

CERN IT-DB Services: Deployment, Status and Outlook

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Gaia DB Workshop, Versoix, March 15th, 2011





Outline

- Review of DB Services for Physics at CERN in 2010
 - Availability
 - Incidents
 - Notable activities
- Infrastructure activities, projects, planned changes
 - Outlook and service evolution in 2011



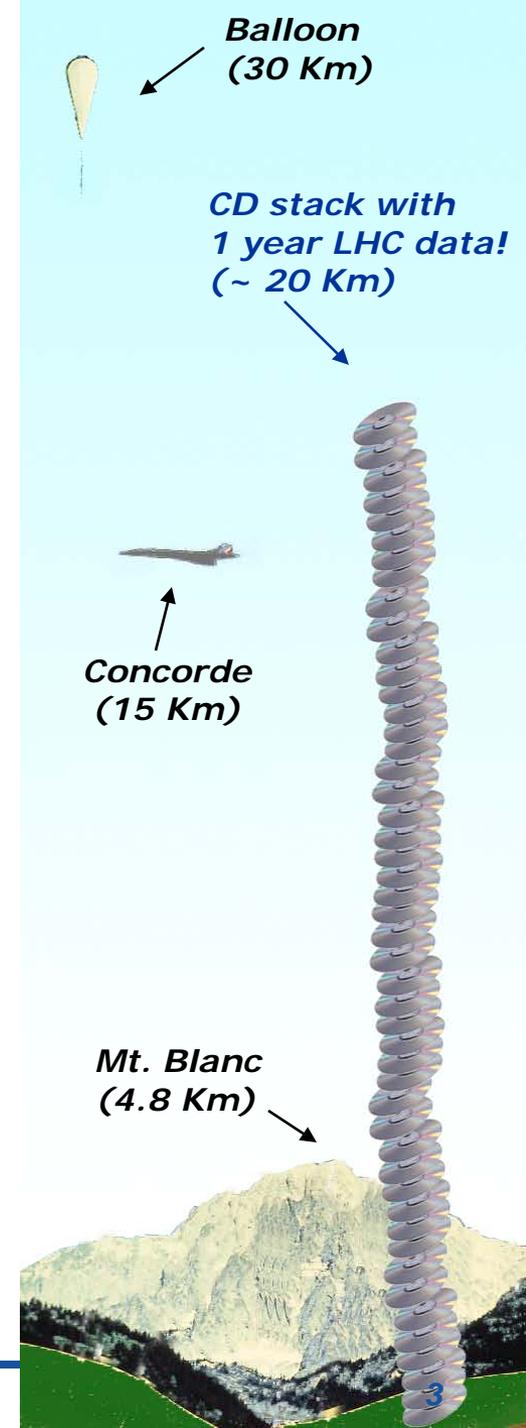
CERN and LHC

CERN – European Organization for Nuclear Research – located at Swiss/French border

LHC – Large Hadron Collider – The most powerful particle accelerator in the world – launched in 2008

LHC data correspond to about 20 million CDs each year!

