Campus Networking Workshop
CIS 399

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Course Notes

• Course Participants:
  – US Computer Science Students
  – Undergraduate students from China
  – Network and IT professionals from Africa and South Asia

• Course Grading (US CS Students Only)
  – No exams
  – Attendance and participation is mandatory
Daily Schedule

• 08:30am-10:00am Morning Session I
• 10:00am-10:30am Morning Break
• 10:30am-12:30pm Morning Session II
• 12:30pm-01:30pm Lunch
• 1:30pm-03:00pm Afternoon Session I
• 03:00pm-03:30pm Afternoon Break
• 03:30pm-05:00pm Afternoon Session II
Week at a Glance

- Monday: Introduction and Cabling Systems
- Tuesday: Layer 2 (in-building edge)
- Wednesday: Layer 3 (campus core routing)
- Thursday: Advanced routing (border)
- Friday: Network Management and Network Engineering Round Table
Today

• Morning session 1:
  Campus Network Best Practices
• Morning session 2:
  Cabling Infrastructure Design
• Afternoon session 1 & 2:
  Fiber termination lab (NSRC Students)
or campus network tour (rest of group)
Why Are We Doing This?

• Our goal is to build networking capacity to support Research and Education
  – Remember: University = Research & Education
• The end game is regional, national, and larger Research and Education Networks (RENs)
• All RENs start with campus networks – they are the foundation of the REN
Why a REN?

• Enable research or services that could not be accomplished otherwise
• Cost Savings (buyers club)
• Vision of building alliances
• Successful RENs find that there are unanticipated benefits
REN Services

• What services are provisioned? Various models:
  – REN provides all Internet connectivity
  – Peering network to exchange traffic between members
  – Advanced peering network that might
    • Develop or peer with a local commercial exchange
    • Provide international connections (GEANT, etc)
  – Other services (video conferencing)
REN as Internet Service Provider

Internet

Internet exchange point

Member

Member

Member

Member
REN as Peering Network

Diagram:
- Internet
- REN
- Member
- Member
- Member

Connecting lines indicate peering relationships between these networks.
What model of NREN will you use?

• NREN as Primary Internet Service Provider?
• NREN as local peering between members?
• NREN as local peer plus other peers?
• What are implications from a public IP and Autonomous System Number perspective of these models?
Who Needs ASN?

• Very Simple:
  – Anyone who is multi-homed (connected to multiple outside networks) needs an ASN

• All RENs need ASN

• Any multi-homed campus needs ASN
Who Needs Public IP Space?

• Every campus must have Public IP address space
• Question is really: Provider dependent or provider independent.
• If provider is REN, then REN must have public IP address space for customers
• Any large campus should have provider independent IP address space
Provider Independent IP Addresses

• What are provider independent IP addresses?
  – Public IP addresses that are not allocated to you by your Internet Service Provider.

• Can move between service providers without renumbering

• If REN assigns IP, then it is NOT provider independent, your REN is a provider
To NAT or not to NAT

• NAT is common technique to reduce number of IP addresses required
• NAT makes some things hard.
  – NAT breaks things like SIP (standard-based VoIP), which you have to work around
  – NAT translation device needs to know about applications. Stifles innovation.
• NAT is probably a reality for some
• Still need some public IP space
What About Campus Networks?

• The Campus Network is the foundation for all Research and Education activity
• Without a good campus network, the Research and Education Network can’t work as well as it should
• Ad-hoc campus networks work OK with VSAT uplinks, but moving to high speed external links, they start to fail.
Campus Network Personnel

• Every campus should have at least one person who does nothing but work on the network. Not email systems, not course management systems. Just networks.
• Larger campuses will need more
• University of Oregon has 8 people just doing networking plus 3 doing security
  – Started small 20 years ago with 2 people
Why is This Stuff Important

• The campus network is the foundation that all services are provisioned on
• Ad hoc networks just don’t work well
• Without a plan, how will you know where to make investments?
• You must develop a plan to get Provider Independent Public IP address space
Campus Network Rules

- Build Separate Core and Edge Networks
- Minimize number of network devices in any path
- Use standard solutions for common situations
- Provide services near the core
- Separate border routers from core
- Provide opportunities to firewall and shape network traffic
Core versus Edge

• Core network is the “core” of your network
  – Provides service between buildings
  – Must have reliable power and air conditioning
  – May have multiple cores
  – Always route in the core

• Edge is toward the edges of your network
  – Edge is inside of individual buildings to individual computers
  – Always switch at the edge
Core versus Edge

Core Router

Fiber Optic Links

Building

Fiber Optic Links

Building

Fiber Optic Links

Building

Fiber Optic Links

Building
Minimize Number of Network Devices in the Path

- Build star networks

- Not daisy chained networks
Edge Networks

• Make every network look like this:

![Diagram of fiber link to core router]
Edge Networks Continued

• Build Edge network incrementally as you have demand and money

• Start Small:

Fiber link to core router
Edge Networks Continued

• Then as you need to add machines to the network, add a switch to get this:

![Diagram of network with fiber link to core router]
Edge Networks Continued

- And keep adding switches to get to the final configuration
Edge Networks Continued

• And keep adding switches to get to the final configuration
Edge Networks Continued

• Resist the urge to save money by breaking this model and daisy chaining networks or buildings together

• Try hard not to do this:
Edge Networks Continued

- There are cases where you can serve multiple small buildings with one subnet.
- Do it carefully.
- Two basic models:
  - Switch in core location
  - Copper or fiber link to core router
  - Fiber link to core router
  - Cat5e or fiber
  - Fiber circuits to small buildings
  - Cat5e or fiber
Core Networks

Core Router

Core

Edge

Fiber Optic Links

Building

Building

Building

Building

Building
Core Network

- Reliability is the key
  - remember many users and possibly your whole network relies on the core
- May have one or more network core locations
- Core location must have reliable power
  - UPS battery backup (redundant UPS as your network evolves)
  - Generator
- Core location must have reliable air conditioning
- As your network evolves, core equipment should be equipped with dual power supplies, each powered from separate UPS
- Border routers separate from Core
- Firewalls and Traffic Shaping Devices
- Intrusion Detection
- Intrusion Prevention
- Network Address Translation
Core Network

- At the core of your network should be routers – you must route, not switch.
- Routers give isolation between subnets
- A simple core:

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Border Router                  Firewall/
                                 Traffic Shaper
                                 Core Router
                                 ...
                                 Central
                                 Servers for
                                 campus
                                 Fiber optic links to remote buildings
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All router interfaces on a separate subnet
Border Router

- Connects to outside world
- RENs and Peering are the reason you need them
- Must get Provider Independent IP address space to really make this work right
Remember the Rules

• Build star networks – don’t daisy chain
• Use managed switches
  – You can’t do a lot of things I’ve talked about with unmanaged switches
  – re-purpose your old unmanaged switches for labs
• Route in the core
• Switch at the edge