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LHCb ONLINE

The LHCb High Level Trigger Software Framework

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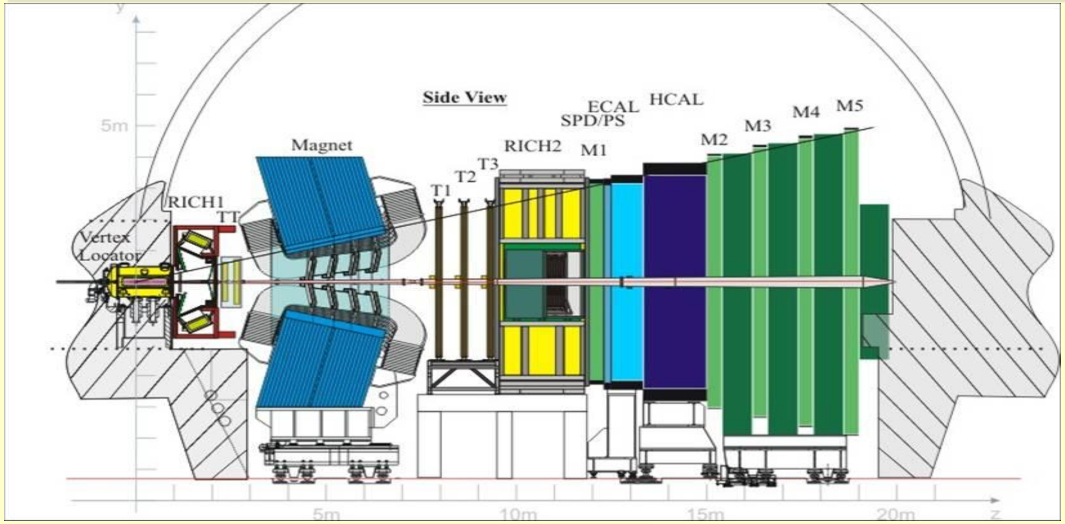
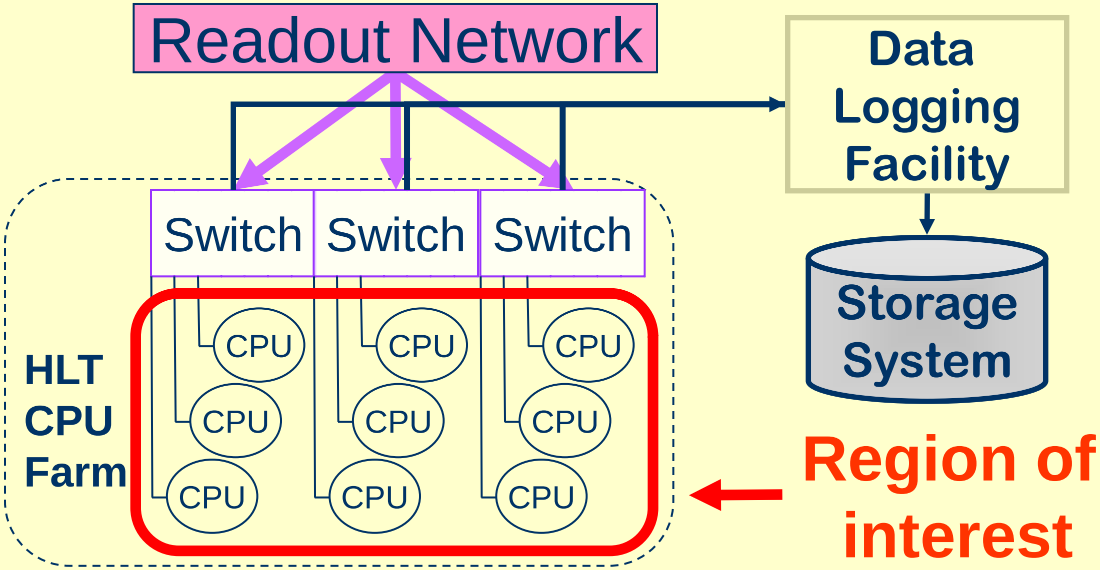
Outline

