Enhancing Science Through Custom Paths For Trusted Users

ZONGMING FEI, UNIVERSITY OF KENTUCKY

Cybersecurity Research Acceleration Workshop and Showcase, Indianapolis, IN
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Enhancing Science Through Custom Paths for Trusted Flows

Zongming Fei

University of Kentucky

(This is a joint work with James Griffioen, Ken Calvert, Sergio Rivera, Jacob Chappell, Mami Hayashida, Pinyi Shi, Charles Carpenter, Yongwook Song, Hussamuddin Nasir)

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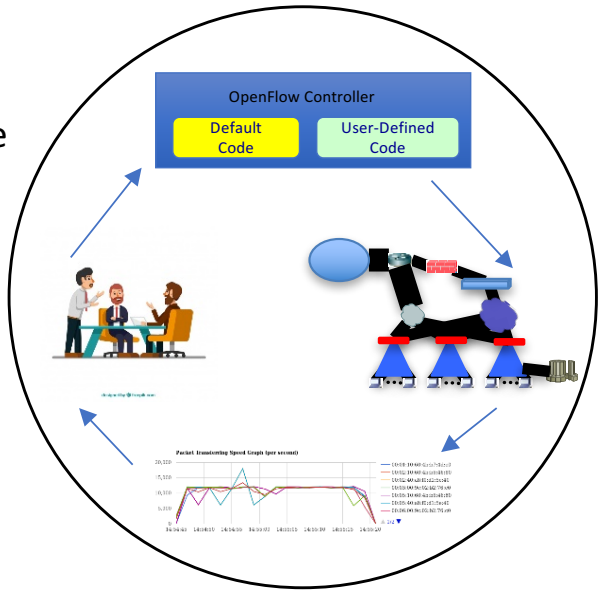
Quad Chart for: Enhancing Science Through Custom Paths For Trusted Users

Challenge:

Provide the ability for pre-authorized, trusted users to create flows that bypass middleboxes, thereby enabling those users to achieve substantially better performance while maintaining security and policy compliance for other network traffic.



Solution:

- Install SDN-enabled routers/switches in the campus network.
- Create two paths to the campus edge.
- By default, forward all packets through the existing campus core and policy-enforcing middleboxes.
- Develop a VIP Lanes server to dynamically install SDN rules (with higher priority) to "pick off" approved flows and forward them directly to the campus edge, by-passing middleboxes.

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University of Kentucky
PI: James Griffioen
Team: Zongming Fei (co-PI), Sergio Rivera, Jacob Chappell, Mami Hiyashida, Pinyi Shi, Charles Carpenter, Yongwook Song, Hussamuddin Nasir, Ken Calvert (former co-PI)

Value proposition:

- Provide better performance for data transfer to big data researchers while still maintaining security and policy compliance for other traffic.
- Deploy SDN on campus networks.
- Presents an opportunity for users and providers to work together to develop solutions that enable explicit negotiation that can lead to trust

What we need to TTP

- Your feedback
- Learn from experience of other projects
- Opportunities to collaborate with researchers and IT from other universities

