NLC Global Controls Architecture

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Overview of Control System

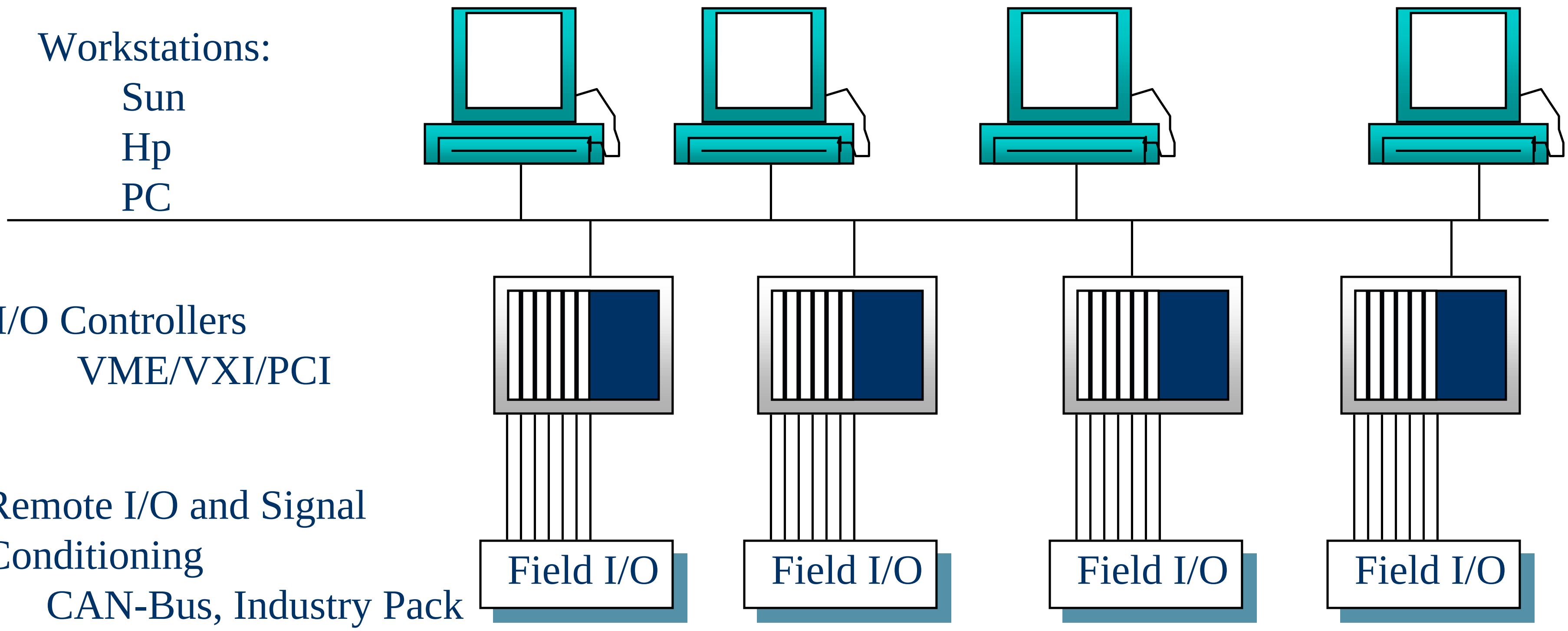
- Distributed control system based on EPICS
- Many TCP/IP based network applications
- 120Hz machine cycle requires control system to be "pulsed"
- Realtime data sharing between CPUs over km distances
- Reliable, general purpose network to provide conventional data connectivity (TCP/IP)
- Reliable, low latency, high bandwidth network to provide realtime data connectivity
- Multiple fieldbus types matched to application needs

