Networking Research Using GENI – From Network Access Control to Software Defined Exchanges

Boston, MA
May 23, 2016

Russ Clark

Georgia Tech

SoX – Southern Crossroads

CREATING THE NEXT

Georgia Institute of Technology

Who am I? Why am I here?

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Georgia Tech

GT-RNOC
Georgia Tech Research Network Operations Center

SoX™
Southern Crossroads

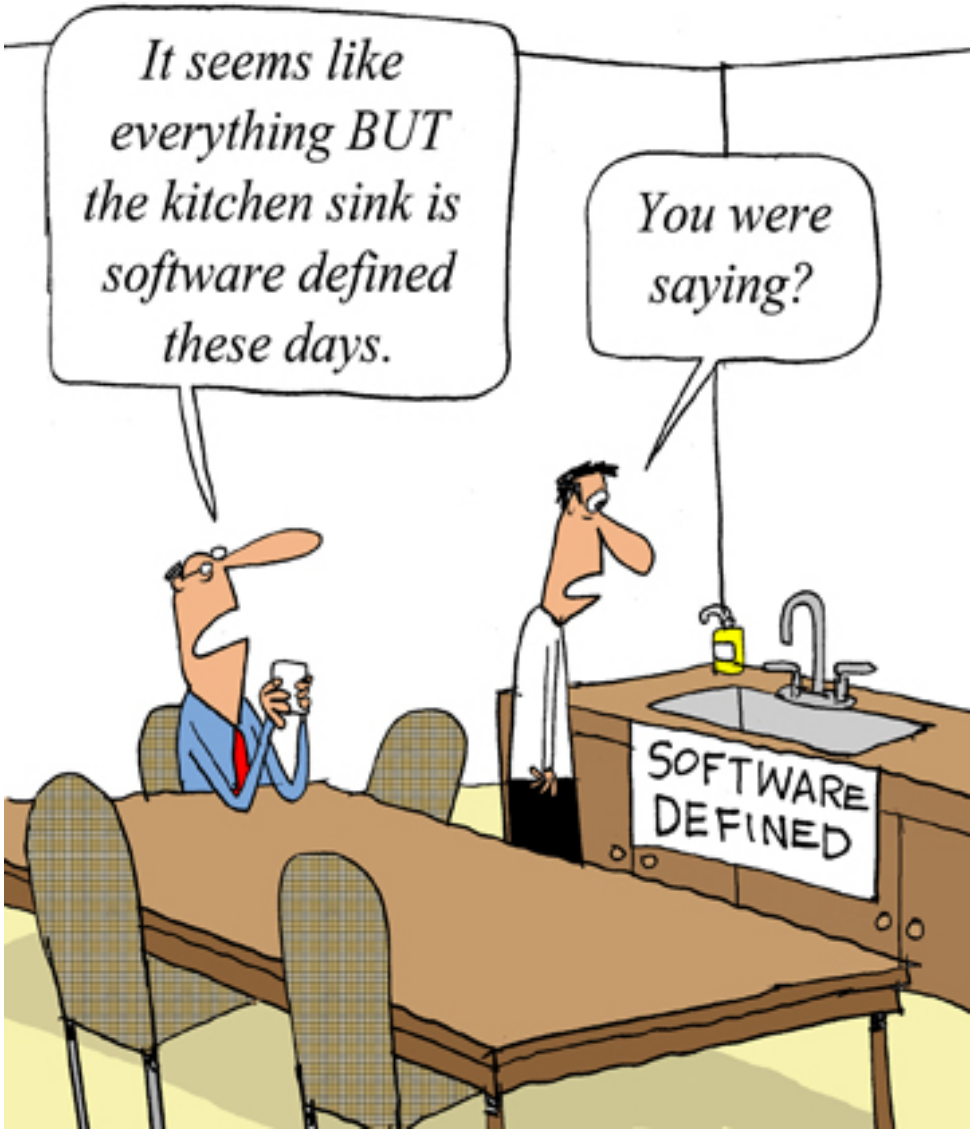
geni
Exploring Networks of the Future

I'm a networking guy at heart. I'm interested in how we can improve the way we operate and manage networks.

We've been at this GENI thing for awhile now

- Early Planning Work
  - w/ Ron Hutchins, Ellen Zegura
- OpenFlow Campus Trials
  - w/ Nick Feamster, Matt Sanders
- GENI @ SoX
  - Regional GENI networking – w/Cas D'Angelo
- GENI SDX – Software Defined eXchange
  - Software Defined Exchange – w/Nick Feamster, Arpit Gupta, Sean Donovan, et al

Software Defined Everything



Software Defined Networking

SDN is about separating the control plane from the data plane

- Open up the switch architecture
  - simplify switches
  - put logic and configuration into separate controllers
- The Results
  - more agility
  - less money
- OpenFlow is ONE EXAMPLE of a standard protocol that enables SDN

Software Defined Networking

Better Control of Our Networks

- Active Control Plane - control in real-time, not just maintenance windows
- Policy Management
  - better than VLANs, Subnets, Firewalls, IDS, IPS, etc
  - VLAN blunt instrument -> blunted further by Wi-Fi SSID
- Network Access Control
- Capacity Monitoring and Management
- Simplified Configuration - “virtual patch panel”
- Security, Data Privacy
  - better monitoring, finer-grained active control
- Better Student Projects!!!

