Why our campus network needed SDN functionality *yesterday*…

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Today’s network challenges

• Increasing security and privacy concerns
• Network load/performance expectations
• Increasing availability expectations
• More wireless traffic
• Increasing management complexity
• Growing technical debt generally

How fundamentally different is this list from 15 years ago?
Observations

• It’s about the services!
• We must overlay the campus network architecture designed around geography and organization with one based on role, function, and risk.
• Paradoxically, as we increasingly rely on outsourced cloud services, network ownership, management, and reliability are more important than ever.
• Identity services could be even more important – especially when used in support of SDN.
• We now see greater overlap between the network research and computational science disciplines.
Emerging campus network requirements

• Network segmentation capability
  • High performance – Science DMZ
  • Protected information
  • High reliability
• Close tie to campus IdAM service
• Centralized and scalable device management
• Compatibility with IPv4/v6 installed base
• Lower total cost of ownership
  • Every CIO knows at least one thing about SDN
    – merchant silicon
The University of Utah: the fourth node on the ARPANET

ARPANET (1969-1980)
Univ. of Utah Computer Science Department
(now School of Computing)

FIGURE 6.2 Drawing of 4 Node Network
(Courtesy of Alex McKenzie)
INTERNET2 NETWORK ADVANCED LAYER 3 SERVICE
October 2014

VLANs over Layer 3 service to connect with other Internet2 Advanced Layer 2 service users and peers

INTERNET2 NETWORK BY THE NUMBERS

- 17: JUNIPER MX960 ROUTERS SUPPORTING LAYER 3 SERVICE
- 34: BROCADE AND JUNIPER SWITCHES SUPPORTING LAYER 2 SERVICE
- 62: CUSTOM COLLOCATION FACILITIES
- 250+: AMPLIFICATION RACKS
- 1,017: MILES OF NEWLY ACQUIRED DARK FIBER
- 8.3: Gbps of optical capacity
- 110: Gbps of hybrid Layer 2 and Layer 3 capacity
- 350+: CIENA ACTIVITIES 5000 NETWORK ELEMENTS
- 2,400+: MILES PARTNERED CAPACITY WITH ZAVO COMMUNICATIONS IN SUPPORT OF THE NORTHERN TIER REGION
Partnership approach

- Campus partners
  - Network research – Emulab/protoGENI/CloudLab
    - Flux research group, School of Computing
  - Computational science
    - Center for High Performance Computing (UIT)
  - Production network
    - UIT Common Infrastructure Services (IdAM, too)
    - UIT Information Security Office
  - Advanced regional network
    - Utah Education Network (UEN)
- External partners – many!
  - Internet2, GENI, NSF, NTIA, NOAA, UDOT, UTA
  - ACI-REF and CloudLab national collaborations
University Information Technology

Utah CC-NIE Integration project: *Science Slices* (NSF #ACI-1341034)
PI: S. Corbató; co-PIs: A. Bolton, T. Cheatham. R. Ricci, K. Van der Merwe; SP: J. Breen, S. Torti
Premise (Rob Ricci): What if we flipped the concept and built our Science DMZ on top of SDN infrastructure, rather than just plugging our SDN testbed into the DMZ?

1) Building a dynamic Science DMZ on top of an SDN-based framework (GENI)

- Detailed Ingredients:
  - Domain Science Workflow
  - Domain Science Instruments
  - Computer Science Technology
  - Advanced, Dynamic, Instrumented Infrastructure
  - Multi-Disciplinary Research Collaboration
  - Research, Central IT, HPC, student collaboration

2) Extending slices to key campus labs, HPC center, and the Honors residential community

3) Working closely with central IT, campus IT Governance, and Utah Education Network

Target areas:
- Molecular dynamics
- Astrophysics data
- Genomics
- Network/systems research
- Honors students

Leverages new infrastructure:
- Downtown Data Center
- Utah Optical Network (BONFIRE)
- NSF MRI for novel cluster (Apt)
- Campus Net Upgrade
The Advanced Profile-Driven Testbed

- Dual purposes
  1) A platform for sharing research artifacts and environments
  2) A facility for building testbeds tailored to specific domains
- 56 Gbps Ethernet/Infiniband
- Funded under NSF MRI award #1338155 (Rob Ricci, PI)
What Is CloudLab?

- Supports transformative cloud research
- Built on Emulab and GENI
- Control to the bare metal
- Diverse, distributed resources
- Repeatable and scientific

Slice A
Geo-Distributed Storage Research

Slice B
Stock OpenStack

Slice C
Virtualization and Isolation Research

Slice D
Allocation and Scheduling Research for Cyber-Physical Systems

Utah
Wisconsin
Clemson
GENI

CC-NIE, Internet2 AL2S, Regionals
CloudLab’s Hardware

One facility, one account, three locations

- About 5,000 cores each (15,000 total)
- 8-16 cores per node
- Baseline: 4GB RAM / core
- Latest virtualization hardware
- TOR / Core switching design
- 10 Gb to nodes, SDN
- 100 Gb to Internet2 AL2S
- Partnerships with multiple vendors

Wisconsin
- Storage and net.
- Per node:
  - 128 GB RAM
  - 2x1TB Disk
  - 400 GB SSD
- Clos topology
- Cisco (OF 1.0)

Clemson
- High-memory
- 16 GB RAM / core
- 16 cores / node
- Bulk block store
- Net. up to 40Gb
- High capacity
- Dell (OF 1.0)

Utah
- Power-efficient
- ARM64 / x86
- Power monitors
- Flash on ARMs
- Disk on x86
- Very dense
- HP (OF 1.3)
Technology Foundations

- Built on Emulab and GENI (“ProtoGENI”)
- In active development at Utah since 1999
- Several thousand users (incl. GENI users)
- Provisions, then gets out of the way
  - “Run-time” services are optional
- Controllable through a web interface and GENI APIs
- Scientific instrument for repeatable research
- CloudLab already federated with GENI
- Availability
  - Now: Technology preview available!
  - Late 2014: Open to early adopters
  - Early 2015: Generally available
For more information
steve.corbato@utah.edu
www.aptlab.net
www.cloudlab.us

Remembering two sources of original ideas…

Jay Lepreau

RL “Bob” Morgan