



RD45 Workshop 16th - 18th July 1997

The BABAR Event Store

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Overview

- Goals
- Overall Design
- Data Model
- Event API
- Data Distribution Strategy
- Data Logging Strategy
- Management Tools
- Monitoring Tools
- Summary

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Goals

- Provide complete coverage of all stages of event processing
 - Simulated Data → Raw Data → Reconstructed Data → Event Summary Data → Analysis Object Data → Tag Data
 - ◆ Terminology taken from Atlas
 - Access to event data should be transparent apart from performance
- Deal with >150TB per year starting in April 1999
 - ~ 10TB Mock Data Challenge Data in April 1998
- Deal with very large event samples
 - >>10⁹
- Provide optimized data distribution across collaboration
 - 500 Collaborators, 80 Institutions, 10 countries

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Overall Design

- *BABAR* DBMS covers several *domains*
 - Event Store
 - Conditions Database
 - Online Databases
- Objectivity is underlying technology
- Domains are logically independent
 - Initially CDB access from event processing is by time interval
 - ◆ Direct references after processing
 - Domains linked by underlying Objectivity Federated Database
 - ◆ Also transaction boundaries
- Allows independent development with late binding

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Authorization Levels

- Several authorization levels to protect database contents
 - Domain specific
 - ◆ System, Group, User
 - System level grants update access to complete database
 - Group level grants update access to particular group's databases
 - ◆ e.g. Subdetector (Conditions DB) or physics group (Event Store)
 - User level grants update access only to user's data
 - ◆ Not meaningful for Conditions DB
- Anyone has read access to complete database
 - Including all subdetectors, physics groups & other users data
- Authorization levels are additional level of protection
 - File access permissions also give protection

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Event Collections

- Event collections
 - Small
 - ◆ Limited to $\sim 10^6$ events
 - Large
 - ◆ Essentially unlimited (current implementation limited to $\sim 10^{11}$ events)
 - Run-based
 - ◆ Designed for possible data logging
 - Other implementations planned
 - ◆ Container-based, database-based etc.
 - All share common abstract interface (iteration etc.)
- Can be named and given aliases
 - Current implementation doesn't yet support aliases

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Event Collections (2)

- Current collections based on Event OID
- Need collections based on Event ID
 - Run Number, Event Number, Processing Release Number
 - Needed for physics analysis
- Need to add more operations
 - Union, *etc.*
 - Currently support just addition
 - ◆ No protection against duplicate entries

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Event Dictionaries & Registry

- One dictionary per user, group and system
- Contain references to named event collections
 - Names must be unique within a dictionary
 - Names may have aliases (not yet implemented)
- Mechanism by which a collection may be located and used as a source of events
 - Application locates the desired dictionary & then the required event collection
- Event Registry
 - Set of all dictionaries & other management information

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Events

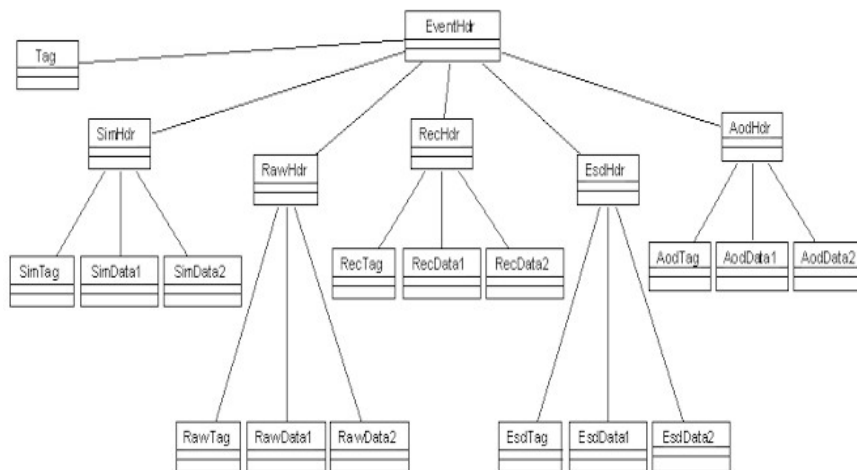
- Hierarchy of objects - *event header, stage headers & tags*
 - Stages
 - ◆ SIM - Simulated Truth where applicable
 - ◆ RAW - Raw Data (~32KB)
 - ◆ REC - Reconstructed Data (~100KB)
 - ◆ ESD - Event Summary Data (~10KB)
 - ◆ AOD - Analysis Object Data (~1KB)
 - ◆ TAG - Event Tag (100-200 bytes)
 - Stage tags ~1-10% of size of corresponding stage information
 - ◆ Overkill?
 - Event Header (<64 bytes)
- Goal is to keep navigation information small

