The Euroball Data Acquisition System [1]

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The paper describes the Fibre Channel Based data acquisition of the *EUROBALL*, a gamma ray spectrometer for nuclear physics experiments. The system architecture is reported and the switching network based event builder presented. The performances of the system are also shown.

Key words: event builder; fibre channel; corba; dsp.

1 Introduction

Euroball [3] is an European collaboration [2] to build a highly efficient and powerful gamma ray spectrometer for nuclear spectroscopy. The apparatus, installed in Legnaro (Italy), did the first run at the end of Jannuary. The spectrometer sphere is composed of about 300 HpGe detectors. Silicon or gas based ancillary detectors can also be integrated in the spectrometer. The main spectrometer characteristics are: energy range form 100 Kev $< E\gamma <$ 20 Mev, Eγ resolution (at 1.33 Mev) $\frac{\Delta\gamma}{E\gamma} = 0.006$, time resolution (1.33 Mev) $\Delta t < 5ns$, Total Photopeack efficiency (1.33 Mev) $Pph > 0.12$, Peak to total ratio (1.33 Mev) $\frac{P}{T} > 0.60$. An average event length of about 300–500 Bytes and an expected trigger rate of 50-100 KHz lead to a bandwith requirement up to 30 MByte/s. This paper describes the acquisition system: the Read Out Unit architecture, the event builder process and the back-end architecture introducing the adopted techniques and the obtained results. We show then the ability of the system to meet the performance requirements.

2 An Overview of the System

Euroball data acquisition system is composed of several readout branches (from 4 to 6) reading in parallel different part of the spectrometer (tapered, cluster, clover, ancillary detectors, etc); a set of modules called Readout Units (RU) whose task is to bridge the readout buses, a Fibre Channel based switching network, a commercial workstation based processor farm with about 5000 specint92 of computing power dedicated to on-line analysis, on-line histograms production and data storage. Storage of the event streams, after reformatting, yields an output stream up to 20–25 MByte/sec. If the contribution to network traffic due to the data to be histogrammed is taken into account, the total required bandwidth is about 80 MByte/sec. The main components of the system are described below.

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[2] Partecipant countries are: Denmark, France, Germany, Italy, Sweden and the UK

3 The Read Out Units and the Event Builder

These collect fragments of events from the front-end crates and send them to the processor farm via the network. Euroball array uses integrated electronics based on the VXI standard as designed for the Eurogam. Basically a RU is composed of an interface to the readout bus, a readout engine, a dual port memory and an interface to the network. In the present version, the Readout Unit is composed of 3 VME cards. The readout engine is based on the Texas C40 DSP and the network interface on the Ancor VME64 VME to FCS board. A 68040 based processor board (Motorola M162FX) running VXWorks 5.2 controls the system. The concept of the readout unit introduces a great modularity in the system and homogenous approach that may be kept to any new front end electronics which will be used in the future (i.e. for the ancillary detectors).

The event builder and the event distributor are critical points of the acquisition system and in this context the switching network plays two crucial tasks. It provides the Event Builder function: fragments of the same event collected in different Readout Units have to be sent to the same destination processor. Fragments are tagged in an early stage with the event number (or trigger number), then sent to the same destination processor (in the farm) identified as function of such tag. In this way the network acts also as a good event distributor. The main features of the usedevent builder protocol can be summarized in the following points:

- collection of the event fragments inside each RU in different queues available in their DSP own memory, a queue for each destination analysis process.
- fragments in the same queue are buffered before being injected in the network both to exploit the network performances and to optimize the accesses to the destination processors. In this case the destination processor provides the software for the buffer un-packing and the real merging of the event fragments contained in the received buffer.
- utilization of the PULL technique (the farm requires data to the RUs): it simplifies the software in the destination processor: no asyncronous data is input to the processor; the demand for data is driven by the processor itself.
- "token based" [4,2] implementation of a "barrel shifter" synchronization between the processors of the farm which avoids concurrent requests being addressed to the same RU.
- UDP/IP protocol as the communication protocol to transport the information from the data sources to the data destination. Over UDP a very simple acknowledge protocol has been built: an acknowledge packet is sent back every n packets received; if no acknowledge packet arrives the transmission is interrupted and repeated from the beginning of the unacknowledged packets.

The described protocol has been tested running a 4×4 system (4 RUs and 4 processors in the farm) over a 16 ports 266 Mbit/s (25 MB/s net point to point link) FCS switch. The system builds event at the rate of 80 MB/s with a global latency of about 400 ms.

4 The Back End

Owing to the distributed nature of the analysis processes over the workstation farm, the back end software has to provide a way to collect histograms, store data to magnetic devices and control the whole acquisition process, while hiding the complexity of the system to end-users. Network based services have been implemented adopting a distributed object oriented approach (CORBA) [1]. The description of the spectrometer configuration, the association of physical channels to program variables, formatting and checking of events is provided by Neo++ (Nuclear Experiment Oriented), a C++ template class library. To avoid slowing down the whole acquisition process, second level analysis performing slower and more sophisticated algorithms has been defined (spies). Distributed services are also incapsulated in library classes and are available in the same way as local objects. The distributed services implementation uses a master/slave architecture. A master process called *manager* controls a set of slave processes called *servers* that are in charge of the management of the resources (tapes, histograms, etc). Analysis programs and servers communications use direct socket API to meet the required bandwith. Resources setup is driven through a TCL/TK GUI connected to all the manager processes. Analysis programs access services according to the manager defined configuration. Following this approach, a Tape System, an Histogram System, a Network Variables System and a Error Logger System are defined. The Tape System provides the management of the tape devices and allows the configuration of logical streams for performing data mirroring and data striping and device control functionality. The Histogram System handles all the histograms defined in an analysis program, collecting updates coming from all the parallel running instances of a program. The Network Variables System provides a set of standard data types (integer, float, etc.) whose scope is network wide, to let calibration parameters be tunable without stopping the acquisition process. Last, the Error Logging System provides a collector of all error messages generated during the acquisition phase. The control of such a distributed system is managed by Load Sharing Facility.

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