- LHCb High Level Trigger in numbers
- Motivation which led to our solution
- Basic data processing concept
- Data processing task architecture in HLT
  - Flow of event data
- Implementation considerations

LHCb High Level Trigger in Numbers





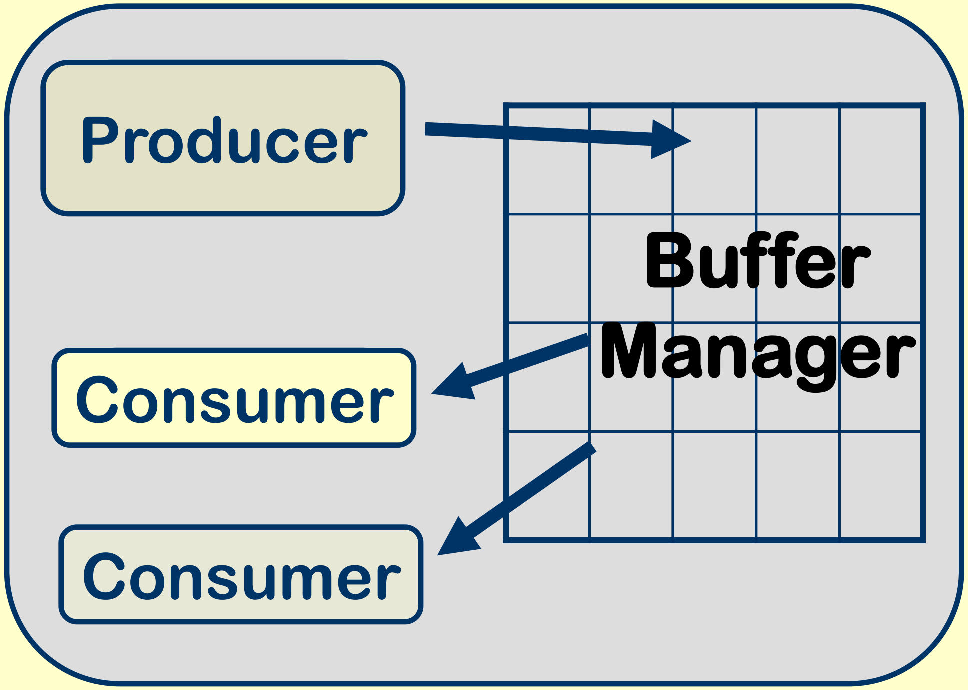
- Spectrometer for b quark analysis at LHC
- 40 MHz collision rate
- L0 trigger (hardware)
  Accept rate: ~ 1 MHz
  Readout NW: ~ 35 GB/s
- HLT (software)
  Accept rate: ~ 2-5 kHz
  Event size: ~ 30 kB
  Data sources: ~ 300
  Event packing: ~ 10
- ~1000 CPU Boxes envisaged
  - 50 Racks
  - 2000 1U boxes space limit
  - 50 x 12 kW cooling/power limit
  - ~16000 CPU cores
  - ~16000 Trigger processes
  - ~ 4000 Infrastructure tasks

Motivation

- Online – Offline: No longer should the worlds be separated
  - Today's High-Level trigger (HLT) applications are developed in an offline environment.
  - HLT applications are based on the Gaudi framework
  - Boundaries to physics analysis code tend to vanish
  - Applications are then deployed in the online environment
- This requires transparent mechanisms
  - to access event data
  - to collect and transfer event data
    => Poster No. 138 (CHEP 2007, Online track)
  - to collect logger messages
  - to collect performance information: histograms & Co
    => Poster No. 140 (CHEP 2007, Online track)
  - to control interacting processes: startup, initialization, finalization
    => Niko's talk No. 137 (CHEP 2007, Online track)
- …this will be described in the following slides

