Using an Object Oriented Database to Store BaBar's Terabytes

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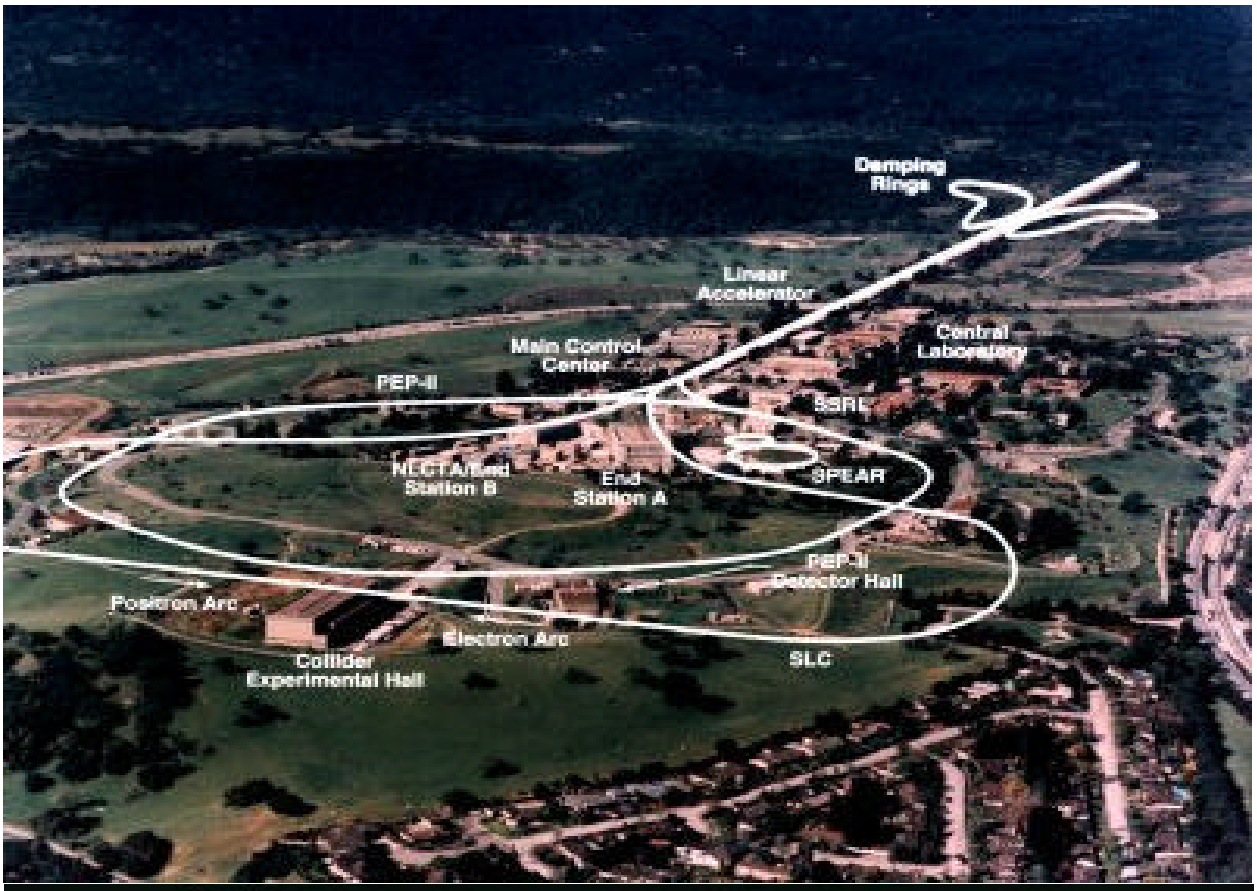
Outline

