BNL-36605
CONF-850579--11
RECEIVED BY OSTI JUN 24 1985

BNL--36605

DE85 012260

THE LEGS DATA ACQUISITION FACILITY

M. J. LeVine
Brookhaven National Laboratory*
Upton, NY 11973

Abstract

The data acquisition facility for the LEGS medium energy photonuclear beam line is composed of an auxiliary crate controller (ACC) acting as a front-end processor, loosely coupled to a time-sharing host computer based on a UNIX-like environment. The ACC services all real-time demands in the CAMAC crate: it responds to LAMs generated by data acquisition modules, to keyboard commands, and it refreshes the graphics display at frequent intervals. The host processor is needed only for printing histograms and recording event buffers on magnetic tape. The host also provides the environment for software development. The CAMAC crate is interfaced by a VERSAbus CAMAC branch driver.

Introduction

LEGS (Laser Electron Gamma Source) is a medium energy photonuclear beam line under construction at the National Synchrotron Light Source at Brookhaven National Laboratory. An intense beam of 300-400 MeV photons is created by backscattering laser light from the stored electrons in a straight section of the 2.5 GeV x-ray ring; this beam will be used for a variety of nuclear physics experiments.

An architecture was chosen which relies heavily on distributed intelligence: All of the measurement and control functions are to be carried out by CAMAC modules residing in two CAMAC crates, one for magnet and laser control, the second for experimental data acquisition. Both crates are equipped with purchased auxiliary crate controllers which autonomously control the modules in the crates. This paper deals with the experimental data acquisition aspects of the system.

The host computer on which this system is based is a Charles River Data Systems Universe 68/35, a UNIX-based [1] time-sharing machine with roughly the power of a VAX11/750 [2].

The nuclear physics CAMAC crate is interfaced to the Universe backplane by a parallel branch driver designed and constructed at BNL. The crate is equipped with the auxiliary crate controller (a Creative Electronic Systems "Firecracker"), a high-speed display (Transiac 4024), and a histogramming memory which contains 64K 24-bit channels (Creative Electronic Systems 2161).

The crate also contains two custom-built modules: an event shutter and an event definition module. The event shutter is, in effect, a CAMAC implementation of a computer-busy flip-flop. The event definition module alerts the Firecracker when all of the devices associated with an event have completed conversion. Thus the Firecracker is presented with the necessity to deal with an event only when the event is complete.

A software package to allow data collection is largely complete. It allows sorting into histograms, automatic updating of displays, display of high resolution two-dimensional data using the point-plot feature of the display, storage of histograms on magnetic tape and printing of spectra, as well as a printer dump of the graphics screen.

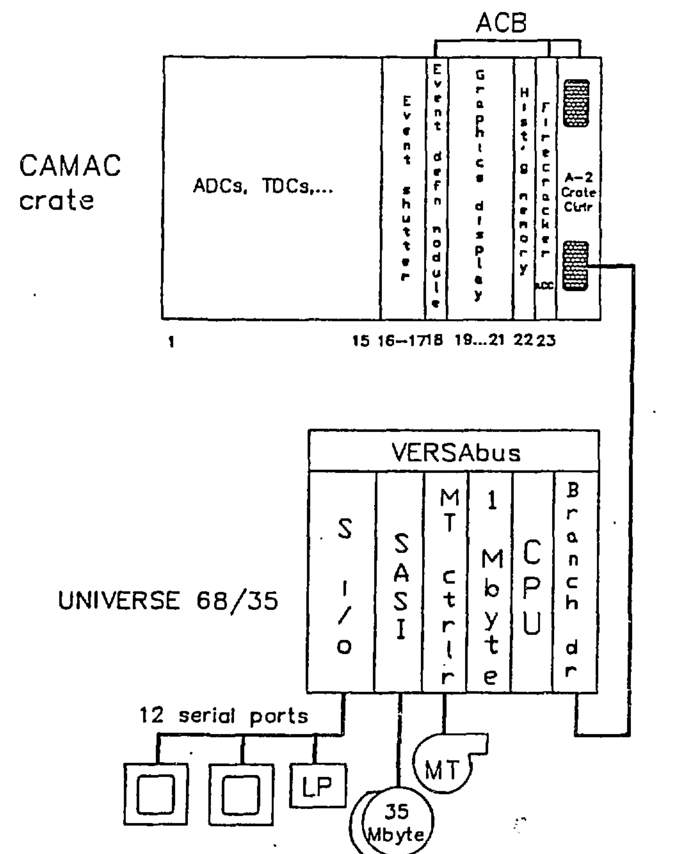

Fig. 1. The LEGS data acquisition hardware.

The Universe 68/35

The Universe 68/35, manufactured by Charles River Data Systems, Concord, MA, is a modestly-priced time-sharing computer running a UNIX-like operating system. It uses two 68000 microprocessors based on a VERSAbus backplane, allowing for 24 bit addresses and 32 bit data transfers. Wait states are minimized by a 4 Kbyte cache, and serial I/O is handled by the second 68000, resulting in a highly optimized system. The system described here is equipped with 1 Mbyte of memory, 12 serial ports, and a 35 Mbyte fixed disk as well as a 1.2 Mbyte floppy disk. This system contains no floating point hardware. Compilers for C (the best supported language on this system) and Fortran 77 were purchased.

