Coyote: all IB, all the time draft

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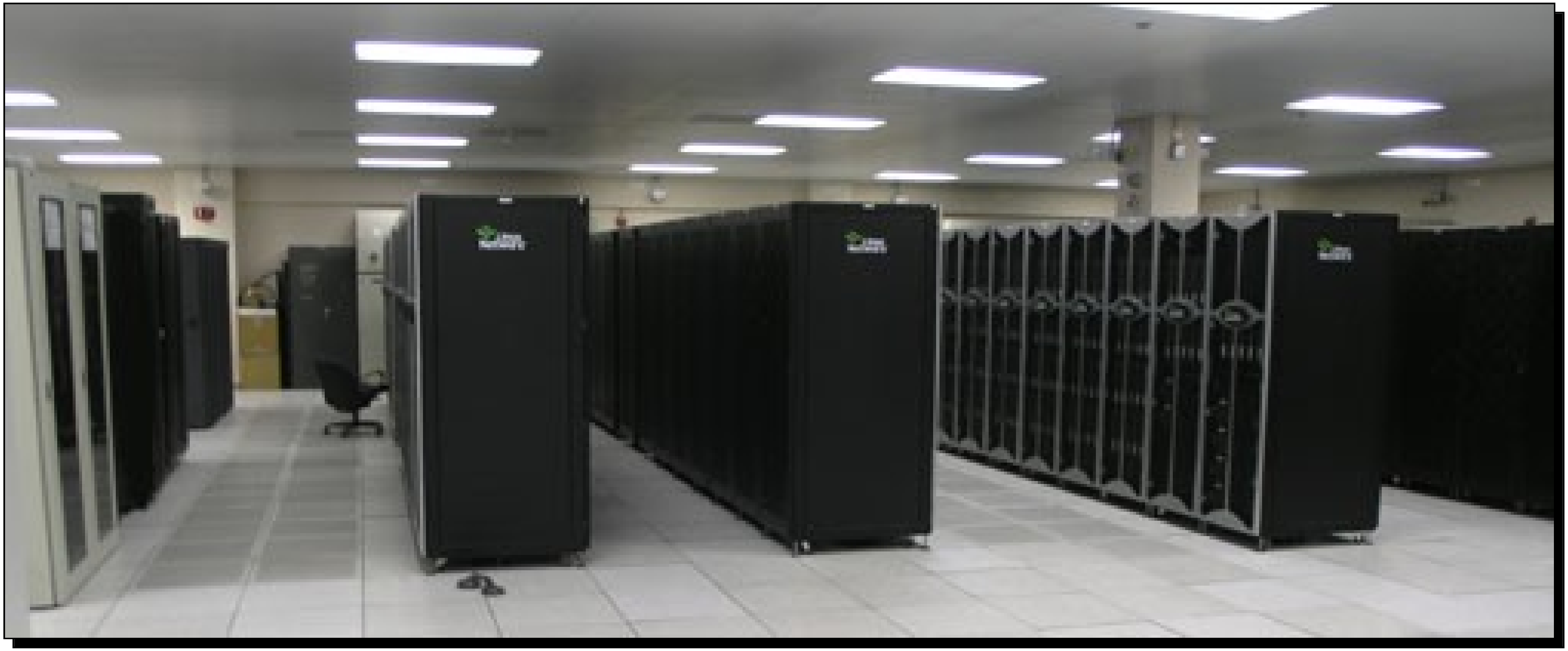

Acknowledgments

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Motivation

- I discovered in 2007 that some of our IB software is, ah, not quite as mature as I thought
- “IB-only boot? Solved problem”
- Well, maybe

