THE CANADIAN LIGHT SOURCE CONTROL SYSTEM – A CASE STUDY IN THE USE OF SINGLE BOARD COMPUTERS AND INDUSTRIAL PC EQUIPMENT FOR SYNCROTRON CONTROL*

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Abstract

Since 2000 the Canadian Light Source (CLS) control system architecture has been based on to the use of small single board computers for equipment control running the RTEMS operating system. CLS has started to migrate to a new off-the-shelf single board computer platform (based on the Moxa embedded computer platform. In 2001 CLS also adopted the use of fibre optic bridges and industrial PC equipment in place of VME slot zero controllers. Today this continues to be the basis of our higher performance data acquisition and control applications. This paper outlines the lessons learned from nearly eight years of operational use of the this technology.

INTRODUCTION

The Saskatchewan Accelerator Laboratory (SAL) was established in 1964 and operated until the late 1990s. In 1999 the pulse stretcher ring was decommissioned and the accelerator was refurbished to become part of the injection system for the new Canadian Light Source (CLS) facility [1].

The CLS facility consists of a linear accelerator, which operates between 200 and 250 MeV, Booster Ring 1 (BR1) - a 2.9 GeV electron synchrotron, Storage Ring 1 (SR1) - a high-current 2.9 GeV electron storage ring, two diagnostic beamlines and seven synchrotron radiation beamlines used for experiments. The phase II expansion is now underway adding an addition seven beamlines while the phase III expansion is in the proposal stages.

The scope of the CLS control system covers the accelerator, storage ring, building mechanical and beamline control functions and consists of over 50 000 data points.

EMBEDDED REAL-TIME OUTPUT CONTROLLERS

Single board computers (SBC's) based on the Motorola 68360 (originally developed for use at SAL) were chosen for the original CLS build project in 2000 [2]. Used extensively for control of RS-232 based devices, the EROC has four RS-232 lines. The RTEMS operating system is exclusively used on this hardware.

RTEMS support existed early for these Input/Output Controllers (IOC), and is now used for IOC applications running on these SBCs. The earliest RTEMS based IOC was installed in 2000. Today there are in excess of 150 IOCs within the facility based on RTEMS. RTEMS has proven to be a very stable and mature platform. A version of RTEMS was selected for the Motorola 68360 based IOCs in 2000. However, the latest upgrades to EPICS (3.14 alpha1 to 3.14 beta1, and 3.14.7 is anticipated in the near future) have necessitated an upgrade to a newer version RTEMS.

PC104

CLS evaluated the use of PC104 and even deployed two IOCs based on PC104 cards. Given the form factor it either used more space than necessary for a rack-mount installation or relied on the boards being placed in stack and placed into a PC104 tube container making it difficult to assemble, trouble shoot and maintain.

In the end CLS chose to look at alternatives. CosyLab MicroIOC was selected for applicableness requiring GPIB support, while the Moxa was selected for serial applications.

MOXA SINGLE BOARD COMPUTERS

Due to difficulty in obtaining component it became clear that the EROC hardware could no longer be effectively supported. At that point CLS chose to adopt an off-the-shelf single board computer for many of the serial interface applications. The MOXA UC-7408 was selected to fill this void.

VME SINGE-BOARD

Connection to VME hardware at the CLS is not accomplished with a CPU board located inside each crate, rather a pair of fiber optic transceivers (1 PCI and 1 VME) [3] are used to connect a single PC computer to 1 or more VME crates. The fiber optic link is achieved by using a pair of cards SIS3100(VME) and SIS1100(PCI) installed into their respective back planes and connected with a fiber optic cable. Once connected, a Linux application is able to map the memory locations of any VME board installed in the VME crate into the application memory space of the Linux application. This allows the Linux application to access the registers or FIFO's of a particular board installed in a VME crate

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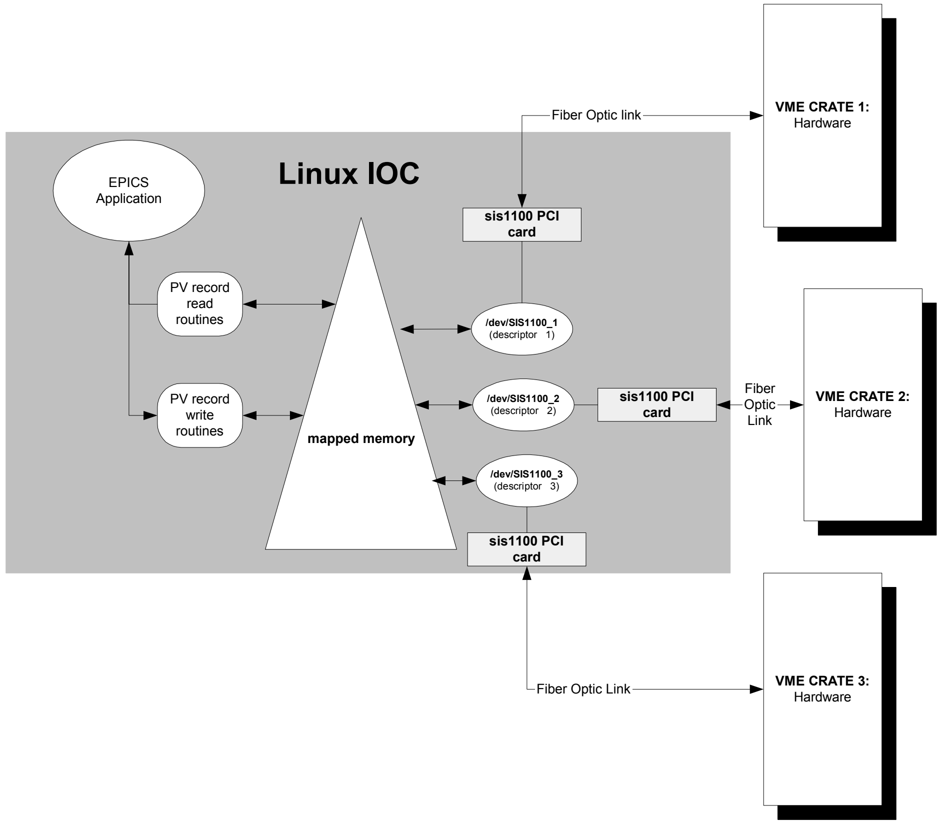

Figure 1: Overview of the VME interface using the SIS 1100 link.

simply by reading a pointer to a memory location. The actual transmission and reception of data across the fiber optic link is transparently taken care of by the SIS1100 PCI driver. Figure 1 shows how a single EPICS application running on a Linux IOC is able to read and write data to 3 different boards located in 3 different VME crates.

Industrial PC Hardware

PC hardware from major desktop computer vendors pose special problems in the design of a control system. These products typically are only on the market for a few months before being replaced by a new model. Given the tight coupling of the device drivers commonly used in control systems with the underlying hardware commodity hardware is not a reasonable option.

We have chosen to either assembly our industrial PC hardware in house or contract a local firm to do this for us. Since the motherboard (with onboard video and network interface) is the critical component in the system from a software driver perspective we have chose to use what are called "configuration controlled motherboards". These are available from some motherboard manufactures where the manufacture guarantees availability of identical form-fit-function replacements for several years.

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