Control of large scale distributed DAQ/trigger systems in the networked PC era

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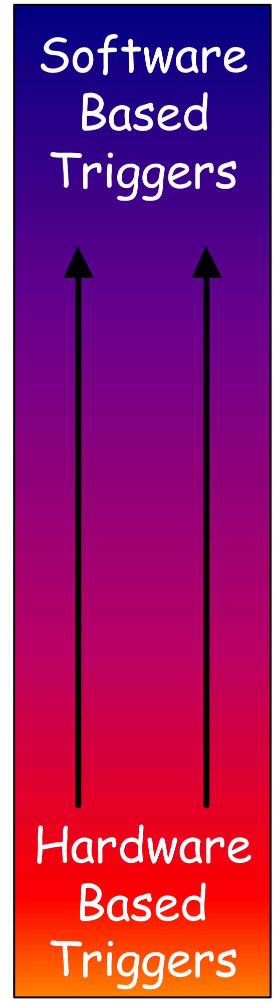
The Trigger Environment

- Pressure on the Trigger
  - Shorter decision times required
  - More complex algorithms
  - More algorithms
  - More Data
- Hardware Triggers
  - Inflexible, dedicated
  - Hard to change as accelerator condition change
  - FPGAs: Hardware moving into firmware.
  - (but) Well understood
- Cheap Commodity Components
  - High speed networks
  - Cheap memory
  - Cheap CPU power as never before
- The ERA of the PC Based Trigger
  - Farms of Triggers where traditional hardware exists
    - BTeV – very little in the way of a HW trigger

Speed!



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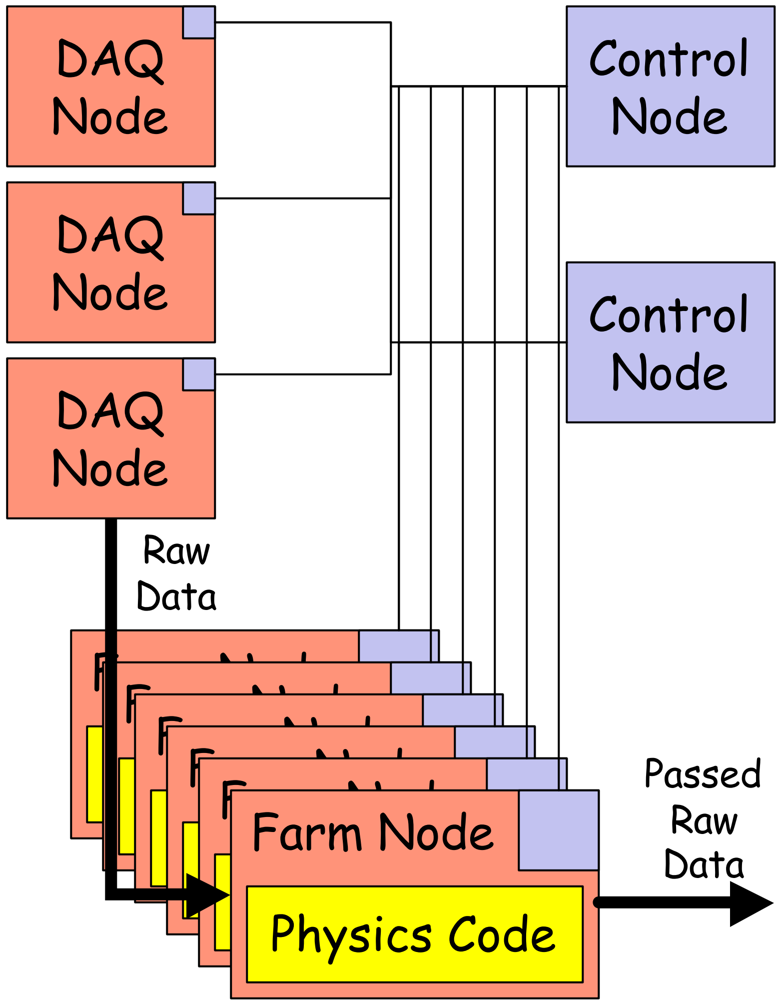
Farm Based Triggers/DAQ