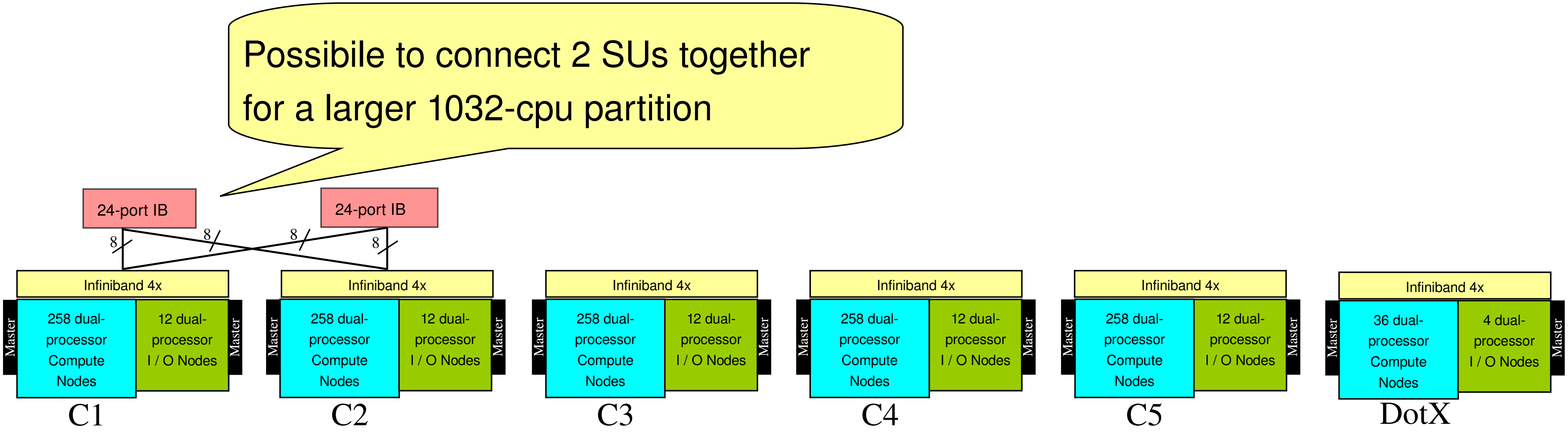
PXE on IB experiences: 2007

- I just tried for SC 07 to set up BluePod cluster to use the PXE-in-firmware on Mellanox cards
- Not surprised, not shocked: required wget this, patch that, things did not quite work
- So, IB has come far, but we're still lacking on the basics
- And I still talk to people who want an “IB only” solution -- and we did this in 2005 at LANL

Overview

- What Coyote is
- The challenge: IB only boot, compute, operate
- How it all fit together
- Challenges and fixes

Coyote



Possibile to connect 2 SUs together
for a larger 1032-cpu partition
24-port IB
24-port IB
8
8
8
8
Infiniband 4x
Master
258 dual-processor Compute Nodes
12 dual-processor I / O Nodes
Master
C1
Infiniband 4x
Master
258 dual-processor Compute Nodes
12 dual-processor I / O Nodes
Master
C2
Infiniband 4x
Master
258 dual-processor Compute Nodes
12 dual-processor I / O Nodes
Master
C3
Infiniband 4x
Master
258 dual-processor Compute Nodes
12 dual-processor I / O Nodes
Master
C4
Infiniband 4x
Master
258 dual-processor Compute Nodes
12 dual-processor I / O Nodes
Master
C5
Infiniband 4x
Master
36 dual-processor Compute Nodes
4 dual-processor I / O Nodes
Master
DotX

- Linux Networx system:
  - 5 Scalable Unit (SU) clusters of 272 nodes + 1 cluster (DotX) of 42 nodes:
  - Dual-2.6GHz AMD Opteron CPUs (single core)
  - 4GB memory / CPU
- 272 node SUs:
  - 258 compute nodes + 1 compute-master
  - 12 I/O nodes + 1 I/O-master
- 42 node DotX:
  - 36 compute nodes + 1 compute-master
  - 4 I/O nodes + 1 I/O-master
- Not pictured: 4 compile & 10 serial job nodes

