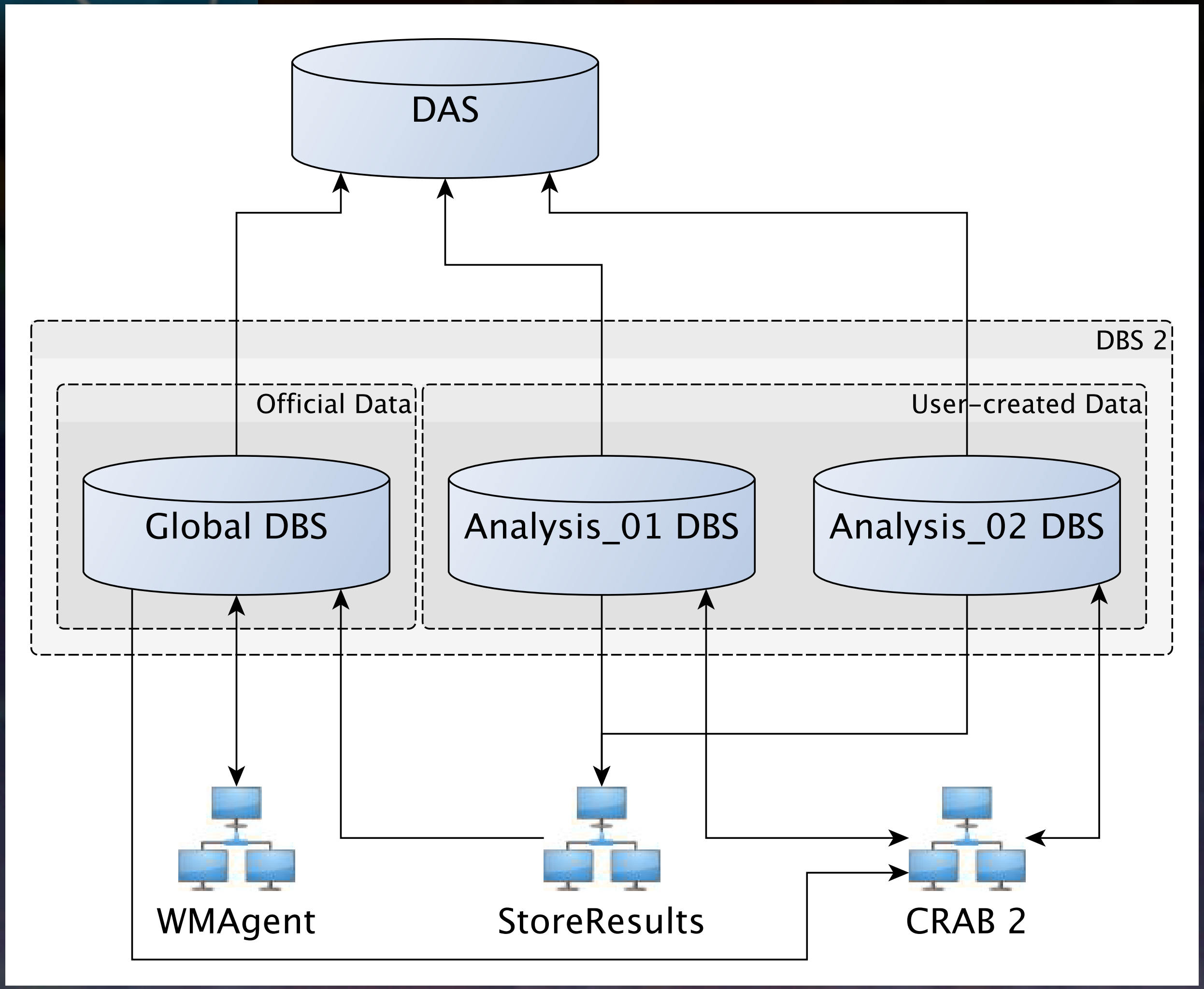
Dependencies on DBS

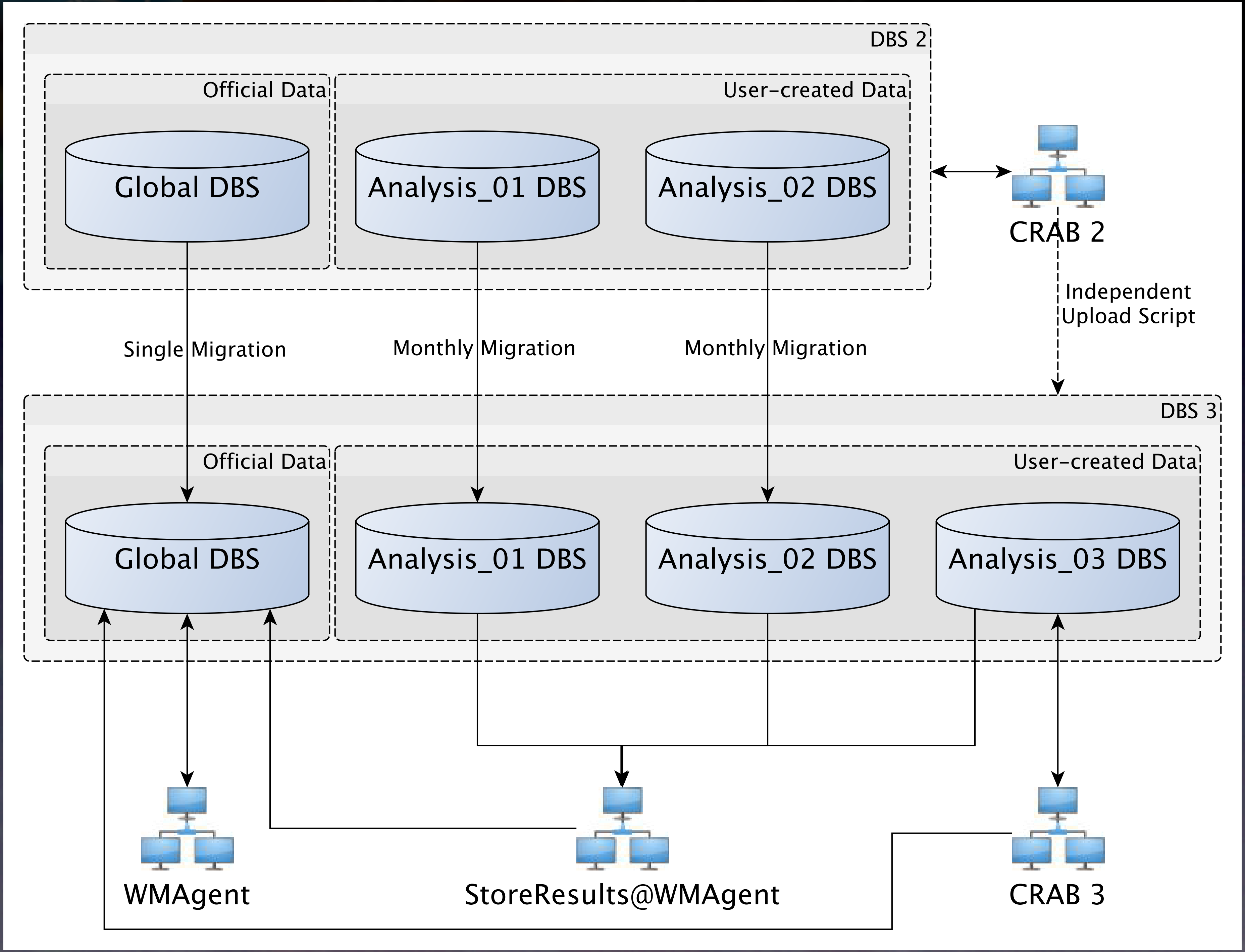


- Official and User-created data separated in CMS
- Splited in Global and Analysis DBS
- Data Aggregation Service (DAS) fetching and displaying information
- WMAgent distributed data processing tool in CMS (Official Data)
- StoreResults data-transfer of user-created data
- CRAB 2 distributed user analysis tool