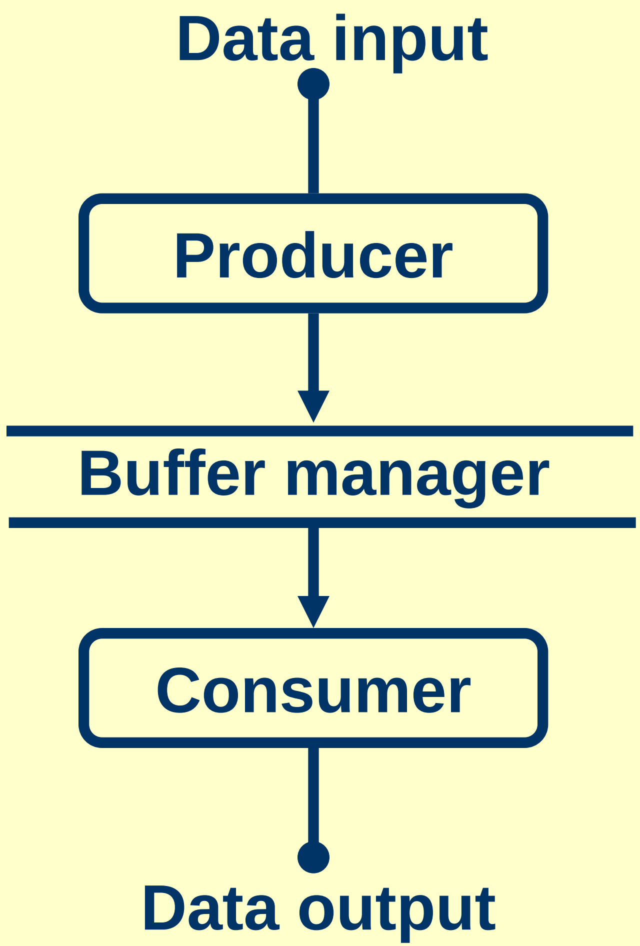
Basic Data Processing Concept

- Producer Tasks
  - Receive data from external sources
    - Network
    - other buffer manager
  - Declare data to a buffer manager
  - Optionally process/reformat data [HLT, event assembly]
- Consumer Tasks
  - Receive data from a buffer manager
  - Send data to data sinks
    - Network
    - other buffer managers
- Buffer managers
  - Data sinks and sources
  - Derandomizing functionality
  - Data selection functionality
  - Multiple buffer managers on each node