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Event Hierarchy



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Event Tag

- Small amount of selection information
 - Attempt to make globally useful for all physics signatures
- Has a bidirectional association with event header
 - Provides the same navigational interface as the Event Header
 - ◆ Can traverse to locate any information from the event
- Event Collections can contain references either to Event Headers or Event Tags
 - Latter is most compact representation
 - ◆ Slightly more overhead for navigation
 - Another database to be opened & another navigation node to traverse

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Event Collections & Access

- Different Event collections by default reference the same event headers for the same event
- Have flexibility
 - Copy the Event Header for dilute samples
 - ◆ Enhanced performance
 - Copy the Event Tag
 - Copy a portion of the event hierarchy
- Garbage collection is an issue
 - Delete those portions of the event that have been copied, but *not* the original portions

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Clustering Strategy

- Strategy for creation of objects
 - Objects likely to be accessed together should be located close together within the same database
 - ◆ Access of one object pre-fetches adjacent objects (page-based server)
- Strategy for creation of database files
 - Final database will have >>>50,000 files
 - ◆ Cannot create them all in a single Unix directory!
 - Spread them throughout a directory hierarchy
 - ◆ Basis for file protection based on authorization levels
 - ◆ Basis for caching/migration with HPSS

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Database Sizes etc.

- Fixed size database files
 - File size varies with processing stage & authorization level
 - 2GB seems a reasonable match to tape capacity
 - ◆ Tape seek performance 10^2 faster than read performance
 - Smaller for Group & User Authorization Levels
- Clustering Hint classes have to have a persistent component
 - Remember where to continue from
- Transition between stage based & class based clustering
 - Early stages use stage based strategy
 - ◆ Stage information for the event kept in same database set
 - Later stages use class based strategy
 - ◆ Objects of same class kept in same database set

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Event API Testbeds

- Understand code changes
- Understand migration issues
 - How to get from where we are now to where we need to be without breaking everything
- Decide on what persistent classes we can use
 - Container classes
- Decide on set of access macros & clustering hint classes
 - Initially intended to use RD45
 - Decided to use our own set of macros & classes to isolate ourselves
 - ◆ Very thin wrapper

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Transient API Testbed

- About 25 classes given transient/persistent siblings so far
 - ~5% of total data model
- A set of smart pointer classes defers references between objects
 - Otherwise would have to create transitive closure of transient objects from their persistent siblings on access.
- Hash table of transient objects maintains one-to-one transient/persistent relationship
- No changes necessary to existing reconstruction code so far
- No performance studies done yet
- Feasibility demonstrated

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Event Database Workshop

- Last week at LBNL
- Invited Dirk Duellmann to take part
- Very useful exchange of information from both sides
- Focussed on event API and use cases
- Use cases in particular highlighted difficulties in data distribution strategies
 - FTO/DRO addresses many issues
 - ◆ Present limitations severely restrict its usability
 - Disjoint federated databases significantly complicate things
 - ◆ Preallocation of database Ids?

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Event API Decision

- Concerns
 - Smart pointers
 - Exposing persistence
 - 400k LOC in 1600 C++ classes in existing reconstruction
 - ◆ Long term estimate is that 500 might eventually be made persistent
- Modified transient/persistent strategy adopted
 - Processing broken into 7-12 “chunks”
 - Input data for each chunks must be explicitly “fetched”
 - ◆ Pure transient objects built from their persistent counterparts
 - Persistent objects created on output
 - Minimizes dependencies

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Event Reprocessing

- Processing chunks
 - Each associated with a reprocessing version
- Processing Release ID
 - Snapshot across the reprocessing versions
 - *c.f.* software package versions & releases
 - Part of Event ID
- Plan is to implement this through data versioning of navigation nodes of the event
 - EventHdr → RecHdr → ChunkHdr → ChunkData
 - ◆ ChunkData for a reprocessing is totally new - no relationship to earlier ChunkData objects
 - Other downstream nodes also get versioned as appropriate

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Schema Evolution Strategy

- Minimize its use whilst realizing that it's necessary
 - Objectivity allows several mechanisms to update existing data
- Also problem is tight schema coupling
 - Event Registry *etc.* dependent on leaf nodes of event
- Decouple at Stage Headers using Objectivity's RTTI
 - Type safe access through templates
 - Break dependencies
 - Concept already used for transient *BABAR* event
 - ◆ ProxyDict
- Extensible event

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Federated Database Strategy

- Protect master federated database
 - Contains schema and database catalog
- *Reference* federated database
 - Contains schema only
 - Used for builds of new *BABAR* software releases
 - Schema evolution disabled by default - managed evolution.
- *Production* federated database
 - Database catalog
- *Developer* federated database
 - Copy per developer, copy of *Reference* FDDB
 - They can extend/modify etc., but propagation back to *Reference* FDDB is inhibited by default