- New versions for CRAB and StoreResults soon available
- Both old systems are not able to talk to DBS 3

▸ Transition to DBS 3 is a complex endeavor

Transition to DBS 3



- Global DBS will be migrated only once
- Global DBS 2 will be read-only
- Analysis DBS will be migrated periodically
- New Analysis DBS for CRAB 3 usage
- StoreResults will be replaced by SR@WM
- CRAB 2/3 used in parallel for a transition period
- WMAgents and CRAB 3 will use DBS 3 only

▸ Transition planed to happen end of the year

Migration to DBS 3

Challenges:

- DBS 2 is growing fast 40M files, 240k blocks and 200k datasets
- DBS 3 is completely different, data conversion is necessary

Migration & Validation:

- Adaption of data to the new schema is done using PL/SQL scripts
- Once data has been transformed, a one-to-one validation is done
- Validation is driven by a python script using standard SQL queries

Limitations:

- Duration of the migration fluctuates depending on DB load
- Migration happens en bloc - no incremental migration of data possible
  - All services need to be ready for DBS 3 before migration can happen

Migration Pilot Runs

Pilot Run Migration March/May 2013:

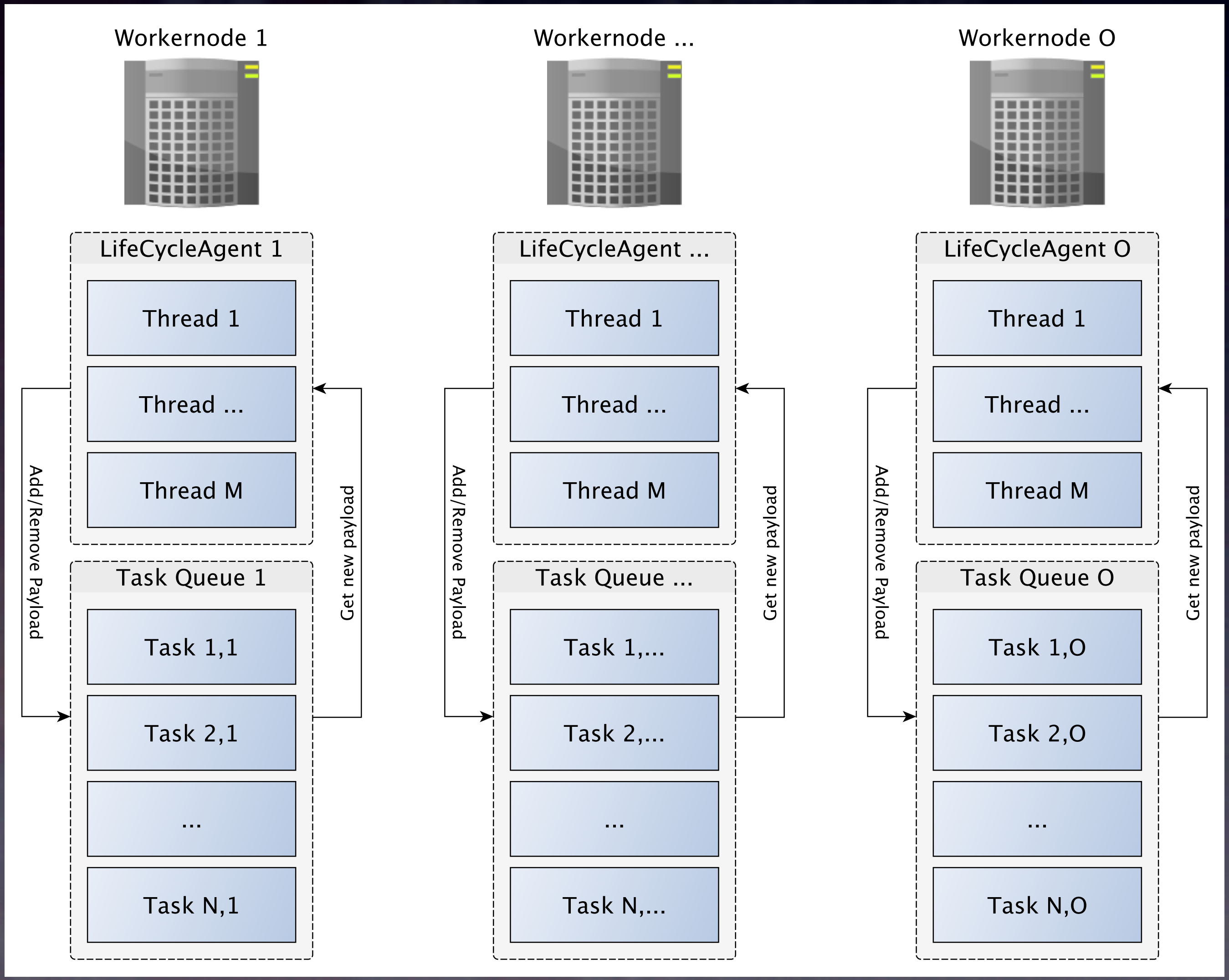
- DBS 2 was operated in read-only mode during the migration
- In March:
  - Data from Heavy Ion run was inserted in both DBS 2/3
- Since May:
  - All WMAgents are inserting all data in both DBS 2/3
  - Inserting around 18000 blocks per month
  - Monthly consistency checks between DBS 2/3 are done
  - Only minor differences found between DBS 2/3 data
    - Differences well understood

Conclusion:

- Migration and validation of data strongly depend on the DB load
- In both cases the migration finished in less than a day

DBS 3 Stress Tests

- Using PhEDEx LifeCycleAgent to drive the stress tests
- DBS 3 is using a dedicated queue on the CERN batch system
  (4 Hosts with 8 job slots each)