RDBMS play a key role for the analysis of LHC data

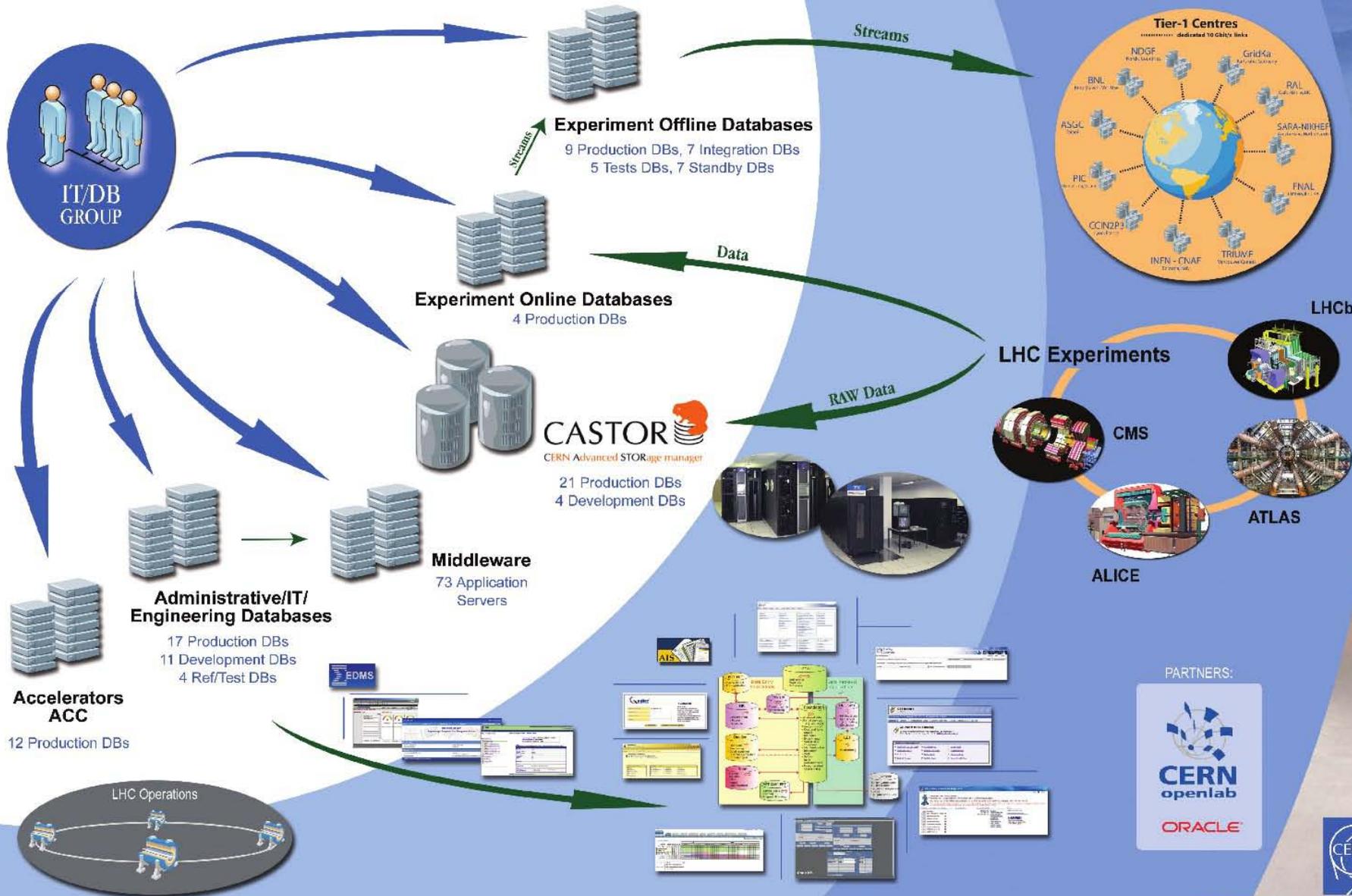




Physics and Databases

- Relational DBs play today a key role for LHC Physics data processing
 - **online** acquisition, **offline** production, data (re)processing, data distribution, analysis
 - SCADA, conditions, geometry, alignment, calibration, file bookkeeping, file transfers, etc..
 - Grid Infrastructure and Operation services
 - Monitoring, Dashboards, User-role management, ..
 - **Data Management Services**
 - File catalogues, file transfers and storage management, ...
 - **Metadata** and **transaction** processing for custom tape-based storage system of physics data
 - Accelerator **logging** and **monitoring** systems

