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Software-Defined Networking
Applications in Network Science and Engineering

Deniz Gurkan, PhD

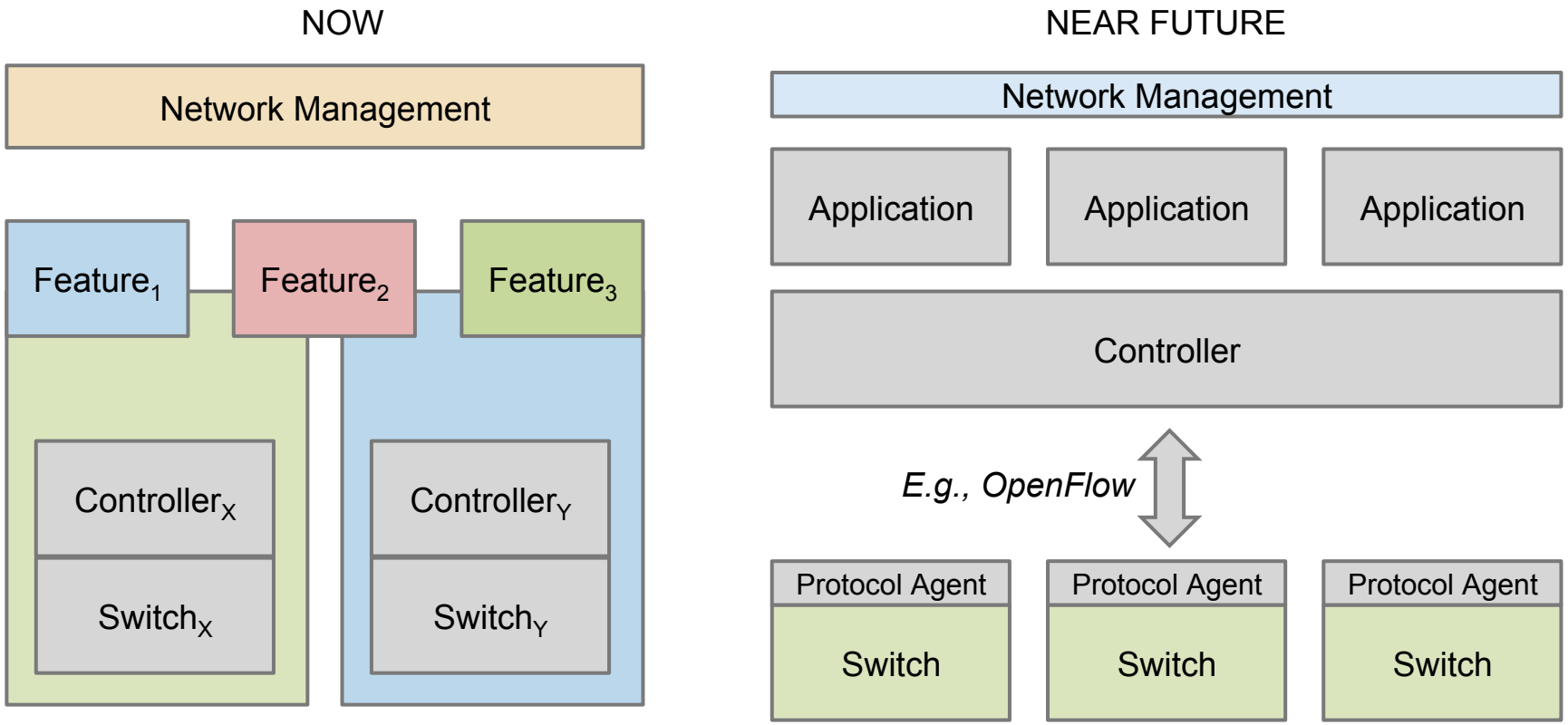
February 21, 2014

Networking Lab: http://sites.tech.uh.edu/networking-lab/
dgurkan@uh.edu

Funded by Dell, Infoblox, vArmour Networks, NSF.
Active collaborations with Juniper, Cavium Networks and Intel.

