Single Board Computers and Industrial PC Hardware at the CLS

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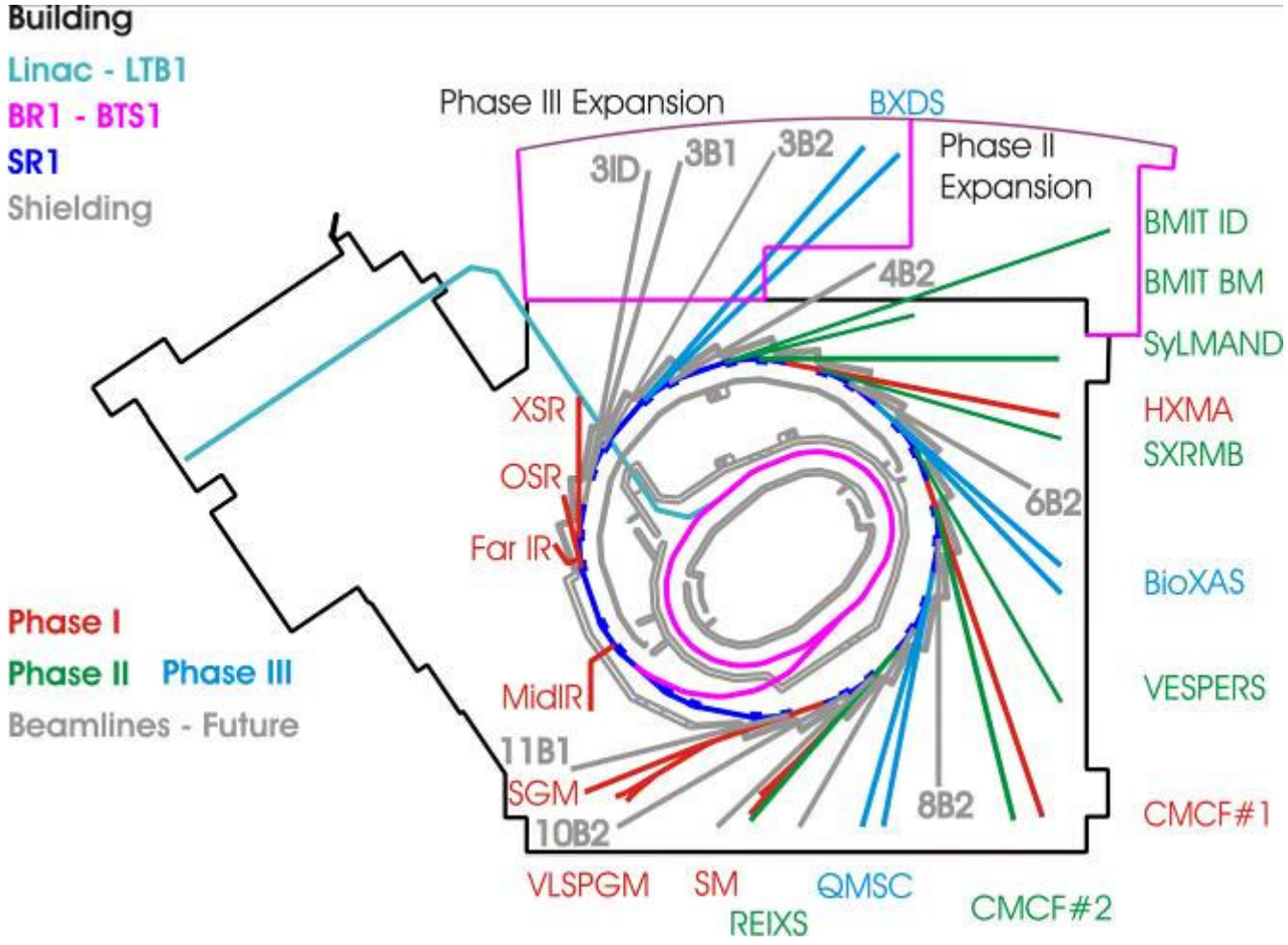
Canadian Light Source

