Experimental Physics and Industrial Control System (EPICS) Overview

Bob Dalesio, June 24, 2001

Outline

- Introduction: What is EPICS
  - The Collaboration
  - Architecture
  - Tool-Kit
- IOC Core
  - Channel Access
  - Process Database
- Conclusions

What is EPICS?

- A collaboration of the controls groups of many research organizations that use the EPICS tool-kit.
- A distributed architecture that supports a wide range of solutions from small test stands to large integrated facilities.
- A set of tools that reduces software application and maintenance costs by providing:

  Configuration tools in place of programming

  A large installed base of tested software

  A modular design that supports incremental upgrades

  Well defined interfaces for extensions at every level

What is EPICS? The Collaboration

- Over 100 independent projects in North America, Europe and Asia
- Applications in particle physics, astronomy, and industrial control
- Distribute software over the network
- Independent development, co-development and incremental development of code done by members
- Problem reporting and resolution via e-mail exploders
- Documentation available on WWW sites
- Large collaboration meetings to report new work, discuss future directions, explore new applications, and explore new requirements for existing codes
- Small design groups from multiple labs meet to discuss design issues on significant codes: Channel Access, Archiving and MMI

What is EPICS? Partial List of Collaboration Members

- Fermilab D0 Experiment
- TRIUMF
- Oakridge National Laboratory
- Institute of High Energy Physics (Beijing)
- Duke University Free Electron Laser
- Deutches Elektronen-Synchrotron
- Stanford Linear Accelerator Center
- Lawrence Berkeley National Laboratory
- Los Alamos National Laboratory
- Argonne National Laboratory
- W. M. Keck Observatory
- Commissariat a l'Energie Atomique (SACLAY)
- Berliner Elekronenspeicherring-Gesellschaft fur Synchrontronsrahlung
- Jefferson Laboratory
- Paul Scherrer Institut
- Gemini Telescope
- KEK (Koh ehnerugii Kencuesho)
- Princton Plasma Physics Laboratory
- Shanghai Syncrotron Radiation Facility
- RIKEN
- Brookhaven National Laboratory
- Budker Institute of Nuclear Physics

EPICS Is Suitable for a Large Range of Applications

PVs I/O Controllers

K Advanced Photon Source 300K 170

E KEK B

240K 94

CCEBAF

180K 98

BBESSY II

150K 110

SSwiss Light Source

90K 160

DD0 (FNL)

