CERN

6 May 2014

CERN openlab IT Challenges workshop, https://indico.cern.ch/event/297559/

CERN and Data Analytics Challenges

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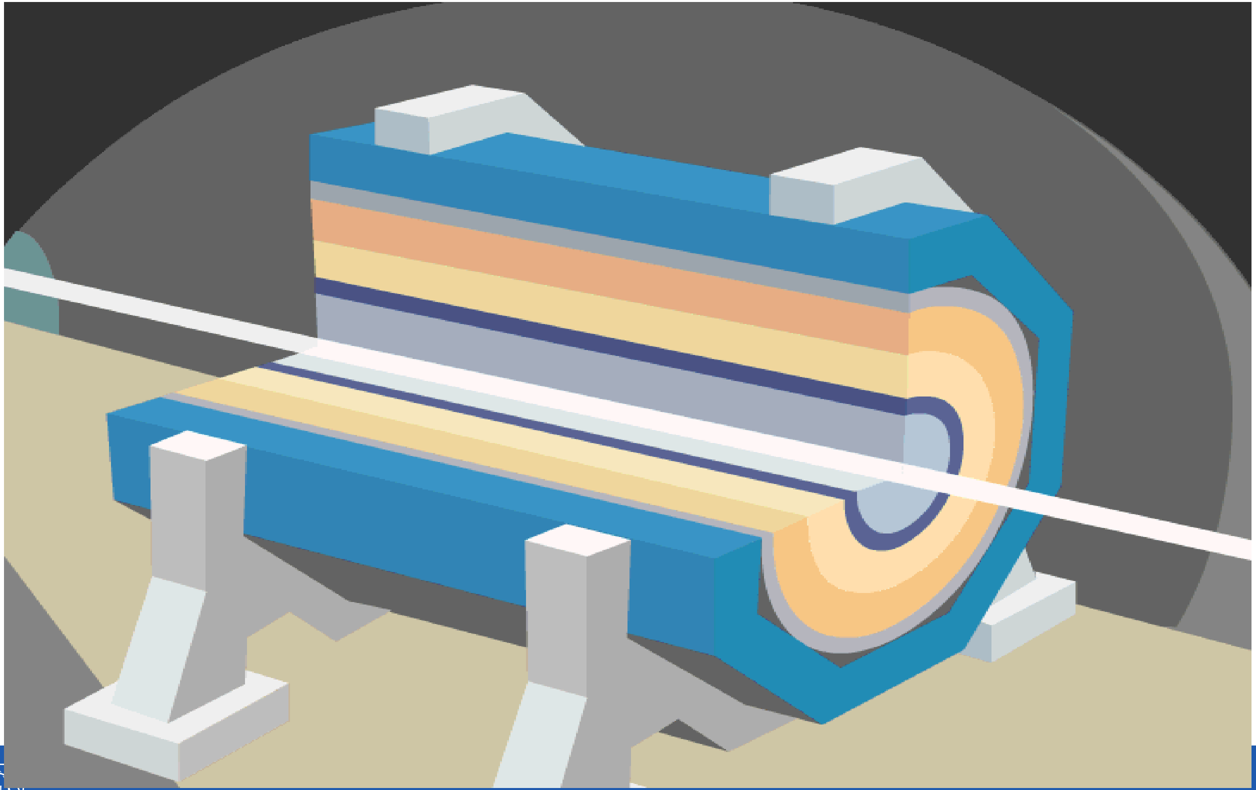
Outline

- CERN and openlab
- Analytics challenges
  - Analytics investigation
  - Fault prediction
  - CERN openlab analytics challenges
  - Technology evolutions
- Analytics as a service