EPICS Overview

Workstations:
- Sun
- Hp
- PC

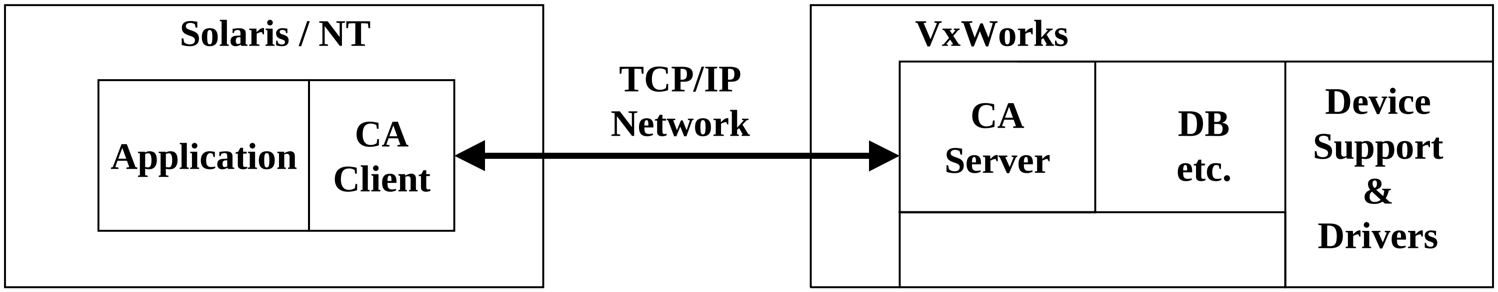
I/O Controllers
- VME/VXI/PCI

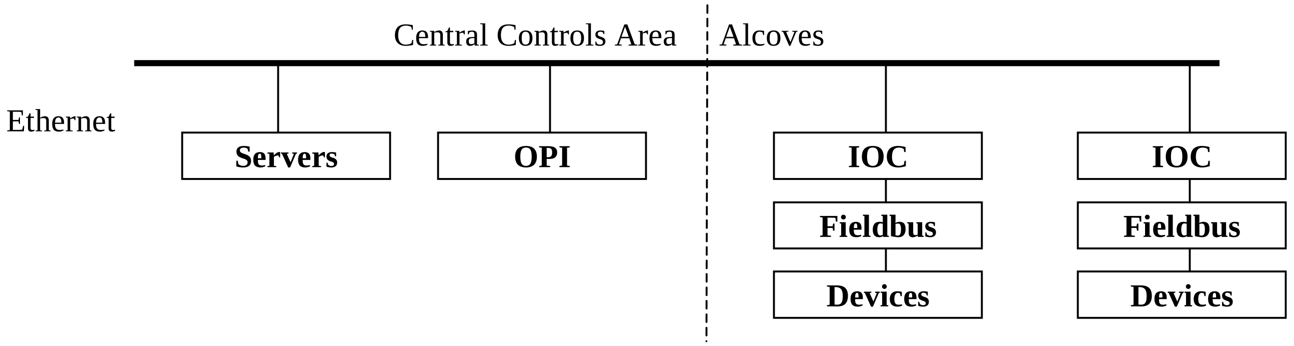
Remote I/O and Signal Conditioning
- CAN-Bus, Industry Pack
- VME, VXI, PCI, ISA
- CAMAC, GPIB
- Profibus, Bitbus, Serial,
- Allen-Bradley, Modbus,
- IEEE 1394 (Firewire)



EPICS Overview cont.

- EPICS
  - Distributed control system using TCP/IP protocols
  - IOC - input output controller
  - Channel Access (CA) is a protocol built on top of TCP/IP





Slow Applications

- EPICS TCP/IP based applications:
  - Boot and debug basic IOC software (VxWorks)
  - EPICS IOC configuration and database load
  - Channel access for high level applications
    - Control, status, logging, etc

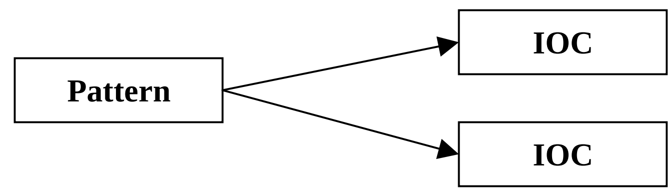
- Other TCP/IP based applications:
  - Video (PPS and others)
  - Portable computing devices
  - Terminal servers for IOC serial outputs
  - Permanent X-Window display devices in alcoves
  - Local data storage in alcoves (steamed data)
  - Diagnostic instrumentation

Pulsed Applications

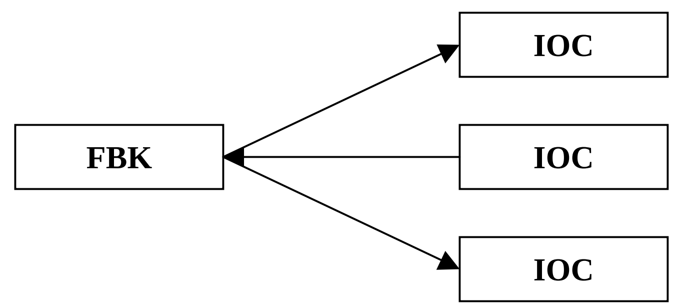
- Acquire, process, and distribute data in the “interpulse time period” of ≅ 8 milliseconds (120Hz)
- There isn’t native support in EPICS for this when combined with NLC data processing requirements
- Applications:
  - Beam Pattern Broadcast
  - Fast Feedback
  - Machine Protection System
  - Synchronized data acquisition on sequential pulses

Pulsed Applications cont.