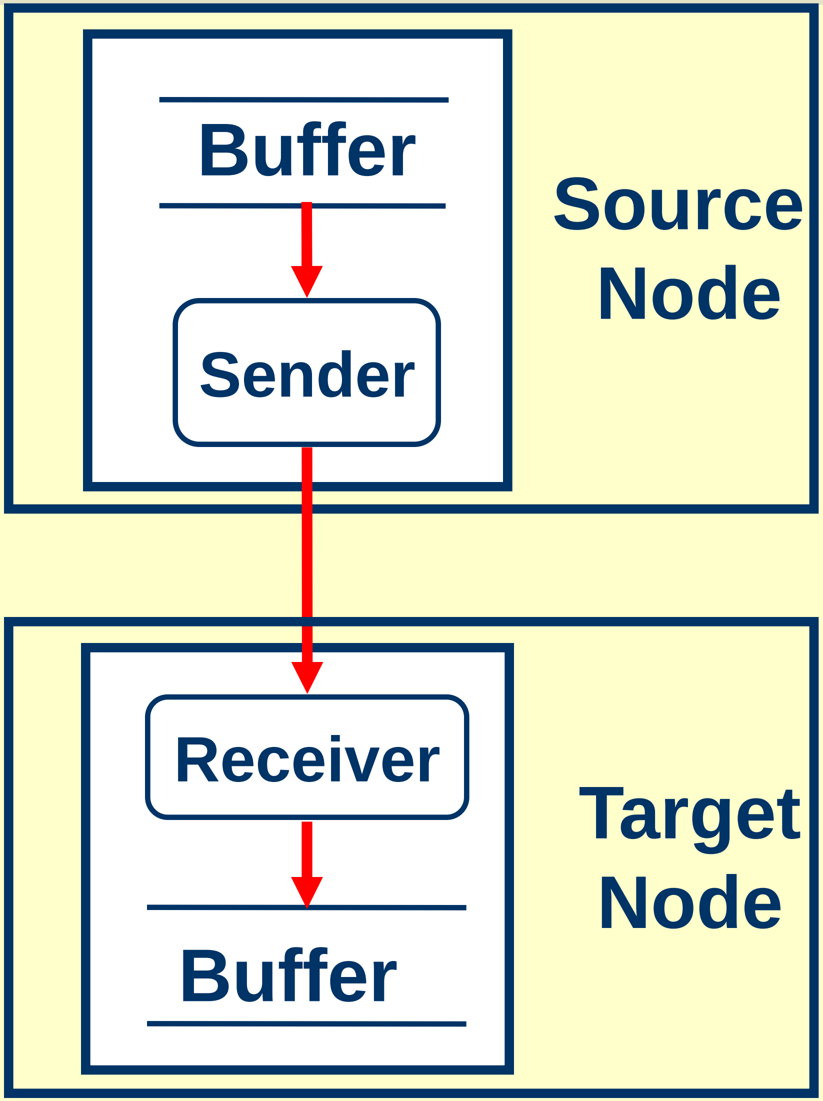
A.Belk et al.; DAQ Software Architecture for ALEPH, A Large HEP Experiment
IEEE Trans. on Nucl.Science Vol 36 (Oct 1989); p.1534-1539

Data Processing Block



- Producers deposit events in buffer manager
  - Partition ID
  - Event type
  - Trigger mask
- Consumers receive events by
  - Partition ID
  - Event type
  - Trigger mask (OR accepted) and VETO mask
  - May queue different requests simultaneously
- 3 Consumer classes
  - **BM_ALL:** Request to receive all events according to request definition.
  - **BM_ONE:** Out of a group of consumers with identical request definition one event is received by exactly one consumer.
  - **BM_NOTALL:** Request to receive some of the events according to request definition and buffer occupancy.