60K 124

PPEP II RF and Longitudinal Control

19K 21

LLow Energy Demonstrator

Accelerator 15K 18

CCompass

1K 1

KKeck II

2K 2

GGemini Telescope

35K 17

*Next Linear Collider Test Accelerator

3K 2

**Diamond

50K 180

**Japanese Hadron Facility

~50K ~100

**PF-AR

~25K ~50

**Spallation Neutron Source

150K 150

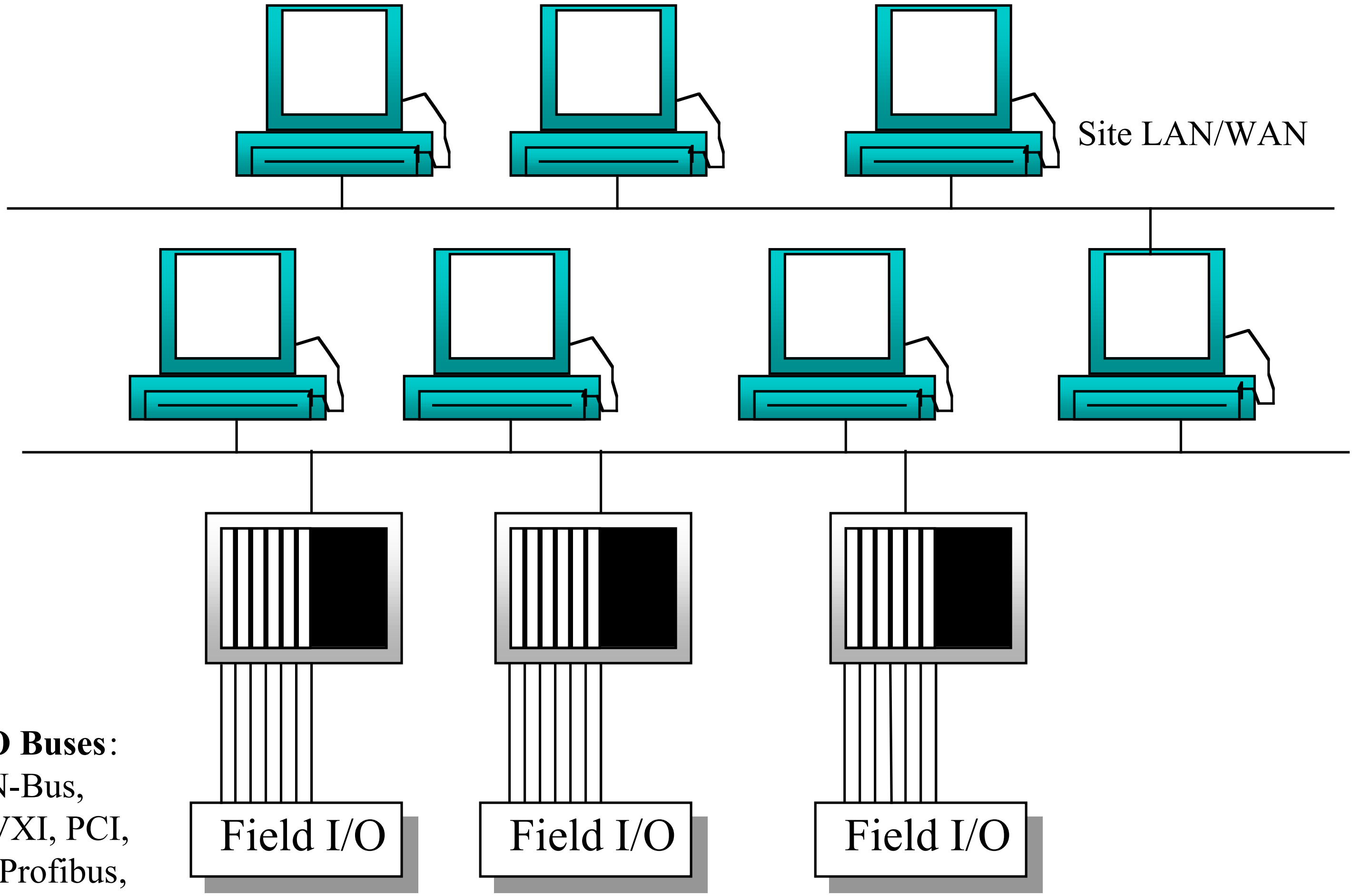
*Planned or under construction

What is EPICS? Distributed Architecture

- EPICS is physically a flat architecture of front-end controllers and operator workstations that communicate via TCP/IP and UDP
    - System scales through the addition of new computers
    - Physical hierarchy is made through bridges, routers, or a gateway
    - Network bandwidth is the primary limiting factor
- EPICS software architecture is client/server based - with independent data stores providing read/write access directly between any two points
    - Local name services mean automatic integration of new components
    - Point-to-point communication supports automation