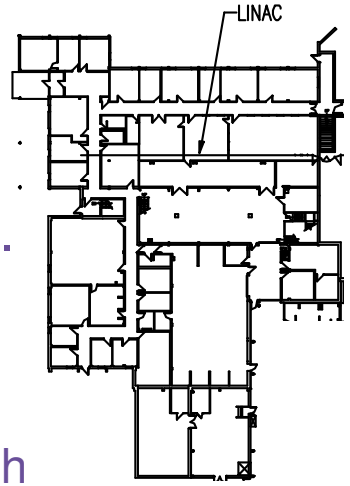
Layout



170.88 m circumference 2.9 GeV ~ 200-300 mA
DBA lattice with 12-fold period

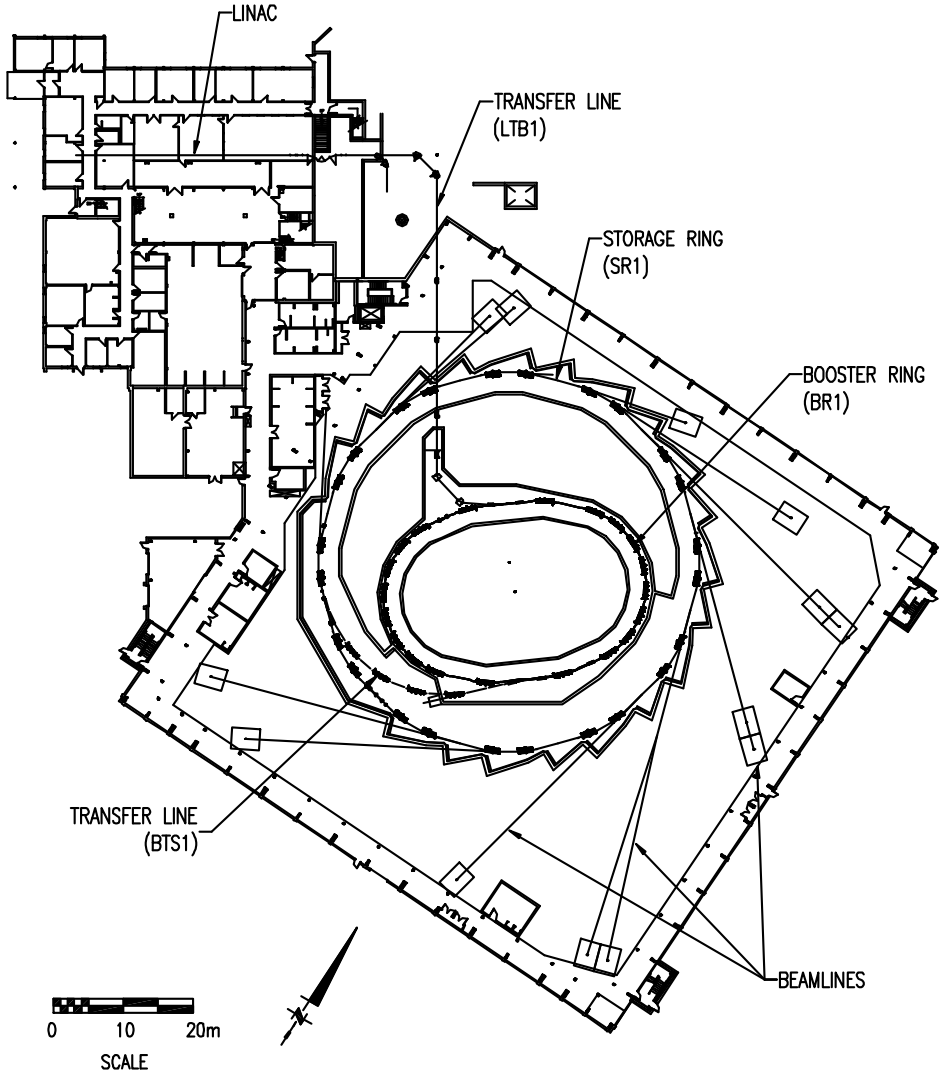
CLS Control System History

- Saskatchewan Accelerator Laboratory (SAL) operated from the late 1960s until 1999.
  - Control system evolved from PDP-8 -> PDP-11 -> VAX -> NeXT and Sun workstations.
  - IO was based on CAMAC with two CAMAC data highways.
  - Some Micro84 PLCs.
- Control System was locally developed running on BSD UNIX.