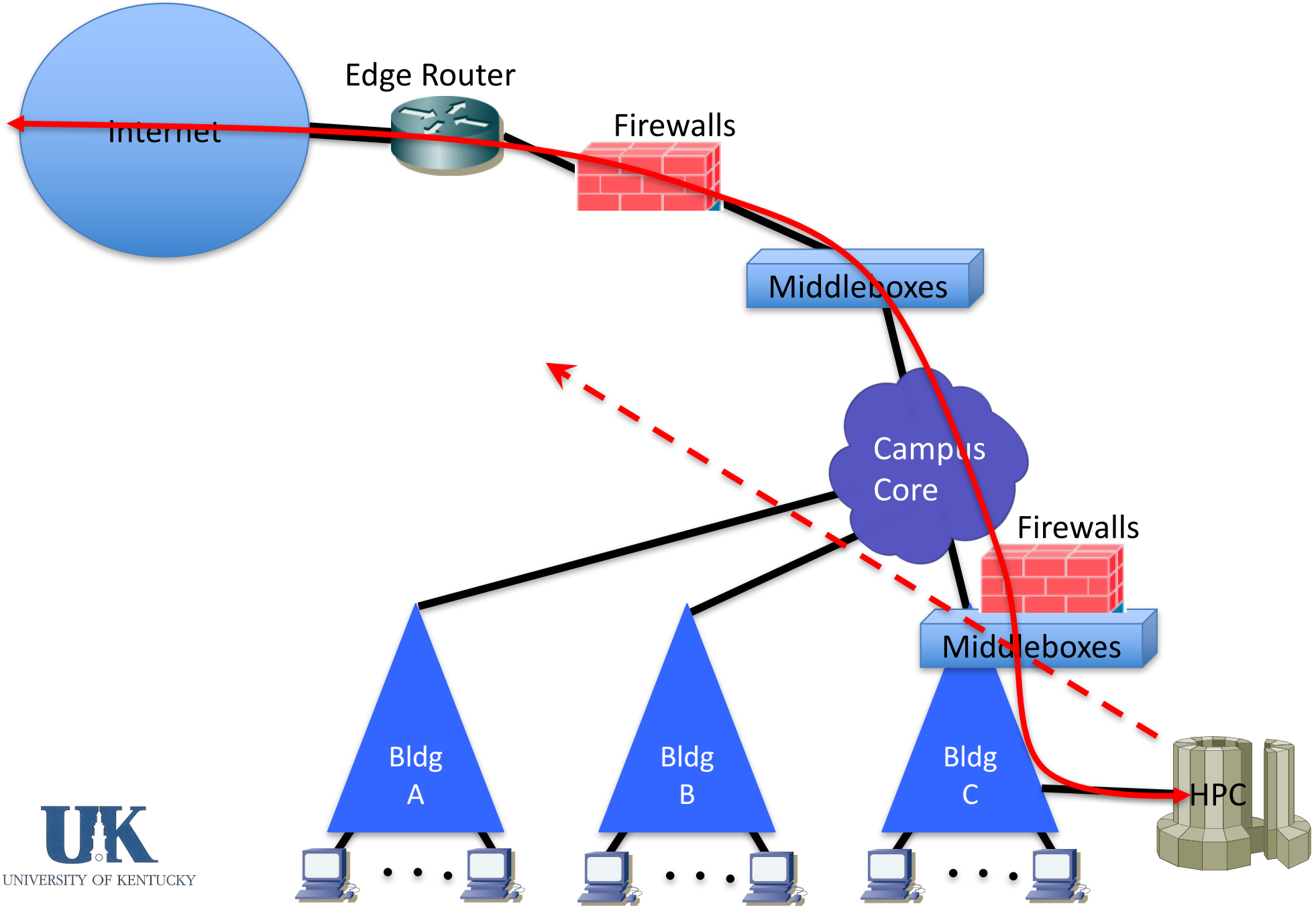
Contact us

- griff@netlab.uky.edu
- fei@netlab.uky.edu

Challenges

- Sharing Big Data in Campus Networks
  - Bid data is driving many research techniques nowadays across all disciplines.
  - The need: share these big data sets efficiently with other researchers.
  - The problem: Campus infrastructure is not designed to support high-throughput transmissions of big datasets.
- Middleboxes
  - Provide important services that enforce policy and offer enhanced functionality (firewalls, VPN).
  - Offer functionalities involving deep packet inspection (IDSs, etc).
  - Provide other functions (NAT, traffic shaping/QoS enforcement, Load Balancers, caching).
  - Middleboxes are placed strategically throughout the network, not just at the edge.
- Because middleboxes operate on packets, they pose a bottleneck to network performance, especially for big data transfer.

