Looking Beyond the Internet

The Rise of Software Defined Infrastructure

SwitchOn Workshop – Brazil / US at FIU

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Chip Elliott, BBN
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My thesis

• SDN is just an opening act

• A major transformation of the Internet has begun

• We can now catch glimpses of what lies beyond

• We can get there by a series of step by step actions
Where I am coming from - GENI

We’re building out GENI through universities across the US

Funds in hand
Need funding
Self funding
As of 2/2014
Slices and deep programmability

Install the software I want *throughout* my network slice (into firewalls, routers, clouds, ...)

And keep my slice isolated from your slice, so we don’t interfere with each other

We can run many different “future internets” in parallel
Agile, deeply programmable infrastructure

• Emerging technologies that enable coherent network / processor / storage virtualization provide a great basis for agile cyber infrastructure.
Slices span many organizational boundaries

My experiment runs across the evolving GENI federation.

My GENI Slice

Backbone #1

Backbone #2

Campus #1

Campus #2

Campus #3

Commercial Clouds

Corporate GENI suites

Other-Nation Projects

Research Testbed

NSF parts of GENI

Goals: avoid technology “lock in,” add new technologies as they mature, and potentially grow quickly by incorporating existing infrastructure into the overall “GENI ecosystem”
And it works! GENI is seeing heavy use

Over 3000 researchers as of 12/2014

Cumulative unique users

Looking Beyond the Internet

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Macro-scale: the Rise of Global Interoperability
And now just starting up - NSFCloud

Rob Ricci

Kate Keahey
The CloudLab Vision

- A “meta-cloud” for building clouds
- Build your own cloud on our hardware resources
- Agnostic to specific cloud software
  - Run existing cloud software stacks (like OpenStack, Hadoop, etc.)
  - ... or new ones built from the ground up
- Control and visibility all the way to the bare metal
- “Sliceable” for multiple, isolated experiments at once

With CloudLab, it will be as easy to get a cloud tomorrow as it is to get a VM today
Federated with GENI

- *CloudLab can be used with a GENI account, and vice-versa*
- GENI Racks: ~ 50 small clusters around the country
- Programmable wide-area network
  - Openflow at dozens of sites
  - Connected in one layer 2 domain
- Large clusters (100s of nodes) at several sites
- Wireless and mobile
  - WiMax at 8 institutions
  - LTE / EPC testbed (”PhantomNet”) at Utah
- International partners
  - Europe (FIRE), Brazil, Japan
What Is CloudLab?

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

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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

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

Utah
- Power-efficient
  - ARM64 / x86
  - Power monitors
  - Flash on ARM6s
  - Disk on x86
  - Very dense
  - HP

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Wisconsin/Cisco

Nexus 3172PQ
8X10G
40G
40G
2X10G

Nexus 3132Q

20X12 servers
Clemson/Dell: High Memory, IB

- 20 cores/node
- 8 nodes/chassis
- 10 chasses/rack
- 1 x 40 Gb IB/node
- 2* x 10 GbE OF/node
- 2*x 1 GbE OF/node
- 256 GB RAM/node
- 2 x 1 TB drive/server

* 1 NIC in 1st build
Use your GENI account or sign up now at CloudLab.us
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Major trends are converging

- Multi-tenant Datacenters
- Software Defined Networks
- Network Functions Virtualization (NFV)
- Distributed Datacenters
Driving the transformation -
A radical change in “router” economics

Economics now favor pervasive computation and storage

**ARPANET Imp** (1969)
- 1 core, clock ~ 1.1 MHz
- 64 Kbytes RAM
- No disk

**Today’s cost:** ~ $650,000

**Commodity GENI rack**
- Each 1U=
  - 32 cores, 2.1 GHz
  - 16 Gbyte, 4 Tbyte

**Today’s cost:** $200,000
for full rack (50 x 1U)

- Disk + controller (IBM 1302)
- **Today’s cost:** ~ $2,545,000

Disks were too expensive in 1969

1/3 the IMP’s price, but with 1500 cores and 200 Tbytes of local storage

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Instantiating services into slices

• Soon each switching point will be able to sustain 10,000 – 100,000 slices

• Can run arbitrary software in each slice

• Decoupling of “service” from infrastructure
Software Defined Infrastructure
We’re all heading to the same place

Rapidly create entire “sliced” cyberinfrastructure / networks on demand
Fast spin new protocols, switching strategies, virtual machines

Clouds
Grid
Network functions virtualization

Distributed Clouds

Software defined networks
Vnode
Ofelia
FLARE
US Ignite
Wivi
GENI

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The Rise of the “Service Store”

• “Drag and drop” Services
• Like an App Store . . .
• . . . that instantiates end-to-end Services

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Software Defined Infrastructure

Looking beyond the Internet

SDI apps from many players

Good old Internet

Federated, authenticated control plane (software)

Multiple, federated sites with interconnected Software Defined Infrastructure

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Where we are today – single-owner “islands”

Primary benefits right now: reduce cost, improve manageability

• Datacenters / clouds
• Experiments with enterprise / campus nets
• Wireless (cellular etc)

Early multi-domain SDN systems include Google and NTT – each datacenter is an SDN island, with a separate SDN WAN interconnecting them

(all same owner, though; no peering)
Necessary steps from today to SDI

• Step 1. Interconnect SDN islands

• Step 2. Make the network fully sliceable

• Step 3. Build out pervasive compute & storage
Step 1. Interconnect islands

SDN Workshop – Dec. 2013, Washington, DC

Inder Monga
ESnet Chief Technologist

About 100 networking experts from academia, industry, national labs and federal agencies

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SDN Workshop – Key themes (1)

• Software-Defined Networking (SDN) is understood as the entire distributed infrastructure needed for next-generation commercial and/or scientific applications – i.e., closely integrated compute, storage, and networks.

• SDN technology has the potential and momentum to provide game changing innovation to the entire Internet eco-system.

• Using SDN technology, we can now envision (and in practical terms, create) scientific “instruments on demand” or app-specific “infrastructure on demand” across multiple networks (multi-domain), on a worldwide scale.
SDN Workshop – Key themes (2)

- The time is right for deploying prototype operational, multi-domain SDNs.

- The focus of initial SDN deployments should include Software-Defined Exchanges (SDXs) to enable interoperability, co-designed in close collaboration with US industry.

- These efforts should actively engage key scientific instruments and next-generation applications as design and prototyping partners.

- A vigorous and sustained research program should investigate the security implications of multi-domain/multi-layer SDNs.
Conclusions

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