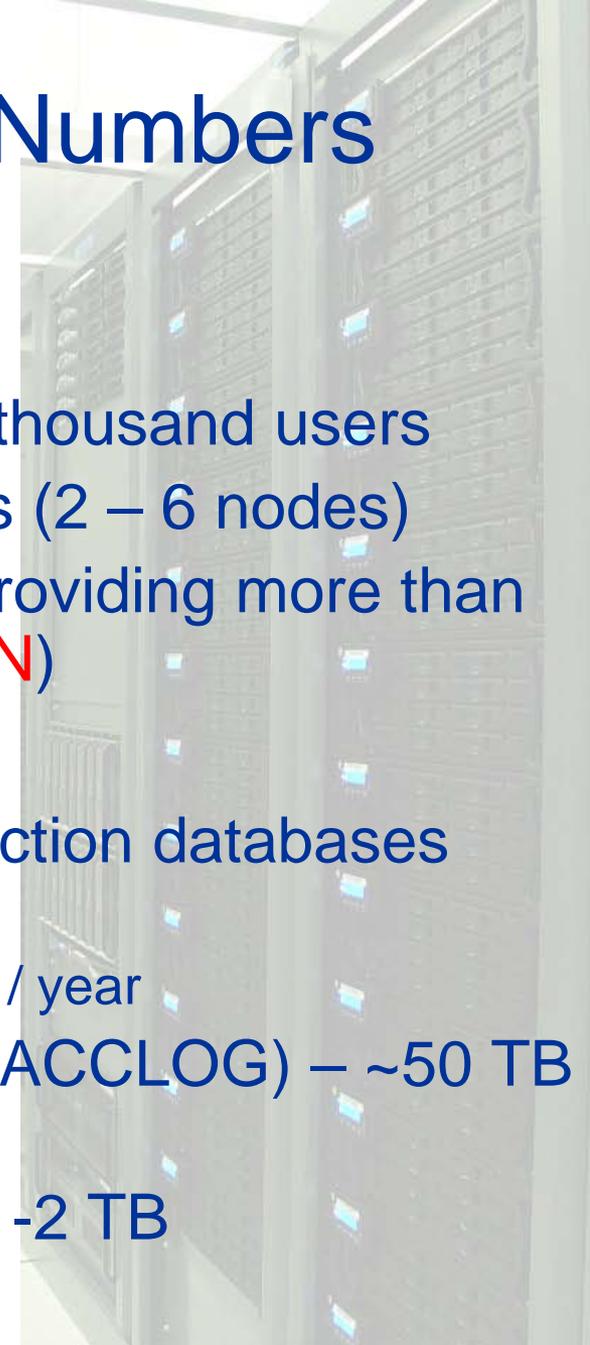
<http://cern.ch/it-dep/db/>





CERN Databases in Numbers

- CERN databases services
 - Global users community of several thousand users
 - ~100 **Oracle RAC** database clusters (2 – 6 nodes)
 - Currently over **3000** disk spindles providing more than ~**3PB** raw disk space (**NAS** and **SAN**)
- Some notable DBs at CERN
 - Experiments' databases – 14 production databases
 - Currently between 1 and 12 TB in size
 - Expected growth between 1 and 10 TB / year
 - LHC accelerator logging database (ACCLOG) – ~50 TB
 - Expected growth up to 30 TB / year
 - ... Several more DBs on the range 1-2 TB