- System Software
  - 2.6.14 based Linux – Fedora Core 3
  - Clustermatic V4 (BProcV4)
  - OpenMPI
  - LSF – Scheduler
  - PathScale Compilers (also gcc, pgi)
  - Mellanox AuCD 2.0 – OpenSM/Gen2
- System Monitoring
  - Hardware monitoring network (not shown) accessed via third network interface (eth2) on master nodes provides for console and power management via conman and powerman.
  - Environment monitoring via Supermon

Coyote boot software (beoboot)

- This software can support any cluster system
- i.e., on top of this:
- can build Rocks, Oscar, OneSIS, Tripod, etc.
  - This software is *not* bproc or Clustermatic specific
- It *is* (in my experience) the fastest, most scalable boot system
- Because it uses Linux to perform the boot, not PXE or similar systems

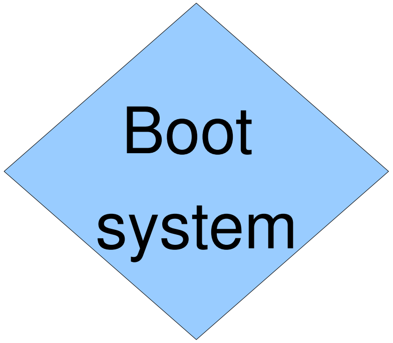
The Challenge: IB only compute, boot, operate

- Early goal was to build Coyote with one, not two, networks
- Experience on Pink and Blue Steel with Ether
  - Pink: Ethernet not needed, greatly reduced cost
  - Pink: Motherboard issues with Ethernet on IO nodes delayed delivery
  - Blue Steel: Ethernet *was* needed, greatly increased headaches

Digression: A note on failure models

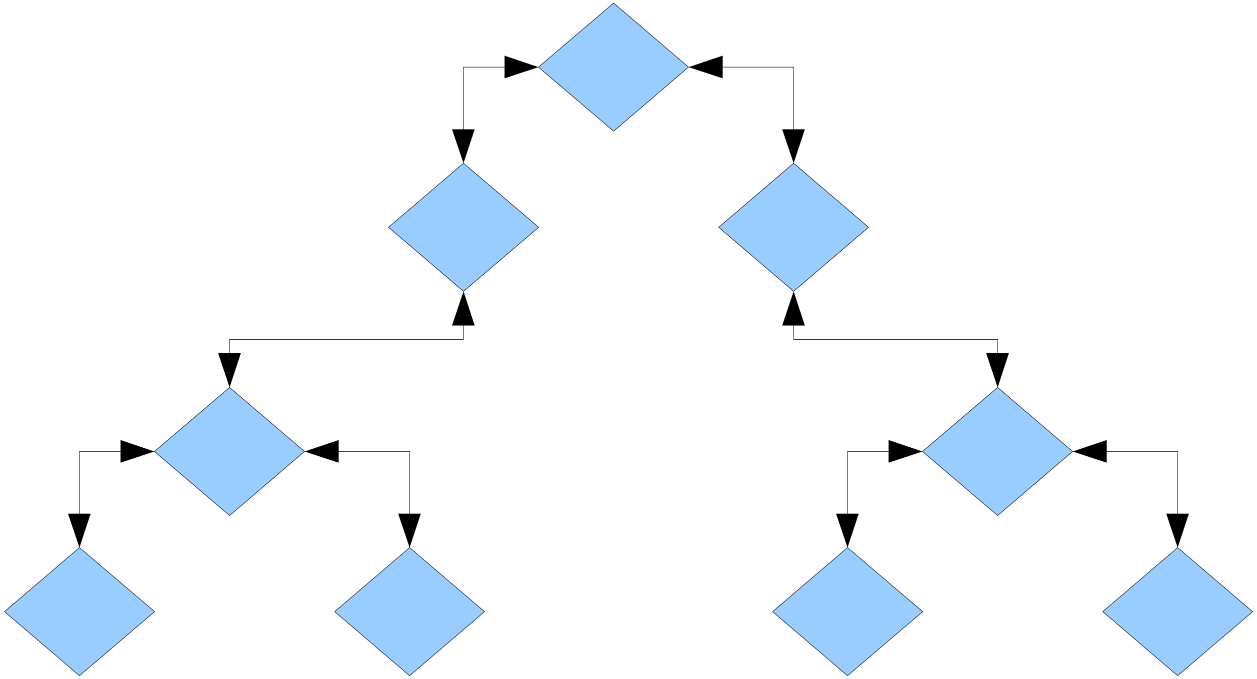
- It is odd to this day to see that the concept of points-of-failure is misunderstood
- People *do* understand a single point of failure
- People *don't always* understand that *multiple points of failure* is not the same as *no single point of failure*
- This confusion leads to strange design decisions