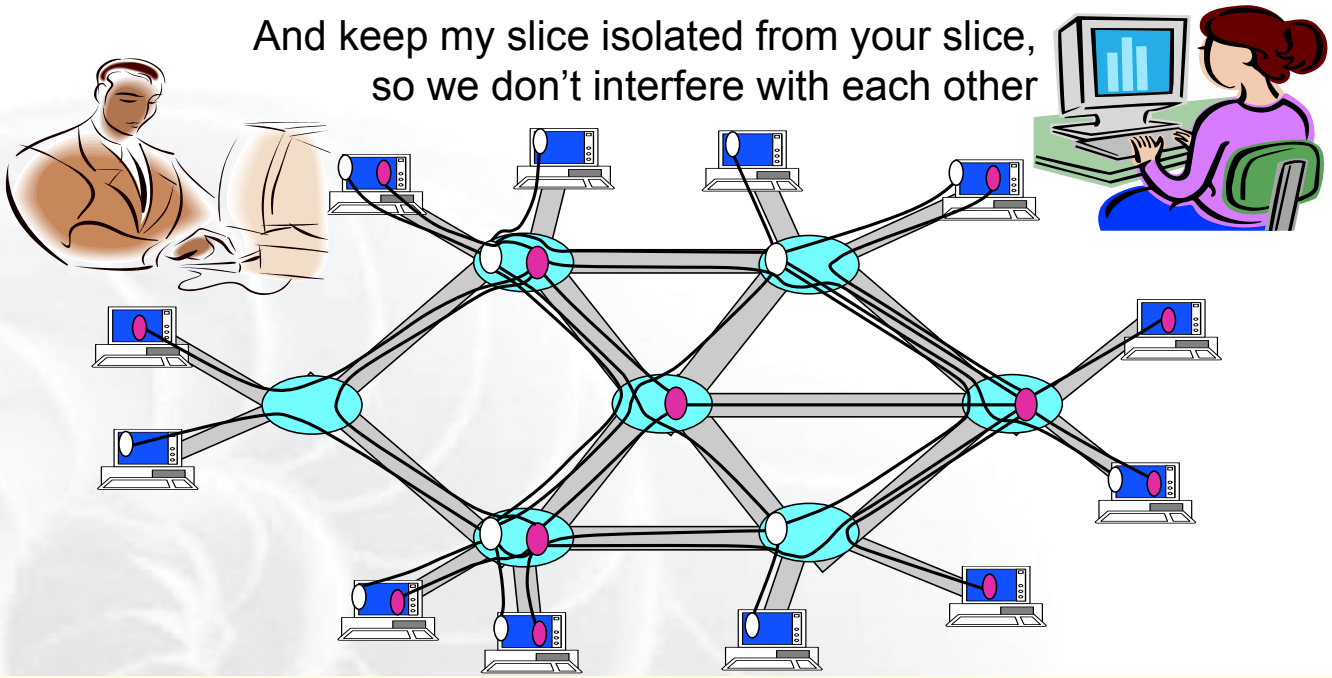
GENI Is A Great Place To Try This

geni
Exploring Networks of the Future

Revolutionary GENI Idea
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



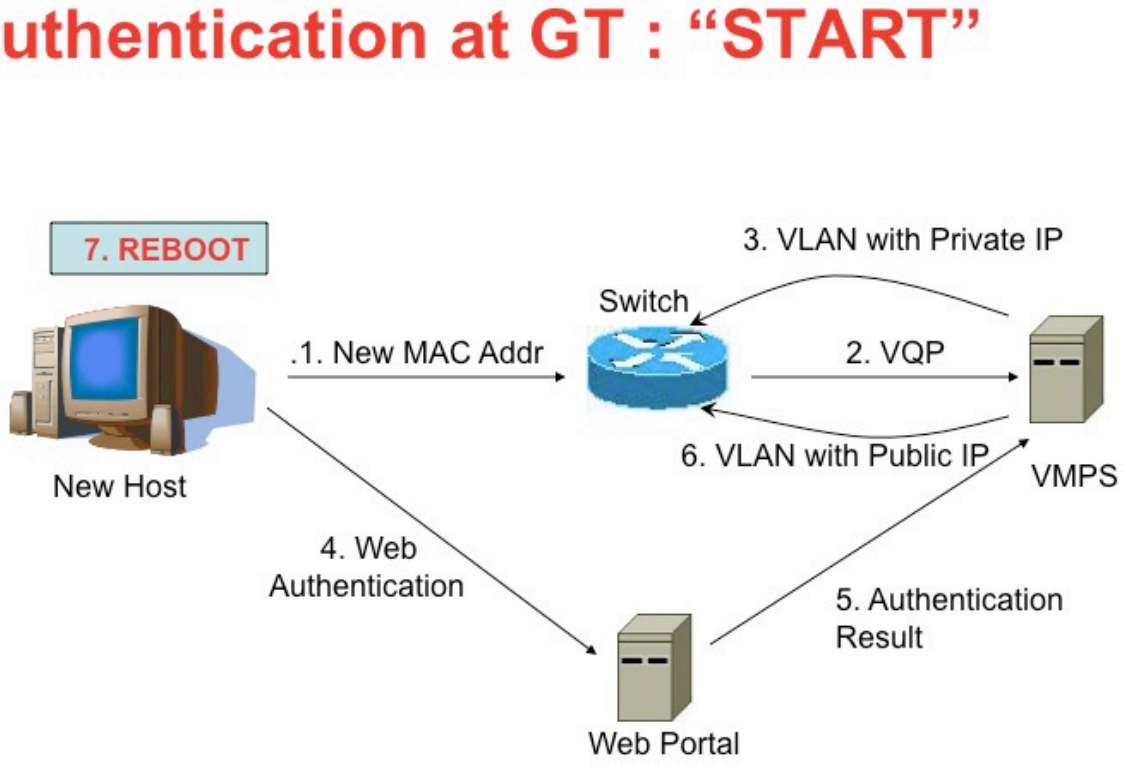
We can run many different "future internets" in parallel

Network Access Control

Our first real-world project for SDN

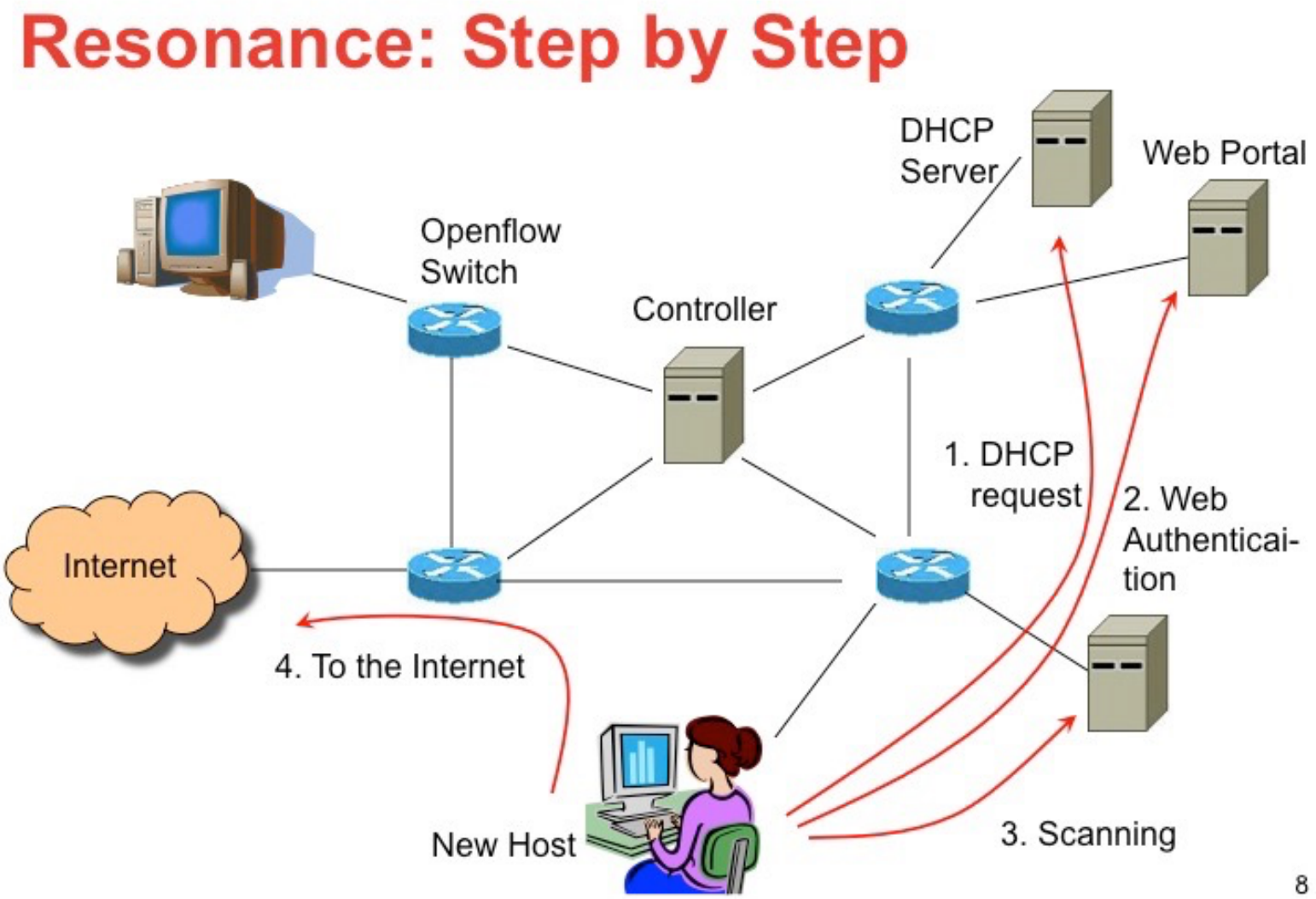
Replace the network access control system for our campus residence halls

Demonstrated at GEC 7



Nayak, A. Reimers, N. Feamster and R. Clark. "Resonance: Dynamic Access Control for Enterprise Networks". *ACM SIGCOMM Workshop on Research in Enterprise Networks (WREN)*. 2009.