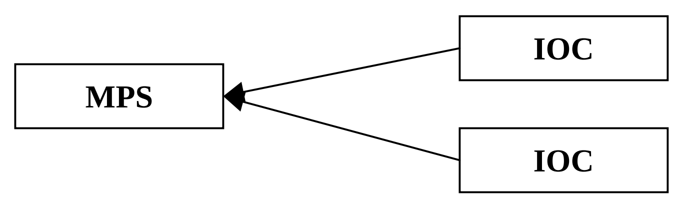
- Beam Pattern Broadcast
  - Beam pattern broadcast to all pulsed IOCs at 120Hz



- Fast Feedback / Cascade
  - IOC to server to IOC data shared at 120Hz



- Machine Protection System
  - Data passed from IOC to central supervisor at 120Hz



Pulsed Applications R&D

- Examine the integration of 120 Hz pulsed functions into the EPICS IOC software structure
- R&D Plans:
  - The goal is to have a subset of the 120 Hz NLC pulsed application code running in conjunction with the EPICS IOC functions
    - Identify NLC pulsed IOC activity occurring at 120 Hz
    - Identify EPICS database devices that are used at 120Hz
    - Specify and write realtime networking software for the VxWorks kernel to perform these pulsed activities
    - Configure and test
- This R&D also aids in the selection and costing of CPU, memory, and network resources in the final design phase

NLC Network Device Scale

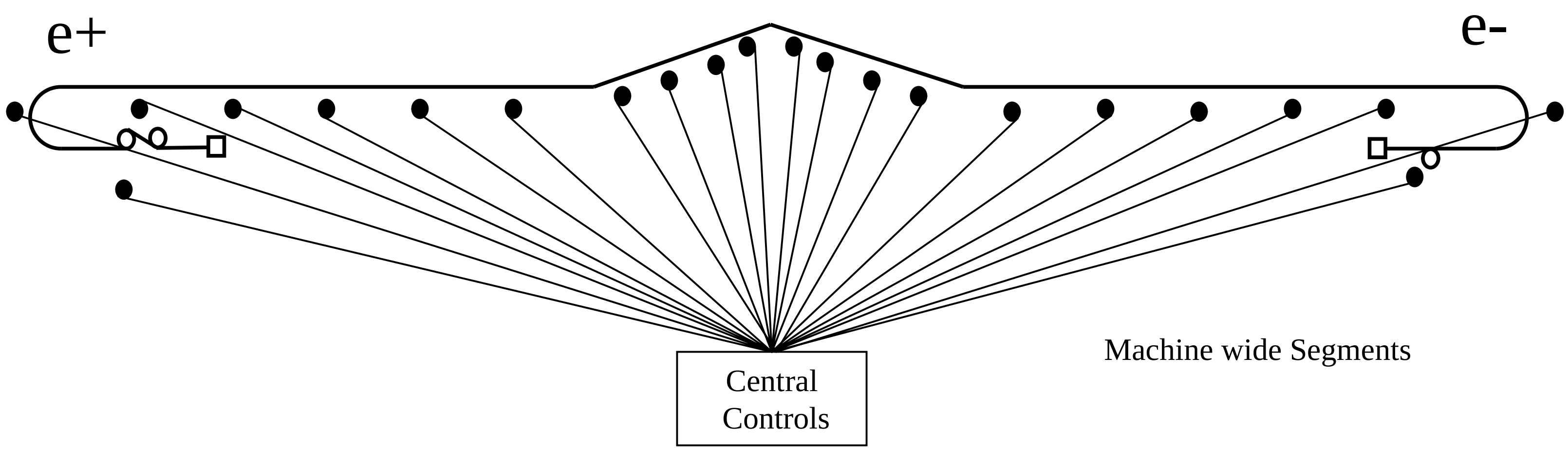
- 380 Pulsed Control System IOCs (282 linac + 98 other)
- 192 Slow Control System IOCs
  - Actual IOC count depends on exact local I/O counts
- 828 Linac RF IOCs (pulsed)
- 60 Special purpose IOCs (some pulsed)
  - Damping rings, diagnostic sections, Master Pattern Generator, Feedback, Machine Protection System
- Total ≅ 1500 IOCs
- 1000 support nodes in the alcoves
- 300 servers and workstations in the Central Controls area