Example: boot management



- Here is a boot system for a 1024-node cluster
- “But it's a Single Point Of Failure”
- So people frequently do this:

Example: boot management: hierarchy of tftp servers



- What happens if one node goes out?
- Answer determines if this is MPOF
- In most cases, it is: you lose some nodes

Coyote software components Firmware (i.e. in BIOS/CF)

- LinuxBIOS
- Linux kernel with:
  - IB Gold stack, IPoIB
  - beoboot
  - kexec
- These components were sufficient to provide a high performance, scalable, ad-hoc boot infrastructure for Coyote

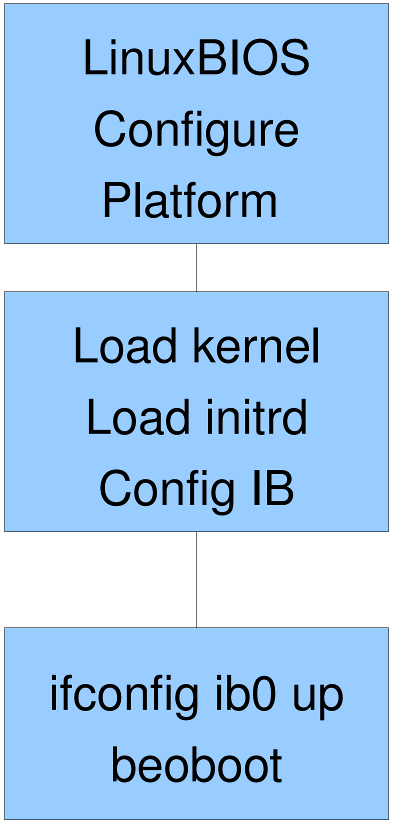
Note: Kernel was in Compact Flash

- In many cases we can put LinuxBIOS + Linux in BIOS flash
  - (see: http://tinyurl.com/2umm66) Linux + X11 BIOS!
- Once we add myrinet or IB drivers, standard FLASH parts are too small (only 1 MB)
- Long term goal:Linux back in BIOS FLASH
  - Else have to fall back to Ether + PXE!
- Newer boards will have 4 MB and up parts

Coyote master node

- This node controls the cluster
- It is contacted by the individual compute/IO nodes for boot management
- Provides a Single Point Of Failure model with *ad-hoc tree* boot system (more on that later)
- Fastest way to boot; far faster than PXE