- Control Code
  - Management
  - Configuration
  - Monitoring
  - Error Recovery
- DAQ Code
  - Controls DAQ components
  - Network Control & Routing for farm
- Physics Code
  - Performs actual trigger decision
  - Frequently interfaces with others



All code, except the control code, is independent of each other

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Control

- Configuration Tasks
  - Management
    - Interface with other parts of Online System
    - Resource Management
    - Controls other components
  - Configuration
    - Event Routing
    - Farm Partitions
      - Multiple Runs
    - Trigger Code
    - DAQ parameters
  - Monitoring
    - System Performance
    - Resource Usage
    - RT Debugging (hardware & software)
  - Error Recovery
    - Asynchronous and synchronous errors
    - Crashed nodes!
    - On the fly reconfiguration
      - Must decide if possible!
    - Diagnostic information for shifters & experts

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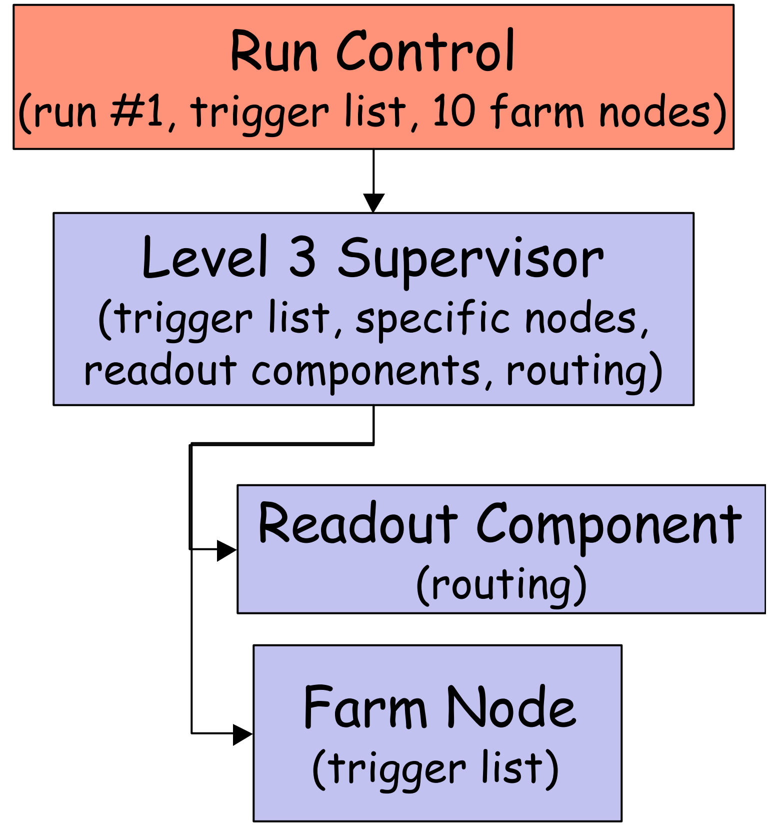
The Environment: Distributed Run Control

- Run Control – Farm Interaction changing
  - Simple RC program used to handle whole DAQ/Trigger system
    - FECs, Trigger, DAQ, etc.
  - DØ Run 1: RC was complex
  - DØ Run 2: To complex for a single RC. → Distributed
- L3 (Farm) Supervisor has more responsibility
  - Hides farm implementation details from RC.
    - Black box for the rest of the online system
  - More flexibility in how the Trigger/DAQ system is managed.



