LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Belle II Conditions Database Overview

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18th International Workshop on Advanced Computing and Analysis Techniques in Physics Research
August 22, 2017

TUM LMU Excellence Cluster Universe

Bundesministerium für Bildung und Forschung

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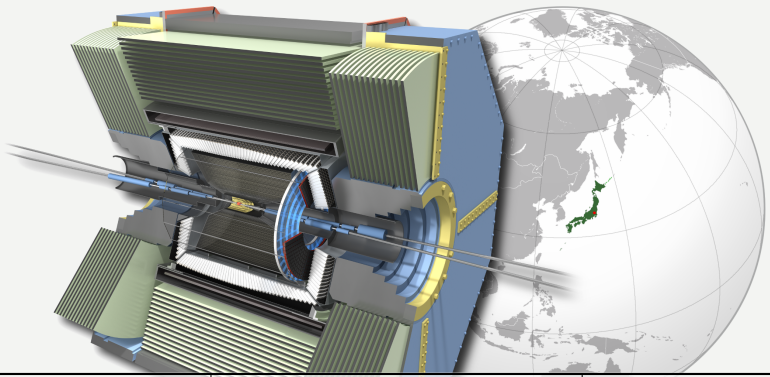
Belle/Belle II Experiment

Asymmetric e^+e^- experiment mainly at the $\Upsilon(4S)$ resonance (10.58 GeV)

Focus on B, charm and τ physics



	KEKB/Belle	SuperKEKB/Belle II
operation	1999–2010	start 2018
peak luminosity	$2.11 \times 10^{34}\,\mathrm{cm^{-2}s^{-1}}$	$8 \times 10^{35}\,\mathrm{cm^{-2}s^{-1}}$
integrated luminosity	$1023\,\mathrm{fb^{-1}}$ (772 million $B\overline{B}$ pairs)	$50\,\mathrm{ab^{-1}}$

Conditions Data

Conditions Data: changes over time, not part of event

- luminosity
- detector status
- calibrations
- reconstruction settings

Challenges:

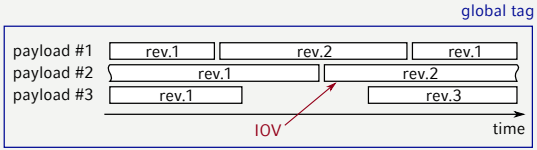
- required for data taking
- required worldwide for grid/cloud processing
- vastly different lifetimes/sizes
- different requirements by different sub-detectors

Terms

payload is one atom of conditions data (e.g. alignment constants)

IOV is short for "interval of validity", the time interval in which a payload is valid

global tag is an immutable set of payloads and their IOVs.

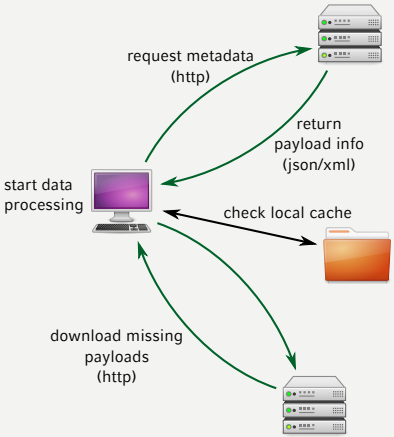


Design Overview

- use industry standard tools where possible
- decouple metadata from content
- use REST service for metadata
- use files for payloads
- smallest granularity: 1 run
  (uninterrupted period of data taking,
  up to a few hours)

➡ REST interface greatly decouples server/client development

➡ Very low requirements, only connect to http(s)



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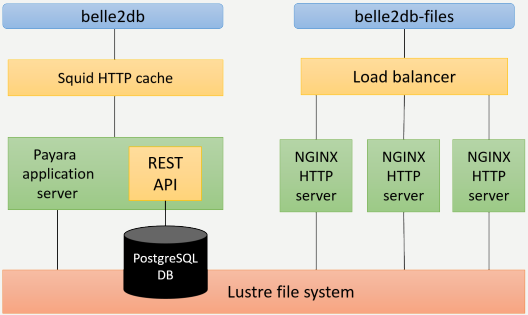
Server Side

Lynn Wood, Todd Elsethagen, Kevin Fox, Jeter Hall,
Bibi Raju, Malachi Schram, Eric Stephan

Current Back-End Configuration

two separate services:

- left: DB access/file upload
- right: payload file download



Database Server

- Squid cache in front of REST application server to reduce load
- Payara Micro Java server
- Hazelcast in-memory data grid platform for caching and stability

Payload server

- Load-balanced NGINX high performance HTTP servers

➡ Each component is implemented as a Docker container managed using Kubernetes – provides modularity and auto-restart

Performance of Current System

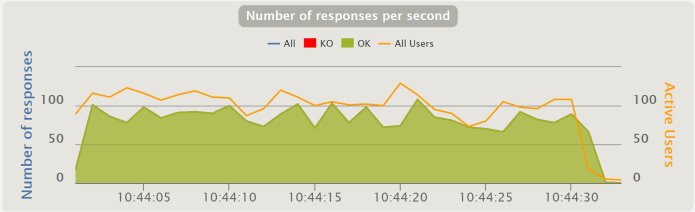
Directed testing with Gatling, a HTTP load stress tool

- Scala scripting for custom test design

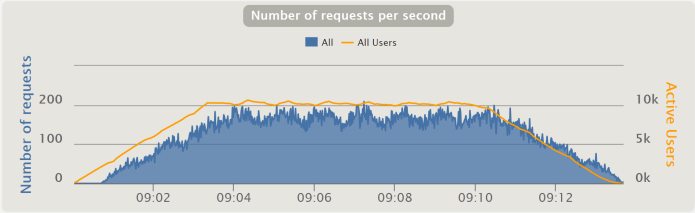
Database server performance dependent on Squid, Java config

Payload file server (load-balanced x3) very stable

Current performance about half of needed levels at full expected Belle II processing.



