EPICS: Experimental Physics and Industrial Control System

Control Architecture
Reading Group

Overview

- What, Why and Who?
- The Subsystems
- Performance
- Conclusions

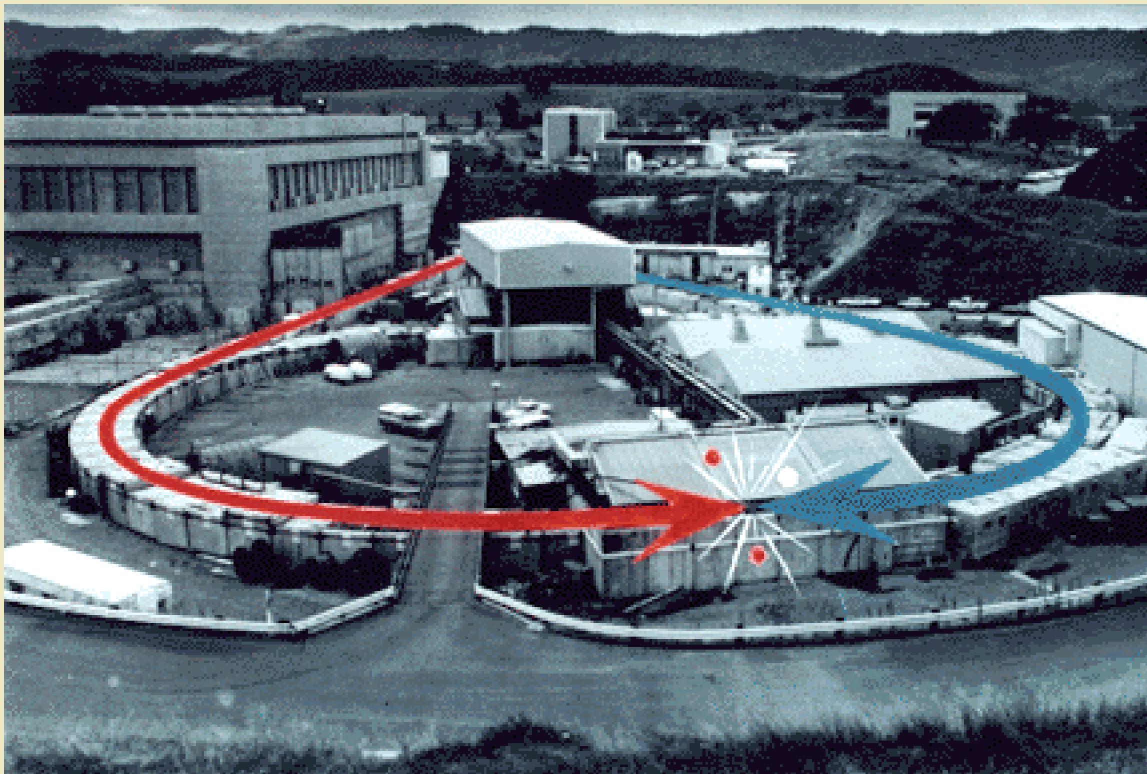
What is EPICS and Why?

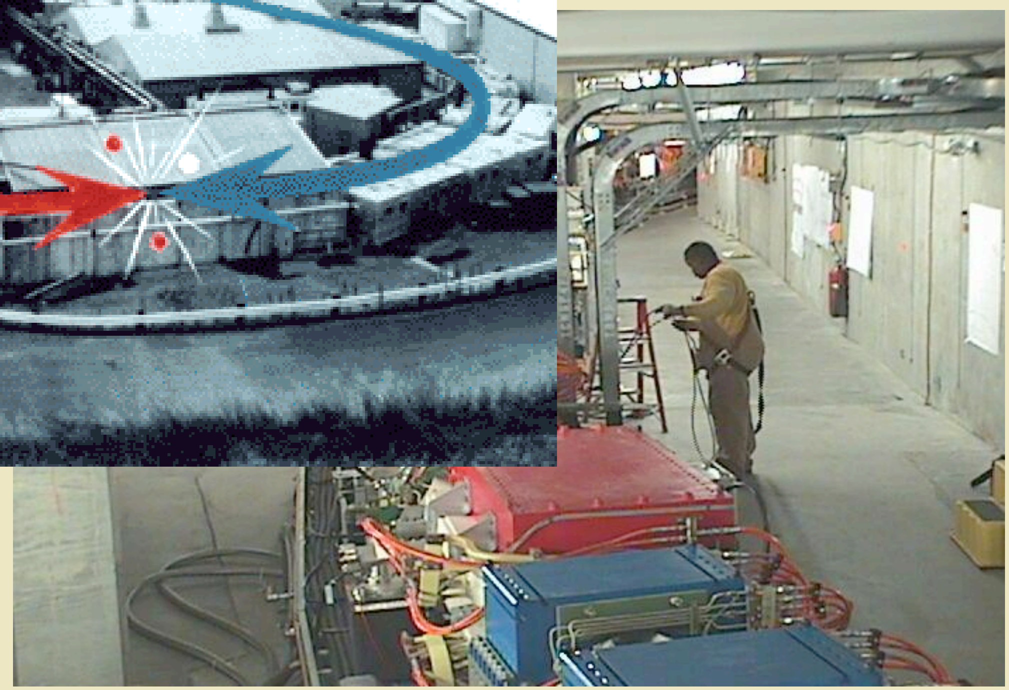
- Scaleable "real-time" remote control
  - distributed systems
  - small test stands
- Client / Server Model
  - Server: low-level hardware
  - Client: user interface
- Control: supervisory, closed-loop and sequential
- "Configuration tools in place of programming"
- Large installed base of tested software
- Modular design that supports incremental upgrades
- Well defined interfaces for extensions at every level

