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THE NIELS BOHR INSTITUTE ON LINE DATA ACQUISITION SYSTEM

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Abstract

A multiple computer data acquisition system is described. The use of multiple central processors, distributed intelligence in a CAMAC system, and large external memories is illustrated.

In the past 10 years, the on-line data acquisition system at the Niels Bohr Institute has evolved from a multi-dimensional hardwired pulse height analyzer into a system of computers with both high speed and low speed links. At the present time it consists of two computers and a CAMAC branch containing local intelligence. Since one of the two computers is in the process of being fully integrated into the system, what is described here is a combination of old well established mechanisms and new barely implemented ideas. In particular, the CAMAC system and Regnecentralen RC4000 computer are old components, while the Norsk Data ND-10 has been used extensively for off line tape sorting, but just now is being brought into on-line use.

A basic idea in the design of the system has been to separate the essentially simple, repetitive task of handling individual events from the complex activity of user interaction and data display. This is a useful division since the characteristics of these tasks are very different and different approaches are best used to effectively implement them. The event handling task performs a single repetitive function, but speed and response time are of the essence. This is best achieved by dedicating a processor to this function alone. On the other hand, user interaction and data display are best done on a machine with well developed software tools. The main computer, the RC4000, has supervisory responsibility for the entire system, but very limited real time duties. The real time flow of events is controlled by programmable command generators in the CAMAC system which eventually write the data into one of several specialized modules. These modules are front ends for either another computer, the ND-10, or a large external memory. A schematic diagram of the main components in the system is shown in Fig. 1.

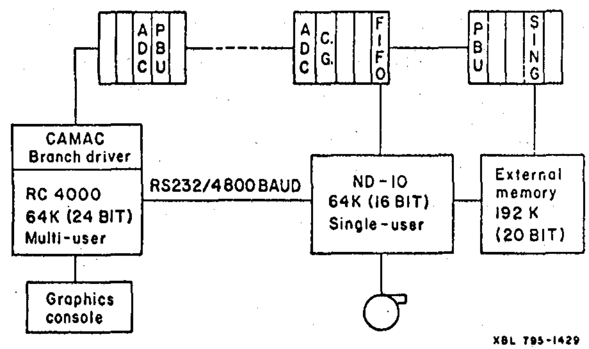

Fig. 1. Schematic diagram of the basic components of the NBI data acquisition system.

The basic function served by the CAMAC system is, of course, data transportation. This function is supervised by command generators. The programmable command generators are designed[1] and built at NBI, but are based on the Harwell series 7000 autonomous command generator. At the initiation of an experiment, a description of the desired CAMAC configuration is translated by the RC4000 into a program which is then downloaded into the command generator. The command generator program basically consists of groups of CNAF commands associated with LAMs. There is also a jump instruction and a test Q instruction, so program sections can be made conditional.

Data is typically presented to the system as an analog signal to an ADC. The ADC then converts the pulse and produces a LAM. The typical command generator sequence associated with such an ADC LAM

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will read the ADC, write the contents into the singles module, write the contents into a patch board unit,[2] and clear the ADC. The singles module will convert the datum into an absolute address in the external memory and present it to the auto-increment controller of the memory. The conversion is merely the addition of 1 of 16 base addresses determined by the sub-address used. This procedure creates a singles spectrum with no processor intervention.

The patch board unit (PBU) is used to process multiparameter coincidence events. It serves several functions, acting as a data buffer, a timing unit, and a data packing unit. If all the ADC's associated with a PBU fire within a specified time interval, the PBU itself produces a LAM. The command generator sequence associated with this LAM will transfer the packed contents of the PBU to a FIFO buffer module and then clear the PBU. The FIFO buffer is actually an interface to the ND-10.

The ND-10 has the unusual property of being able to respond to an interrupt with only 900 nsec. overhead. As a result of this, the interface can be a simple interrupt driven device producing one interrupt per event. The standard multiple user operating system has been discarded, and a simple, but very efficient, single user system written.

The ND-10 contains a user specified algorithm describing the treatment of each event. This algorithm is written in a dedicated language, EVAL.[3] If the event falls into one or more spectra, they are incremented. If desired, the event is placed in a tape buffer for storage on the local tape drive.

All spectra are stored in an external memory of 192K 20 bit words. This has several advantages. The 16 bit address space of many computers is a common limitation. Since the external memory is merely another I/O device, its address space is unlimited. One can also configure the memory so that the word size is appropriate, making for efficient memory usage. In addition, bulk memory is substantially cheaper than buying additional internal memory.

The RC4000 serves as both a supervisor and a user interface for this system. At the start of an experiment it compiles and downloads the command generator programs, reserves CAMAC modules, and compiles the users' EVAL program and downloads it into the ND-10. During the course of an experiment it starts and stops the data taking, displays the accumulated spectra, and writes them on tape. The display data is retrieved by taking snapshots of sections of the external memory through the CAMAC system. In addition the RC4000, being a multiprocessing computer, can simultaneously be available for general data analysis.

This system separates the real time, event by event handling of data from the more general supervisory and analysis functions. This separation makes expansion straightforward. An additional real time user can be included in the system by adding another ND-10 and external memory. For analysis, of course, multiple users are supported by the RC4000 multiprocessing operating system. In addition the ND-10 can be used for off line tape sorting, by simply downloading a slightly different program from the RC4000.

The system described here is obviously not the work of one person. I wish to thank my colleagues, K. Hagemann, A. Holm, E. Hviid, P. Høy-Christensen, and F. Videbæck for making this system happen. I would like to thank Lawrence Berkeley Laboratory for the hospitality shown me during the preparation of this paper.

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2. P. Høy-Christensen, NBI internal documentation.
3. A. Holm, Construction of Efficient Nuclear Event Analysis Programs Using a Simple Dedicated Language, presented at this conference.

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