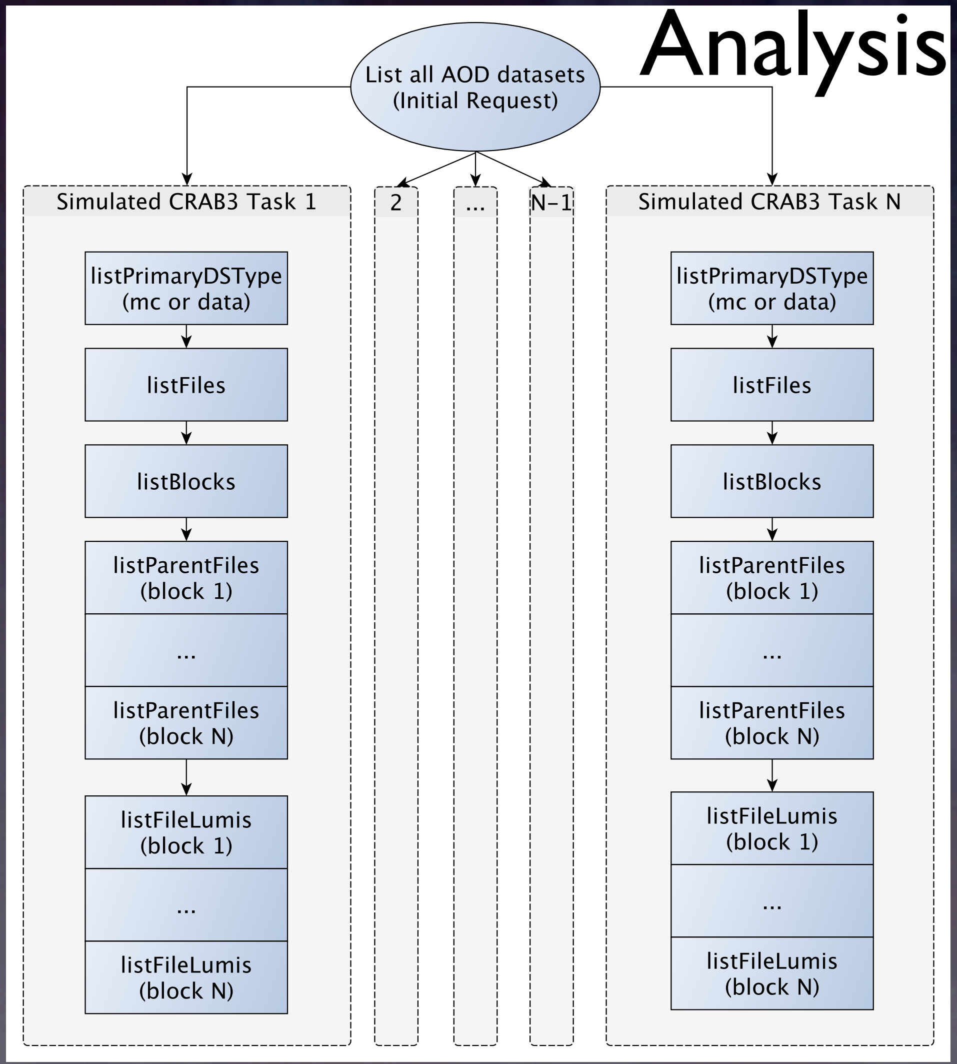
Poster at CHEP13: Integration and validation testing for PhEDEx, DBS and DAS with PhEDEx LifeCycleAgent

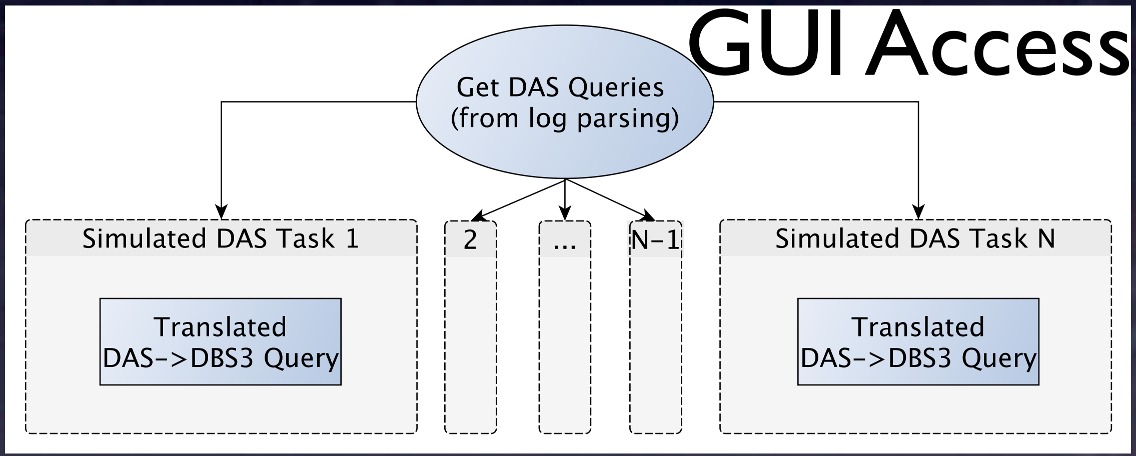
DBS 3 Stress Tests

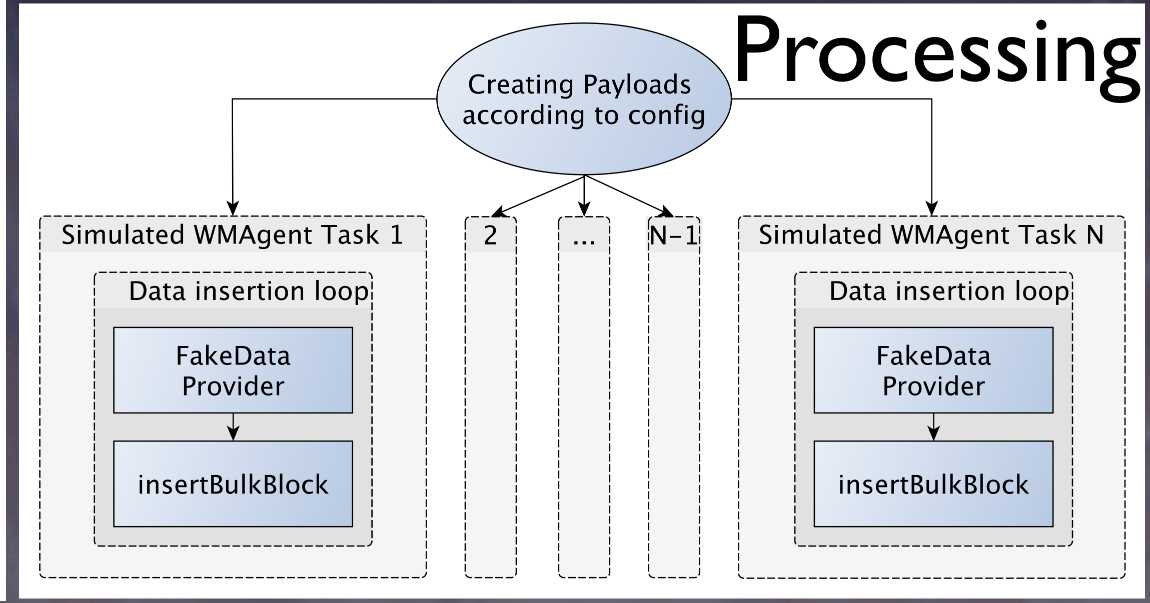
- Simulated CRAB 3 access pattern to DBS 3 (Distributed Analysis)
- Simulated DAS access pattern to DBS 3 (GUI Access from Users)
- WMAgent bulk block insertion simulation (Official Processing)