Events at LHC



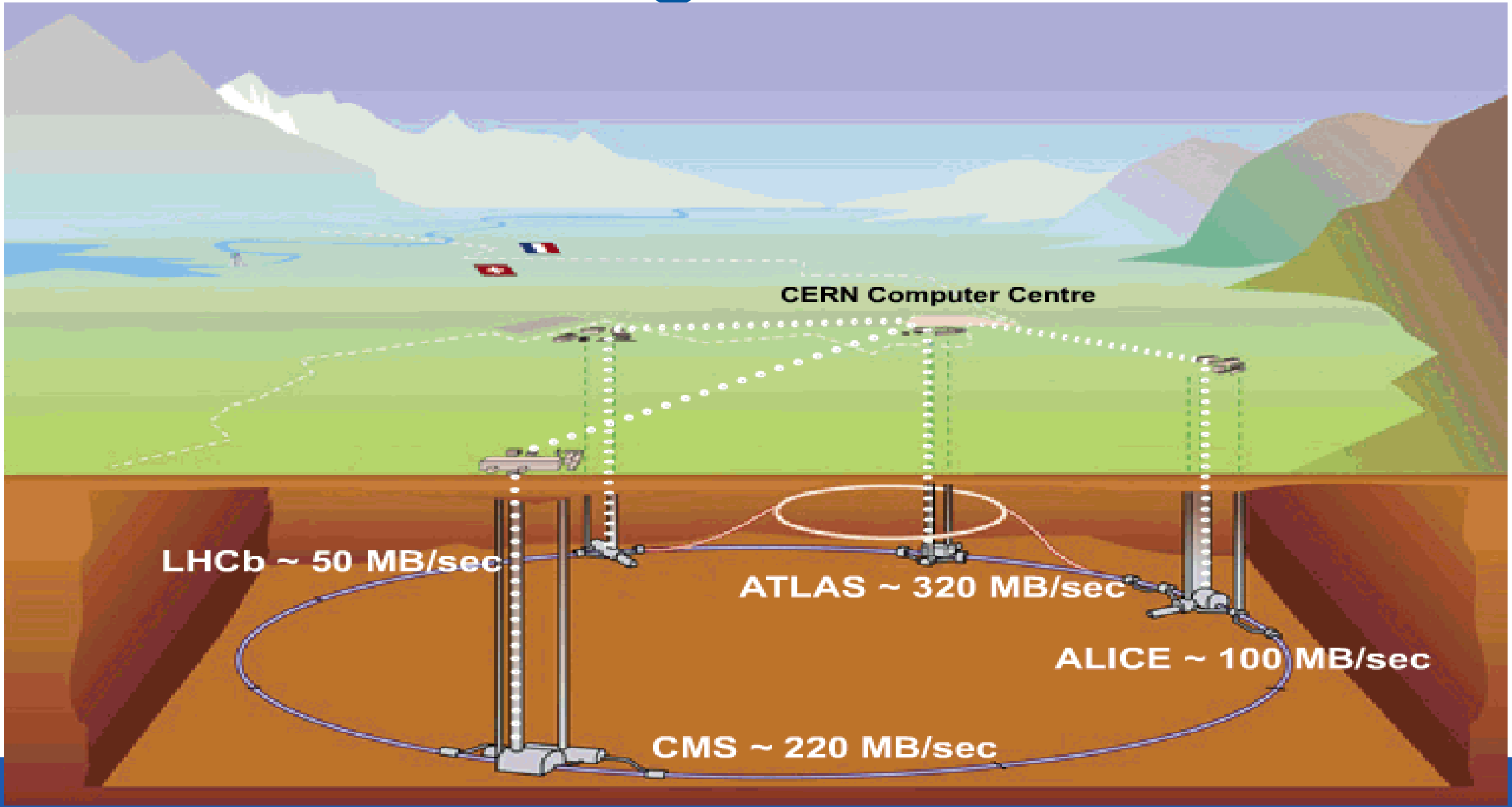
Luminosity :
10^{34}cm^{-2} s^{-1}

40 MHz – every 25 ns

20 events overlaying

Trigger & Data Acquisition

Data Recording



Credit: Alberto Pace

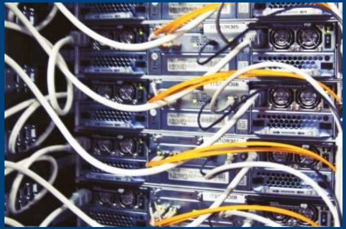
# of cores:	99,061
# of disks:	80,754
# of processors:	18,633
# of 10GB NICs:	3,218
# of 1GB NICs:	19,334
# of servers:	10,809
Disk space (TiB):	129,455
RAM memory (TiB):	349

CERN

Distributed analysis in the different sites (« LHC Computing Grid »)

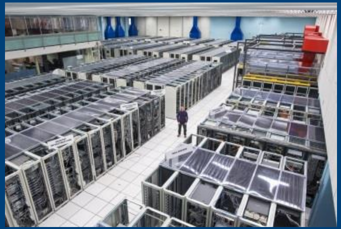
CPUs

Network



Databases

Storage



Infrastructure

openlab (1/3)

- Public-private partnership between CERN and leading ICT companies, currently in fourth phase (started in 2003)
- Its mission is to accelerate the development of cutting-edge solutions to be used by the worldwide LHC community
- Innovative ideas aligned between CERN and the partners, for products “you make it, we break it”