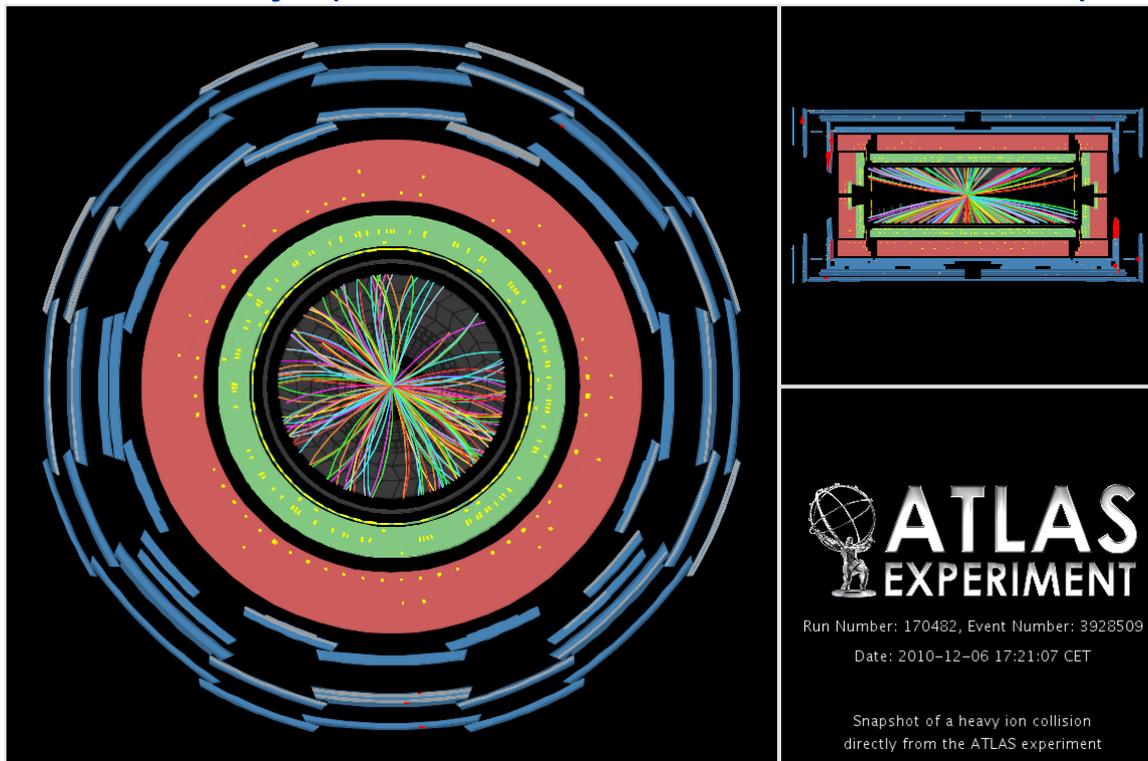




Updates on LHC

Successful re-start of LHC operation in 2010

- 2011 run started mid Feb., beam energy of 3.5 TeV
- Work going on with the acceleration to increase luminosity (and rate of data collection)





Status of the DB Services for Physics



Service Numbers

- Infrastructure for Physics DB Services
 - ~115 quadcore machines
 - ~2500 disks on FC infrastructure
- 9 major production RAC databases.
- In addition:
 - Standby systems
 - Archive DBs
 - Integration systems and test systems
 - Systems for testing streams and 11.2



Services and Customers

- **Offline DB Service** of LHC experiments and WLCG
- **Online DB Service**
- **Replication** from online to offline
- Replication from offline to Tier1s
- Non-LHC
 - biggest user in this category is COMPASS
 - and other smaller experiments



DBA Support

- **24x7 support** for online and offline DBs
 - Formalized with a 'CERN **piquet**'
 - 8 DBAs on the piquet
 - Temporary reduced personnel in Q3 and Q4:
 - Note on replication from offline to Tier1s
 - is 'best effort', no SMS alert (only email alert)
 - on-call DBA checks email 3 times per day



Service Availability

- Focus on providing **stable DB** services
 - Minimize changes to services and provide smooth running as much as possible
 - Changes grouped during technical stops
 - 4 days of stop every ~5 weeks
 - Security patches, reorg of tables
 - Major changes pushed to end-of-the-year technical stop (~2 months of stop)
- **Service availability:**
 - Note these are averages across all production services
 - Offline Service availability: 99.96%
 - Online Service availability: 99.62%



Notable incidents in 2010 1/2

- **Non-rollingness** of April Patch
 - Security and recommended patch bundle for April 2010 (aka PSU 10.2.0.4.4)
 - Contains patches marked as rolling
 - Passed tests and integration
- Two issues show up when applied in production
 - Non rolling on clusters of 3 or more nodes with load
 - On DBs with cool workload
 - Symptoms: after ora-7445 and spikes of load appear
- **Ora-7445**
 - Reproduced on test and patch available from Oracle
 - Thanks to persistency team for help
- **Non-rollingness**
 - Reproduced at CERN
 - Related to ASM



Notable incidents in 2010 2/2

- Two issues of unscheduled **power cut** at LHCb online pit
 - ~5 hours first occurrence (9/8)
 - ~2 hours for second occurrence (22/8)
- In first incident DB became corrupted
 - Storage corruption
 - Lost write caused by **missing BBUs** on storage after previous maintenance
 - Restore attempted from compressed backup, too time consuming
 - Finally switchover to standby performed
 - See also further comments on testing standby switchover in this presentation
- Another instance of corrupted DB after power cut
 - 18-12-2010, archive DB for Atlas corrupted
 - Recovery from tape: about 2 days



Notable recurring issues



- Streams
 - Several incidents
 - Different parts of replication affected
 - Often blocks generated by users workload and operations
- High loads and node reboots
 - Sporadic but recurrent issues
 - Instabilities caused by load
 - Run-away queries
 - Large memory consumption makes machine swap and become unresponsive
 - Execution plan instabilities make for sudden spikes of load
 - Overall application-related. Addressed by DBAs together with developers