EPICS Supports a Standard Control System Architecture

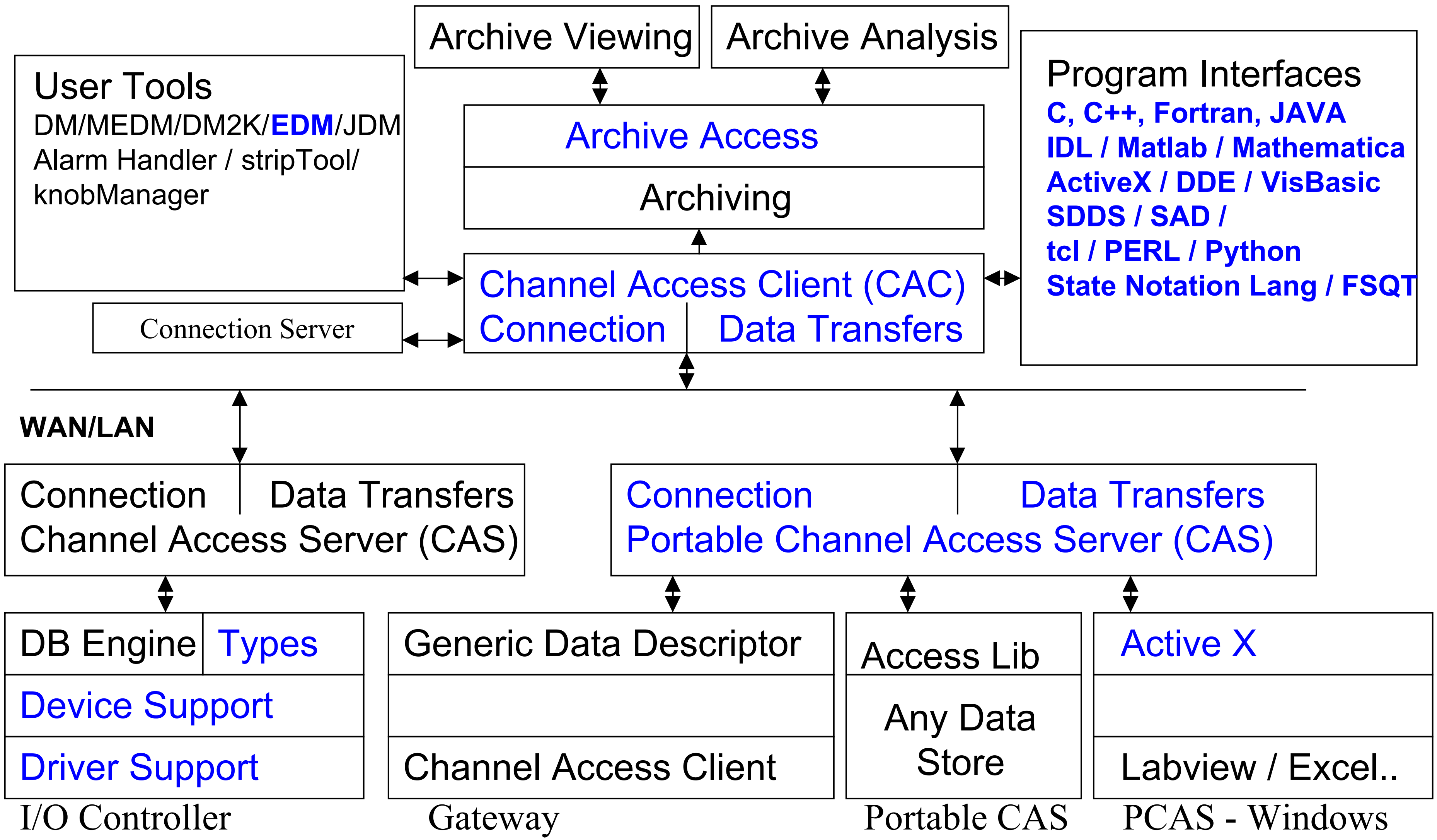
Workstations:
- Sun
- Hp
- DEC/Alpha
- Silicon Graphics
- PC