Run tests against cmsweb pre-production cluster

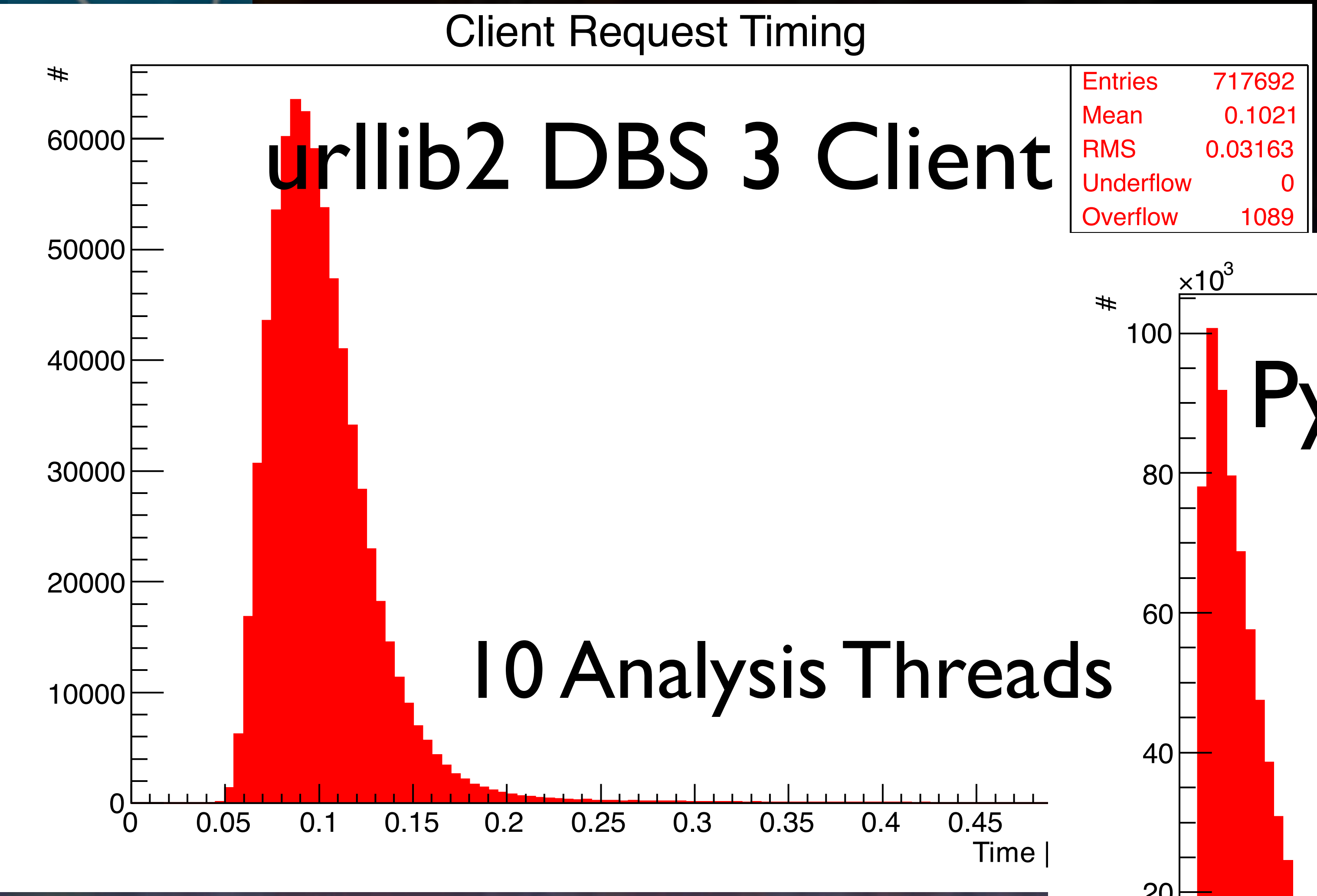
(2 Apache frontends, 2 cherrypy backends each running on a dual core VM having 4GB RAM)

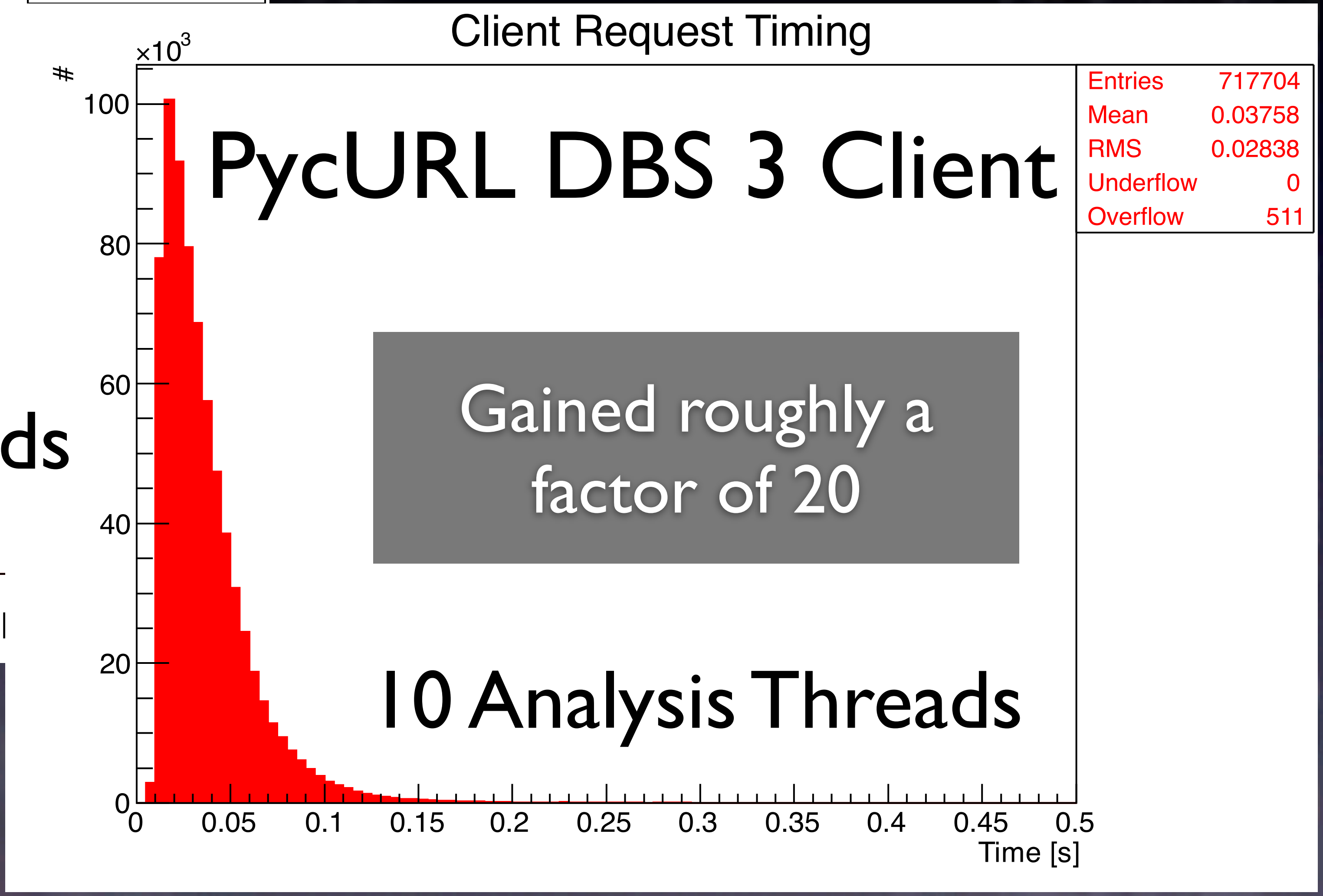



GUI Access
Get DAS Queries (from log parsing)
Simulated DAS Task 1
2
...
N-1
Simulated DAS Task N
Translated DAS->DBS3 Query



Results(Analysis Task)





Gained roughly a factor of 20

Each client calls several DBS 3 APIs in a row. We can gain a lot by using PycURL ssl authentication caching