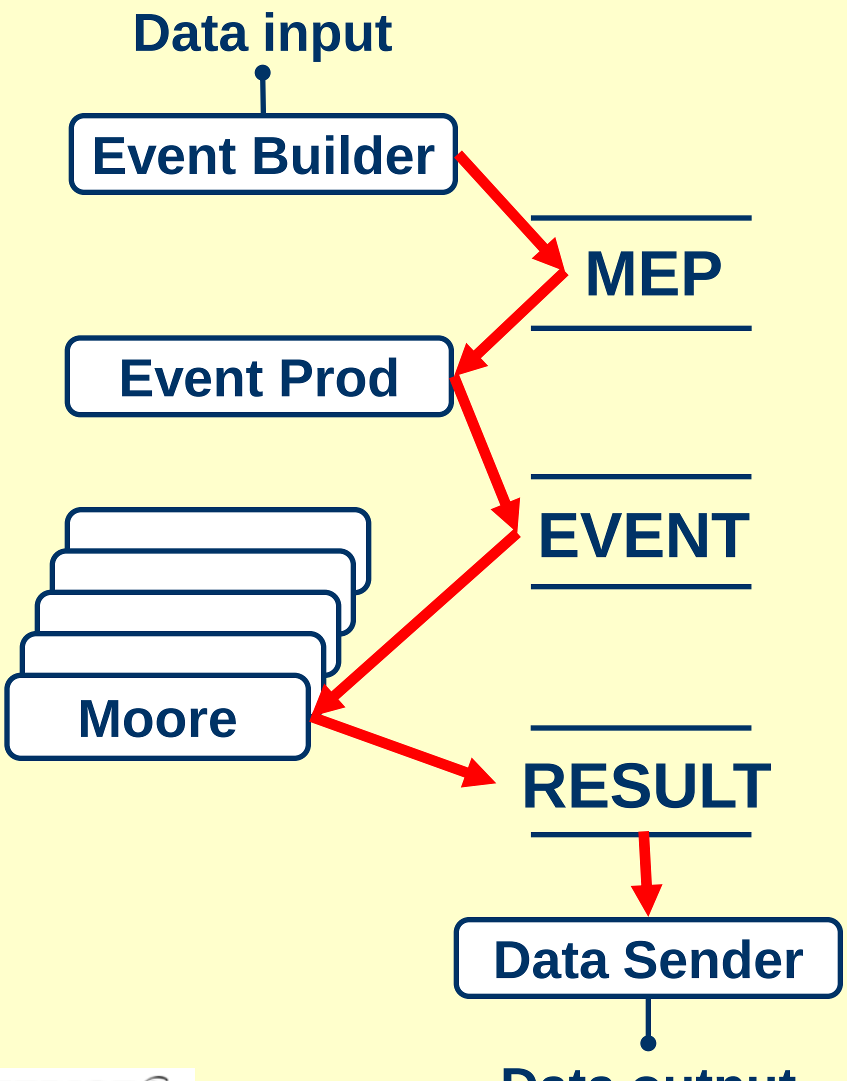
Data Transfer Block



- Reversed data processing block
- Sender tasks accesses events from buffer manager on the source node
  - Consumer process
  - Send data to target process
  - Example: Data Sender on HLT farm node
- Receiver task reads data sent and declares data to buffer manager on the target node
  - Producer process
  - Example: Receiving process on the Storage System

See poster presentation No. 138:
"Data Stream handling in the LHCb experiment"

Task Architecture on HLT Node



- The **Event Builder** receives the data from the frontend boards and declares a contiguous block to the MEP buffer (N events)
- The **Event Producer** computes N event descriptors and declares them as separate events to the EVENT buffer
- **Moore** trigger processes compute trigger decision and declare accepted events to the RESULT buffer
- **Data Sender** tasks send accepted events to the Storage System

MEP Buffer and Event Descriptors

- Store data once, pass references to banks from frontend boards
- Important optimization to avoid many expensive, unaligned memory copies
  - LHCb data / frontend source: ~ 100 Bytes => event size: 30 kB
  - very ineffective for DMA transfers