Separation of control and data planes = SDN

Innovation opportunities unleashed

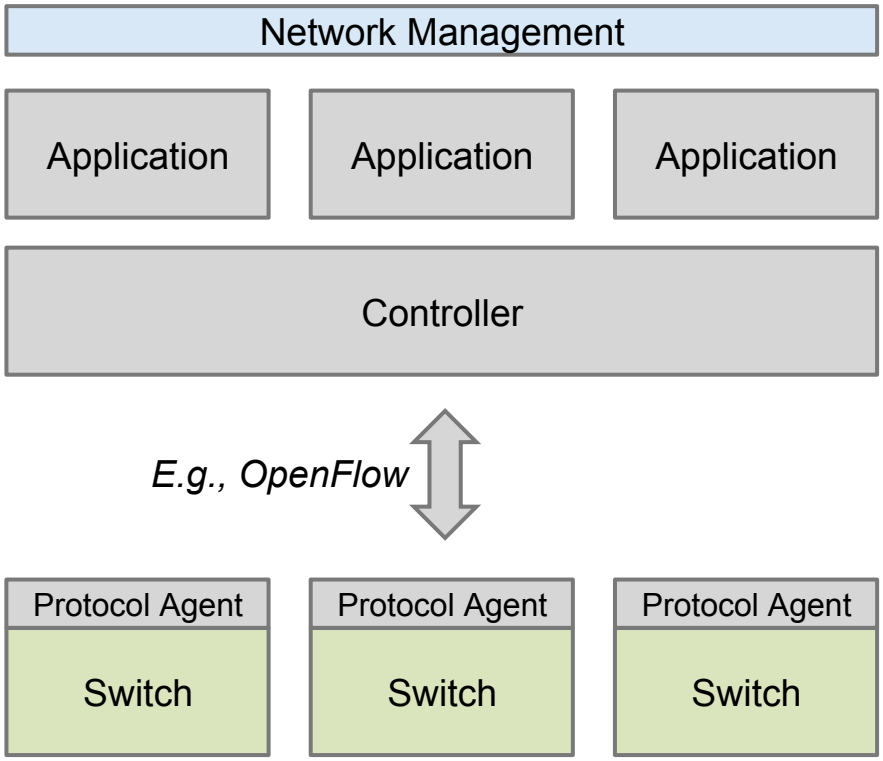


Research Directions

1. Network management
2. New network abstractions with capability-based nodes
3. Network functions virtualization and distribution
    1. On-demand network programmability
    2. Traffic steering
4. Switching/forwarding as a software construct
5. Future directions

Motivation

Deep programmability of management, control, and data plane

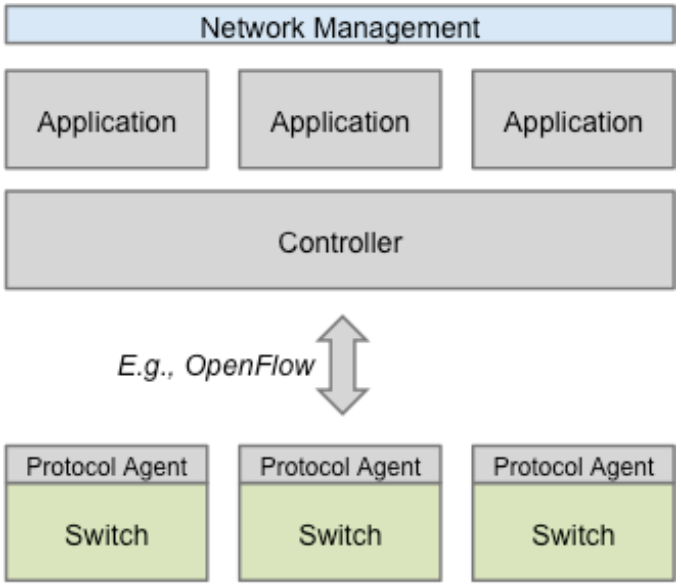


Network Management

- Control plane: program forwarding elements
- Data plane: forward data packets/flows
- Management plane: discover/monitor/manage resources

Research on:

1. Managed object models
2. Management primitives
3. Share control/management



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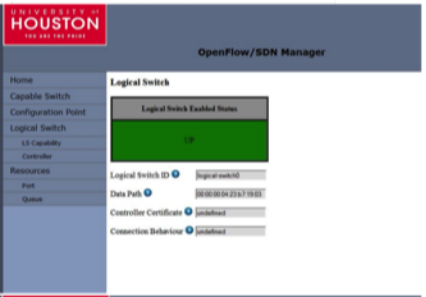
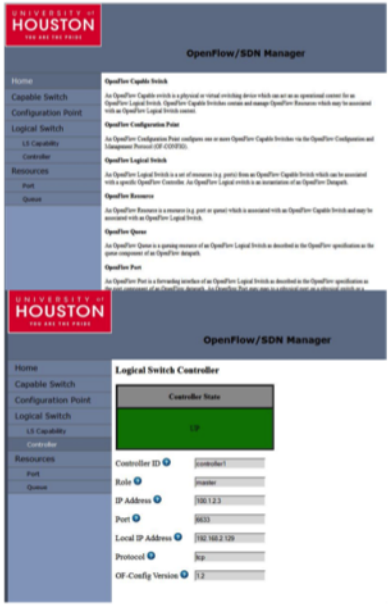
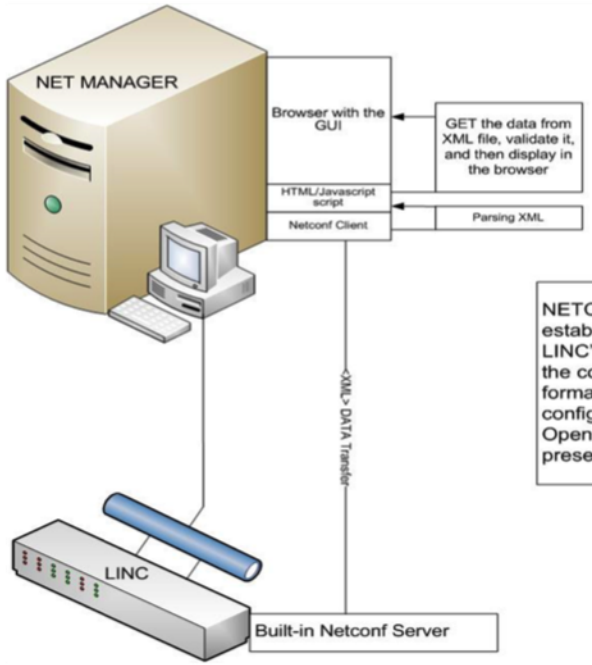
OF-Config Protocol: Visualization of the Management Plane in OpenFlow/SDN Networks