CLS Control System History

- 1999 March 31 funding for CLS was approved. Nuclear physics program was discontinued.
- The existing Linac would need to be reconfigured and refurbished.
- Linac Controls:
  - CAMAC hardware would need to be replaced.
  - Power supplies would need to be upgraded.
  - RF control would need to be redesigned.
  - The old computer hardware would need to be replaced.
- *We need to make some design choices....*

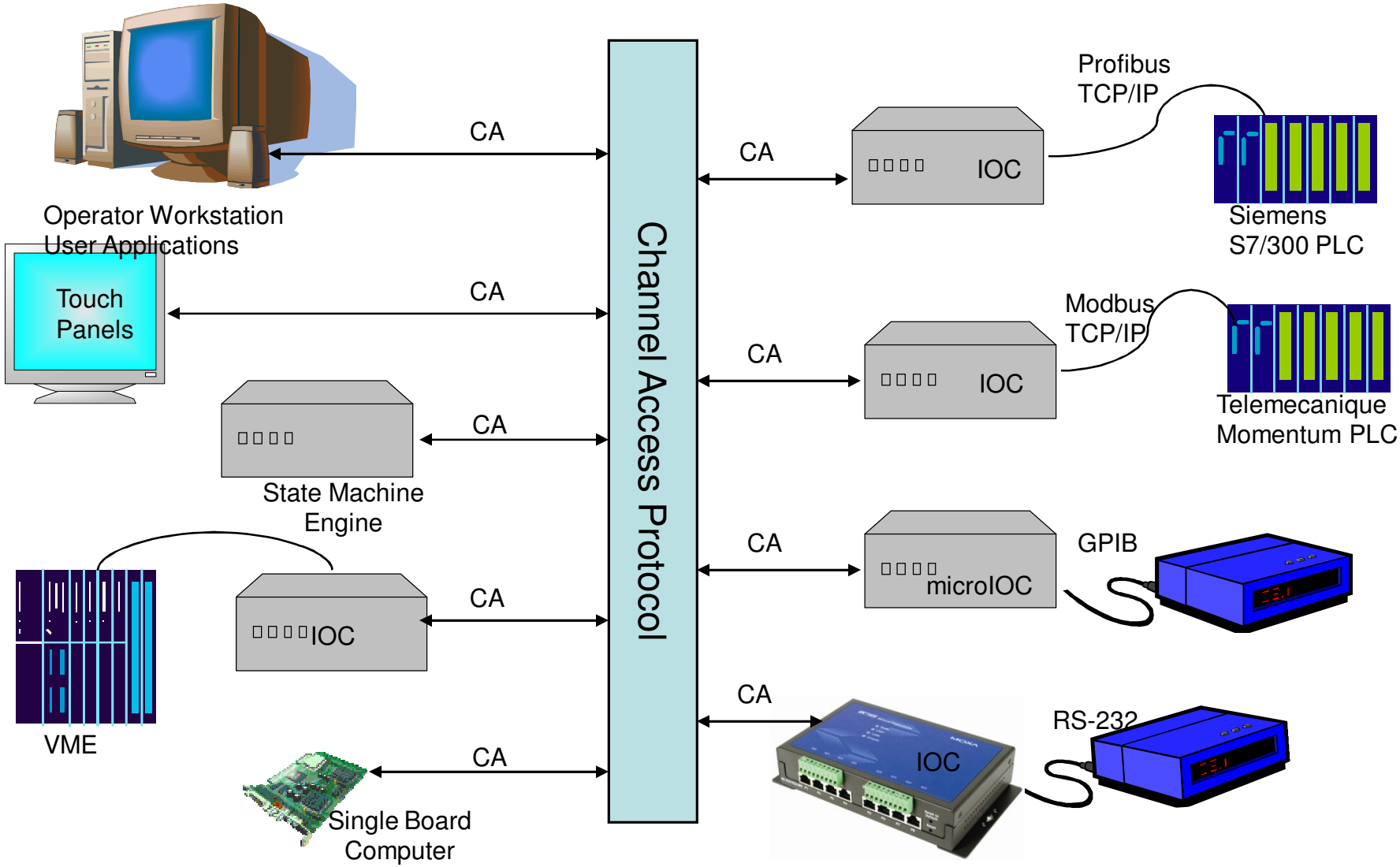


CLS Control System Principles

- System design based on highly distributed control.
- Extensive use of single board computers (originally used in SAL).
- Target lifetime of 15+ years.
- Data communication over Ethernet when possible.
- System must be user-friendly.
- The accelerator and beamline systems must be maintainable by a small team.
- Reliability and availability of beam are critical to the success of the facility.
- Building an open source control system was not the initial goal, it was the outcome.

- Accelerator complex must be complete by Dec. 2003 and the first phase of beamlines by Dec. 2004. The project must come in on budget.

EPICS at the CLS



EPICS Hardware

- Common environment across the accelerator and beamlines