The Universe purchased from Charles River was supplemented by a magnetic tape subsystem consisting of a HalVersa-Ciprico Tapemaster tape channel and a TDX 1600 bpi, 75 ips tape transport.

*This research was supported by the U. S. Department of Energy, Division of Basic Energy Sciences under Contract No. DE-AC02-76CH00016.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

CAMAC Interface

Interface to CAMAC consists of a VERSAbus branch driver constructed at BNL. Its design is derived from a VME version [3] originating at Fermilab, due to M. Shea and A. Jones. The branch driver is memory-mapped; an entire CAMAC branch occupies 256 Kbyte of the 16 Mbytes available in the UNIVERSE. Each CAMAC CNAF occupies 4 bytes (24 bits of data and a status byte which includes X- and Q-responses and Branch Demand). This branch driver is a minimum implementation in the sense that it does not provide for an interrupt to the Universe when a Branch Demand is asserted. It will be seen below, however, that this feature is not necessary in the system described here.

The Auxiliary Crate Controller

The front end of the system is a single crate managed by an auxiliary crate controller, the Model 2160 "Firecracker" manufactured by Creative Electronic Systems of Geneva, Switzerland. This controller is based on the Texas Instruments 99105, a 16 bit microprocessor. The 99105 has a unique architecture in which the usual registers reside in memory. Consequently, a context switch does not require registers to be pushed onto a stack; the result is an extremely fast interrupt response (2 μsec). Times representative of other instructions in its comprehensive instruction set are memory-to-memory move (0.8 μsec), 16 x 16 bit multiply (4 μsec), 32 x 16 bit divide (5 μsec). It has 16 vectored interrupts and 16 software vectored traps. This chip is restricted to 16 bit addressing, making it undesirable as a general-purpose computer; it is, however, an extremely versatile controller.

In the CES implementation of the Firecracker, CAMAC functions are memory-mapped into the upper half of the 99105's 64 Kbyte address space. In this scheme, data movements to and from CAMAC modules are rapid and straightforward, allowing all of the addressing modes of the 99105 to be used in accessing CAMAC. A typical CAMAC read would be implemented as

```
MOV @NAF,*R1+ .
```

CAMAC accesses are performed in less than 2 μsec. Missing Q- or X-responses can cause an interrupt, obviating the need to check for a Q-response on every CAMAC instruction.

The remaining 32 Kbyte of the address space is configured either as static RAM or as a RAM/EPROM mixture, allowing for a resident debugging monitor.

The Firecracker is also equipped with an RS-232 serial port, as well as a programmable timer.

Histogramming Memory

The 32 Kbyte of RAM in the Firecracker would allow a maximum of 16 K channels (16 bits/channel) of histograms. Not only is this limit uncomfortably small, but 16 bits/channel is ill-suited to many nuclear physics requirements (e.g., singles spectra). For these reasons, a histogramming memory (Creative Electronic Systems Model 2161) was included in the CAMAC crate. It contains 64K channels (24 bits/channel) which may be incremented in a single CAMAC cycle. It can be configured so that an overflow in any channel asserts the LAM. It is capable of running in several other modes (e.g., directly interfaced to an ADC or in list mode) which are not relevant to this application.

Graphics Display

A graphics display which is capable of Tektronix 4010 emulation with resolution of 1024 X 768 was desirable for this system. The Transiac Model 4024 was chosen because it is directly accessible from the CAMAC dataway, yielding an effective input rate of >50Kbaud. It is also capable of generating a hardware screen dump to either of two supported printers.

Event Shutter

The event shutter is a BNL-designed CAMAC implementation of the "computer busy" latch which is necessary for almost every experiment. It has 8 inputs, six of which are "slow" and the remaining two are "fast". When the latch is in its reset state, all inputs appear transparently on the corresponding output. After an input has disappeared, the latch is set, and all inputs are blocked until the latch is reset via the CAMAC dataway F(2). The fast inputs are ORed; the quiescent state of the OR output blocks further fast inputs. The slow inputs are treated somewhat differently: All eight inputs (fast and slow) are ORed, and the OR output is stretched up to 0.5 μsec. The quiescent state of this stretched OR is used to close (set) the shutter.

The shutter thus provides for ADC gates (slow inputs) which may be required to have some time slewing, as well as for bit registers (fast inputs) where a sloppy time window may cause misinterpreted events.

The shutter can be opened and closed using the dataway Inhibit in addition to its normal operation.

Finally, the F(2) command returns the value of a 1 MHz counter which is activated on the shutter closing and stopped on the receipt of F(2), providing a convenient method for monitoring the dead time for each event.

Event Definition Module

The event definition module (EDM) was designed to relieve the Firecracker of the necessity to wait for all devices associated with a given event trigger to complete conversion. An event trigger is often associated with a number of devices which varies from event to event, and conversion time can be variable (Wilkinson ADCs). Both of these circumstances can be wasteful of the Firecracker's computing capability.