Multi event buffer block → Descriptors with single events

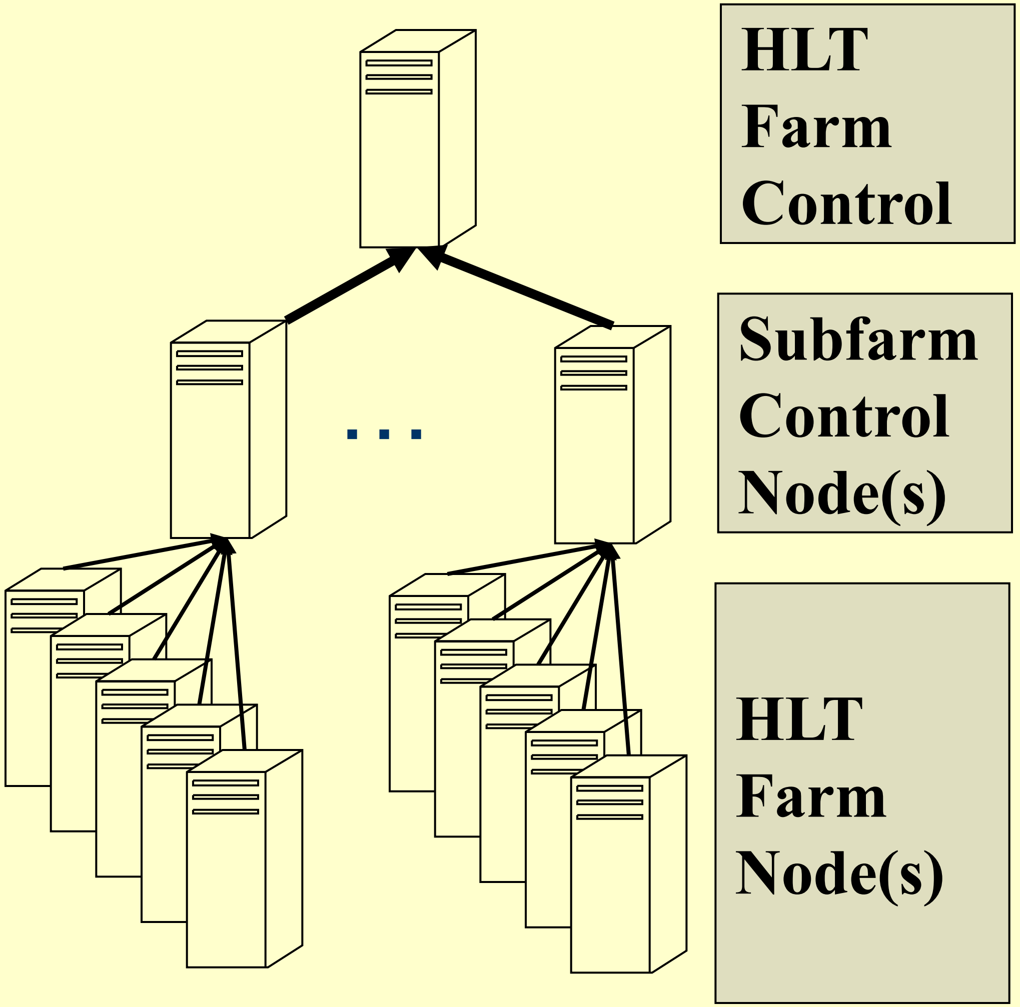
Multi Event: packing factor m			
Source ID 1	Evt 1	…	Evt m
Source ID 2	Evt 1	…	Evt m
…	…	…	…
Source ID n	Evt 1	…	Evt m

Event # 1		
Ptr	Source ID 1	MEP 1
Ptr	Source ID 2	MEP 1
…	…	
Ptr	Source ID n	MEP 1