- IOC Hardware
  - Motorola 68360 Single board computers *(approximately 150)*
  - Moxa IOCs *(approximately 50)*
  - VME 64x with SIS Optical Links *(approximately 25-30)*
  - Micro-IOC (*approximately 5)*

- PLC
  - Modicon Momentum *(approximately 45)*
  - Siemens S7/300, S7/400, S7 F

- Servers
  - Dell Power Edge

- Network
  - Dual Redundant Optical Backbone
  - Cisco Switches using VLANs
  - Common network

Traditional EPICS Installation

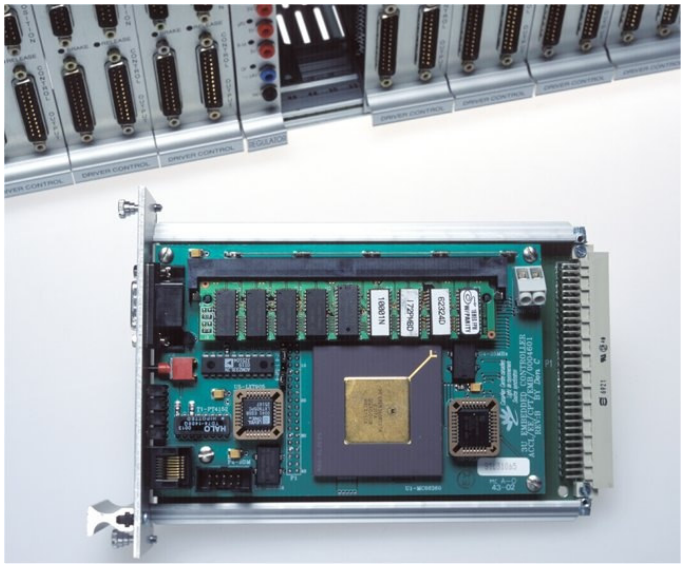
- Few IOCs
- Generally all (most) based on VxWorks
- Less dependence on PLC equipment
- Where PLCs are used they are connected to the VME crate using a fieldbus

CLS Approach

- Partition IOCs based on functional breakdown
- Embedding the concepts of:
  - Module (IOC) Cohesion
  - Low inter-module (IOC) Coupling

EROCS

- Motorola 68360
  - Deployed 1999-2003
  - Locally Developed
  - RTEMS with EPICS
  - Diskless bootp based
  - Linux cross complier
  - Remote debugging
  - Approximately 150 still in use



(www.sil.sk.ca/micro)

How are they used?

- Embedded in power supplies
- Embedded in stepper motor controllers
- RS-232 Device interface
- General purpose “small” computer that can be deeply embedded into system