Anatoliy Malishevskiy and Deniz Gurkan







Sponsored by Infoblox

LINC switch, more info at: FLOWFORWARDING.ORG

NETCONF over SSH Client establishes a new session with LINC's NETCONF Server and pull the configurations in the XML format. After parsing and validating configuration data, all the OpenFlow parameters, if they are present, are displaying

- Implemented on ProtoGENI
- OF-Config: Network Management for OpenFlow networks
- DEMO: Displaing LINC Switch configurations through NETCONF using OF-Config specification
- OF-Config Specification uses NetConf as transport
- YangCli (YUMA) mechanism is used to get switch configurations
- GREE 2013 work in progress paper

The data model for OF-Configurations Protocol is structured into classes and attributes of classes. Each class is described in a separate sub-section by XML, UML, and YANG. The core of the model is an OF Capable Switch that is configured by OF Configuration Points. Instances of OF logical switches are contained within the OF Capable Switch. A set of OF Controllers is assigned to each OF logical switch. When issuing a NETCONF "get-request" all elements in the requested sub-class or sub-tree must be returned in the result and then manipulation can be done.

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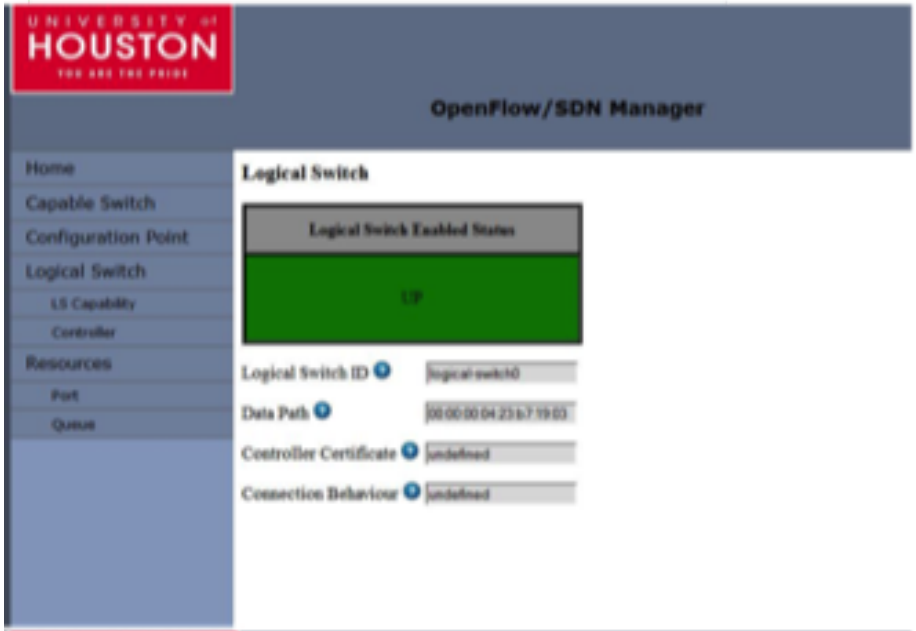