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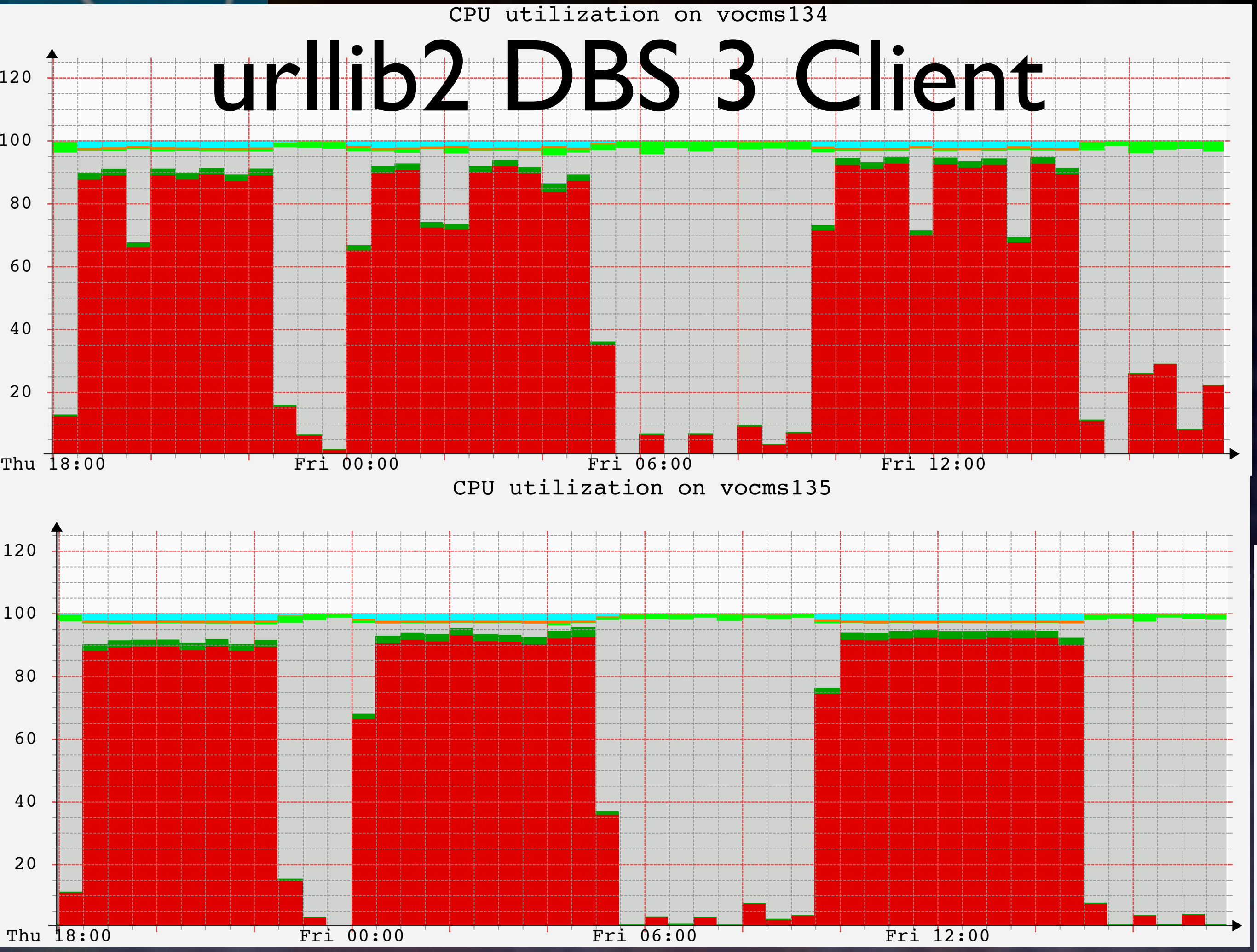
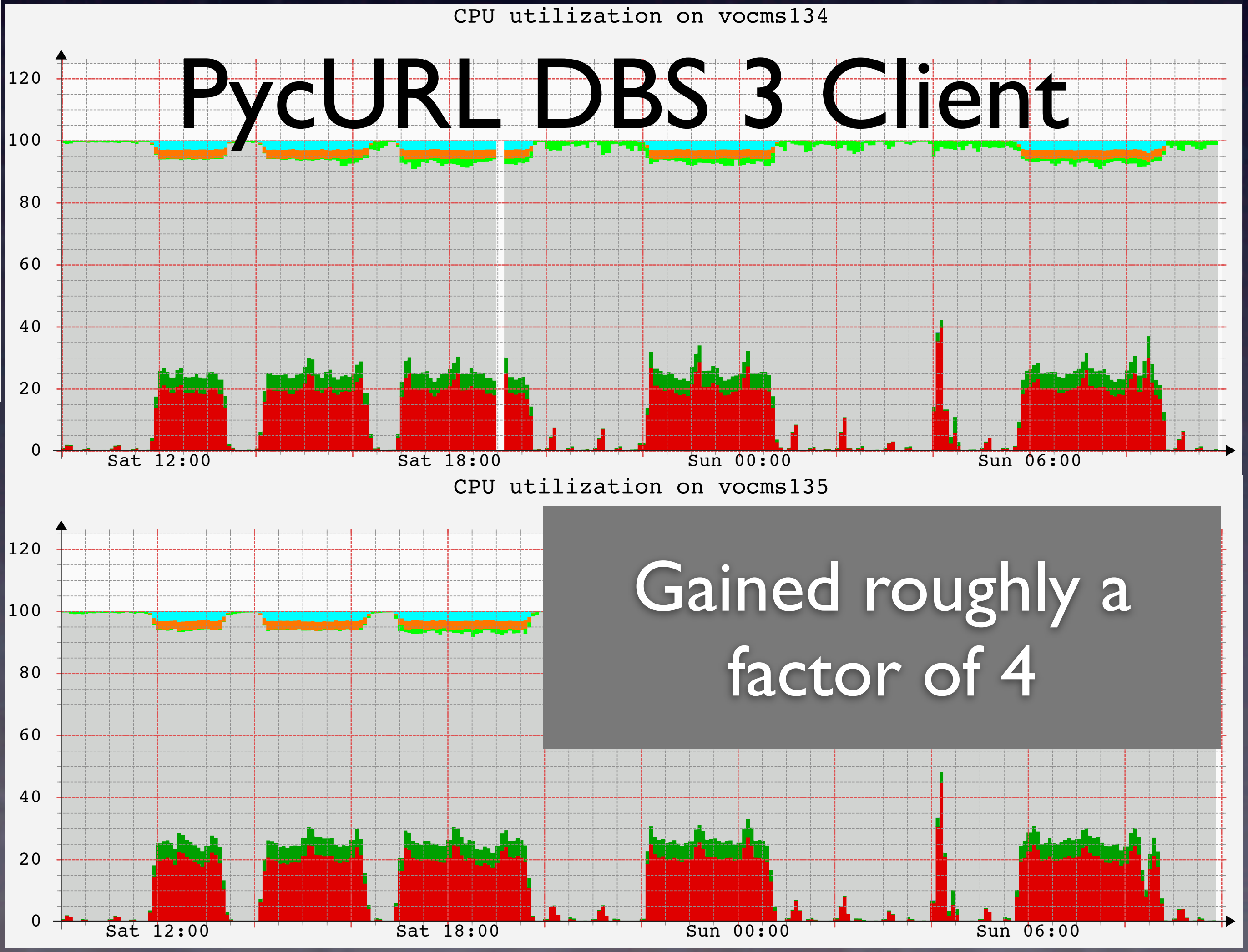