- Components can fail in way that doesn't bring down the run
  - A node crash
- Allows it to recover from errors in farm and DAQ without having to involve RC when possible

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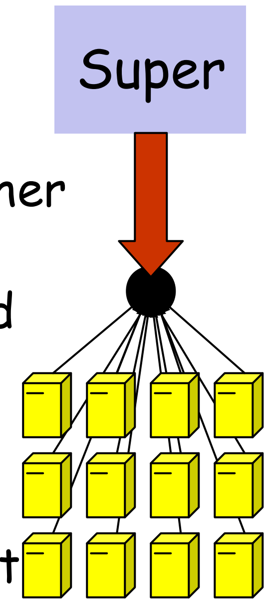
Design of Supervisor

- Goals
  - Configuration
    - Effectively manage transitions from one state to another
      - running, paused, new run, etc.
    - A large number of separate entities must be controlled
    - Speed issues
      - Recovery, short accelerator times between shots, etc.
  - Recovery
    - Physics code will change through out life of experiment
      - Test Test Test!
      - Will still have crashes & explosions
    - One of the few systems that can suffer a major component failure and not terminate a run!
- State Diagrams – standard approach
  - Use a state definition language to define each transition in the farm
    - Reconfiguration requests that don't change the global state
    - Difficult to deal with exception conditions, asynchronous errors.



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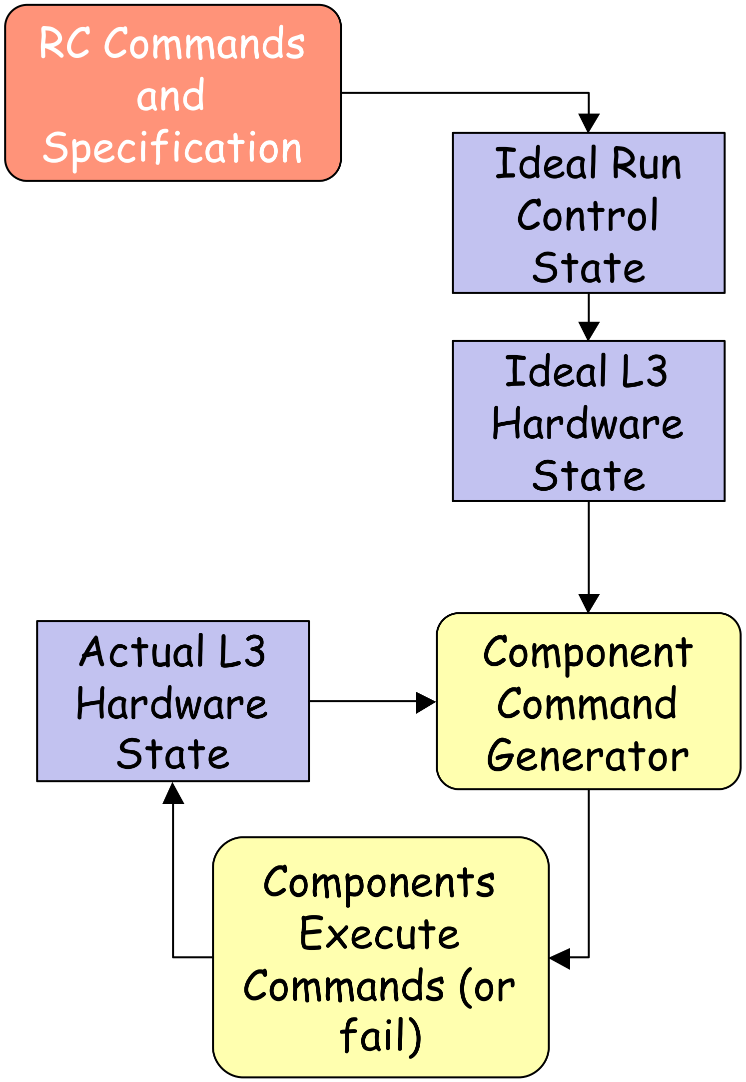
The Ideal State

- Maintain an ideal state
  - Ideal state is built only if RC commands make sense
  - Eliminates erroneous input
  - Prevents leaving the farm in an unknown state due to a RC failure
- There is a mapping from an ideal state to a Hardware State/configuration
- Maintain Actual State
  - Comparison between ideal and actual generates commands
- Did a RC Configuration Change Succeed?
  - Are the Actual and Ideal states close enough to report success?