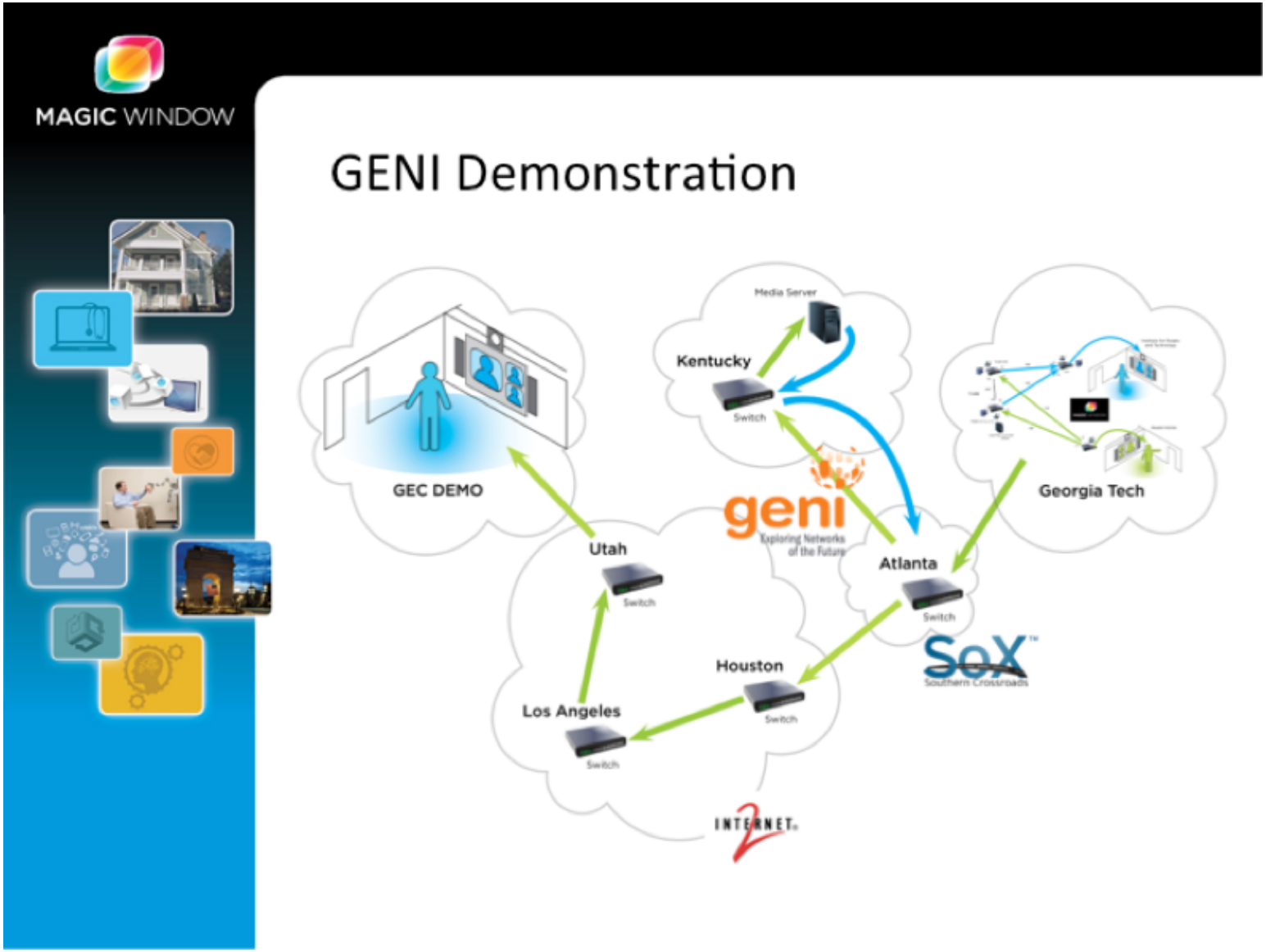
Network Access Control



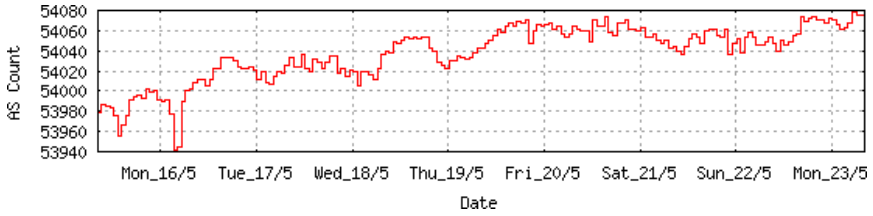
Video Augmentation

Enhanced Conferencing Experience

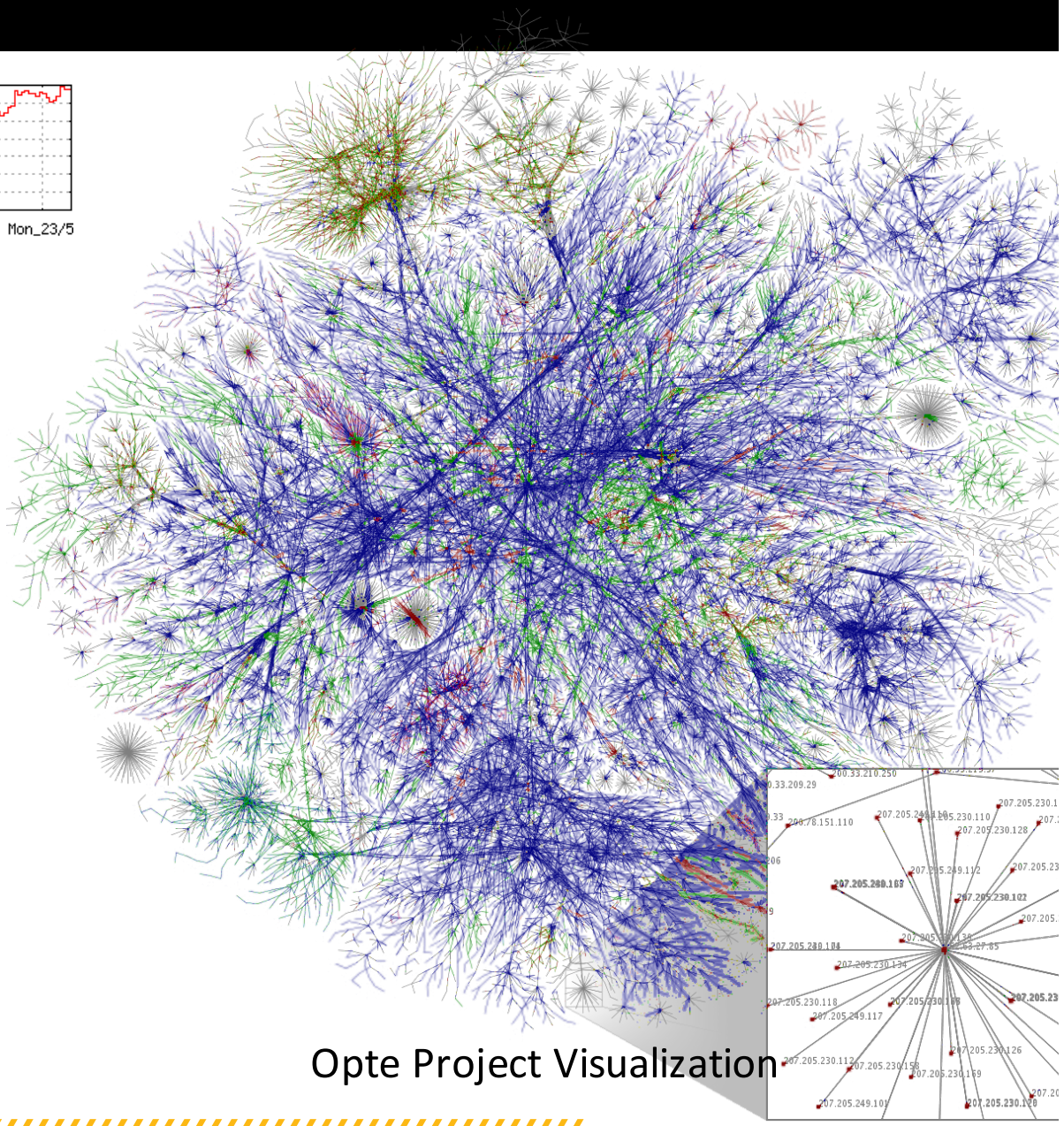
Demonstrated at GEC 16



Good Stuff, But It's All One Domain



- The real Internet is separate domains of control
- According to CIDR-Report, there 54,072 active AS numbers in BGP today!
- How do we apply SDN across these different domains?



