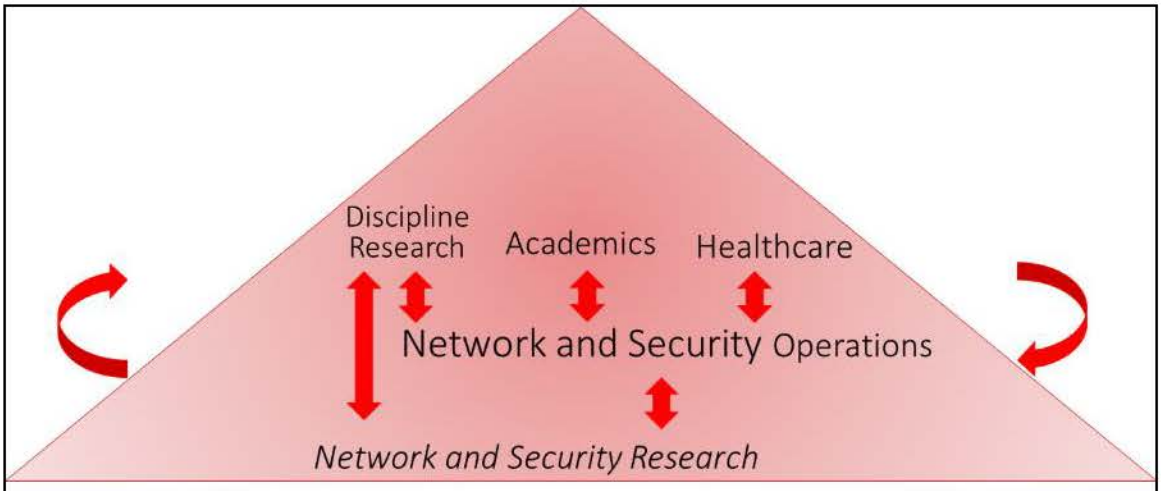

Research to Operations to University Missions

Flux Research Group
Joe Breen
University of Utah Center for High Performance Computing

What are we trying to accomplish?

- Develop network and security research ideas into operational paradigms that can enhance discipline research, academics and healthcare – the three core missions of the university.
- Create a vision of the future for network and security operations
- Create new platforms and frameworks to better support discipline research collaborations, and, network and security operations
- Enable network and security research to explore unfettered

Why are we trying to accomplish these goals?

- The three core missions of the university rely on network and security more than they ever have in the past.
- Innovative network and security research provide models and prototypes for innovative network and security operations
- Network and security operations provide interesting problems for network and security research students which provide fodder for papers and thesis projects

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* Network and security are more prevalent than the past due to increasing security attacks, increased regulatory presence, i.e. PCI, HIPAA, FISMA, FERPA, etc.

How are we accomplishing these goals?

- Create infrastructure testbeds and prototype environments that can simultaneously support production work and research work.
  - Should Network research create a disruptive environment?
    - Yes, if we are to progress.
  - Should the network be a stable platform for all to use with high availability, security, integrity?
    - Yes, if we are to get work done.
  - How to use this orthogonal problem to create opportunities?
    - Opportunities to stretch the stable production world in the direction of research vision
    - Opportunities to make use of research vision to solve production issues with more efficient methods
- Create new approaches to solve difficult problems across various disciplines
  - How to use creativity in both network and security research and network and security operations to enhance other research disciplines and the academic and business missions of the university?

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NOTE: These bullets are questions and not statements. Questions explore. Statements tell.
"The art and science of asking questions is the source of all knowledge." Thomas Berger

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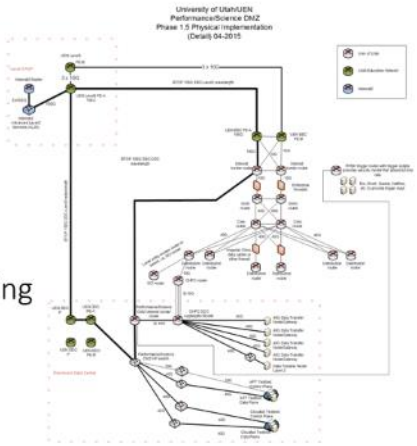
UTAH EDUCATION NETWORK