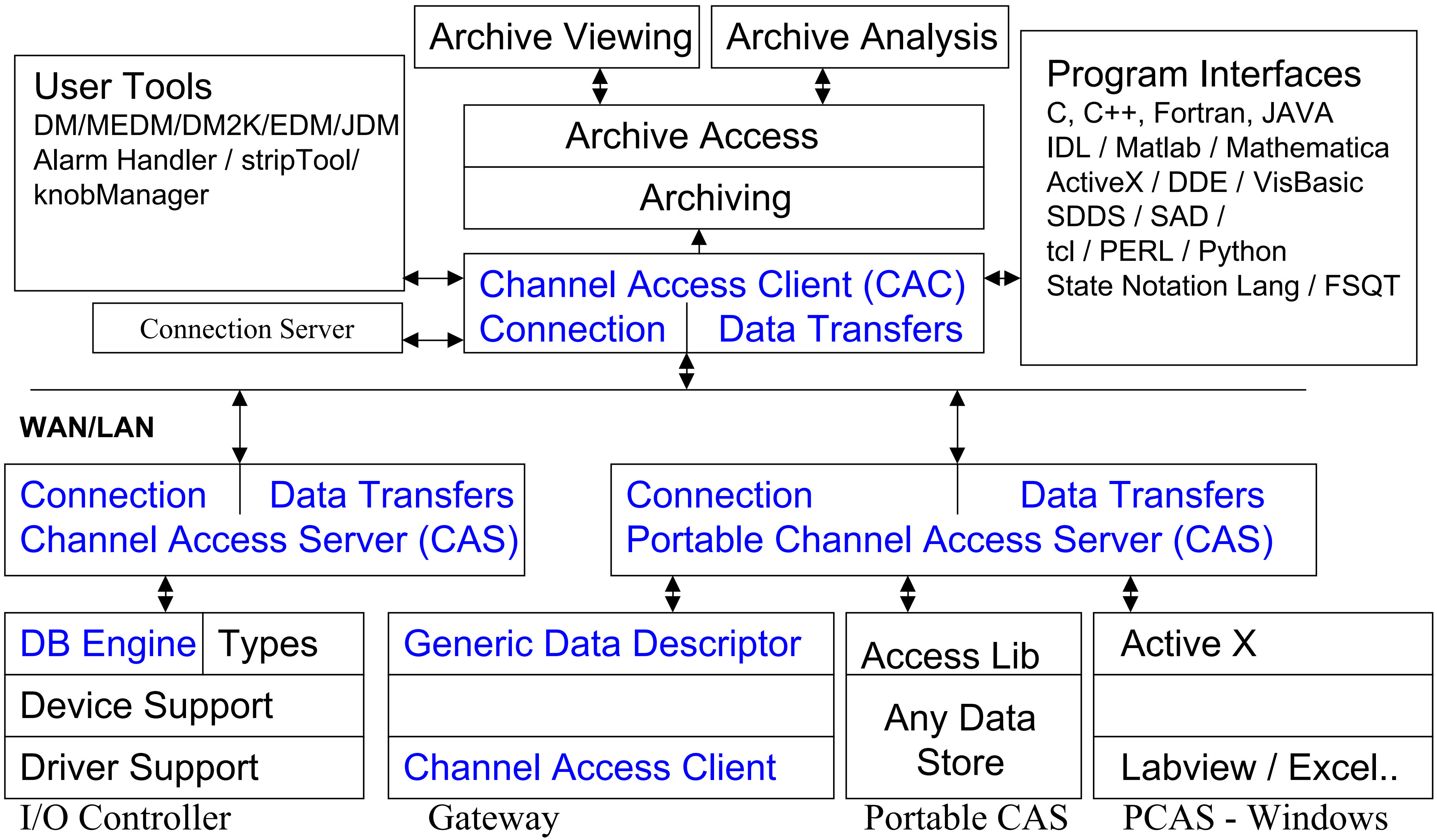
I/O Controllers:
- VME
- VXI
- PCI

Remote and Local I/O Buses: Control Net, PCI, CAN-Bus, Industry Pack, VME, VXI, PCI, ISA, CAMAC, GPIB, Profibus, Bitbus, Serial, Allen-Bradley, Modbus, Yokogawa, G-3, Ethernet/IP

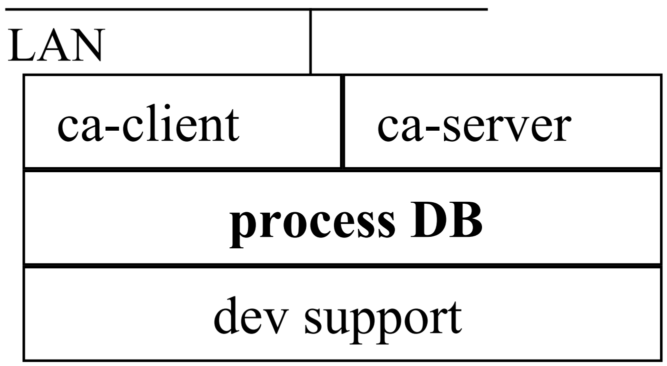
EPICS Has Well Defined Interfaces for Extensions at all Levels



Support For This Extensive Code Base is Divided into Core and Extensions



IOC Core: Process Database



A Channel Access server provides connection, get, put, and monitor services to this database

A Channel Access client provides access to process DBs in other IOCs

Process Blocks are the basic elements: AI, AO, BI, BO, Motor, CALC, PID, SUB, etc.…