Traditional Solution: Science DMZ



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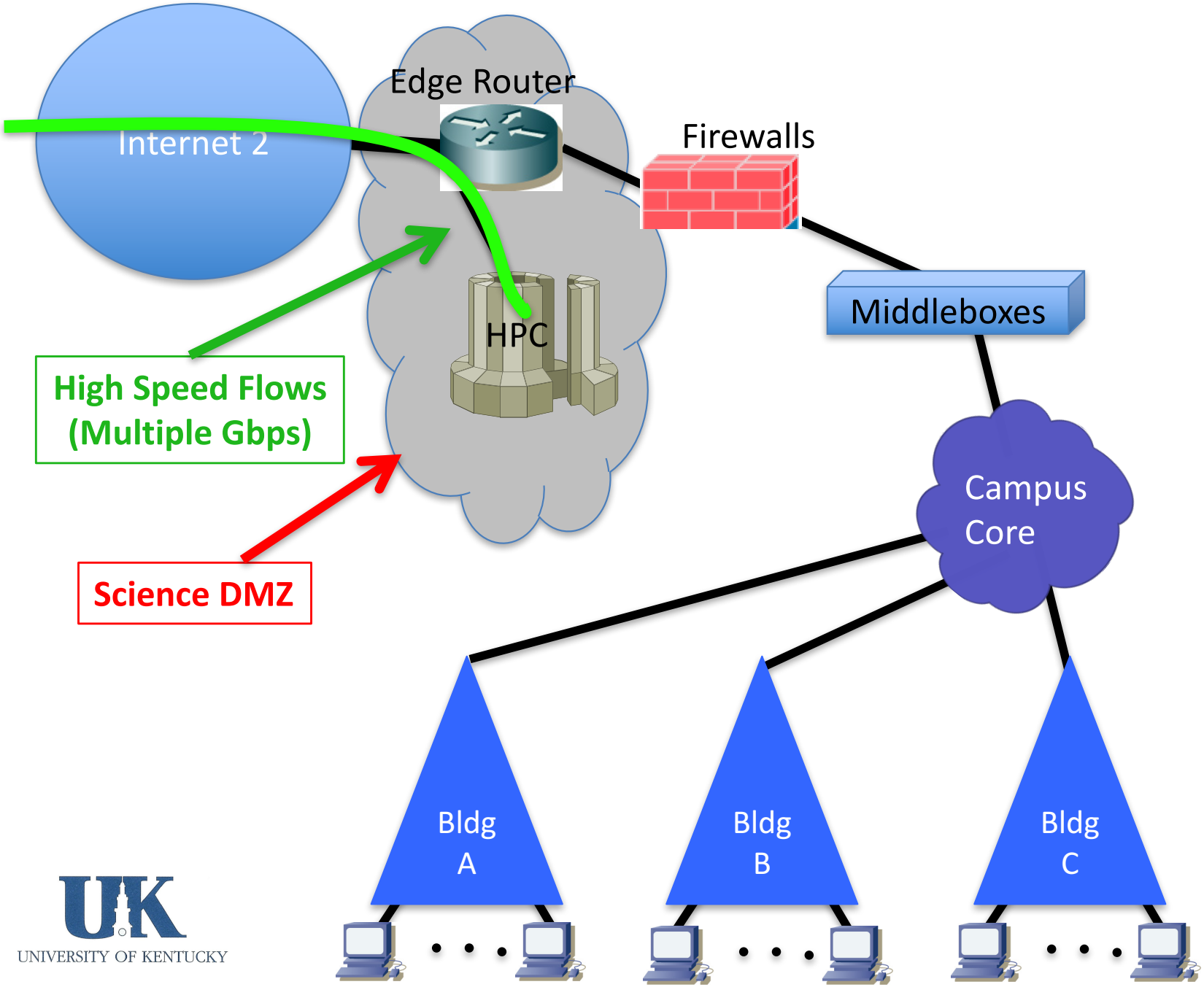
Traditional Solution: Science DMZ



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Science DMZ Solution

- Deploy a Science DMZ network connected to the network edge.
- Move HPC and some other machines to the Science DMZ network
- Advantages:
  - Traffic from HPC machines bypass middlebox bottlenecks
- Disadvantages:
  - Science DMZ machines are not protected by middleboxes.
  - Campus (middlebox) policy enforcement is not applied to any traffic from Science DMZ machines. Even non-science flows (e.g., Netflix) bypass campus policy enforcement.
  - Researchers must decide whether to connect their machines to the Science DMZ or the Campus Network.