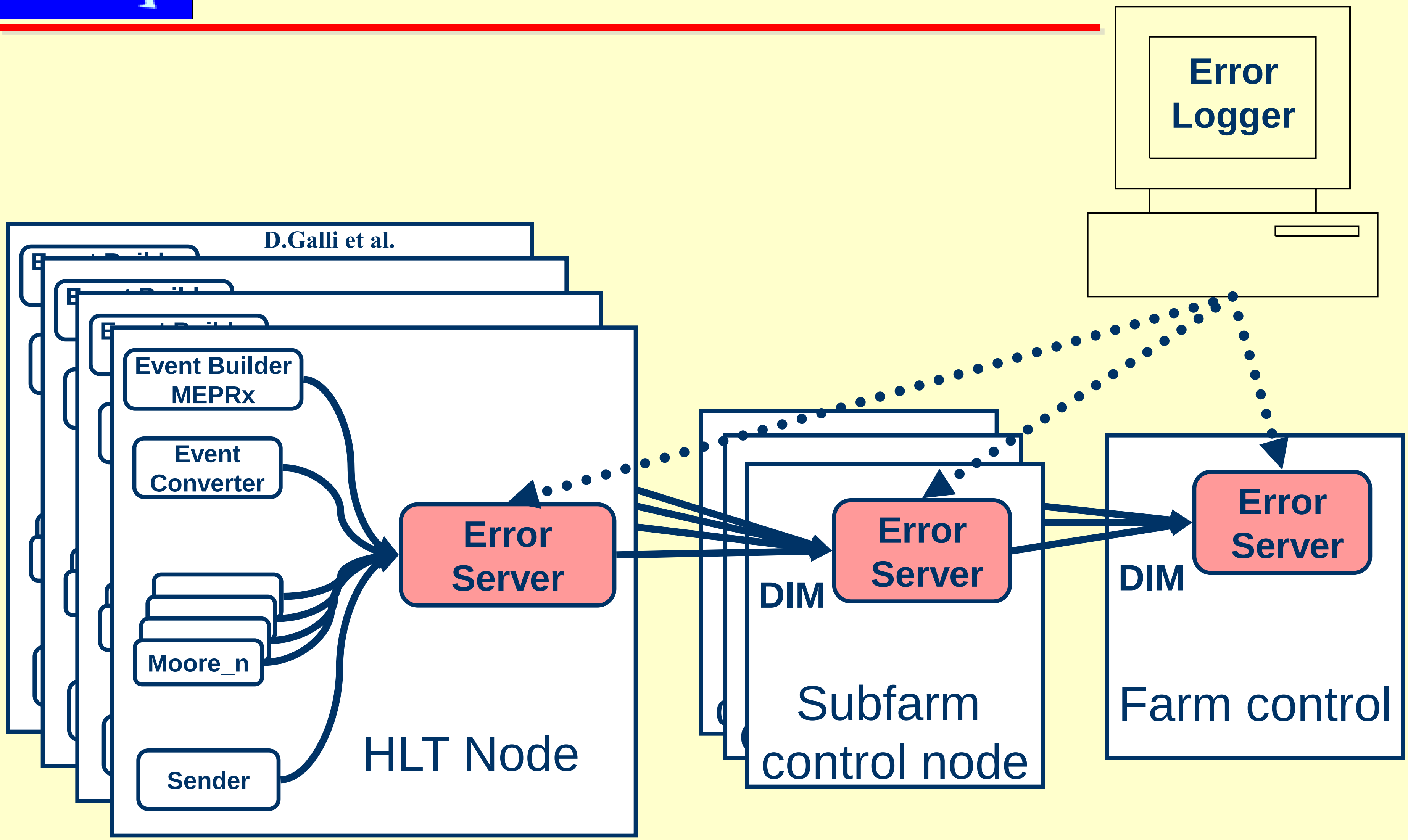
Event # m		
Ptr	Source ID 1	MEP 1
Ptr	Source ID 2	MEP 1
…	…	
Ptr	Source ID n	MEP 1