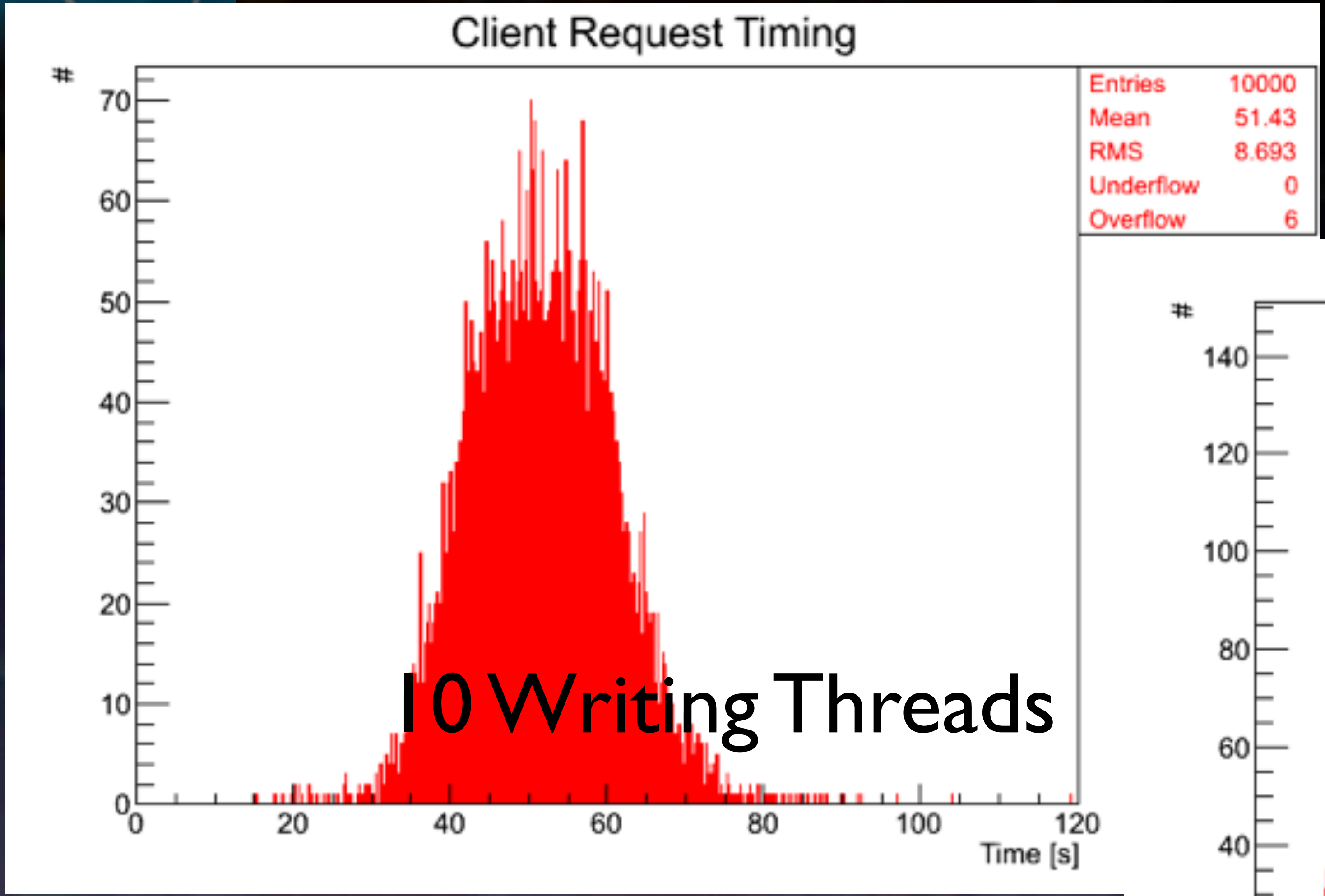
Using PycURL ssl authentication caching, reduces the number of authentications to the Apache Frontends of CMSWEB.



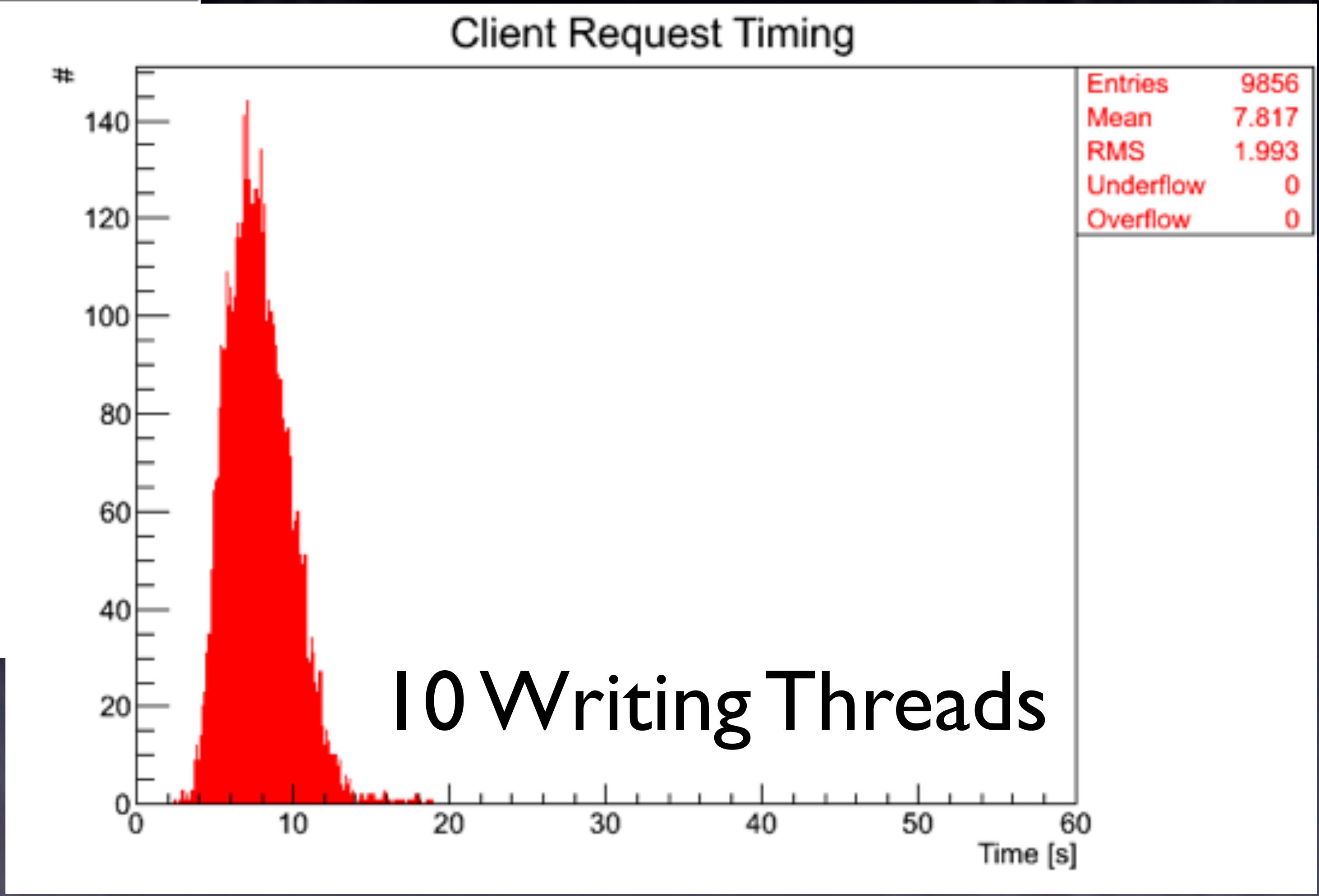
That means less load on the Apache Frontends of CMSWEB.