Coyote boot process

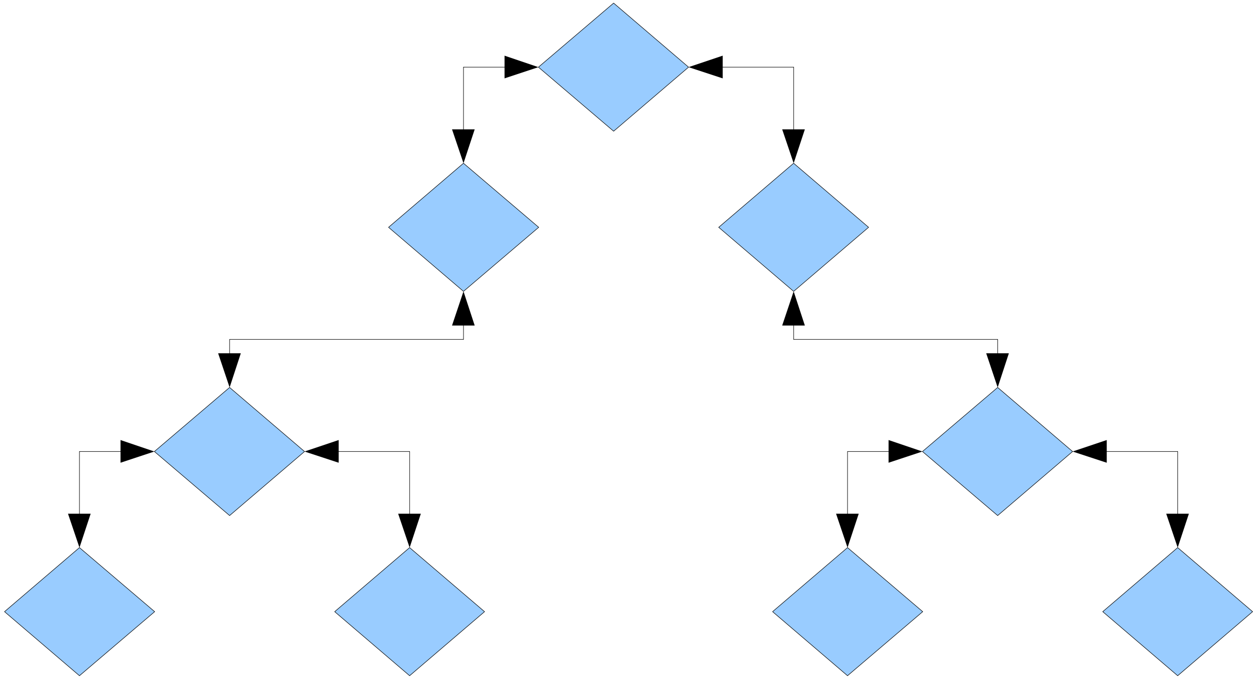


- LinuxBIOS is not required, just a good idea
- Initrd contains drivers
- At this point, modprobe+ifconfig worked fine (thanks!)
- Thanks to Hal for DHCP that worked

Why not just use PXE at this point?

- The problem: PXE is slow and unsophisticated
- Requires network card firmware to make the card act like an ethernet
- Simple-minded, slow, programmed-IO device model
- In practice, we have booted 1024 node clusters with Linux in the time it takes PXE to *not* configure one network interface