CC-NIE Infrastructure Investment
Part 1:
Science slices: Converting Network Research Innovation into Enhanced Capability for Computational Science and Engineering



- Science DMZ as a slice
  - Delivering Science DMZ as a Slice in the data center today
  - now in a position to deliver Science DMZ throughout campus environment over appropriate hardware through traditional MPLS and virtual routing delivery
  - one more piece of hardware needed to be able to deliver programmability to any directly connected equipment

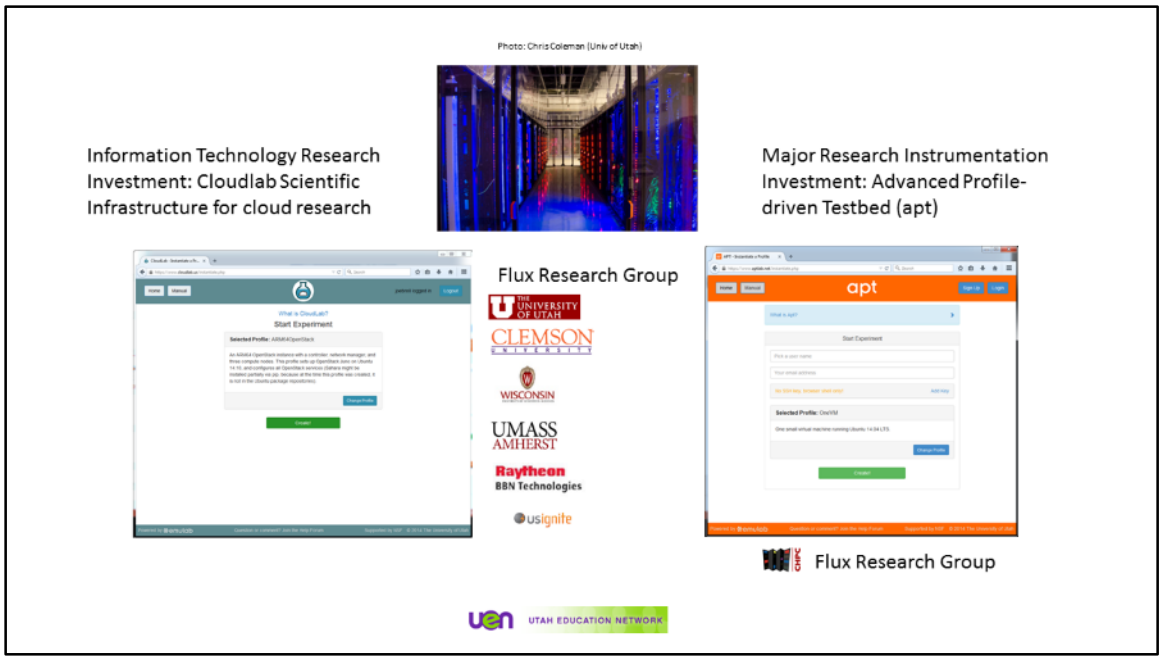


Photo: Chris Coleman (Univ of Utah)

Major Research Instrumentation (MRI): Apt: Utah internal collaboration to create a profile driven testbed for network/security experiments and HPC development

- Enabling prototypes of dynamic bare metal HPC image with ability to expand/shrink and simultaneously supporting other experiments
- Enabling multiple papers for various network and security experiments
- https://www.aptlab.net/ --
- http://www.nsf.gov/awardsearch/showAward?AWD_ID=1338155&HistoricalAwards=false
- http://aptlab.net