Gained roughly a factor of 4

Results(Writing)



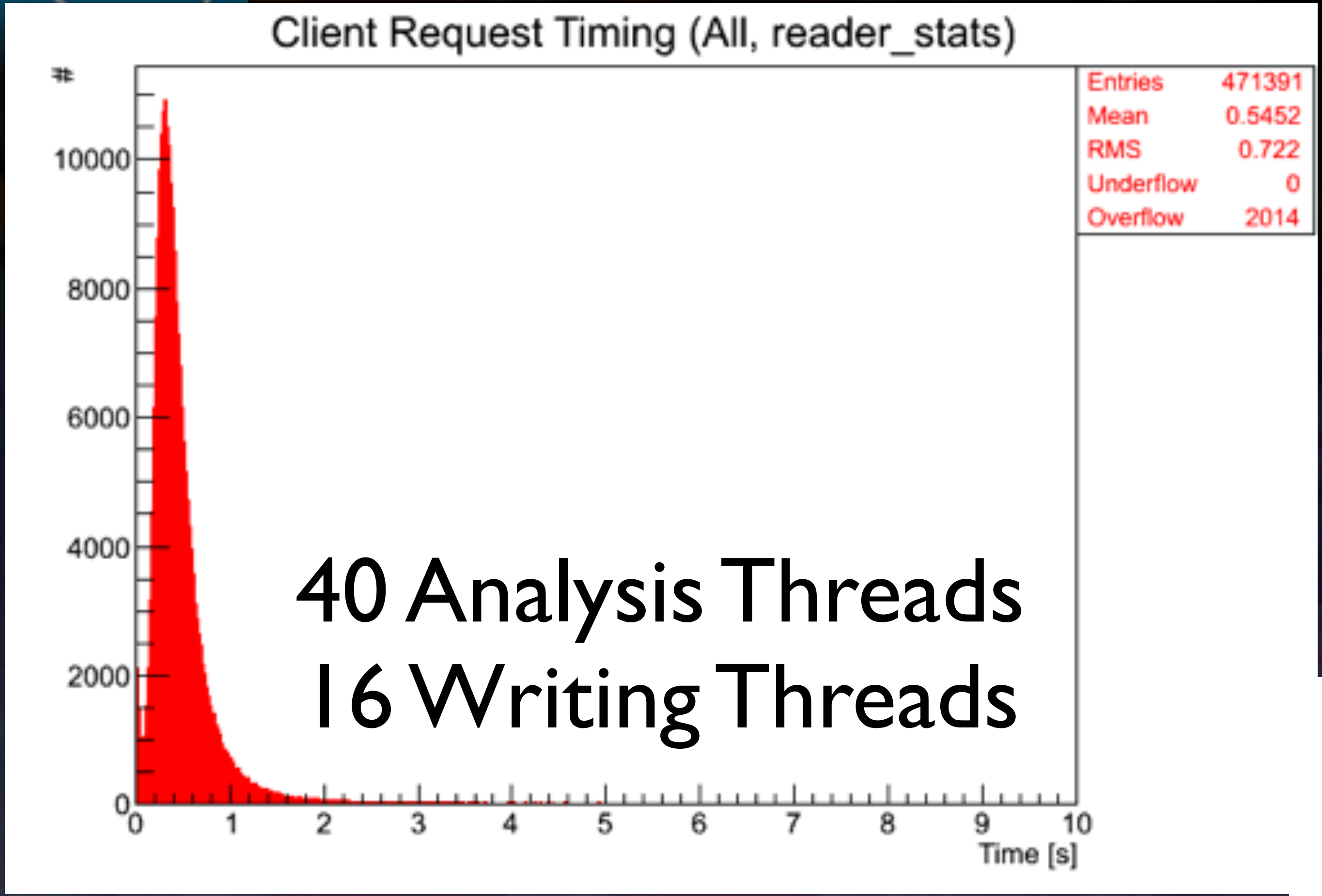
10000 Blocks, 100 Files each, 100 Lumisections each



10000 Blocks, 100 Files each, 14000 Lumisections each

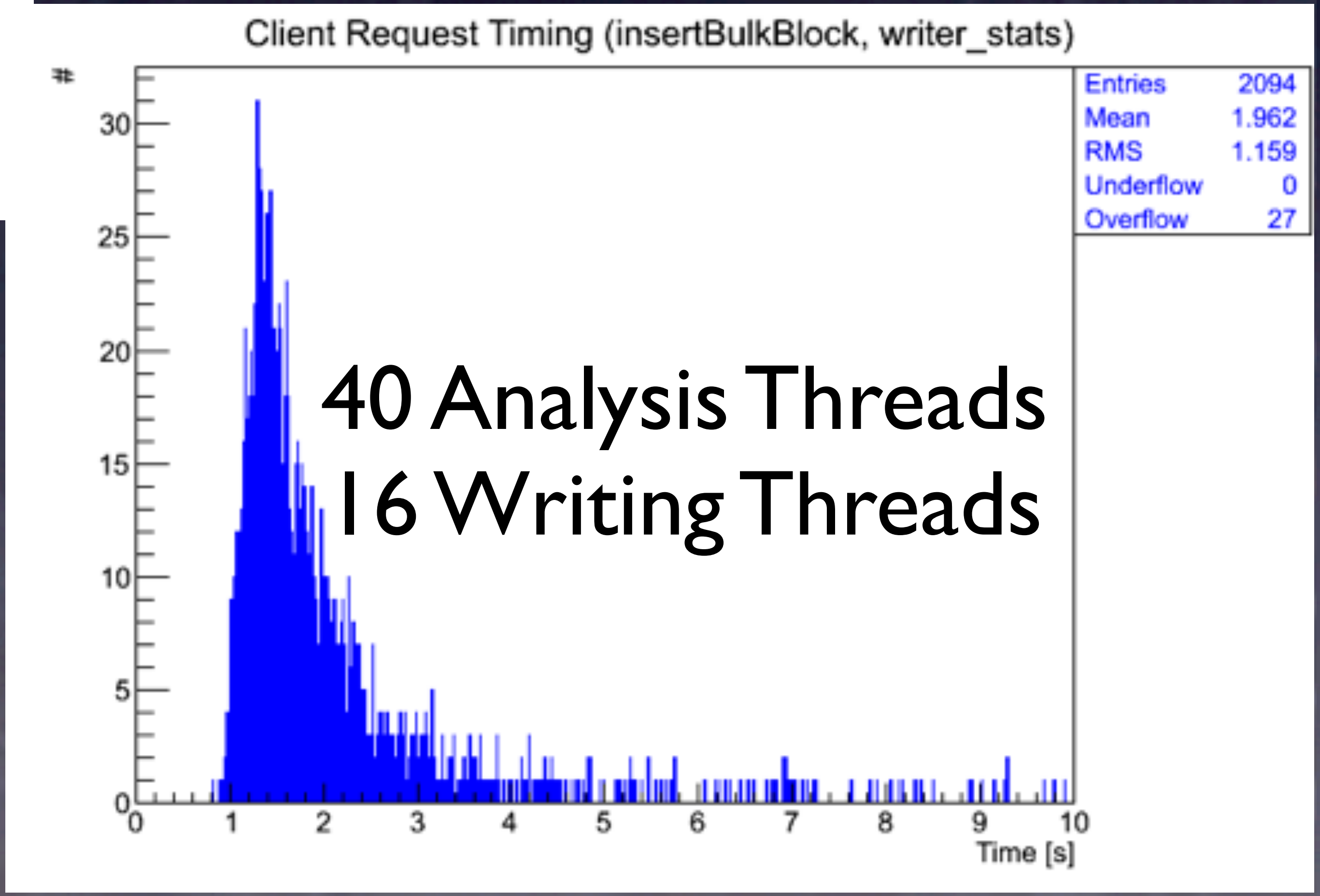
Even for the a large production task with 14000 Lumisections, the block injection in DBS 3 takes only 50s per block, compared to about 4 hours in DBS 2.