Who is Using EPICS?

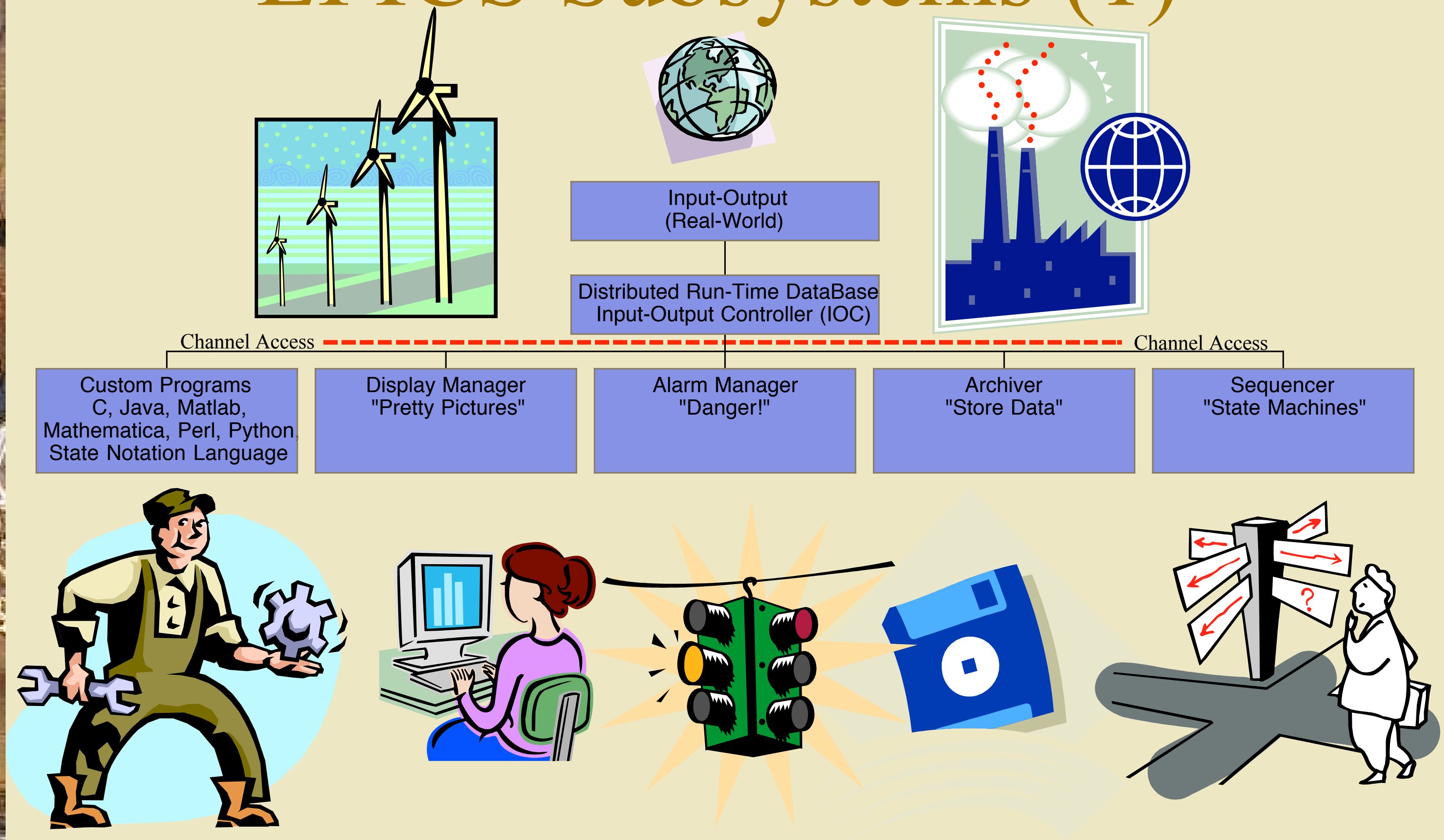
- Over 90 independent projects in North America, Europe and Asia
  - Los Alamos National Laboratory
  - Argonne National Laboratory
  - Lawrence Berkeley Laboratory
  - Superconducting Super Collider Laboratory
  - Continuous Electron Beam Accelerator Facility
  - University of Saskatchewan, UBC
  - Duke University, Stanford
  - Scientific Instrument Limited