Error & Output Logging

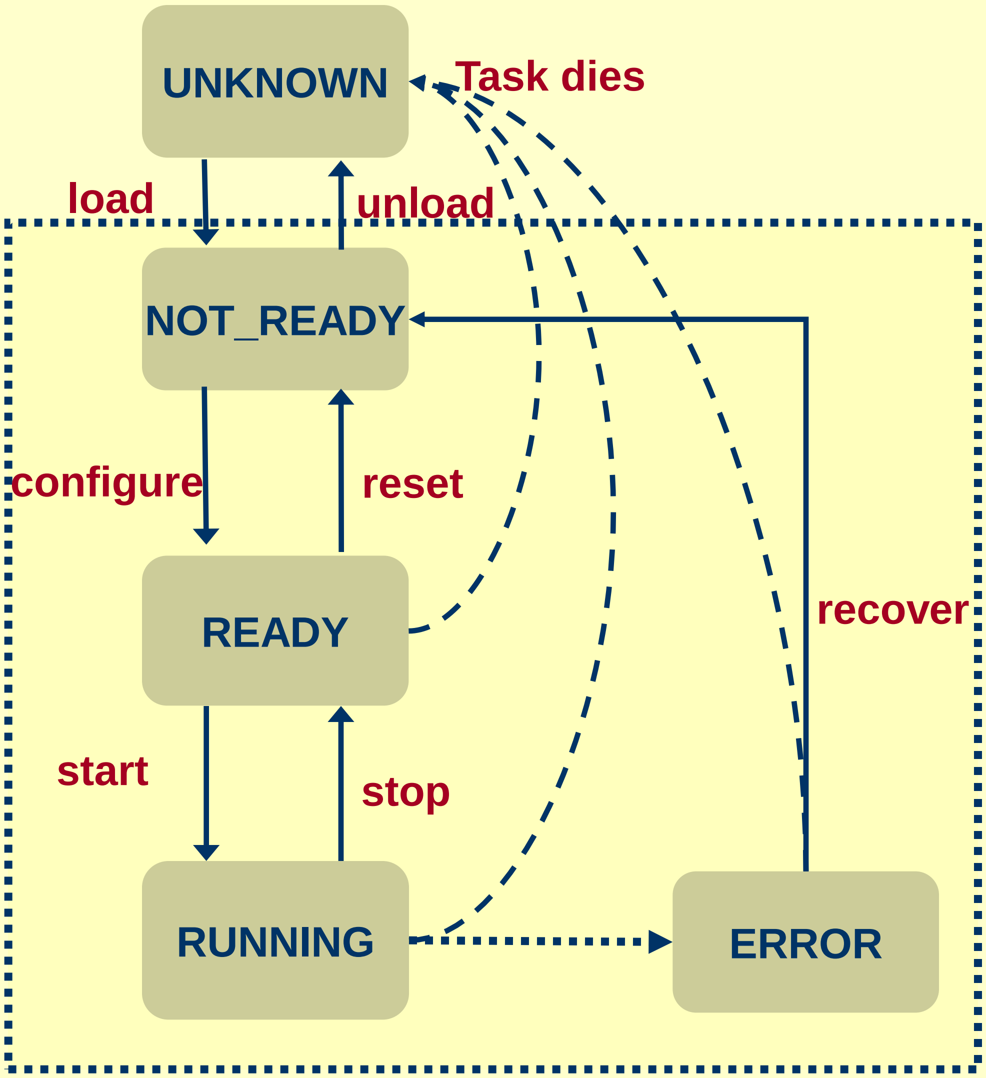
- Every tasks tends to print the bible
  - x 16000 => cannot be managed
  - Need to restrict output
- Hierarchical approach
  - HLT Farm
    - Subfarm
      - Farm Node
    - Storage network
- Filtering at each layer
  - Accept/refuse messages
    - By task name (UTGID)
    - By component/algorithm name
    - By node
    - By message content
  - Wildcard selection
- Intercept at each level



Error & Output Logging (2)



Task Control



- All tasks are based on Gaudi data processing framework
- Common state diagram as shown
- Control using common Experiment Controls System [ECS] based on DIM / PVSS
- Transitions are mapped to Gaudi transitions
- Satisfies required functionality for:
  - Infrastructure tasks: buffer managers
  - Data processing tasks: event builders, HLT filters/Moore and data transfer tasks

Implementation Considerations

- All applications are implemented as Gaudi tasks
  - Ease offline development of HLT algorithms and online deployment
  - Event filter algorithms are identical in offline and online
  - The offline application is executing in the online environment
    - Some services were replaced/adapted to the online:
      - Identical interfaces
      - Event access using buffer manager
      - Message reporting utility
  - Dynamic application bootstrap
- All components available in 2 shared libraries, which are loaded at image activation time
- All OS dependencies are encapsulated
  - Supported platforms are WIN32 (development/debugging) and linux (deployment on HLT farm)

Conclusions

- We developed an open framework to execute HLT code in the LHCb online environment
- No online-offline separation
  - Transparent data access
  - Transparent data transport
- Both realized using very simple building blocks
  - Buffer managers
  - Common control structure interfaced to Experiment Control System which uses PVSS
  - Networking library to transfer data between processors
- All OS dependencies are encapsulated