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Data Distribution Strategy

- Goals
 - Efficient access to data from anywhere in collaboration
 - ◆ From bulk processing engines
 - ◆ From desktops in any Institution
 - Flexible placement of data
 - ◆ Strategy should allow replication of data to optimize access
- Components
 - Regional Centers
 - ◆ Secondary data repositories
 - ◆ Better bandwidth between Institutions & their Regional Center
 - Database *Partitioning*
 - ◆ Replicate portions of database & act as local cache

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Regional Centers

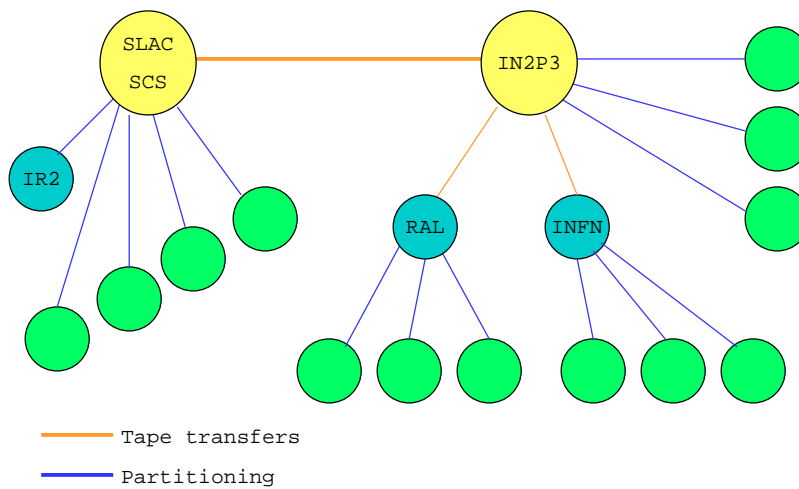
- SLAC
 - Main Collaboration Center (Regional Center for USA & Canada)
 - Primary repository for all data
- IN2P3
 - Primary European Regional Center
 - Replicates the complete data repository (present plan)
- RAL
 - Restricted subset of data
- INFN
 - Restricted subset of data

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Data Distribution Strategy



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Problems with Distribution Strategy

- Not clear that FTO/DRO addresses all issues
 - Technical limitations of existing implementation
- Need to allow developers to extend/modify schema
 - Disjoint FDDBs based on Reference FDDB
 - Issue of exchange of events
 - Many unresolved issues here
- General management
- Poor networking between USA & Europe

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Data Logging

- Current strategy (changing...)
 - OEP (Level 3 Trigger) outputs streamed event data
 - ◆ *Not* objects
 - Spooled to conventional disk files
 - ◆ Location of spool disk? Probably experiment
 - ◆ Stage to DLT tape if disk becomes full
 - Prompt Reconstruction inputs from spool disk files & outputs to database
 - ◆ First contact with HPSS
 - Each PR node writes to a different output database
 - ◆ Lock conflicts only when a database becomes full in updating event collection (single OID).

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Data Logging - Conditions DB

- Both online & offline require access to conditions database
- Proposal is to make online a secondary Objectivity partition
 - SCS is primary partition
- Updates from online automatically propagated to offline
- Updates from offline automatically propagated to online
- Semi-autonomous in case of network failure

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Management Tools

- Database management tools
 - Monitor usage & access efficiency
 - Cleanup database
 - Perform replication or re-clustering etc.
 - User Interface rather than programmatic interface
- Large Hole at the moment
 - Long term schedule details tasks but nothing available until next year
 - Hope can use SLAC Database/Web expertise to help us develop user interfaces

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Objectivity/HPSS Integration

- Initial goal was to use SLAC as development site
 - Timescale mismatch
 - Trying to accelerate their installation using NERSC expertise
- Establishing alternative configuration at NERSC
- Beneficial all around
 - NERSC is site of HENP Grand Challenge Project
 - ◆ Mainly targeted at RHIC (STAR, PHENIX)
 - ◆ *BABAR* is “consultant” on this project
 - ◆ We’ve stimulated interest in their using Objectivity

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Relationship with RD45

- Somewhat painful up until now
- Currently *BABAR* is not using RD45 software
 - Trying to re-incorporate updated libRD45 version this week
 - Will incorporate HepODBMS as soon as it’s available
- All of us recognize need for better communication
- All of us recognize the benefits of collaboration
- We’ve been discussing ways to improve things
- *BABAR* offering to host RD45 workshop in USA next year

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Summary

- Good progress on overall design
 - Integration of database domains
 - Testbed prototypes
- Event API has been a really tough decision
 - We have a decision - now we have to implement it
- Much still to be understood about data distribution
- Scaling & HPSS integration issues
- Staffing is an ongoing problem
- Schedule looks tight but doable