Accelerators: Think BIG!

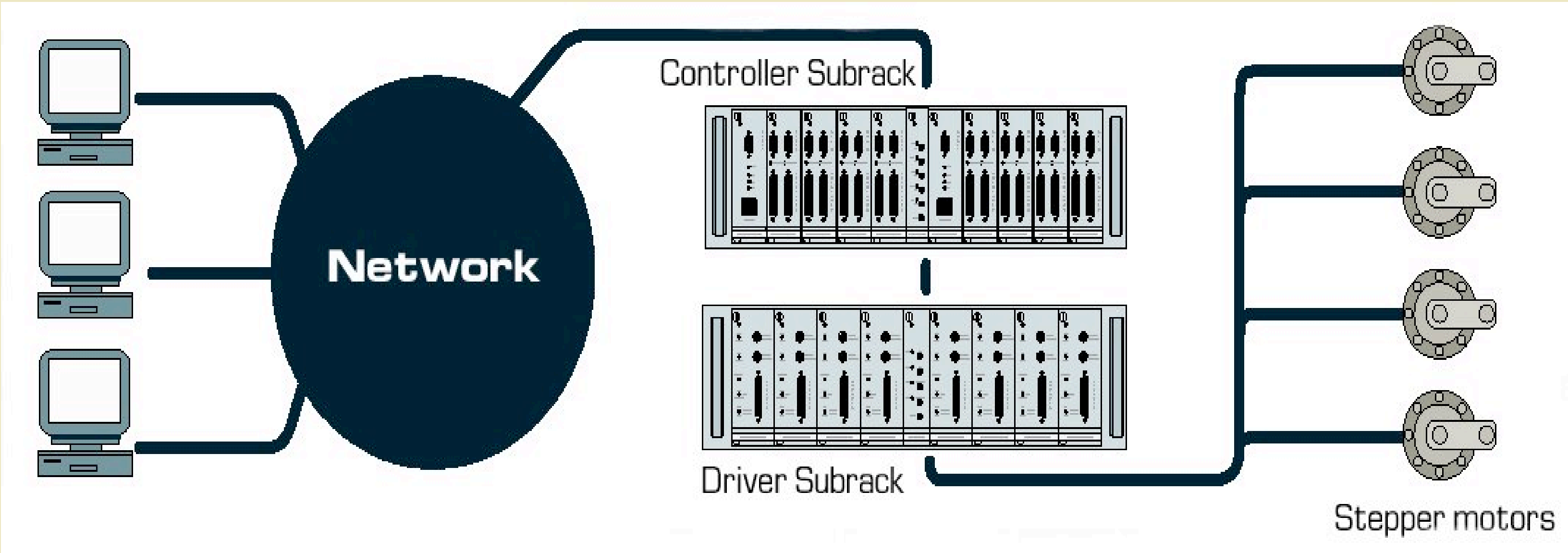




EPICS Subsystems (1)