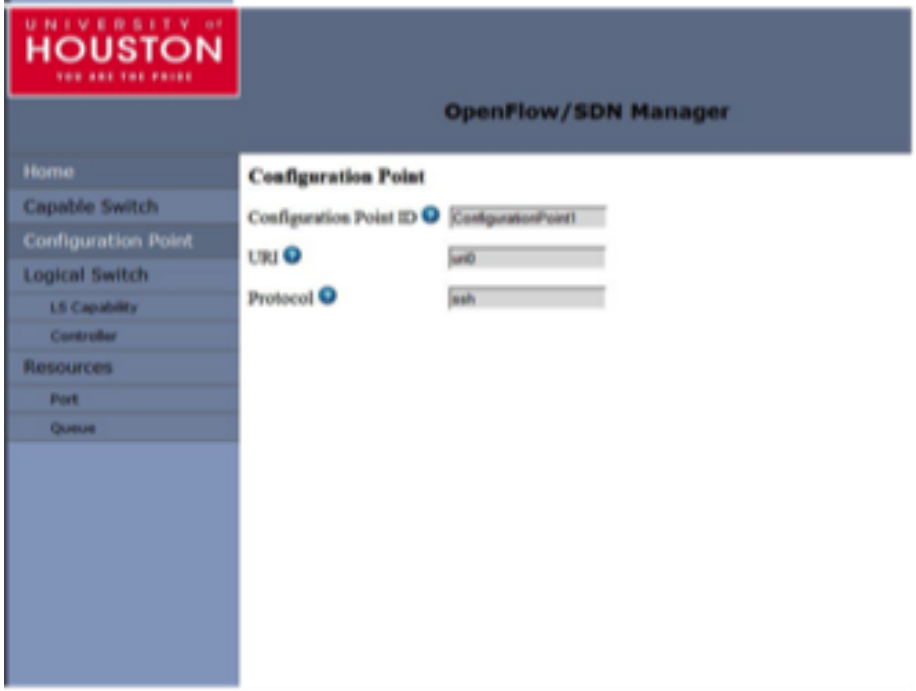

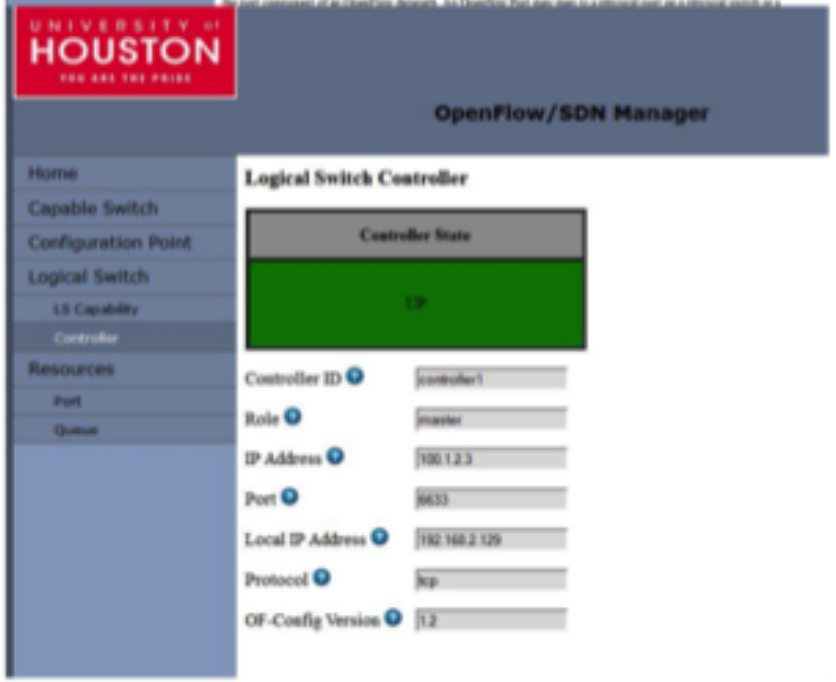

Outline

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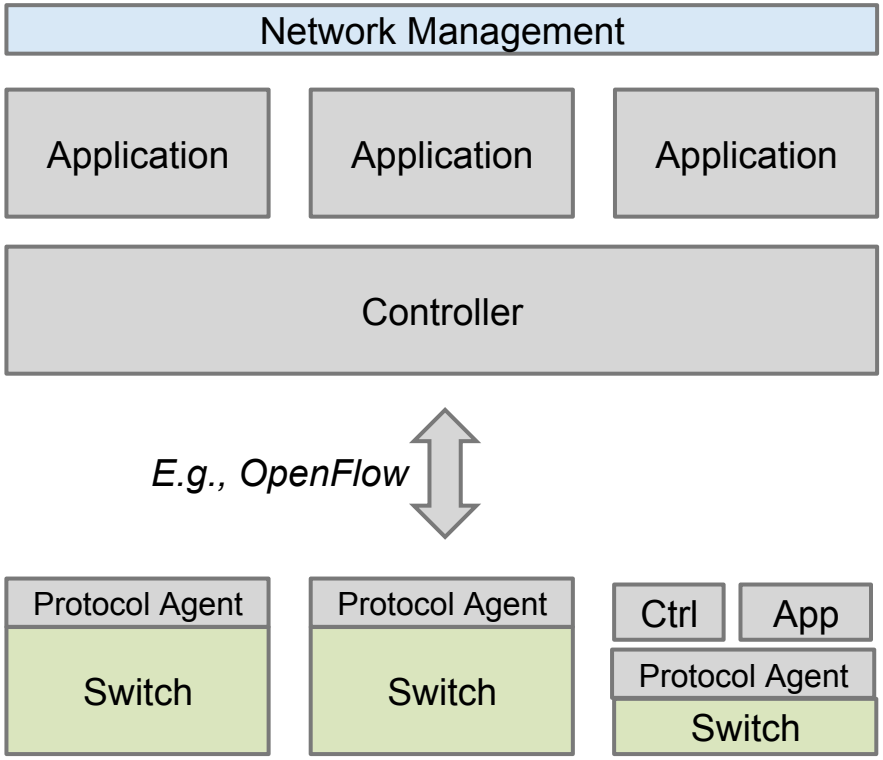
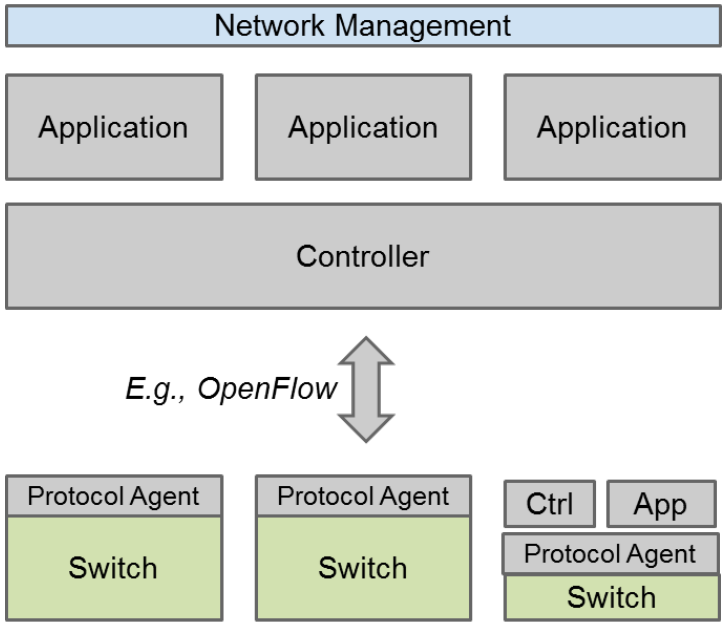
Motivation