Results(Combined)



- Combined reading and writing test
- Even under high load DBS 3 behaves well

- The tests corresponds to 40 servers reading in parallel and 16 writing every 60s a block of 100 Files, having 100 Lumisections
- CMS currently has ~10 servers



Summary & Outlook

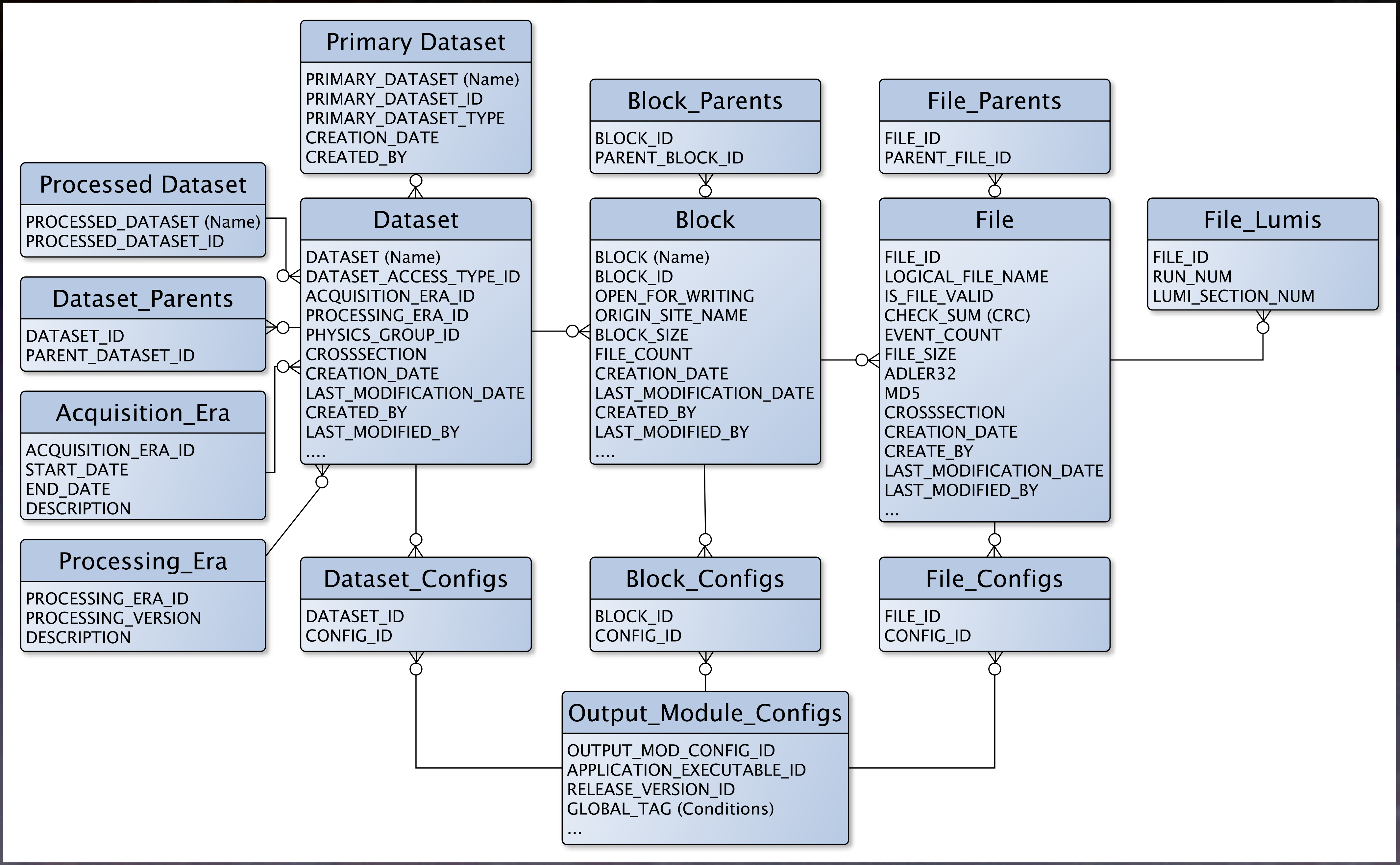
- DBS 3 is an essential part of the Data Management and Workload Management in CMS
- Without DBS MC production, data processing and user analysis are not possible
- The design of DBS is following the original design goals
- Transition from DBS 2/3 is a complex endeavour
- Migration pilot runs were successful, help to spot problems before going official to production
- Stress-tests showing that performance of DBS 3 is good

- Doing another migration pilot run before DBS 3 is going into production
- Make DAS querying both DBS 2/3 will move it a bit closer to production

Backup

Simplified DBS Schema

What information is stored in DBS?



Primary Dataset
PRIMARY_DATASET (Name)
PRIMARY_DATASET_ID
PRIMARY_DATASET_TYPE
CREATION_DATE
CREATED_BY
Block_Parents
BLOCK_ID
PARENT_BLOCK_ID
File_Parents
FILE_ID
PARENT_FILE_ID
Processed Dataset
PROCESSED_DATASET (Name)
PROCESSED_DATASET_ID
Dataset
DATASET (Name)
DATASET_ACCESS_TYPE_ID
ACQUISITION_ERA_ID
PROCESSING_ERA_ID
PHYSICS_GROUP_ID
CROSSSECTION
CREATION_DATE
LAST_MODIFICATION_DATE
CREATED_BY
LAST_MODIFIED_BY
....
Block
BLOCK (Name)
BLOCK_ID
OPEN_FOR_WRITING
ORIGIN_SITE_NAME
BLOCK_SIZE
FILE_COUNT
CREATION_DATE
LAST_MODIFICATION_DATE
CREATED_BY
LAST_MODIFIED_BY
....
File
FILE_ID
LOGICAL_FILE_NAME
IS_FILE_VALID
CHECK_SUM (CRC)
EVENT_COUNT
FILE_SIZE
ADLER32
MD5
CROSSSECTION
CREATION_DATE
CREATE_BY
LAST_MODIFICATION_DATE
LAST_MODIFIED_BY
...
File_Lumis
FILE_ID
RUN_NUM
LUMI_SECTION_NUM
Dataset_Parents
DATASET_ID
PARENT_DATASET_ID
Acquisition_Era
ACQUISITION_ERA_ID
START_DATE
END_DATE
DESCRIPTION
Processing_Era
PROCESSING_ERA_ID
PROCESSING_VERSION
DESCRIPTION
Dataset_Configs
DATASET_ID
CONFIG_ID
Block_Configs
BLOCK_ID
CONFIG_ID
File_Configs
FILE_ID
CONFIG_ID
Output_Module_Configs
OUTPUT_MOD_CONFIG_ID
APPLICATION_EXECUTABLE_ID
RELEASE_VERSION_ID
GLOBAL_TAG (Conditions)
...