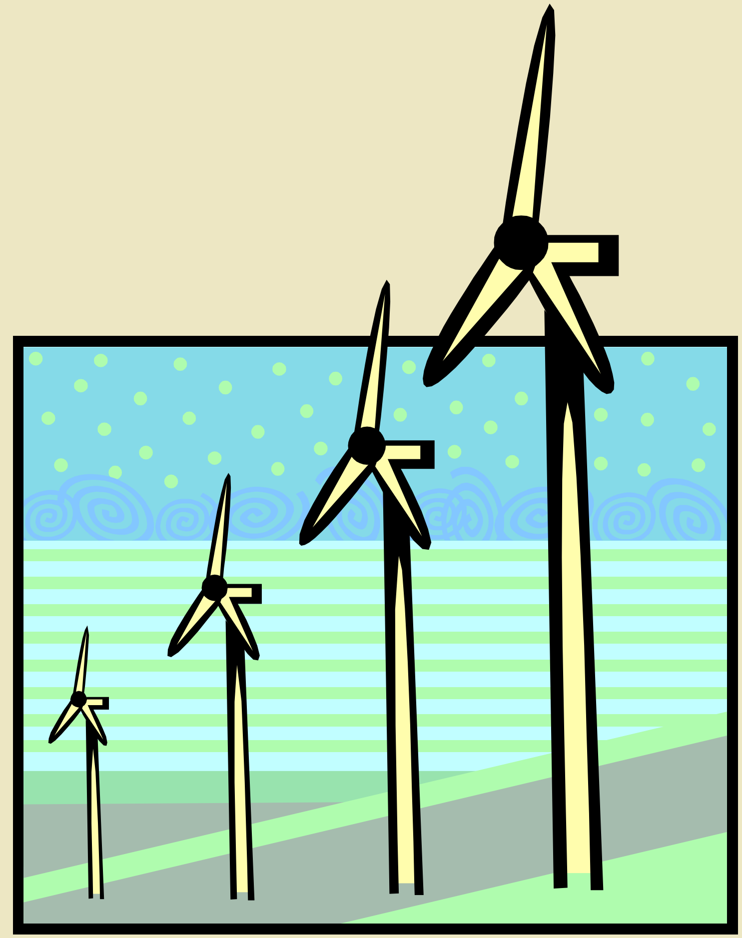


EPICS Subsystems (2)



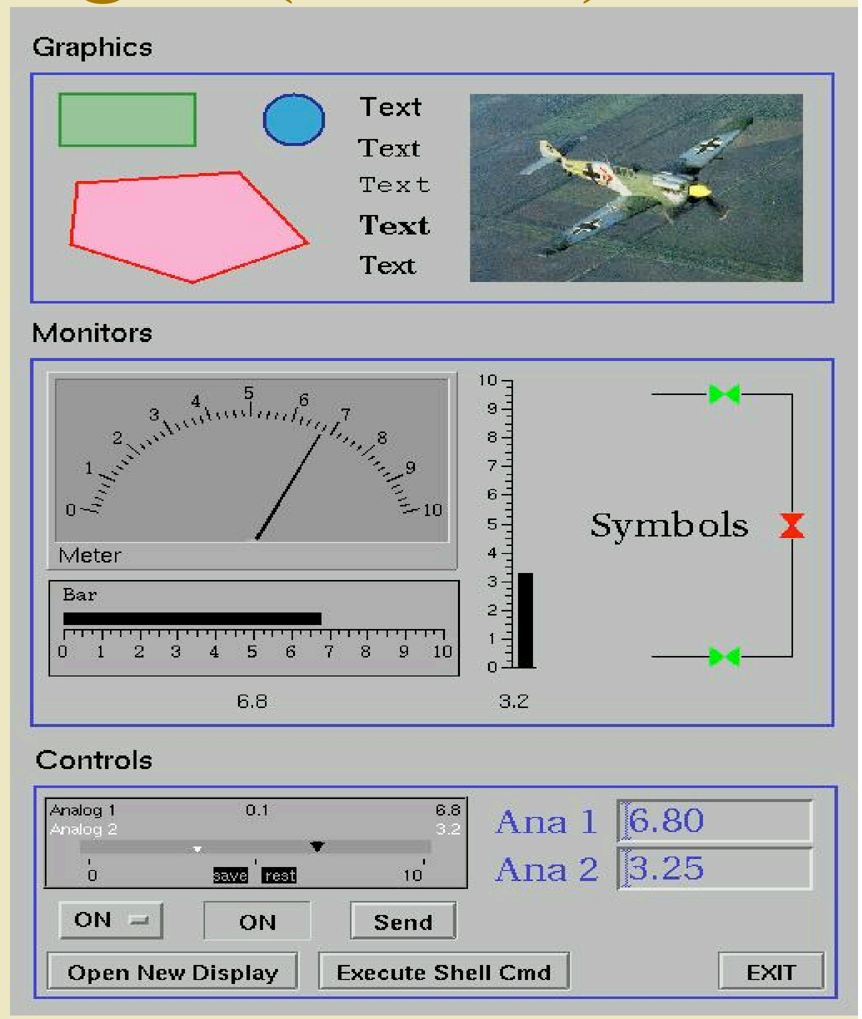
Distributed Database (Servers)

