Projects of data acquisition systems for experiments at high luminosity facilities

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The preliminary specifications for new detectors operating at high luminosity future accelerators (e.g. DAΦNE at the INFN Laboratori Nazionali di Frascati) have motivated the search of integrated hardware/software solutions to problems related to the acquisition and the treatment of data. This project contains items to be jointly developed/tested with Digital Equipment in the following fields: Single Board Computers, high performance hardware/software for networks, and tools for storage and data management.

Introduction

DAΦNE [1], the e+e- Φ-Factory being realized at the INFN Laboratori Nazionali di Frascati, has been approved and funded by the INFN Board of Directors in June 1990. Construction and commissioning is scheduled for the end of 1995. Although smaller than LHC (the Large Hadron Collider) at CERN and SSC (the Superconducting Super Collider) in Texas, DAΦNE requires a similar high sophistication in the triggering and in the data acquisition systems, due to the very short time (2.8 ns) between bunch-crossing and the high rate of physical events to be reconstructed and stored. At the final luminosity of $\sim 10^{33} cm^{-2} sec^{-1}$, the trigger should operate in an environment where the number of physical events is in the range of 50K per second.

The ALSAT collaboration [2] is studying and evaluating solutions to the problems related to the architecture of data acquisition and storage techniques for experiments at the future high luminosity facilities; of them, DAΦNE will be one of the first to be operated. A tight collaboration with industries and manufactures has been individuated as a key point for having a closer contact with new technologies and products. The ALSAT collaboration is working now on a data acquisition model for the KLOE experiment [3] at DAΦNE. The proposed solutions could be scaled to be used in experiments with higher demand in total throughput.

At the actual stage of the KLOE proposal, a level-1 trigger from the Electromagnetic Calorimeter will allow to pre-scale the small angle Bhabha events and to cut the cosmic background. The data acquisition system will sustain a final data throughput of about 100-120 MBytes/sec corresponding to 10K events/sec. In Fig.1 a data acquisition scheme is presented; data coming from the Central Tracking Chamber (CTC) and from the Calorimeter (CALO) are collected in several VME crates. Sub-events are built by several (8-10) Readout Controllers (RC) that are connected to a switch using FDDI protocol. This switch acts as the final event builder feeding the Farms with complete events (10-16). The estimated computer power for the online event processing is about 12000 MIPS [3]. Processed events are flagged and distributed via a second switch to the data storage sub-systems.

The architectural elements of this data acquisition system are being studied by a Joint project INFN-Digital. These elements are:

- A single board computer (SBC+) based on Futurebus+ Profile B, [4] to be used at the Farm level, and, possibly, as subsystem data "synthesizer" in the first levels of the data acquisition. The SBC+ will be completed in June 1994. It will have the following features:
  - 21064 CPU (based on Digital Alpha RISC architecture chip), over 100 specmarks
  - 16 MB of static RAM addressed like secondary cache memory
  - Selftest ROM, with booting capabilities from SCSI or Ethernet
  - On-board FDDI controller
  - Real-time clock
  - On-board SCSI-2 controller (optional)
  - Ethernet interface
  - Console interface/serial lines
  - Programmable Watch Dog Timer
  - FB+ interface
  - Interrupt logic
  - VAXELN portability