Partners

HUAWEI

intel

ORACLE

SIEMENS

Contributors

rackspace the open cloud company

Associates

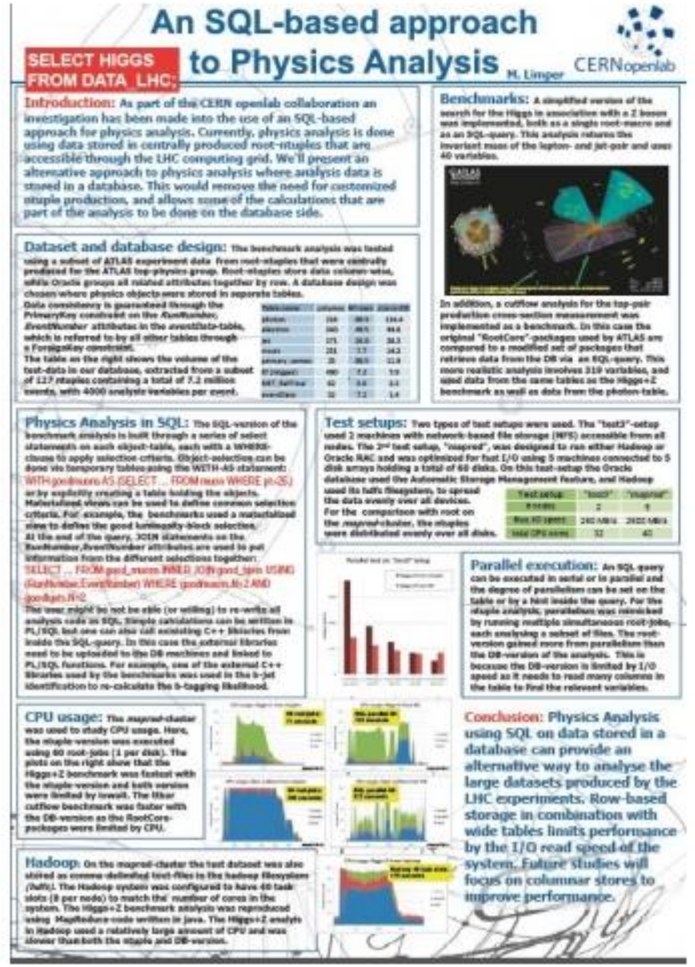
Yandex

openlab (2/3)

- Many successes (DB competence center/Oracle):
  - RAC on Linux x86 (9.2 PoC, 10.1 production with ASM),
  - Additional required functionality (IEEE numbers, OCCI, instant client, etc.),
  - WinCC OA and RAC scalability,
  - Monitoring with Grid Control,
  - Streams world wide distribution,
  - Active DG, GoldenGate,
  - Analytics for accelerator, experiment and IT,
  - Etc.

openlab (3/3)

- Publications (web, paper) and presentations of results, visitors
- Maaike Limper, best poster award at The International Conference on Computing in High Energy and Nuclear Physics 2013