Our Approach:
SDN-based Custom Paths for Trusted Flows

- Observation: Science DMZs enable "privileged traffic" – traffic that has been pre-approved to by-pass campus middleboxes.
- Approach: Use Software Defined Network (SDN) capabilities to intercept approved science flows and route around performance-limiting middleboxes.
  1. Install SDN-enabled routers/switches in the campus network. (Where?)
  2. Create two paths to the campus edge
     - One through the existing campus core network
     - One through a new middlebox-free path to the campus edge.
  3. By default, forward all packets through the existing campus core and policy-enforcing middleboxes.
  4. Dynamically install SDN rules (with higher priority) to "pick off" approved flows and forward them directly to the campus edge, by-passing middleboxes.

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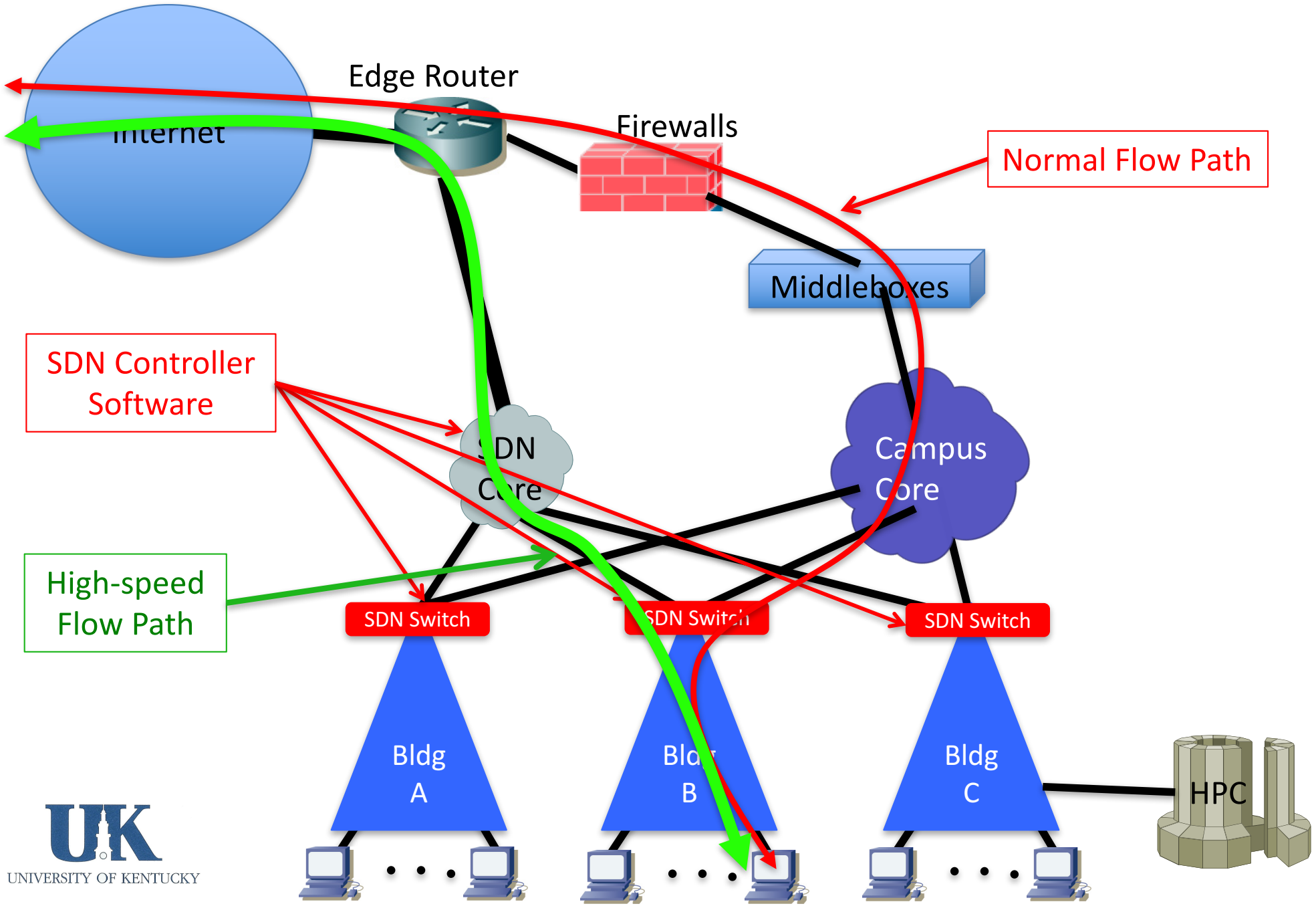
VIP Lanes for Trusted Flows