Leverage hardware capabilities



Application-Network Interfaces

- Network abstraction for application development
  - Socket API: connect/send/receive/listen
  - ?
- Manipulate flows on their way from source to destination
  - Not at end points
  - Leverage hardware: Acceleration, buffering, storage, DPI, etc.



Research on:

1. Taxonomy of functions
2. Control/routing with sub-units

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Split Data Plane SDN: Development of Applications for Network Programming at the Network Nodes

Rajesh Narayanan (Dell), Fahd Gilani (XFlow Research), Praveen Mala (UoH) and Deniz Gurkan (UoH)

Project in collaboration with DELL and XFLOW RESEARCH

Special thanks to Michael Blair Wever from CAVIUM

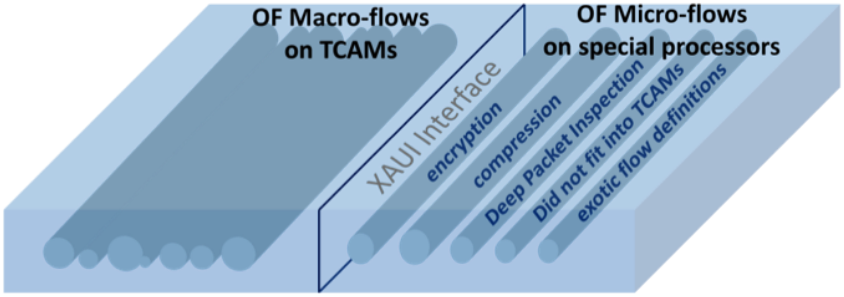
Network Programmability

Definition: Configure, provision, and specialize an underlying network according to the service application and user needs

Current: program end point behavior, take network as quasi-rigid setup

OpenFlow/SDN: dynamically control flow definitions by a controller

Split Data Plane (SDP) SDN: dynamically control and change flows at network nodes *while high-level flow definitions are still governed by the controller*