- Grand total ≅ 2800 total nodes in this network (for now)

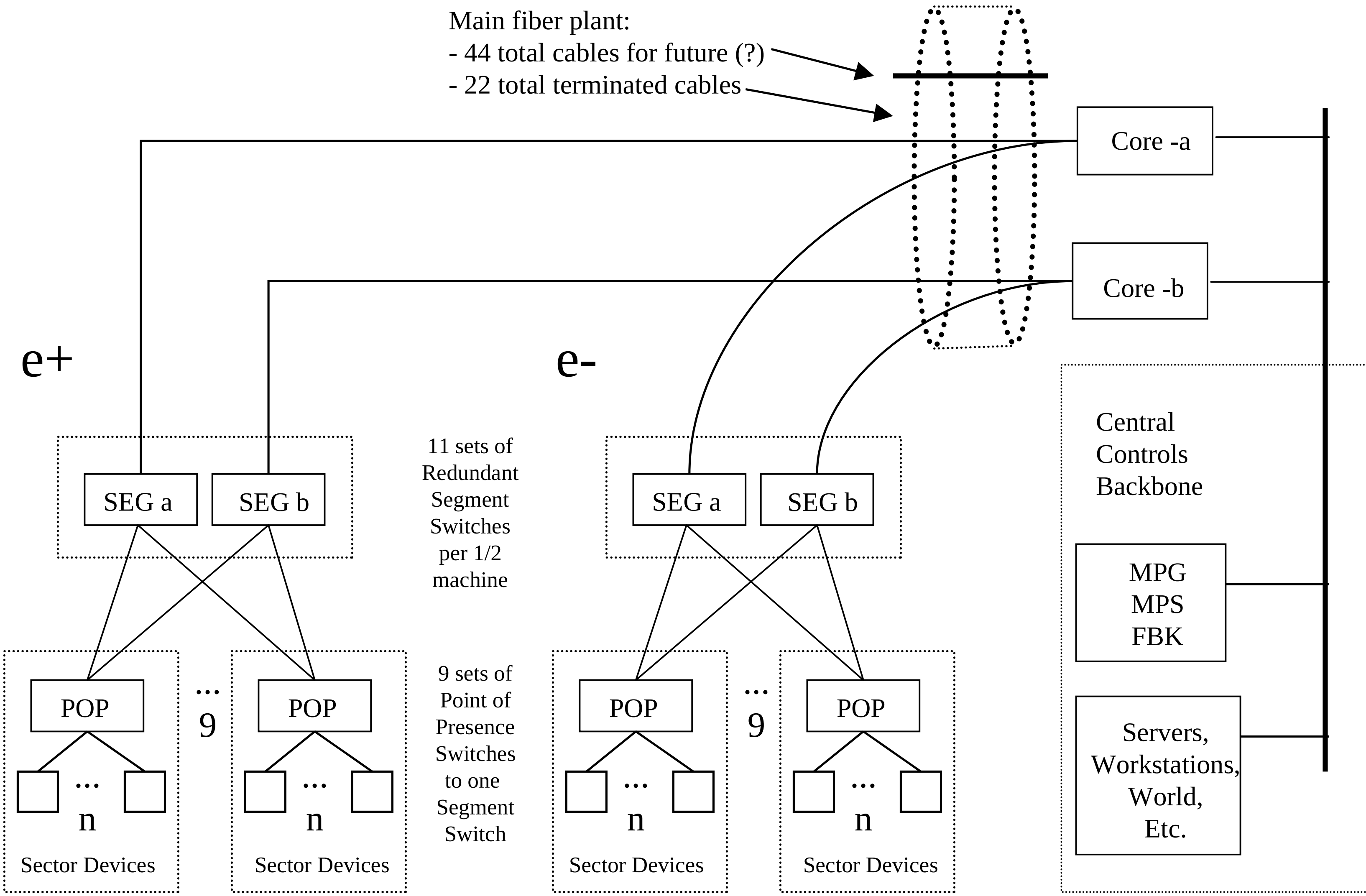
Global Network

- Global network to provide alcove connectivity
  - Model uses Gigabit Ethernet as the physical layer protocol
  - Scaleable, fault tolerant, commercial network
  - TCP/IP based protocols to allow network segmentation
  - Backbone is 100% optical fiber, node access is mixed fiber/copper
  - Redundant systems are used for reliability
  - Long fiber runs from central campus area to every third sector in main linac for future expansion capabilities
  - Integrated network monitoring and management tools
  - Cisco switching products are used for cost baseline