Activities and Projects in 2010



Service Evolution

- **Replaced** ~40% of HW
 - New machines are dual quadcores (Nehalem-EP)
 - Old generation was based on single-core Pentiums
 - New storage arrays use **2TB SATA** disks
 - Replaced disks of 250GB
- New HW used for **standby and integration DBs**
 - New HW (RAC8+RAC9): 44 servers and 71 storage arrays (12 bay)
 - Old HW (RAC3+RAC4): 60 servers and 60 storage arrays (8 bay)





Consolidation of Standby DBs

- New HW installed for standby DBs
 - Quadcore servers and high-capacity disks
 - This has **increased resources on standby DBs**
 - Provided good compromise cost/performance in case of switchover operation (i.e. standby becomes primary)
 - Installed in Safehost (**outside CERN campus**)
 - Reduce risk in case of disaster recovery
 - Used for stand by DBs when primary in CERN IT





Oracle Evolution



- Evaluation of **11.2 features**. Notably:
 - Evaluation of Oracle **replication evolution**:
 - Streams 11g, Goldengate, Active Dataguard
 - Evolution of clusterware and RAC
 - Evolution of storage
 - ASM, ACFS, direct NFS
 - SQL plan management
 - for plan stability
 - Advanced compression
- Work in collaboration with Oracle (Openlab)



10.2.0.5 Upgrade - Evaluation

- Evaluation of possible upgrade scenarios
 - 11.2.0.2, vs 10,2.0.5, vs staying 10.2.0.4
 - 11g has several new features
 - Although extensive testing is needed
 - 11.2.0.2 patch set came out in September and with several changes from 11.2.0.1
 - 10.2.0.4 will go out of patch support in April 2011
 - 10.2.0.5 supported till 2013
 - 10.2.0.x requires extended support contract from end July 2011
 - Decision taken in Q3 2010 to **upgrade to 10.2.0.5** (following **successful validation**)



10.2.0.5 Upgrade - Review



- Testing activity
 - Several key applications tested
 - No major issues found
 - Very difficult to organize a 'real world' tests
- Upgrade of production during January 2011
 - Technical stop for the experiments
 - Mostly a smooth change
 - Some minor issues found only when switching to production
 - A few workaround and patches add to be added



Activities on Backup



- **Backups to tape using 10gbps**
 - have been successfully tested
 - Speed up to 250 MBPS per 'RMAN channel'
- **First phase of production implementation**
 - Destination TSM at 10gbps
 - Source multiple RAC nodes at 1gbps
 - Typically 3 nodes
 - In progress (~30% of DBs by Q1 2011)
- **Other activities**
 - Moving backup management to a unified tool inside the group
 - Unified tool for routine test of DB recoveries from tape



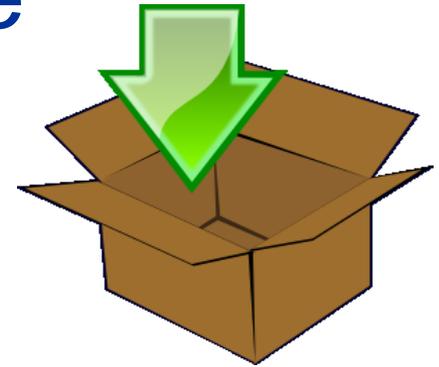
Activities on Monitoring



- Improvements to custom **streams monitoring**
 - Added Tier1 weekly reports
 - Maintenance and improvements to streammon
 - DML activity per schema, PGA memory usage
- **OEM 11g**
 - Currently deployed at CERN
 - Several issues needed troubleshooting
 - Notably a memory leak triggered by browser
- Internal activities on monitoring
 - We are unifying monitoring infrastructure across DB group



Activities on Data Lifecycle



- Goal: avoid that DB growth impact manageability and performance
 - Activity launched in 2008
 - Partitioning and data movement main tools
 - Compression used too
 - In 2010 more applications modified to allow partitioning
 - Data start to be moved to archive DBs
 - Joint work DB group and experiments/development



Activities on Security

- Internal application developed
 - To track access to DBs
 - Mining audit data
 - Allows to spot unusual access patterns
 - Can be source of info for defining white lists
- Firewall active on DB servers
 - Further discussion on activating white lists going on