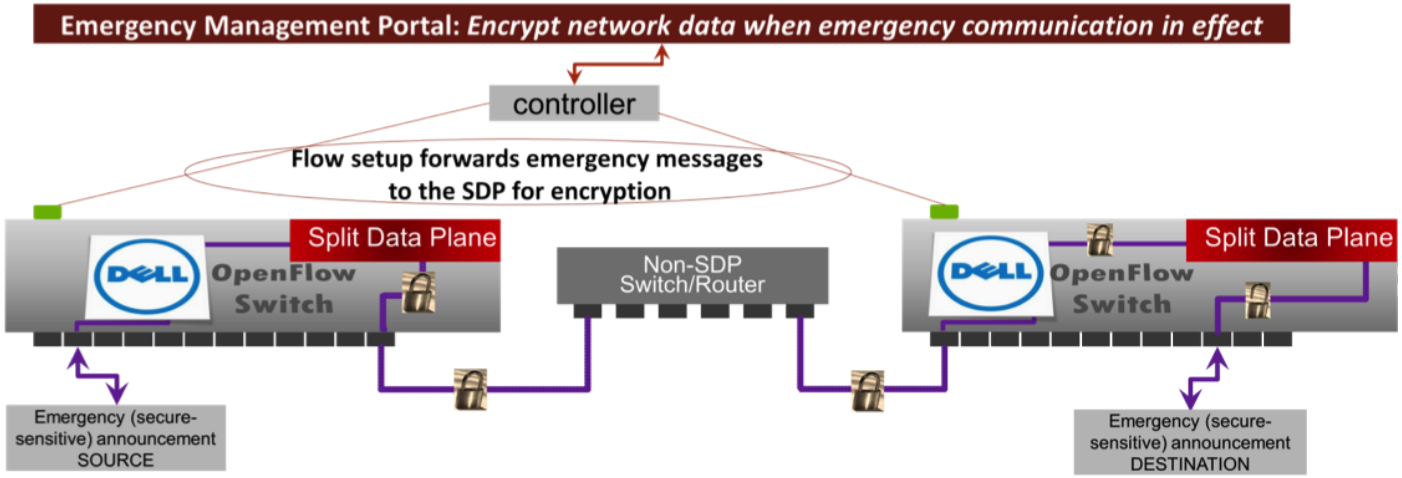


GOAL

Creation of applications that leverage SDN technologies and OpenFlow protocol to deliver network processor capabilities into network programmability.

DEMO SETUP

An emergency application sends secure-sensitive announcement over the network: network-level encryption and decryption is achieved.



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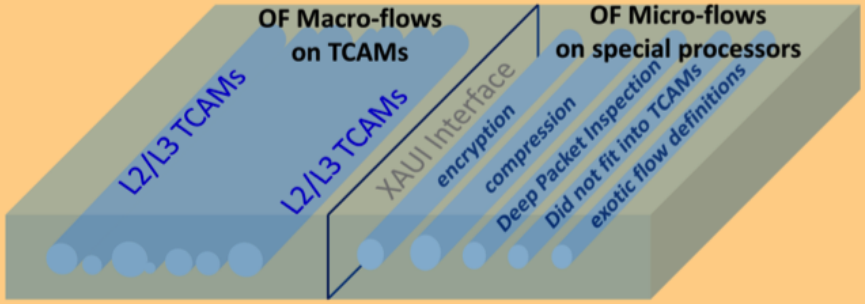
SDN Innovation Platform

Rajesh Narayanan (Dell), Fahd Gilani (XFlow Research), Deniz Gurkan and Levent Dane (UoH)

Project sponsored by XFLOW RESEARCH and DELL

Special thanks to Michael Weaver from CAVIUM

What is SDN Innovation Platform?



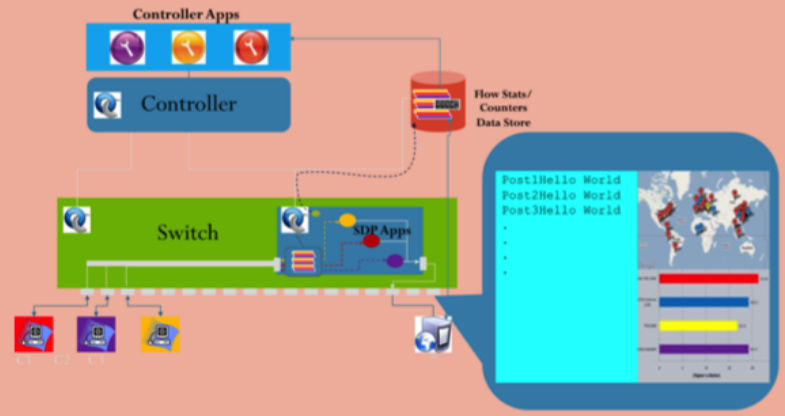
Developing Applications

- As easy as socket programming – *not at end points but on network nodes*
- Popular programming languages
- Hands-on experimentation
- *Sky is the limit*