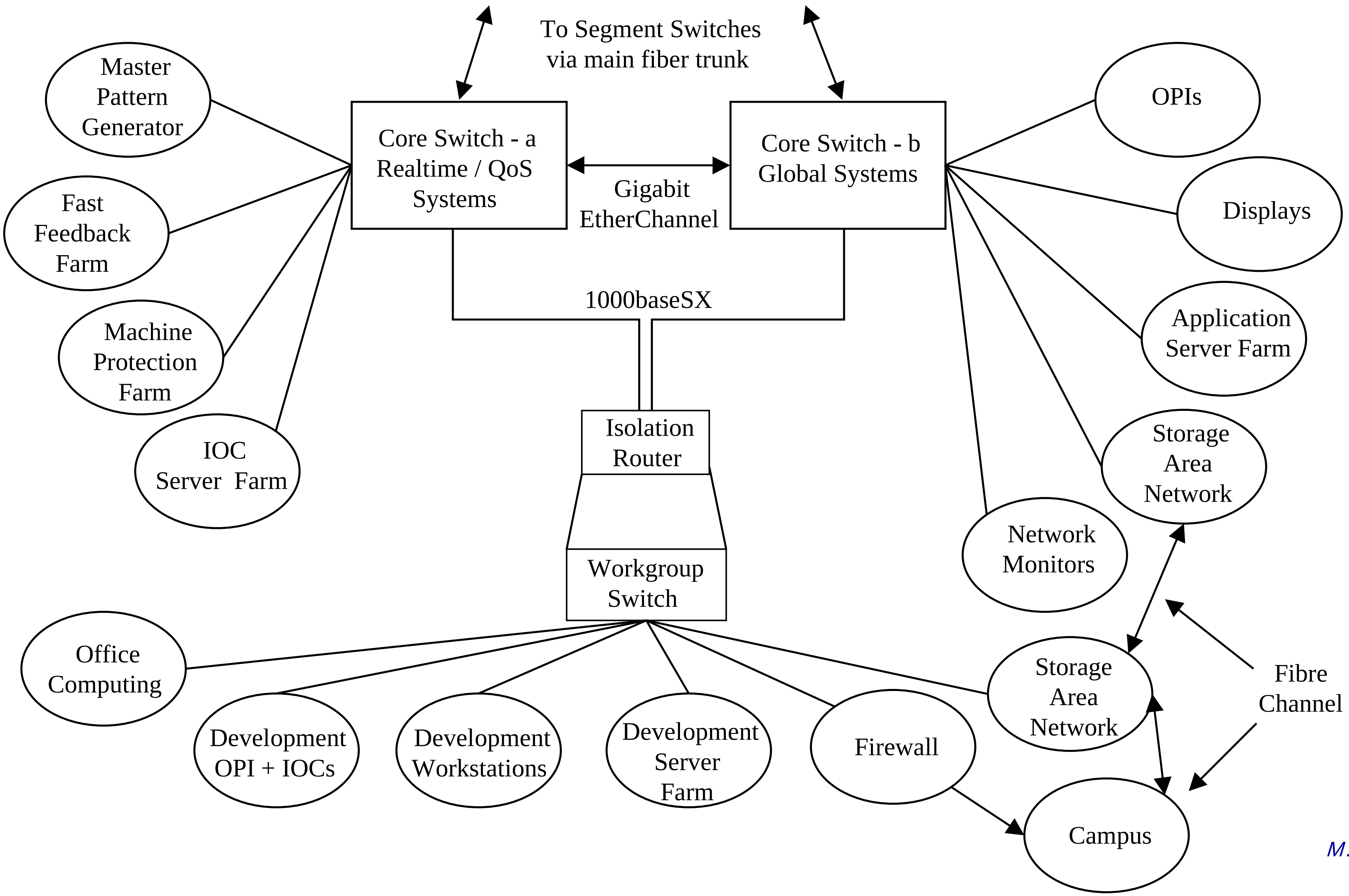
Distributed Backbone



