Event Builder and Level 3 at the CDF Experiment

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The Event Builder and Level3 systems constitute critical components of the DAQ in the CDF experiment at Fermilab. These systems are responsible for collecting data fragments from the front end electronics, assembling the data into complete event records, reconstructing the events, and forming the final trigger decision.

With Tevatron Run IIa in progress, the systems have been running successfully at high throughput rates, the design utilizing scalable architecture and distributed event processing to meet the requirements. A brief description current performance in Run IIa and possible upgrade for Run IIb is presented.

1. Introduction

The Collider Detector at Fermilab (CDF) [1] is a general purpose particle detector which have been taking data again since 2001. A three-level trigger system is used, where each succeeding level filters events on the basis of increasingly refined reconstructions of objects within the event. The first two trigger levels reduces the event rate from 7.6 MHz to about 300 Hz.

When an event is accepted by the Level 2 trigger, its data become available for readout distributed over a couple of hundred of VME Readout Buffers (VRBs). The purpose of Event Builder is to take all these small pieces of data and send them to one place in the Level 3 farm where the final level of event filtering is done, reducing the rate to roughly 50 Hz, which can be recorded for off-line analysis. The average processing time per event in Level 3 is on the order of a few seconds. A more detailed description is found in [2].

2. Event Builder Overview

Event data enters the Event Builder system through the Scanner CPUs and is sent through the event network, which in this system is the ATM switch, to Level 3 via several Linux PCs, so called “converter nodes”.

The switch delivers event fragments from 15 input to 16 output ports and can be extended up to 64 I/O ports total. The I/O ports are connected via OC-3 (155Mbps) optical fiber.

On the input side, MVME2603 processors (Scanner CPUs) running VxWorks 5.3 scan data from the VME readout boards The processors function as FIFO buffers into the switch. The ATM interface is an Interphase 4515 PMC/ATM adapter with 1 MB on-board data RAM. On the output side, Intel processor-based PCs running Linux receive and assemble the event for shipment to the processor nodes (PCs where L3 trigger decision is done).

A single-board computer called the Scanner Manager acts as a central coordinator for the Event Builder, which communicates with the Scanners and converters via the separate command network. This is where the various components are combined into a functional whole. The Scanner Manager is not directly connected to the Level 2 trigger hardware. Instead, it communicates with the Trigger Manager, a single-board computer in the Trigger Supervisor Level 2 crate. The Trigger Manager reads trigger data from each TS and sends the information to the Scanner Manager, which acknowledges after the SCPUs have loaded the event (or tried to). There is also a simple protocol between Scanner Manager and Trigger Manager for error recovery.

In order to prevent cell loss due to output overflows, each sender is allocated a fixed rate for sending to each receiver. While the transmission is going on, other VxWorks tasks load new events and prepare them for shipping, so that the ATM interface remains saturated as long as the fragment size is larger then 4 KBytes. This simple form of traffic shaping is needed because we are using the raw AAL5 protocol of ATM, which does not by itself guarantee safe delivery of all the data [2].

3. Level 3 Overview

The Level 3 trigger is a processor based filtering mechanism which has access to the full event record. The CDF Run II Level 3 trigger is realized as a PC farm. A small number of nodes in the Level 3 farm are equipped with ATM interfaces. All the fragments making up a given event are collected by one such "converter" node. That node then passes the assembled event via fast Ethernet to one of the processing nodes connected to it. A converter node has a small number of event buffers, any one of which can be sent to by the Scanner CPUs, so that a new event may be received while a previous one is still being processed. Each processor node is connected to just one converter node, splitting the L3 farm into distinct sub-farms each with a converter node at its head. Events that pass the L3 filter are routed first to special farm output nodes, collecting all accepted events and directing them to the Consumer Server which is responsible for distributing the data to the data logger as well as on-line monitors.

The full Level 3 system contains 16 subfarms with each subfarm consisting of one converter node and about sixteen processor nodes. Each pair of subfarms is connected to an output node. A few months ago the system was upgraded by replacing some older PCs with 64 dual-Athlon PCs running at 1.6 GHz.

4. RunII-b upgrade

The stated goal of Tevatron run IIb is the accumulation of $15fb^{-1}$ at $\sqrt{s}$=1.96 TeV. To get it, one will need to increase the luminosity to $5 \times 10^{32} cm^{-2} sec^{-1}$. Then, several parts of the system should be upgraded, including the Trigger system [3].

A rate of 750 Hz, which corresponds to a data throughout of 375 MBytes/s (assuming the events sizes of 500 kBytes) is expected in the Event Builder. So, the existing system needs to be upgraded. For the Event Builder a sustained bandwidth of at least 400 MBytes/s will be needed to take account the system requirements. The actual design of the Level 3 Trigger farm will not need an upgrade; the number of PCs simply has to be adjusted according the CPU requirement. Therefore, the Event Builder upgrade is the most important improvement needed. Higher performances in the Event Builder can be achieved by a straightforward extension of the ATM switch from OC3 to OC12 optical fibers foreseen. Another possible option is to replace ATM with gigabit ethernet. In both cases, the upgraded version is able to deal with rates as high as 1000 Hz and throughput of 450-600 MBytes/s.

5. Summary

This short note presents the current status of the Event Builder and Level 3 systems of the CDF experiment. We briefly describe the hardware as well as software of these sytems. A possible upgrade for Run IIb is also presented.

REFERENCES

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