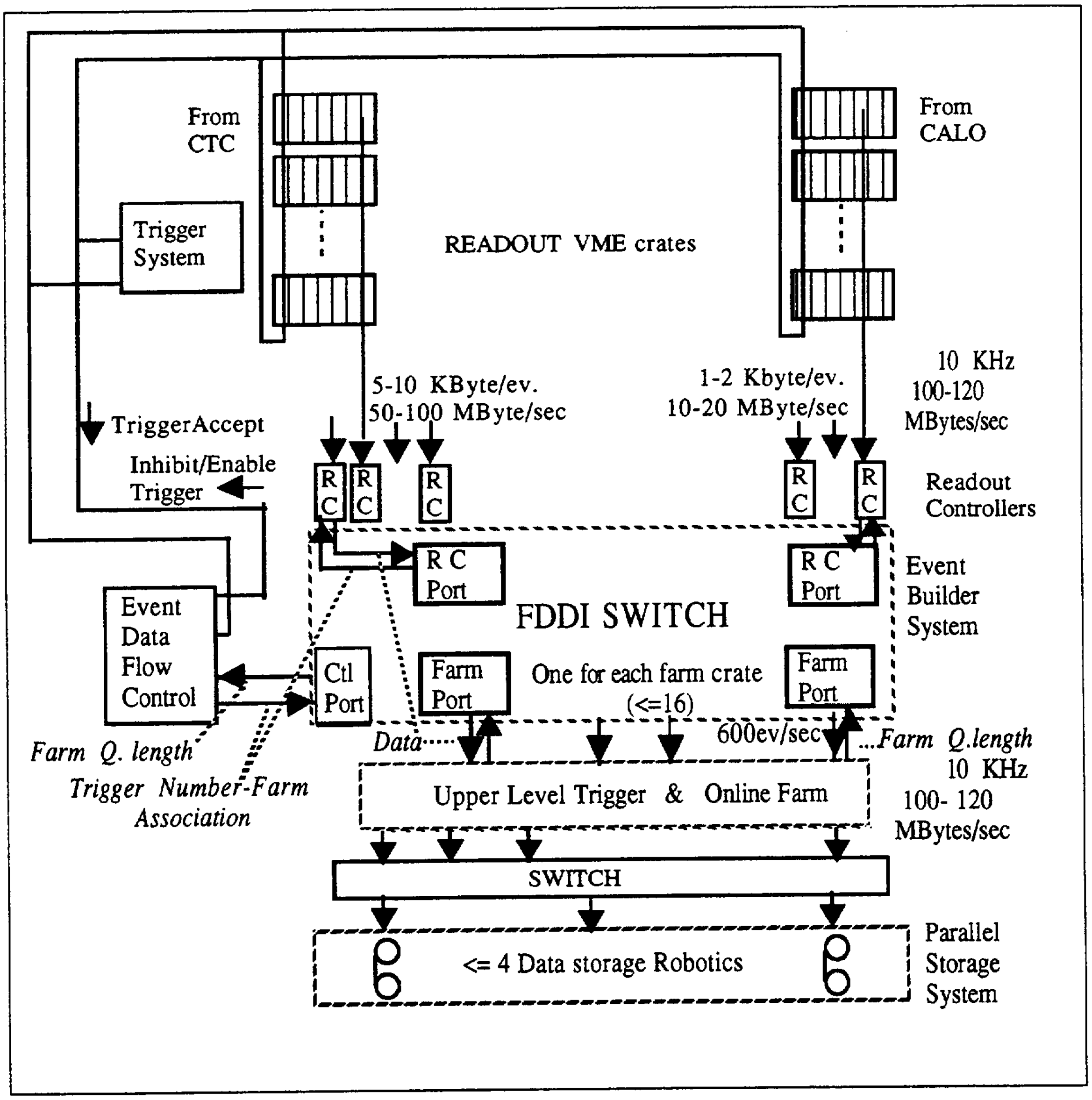

Figure 1: KLOE data acquisition scheme and protocol (italics characters)

- Use of the FDDI switch, being developed by DEC, to provide the event building functionality. This device offers interesting features allowing its use at the Event builder system level:
  - 4MB of buffering capabilities for each port (22 ports in the first model) allowing a completely decoupled transmission between Readout Controllers, Switch and Farms
  - Point-to-point FDDI links capable of working in Full-duplex mode, then allowing 2 parallel communication channels of 100 Mbps in each direction
  - A very efficient bridging capabilities between FDDI connections. 10-20 μsec is the time necessary for the switch to accept a packet from the input port, process it, and send it to the required output port, if the path is free.
- High bandwidth I/O devices for data storage and file system software be studied in future work.

The use of the FDDI switch in the DAQ system has been simulated using a VERILOG-C language model according to the scheme presented in Fig. 1. A Data flow controller connected both to the Trigger system and to the Switch decides the Event-number which is the distinctive element for the association with a member of the Farm. The association is based on the occupancy of the Farm queues. The relatively long time taken by the propagation of the association message to each RC imposes the following requirement: more than one event need to be bufferized in one single I/O operation (2-3 are sufficient). Data packets going from the Readout Controllers to the switch already contain the final destination, then no multicast traffic is generated. The simulation results show that the switch internal buffers are sufficient to maintain the required Event-building throughput in an essentially asynchronous way. The installation of a FDDI switch before the end of this year in LNF-Frascati will allow direct tests and measurements.

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