Opte Project Visualization

SDX – The Software Defined Exchange

The Software Defined eXchange is about applying SDN concepts to the real world of multiple management domains

"SDX: A Software-Defined Exchange Point" (SIGCOMM 2014)

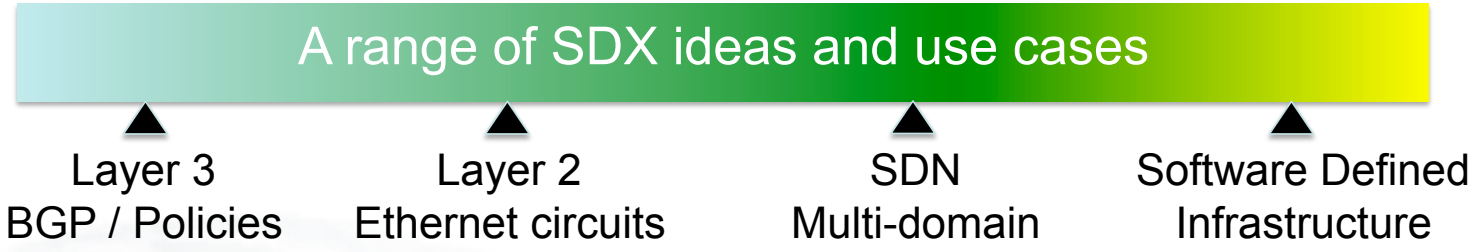
Arpit Gupta, Nick Feamster, Laurent Vanbever, Muhammad Shahbaz, Sean Donovan, Brandon Schlinker, Scott Shenker, Russ Clark, Ethan Katz-Bassett

Time Frame Reference

Atlanta SnowPocalypse – January 28, 2014

What is SDX?

What does "SDX" mean ?



- "Networking" SDX – connectivity / routing
  - Layer 3 (IP) – e.g., connect AS's
  - Layer 2 (Ethernet) – e.g., multi-domain circuits
  - SDN – connect SDN islands
- "Cloud service" SDX – with compute/storage
  - Connect SDI islands
  - Compute / storage / network / instruments
  - GENI as an early instance

SDX Projects in GENI

- Joe Mambretti et al

  STARLIGHT in Chicago

  focus on layer 1 and 2 stitching

- Russ Clark et al

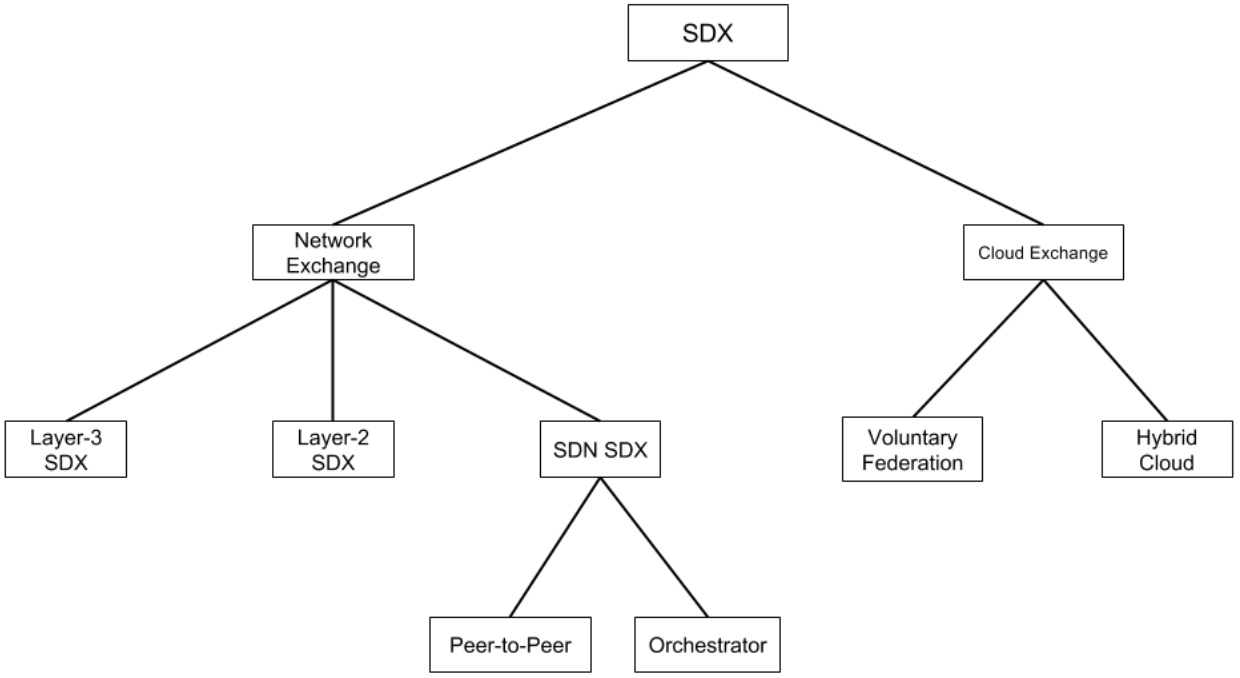
  SoX in Atlanta

  focus on integrating layer 3

But we're all doing all of the above today

SDX Taxonomy

An SDX Taxonomy



J. Chung, J. Cox, J. Ibarra, J. Bezerra, H. Morgan, R. Clark, H. Owen, "AtlanticWave-SDX: An International SDX to Support Science Data Applications", *Software Defined Networking for Scientific Networking Workshop,* Austin, TX. November 2015.

Limitations Of BGP-based Peering

- Routing only on destination IP prefixes
  - No customization by application or sender
- Can only influence immediate neighbors
  - No remote control
- Indirect control over data-plane forward
  - No direct path selection

Goals For SDX-based Peering

- Forwarding on multiple header fields
- Control over multiple networks from a single location
- Direct control over dataplane forwarding

So, how do we deploy this in today's Internet?

