Network Redesign at Bates College

MTUG 2018
If the network is supposed to be up all of the time, then how do you maintain and upgrade it?
Bates College

“A private, highly selective, residential college devoted to undergraduate study in the liberal arts...”

5,526 applicants, 498 enrolled, including 43 from Maine in Freshman class

1,780 students, Maine is the 3rd most represented state

88% graduation rate

95% of first year students return for sophomore year

47% of students receive aid

100% of student need met
Bates College Campus
Network Topology - Before

Collapsed backbone

Layer 2 switching

Core distribution layer based on Juniper Virtual Chassis

Virtual Chassis made up of 5 ex4500 series switches across campus
Network Topology - After

Distributed backbone

Layer 3 routing

Core aggregation layer based on Juniper qfx5100 series switches across campus
Why Change?

ex4500 nearing end of life

Increase network core speed from 10Gb

Redundant uplinks to avoid single points of failure

Easier upgrades to core software than on Virtual Chassis
Where do layers come from?

Developed by International Organization for Standardization (ISO) in the 1970s

Source: http://www.zeronetwork.co.in/2015/06/osi-model.html
Layer 0 - Bates campus

133 acres in Lewiston, Maine

Some buildings were built before the college founding in 1855

Continuous renovation and new construction

Buried conduit for data and phone cables connects all major buildings and most others

Some with generator backup
Layer 1 - Fiber Network

62.5 micron multi-mode from 1990s: 220 meters, 1 Gigabit

50 micron multi-mode from 2000s: 300 meters, 1-10 Gigabit

9 micron single-mode from mid-2000s: 40,000 meters 1-10-40 Gigabit
Layer 2 - Ethernet Frame

Created by DEC, Intel, and Xerox in 1970s

Media Access Control

MAC Address

48 bits - 6 bytes
00:00:00:00:00:00
ff:ff:ff:ff:ff:ff

Source: http://docwiki.cisco.com/wiki/Ethernet_Technologies
Layer 2 - Network Core

Juniper Virtual Chassis ex4500 switches

- 280 College FCP4 line
- Lane FCP3 line
- Pettengill FCP0 master
- Coram FCP2 backup
- Dining FCP1 line
Juniper Junos

switch / router OS based on NetBSD

CLI via serial console or SSH

GUI via web browser
Layer 3 - IP Packet

Invented by Vint Cerf and Bob Kahn in the 1970s

IP address (v4)
32 bits

134.181.139.37

“dotted quad”
0-255

Maintaining Reliability

Regular software upgrades - PM

Regular hardware upgrades - EOL, BYOD

Control and Data Planes for online changes

Juniper and Cisco options for fallback (confirm, rollback and reboot)
Multi-Chassis LAG

Juniper MC-LAG
Cisco Virtual PortChannel
Cisco Multichassis Etherchannel

Source: Juniper nce-143-mid-size-enterprise-campus-solution.pdf
Layer 2 - Spanning Tree

Redundant links but not all are used

Convergence

Avoid spanning tree with VC, LAG, or L3
Options

MC-LAG - SP focus, complicated, not on all hardware models

RTG - still unused links, just rapid convergence

L3 at buildings - diverse paths, easy to upgrade or replace a device
L3 issues

Some devices still require L2 connectivity across campus

EVPN / VXLAN

Can’t have L2 and L3 on the same interface

Need a routing protocol

IP addressing changes
L3 implementation

Reconfigure the distribution and access switches in a building
  ex4200 - adds routing to previous switching role
  ex2200 - change VLANs and management configuration
Add 2nd link for L2 network
Update DHCP servers
Update DNS servers
Add OSPF routing protocol
Routing Protocols

Static
RIP
OSPF
BGP
  iBGP
eBGP
OSPF history

Open Shortest Path First
Link-State
Developed in 1991 by John Moy
OSPF handshake

3 way handshake ensures bi-directional connectivity
OSPF priority

Designated router
OSPF route injection
OSPF metrics
OSPF guidelines
L3 at Building Switches

No spanning tree convergence issue

Diverse paths
L3 Implementation at Bates

PM opportunities
Minimize disruption to academic activities

First Approach
  Do everything at one time

Second Approach
  Parallel installation in a building to allow phases
Operational Issues

DHCP
  Protocol handshake
  Helper / Relay

MAC-IP binding
  L2 forwarding
  L3 routing

ARP
Operational Issues

Computers
  Macs
  Windows
  Linux
Printers
Audio-Visual equipment
Security - cameras, etc.
Building Automation equipment
Future Projects at Bates

Multi-Rate switches for increased AP bandwidth
Data Center Interconnect
Juniper MC-LAG
Juniper VXLAN
Vendor Partners:
  Juniper, Jason Rioux, Systems Engineer

Bates College, Information and Library Services, Network and Infrastructure Services:
  Jim Bauer, Director
  Rob Spellman, Associate Director for Network Services
  Kevin Poland, Network Infrastructure Project Manager
  Ryan Odom, Network Infrastructure Project Manager
  Karen McArthur, System Administrator
  Bruce Hall, Network Administrator
Future MTUG Topics?

Cable management (over time and at scale, documentation, labeling)

Network Monitoring

Network Management and Automation

802.1X Network Access Control

Emerging standards for 2.5Gb and 5Gb on copper