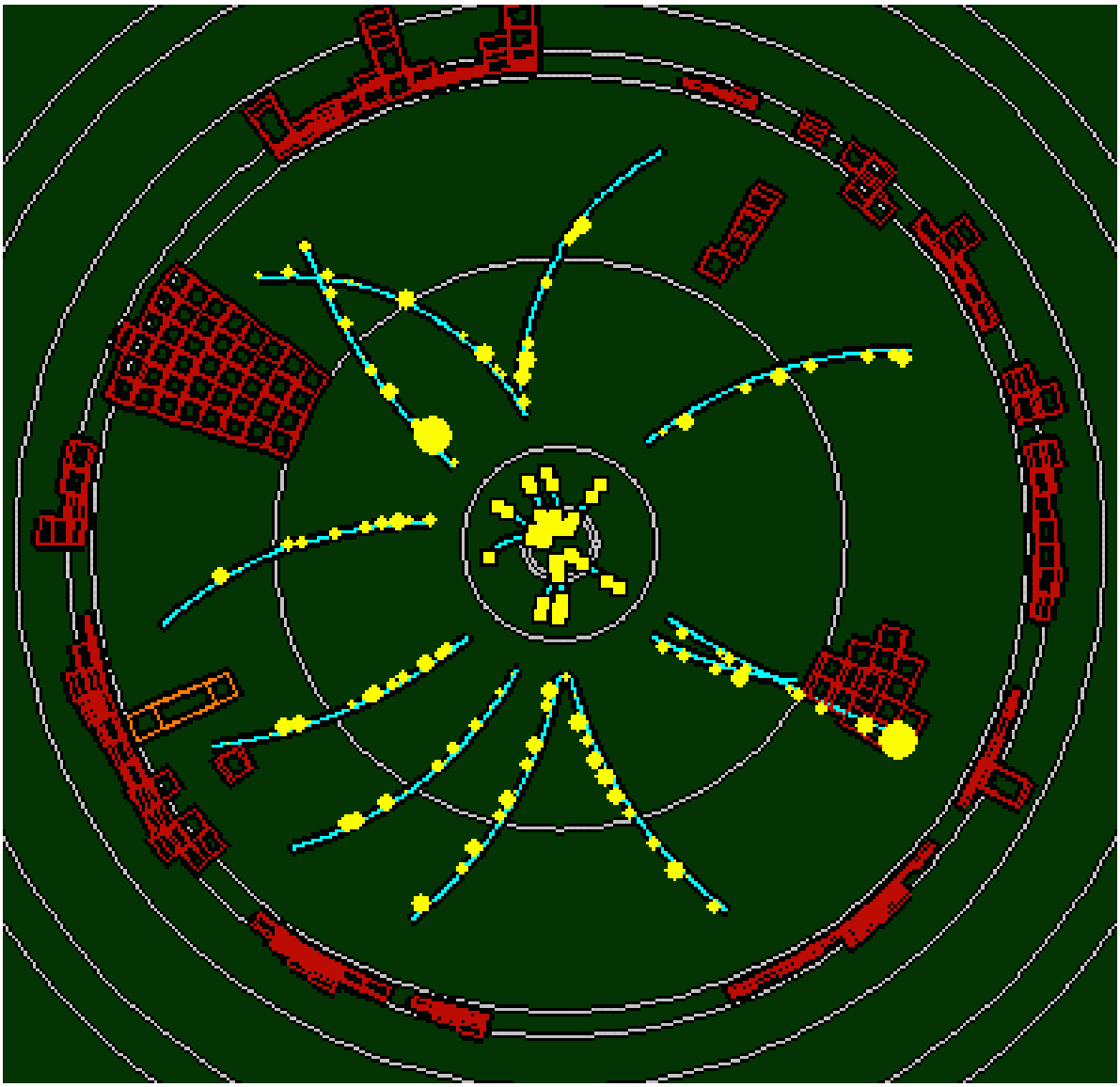
- The BaBar experiment at SLAC
- Data storage requirements
- Use of an Object Oriented Database
- Data organisation
- SLAC
- UK
- Future experiments

- The BaBar experiment is based in California at the Stanford Linear Accelerator Center, and was designed and built by more than 500 physicists from 10 countries, including from 9 UK Universities and RAL.
- It is looking for the subtle differences between the decay of the B^0 meson and its antiparticle ($\overline{B^0}$).
  - If this “CP Violation” is large enough, it could explain the cosmological matter-antimatter asymmetry.
- We are are looking for a subtle effect in a rare (and difficult to identify) decay, so need to record the results of a large numbers of events.