Internet Exchange Point - IXP

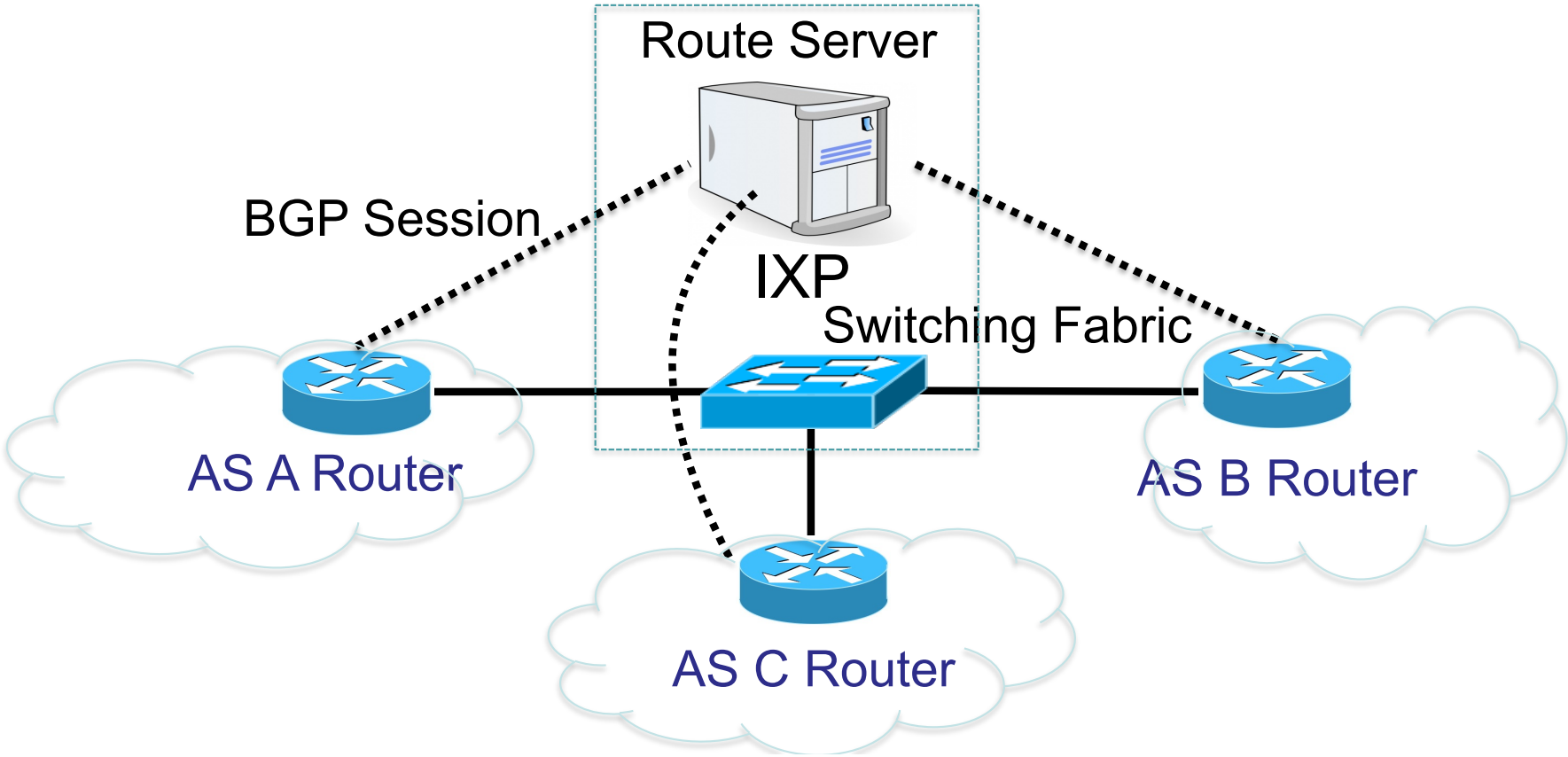


Diagram credit to Arpit Gupta

Software Defined IXP - SDX

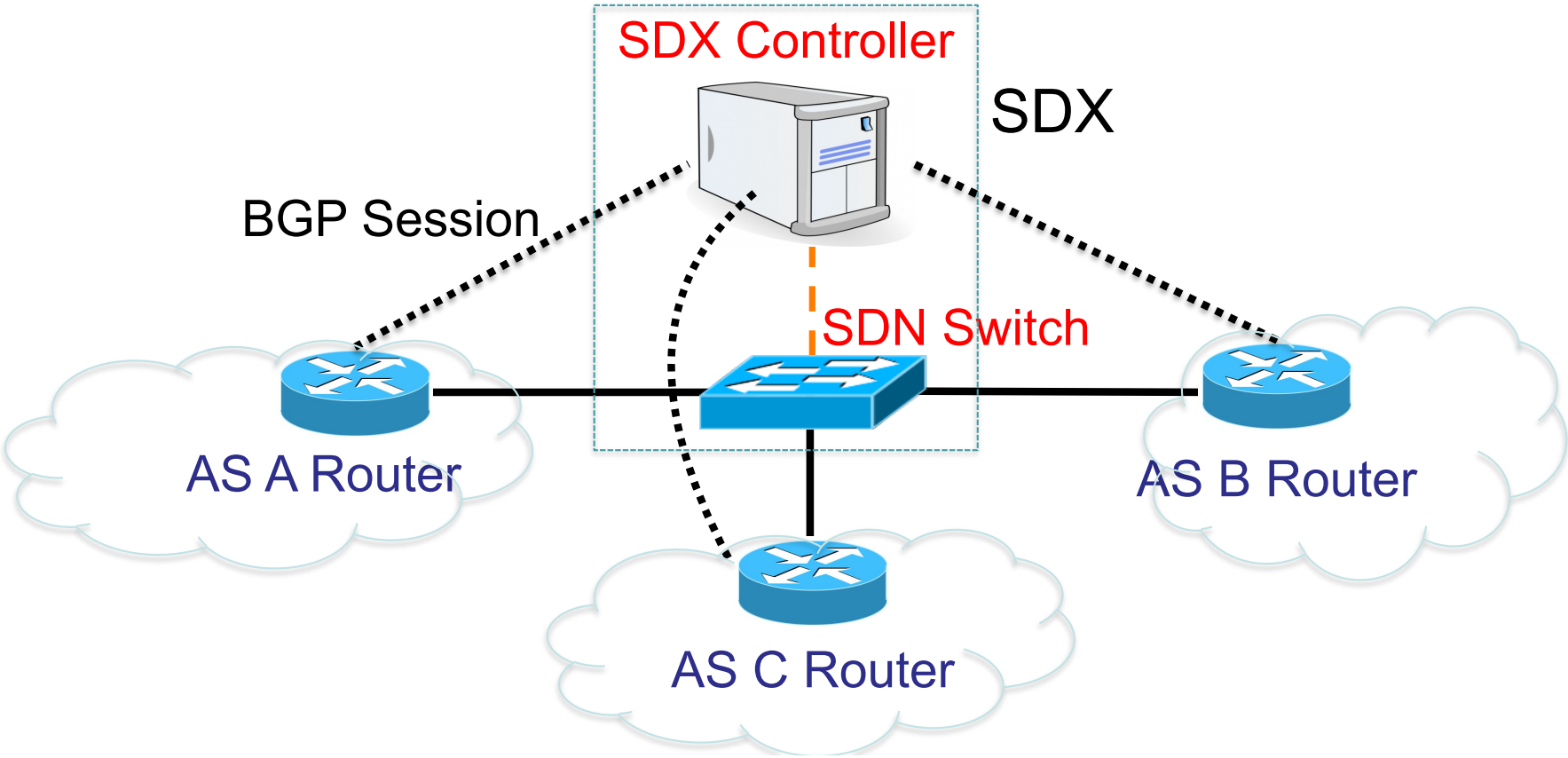


Diagram credit to Arpit Gupta

New SDX Possibilities

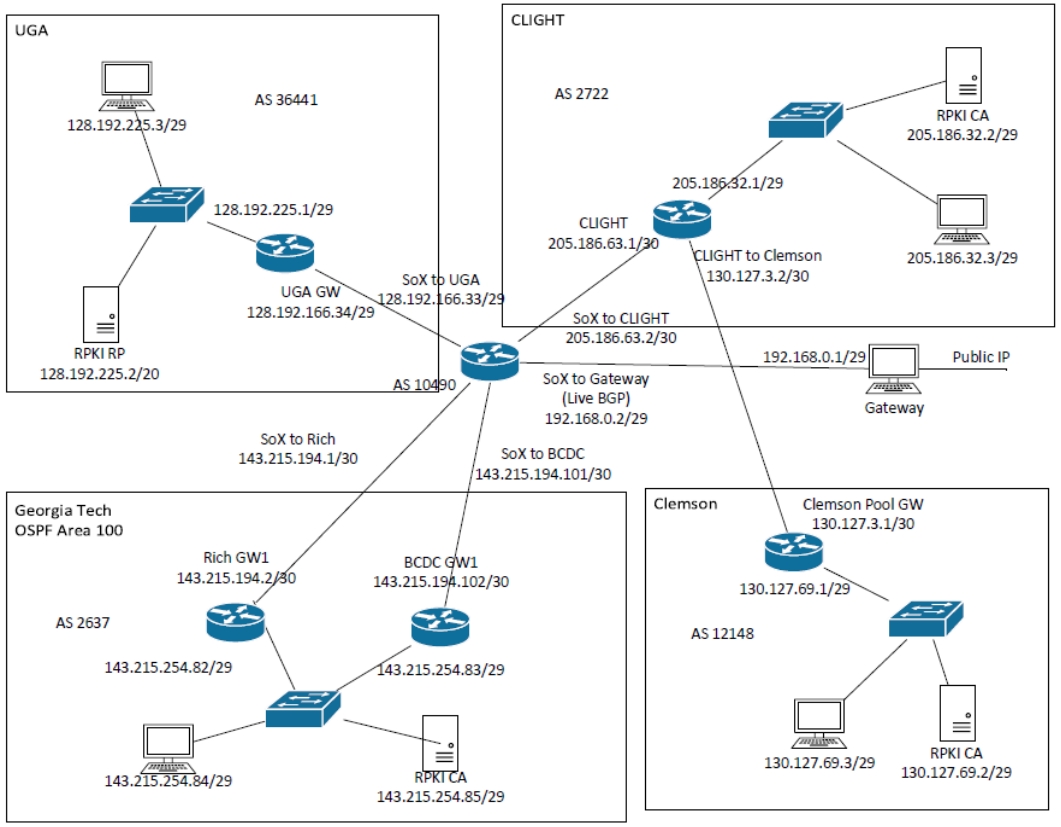
- More flexible and interesting business relationships
  - Make peering decisions based on broad policy arrangements
- More direct and flexible traffic control
  - Fine grained traffic engineering
- Improved security
  - Prefer “more secure” routes

Routing Security

We have a separate active project exploring RPKI deployment scenarios.

- Evaluate software and configurations
- Work through policy and legal issues
- Leverage GENI for larger scale evaluation

Southern Crossroads (SoX) Network



Back to SDX

Play with iSDX today!

Running code

- Vagrant & Docker based setup
- Instructions to run with HW switches
- **Github Repo:** https://github.com/sdn-ixp/iSDX

Also see Arpit's webinar at SDXCentral

https://www.sdxcentral.com/resources/nfv-sdn-training-sdnuniversity-archives/onf-isdx-webinar-internet-exchange-points/

International SDX

AtlanticWave SDX
INTERNATIONAL DISTRIBUTED SOFTWARE-DEFINED EXCHANGE

NSF Award ACI-1451024

