BELLE DAQ System
- Status and Future-

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CHEP2000, Padova
1. Introduction

B-factory experiment @ KEK: KEKB / BELLE

KEKB: The accelerator for KEK B-factory:

- being built reusing ex-TRISTAN tunnel
- e+e- collider with two separate rings
- asymmetric collision
  $3.5\text{GeV (e+)} \times 8.0\text{GeV (e-)}$
- design luminosity:
  $1.0 \times 10^{34} /\text{cm}^2/\text{sec}$
Typical trigger rate : ~ 200Hz (max. 500Hz)
Typical raw data size : 30KB/event

Requirement:
> 15MB/sec throughrate @ 500Hz
2. Architecture
2.1 Frontend Readout

*based on Q-to-T conversion + multihit TDC

Q-to-T : LeCroy MQT300
TDC    : LeCroy LRS1877S
used for most of detectors
CDC, ACC, TOF, EFC, ECL

KLM: "hit" timing on strips
-> serialized by multiplexor and
read by TDC (to reduce # of ch.)

SVD: FADC + DSP system

* Control of readout sequence
- Timing is generated by
  "Sequence Controller (SEQ)"
  by receiving trigger from GDL
- Timing signal
  -> sent to "Timing Distributor(TDM)"
on each subsystem
2.2 Readout Subsystem

![Diagram showing Readout Subsystem components: Controller, Dual Port Memory, EB-tx, TDM, Local CPU, VME, Event Builder, SEQ, TDC, TDC, TDC, FPI (Fastbus Processor Interface), and DOG.]

**Performance:**

- FASTBUS->Dual Port Memory: 5.5MB/sec
- FASTBUS->EB-tx: 3.5MB/sec
2.3 Event Builder

* 12 inputs / 6 outputs
* built by combining 4x4 and 2x2 barrel shifting ECL-signal switches
* external switch control

Performance:
maximum switching speed : 30KHz
maximum transfer rate : 160MB/sec
(w/o VME access on tx/rx)
transfer rate in BELLE DAQ :
4 MB/sec/link, >15MB/sec in total
2.4 Online Farm / Event Monitoring

* consists of 6 VME crates housing 96 chips of MC88100 -> parallel processing
  Total CPU power : ~2500 MIPS
* events are sampled and sent to a PC server for data monitoring

**Performance:**

- Maximum transfer speed : 3MB/crate
  (only data formatting on farm)
- Maximum sampling rate to PC server: 50Hz @ 30KB/sec
2.5 Data Transfer System

* send data to computer center and write them onto tape
* Fujitsu built this system using protocol: Fujitsu-grown (reflective memory)
  physical connection: TAXI/ATM over optical fiber

**Performance:**
- ~ 8MB/sec/link
- > 15MB/sec in total
2.6 Run Control

* Run control is done by a closed Ether/FastEther network

* A home–grown communication software called "NSM (Network Shared Memory)" is used.
  
  -> provides facilities:
  
  – calls functions on remote node by sending a message
  – shared memory extended over network space

* Both of run control and monitoring are done using NSM
### Detector Subsystems
- Included: SVD, CDC, ACC, TOF, KLM, EFC, TRG
- Excluded: ECL

### Trigger and DAQ Subsystems
- Included: SEQ, EBCTL, FARM, STOR, GDL, TOFTRG
- Excluded:

### Other Subsystems
- Included: DQM, RSUM, MOND, HVC, ECL_BHA, KEBK
- Excluded:

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**Event Log**

- Oct 28, 1999: 10:39:08 Global operation state changed to TRANS.
- Oct 28, 1999: 10:44:13 Global operation state changed to OFFLINE.
- Oct 28, 1999: 10:44:13 Global operation state changed to ONLINE.
3. Event Processing on BELLE DAQ system

- Fast event processing is done on
  * Online Computer Farm
  * PC server (for sampled events)

3.1 Online Farm Processing

Purpose:
1) Formatting of event data
   ("Panther" format for offline analysis)
2) Fast event reconstruction
3) L3 trigger

* Event processing framework on online farm

- the same framework as that used for offline analysis (B.A.S.F.).
- program development is done in offline environment
* Fast Reconstruction

Fast track reconstruction is done using track trigger information

- track finding is done using track trigger info.
- track fitting using wire position
  * no x–t relation is used

--> the performance is being studied for the use in L3 trigger
  (L3 trigger is not yet turned on.)

• \( \bar{b}b \) event
Level 3 Trigger Performance

– Processing speed of Fast Tracker
  * tested in beam runs (>200Hz)
    (executed on Online Farm)
  -> no deadtime (due to fast tracker) was observed.

– L3 performance
  * currently tested in offline analysis using real data

Reduction factor for L1–triggered events : 0.38
  – this is enough for us.
    + L1 trigger is already tight enough
  -> typically 200Hz, Max 500Hz

Efficiency:
  Hadronic : 95.5%
  $\mu^+\mu^-$ : 89.2%
  $\tau^+\tau^-$ : 79.6%

-> planning to turn–on L3 trigger soon
3.2 Event Monitoring

* Events are sampled from online farm via FastEthernet.

* Sampled raw data are "queued" in the shared memory ("nova" buffer manager)

* Events in the "queue" can be retrieved by multiple analysis frameworks (BASF) attached to the shared memory.
  - Data Quality Monitor (DQM)
  - Event Display

* Each program attached to shared mem. can be started/stopped at any time without affecting on other attached programs.
4. Overall Performance

Current condition:
- Trigger rate: 100 - 250 Hz
- Event Size: 25 - 35 KB/event

Average: 28.4KB
- CDC: 9.2KB
- SVD: 9.6KB
- ECL: 3.5KB
- KLM: 2.0KB

DAQ deadtime: less than 4% @ 250Hz
- mostly FASTBUS/VME readout speed

Error rate: < 0.05%
- error in TDC readout
- parity error in the transfer from FASTBUS to VME
Event Size

Ave: 28.5KB

Transfer Rate

7MB/sec
DAQ Dead Time

DAQ dead time (%) vs. trigger rate (Hz)

4%
5. Plan for upgrade

- current problems
  * difficulty in long-term maintainance
    Online Farm / Event Builder / Recording System
    <- old fashioned, home-grown
  * processing power for L3 trigger is not enough
  * needs semi-realtime reconstruction facility for L4 trigger

- based on PC-servers(4CPU/Linux)
  connected via Fast/Gigabit Ethernet
- no network switch for event building
  -> point-to-point connection

R&D is in progress
This system will replace the current system in early 2001.
6. Summary

- The BELLE DAQ system was built and is now working successfully in the beam runs.

- Each component in the system achieved the expected performance.

- The overall performance in the beam run condition was measured:
  event size : ~30KB, trigger rate < 250Hz
  -> DAQ Dead Time < 4%

- L3 trigger scheme on Online Farm is now in preparation

- Data monitoring on a Linux-driven SMP PC server using events sampled over network is successfully working.

- Upgrade project is in progress. The DAQ system will be replaced in early 2001.