EVOLUTION OF CONTROL SYSTEM STANDARDS ON THE DIAMOND SYNCHROTRON LIGHT SOURCE

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DIAMOND LIGHT SOURCE

- Diamond Light Source is a third generation 3GeV synchrotron light source based on a 24-cell double bend achromatic lattice of 561m circumference. The photon output is optimised for high brightness from undulators and high flux from multi-pole wigglers.
  - Accelerators and the first seven photon beamline were constructed between 2002 to 2007.
  - Second phase of fifteen photon beamlines from 2006 to 2012.
  - Third phase of ten photon beamlines were approved in 2011 to 2017.

ORIGINAL CONTROL SYSTEM

- Uses the EPICS toolkit and provides a high degree of integration.
- Most equipment is interfaced through a range of generic VME IO based on VME IP carriers, IP modules.
- Motion control, initially used OMS VME58 for straightforward applications on the accelerators; whereas for the photon beamlines for synchronous control, the Delta Tau PMAC controller is largely used.
- Programmable Logic Controllers (PLCs) from Omron are used for interlocking and from Siemens for process control.
- Client side tool use the standard EPICS tools for display panels (EDM), archiving (Channel Archiver), alarm management (ALH) and restoring system state (BURT and Save\Restore).
- Diamond has standardized on a combination of EPICS and GDA for the control of photon beamlines, experimental stations and detectors.

EVOLUTION OF CORE SOFTWARE COMPONENTS

- Policy is to try and keep all systems on a common version of EPICS base, core components and modules.
  - Initial machine control system EPICS 3.13.9 with 3.14 for the Libera BPMs and soft IOCs.
  - Beamline control systems which started in development in 2005 adopted EPICS version 3.14.8.2.
  - During 2008 to 2011, the machine control system was upgraded to 3.14.8.2.
  - As of 2013 majority of control systems are now at EPICS version 3.14.11 with an upgrade underway to 3.14.12.2.
- All applications are built on a build-and-deployment-server, thereby ensuring consistency of the tool chain for the build of all operational systems

EVOLUTION OF OPERATING SYSTEM

- Standardized on Linux for development.
  - 2003 Red Hat version 9, for development.
  - 2004 Red Hat Enterprise Linux 3 development and initial operations.
  - 2005 Red Hat Enterprise Linux 4 development and operations.
  - 2008 Red Hat Enterprise Linux 5 development and operations.
  - 2011 Red Hat Enterprise Linux 6 at 64 bit for development and operations.
- Coincident with operating system uplift a new version of EPICS Base, Extensions and external modules are taken; along with other dependent software components.
- IOCs predominantly run under Linux or VxWorks, there are inevitably a few Windows systems, where only Windows drivers are available for a given piece of hardware.

EVOLUTION OF HARDWARE

- The new control systems standard is based on running EPICS IOCs on 1U x86 PCs running Linux with real-time extensions.
- IOCs are located within equipment they control as so are not regarded as a “soft IOCs”.
- All instrumentation is then connected to the IOC by local network connections.

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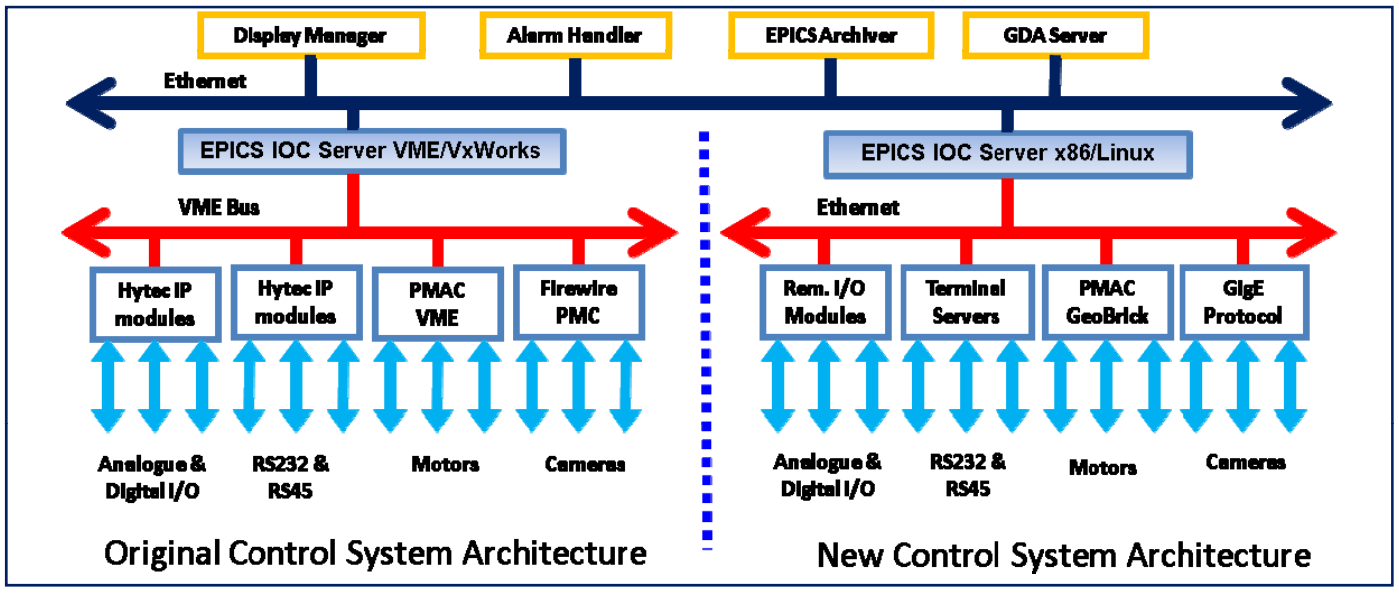
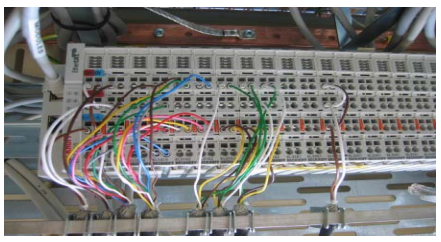