Activities for Online Setups

- ALICE, LHCb and CMS online
 - Installations of the **DBs at the experiments' pits**
 - HW is managed by experiments
- HW warranty expiring
 - **Replacement** under way
 - IT discussed with experiments on HW replacement
 - Goal of having similar HW at the pit as in IT to reduce maintenance effort and complexity
 - Deployment of new HW expected in Q1 2011



Standby Tests

- Standby DBs and switchover operation
 - Tested and documented
 - Ideally a test switch should be performed on all production DBs
 - Activity needed to validate the **disaster recovery** infrastructure
 - During technical stop in Q1 2011
 - Scheduled test of Atlas online standby DB
 - **Downtime** ~.5h to switch to standby and ~.5h to switch back



Outlook and Activities for 2011



Major Scheduled Changes

- **Upgrade to 11gR2**
 - Upgrade of Oracle to 11gR2 in Q1 2012 (11.2.0.3?)
- Replacement of 2/3 of production HW
 - **New servers and storage**
- Combined change
 - 'Swing upgrade': upgrade of standby built on new HW
 - Production DBs and constraints from experiments
 - Maintenance window limited to 'extended technical stop' for many DBs, i.e. Q1 2012



Software changes preparation

- **Testing** of existing applications on 11gR2
 - In collaboration with the experiments
 - Our experience is that some issues are only seen under load
 - **Load-based testing** necessary
 - Investigating Oracle RAT?
- **Other software changes**
 - Investigating **RHEL6**
 - rpm-based installation (integrated with CERN OS installation, i.e. quattor)
- Overall goal of unifying procedures across IT-DB group



11gR2 Features

- We will further testing and prepare to deploy new 11gR2 features of interest
- Very interested in
 - **Active Data Guard**
- Other notable features of interest for us:
 - Improvements to streams
 - Improvements to ASM and NFS
 - Improvements to clusterware
 - SQL plan management
 - Interval partitioning