Damping Rings
Linear Accelerator
Central Laboratory
Main Control Center
PEP-II
SSRL
SPEAR
NLCTA/End Station B
End Station A
PEP-II Detector Hall
Positron Arc
Electron Arc
Collider Experimental Hall
SLC


BABAR DETECTOR FOR THE PEP-II B FACTORY
Modeled by Daryl Chhatz • Berkeley Lab

A BaBar Event



How much data?

- Since BaBar started operation last May, we have recorded and analysed 210 million events.
  - 48 million written to database
    - remainder rejected after analysis
  - At least 4 more years' running and continually improving luminosity.
  - Eventually record data at ~100 Hz; ~10^9 events/year.
    - Each event uses 100-300kb.
  - Also need to generate 1-10 times that number of simulated events.
- Database currently holds 33 Tb
  - Expect to reach ~300 Tb/year
  - Ie. 1-2 Pb in the lifetime of the experiment.

Why an OODBMS?

- BaBar has adopted C++ and OO techniques
  - The first large HEP experiment to do so wholesale.
- An OO Database has a more natural interface for C++ (and Java).
- Require distributed database
  - Event processing and analysis takes place on many processors
    - 200 node farm at SLAC
    - A single data server cannot cope
- Data structures will change over time
  - Cannot afford to reprocess everything
  - Schema evolution
- Objectivity chosen
  - Front runner also at CERN

How do we organise the data?

- Traditional HEP analyses read each event and select relevant events, for which additional processing is done.
  - Can be done with sequential file
  - Many different analyses performed by BaBar physicists.
- In BaBar there is too much data.
  - Won't work if all the people to read all the data all of the time.
    - Even if all of it could be on disk.
- Organise data into different levels of detail
  - Stored in separate files
    - tag, "microDST", "miniDST", full reconstruction, raw data
  - Objectivity keeps track of cross-references
- Only read more detailed information for selected events.
  - But different selections for different analyses

What happens at SLAC?

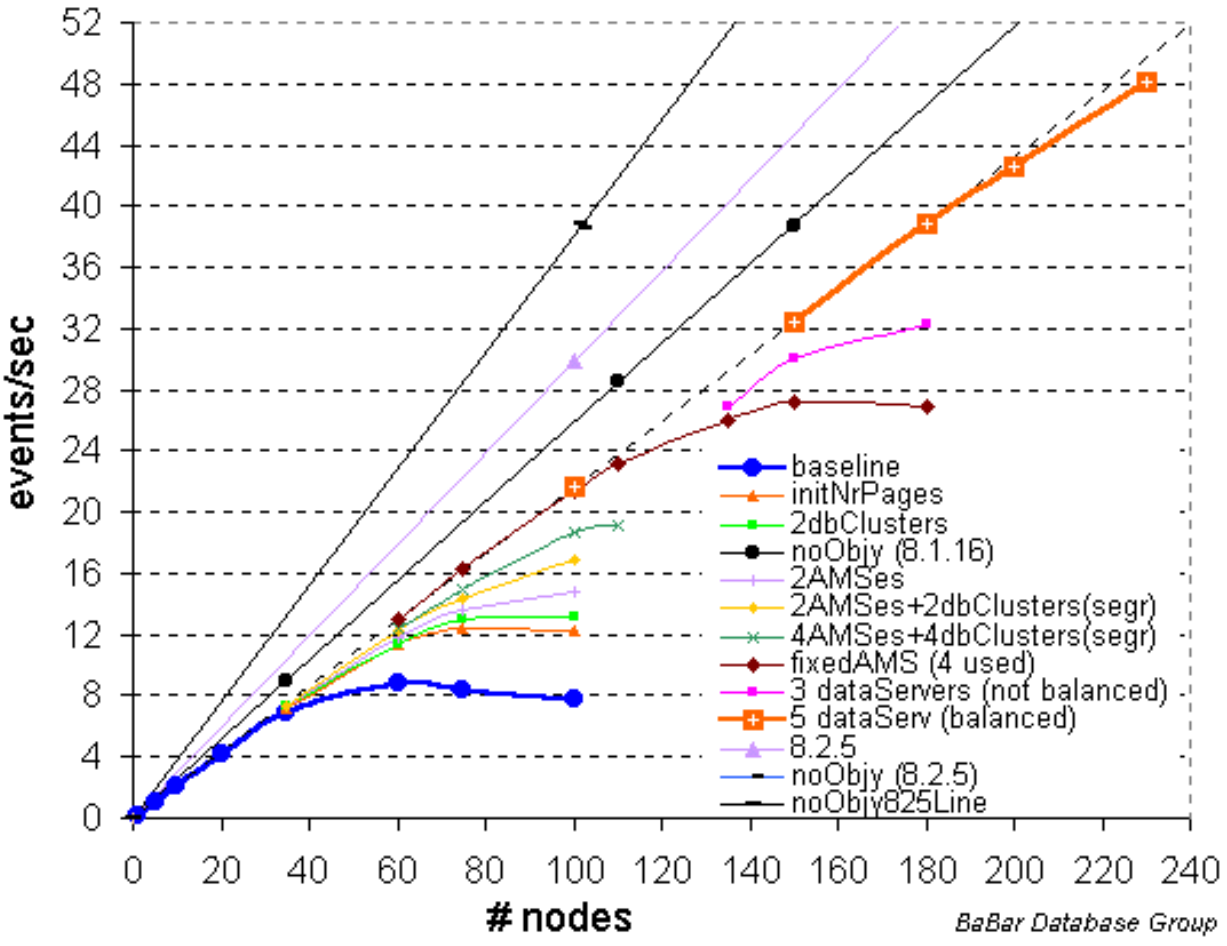
- Cannot store everything on disk
  - Maybe 10 Tb, but not 1 Pb.
  - Already buying ~1 Tb disk per month.
- Analysis requires frequent access to summary information.
  - Keep tag and “microDST” on disk
  - More information for most interesting events on disk
  - Rest in mass store (HPSS at SLAC)
- In future even this may not be enough
  - Only tag and “dataset of the month” on disk?