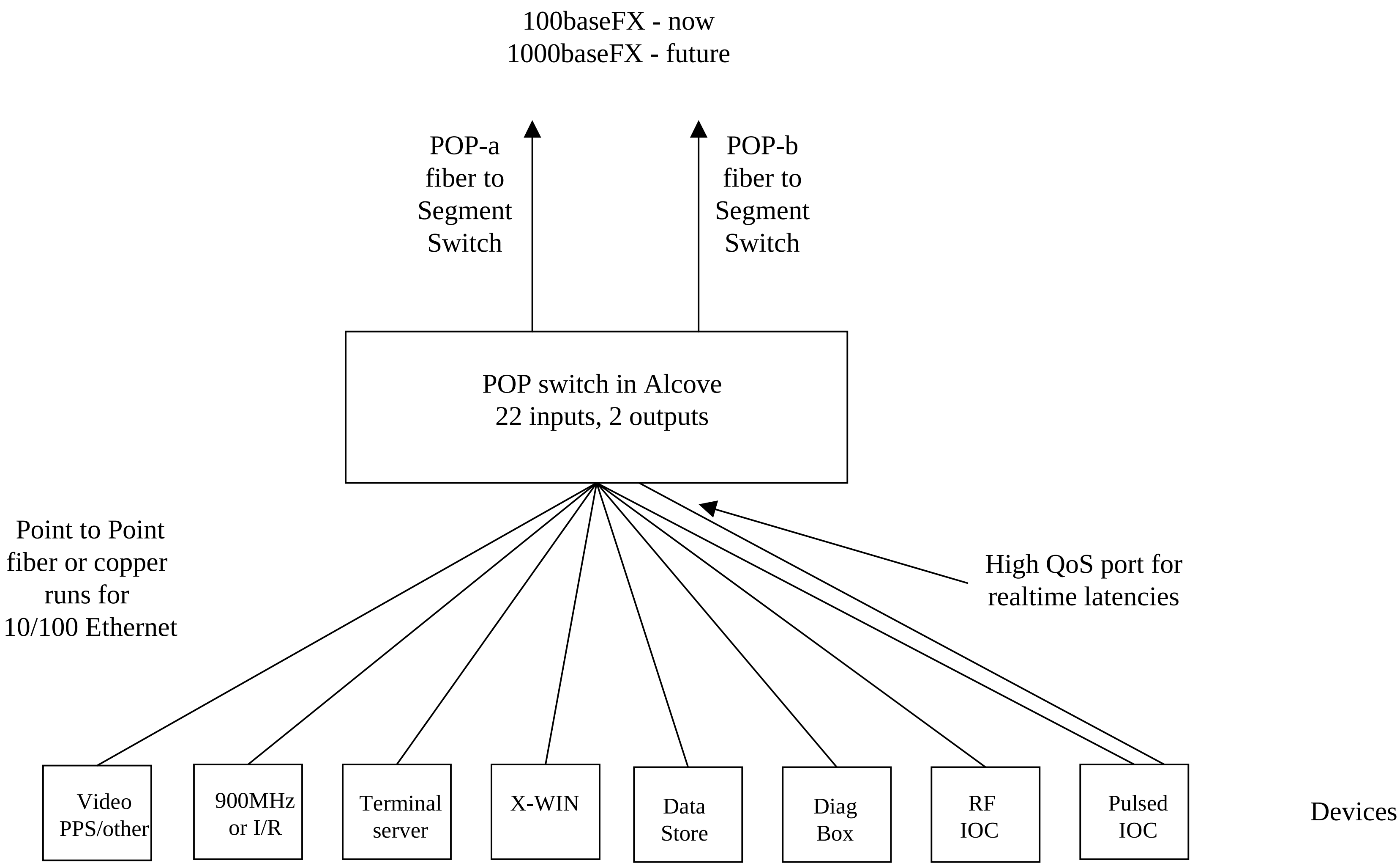
Distributed Backbone cont.