EROCs

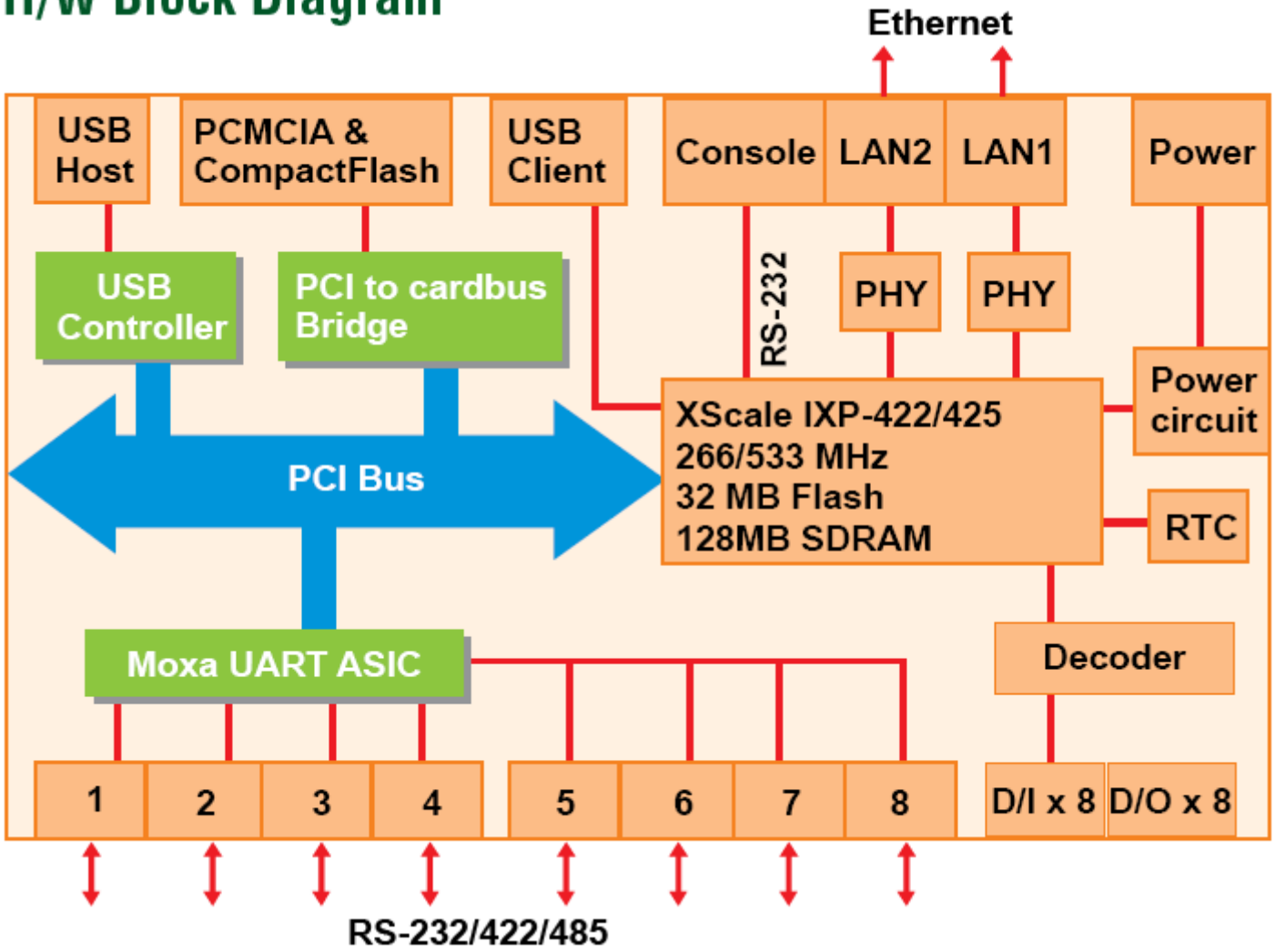
- Pros:
  - Simple design, deployment was based on logical systematic partitioning
  - High level of reliability
- Cons:
  - The more equipment the more potential points of failure
  - Local hardware design, CLS is in the science business not the computer business
  - Out of production

Moxa UC-7408

- We needed a replacement for the EROCs….
- We found one, the Moxa UC-7408
  - 8 serial lines
  - Linux based running EPICS
  - Cross compiler platform
  - EPICS is NFS mounted from a server
  - Low maintenance (no fans, hard-drives)