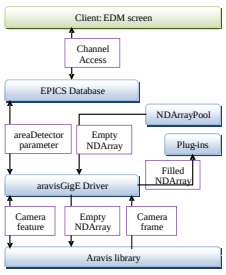
ADCs DACs and DIO

- ADCs, DACs and digital I/O connect directly to the IOC using, a range of Ethercat I/O modules from Beckhoff Automation.
- Use EtherCAT, an industrial Ethernet-based fieldbus system.
- This I/O will be used for all non-interlocking type applications, and provides lower latency from the plant to the IOC.



Video Cameras

- Use GigE cameras from AVT (formerly Prosilica).
- Use areaDetector to control, process and store images.
- AreaDetector is a modular system of EPICS drivers and plug-ins that can be "rewired" at run time, allowing a flexible image processing chain to be set up.
- Plug-ins for controlling the camera, providing statistics on the images that are produced, filtering them and writing them to disk.
- FfmpegServer is a plug-in that compresses a stream of images to mjpg and serves them over http.



Motion Control

- Motion control, uses a standard solution based on the Delta Tau Geobrick LV Ethernet-based motor.
- Provides 8 axes of motion control and comes complete with amplifiers in a 4U rack-mount box. .

Programmable Logic Controllers

- Interlocking and protection of equipment is realised in Omron CJ1 PLCs.
- PLCs are interfaced to the IOC using Ethernet and the FINS protocol.
- PLCs optionally use remote I/O modules called SmartSlice which will be located in the beamline optics and experiment hutches.

Serial Devices

- Vacuum instrumentation (Gauges and Pump Controllers) and other serial devices are interfaced through RS232, RS422 or RS485 serial connections to Moxa terminal Server.
- Terminal server connect via Ethernet to the IOC

BEYOND THE STANDARD SOLUTION

- Some functionality for example Scalers and Time Frame generator are still only available as a VME solution.
- For some commercial detectors for examples the PCO Edge camera, for which there are only Windows drivers; then the IOC for control is realised on Windows.
- Where the acquisition rate or latency requirements exceed what is realisable with the standard solution and in particular what is possible in software, then a solution has been realised in a FPGA. These have use a various Xilinx parts with a UDP stack implement in VHDL to communicate with a soft IOC.
- Xilinx Zynq system-on-chip is such that it is now practical that Linux and EPICS can run directly on the FPGA.

CONCLUSIONS

- VME was an excellent basis for the Diamond control system
  - Longevity of product and standard.
  - Open standard with multi-vendor support.
  - Good hardware interoperability.
- Key aspect to building a distributed control system and subsequently maintaining it.
- Control systems interface requirements have largely moved on with increased availability of “intelligent instruments” with communication based interfaces.
- Performance (response time and resolution) of PLCs has also evolved considerable in the past decade and costs have fallen.
- Commercial hardware and more mainstream operating systems provides great with benefits in functionality and cost.
  - Loss of physical interoperability.
  - Loss of cross vendors operability in the case of PLC solution.
  - Reduced life expectancy of hardware.
  - Loss of mechanical standards.
  - Loss of the inability to accurately timestamp an acquisition or transition of a signal.

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