The Eventbuilder of the ZEUS Experiment

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The Eventbuilder of the ZEUS experiment is a real-time parallel data format and transport system. It combines data flows originating from various detector components and transfers them to the third level trigger processor farm. The Eventbuilder is based on an asynchronous packet-switching transputer network and uses transputer links for bulk data transfer. It achieves a sustained data throughput of more than 24 MB/s over a distance of 100 m. A high-speed 64×64 custom made crossbar switch allows dynamic linking of any component to any branch of third level processor nodes. Implementation and system operation are briefly described and future plans introduced.

Introduction

The trigger and data acquisition system of the ZEUS experiment is a highly-parallel distributed real-time system. It consists of several independent readout systems and three trigger levels for data filtering. Its central part, the Eventbuilder, combines and formats the data flows originating from the various readout subsystems [1, 2, 3]. The Eventbuilder is subject to the highest data rate within the ZEUS trigger and data acquisition system. Its many connections to almost all parts of the trigger and data acquisition system make the Eventbuilder an important tool for system analysis and diagnosis.

Requirements and Structured System Development

The Eventbuilder has to combine and format the data flows originating from the different readout systems, transfer the formatted events over a distance of 100 m to the third level trigger processor farm and sustain a trigger accept rate of 100 Hz, corresponding to a total bandwidth of 15 MB/s. Further requirements include format checks of component data, careful on-line monitoring for debugging and system analysis purposes and conceptual simplicity regarding maintenance, future upgrades and cost.

The performance of the ZEUS Eventbuilder has strong influence on the output of the entire experiment. The use of structured system development techniques ([4, 5]) resulted in a well-partitioned and flexible system structure and ensured all requirements being met. Prototyping and simulation were strongly supported, thus many integration tools and reliable performance estimates at any stage of project development were available.

By requirements analysis, a so-called Essential Model of the Eventbuilder was produced. The Essential Model defines the Eventbuilder’s database and its functional and time-dependent behaviour in a graphical, hierarchical way. As an example, fig.1 shows two simplified diagrams defining objects involved in building events and how to process them.
Figure 1: "Components respond to GSLT decisions by sending component data to the Eventbuilder...". Objects involved in building events and relations among them are defined in a (simplified) Entity-Relationship Diagram (left). The Data-Flow Diagram (right) illustrates, how the objects are processed.

The Eventbuilder hardware is based on transputers (fig. 2): Interfaces to component subsystems and branches of third level trigger (TLT) processor nodes connect the Eventbuilder to the trigger and data acquisition system of the ZEUS experiment. A crossbar switch connects the interfaces and allows to transport data from every component sub-system to any branch of TLT nodes. A control unit surveys the data flow through the Eventbuilder and configures the crossbar switch according to the data arriving at the component interfaces.

**Monitoring Eventbuilder Performance**

The Eventbuilder has seen successful operation for more than one year. To determine the performance of the Eventbuilder, a set of characteristic quantities is acquired during system operation. As the monitoring quantities are passed along with synchronization messages and are analyzed on a dedicated processor, no extra traffic or processor load are introduced on the Eventbuilder due to performance monitoring.

The Eventbuilder achieves a total bandwidth of more than 24 MB/s. It can handle peak trigger rates above 250 events/s. Up to 72 events can be constructed simultaneously, and the input buffers can accommodate at least 75 more events.

For on-line monitoring purposes it is sufficient to simply survey the load of the buffers inside the Eventbuilder. Any unusual system behaviour can be detected, sometimes even predicted from heavy buffer load. As an example, the right of fig. 3 shows how the
Figure 2: Layout of the Eventbuilder hardware. Interfaces to Component Subsystems and branches of third level trigger (TLT) processor nodes use ZEUS standard transputer modules, while Control Unit and Crossbar Switch are custom made.

Figure 3: Buffer loads in the Eventbuilder reveal unusual behaviour of the data acquisition system (explanation in the text).
Eventbuilder's buffers fill when the trigger accept rate exceeds the speed of the third level trigger processors (TLT). First, the common memories with the TLT (P.TLTn) fill up, followed by the internal buffers for complete events (I.TLTn) and the input buffers of the interfaces to component subsystems (I.Comp).

An Expert System for Experiment Control

Monitoring the Eventbuilder can also be used to determine the performance of other components of the trigger and data acquisition system [2, 3]. The powerful monitoring system enabled the Eventbuilder to become an important analytic and diagnostic tool for the entire data acquisition system. Currently, efforts are spent in extending the monitoring system and improving the diagnostic capabilities of the Eventbuilder. The goal is to provide on-line diagnostics and guidance for the operators on shift.

As a first step, any anomaly occurring in the trigger and data acquisition system is classified and recorded in a knowledge base (fig.4). Thus, whenever a similar situation occurs, it can be recognized, and the operators on shift can be provided with online diagnostics. In a second step, possible measures against erroneous behaviour in the data acquisition system will be recorded and associated with the knowledge base. This will enable the system to offer online guidance for the shift crew. The final step will be to provide for feedback from the operators on the usefulness of the instructions they received.
Conclusion

The Eventbuilder of the ZEUS experiment is a transputer-based real-time parallel data format and transport system with a total bandwidth of 24 MB/s. It has seen successful operation for more than one year.

The Eventbuilder has been developed making extensive use of structured system development techniques. Application of Structured Analysis and Structured Design (SA/SD) resulted in a well-partitioned and flexible system structure and ensured all requirements being met.

Its central position has enabled the Eventbuilder to become an important diagnostic and analytic tool for the entire trigger and data acquisition system of the ZEUS experiment. Current efforts are spent in expertizing the diagnostic capabilities of the Eventbuilder.

References