International Research Network Connections Program

IRNC-RXP:

AtlanticWave-Software Defined Exchange:

A Distributed Intercontinental Experimental Software Defined Exchange (SDX)

Julio Ibarra, PI
Russ Clark, Co-PI
Heidi Morgan, Co-PI
Jeronimo Bezerra, Network Engineer
Cas D'Angelo, Network Engineer
Sean Donovan, DevOps

Science Driver: LSST

- Large-aperture wide-field ground-based 8.4 meter optical telescope in Northern Chile – Coming online in 2019
- Will take 6.4GB image every 17 seconds
- Network must transport images to NCSA within 5 seconds
- LSST operation will be composed of 2 channels, a control channel and a data channel
    - Control channel handles remote operation of the telescopes by NOAO in Tucson, AZ
        - Control channel must be secure, with low latency, high priority and low bandwidth
    - Data channel will transmit 6.4GB images within 5 seconds
        - Data Channel requires high bandwidth availability, low latency and high priority
        - Support bursts close to 100G

Science Driver: LSST

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- Network must…
- LSST operation… … data channel
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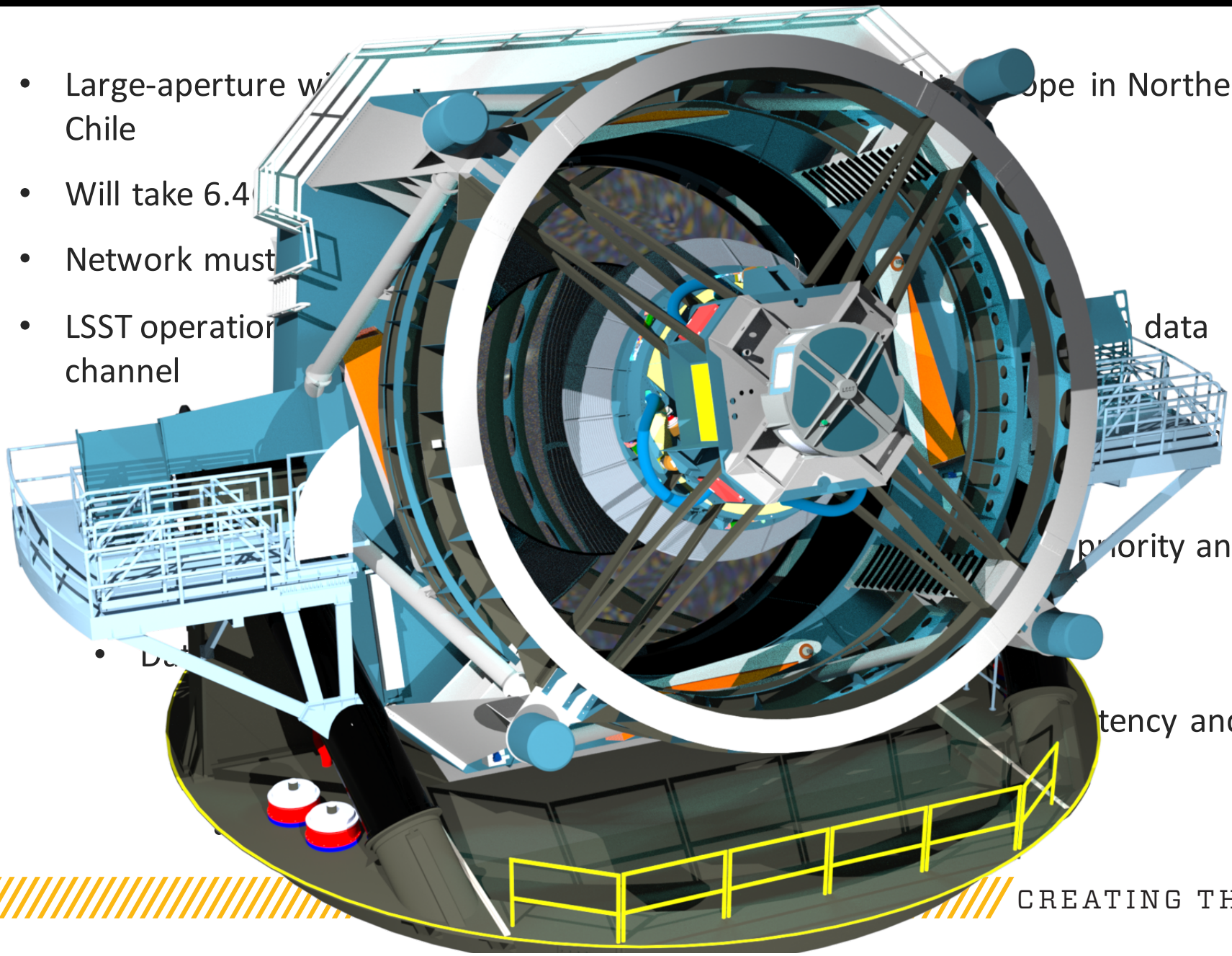
- …tency and high