Process Blocks consist of fields for: SCHEDULE, I/O, CONVERT, ALARM, MONITOR

They hold runtime values: VALUE, TIMESTAMP, ALARM CONDITION, etc.…

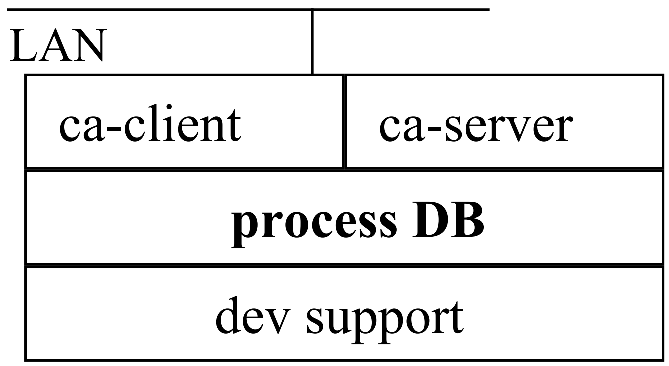
New process block are easily added

Configured using CAPFAST, GDCT, Relational DB, Text Editor at the workstation

Loaded as ASCII records into vxWorks at boot time

All fields can be read/written through the channel access client interface during operation

IOC Core: Process Database



Process Block execution time varies from block type to block type

AI on a PowerPC ~100,000/second (50% idle)
AI on a 68060 is ~18,000/second (50% idle)
AI on a 68040 is ~6,000/second (50% idle)

Fastest periodic scan rate is dependent on vxWorks clock tick - 60 Hz

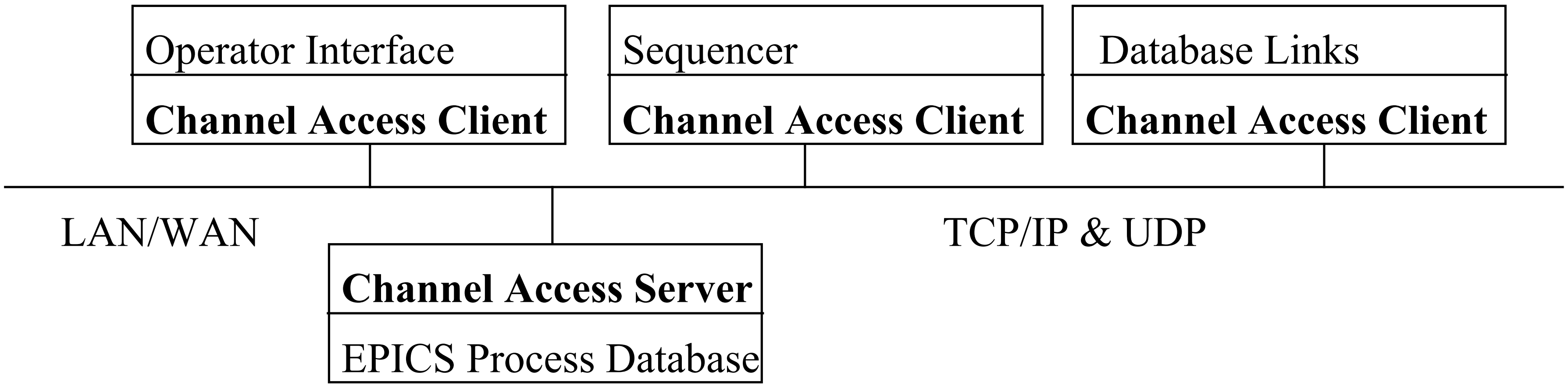
Interrupt scanning is limited by the CPU bandwidth (interrupt delay ~33usec 68040)

Name resolution - 10,000/second - runs at the lowest priority

2,500 Process blocks use around 1 Megabyte of memory

Support to particular physical I/O is distinct from process logic - ASCII device type

IOC Core: Channel Access Client/Server Libraries



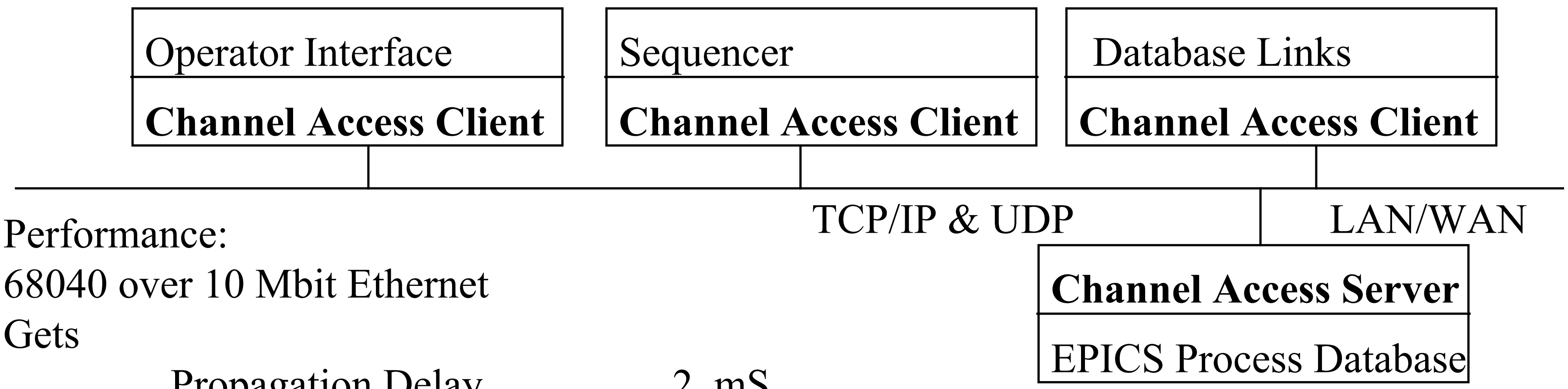
Client: Provides read/write connections to any subsystem on the network with a channel access server