The EDM contains a 24 bit register which defines the addresses of the devices participating in the event. It contains an internal timer, front panel adjustable from 20-200 μsec, which starts when either:

1) A front panel NIM input is detected, or
2) Any of the participating devices asserts its LAM.

The EDM considers an event to be terminated and raises its own LAM when either:

1) The timer expires, or
2) All of the participating devices have asserted their LAMs.

An F(2) command received by the EDM returns the 24 bit pattern of LAMs asserted, so that the Firecracker can determine, without polling, the devices to be read.

Software

The Firecracker software is a self-contained package written in assembly language using a macro assembler (purchased from Texas Instruments) which resides on a VAX. It consists of a main program which loops testing flags which may have been set by, for example, the programmable timer or the keyboard interrupt service routine. An appropriate subroutine, e.g., display update or command interpreter is then called. All interrupt service routines communicate with the main program via flags.

A variety of common functions is provided by the command interpreter, including changing display parameters, zeroing selected histograms, entering dot-plot mode, starting and stopping collection, requesting a screen dump, requesting a histogram be recorded on magnetic tape, requesting a histogram be printed. All requests which require resources not present in the CAMAC crate (magnetic tape, disk, printer) are passed to the Universe via a Branch Demand and a request type number. These requests are handled by a program resident in the Universe which polls the Branch Demand at 1 second intervals. This response time is adequate for the kinds of service being requested.

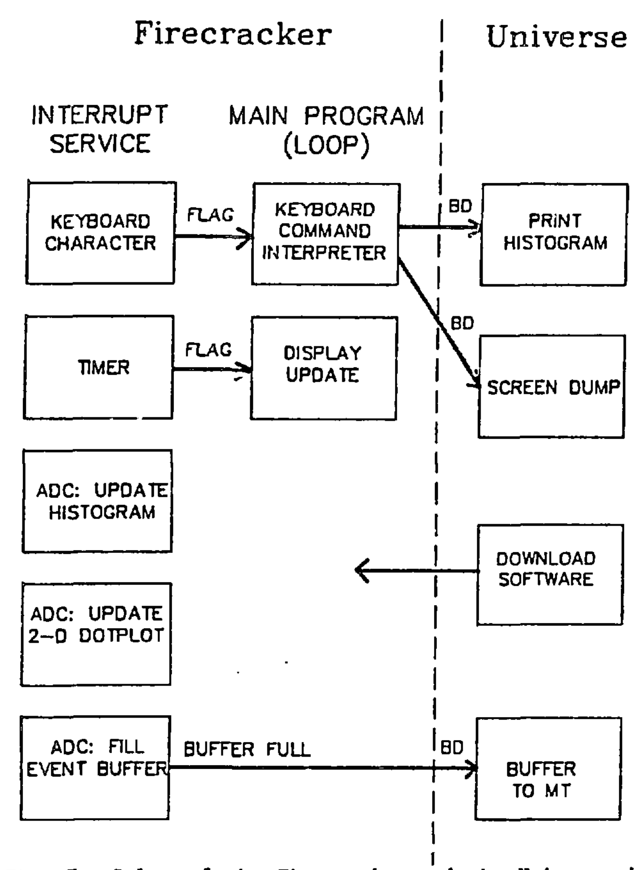

Fig. 2. Roles of the Firecracker and the Universe in the data acquisition software package.

Each experiment requires only that an interrupt service routine be written. At the present time, these subroutines are written in assembly language. However, the difficulty of writing such routines is minimized by the macro assembler, which allows devices to be defined using meaningful names (for example DEFDEV ADC1,811,19 associates the label ADC1 with a device type 811 found at address 19), and which defines CAMAC commands for all devices using terms like RDCLR for F(2). Thus assembly instructions such as TSTLAM ADC1 have meanings which are transparent.

Summary and Present Status

The loose coupling of a fast, general-purpose auxiliary crate controller which manages all real-time functions in the data acquisition process to a modern, time-sharing computer provides many advantages. The user enjoys the comfortable interface provided by a UNIX-like environment, including off-line data analysis and program development concurrent with data acquisition. The slow response times of time sharing systems (typically 700 μsec) becomes irrelevant in this system.

Future plans include the implementation of a cross-assembler for the 99105 resident on the Universe. This cross-assembler is presently about 60 per cent complete. In addition, a higher-level data acquisition language similar to EVAL is anticipated. This language would generate the required interrupt service routines specific to each experiment without explicit use of assembly language.

Acknowledgements

I would like to acknowledge the generosity of M. Shea of Fermilab in sharing his branch driver design with us. It is also a pleasure to acknowledge the expert assistance of A. Kuczewski who constructed and debugged the branch driver, the event shutter, and the event definition module.

References

[1] UNIX is a trademark of American Telephone and Telegraph.

[2] VAX is a trademark of Digital Equipment Corporation.

[3] M. Shea and A. Jones, Fermilab, unpublished.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.