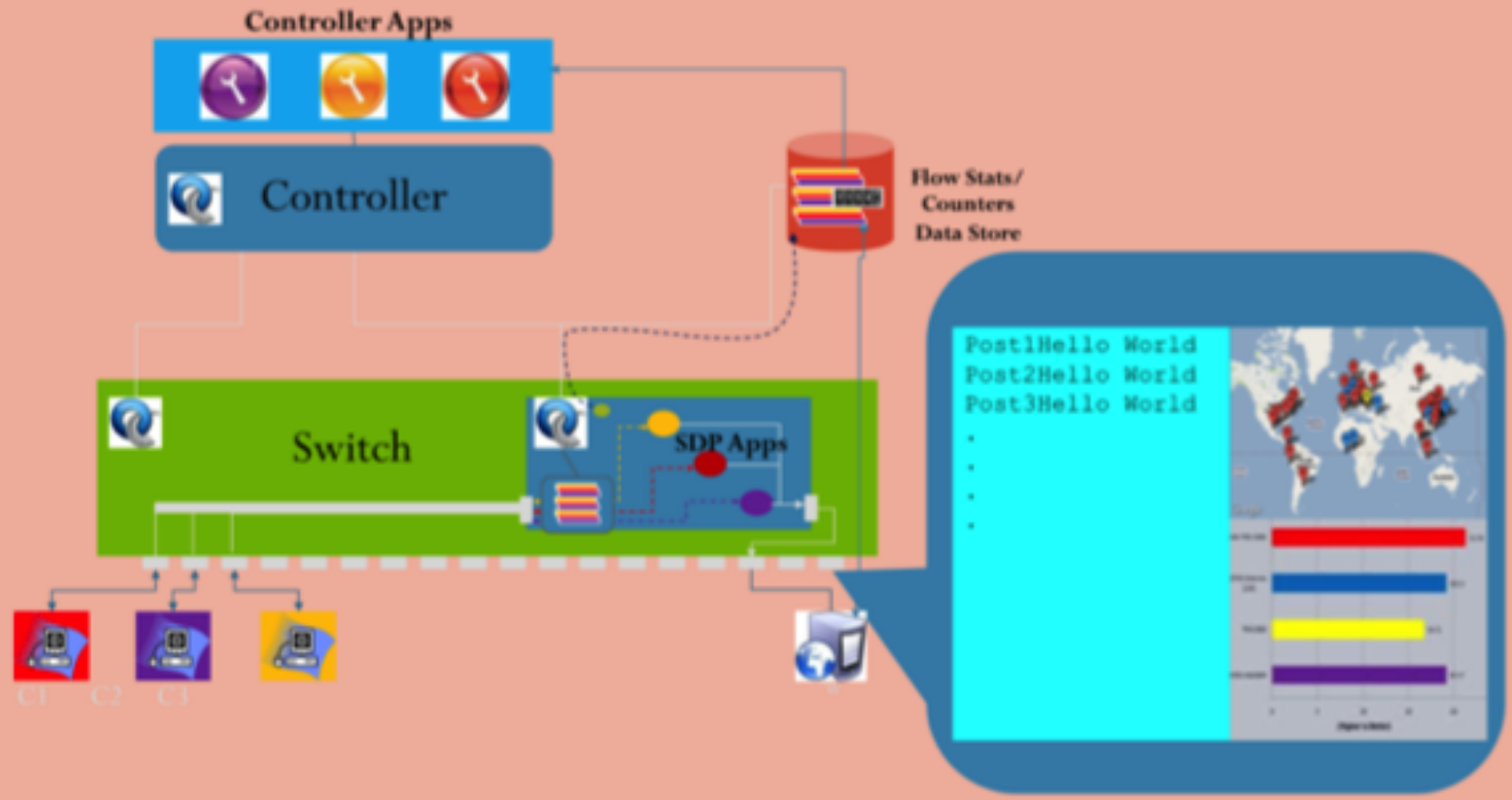
Deploying on GENI

- Booting capabilities are similar to GENI
- Better way to generate applications and experiments on the physical network nodes
- Network visualization
- Opening up new research fields

ICMP-Proxy



ICMP-Proxy


Controller Apps
Controller
Flow Stats/
Counters
Data Store
Switch
SDP Apps
Post1Hello World
Post2Hello World
Post3Hello World
.
.
.
.
C1
C2
C3

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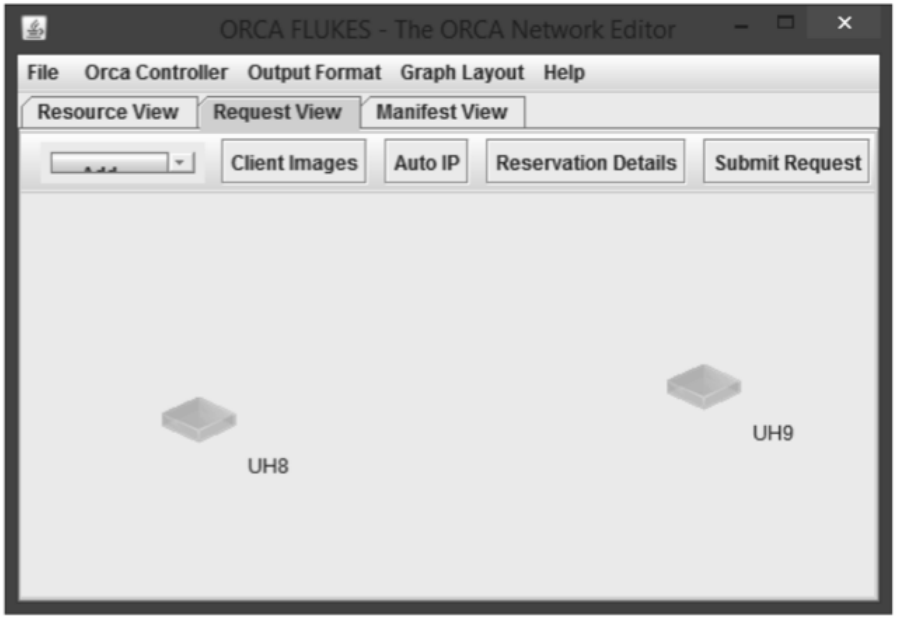
SDP-Network Processing Unit (NPU) on ExoGENI