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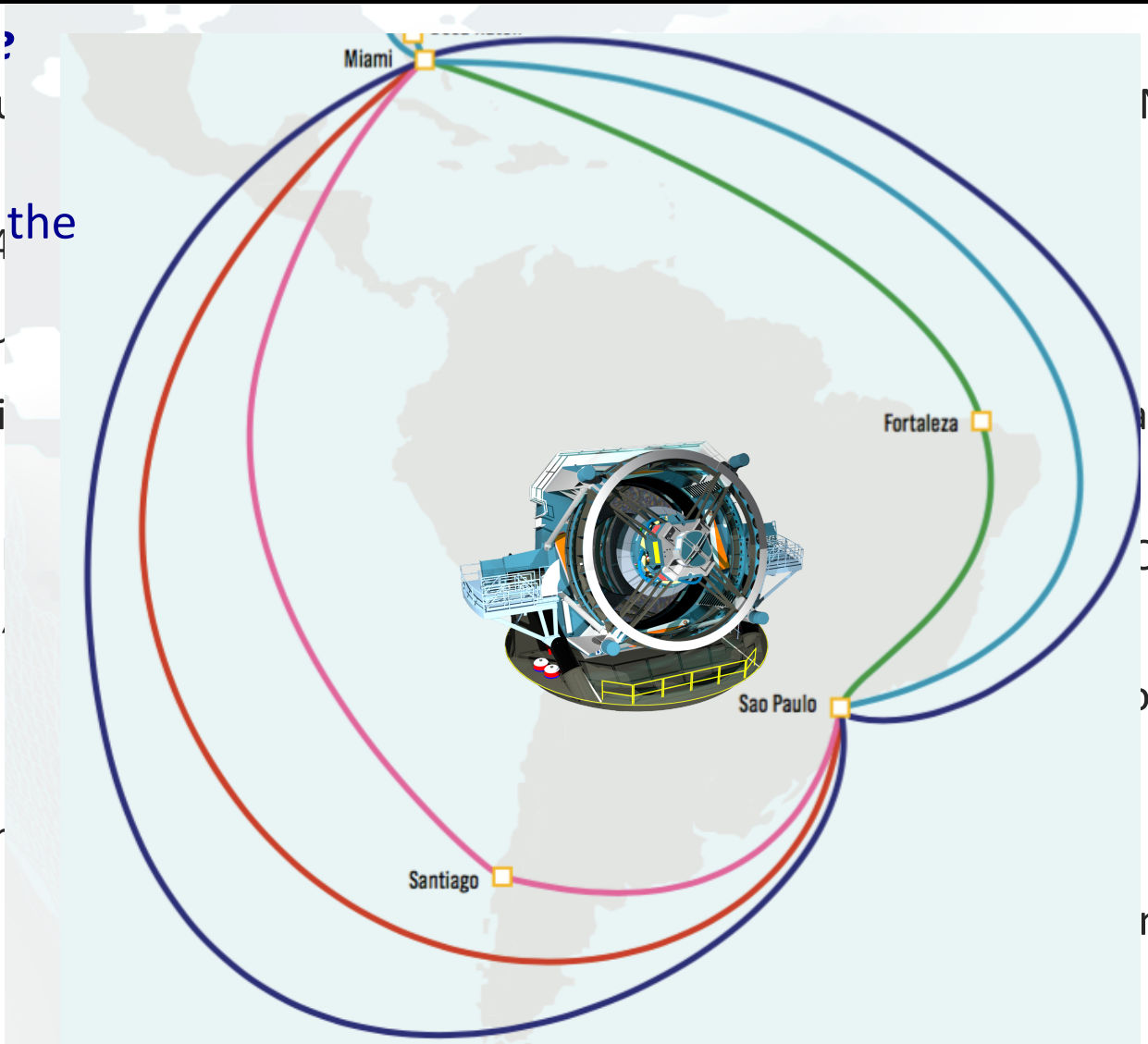


AtlanticWave-SDX Design

Extending SDX concept to a multi-domain SDX across 3 exchange points

Option 1 (yellow): Single SDX controller that manages the IXP switch fabric.

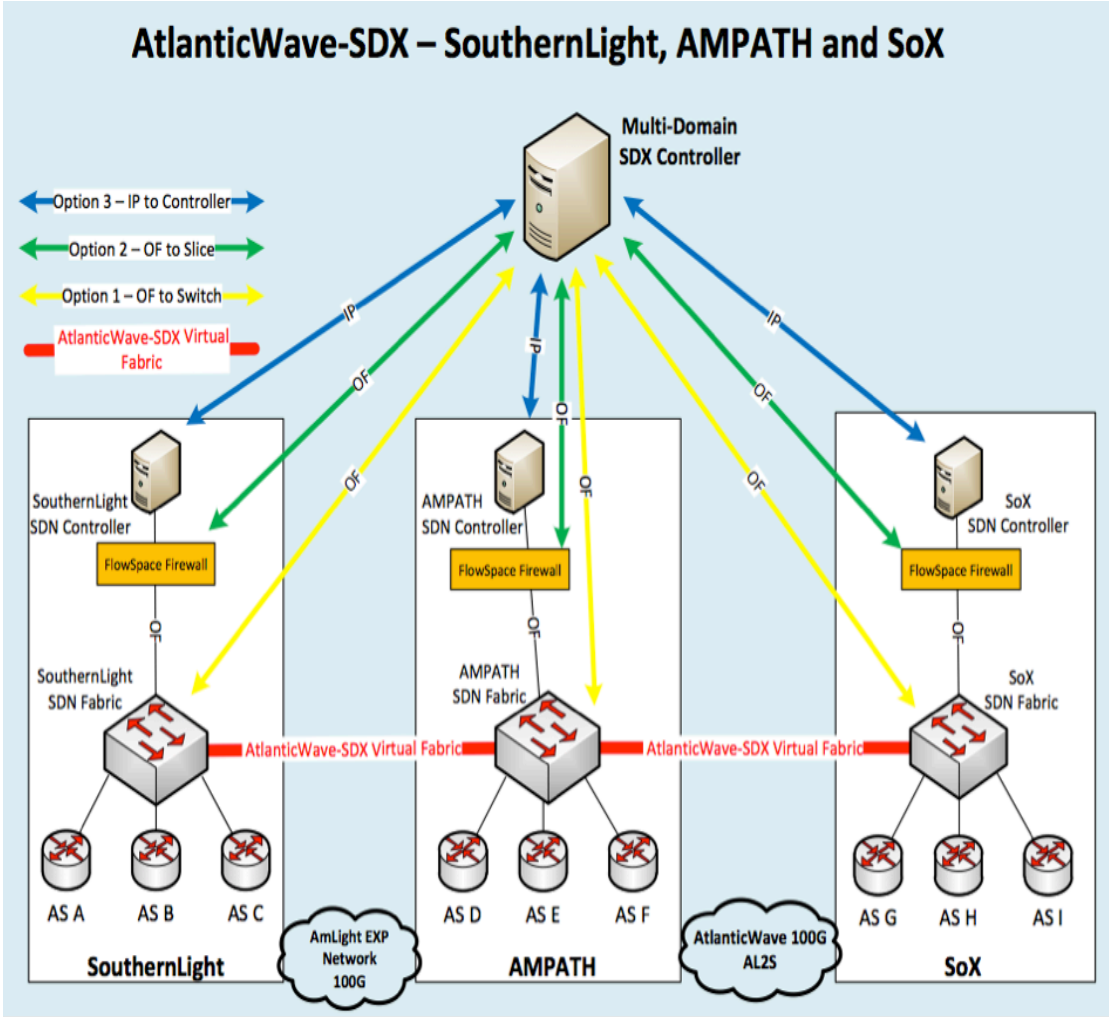
Option 2 (green): Intermediate slice manager (FlowVisor or FSFW)

- Individual controllers assigned a slice of network resources to be managed.
- Achieves resource isolation