PXE inefficiencies lead to construction of unreliable boot setup

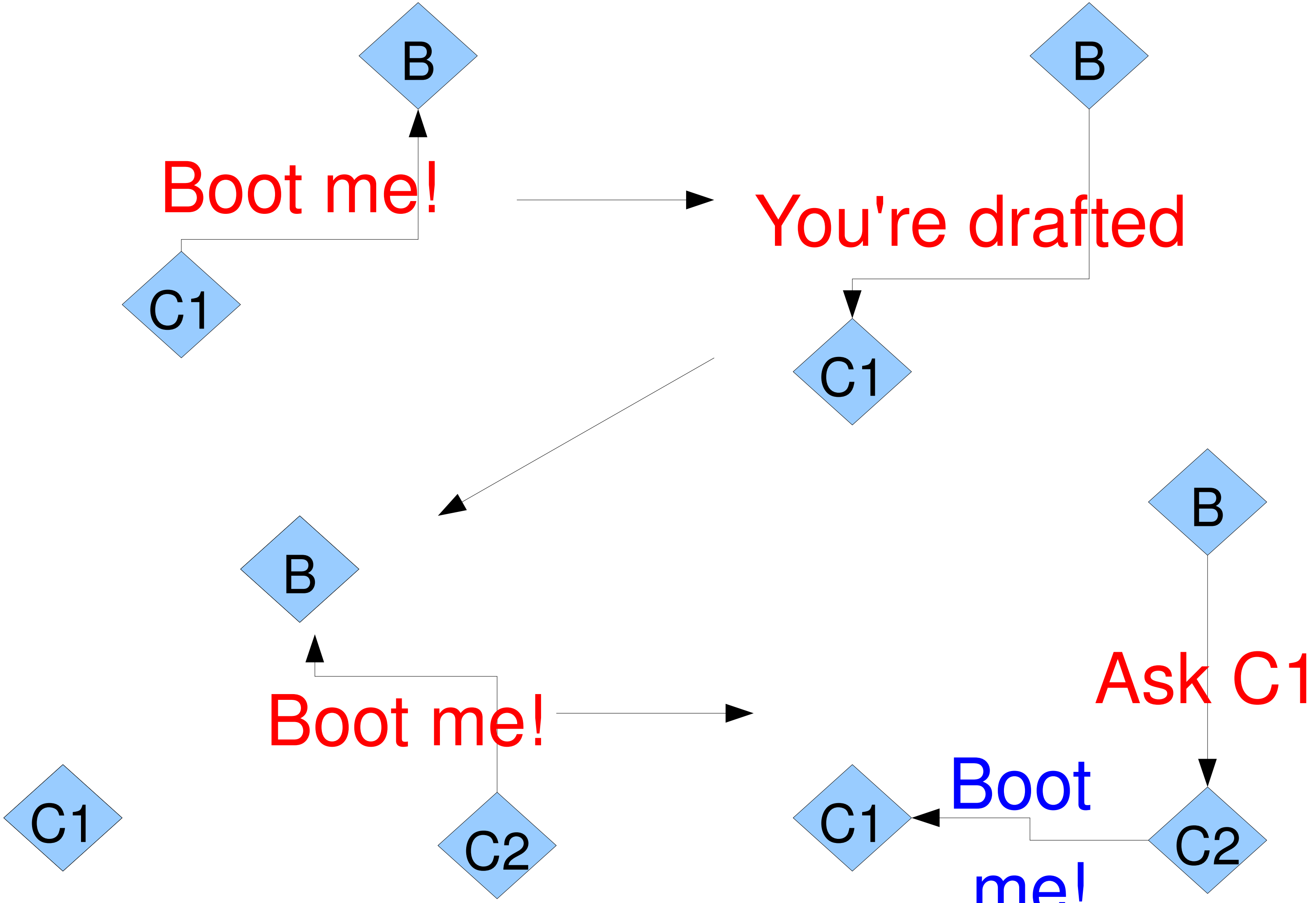


- Our old friend, MPOF, we meet again

The right way to boot

- Use the strengths of the HPC network and Linux
- We'd been doing this at LANL since 2000, and understood it pretty well
- The idea is simple: conscript the booting nodes to help boot other nodes
- That's the beoboot component

Booting fast and reliably



Ad-hoc tree boot

- In practice, this is incredibly fast
- Image distribution: 1024 nodes, < 10 seconds
- Most boot time: Linux serial output
- Extraordinarily reliable
  - Tested, fast Linux drivers
  - Not slow, buggy PXE drivers
  - Who wants 10Gb IB to emulate 10 Mb ethernet?

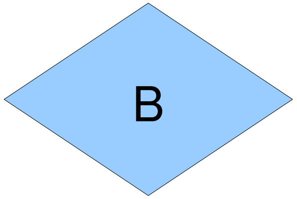
Next steps

- Beoboot used special protocol
- We have moved to 9p-based system called xbootfs

9P?