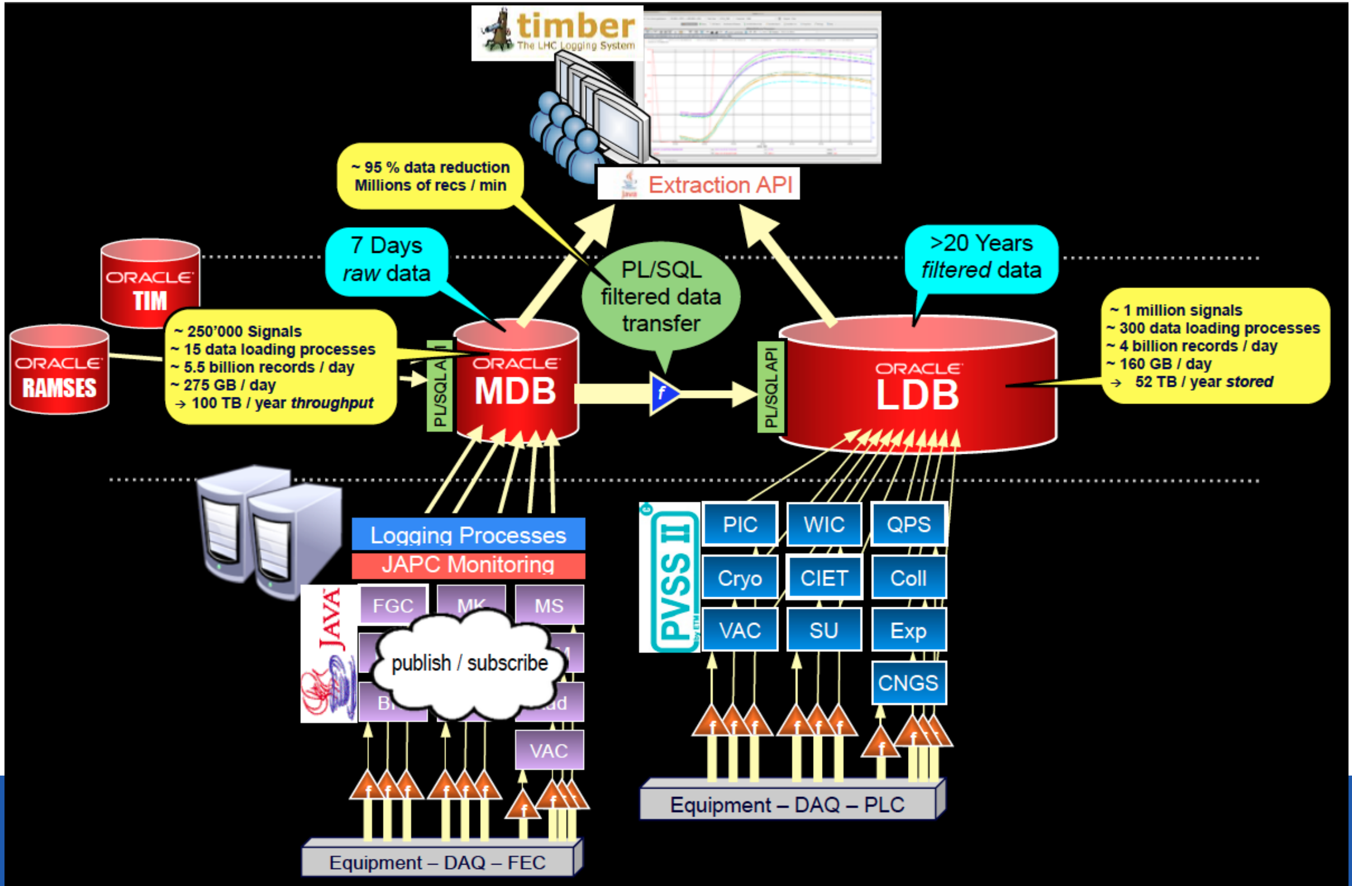


Networked devices

- Large number of control devices, front-end equipment, etc.
- Many critical systems: Cryogenics, Vacuums, Machine Protection, etc.
- (Also called “Internet of Things”)
- Example: LHC logging service (BE-CO)

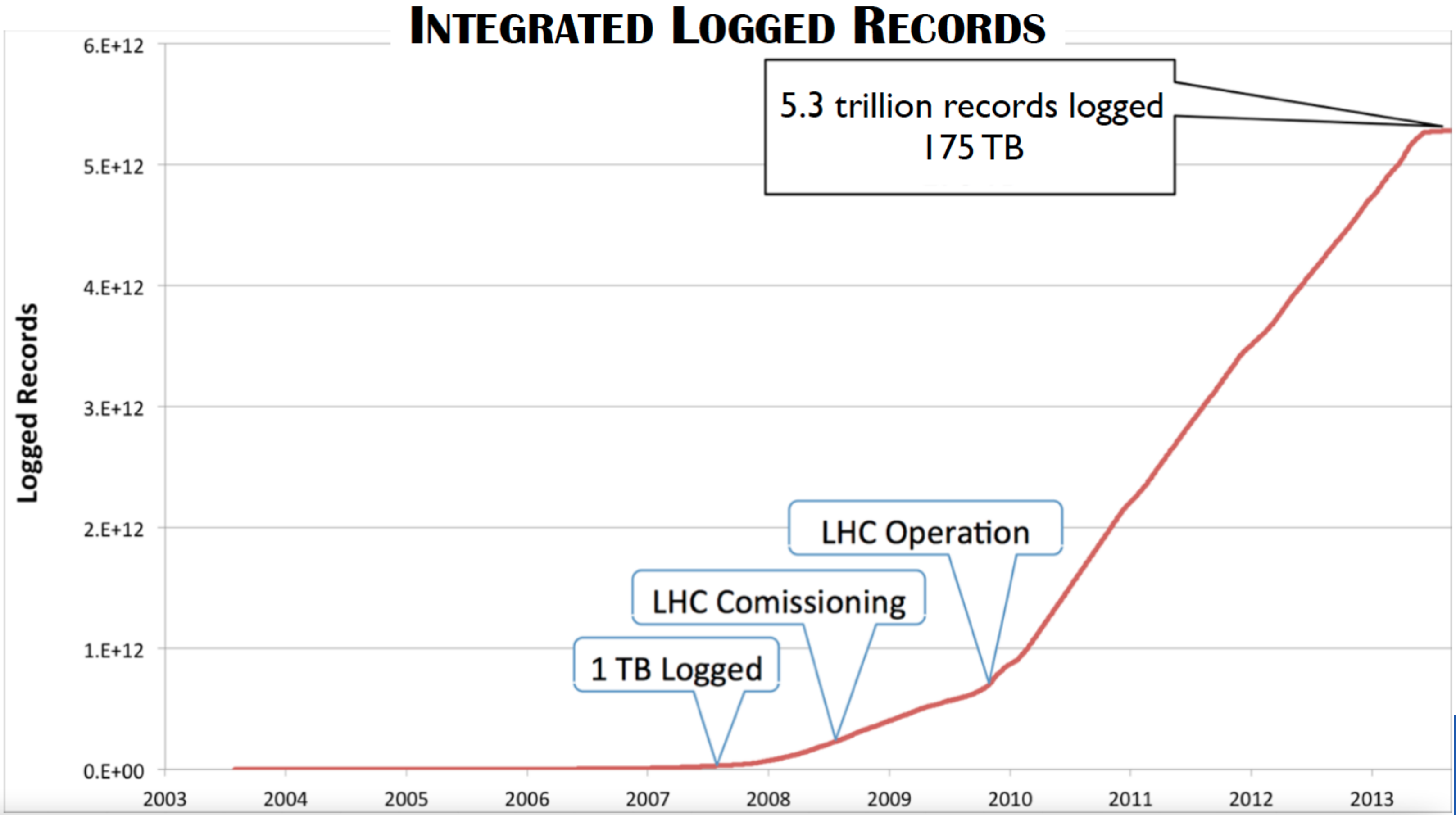
Logging service (1/3)

