Silicon Detector Test Setup in Elementary Particle Physics with Mac OS X

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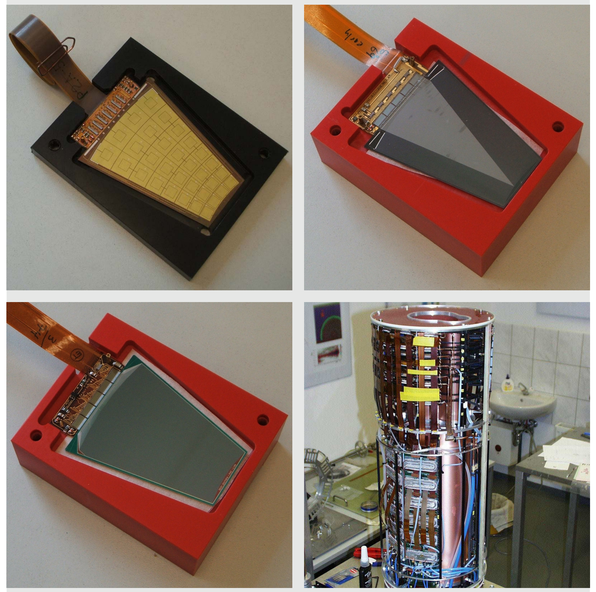
Introduction

Application area

In particle physics, silicon detectors are used to track and measure elementary particles produced in particle accelerator experiments. Electrons are smashed into protons to gain insightful views at the smallest distances (10^{-17}m), into the very inner structure of matter. Before assembly these detectors need to be thoroughly tested and verified as there is no possibility to replace defective parts after installation in the experiment.



Picture 1 to 3 are showing different detector modules mounted in a protection case. Picture 4 shows the upper part of the final assembled detector setup which is installed in the experiment.

Objective

For the last few years the H1 group at Deutsches Elektronen Synchrotron (DESY) have used a Macintosh Quadra 840 system with a Nubus extension card providing a VME interface (MacVEE). A piece of custom VME hardware (OnSiRoC) was used to control and test drive the detector modules. The operating system was Mac OS 8. The OnSiRoC was controlled by LabView[1] programs and the test results were also reported back to LabView. To manage and investigate VME configurations (e.g. available memory, memory properties) a classic Mac OS application called Zaradann[2] was used.
Aiming for more complex tests, the existing workflow should be switched to a Mac OS X based system using the SIS1100 PCI-to-VME interface of the German Struck GmbH.

1 National Instruments Corp
2 developed at the Murrough Landon Physics Department Queen Mary & Westfield College

Methods

Hardware

The SIS1100 PCI-to-VME card is plugged into the computer. It communicates over fiber optics with the SIS3100 VME sequencer. A 16 Byte wide protocol is used to transfer 4 Bytes of data. This has implications for the drivers performance especially when transferring small amounts of data often.
A PowerMac G4/400 was chosen as the new computer system because it

- is faster than the Macintosh Quadra 840,
- has PCI slots
- and is capable of running Mac OS X.

On the VME side nothing needed to be modified as the SIS3100 acted as a VME bus master.

Picture 1 and 2 show the Macintosh Quadra 840 connected with a VME crate. Note the massive wire for data and addresses. Picture 3 shows the SIS1100 PCI and the SIS3100 VME card connected with fiber. Picture 4 shows the PCI card built into a PowerMac G4.

Software

The actual work had to be done on the software side. Because the Struck GmbH only provided Windows and Linux drivers for their cards, a Mac OS X driver for the SIS1100 had to be developed.
To test and improve the new driver a basic version of Zaradann was ported to Mac OS X.
To completely switch the test workflow the existing LabView programs needed to be adapted. This was done as the last step after the driver and the new Zaradann had proven their reliability.

SIS1100 Mac OS X Driver

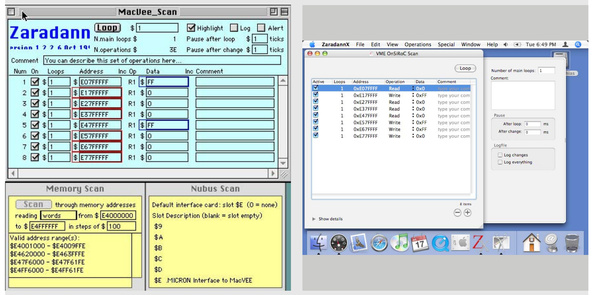
The driver for the PCI-to-VME interface card was developed using Mac OS Xs I/O Kit. By providing a lot of convenient functions it really helped to speed up the development of the driver. The process of driver development was divided into three parts:

- understanding how the SIS1100 hardware works and basic communication with the card (switch LEDs)
- implementing the SIS1100/SIS3100 transfer protocol and a driver interface accessible to user-land applications
- testing and performance optimization

The driver is compatible with Mac OS X version 10.3.9 or higher.

Zaradann

Zaradann is an application which was developed to investigate and manage VME configurations. It is used to determine memory space properties (read-only, read/write, write-only) and to retrieve the amount of available memory of VME modules. It was written for the classic Mac OS and thus required a port to Mac OS X.
The Cocoa framework of Mac OS X made this task pretty straight forward as ZaradannX was completely rewritten from scratch. The philosophy of Cocoa of making simple tasks simple and difficult things possible helped to keep the focus on the “business logic”.



Picture 1 is a screenshot of the classic Zaradann. In comparison you can see the Mac OS X rewrite in picture 2. Picture 3 shows part of the running ‘OnSiRoC Expert’ in LabView.

LabView

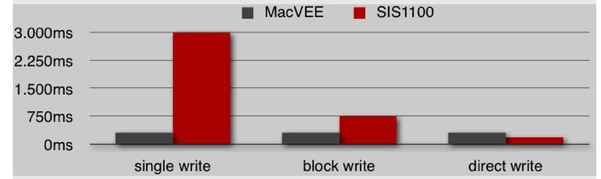
In the year 2005 National Instruments Corp. released version 7 of its powerful graphic programming tool. The existing LabView programs needed to be adapted to the new version as well as to the new driver interface.
For that purpose a library was developed which is called from a small piece of LabView C-code. The driver interface is wrapped by the library, which also provides a lot of convenient functions to work with VME hardware.

Results

The old MacVEE/Macintosh Quadra 840 based detector test setup was replaced with a PowerMac G4 and a SIS1100 PCI-to-VME interface card.
A Mac OS X driver for Strucks VME hardware was developed which allows using one of the following VME transfer modes:

- single read/write (32bit, 16bit and 8bit data),
- block read/write (32bit, 16bit and 8bit data) and
- direct VME bus access (32bit, 16bit and 8bit data).

The driver was developed with the help of Mac OS Xs I/O Kit making the development process straight forward.
The application Zaradann was completely rewritten to take full advantage of Mac OS X Cocoa technology. It allows peeking and poking of VME memory space.
To provide a common interface to VME a library was written which wraps the driver interface and offers a lot of convenient functions to work with VME.



Performance comparison of various VME access methods with the old system (PowerMac G4/400, Mac OS X 10.3.9, 128KB data)

Conclusion

Maccent Software Development has helped the H1 group to switch their test workflow to a system based on a PowerMac G4 and Mac OS X. The powerful and rich frameworks (I/O Kit, Cocoa) of Mac OS X eased the task of development and made a quick transition possible. The new system is more powerful and allows the H1 group to run more complex tests on their detectors thus improving their work.

References

Maccent Software Development
http://www.maccent-software.de

Deutsches Elektronen Synchrotron
http://www.desy.de

Struck Innovative Systeme GmbH
http://www.struck.de