Data-acquisition and triggering with transputer-like devices

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In the ZEUS-experiment the transputer microprocessor of INMOS will be applied in a substantial part of the data-acquisition and second-level triggering system [1]. Important features of the transputer - not found in other microprocessors - are: (i) 4 high-speed serial links (1.7 MByte/s per link) with associated DMA-controllers, and (ii) support for multi-tasking in micro-code, resulting in task-switching times of just a few µs. Moreover, the CPU of the transputer is powerful (for the 32-bits T800: 10 Mips, 1.5 MFlops). The OCCAM language provides direct support for parallel processing and for inter-process communication and synchronization.

About 45 % of the 260.000 electronics channels of the subdetectors of ZEUS will be read-out by transputers (fig.1 and 2), the other 55 % by Motorola 680x0 processors; but most of the data (80-90 %) will be transported by the transputer systems in the experiment. Two solutions are pursued for the backplane bus in the crates with a transputer read-out controller: (i) an extension of the external transputer bus for the Tracking Detector read-out, and (ii) the VME-bus for the Calorimeter read-out. The advantage of (i) is the simpler interface, of (ii) the more general potential. In fig. 3 the layout is sketched for the VME-based controller (2TP-module) for use in the Calorimeter read-out and second-level calorimeter trigger processing, the Event Builder and the Global Second-Level Trigger Box (GSLTB). For test set-ups a prototype series of 24 modules has been made, in spring of 1990 the final production modules will be available.

In the calorimeter read-out a 2TP-module handles the data of a crate. The full data is read-out and transported via the links of transputer Y to the Event Builder at an expected second-level trigger frequency of 100 Hz. The data of 36 read-out crates are sent from the collecting 2TP-modules over multiplexers, built around INMOS crossbar C004 Link Switches, to 3 2TP-modules in the subsystem crates of the calorimeter (fig. 4).

The X transputers in the front-end calorimeter crates search in parallel a subset of the full data read-out by the Y transputers, for local clusters of energy at an average event rate of 1 KHz. The results are combined in a tree structured network (fig. 5) and sent to the global second-level trigger. The total latency is about 3.5 ms, with a maximum processing time of about 1 ms for each of the three processing stages. For the Central Tracking Detector second-level trigger the processing transputers in the front-end crates form a linear chain. The track segments found are combined in a second chain of transputers (fig. 6) [2].

About 10 subdetectors are participating in the second-level processing. From every subdetector the data is broadcast to 10 transputers in 5 2TP-modules in the Global Second Level Trigger Box (fig. 7). One 2TP-module monitors the incoming data; the remaining transputers run different trigger algorithms. The results of the processing are sent over the VME-bus to a master processor, that takes the final decision. The decision is broadcast back to the subdetectors via the Event Builder.

Instead of building events centrally, data is sent from 2TP-modules in the subsystem crates via 48 links in parallel over 3 switches to six 2TP-modules in the third-level trigger crates (fig. 8). At most 12 events are built simultaneously in the third-level crates.

MicroVaxes controlling the subdetectors, are equipped with an Q-Bus to transputer link interface of CAPLIN Cybernetics Corporation. Monitor data is sent from the transputer systems to the MicroVaxes, displayed there and messages are sent to the main data-acquisition Vax for control and monitoring.

In the ZEUS experiment for the first time transputers are applied on a large scale in a trigger and data read-out system. Key features are: massive parallelism, pipelined processing combined with extensive data buffering, dynamically switched point-to-point links, effective use of multi-tasking and integration with standard minicomputers (i.e.VAXes). Therefore we consider the experience gained with this system to be of value in designing trigger and read-out systems for experiments at high luminosity hadron colliders, although higher speed processors with faster links (already in development) will be required.

References :

1. L. W. Wiggers and J. C. Vermeulen, Comp. Phys. Comm., to be published.
2. R. C. E. Devenish et al., OUNP-89-19 / ZEUS-89-76.

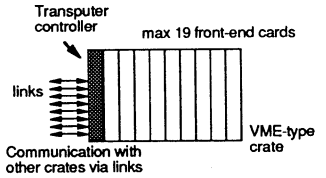

Fig. 1: Front-end crate with transputer controller

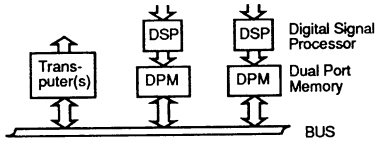

Fig. 2: Configuration inside a crate

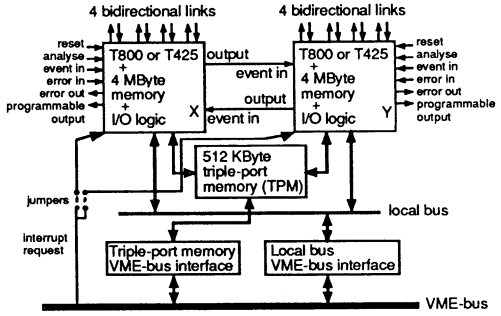

Fig. 3: The NIKHEF 2 transputer VME (2TP) module

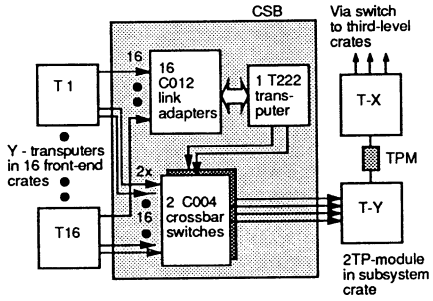

Fig. 4: Read-out of calorimeter data via the Control & Switch Box (CSB)

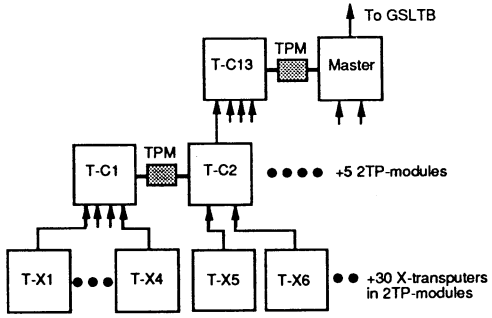

Fig. 5: Transputer network for calorimeter second-level trigger

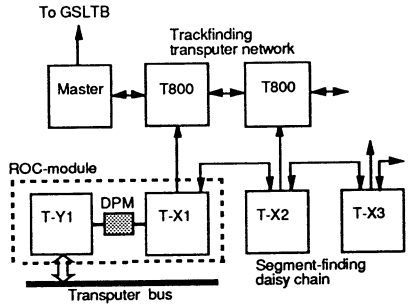

Fig. 6: Transputer network for Central Tracking Detector second-level trigger

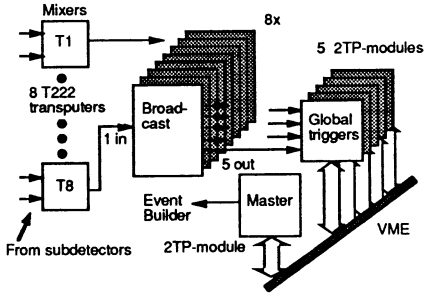

Fig. 7: The Global Second-Level Trigger Box (GSLTB)

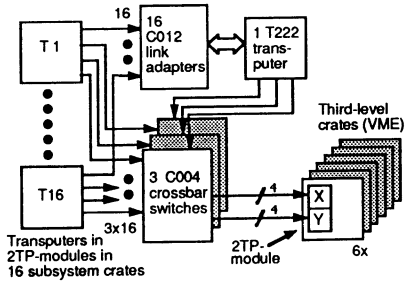

Fig. 8: The Event Builder transputer network