MOXA UC-7408

H/W Block Diagram



Source: Moxa Data Sheet

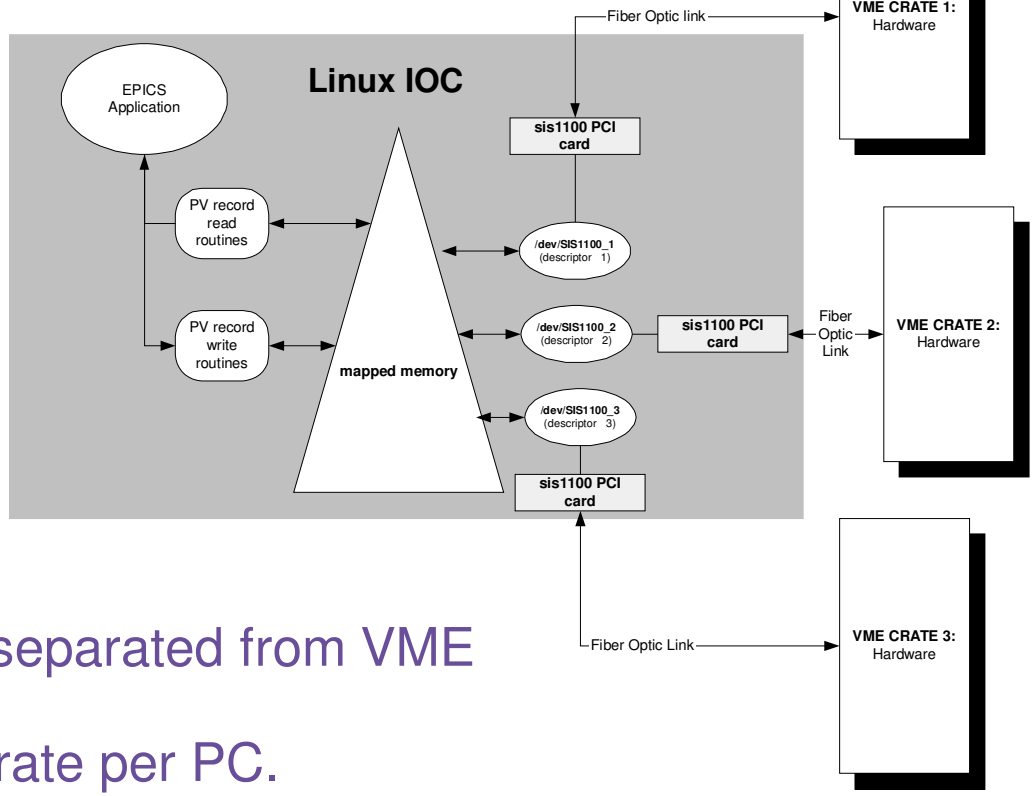
VME

- We chose not to use slot 0 controllers
- We are using the SIS optical link

- Industrial Intel PC
  - Standardized PC configuration
  - Configuration controlled motherboards
  - Linux or RTEMS based software
  - Provides option to integrate PCI, MXI devices

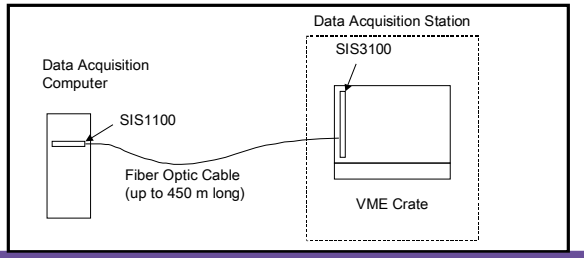
VME

- Using VME hardware connected to a Linux PC.
- SIS1100 PCI card <-> fiber optic link <-> SIS3100 VME module
- Maps VME backplane to IOC memory.