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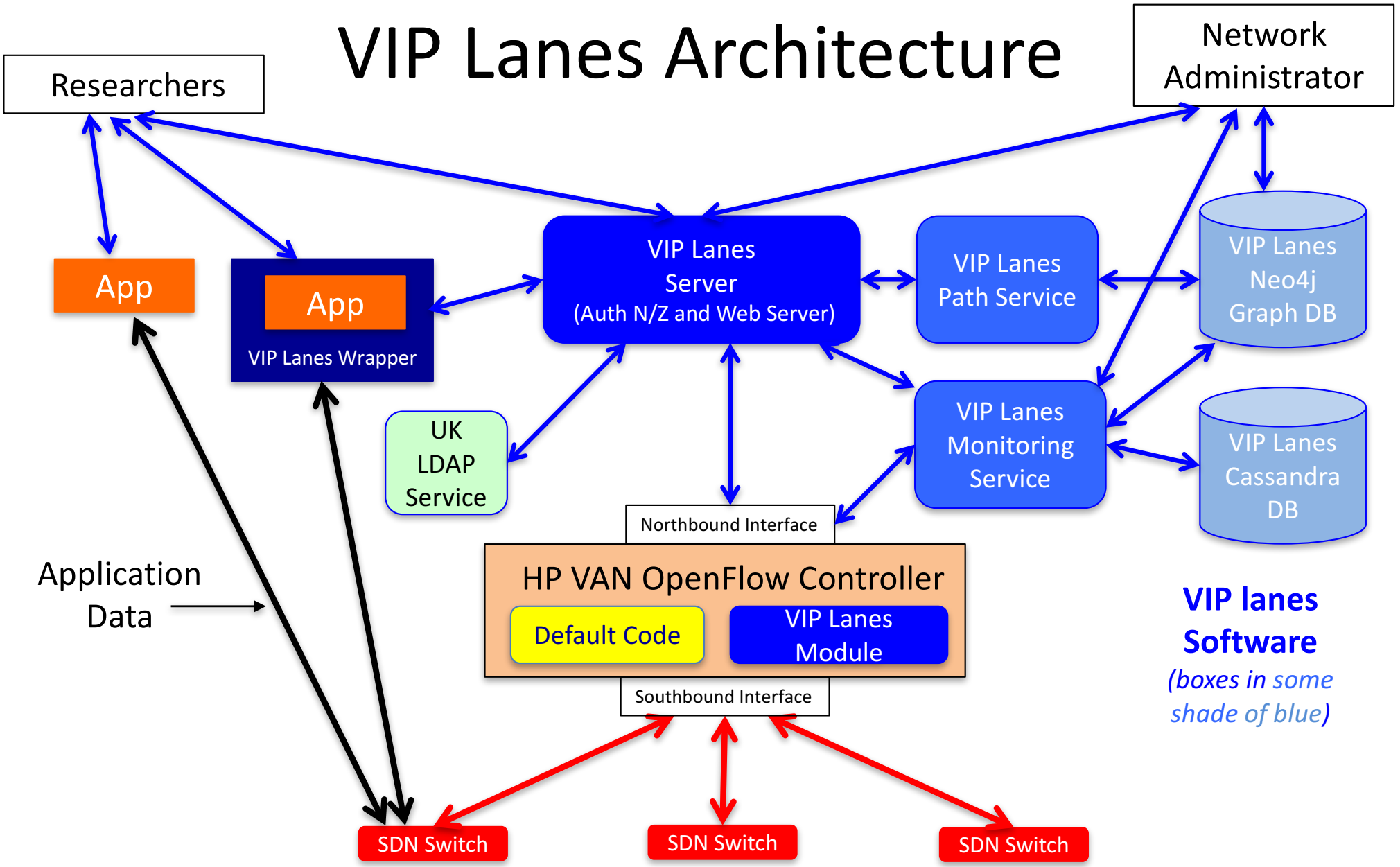
The SDN Control Software (aka VIP Lanes)

Prereq:

- Switches/Routers must be configured to process packets “normally” by default
- Multiple ways to achieve this. Easy way is to insert a “normal” rule.