Credit: Chris Roderick



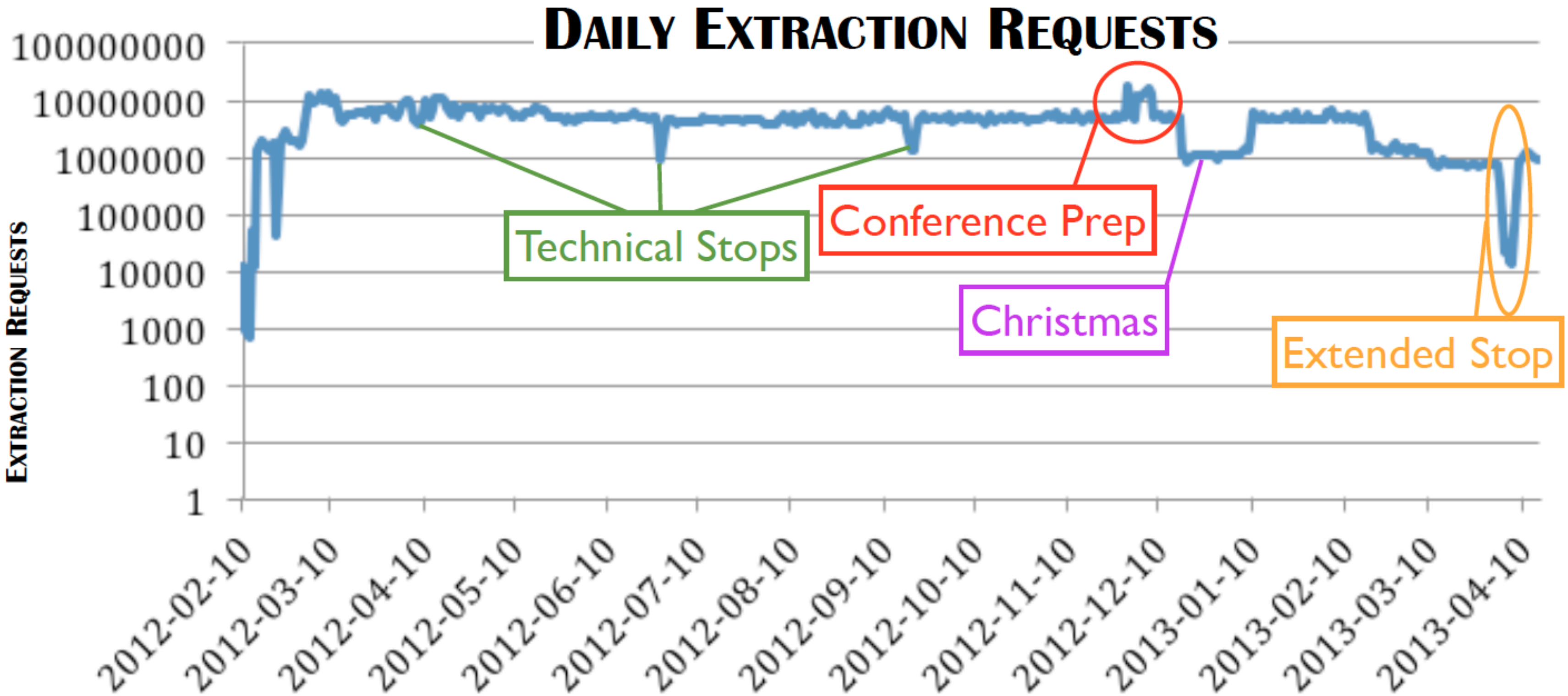
Logging service (2/3)

Credit: Chris Roderick



Logging service (3/3)

Credit: Chris Roderick



Improvements for Archiver of WinCC Open Architecture

Report on work by departments:

