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Access to CAMAC from VxWorks and UNIX in DART

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Abstract

As part of the DART Project [1] we have developed a package of software for CAMAC access from UNIX and VxWorks [2] platforms, with support for several hardware interfaces. We report on developments for the CES CBD8210 [3] VME to parallel CAMAC, the Hytec VSD2992 [4] VME to serial CAMAC and Jorway 411S [5] SCSI to parallel and serial CAMAC branch drivers, and give a summary of the timings obtained.

I. Introduction

All High Energy Physics experiments at Fermilab include CAMAC modules which need to be read out for each triggered event. There is also a need to access CAMAC modules for control and monitoring of the experiment. Traditionally these experiments have accessed CAMAC from VaxStation 3200s using the QBUS-Jorway branch highway driver, which can control both a parallel and serial CAMAC branch [6], or have used the Fermilab CAMAC Smart Crate Controller [7] which access a single CAMAC crate using an embedded 68000 processor.

With the migration to the use of embedded processors in VME and workstations running the UNIX operating system we have developed support for CAMAC interfaces in these new environments. Because of the existing infrastructure of CAMAC already in place at experiments we have concentrated our efforts on the support of Branch Highway Controllers rather than single Crate Controllers of which there are a variety from which to choose.

II. Hardware Supported

Several of the smaller fixed target experiments collect and log their data in a single processor board on VME (using Motorola MVME167s). For these applications the CES CBD8210 is used to control a parallel CAMAC branch highway, and the Hytec VSD2992 is used to control a serial branch highway.

Many experiments perform the central data acquisition run control from Silicon Graphics computers, from where they need to have direct access to CAMAC for managing triggers. Other workstations are used for downloading calibration constants and monitoring the detectors. For these applications we support the Hytec VSD2992 and CES CBD8210 directly plugged into the VME backplane of a Silicon Graphics Challenge L, Crimson or 4D/35 computer. We have also evaluated and developed support for the Jorway 411 SCSI interface - a single board upgrade to the QBUS Jorway 411 already in widespread use at Fermilab. For all these interfaces, access from other workstations is supported via Ethernet and the use of Remote Procedure Calls to the processor which directly controls the CAMAC interface (see Fig. 1).

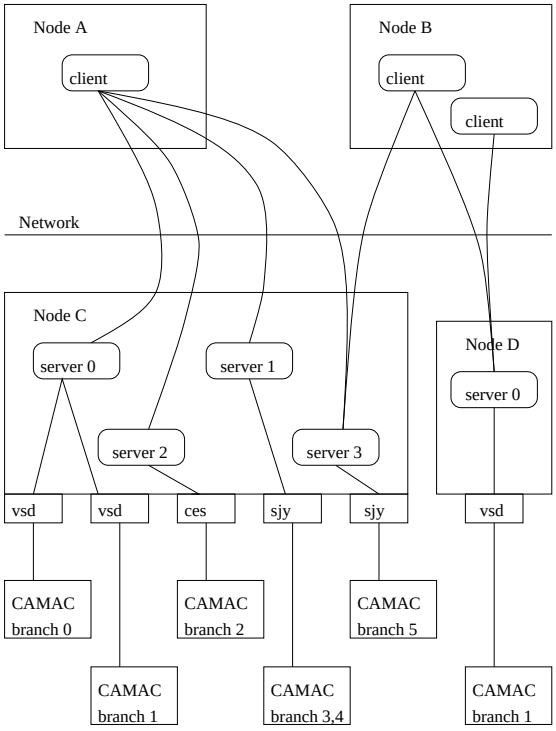

Figure 1: Multi-user and multi-branch support in rcam.

We are maintaining our support for the Smart Crate Controller with downloading from UNIX - although at the present time the cross assembly for the embedded code is

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still only available on VMS [8]. The Smart Crate Controller provides a fast read out of CAMAC via a list processor controlled by a Motorola 68000 processor. The SCC can read CAMAC data at 1 microsecond (600 nanoseconds in "fast-mode"), and writes at 2 microseconds per word. Data can be sent to the on board RS485 port. We measured a trigger latency of 7 microseconds.

III. Software Packages Developed

For each of the CES CBD8210, Hytec VSD2992 and Jorway 411S we have developed the following software support:

1. Implementation of the "IEEE ANSI standard 758-1979 for CAMAC subroutines" [9] for each of the three modules [10–12]. These are written in C and provide C and Fortran calling interfaces for application progams. These implementations have provided experiments with an easy migration path for existing code which used the IEEE routines but other CAMAC drivers.

2. An RPC interface to allow access to the CAMAC interface from remote computers over Ethernet [13]. This allows a workstation access to one or more of the supported CAMAC interfaces attached to remote computers.