1. OpenFlow controller module
   - Discover topology information and makes it available to VIPlanes services
   - Accept requests to insert a set of rules comprising a flow
2. VIPlanes services
   - Discover the placement/role of middleboxes
     - Via topology discovery and config files
   - Accept requests to enable “privileged flows”
     - VIPlanes server authenticates/authorizes requests
   - Compute paths that by-pass middleboxes
     - Path computation service uses topo info to compute middlebox free paths
   - Compute SDN rules and invokes controller to insert them to “pick off” privileged flows
     - Path computation service and new controller module create and install rules
   - Ensure rules remain in place for the duration of the flow
   - Remove rules that are no longer needed
   - Gracefully handle failures

VIP Lanes Architecture



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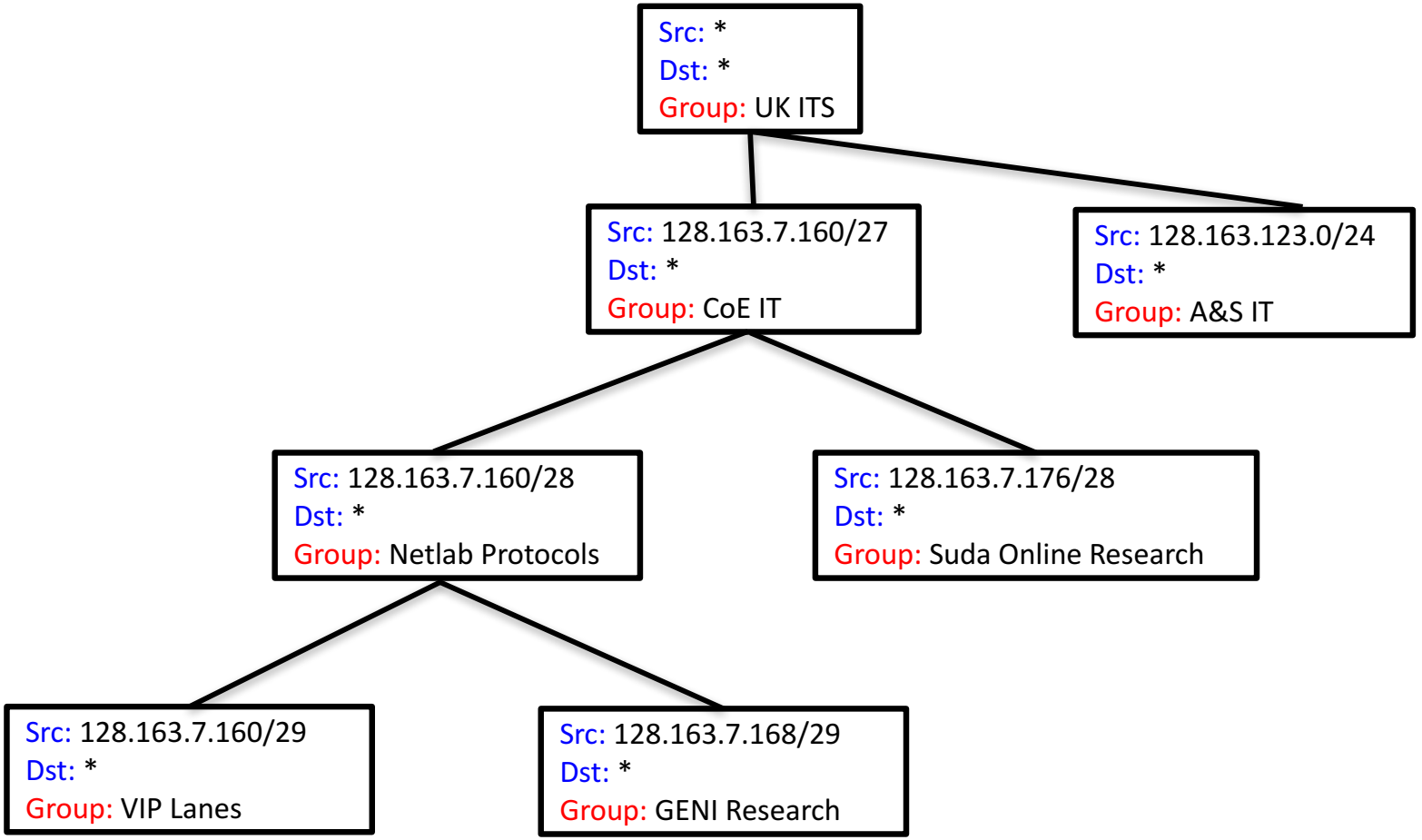