Information Technology

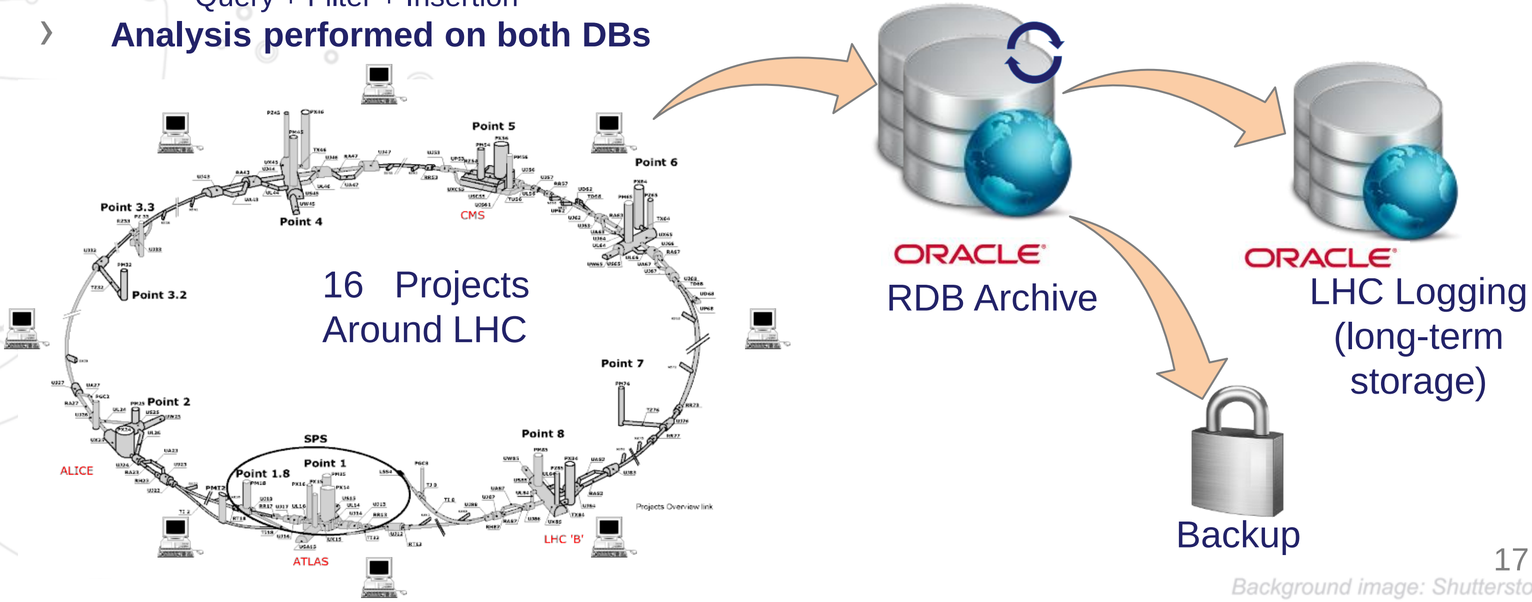
Beams

Engineering

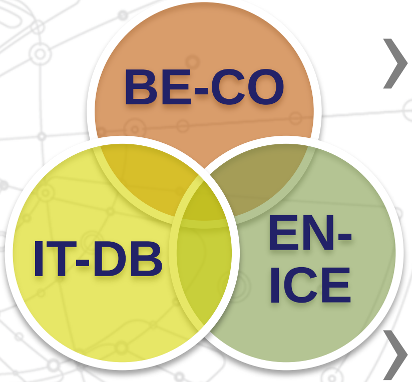
Kacper Szkudlarek

Use case: Quench Protection System

- **Critical system for LHC operation**
  - Major upgrade for LHC Run 2 (2015-2018)
- **High throughput for data storage requirement**
  - Constant load of 150k changes/s from 100k signals
- **Whole data set is transfered to long-term storage DB**
  - Query + Filter + Insertion
- **Analysis performed on both DBs**

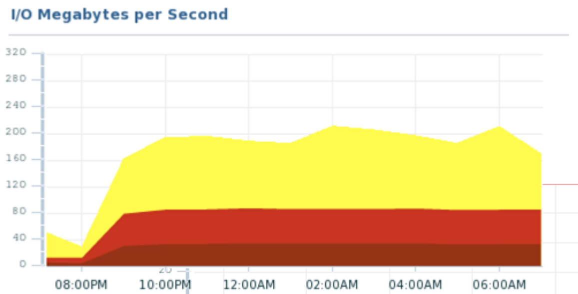


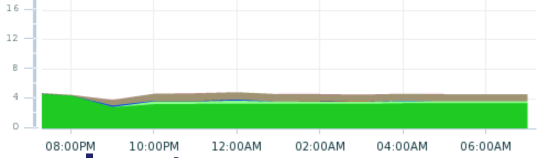
Performance Optimizations



- **Use of Oracle Index Organized Tables**
- **Tuning of DB data queries**
  - Search predicates, time-based partitioning
  - Alignment of data in RAC cluster
- **Changes in database schema**
  - Focus on redo log and space reduction
- **Tuning of database parameters**

Results summary



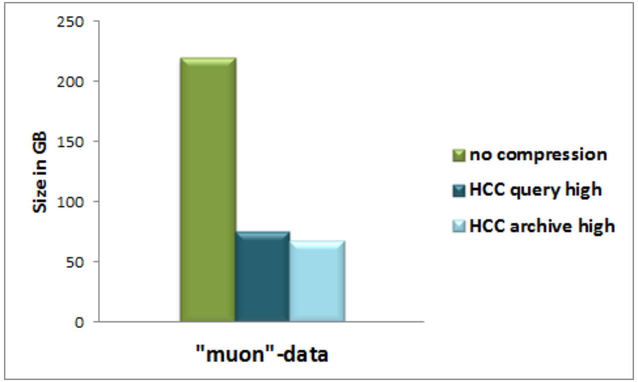


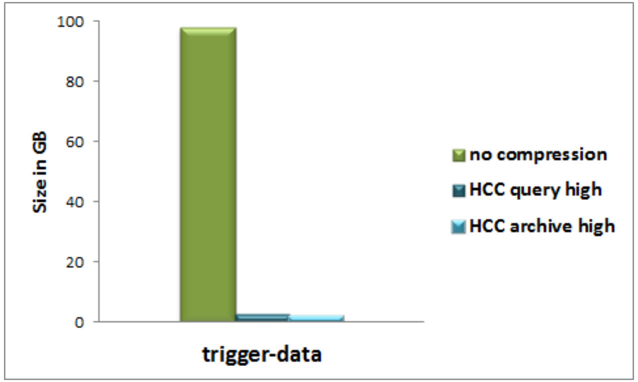
- **Nominal conditions**
  - Stable **constant load of 150k changes/s**
  - 100 MB/s of I/O operations
  - 500 GB of data stored each day
- **Peak performance**
  - Exceeded **1 million value changes per second**
  - 500-600 MB/s of I/O operations
- **All CERN production WinCC OA systems (accelerators, detectors and technical infrastructure, 600 servers) will benefit from these optimizations**
- **Next challenge: ~10x increase**
  - Required for next major upgrade (2019-2020)