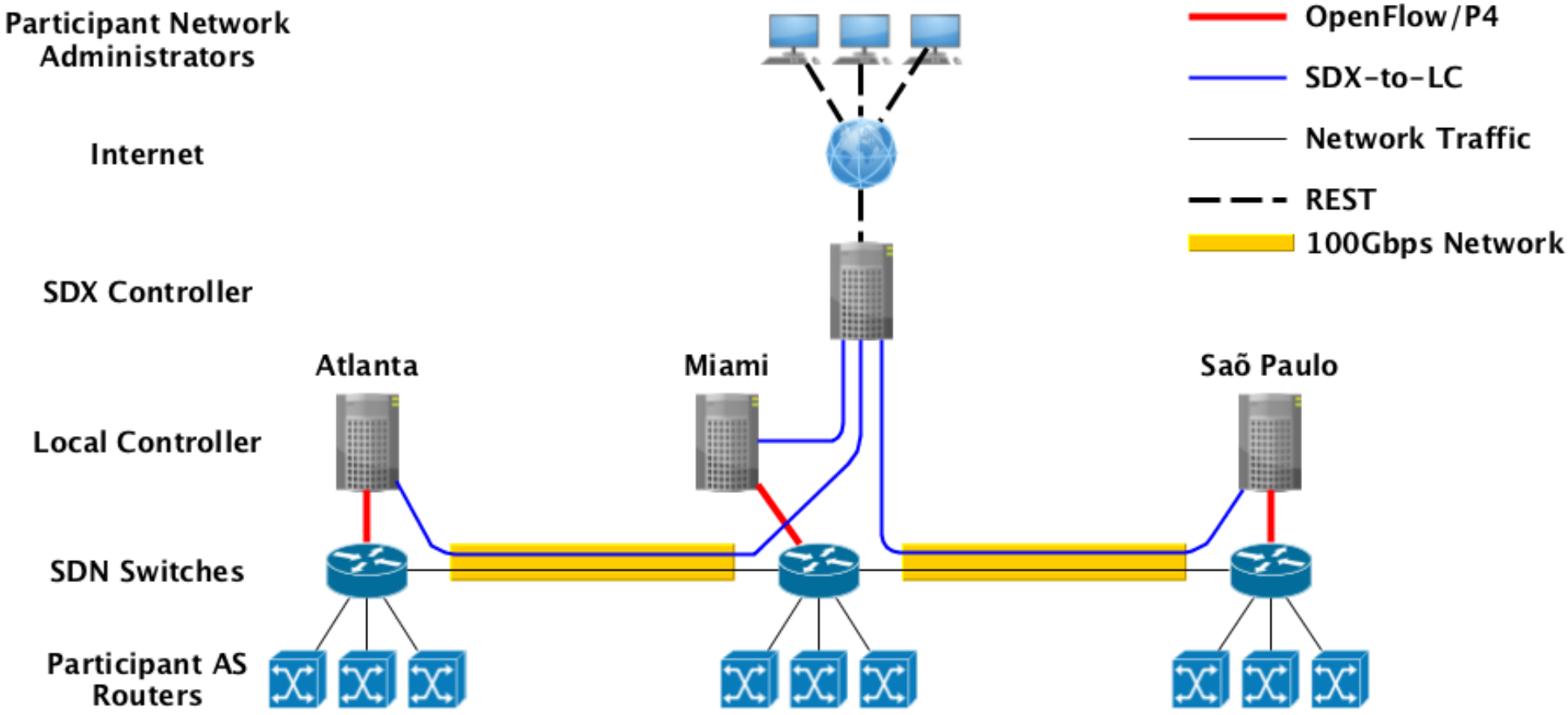
Option 3 (blue): Creates a hierarchy of controllers.

- Local controller at each XP managed by a higher level controller

SDX Virtual Fabric refers to a slice (a set of network headers) that will define the forwarding behavior between all the exchange points



International SDX



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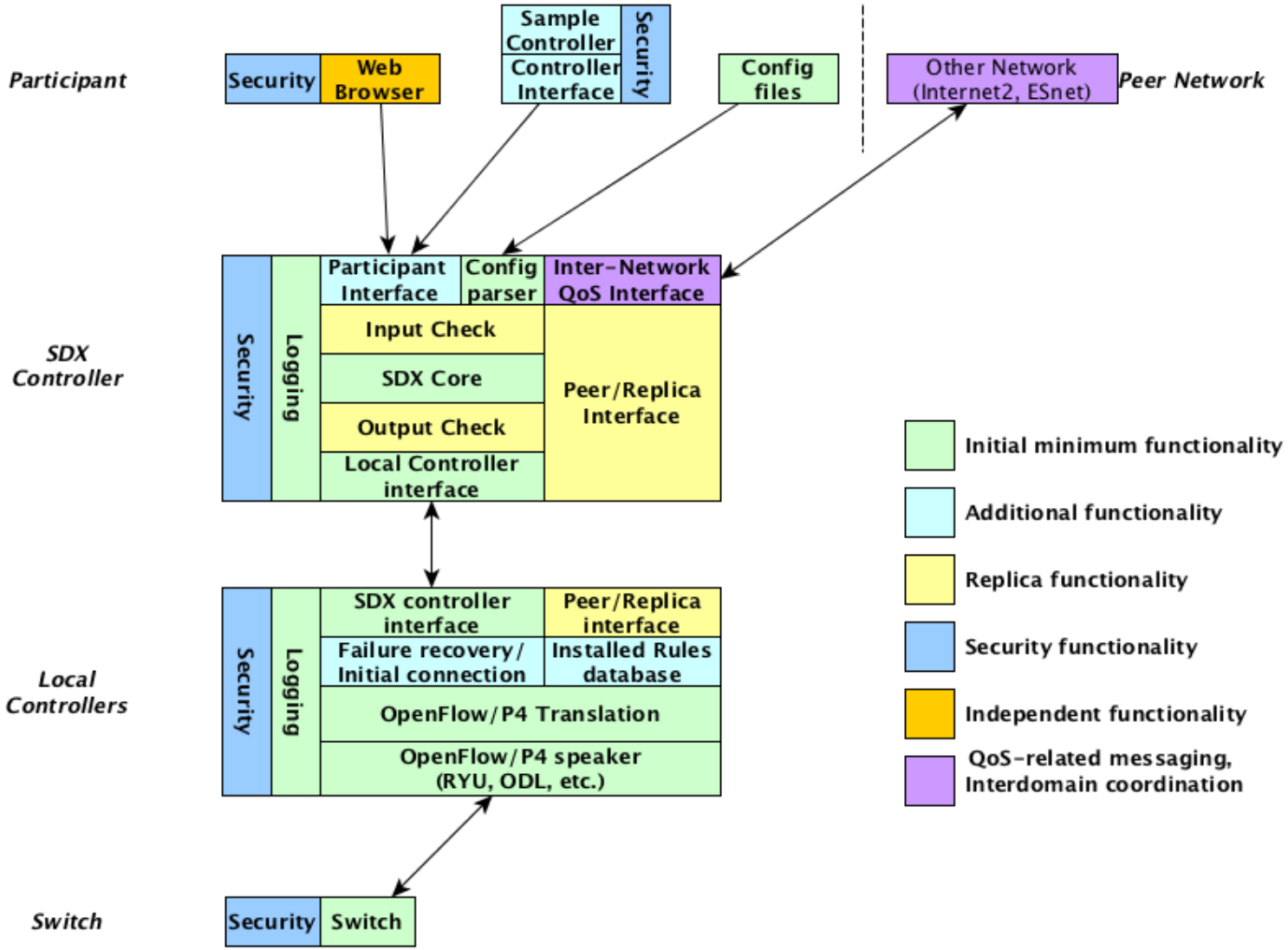

SDX Meets IoT And Smart Cities

Lots of interesting applications of our SDX work in the Smart Cities space

- Multi-tenancy of shared facilities
- Multiple stakeholders
- Shared infrastructure and shared data

Smart Cities Innovation Summit

GLOBAL CITY TEAMS CHALLENGE

usignite APPLICATIONSUMMIT

June 13-15 in Austin, TX

Get Involved

This is an exciting area. There is lots of work to do.

- Play with the SDX and iSDX code
- Read the Beyond the Internet reports
  - Applications and Services in 2021
  - Future Wireless Cities
  - SDX and SDI
  - https://lookingbeyondtheinternetblog.wordpress.com
- Contact me: Russ.Clark@gatech.edu

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