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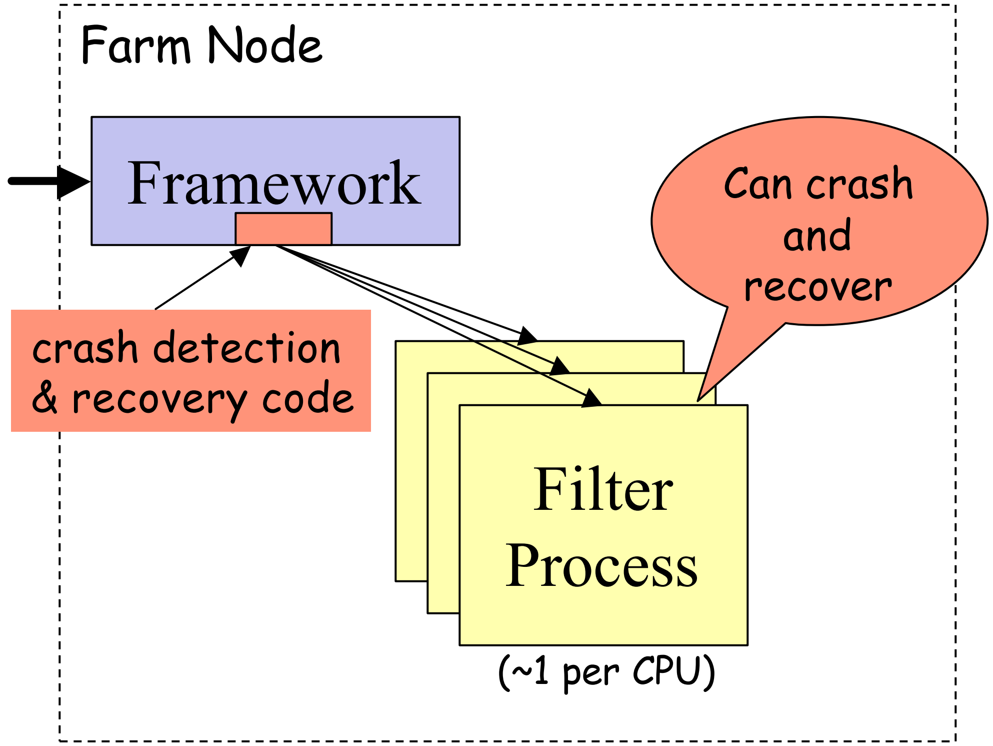
Faults & Errors

- Ultimate goal is 100% uptime; 0% trigger deadtime!
- Faults are rarely predictable.
  - Hardware: Always knew every input and output
  - In software, this is no longer always true
- Two classes
  - Catastrophes
    - Whole Farm Crashes, on every event
    - Critical Readout component fails to configure correctly
  - Minor errors
    - Low grade crashes
      - In Run 1 we lost the use of our build system due to a licensing issue for a short while: had to deal with a farm crash once per 20 minutes.
    - Non-critical component fails to configure
- Failure Mode Analysis
  - Will tell you the most likely failures
  - And the places that a failure will do the most damage.
  - Helps to focus error recovery efforts

Still need humans!

