CONTROLS EVOLUTION ON ISIS, AN ACCELERATOR BASED NEUTRON PRODUCTION FACILITY

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Abstract

The ISIS [1] spallation neutron source has been a production facility since 1984 with the original, single, target station. ISIS is now starting the second phase of its life with two target stations and the possibility of further upgrades. The author has worked in the ISIS controls group since before first neutrons and leads the group into this new phase. The difficulties and solutions surrounding legacy systems in such an environment (where a facility lifetime may approach 50 years) are presented.

HISTORY

In the late 1970's, work started on a new accelerator-based Spallation neutron source (then called the SNS) at the Rutherford Appleton laboratory, housed where a previous 8Mev Proton synchrotron, NIMROD, had been for many years. Having had experience of the very earliest interpreter based control systems (FOCAL on PDP-4/8) on NIMROD, it was decided to base the SNS control system on GEC 4000 series minicomputers, using CAMAC and a copy of the CERN SPS General Purpose Multiplex system for equipment interfacing and a copy of the SPS "data module" concept with a higher, interpreter based software system ("GRACES") for program development and operation. This was a very successful, well-liked system.

Figure 1: 1982 - the author runs his first control program using GRACES.

Figure 2: 1985 - the author demonstrates the finished control system to a VIP (and "SNS" becomes "ISIS").

In the 1990's, after being renamed ISIS [1], work started on upgrading the mature (and working) control system onto new platforms and using commercial software, Vsystem from Vista Controls [2]. The control system is medium sized, with about 15,000 channels.

PROBLEMS

ISIS is a production neutron facility. All priority is given to delivering pre-booked beam time and minimizing off periods. During the off periods, the control system is still required, so we were faced with the problem of upgrading a system that could not be shut down. This inevitably meant that old and new control systems had to share access to the hardware and run in parallel for some considerable time. There were: a lot of vested interests; legacy software; an established culture. Progress was very slow as the facility already operated, giving little incentive for change.

Figure 3: 2007 - a controls group member, unborn when it started operation, turns off the last original, running, supported GEC 4000 series computer in the world!

SOLUTIONS – REPLACEMENT

The original touch screen menus were recreated on the new displays. GRACES programs were converted, where necessary, into BASIC as BASIC was an easy move for those used to GRACES, a BASIC-like language. The original programmable knobs were replaced with networked equivalents from Hytec Electronics [3].

To enable concurrent access of the CAMAC/MPX based systems, CAMAC crates were fitted with two controllers, an A2 Parallel controller for the old system and the ECC-1365 Ethernet Camac Crate controller from Hytec Electronics, operating in Auxiliary Controller Bus mode.

Space on the control desk was severely stretched until the removal of the old system began and the dual access to the CAMAC/MPX system was slow – this was the only way migration could be achieved.

Figure 4: 2008 – First neutrons on Target Station 2. Head of Diagnostics section, Tony Kershaw, watches at new version of control desk.

SOLUTIONS – REPLACEMENT

Clearly, while efforts were underway to replace what already existed, developments and enhancements were also required, sometimes representing changes in control system philosophy.

A huge increase in the requirement to interface intelligent external systems changed the dynamic of the control system. The use of a general purpose network such as Ethernet, while bringing many advantages, implies that response times are no longer deterministic and access is slower. This required more intelligence in the front end i/o controllers provided by the controls group and the incorporation of commercial systems.

The first generation of ISIS Controls front-end i/o processors was based on the STEbus standard and we have now moved to CompactPCI systems running XP (see T Gray oral paper at this conference, THA003). Commercial PLC systems and intelligent equipment have changed the controls paradigm significantly.

Users decided that the programmable knob units were unnecessary (having demanded them).

CONCLUSIONS

The replacement or upgrading of control systems on an experimental machine (such as a particle physics accelerator) can be programmed in with other developments quite easily. For production machines such as ISIS, there is an expectation that control systems are always available. Concurrent operation of new and old control systems is inevitable and must be planned.

There will be no acceptance of upgrades without the flexibility to accede to customer demands. With a new facility, the staff has no prior experience and take what they get. With control system evolution, elements of the first control system will always be found in subsequent versions

Although control systems evolve, their changing nature does not always bring about the expected changes. From an operator button press to something happening on the equipment has always taken about 3.5ms on ISIS, no matter where one is in the evolutionary process!

The various configurations of the ISIS Controls system throughout its lifetime are summarized in Tables 5-8.

Table 5: ISIS Controls – Period 1

Evolutionary period	**Pre-network (NIMROD)**
Computer system	PDP8
Network	None
Operating system	RTI-75 (FOCAL) interpreter
User language	RTI-75 (FOCAL) interpreter
Control object data	Data table
Control object method	Fixed library call (assembler)
Hardware I/O	“STAR” or “CAMAC”
MMI	Teletype, “NIXIE” lights

Table 6: ISIS Controls – Period 2

Evolutionary period	**Proto-network (SNS/ISIS)**
Computer system	GEC 4000 series
Network	CAMAC based star network (internal only)
Operating system	GEC DOS 2.6 (modified)
User language	GRACES semi-compiled interpreter
Control object data	Data table
Control object method	Fixed Data Module (High level assembly language, BABBAGE)
Hardware I/O	CAMAC plus General Purpose Multiplex system (As CERN SPS)
MMI	CAMAC: Colour TV display controllers, touch screens, programmable knobs

Table 7: ISIS Controls – Period 3

Evolutionary period	**Metamorphosis (single target ISIS from 1985)**	
Computer system	GEC4000 series	DEC Workstations
Network	CAMAC based star network	Thick-wire Ethernet
Operating system	GEC DOS 2.6 (modified)	OpenVMS
User language	GRACES semi-compiled interpreter	BASIC, FORTRAN, C
Control object data	Data table	Run time database
Control object method	Fixed Data Module (BABBAGE)	Parameterized handler (C)
Hardware I/O	CAMAC/ MPX	CAMAC/ MPX/STEbus/ PLC
MMI	CAMAC Display/touch/ knobs	X-windows, Programmed knobs

Table 8: ISIS Controls – Period 4

Evolutionary period	**Maturity (Two target ISIS)**
Computer system	HP Itanium / Intel
Network	UTP flood-wired Ethernet sharing site network infrastructure >100MB/s
Operating system	OpenVMS / XP
User language	BASIC, FORTRAN, C, C++
Control object data	Run time databases (~15000 channels)
Control object method	Parameterized handler (C)
Hardware I/O systems	CAMAC/MPX/STEbus/CompactPCI/PLC/LabView (See T Gray paper on XP embedded CompactPCI systems)
MMI	X-windows/Exceed

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REFERENCES

[1] http://www.isis.stfc.ac.uk
[2] hrrp://www.vista-controls.com
[3] hrrp://www.hytec-electronics.co.uk