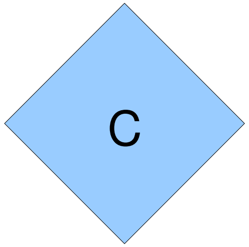
- New (to Linux) file system protocol
- Extremely light weight, easy to program
- Can be mounted via Linux 9p file system
- Created a new program called xbootfs
- Testing on clusters at LANL, SNL, partners

xbootfs



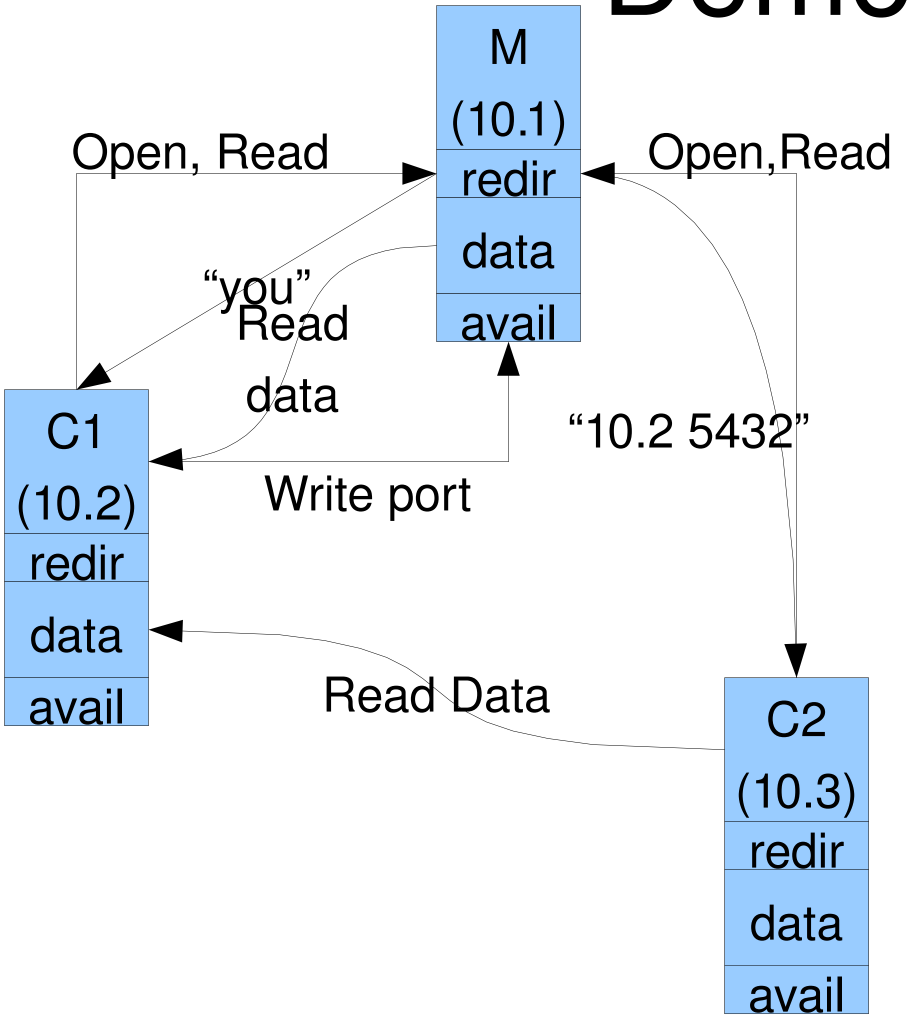
serves “files”:

data, avail, redir



- Client: Open redir
- Read “IP”, or “me”, or “you”
- If “me”, open “data”, read, done
- If “you”, also become server
- if “IP”, go to other client for data

Demo ...


M
(10.1)
redir
data
avail
Open, Read
Open,Read
“you”
Read
data
C1
(10.2)
redir
data
avail
Write port
“10.2 5432”
Read Data
C2
(10.3)
redir
data
avail

Once a client becomes a server

- Other clients are redirected to it
- Clean, easy recursion
- In tests, it's fast and easy to modify

Conclusions

- IB-only systems are best built with Linux “firmware”
- Ad-hoc trees use HPC network for booting, eliminate slow, failure-prone static trees
- Have been working since 2005
- Our next-gen software builds on 9p protocol (working on *BSD, Linux, MACOS, ...)