- Database: local control
  - Highest level on each IOC
  - Above hardware drivers
  - *Simple* config file
- Data Acquisition
- Data Conversion
- Alarm Detection
- Closed Loop Control
- 4-100 kHz PID loops



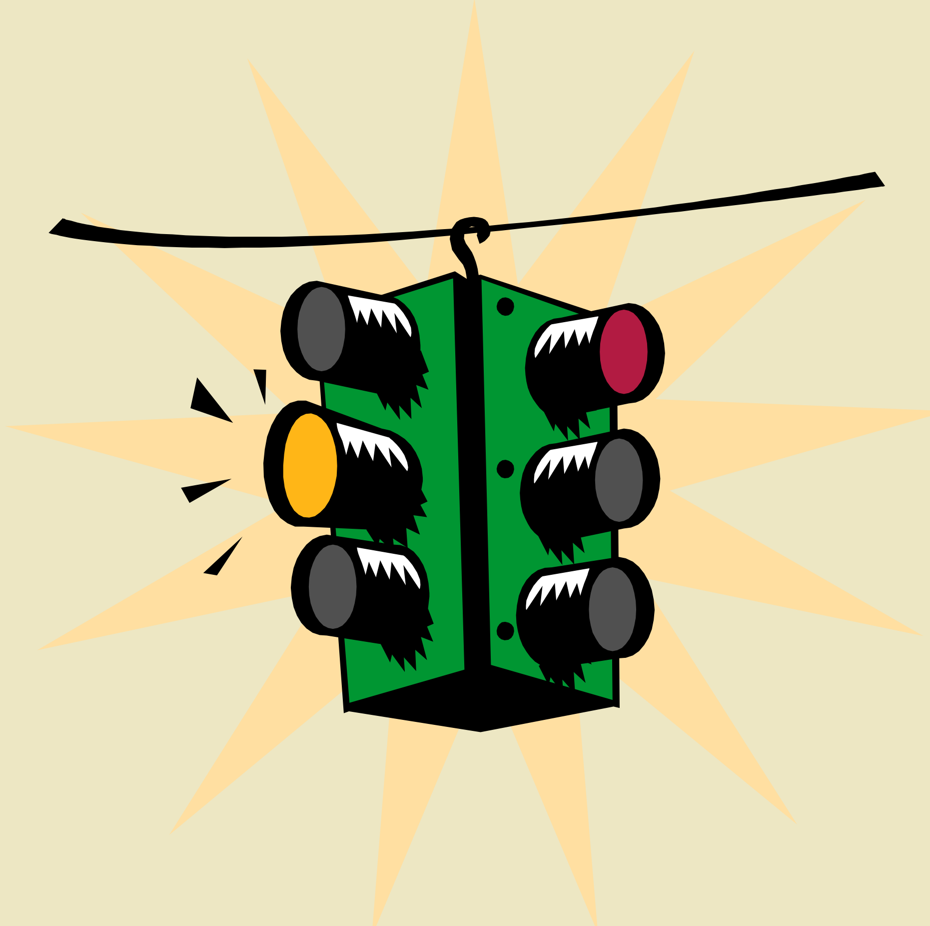
Display Manager (Client)

- Interface to Operator
- X-Windows
- Strip Charts, etc.



Alarm Manager (Client)

- “Fault Trees”
- Steady State Operation
- Give guidance to operator



Archiver (Client)