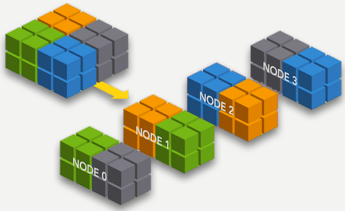
Stress test of the database server, showing a sustained rate of ~ 80 requests/second



Stress test of the payload file server, showing a sustained rate of ~ 180 requests/second and support of 10,000 simultaneous connections

Multi-Site Caching via Hazelcast

- Currently all Conditions DB services are installed on a **single** PNNL-managed host
- Hazelcast provides standalone caching store to improve service performance
  - Data is evenly distributed among the nodes
    ⇨ **horizontal scaling** of processing and storage
  - Backups also distributed among nodes
    ⇨ protect against **single-node failure**
  - Each site also supports a dedicated "local cache" for commonly requested items



- Evaluating multi-site system at PNNL now
  - Hazelcast would auto-cluster sites as they come online
  - Cache distributed/partitioned across the memory resources (Java heap) contributed by each site
  - Access to partitioned cache would be **transparent** to the application: Hazelcast manages routing, no code changes for distributed access
  - Frequently accessed remote cache entries will be stored in a "Near Cache"

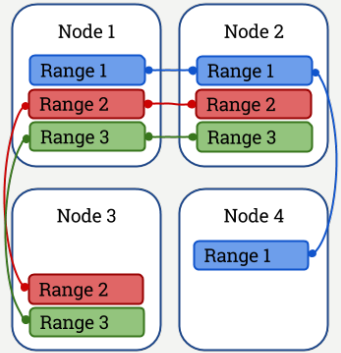
Database Replication and Authentication

The PostgreSQL database also not currently scalable

- Investigating distributed database options such as CockroachDB
  - Symmetric node architecture, horizontal scalability per site
  - Distributed transactions, majority consensus for consistent replication
  - Automated repair after failure

Authentication currently not implemented

- Expectation is to leave read operations open, but require authentication for write operations
- Considering leveraging the X.509 authentication already present in the Belle II Grid computing interface
- Create new roles for database



Range Replication in CockroachDB

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Client Side

Martin Ritter, Thomas Kuhr, Christian Pulvermacher

Client Side

Belle II Software Framework

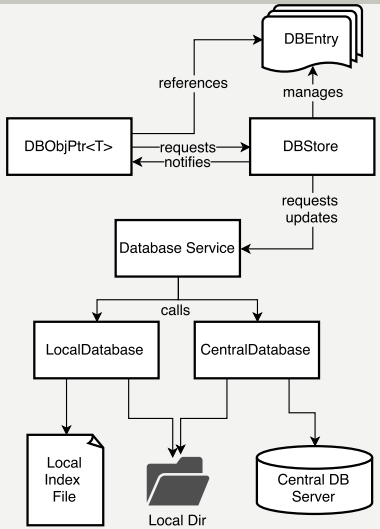
- C++14, ROOT 6
- Python 3 configuration/scripting
- Multi processing capabilities

➡ use ROOT files for conditions payloads

- users obtain reference to payload by name
- framework will obtain payload information
- handle updates transparently
- users can check/be notified on changes

➡ allow operation without connectivity

- read payload information from file.
- allow downloading of (partial) database



Payload Information and Distribution

Allow cascade of payload information providers

- testing of new payloads locally
- additional analysis-specific payloads (e.g. training-data)

Payloads as files allows for flexible payload delivery

- trivial caching in file system
- various distribution possibilities could be investigated (cvmfs, key-value stores, pack-files, …)
- hybrid solutions possible (e.g. only some payloads on cvmfs)
- http as reliable fallback

Intra Run Dependency

Some conditions data might change more frequently than per run

- payload will contain multiple objects
- handled transparently on client side

Command Line Interface

REST interface makes implementation of clients very easy

- libcurl for C/C++ client in the software framework
- requests library for Python
- large amount of standard tools

User friendly command line interface

- pure python
- inspect/modify database contents
- e.g. compare global tags
  `b2conditionsdb diff tag1 tag2`

Python Requests

```
#!/usr/bin/env python3.6
import requests
BASE_URL = "http://..."
globalTag = "development"
r = requests.get(f"{BASE_URL}/globalTag/"
                 "{globalTag}/payloads")
r.raise_for_status()
for payload in r.json():
    print(payload["checksum"])
```

Conclusions

Belle II Conditions Database

- leverage existing tools where possible
- REST: easy, well defined interface between client and server

Server

- payload content agnostic web service
- implemented using industry tools
- single server setup at half the expected performance

Client

- use ROOT files as payloads
- automatic updates, “offline” mode
- independent command line client

Additional Details

Two Posters today

- Implementing the Belle II Conditions Database using Industry-Standard Tools (L. Wood et al.)
- Belle II Conditions Database Interface (M. Ritter et al.)

Thank you
for your attention