Farm Node Failures

- Separate the physics code from the Framework and Control Code
  - Physics code changes over life of the experiment
  - Separate memory space
  - Assure that data back from the Filter Process is not interpreted by Framework at all
    - Blindly handed off to Tape
  - Automatically restart a dead filter process
    - Or start debugger on it without interrupting other filter processes



A Special Case Recovery

indicated by a failure mode analysis

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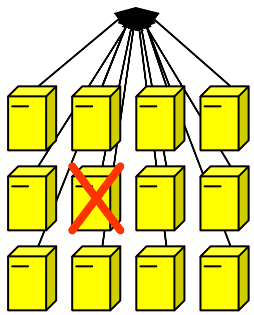
General Recovery

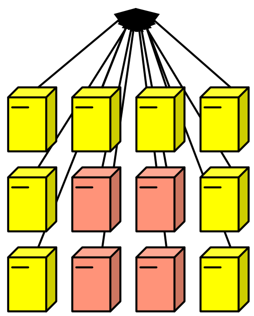
- At Failure
  - Supervisor is notified of the failure
  - The Actual State is updated to reflect the failure
    - There is an understanding of what constitutes a minimal working L3 system
    - Stop Run is issued if this test isn't satisfied.
- Recovery
  - Notify Shifter of problem, or
  - Measure current state against ideal state and re-issue commands
    - Will repair broken device/node
    - Reconfigure the farm (expensive)
    - Type of failure can effect the hardware state
      - Means special recovery commands can be automatically generated
    - Repeated Failure Detection should be implemented
    - No need to notify RC
    - Accounting (trigger information)

Local/Global Fault Detection

- Local
  - Timeout from command, etc.
  - Explicitly designed detection in control code
  - Must be careful to track the source of the error and record it in the Actual State
  - real-time detection
  - Similar to old-time hardware faults
    - Know exactly where the fault occurred
    - Limited number of fault types
    - Specific – simpler for computers to handle directly.



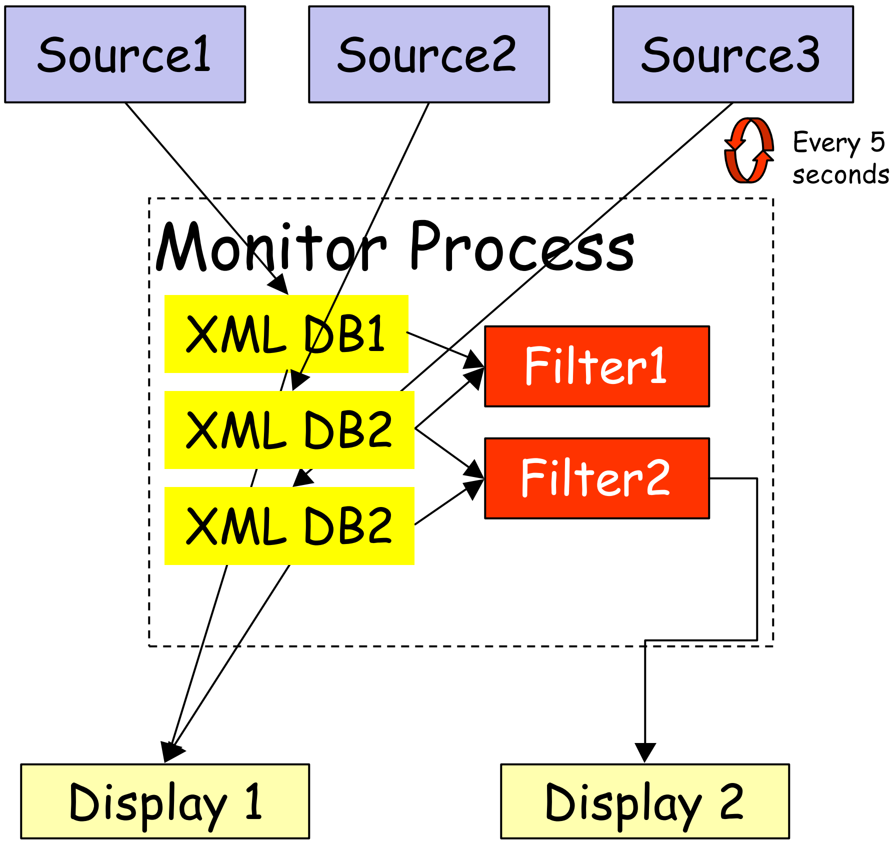
- Global
  - Single monitor point can't determine sickness
  - Global Monitoring is crucial for this
  - Useful to help diagnose problems for the shifters
    - Recommend solutions?
    - One day… it will go farther!
      - Input to rule based system??
  - Detection isn't on an event-by-event basis