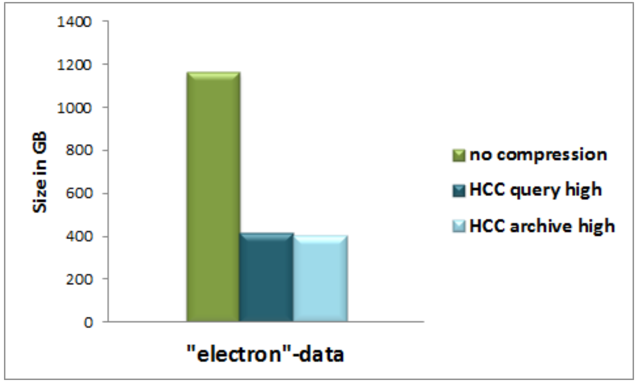
Technology evolutions (1/4)

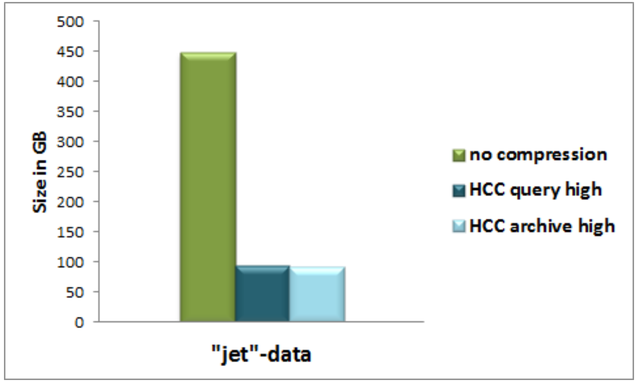
Credit: Maaike Limper

- Columnar compression









Technology evolutions (2/4)

- In-memory databases
  - Commodity servers with 6TB memory or more
  - Together with compression, enable to have (for some applications) the active data set fully in memory
- Flash with low latency storage

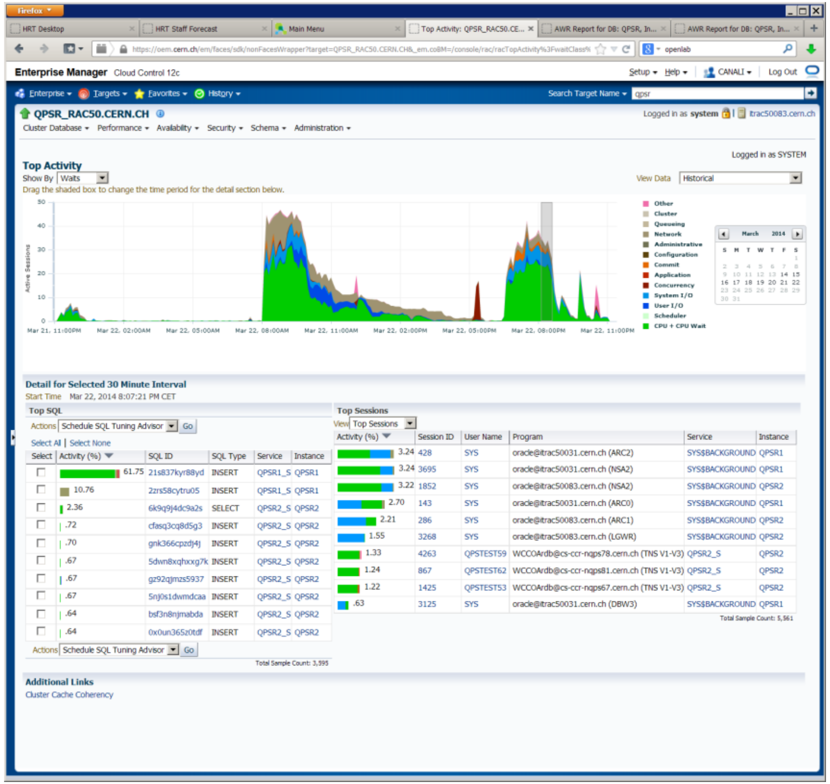
Technology evolutions (3/4)

- Networking
  - 10GbE and more
  - (security…)

Technology innovation (4/4)

Credit: Luca Canali

- Scalable database and storage infrastructure
- Powerful analysis packages like ROOT and R



Anomaly detection

Credit: Massimo Lamanna, Sebastien Ponce (IT-DSS), Stefano Alberto Russo (ex IT-DB)