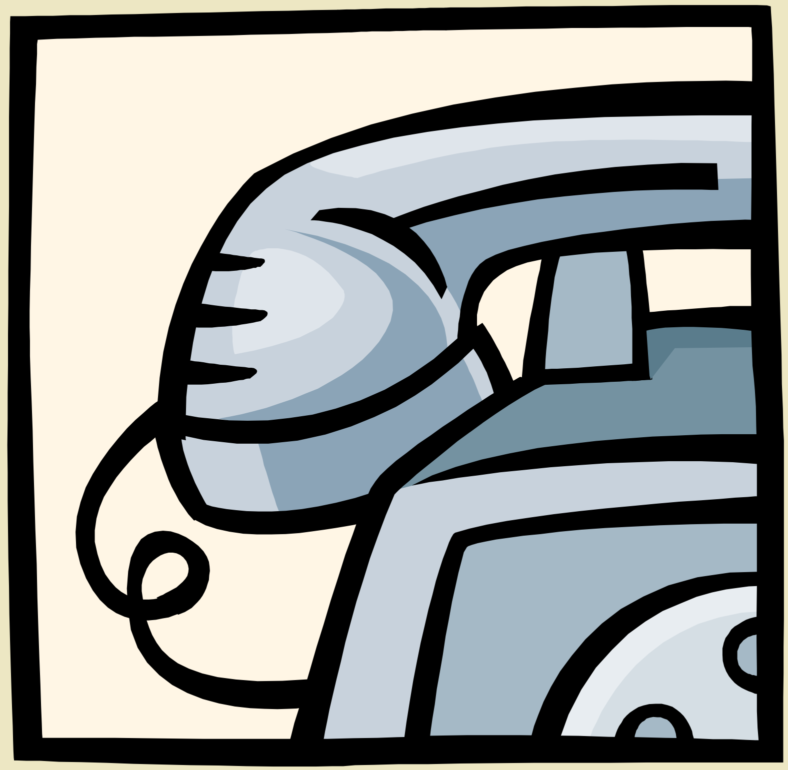
- Data to Disk
- Select Channels to Retrieve
- 5000 Channels / sec
- Multiple Archivers at once on network

Sequencer (Client)

- Execute State Machines
- Runs on each IOC
- “State Notation Language”
- Switches Op. Modes
- Handles Exceptions
- C code can be added

Channel Access

- Controls how clients and servers talk to each other
- "Software Bus"
- Over TCP or UDP
- Establish connections
- Get, Put, Monitor Info



Event Synchronization

- "Real Time" across network
  - millisecond time-stamps
- Measure same event across network
- Based on individual local machine clock
- Avoid Ethernet "collisions"

I/O & Network Performance

- 4-100 kHz IOC low-level loops
- < 60 Hz Channel Access Loops
- 10,000 Channel Access monitors per second on 10 MBit Ethernet
- Ethernet load < 30% (for determinism)
- Signal latency on network: 2ms+
  - 68040 on 10 Mbit Ethernet
- "Network bandwidth is the primary limiting factor"
- The Ground Test Accelerator (old stats)
  - 2,500 physical connections
  - 10,000 database records in 14 IOCs
  - 8 workstations
  - 5-7% of 10 Mbit Ethernet.

Reliability

- Accidents are Expensive!
- 95% uptime
- Lots of testing, been around for years
- Not a toy or pet project

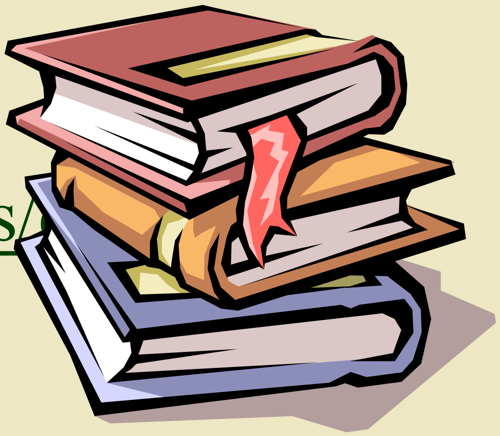
Portability

- VxWorks, Linux, Windows, RTEMS, Darwin, Solaris
- Control Net, PCI, CAN-Bus, Industry Pack, VME, VXI, PCI, ISA, CAMAC, GPIB, Profibus, Bitbus, Serial, Allen-Bradley, Modbus, Yokogawa, G-3, Ethernet/IP
- 500kB+ Server Executable
- RTEMS vs. VxWorks
  - IOC
  - Critical: Hard real-time
  - RTEMS *as fast as VxWorks*
- Linux (“all-in-one”)
  - non-critical systems

Conclusion

- Scaleable
- Distributed
- Deterministic & relatively fast
  - (1ms time-stamps)
- Reliable
- Ethernet-based control architecture
- Standard open-source Unix tools

Further Reading



- “Recommended” Documents
- http://lansce.lanl.gov/lansce8/Epics/
  csX5Farch-1.html
- EPICS Architecture @ ANL
- EPICS: Recent Developments and Future Perspectives
- EPICS on the RTEMS real-time executive for multiprocessor systems