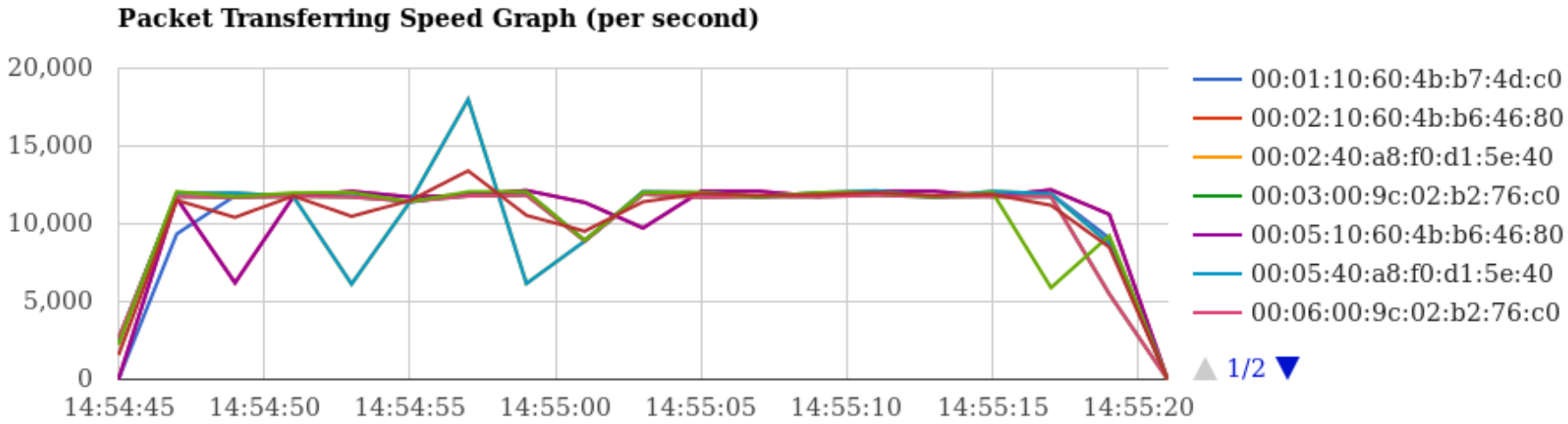
Example Flow Space Tree



Another Advantage:
Flow-level Monitoring

- OpenFlow support flow metrics (packet/byte counts) that enable flow-level monitoring
- Allows Users/IT to monitor performance of specific data transfers
- Can also be used for bandwidth management and debugging purposes



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Deployment on UK Campus Network

- Deployed a new SDN Core network (OpenFlow) and connected it directly to the campus edge router.
- Deployed SDN-enabled switches/routers at the head-end of multiple science buildings. Some buildings are fully SDN-enabled.
- Deployed the VIP Lanes server to control the two buildings hosting CS department and Laboratory for Advanced Networking.

Sites	Normal (Mbps)	VIP Lanes (Gbps)	Speedup
ga-ptl.es.net (San Diego)	20.2	1.73	**85.6x**
hous-ptl.es.net (Houston)	34.6	3.00	**86.7x**
chic-ptl.es.net (Chicago)	55.98	4.86	**86.9x**
Wash-ptl.es.net (D.C.)	79.49	6.96	**87.6x**