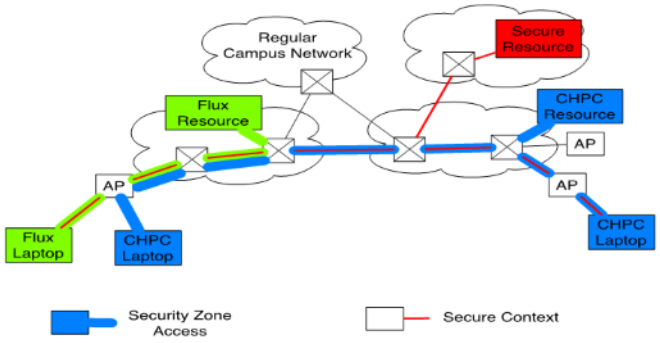
Information Technology Research: Cloudlab: Utah led collaboration to create a national profile-driven testbed supporting multiple hardware platforms and Software Defined Networking

- Enabling multiple papers for various cloud experiments
- Enabling future prototype of dynamic HPC image in multiple locations
- Enabling power investigation of low power processors in a cloud
- https://www.cloudlab.us/ --

CC-NIE Part 2: "Opt-in"

- What does "Opt-in" really mean?
  - Getting to what you really want with the right network and security characteristics
- Opt-in implies:
  - data driven
  - service driven
  - Security characteristics
  - network characteristics
- Opt-in drives the need for strong, dynamic network operations support, provisioning, management, and visibility

KnowU campus prototype



- Security contexts – Can we realize aspects of our campus data-driven security policy and manage the infrastructure seamlessly?
  - Fine grained
  - Use SSO to perform **network level access control**
  - Successful SSO authentication/authorization: dynamic user specific access to secure resource
  - Secure context after successful access to security zone

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KnowU Proposal: Collaborate with the UIT Network, Security, and Identity and Access Management teams to develop a prototype platform to explore emerging network technologies, and network and security management approaches in the context of the University of Utah campus network

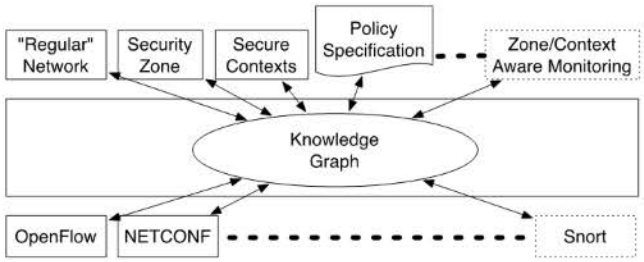
KnowU Proposal IT Goals:

- Experiment with using both "conventional" networking and software defined networking (SDN) approaches in the same network.
- Experiment with the use of "white-box" network equipment together with equipment from traditional vendors.
- Develop fine-grained security zone enforcement and monitoring mechanisms using SDN for both wired and wireless networks.
- Move towards automated network and security management

KnowU Proposal Research Goals

- Apply knowledge-centric approach to perform automated network management functions in a semi-production network environment
- Develop network management application(s) to realize fine-grained security zones on both wired and wireless networks.
- Explore application specific monitoring and management.

KnowU Architecture



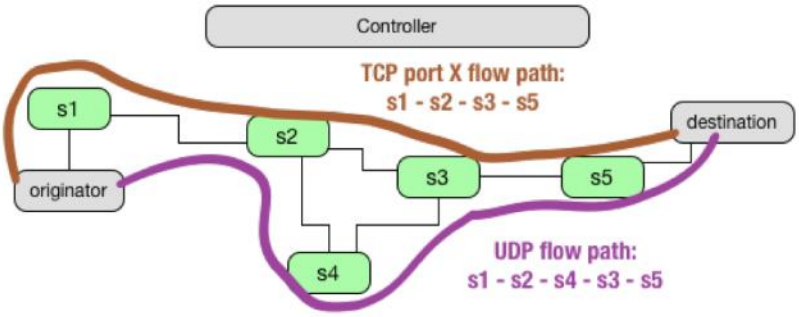
- Knowledge-centric approach
  - All data/knowledge/information about network stored in a knowledge graph (KG)
  - Network management:
    - applications interacting via KG
    - use, add, modify data in KG
    - result in network configuration changes (OpenFlow/NETCONF)

Need for tools operating at true flow level

- Tom Lehman (MAX): "I don't want to control every flow on the network, I want to control ANY flow on the network"
- How to look at flows regardless of protocol?
- How to look at flows across dynamic topologies?
- How to actively measure dynamic topologies to provide baselines of network characteristics?

