Trigger and Data Acquisition Improvements

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The Scope of "Trigger and Data Acquisition"

- Moves the data from the front-end electronics to disk.
- In *BaBar* jargon, and in management hierarchy, this involves three steps:

  -> the "level 1 trigger" selects interesting time slots

  -> "data-flow" moves the data selected by the level 1 trigger from the front ends to the on-line farm nodes.

  -> "on-line event processing" filters the data ("level 3 trigger") and moves the data to disk.

- Related to Data Acquisition, but not part of it, is the background filter (could be called the level 4 trigger) that resides at the front of the first-pass full reconstruction.

Trigger and Data Acquisition Structure

@ Level 1 trigger rate (now 1 kHz)

- from Front-end electronics
- via 410 fibers to
- 157 (slot-n) Read-Out Modules
  IO channel/Fast Timing/Single Board Computer does the feature extraction
- via VME back-planes to
- 23 slot-0 Read-Out Modules.
  Collect and assemble the data from the crate
- via 100 Megabit switched ethernet to
- 32, 333 MHz, Sun Ultra 5 on-line farm nodes assemble the event, do the L3 trigger, etc.

@ Level 3 trigger rate (now 100 Hz)

- 100 Megabit switched ethernet to
- a Sun Ultra Enterprise 450, which writes the data to disk

Level 1 trigger

Charged track trigger

- Track segment finder
  24 modules
- Transverse Momentum Discriminator
  8 modules
- Binary Link Tracker
  1 module

Calorimeter trigger

- Calorimeter Trigger Processor
  10 modules

Global trigger
  1 module

Current status at 2.3 x 10^{33}

- The level 1 trigger rate is less than 1 kHz
- The level 3 trigger rate is 100 Hz (includes 23 Hz of calibration Bhabha events)
- The event size is typically 28 k Bytes.
- The peak event throughput (L1 rate) is almost 3 kHz.
- The peak logging rate is 800 Hz.
- The system degrades gracefully, i.e., the throughput remains near the maximum as the trigger rate exceeds the maximum.
- A throughput capability of twice the average low background trigger rate is needed to avoid dead-time problems during less than ideal conditions.
- The 1 kHz is now dominated by beam background triggers.
- Software and firmware changes in process will improve some of these numbers 10 to 15 %.

Extrapolations to the future (without any improvements)

Dec 2002 (9×10^{33})

- L1: best=1540 Hz, double background=2300 Hz, allow for error: need 3 kHz
- event size: 45 k Bytes
- L3: about 220 Hz
- max throughput: 2.5 kHz

Dec 2003 (1.5×10^{34})

- L1: best=2120 Hz, double background=3070 Hz, allow for error: need 4 kHz
- event size: 52 k Bytes
- L3: 310 Hz
- max throughput: 2 kHz

Improvement requirements

- We have a 20% problem in Dec. 2002
- We have a factor of two problem in Dec. 2003
- Beyond 2003 we will need even more capacity.

- We can lower the Level 1 trigger rate or increase the throughput, or both.
- Lowering the trigger rate provides a simple to understand reduction in the load on all components.
- Increasing the throughput is a more complex statement, since there are many different bottlenecks in the data-flow. Some are sensitive to the number of events, and others to data volume. Some elements (such as the level 3 trigger) may have non-linear behavior.

Level 1 Trigger Upgrade

- Since most background tracks originate from 20 cm or more from the IP, requiring all events to have at least one charged track from the IP would reduce the background induced triggers.
- The current trigger uses no z information.
- The charged track trigger could be replaced with one of similar design which uses the stereo angle information to restrict tracks to those that appear to come from within 14 cm of the IP.
- With this requirement, the revised L1 rate extrapolations are:

Dec 2002 best: 1100 background doubled: 1420
with allowance for extrapolation error: 1900

Dec 2003 best: 1580 background doubled: 1900
with allowance for extrapolation error: 2500

Data-flow choke points

The data-flow system is expected to run into limitations at three points:

- The slot 0 Readout Module CPU time (mainly data manipulation, event number).
- The ether-network (bandwidth).
- The slot n Readout Module CPU time (mainly feature extraction, data volume).

Solutions:

- Slot 0 CPU: batching events evades this limit. Will know if this works before March.
- Network: split high rate crates (2 crates, 4 ROMs), or replace 100 Megabit with Gigabit network (requires new online farm nodes).
- slot n CPU: faster or more Readout Modules for the limiting systems (involving 10 ROMs), better feature extraction code.

Online Farm Limitations

- These have not been studied as carefully. We will know more soon.
- Current rate limit is about 2.8 kHz.
- Rate will degrade some with larger data volume from the DCH and EMC. The DCH event size may more than double by Dec. 2003, while the EMC is expected to increase by 50%.
- We need more capacity so that more of the background filtering may be done at level 3.
- We will need to do something by Dec 2003 even with the trigger upgrade.

Possibilities:

- Increase the number of nodes. This will require substantial software effort and has some risks.
- Replace with new nodes, probably Linux boxes.

What to do, and when to do it

Now

- Prepare conceptual design for the trigger upgrade.
- Continue studies of the DAQ limitations.
- Implement software fixes to alleviate choke points where possible.
- Start porting online code to Linux. This involves setting up a Linux test stand.

March 01

- Decide on trigger upgrade, start engineering.
- Study backgrounds of the upgraded machine.
- Study success of software improvements (batching, feature extraction).
- Begin exploring using >32 farm nodes

More What and When

Fall 2001

- prototypes for new trigger boards
- decide on Readout Module improvements, start work
- evaluate >32 node efforts

Summer 2002

- install trigger upgrade
- install more/faster Readout Modules in the DCH and/or DRC systems
- Decide on node replacement
- Decide on network replacement

Winter 2003

- install new nodes
- install Gigabit network

Costs

Trigger	$440K
Slot n Readout Modules	$100K
Slot 0 ROMs and crates	($60K)
Online farm	$300K
Network	$430K
Total	$1270K

Costs are approximately half M&S, half engineering.

( ) -> alternate solution, not included in the sum