Performance

- Main challenge is getting this to scale to hundreds of processes/ors reading and writing at the same time.
  - The vendor seems to believe we can do it.
    - "The Terabyte Wars are over
      While other vendors quarrel about who can store 1 Terabyte in a database, the *BaBar* physics experiment at the *Stanford Linear Accelerator Center (SLAC)* has demonstrated putting 1 Terabyte of data PER DAY into an Objectivity Database."
      - Top news item on *Objectivity* web site
  - But it took a lot of work...

Performance Scaling

- A lot of effort has gone into improving speed of recording events



- Ongoing work on obtain similar improvements in data access.

Regional Centres

- Cannot do everything at SLAC
  - Even with all the measures to improve analysis efficiency at SLAC, it cannot support entire collaboration.
  - Network connection from UK is slow, sometimes very slow, occasionally unreliable.
- Therefore need to allow analysis outside SLAC.
  - “Regional Centres” in UK, France, and Italy.
  - RAL is the UK Regional Centre.
- Major challenge to transfer data from SLAC, and to reproduce databases and analysis environment at RAL.

UK Setup

- At RAL, have Sun analysis and data server machines with 5 Tb disk
  - UK Universities have 0.5-1 Tb locally
  - All part of £800k JREI award
- Import microDST using DLT-IV
  - ~50 Gb/tape with compression
  - So far exported 2 Tb
- Interfaced to Atlas Datastore (see Tim Folkes' talk).
  - Less-used parts of the federation can be archived
  - Can be brought back to disk on demand
    - needs further automation
  - Also acts as a local backup.

Other Experiments

- BaBar's requirements are modest with respect to what is to come.
- 2001 Tevatron Run II
  - ~1 Pb/year
  - CDF JIF (Joint Infrastructure Fund) award
    - Regional Centre at RAL
- 2005 4 LHC Experiments
  - many Pb/year
  - Prototype Tier 1 centre at RAL
    - 3100 PC99, 125 Tb disk, 0.3 Pb tape, 50 Mbps network to CERN
  - Tier 2 centres at Edinburgh and Liverpool
  - Require ~5 times more at startup

Future Software

- Choice of HSM.
  - HPSS is expensive. Maybe we don't need all the bells and whistles.
    - But already in use at SLAC/CERN/...
  - EuroStore (EU/CERN/DESY/...)
  - ENSTORE (Fermilab)
  - CASTOR (CERN)
  - LHC Experiments still have time to decide...
- Is Objectivity well-suited to our use?
  - Develop our own OODBMS?
    - Espresso (CERN)
  - BaBar is being watched closely...