SDNTrace

- Implemented as Northbound application/process on each hop with defined protocol
- Carries all path information in reply message
- Uses existing path state
- Specific to individual flow path
- Agnostic of higher layer protocols
- http://sdntraceprotocol.readthedocs.org/en/latest/



Research and prototype implementation: Deniz Gurkan, Nicholas Bastin, Ali Kouhi Kamali, Long Tran

Original operations problem description: Michael Van Norman, Dan Schmiedt, Chris Konger, Dale Carder, Kevin Mayeshiro, Joe Breen, Anita Nikolich - Internet2 SDN Working Group 2014; refinements by Internet2 SDN Working Group as a whole

Documentation:

- http://sdntraceprotocol.readthedocs.org/en/latest/
- https://media.readthedocs.org/pdf/sdntraceprotocol/latest/sdntraceprotocol.pdf
- https://bitbucket.org/dgurkan/sdntrace_protocol/overview

Original problem charter:
https://spaces.internet2.edu/display/sdn/Project+Charter+Draft

Active Measurement in network sliced world/network virtual world

- Measuring a base network substrate yields a baseline for all virtual networks crossing that portion of topology
  - What visibility exists when the virtual environment goes over another portion of topology that does not have measurement?
  - What visibility exists when the virtual environment crosses administrative domains?
  - What happens when the topology changes?
- How does one actively measure particular virtual environments?
- How does one actively measure multiple environments without causing more measurement than production traffic?
- How does one inject measurement into a "virtual network of interest"?
- Exploring a framework based on BLIPP, UNIS, HELM

Research and prototype implementation: Miao Zhang, Bruce Mah, Joe Breen, Ezra Kissel, Brian Tierney, Eric Pouyoul
Other collaborators: Eric Boyd, Martin Swany, Luke Fowler, Ed Balas

Research Projects and Papers

- DeidTect – Towards a Distributed Elastic Intrusion Detection
  - https://www.flux.utah.edu/paper/shanmugam-dcc14
- SeaCat – End to End application containment
  - http://www.flux.utah.edu/project/SeaCat
- FlowOps – FlowOps: Open Access Network Management and Operation
  - https://www.flux.utah.edu/paper/strum-thesis
- KnowOps – Network Management, Software Defined
  - https://www.flux.utah.edu/project/KnowOps
- TCloud – Self-defending, self-evolving, and self-accounting trustworthy cloud platform
  - https://www.flux.utah.edu/project/tcloud

Examples of other research that look at the network based on flows and how to automate network management, visibility, operations, etc.

Challenges and shortcomings of today's technologies (a.k.a. opportunities)

- Challenges
  - Researcher expectations vs how IT operations go...
  - Hooks into Federated Identity and Access Management
- How to better obtain clarity and transparency of what each vendor truly supports?
  - Clear datasheets regarding SDN offerings
  - Clear descriptions of exactly what OpenFlow features supported, how these features map in memory
  - Test results to be provided with time, message, and state diagrams, etc. (These may be NDA but have them available for customers.)
  - Clear descriptions of what controllers supported well
- Truly flow based toolsets, visibility into the flows, collections of statistics per flows, standard flow-based APIs
- Ability for hardware to fully support features such as multi-table, meter table supporting full rate limiting of traffic, more flexible match capabilities,
- Easy consistent access to topology information
- Security, i.e. rate limits on control plane, additional visibility for the data plane, etc.

Summary

- Research <-> Operations <-> Missions of the University of Utah
  - Develop network and security research ideas into operational paradigms that can enhance discipline research, academics and healthcare – the three core missions of the university.
  - Bring back harder questions to feed into research
- What do you really want?
  - Data-driven
  - Services driven
  - Specific network and security characteristics
- These drivers require flow based tools and frameworks to provide the management, operations, visibility, provisioning, etc. at the granularity, performance, and security level desired.