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CONTROL SYSTEM EVOLUTION ON THE ISIS SPALLATION NEUTRON SOURCE

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Abstract

The ISIS spallation neutron source has been a production facility for over 30 years, with a second target station commissioned in 2008. Over that time, the control system has had to incorporate several generations of computer and embedded systems, and interface with an increasingly diverse range of equipment. We discuss some of the challenges involved in maintaining and developing such a long lifetime facility.

ORIGINAL DESIGN

The original control system for ISIS was based on GEC 4000 series minicomputers. Hardware interfacing was via CAMAC controller, branching out to a General Purpose MPX system (as used on the CERN SPS). Software was developed using a high level assembly language called BABBAGE as a systems language, and an interpreted language called GRACES for user programs. As at CERN, touch screen displays were used to provide menu driven systems.

TRANSITION TO VSYSTEM

By the early 1990's, it became clear that the existing control system had to be replaced. Vista Control Systems product Vsystem[1], which grew out of work at Los Alamos National Laboratory, was chosen as the replacement system. By that time, ISIS was well established as a production neutron facility, which severely restricted the downtime available to progress the migration. A new system would thus have to run in parallel for some time.

The ability of CAMAC to support multiple controllers was extremely useful in that it provided a means for Vsystem to have direct access to all the existing MPX hardware. Hytec ECC 1365 controllers were installed to allow Vsystem to access the CAMAC over the growing Ethernet network.

C was used as a low level language, replacing BABBAGE. BASIC was chosen as a simple language to port user's GRACES programs to. A simple menu toolkit was developed to map the old touchscreen interface, and also a graphics toolkit emulating the limited graphics previously available.

The two systems ran in parallel for several years, as the functions of the original GEC software were gradually migrated to Vsystem. The original touch screen based design still influences the navigation of the control screens, and the operation of some of the utilities.

FRONT END SYSTEMS – STEBUS

As the number of systems monitored increased, it became necessary to offload the interface work to more intelligent I/O processors. Initially these were based on the STEbus standard[2]. These included an Intel 80188 processor, an Ethernet card, and one or more I/O cards. The latter are a mix of commercial off-the-shelf cards (e.g. for GPIB and RS422 interfaces) and ISIS designed ones (e.g. timing and function generators).

The software on these systems is stored on an EPROM: device handlers for various hardware devices are built into the image. This allows them to encode and decode read/write operations as (for example) query strings to send over local bus connections such as RS422 or GPIB. A simple polling loop regularly reads and caches equipment values, and listens for read/write requests from the network.

An important feature of the design is that the software configuration is downloaded over the Ethernet at boot time. This means that the hardware is interchangeable: so, despite the local intelligence, any faulty component can be readily replaced.

FRONT END SYSTEMS - COMPACTPCI

STEbus systems proved to be a dependable workhorse throughout the 1990's, supplementing, and in some cases replacing, existing MPX equipment. After some investigation of alternatives, the decision was made to base the next generation front end system on CompactPCI hardware. Windows XP Embedded was used as the operating system.

Like the STEbus systems, their configuration is downloaded at boot time to keep the hardware as interchangeable as possible. The main boot image is also loaded over the network, which makes it easier to manage updates centrally.

Much of the design of the STEbus systems carried over to the CompactPCI systems, although there were some subtleties in the implementation of exactly what happened at initialization that were missed and had to be added later. The original STEbus design was also single threaded, with mainly synchronous I/O. With the speed of the newer hardware, it became clear that this design was a serious bottleneck when addressing multiple slow devices, and read parallelization had to be retrofitted onto the code.

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TARGET STATION 2

One of the largest changes to the control system on ISIS was the design and commissioning of a second (10 Hz) target station optimized for cold neutrons. In normal operation, one in five pulses is diverted to the second target but the rates to the individual targets can be varied independently for machine setup and beam physics.

These changes to the timing system required a complete redesign of the Central Timing Distributor, using the CompactPCI system as a base. It also had to incorporate interfaces to the new IEC 61508 functional safety system[3].

INTELLIGENT, NETWORKED PERIPHERALS

One of the ongoing trends in the last few years has been the growth of local intelligence, and in particular direct network connections. Much of the routine development of the control system has been based around incorporating new PLC systems, rather than taking digital inputs directly into a front end system. Direct network connectivity of e.g. magnet power supplies is likely to increase.

CONCLUSIONS

Our experience running a control system on a production neutron and muon source over many years has taught us a number of lessons: firstly, it's very hard to replace a working production system. The GEC systems lived on well past a reasonable end of life; although these have now been removed, there is still a substantial installed base of the original MPX equipment. The removal of obsolescent equipment needs to be properly prioritised against ongoing development work.

Secondly, a long lifetime facility will likely see a lot of systems reimplemented using newer technology. One of the problems we have found with the control system is that often the design rationale for older systems is missing or non-existent (the documentation explains 'how' but not 'why'). This risks either failing to provide all the functionality of the earlier system through misunderstanding, or rigidly duplicating an earlier design that is no longer appropriate.

Finally, a long lifetime facility will inevitably be used in ways that the original designers had not foreseen. Having a design that has the flexibility to accommodate this, whilst retaining a reasonable level of standardization, is an ongoing challenge.

REFERENCES

[1] Vista Control Systems, Inc. http://www.vista-control.com

[2] 1000-1987 - IEEE Standard for an 8-Bit Backplane Interface: STEbus.

[3] Functional Safety and IEC 61508, http://www.iec.ch/functionalsafety/.