Central Controls Area



Point of Presence Diagram



Realtime Network

- Provide IOC to IOC data transfer between 120Hz beams
- Most systems have a separate network for this purpose, new technologies should allow a single network
- A single network reduces costs by using common test equipment, monitoring systems, and technical knowledge
- Allows us to use the standard EPICS installation - IOCs in the alcoves
- The risk is that it works well locally, but cannot be reliably extended to the distances required for the NLC
  - Lost packets, mangled packets, and high latency caused by the number of interfaces between source and destination

Realtime Network R&D

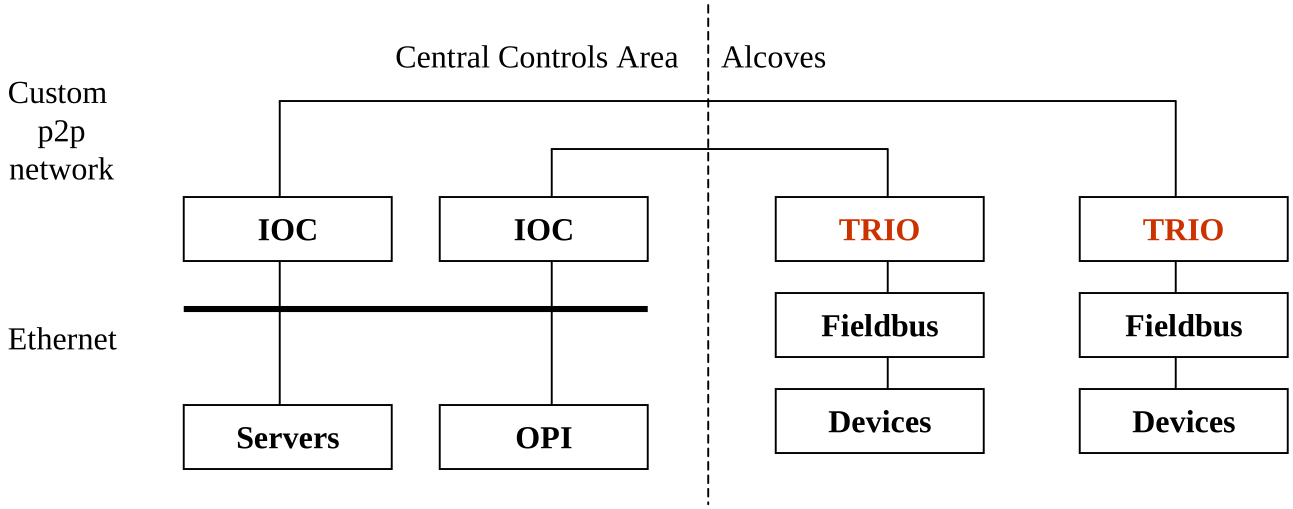
- Demonstrate that standard, commercial, “open” network technologies can provide high bandwidth, low latency, and reliable quality of service guaranties.
- R&D Plans:
  - Perform point-to-point, low latency, deterministic communications on the same network as bursty, high bandwidth traffic
  - Segment system and provide wire speed QoS (IP based protocols)
  - Scale to 1300 QoS nodes plus >1500 normal nodes (traffic simulation)
  - Reliably (and cost effectively) extend from 100 meters to 18 kilometers
  - Provide testbed for other systems who will use this network

Trio Architecture

- Triggered Remote Input / Output system
- Address electrical noise and physical environment issues
  - Provide noise immune communications and processing
  - Provide custom rugged hardware with very low failure rates
  - Buy inexpensive IOC hardware for “nice” environment
- Address communication needs
  - Fast, low latency, deterministic data flows and normal data flows
  - Provide 18Km point to point fiber links
  - Provide IP traffic gateway
- Address pulsed operations
  - Provide very reliable software near the devices which are processed at 120 Hz
  - Pass the rest of the data up to IOC for general processing

Trio Architecture cont.

- IOCs in "glass house" in the central controls area
- Rugged CPU platform in the alcove connected to custom network with reliability and low latency designed in
- Fieldbusses connected using custom hardware
- SBIR project in place to develop this architecture
  - In Phase II application stage



