Fermi National Accelerator Laboratory

CAMAC Driver Support for Windows NT® and Linux®

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Abstract

CAMAC is a Modular Instrumentation and Digital Interface System defined as a standardized instrumentation system for Computer Automated Measurement and Control. CAMAC hardware and software has been defined by the NIM Committee (National Instrumentation Methods Committee) of the U.S Department of Energy and the ESONE Committee (European Standards on Nuclear Electronics Committee) of European Laboratories. Fermi National Accelerator Laboratory[1] has for many years produced software packages that follow the ANSI/IEEE standard 758-1979 for a variety of computers, CAMAC controller interfaces, and operating systems. In order to enable the re-use of existing hardware and software, Fermilab now supports standard routine libraries and drivers for Windows NT 4.0 and the Linux operating systems for the Jorway 411S SCSI Bus CAMAC Driver[1] and the Jorway73A SCSI Bus CAMAC Crate Controller. A number of test stands and small experiments both on-site and off-site are using this software for their CAMAC data acquisition needs.

I. INTRODUCTION

The term "standard routines" has been used to describe a standardized software interface for CAMAC readout and control under a variety of operating systems. In 1982, Fermilab released a package of FORTRAN and MACRO callable subroutines[2] that met the specifications of the U.S. NIM and ESONE Committees[3]. These subroutines supported the Jorway 411 and the Jorway BD011 PDP-11[4] branch driver, a predecessor of the Jorway 411, under the RT-11 operating system. Later, the term "IEEE standard CAMAC routines" was used to describe a library of subroutines that met the software specifications of ANSI/IEEE standard 758-1979[5][6]. Fermilab supported standard routines for the Jorway Q-Bus model 411 introduced in 1983 under VMS. In 1994, the Jorway Corporation offered a SCSI bus conversion kit for the Q-Bus model 411, which when converted was given the model name Jorway 411S SCSI Bus CAMAC Driver. In the same year Fermilab ported the standard routines to IRIX for the Jorway 411S, and continues support today under IRIX 6.5[7]. In 1994, the standard routines were also adapted for the Jorway Model 73A SCSI Bus Crate Controller introduced in 1991. Support for the Jorway Model 73A continues in parallel with the Model 411S with separate software products[8].

As the popularity of IBM compatible PCs grew for use in desk top computing and experiment test stands, Fermilab looked for ways to leverage this inexpensive computing power. In 1996, Fermilab combined standard routine support for both the Jorway 411S and the Jorway 73A with one software package under Windows NT 4.0 and in 1997, offered combined support under Linux. Both packages are in use at Fermilab as well as other laboratories, universities, and private industry.

II. SOFTWARE FEATURES

All of the currently supported standard routine packages have an identical application program interface so that CAMAC programs may be ported between the different operating systems with only library re-linking required. The Jorway 411S supports both Serial and Parallel CAMAC controllers, and the same software can be used with either crate controller with the exception of minor differences in initialization calls. The standard routine libraries for Windows NT and Linux are supplied for CAMAC programs written in C and Fortran, however, the driver contained in the Windows NT package has also been used with LabVIEW and Visual Basic.

Both the Windows NT and Linux packages offer *multi-user* support, while the Linux package additionally contains *multi-branch* support. *Multi-user* support means that the libraries support *n* different processes on the same PC reading and writing different CAMAC modules through the same SCSI host adapter and the same CAMAC controller. Under Linux the *multi-user* feature creates significant semaphore overhead so the libraries may optionally be built without the semaphore functions to get maximum performance from a single process. The *multi-branch* support under Linux means that any combination of Jorway 411S or Jorway 73A controllers can be installed on a PC's host adapter SCSI bus. The limitations to this feature are that only one SCSI bus is currently supported, and only seven SCSI devices can use the SCSI bus (one slot is taken by the PC SCSI bus host adapter card). The Jorway 411S expands on this capability as each can have 2 CAMAC branches, 1 branch with 62 Serial crates, and 1 branch with 7 Parallel crates.

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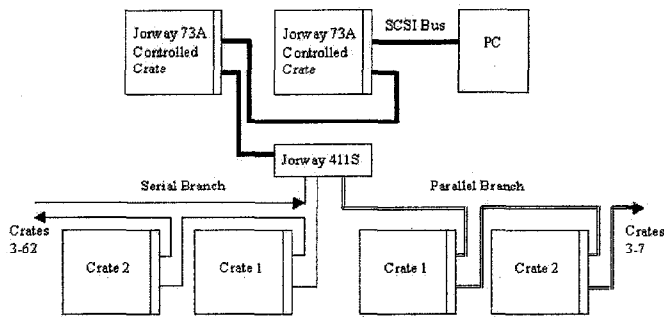
Figure 1: Multi-Branch configuration

A. Windows NT package

The main components of the Windows NT package are the IEEE CAMAC standard routine library and the kernel mode driver. The driver was developed using the Microsoft Windows NT Version 4.0 Device Driver Kit and the Microsoft Win32 Software Development Kit. The driver is primarily responsible for creating a device. In the Win32 environment, user processes cannot access drivers directly, so an intermediate software layer interacts with the driver on behalf of the standard routines using DeviceIoControl (ioctl like) calls. A small subset of the functionality needed to support the standard routines is contained within the driver in the form of custom I/O control codes. The remainder is handled with Microsoft provided SCSI_PASS_THROUGH and SCSI_PASS_THROUGH_DIRECT I/O control codes. Non-data operations use the SCSI_PASS_THROUGH control code, and data (read/write) operations use the SCSI_PASS_THROUGH_DIRECT control code. Data operations do not use the Microsoft WriteFile or ReadFile functions because of the difficulty involved in passing the information necessary to create the SCSI control block to the driver without copying user buffers. The library of standard routines is a collection of subroutines that uses the intermediate software layer described above.