Server: Provides read/write connections to information in this node to any client on the network through channel access client calls. The data resides here!

Services: Dynamic Channel Location, Get, Put, Monitor
Access Control, Connection Monitoring, Automatic Reconnect
Conversion to client types, Composite Data Structures

Platforms: UNIX, vxWorks, VMS (Client only), Windows NT

IOC Core: Channel Access Services



Performance:
68040 over 10 Mbit Ethernet

Gets

Propagation Delay	2 mS
Throughput	7.8K /sec

Puts

Propagation Delay	1 mS
Throughput	17K /sec

Monitors

Propagation Delay	Dependent
Throughput	10K / sec

(Typically 10% channels have monitors)
(memory use in IOC - 2 Meg / 60 connections)
(30% network load for 10K monitors / second)

Increase bandwidth with Routers, Bridges, Higher speed networks and EPICS gateway

IOC Core: Mapping Records to Channels

AI:	
Name	
SCAN	
VAL	
STAT	ACK
SEVR	ACKT
HOPR	EGU
LOPR	
HIHI	HHSV
HIGH	HSV
LOW	LSV
LOLO	LLSV

Channel Access Client:
Connect to “Name”
Add Event to
- alarm change
- monitor change
- archive change

Make data type request
- Value
- Status & Severity
- Time Stamp
- Display and Control Information

Channel Access Client:
Connect to “AI<.VAL>”
- AI.VAL
- AI.STAT
- AI.SEVR
- AI.TS
- AI.HOPR
- AI.LOPR
- AI.EGU

Connect to AI.SCAN
- AI.SCAN
- AI.STAT
- AI.SEVR
- AI.TS
- Scan menu
- # Choices

The Learning Curve for EPICS is difficult

- Installing EPICS
- Setting up the application environment to automatically build databases
- Setting up the IOC to boot from the workstation
- Installing the new drivers
- Knowledge of how to debug the application - is needed by everyone
- Learning to use the process database
- Choosing and learning which client tools to use

- This learning curve can be eased by receiving training from other laboratories, having one of your employees work and train at an EPICS site, or reading the documents and using the software support document to determine the collaboration member supporting your platform.

New Developments Take Advantage of Changes in Technology and Improve Functionality, Ease of Use, and Performance While Reducing Cost

- Port the EPICS database to other operating systems (ANL,LANL)
- Upgrade channel access to support an improved protocol, new monitor options, OO interfaces, and an optimized server for both the database and other data stores (LANL/ANL/SLAC)
- Provide native windows NT capabilities to lower cost and provide data to every desktop (LANL)
- Provide extensions required to scale to 1 million channels for Next Linear Collider (SLAC/LANL)
- Provide a distributed archiving/archive retrieval capability to better support analysis and operations (LANL/JLAB/DESY/BESSY)
- Develop new database configuration tools for ORACLE

Conclusions: EPICS Continues to Meet the Needs of Its Members Through Cooperative Development of a Scaleable, Flexible Tool-kit

- The fundamental performance and functionality is scaleable and easily configured.
- Clean interfaces for clients, new record types, data stores and hardware promote independent development, support ease of reintegration, and protect against obsolescence.
- Open software development supports cooperative collaboration and gives members laboratories a larger pool of talent to support their controls requirements.
- Continual improvements allow members to expand functionality, performance, reliability and function while taking advantage of latest technology.