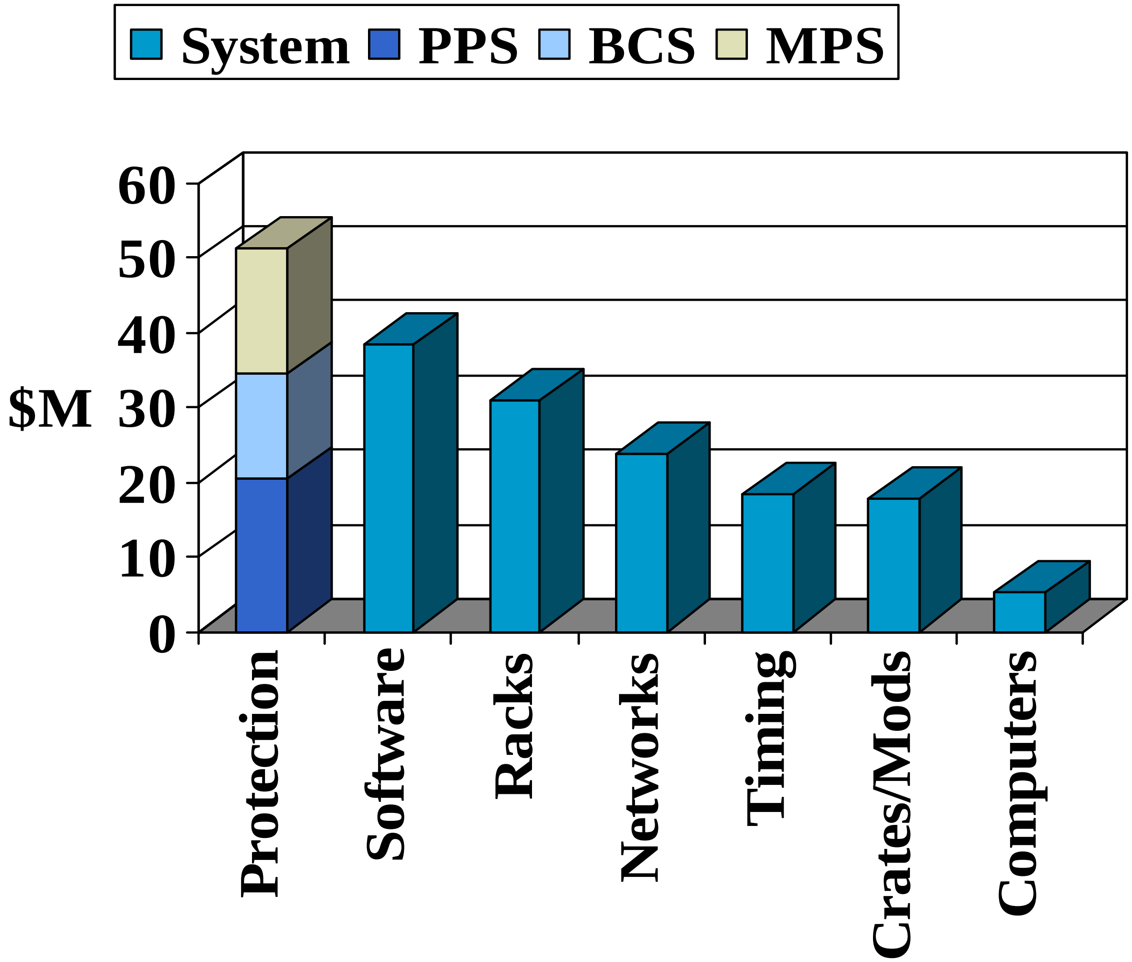
Fieldbus

- Fieldbusses are used to acquire data from the actual devices such as temperature, vacuum, flow, BPMs, etc
- Some acquisition is slow (seconds) and some is fast (microseconds)
- Multiple technologies available to match application requirements
  - CANbus
  - IEEE 1394 (Apple's Firewire)
  - Ethernet
  - various PLC serial busses
  - GPIB
  - others...

Fieldbus R&D

- Evaluate fieldbus requirements and prototype selections
- R&D Plans:
  - Gather fieldbus usage information from the other groups
  - Identify special requirements for data acquisition for the control system
  - Formulate test plans to support identified busses
  - Identify the hardware and software required for access to each of these busses using either architectures
  - Purchase hardware and driver software to test each bus
  - Integrate testing into the NLC test network IOCs and/or the 120Hz testbed

WBS1 Architecture Costs



Summary

- R&D projects to integrate “pulsed” functions into the EPICS structure, to pass realtime data around a large TCP/IP based network, and integrate new fieldbusses into EPICS
- SBIR project to develop a reliable remote I/O system which alleviates the potential technical risk with the realtime data network R&D project
- The output from these projects provide direct information for system design choices and cost reductions during the NLC design phase