B. Linux package

The main components of the Linux package are the IEEE CAMAC standard routine library and a user level interface between the standard routine library and the Linux generic SCSI driver. Generic SCSI driver commands are processed by the low level driver specific to the PC SCSI host adapter card. As with the Window NT package, the Linux standard routine library is a collection of subroutines that uses the user level interface. The Linux package was developed with Slackware 2.0.29, and has recently been tested with RedHat 2.0.35.

III. TIMINGS

Timing tests were done to characterize several combinations of readout word size, CAMAC controller type, and operating system. The following tables represent performance for large block transfers. We found that data rates could be described by a set up time and a rate in kilobytes per second. The setup time for Windows NT was 0.8 milliseconds, and for Linux was 0.2 milliseconds. The setup times were found to be independent of other variables, and are a reasonable estimate of single word transfer times. The test

system was a 100Mhz Pentium PC with an Adaptec[9] AHA-2940 SCSI host adapter card.

In the Jorway 411S timings below, the Jorway 71B was used as the Parallel crate controller, and the Kinetic Systems[10] K3952 was used as the Serial crate controller. The Jorway 73A acts as a crate controller, so while no controller type is indicated, it acts similarly to a parallel crate controller.

Table 1
Windows NT timings with Jorway 411S

Crate Controller	16 bit (kbyte/s)	24 bit (kbyte/s)
Type A-2 (Parallel)	952	1,364
Type L-2 (Serial)	370	545

Table 2
Linux timings with Jorway 411S

Crate Controller	16 bit (kbyte/s)	24 bit (kbyte/s)
Type A-2 (Parallel)	773	1,289
Type L-2 (Serial)	330	635

Table 3
Linux timings with Jorway 73A

16 bit (kbyte/s)	24 bit (kbyte/s)
1,558	1,538

II. USERS

While CAMAC systems have been in use for over 20 years at the High Energy Physics experiments at Fermilab, most new users are applying PC controlled CAMAC systems to test stands and small experiments. The following examples are typical of these new systems.

- Members of the CDF (Collider Detector at Fermilab) experiment are using a Windows NT-CAMAC system for monitoring and controlling a high voltage system.

- D0 (The D0 Experiment at Fermilab) has setup two Linux-CAMAC systems to test and characterize new detector components.

- Southern University is setting up a Linux-CAMAC data acquisition system as a permanent test stand for testing detector components for future particle and nuclear experiments and for training students.

V. FUTURE PLANS

A limitation in both the Windows NT and Linux packages is that there is no way for CAMAC LAM (Look at Me) signals to interrupt host processors, so systems using LAMs to trigger readout must poll LAM generating modules. For the Jorway controllers to initiate an interrupt, the PC SCSI host adapter card must relinquish the role of SCSI initiator and become a SCSI target. At present, none of the SCSI host adapter cards found to work with the Jorway 411S and Jorway 73A support SCSI target mode. We will continue to evaluate new SCSI host adapter cards to find ones that have target capability so that we can investigate supporting LAM interrupts in software.

Preliminary information on Windows 2000 indicates that there are new requirements imposed on kernel mode drivers. We anticipate porting the Windows NT package to Windows 2000 when the driver development tools become available.

VI. OTHER OPTIONS

Readers may be interested in similar software for other CAMAC controllers such as the Hytec VSD2992[11] VME-Serial CAMAC driver[12] and the CES CES8210[13] VME-Parallel CAMAC driver[14]. A RPC(Remote Procedure Call)-CAMAC wrapper is available for both of these controllers[15].

There is commercial software available for the Jorway 73A controller as well as others from the SPARROW Corporation[16] with their Kmax products, and from National Instruments[17] with their LabVIEW product.

VII. SUMMARY

Although CAMAC has been replaced by newer, faster systems in many experiment systems, it continues to find applications because of several important features[18].

- CAMAC is an international standard and has been a stable system for many years.

- It is modular so that a control, monitor, or data acquisition system can assembled in discrete units that are easily understood and maintained.

- CAMAC is computer independent so advances in computer technology have not made CAMAC I/O capability obsolete.

- And finally, CAMAC modules are familiar to a generation of experimenters and are often available from experiment equipment pools.

Test stands and small experiments have found that PC based systems are a good fit within economic and performance constraints. Supporting the Jorway 411S and Jorway 73A CAMAC controllers under Windows NT and Linux has enabled re-use of both stable data acquisition software and hardware.

The software described here and further documentation are available from the URL:

http://www.fnal.gov/fermitools/abstracts/camac/abstract.html

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