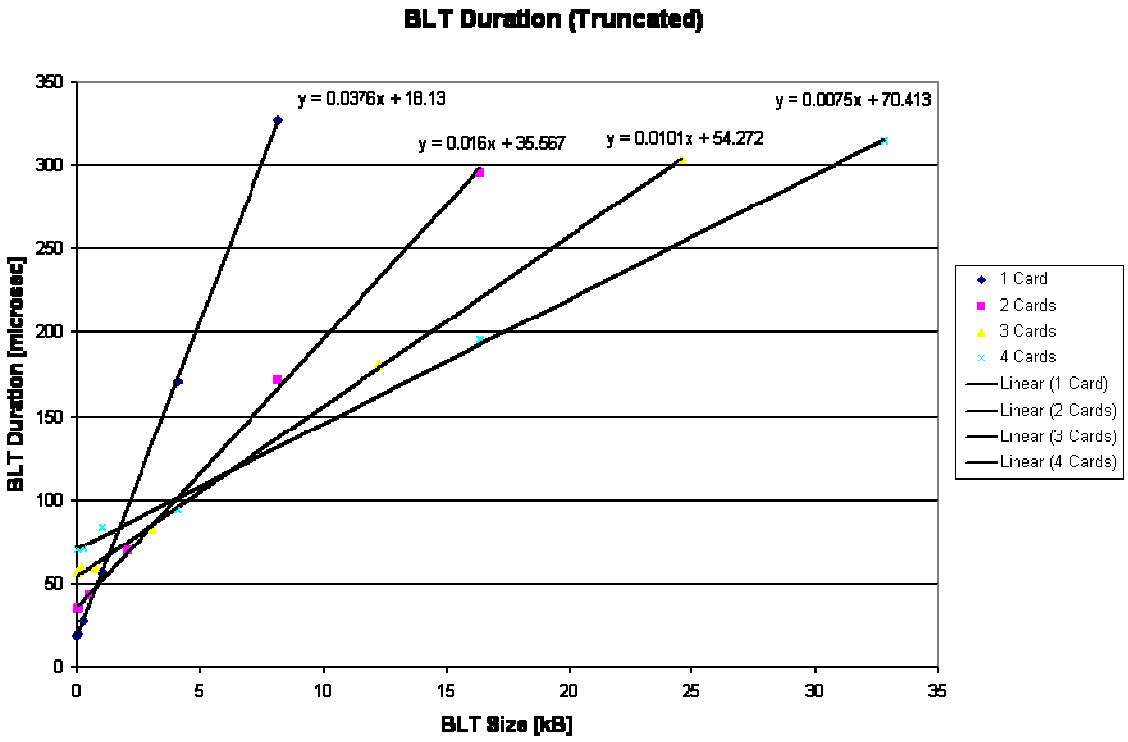


- Advantages:
  - PC can be physically separated from VME crate.
  - More than one VME crate per PC.
  - Multiple applications can access the same crate.
  - High throughput 25 to 80 Mbytes/sec block transfer.

- Work ongoing on RTEMS support.



Block Transfer Measurements



Number of ADC cards	BLT Rate (Mb/s)	BLT Minimum Cost (µs)
1	26.6	18.1
2	62.5	35.6
3	99.0	54.3
4	132.0	70.4

Measured block transfer with ICS 110B ADC/SIS1100/RTEMS, see CLS Internal Report - Orbit Control System Design Report (Chabot 2008) for assumptions and measurement criteria.

VME

- Pros:
  - Flexibility with additional hardware formats in time critical applications
  - Processors and IO can be geographically distributed
- Cons:
  - Optical cable is a bit more “fragile”
  - Extra layer of indirection

PLCs

- Ethernet based PLCs
- Apply the same principles,
  - Many small low-end PLCs
  - Ethernet aware
- Implementation:
  - Modicon Momentum
  - Siemens S7/300, 400 and F

Funding Partners

Canadian Light Source / Centre canadien de rayonnement synchrotron

Canada Foundation for Innovation
Fondation canadienne pour l'innovation

CANARIE

Canada
National Research Council Canada / Conseil national de recherches Canada

CIHR IRSC
Canadian Institutes of Health Research / Instituts de recherche en santé du Canada

NSERC CRSNG

Saskatchewan Ministry of Enterprise and Innovation

Alberta Innovation and Science

British Columbia

University of Saskatchewan

Saskatchewan Ministry of Advanced Education, Employment and Labour

Canada
Western Economic Diversification Canada / Diversification de l'économie de l'Ouest Canada

Ontario

Ontario Innovation Trust

Alberta Heritage Foundation for Medical Research

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