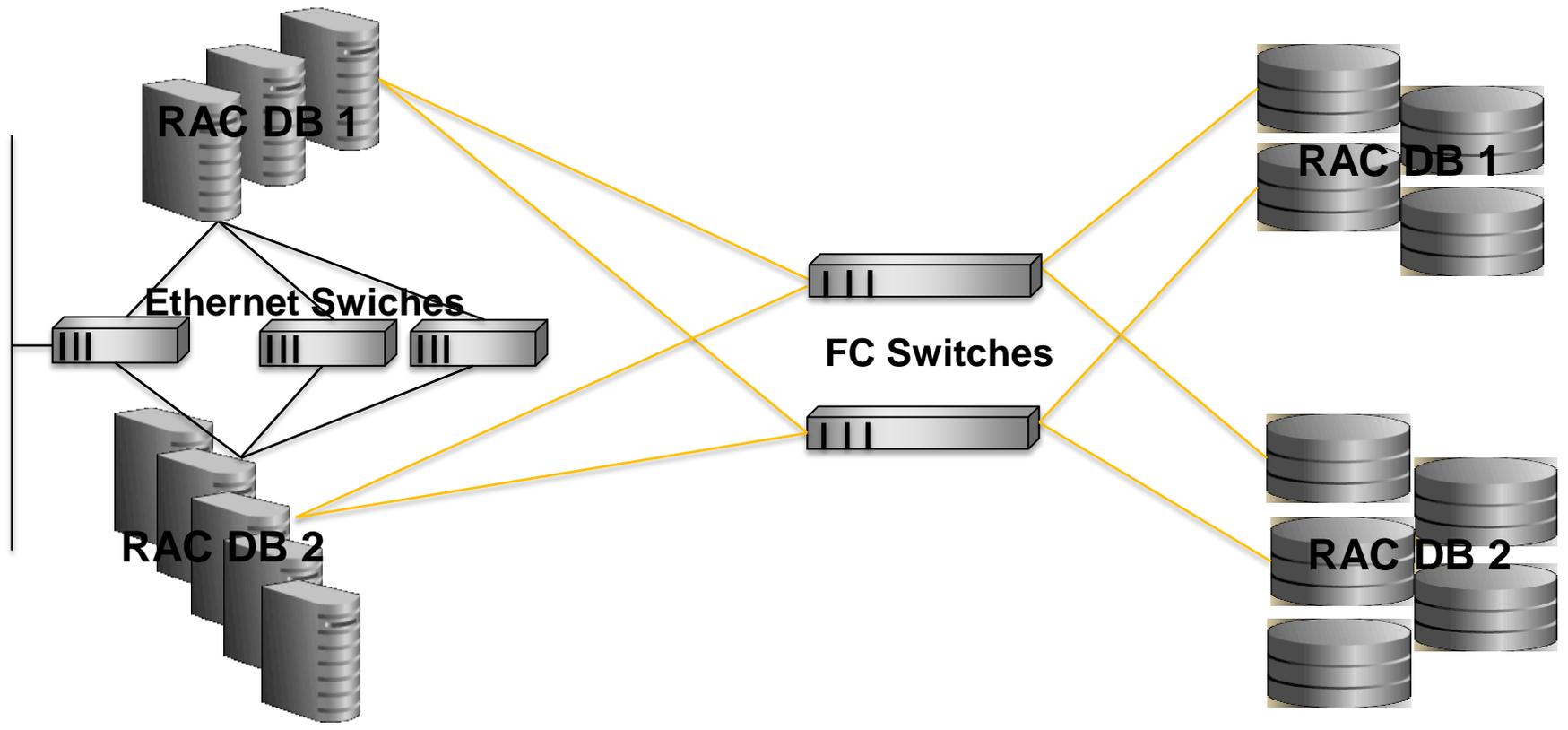
Activities on Architecture

- New HW acquisition
 - In **2011** a large group of production machines goes out of warranty
 - **HW renewal** and occasion to profit from more recent HW for performance and capacity
 - Several technologies have been evaluated
 - Use of SSD for caching
 - **10gbps Ethernet** for interconnect
 - 8gbps Fiber Channel storage access
 - NAS at 10gbps with flash cache
 - Evaluation of **Oracle VM**



Current Model

- Dual-socket quad-core DELL blade servers, 24GB memory, Intel Xeon “Nehalem”; 2.27GHz
- Dual power supplies, mirrored local disks, redundant 1GigE, dual HBAs, “RAID 1+0 like” with ASM and JBOD





NAS and NetApp at CERN

- Evolution of technology is very interesting
- Performance and capacity
 - 10 GigE connectivity
 - SSD cache to boost IOPS (PAM modules)
 - Allow large DBs with 2TB SATA disks
- Maintenance and reliability
 - 'Filesystem Snapshots' to be used as backup against logical corruption
 - Mature OS and filesystem for stability
 - Redundant controllers for transparent rolling maintenance
 - Support from a major storage vendor
 - Experience at CERN



Solid State Storage

- A revolution in storage
 - Many physics applications spend significant time on **random IO read**
 - SSD for large increase in IOPS and **reduced latency**
- Areas of interest
 - **Flash-based cache** in NAS controllers
 - DB Flash cache feature in 11gR2
 - To be further investigated
 - Entire DB on SSD?
 - For the moment on hold because of cost for multi-TB DBs
- Area in evolution
 - at present a multi-TB DB on SSD is very expensive



Server Specs

- New HW acquisition allows us to profit of technology evolution
- Latest **CPUs**
 - Although probably 4-cores still best choice for licensing reasons
- More **RAM**
 - Enlarge Oracle cache to **reduce random IO**
 - For example servers with 48 GB of RAM
- Faster interconnect: **10GigE**
 - For storage access
 - Backup to tape



Database technology

- Future needs regarding DB services
 - Review for medium to long term in collaboration with physics experiments and users community at CERN
- **NoSQL** DBs
 - Preliminary talks and interest from the experiments



Conclusions

- Focus on **stability** of DB services in 2010
 - Following several years of preparation
 - Infrastructure activities on improving backups, archive, application testing, HW testing
 - Upgrade to 10.2.0.5 performed before 2011 run
- Continuity of DB operations in 2011
 - Priority on running **smooth services** during data acquisition
 - Preparation for **11gR2** upgrade
 - New HW acquisition, **evolution of storage** and servers
 - Investigations of new technologies HW and SW



Acknowledgments

- CERN IT-DB group and in particular:
 - Zbigniew Baranowski, Marcin Blaszczyk, Eva Dafonte, Kate Dzedziniewicz, Przemyslaw Radowiecki, Jacek Wojcieszuk, Dawid Wojcik.

- More info:

<http://cern.ch/it-dep/db>

<http://cern.ch/canali>