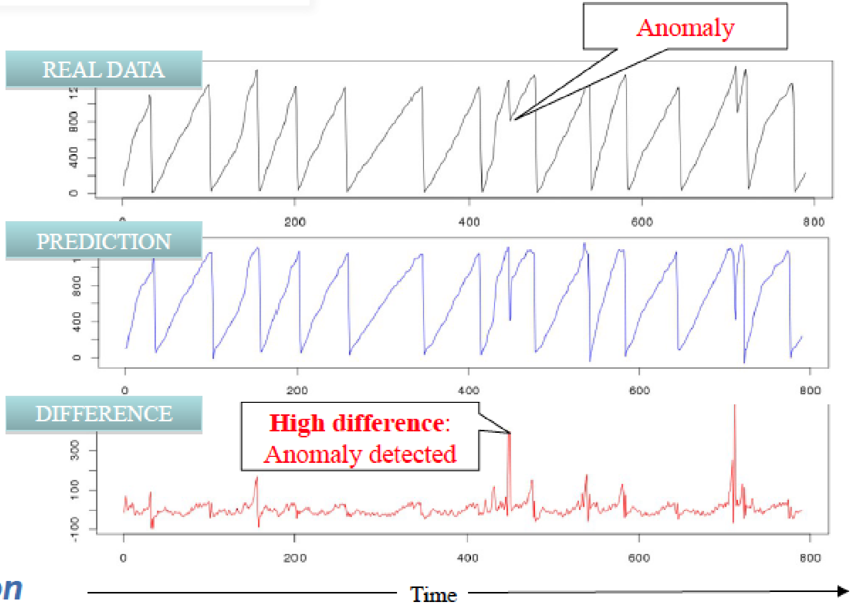
SVM - Support Vector Machines

1) Build a **SVM** (*Neural Network like*) **model**
   - self trained
   - no supervision

2) Predict and compare:

Real data Vs Prediction

1) **Blindly recognize anomalies**
2) ***No other information required*** *(i.e. thresholds)*

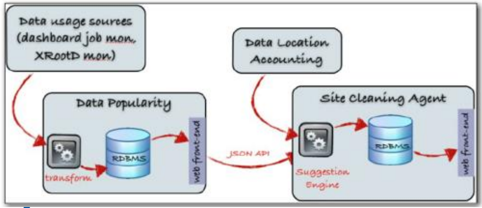


Information discovery

URL link

Manuel Martin Marquez, CERN IT-DB

Experiment data placement

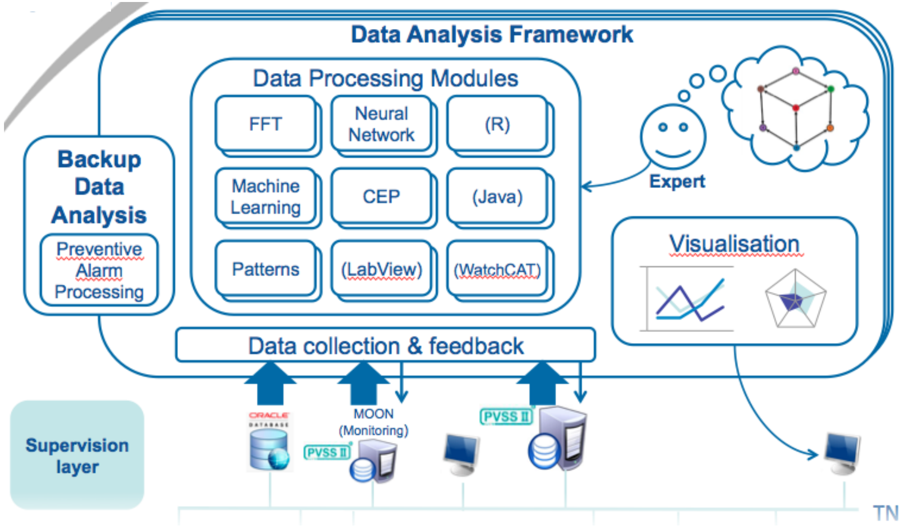


- Intelligent data placement models for the CMS and ATLAS experiments
- Need to extract further knowledge from the monitoring data in order to implement an effective data placement
  - Correlate file-access monitoring with site status
  - Readiness, queue length, storage and CPU available
  - Classify analysis activities and needed resources
  - Making recommendations
  - Learn from the past trends and patterns

Analytics as a service

- “Analytics platform” or (Big data) “Analytics-as-a-service” (A^{3}S ?):
- Data fed from multiple sources (live)
- Stored reliably
- Data processing with multiple systems
- Easy access, domain expert natural language (DSL)
- Visualisation

Credit: CERN EN-ICE



Conclusion

- CERN: very diverse and challenging requirements
- CERN openlab IV, a lot done on Analytics
- CERN openlab V, a lot to be done, CERN and others (EMBL-EBI, ESA, etc.), whitepaper http://cern.ch/openlab/
- “you make it, we break it”
- Complex integration challenges of rapidly evolving technologies
- Some more about Oracle and CERN… DB12c