3. A Tcl [14] interface to the IEEE routines, which can be used to control either of the three branch drivers or the RPC interface [15].

The software for the CES and Hytec branch drivers runs on Motorola MVME167 or MVME162 embedded processor boards running the VxWorks real time operating system [16]. The VME-CAMAC drivers map the VME registers of the interface into memory and have fast (a few microsecond) CAMAC transfer time.

The IRIX software for the CES and Hytec drivers also maps the VME registers of the interface directly into memory and has a similarly fast CAMAC access and transfer time.

Neither the CBD8210 nor VSD2992 support true DMAs (such as Q-scan), however the VSD2992 does have a fast repeat mode. The IEEE routines use this mode for the VSD2992, but the CBD8210 block transfer routines are repeated single word transfers.

In support of the Jorway 411S we have written a kernel level SCSI driver for the SGI/IRIX operating system. The SCSI transfer overhead is of order 1 millisecond, and CAMAC data throughput is around 500 kilobytes/second.

All the software developed supports access to multiple CAMAC branches. It also supports multi-user access to the CAMAC where a single CAMAC interface is shared by multiple users.

The RPC software consists of two parts: 1, a server, which runs on the host CPU, which has access to the CAMAC branch driver, and 2,a client library, which contains the IEEE ANSI CAMAC routine calls. A client can access multiple servers through the use of routines added to the package. Each server can control one or more interfaces of the same type. A routine interface is provided to allow the client to specify the node name and program number of the RPC server.

The Tcl interface provided allows the use of the IEEE CAMAC calls from a Tcl shell, for testing or for lower data rate applications. It parallels the traditional CDL languages popular with experimenters.

The software uses the DART murmur error message system for reporting errors [17]. However, it can be used independently of murmur when required.

IV. Timings

Timing tests have been done with many combinations of the software - but not all. We present here a representative sample of the timings obtained for single word CAMAC transfers (Program Data Transfers or PDTs) and for CAMAC DMAs - where multiple words are read from CAMAC through a single command to the interface. These timings are measured in application programs performing a tight loop of 1000 operations and represent the overall time per operation in usecs or throughput of the system in kilobytes/sec. More timings are presented elsewhere [10–13,15].

Table 1: Timings for CES8210 from 33MHz MVME167.

	read (μsec)	*write (μsec)*
16bit PDT	2.24	2.24
24bit PDT	3.04	4.84

Table 2: Timings for VSD2992 from 33MHz MVME167.

	read (μsec)	*write (μsec)*
16bit PDT	14.11	14.25
16bit "DMA"	7.06	9.77
24bit PDT	15.78	15.75
24bit "DMA"	8.78	11.25

Table 3: Timings for Jorway 411S from 100MHz Crimson.

	16bit (kb/sec)	*24bit (kb/sec)*
Parallel CAMAC	530	398
Serial CAMAC	369	398

Table 4: DMA setup times for Jorway 411S.

	setup time (μsec)
Crimson	2.0
Indy	0.8

Table 5: Timings for rcam. Server on a 100MHz Crimson controlling a VSD2992, client on a 33MHz MVME167.

	setup time (ms)	*data rate (kb/sec)*
16bit PDT	2.5	0.8
24bit PDT	2.5	1.2
16bit DMA	2.8	3.8
24bit DMA	2.8	5.6

Table 6: Timings for tcam. A VSD2992 on a 100MHz Crimson.

	data rate (kb/sec)
16bit PDT	3.8
24bit PDT	5.6
16bit DMA	4.8
24bit DMA	7.5

V. Future Plans

At present there is no general support for LAMs to interrupt host processors. In collaboration with Jorway, we plan further development of the SCSI Jorway driver to support the use of LAM interrupts on the Silicon Graphics and processing of lists of CAMAC commands within the Jorway interface itself.

Within the next year we anticipate several test beam and small experiments - with trigger rates around 100-300 Hz and data rates less than 1 Mbyte/sec - will be approved for support by DART. The CAMAC software will need to be integrated into the data acquisition system to provide for their needs. If required, we will also port the existing software to other platforms.

VI. Summary

We have summarized the current status of the DART CAMAC project, and presented some of the timings we have measured. Several experiments and groups at FNAL are currently using all the software developed and reported here. Further documentation for this software is available from the URL:

http://www-dart.fnal.gov:8000/hardware/camac.html.

VII. References

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[2] UNIX is registered trademark of UNIX System Laboratories.
VxWorks is a registered trademark of Wind River Systems.
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SGI, IRIX, Challenge L, Indy, Crimson and 4D/35 are registered trademarks of Silicon Graphics, Inc..

[3] Creative Electronics Systems, 70 Route du Pont-Butin, P.O.Box 107, CH-1213 Petit-Lancy 1, Geneva, Switzerland.

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