Flexible Monitoring

- Monitoring
  - XML Based
  - Generic WEB front-end
    - take advantage of commodity software market!
  - Drop-in Aggregate Filters.
  - Displays query via http requests
    - Cross platform
    - SOAP?
    - Custom designed displays (graphics) or simple static web pages
  - Use actual program in limited circumstances
  - Interface for rule-based system??

Java?



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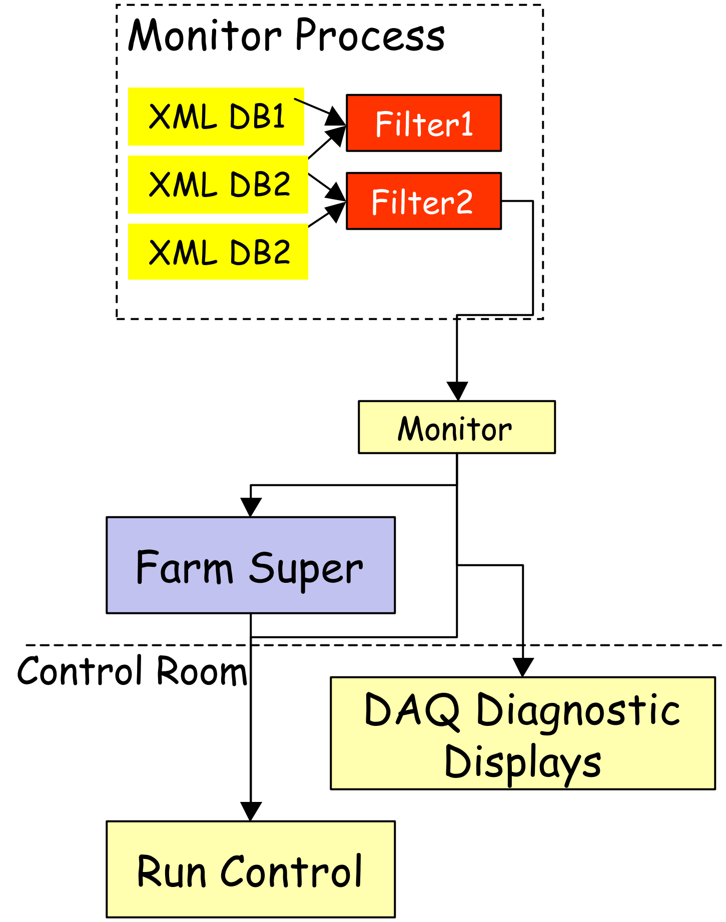
Putting It Together

- No reason for a display to be the only consumer for Monitor Information
- Intelligent process can watch for known patterns
  - Good
    - Look for correct running patterns, warning when they aren't present
  - Bad:
    - Look for known bad patters, warning when they are present, perhaps taking automatic action, even.
    - Rule based system
      - Difficult to maintain.
      - Would like a snap-shot feature



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Conclusions

- PC Based DAQ/Trigger
  - Large component count
  - Uptime must be almost 100% for each component
  - Software bugs are a reality
  - Approach system design in a unified way
- A General Approach Means
  - Flexible system
  - Ease of extension
    - Hooks for adding monitor and other capabilities, for example.
    - Hooks to deal with many error situations one can expect to encounter over 10 years of running.
  - Failure Mode Analysis
- This Requires
  - Robust, extensible Monitoring
  - Extensible Control System
    - Can handle addition of error conditions at a later time
  - Software infrastructure to tie the two together
  - Being aware of shifters!

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