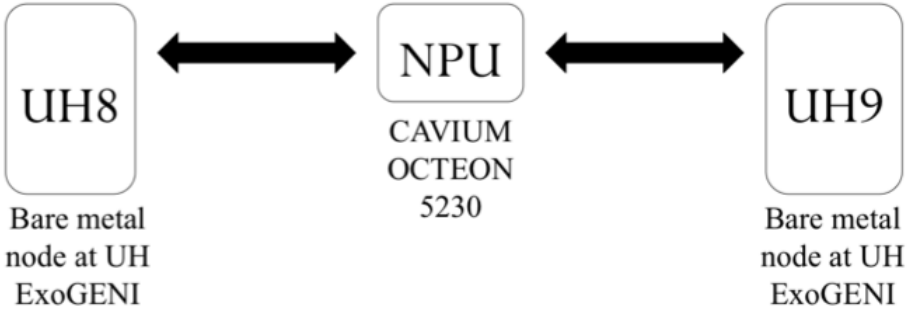
Levent Dane, Deniz Gurkan (UoH)

Project sponsored by DELL

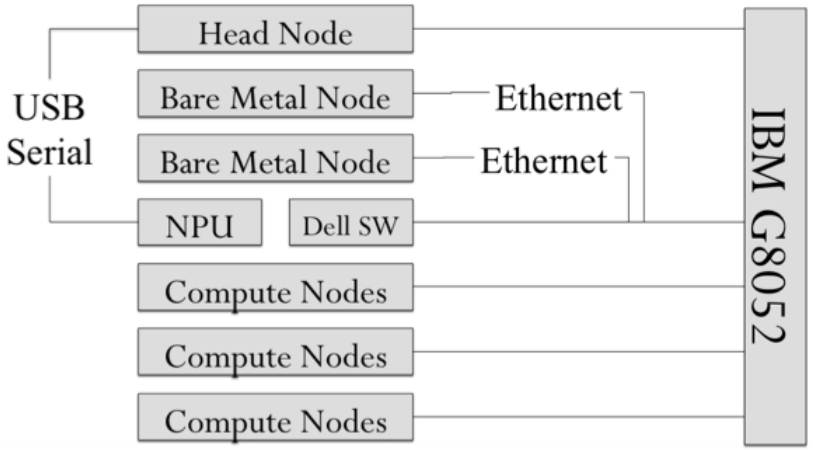
Special thanks to Michael Wever from CAVIUM

ExoGENI Integration





ExoGENI Rack



Current Status

- ✓ Physically in between two bare metal nodes
- ✓ Contact UH for application deployment

Future Work

- ❑ Dynamic Authorization
- ❑ ORCA integration
- ❑ Dynamic VLAN pass through

Outline

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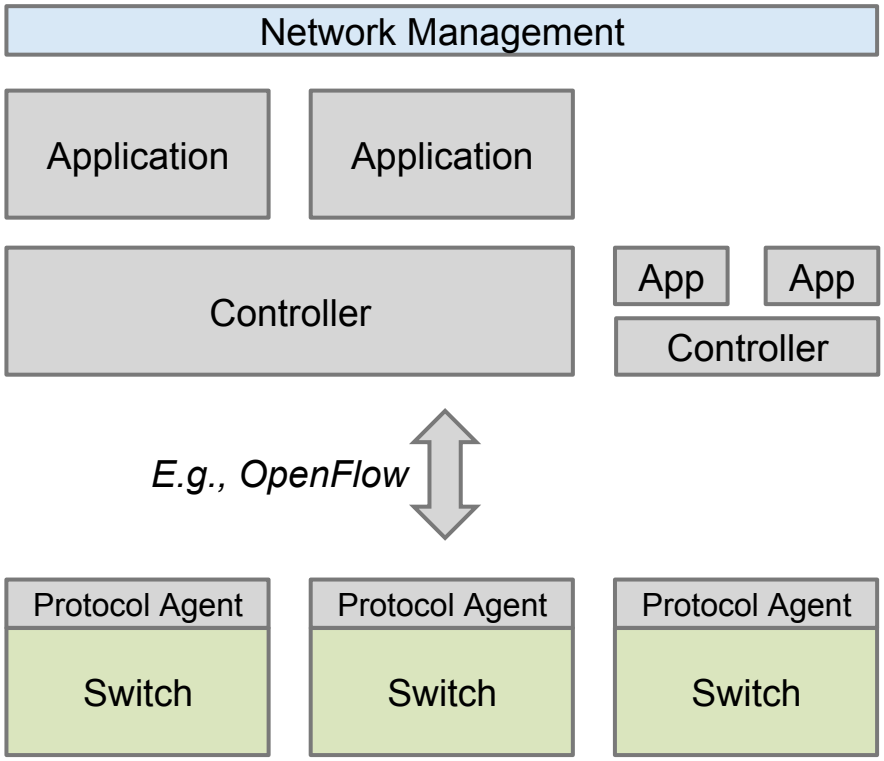
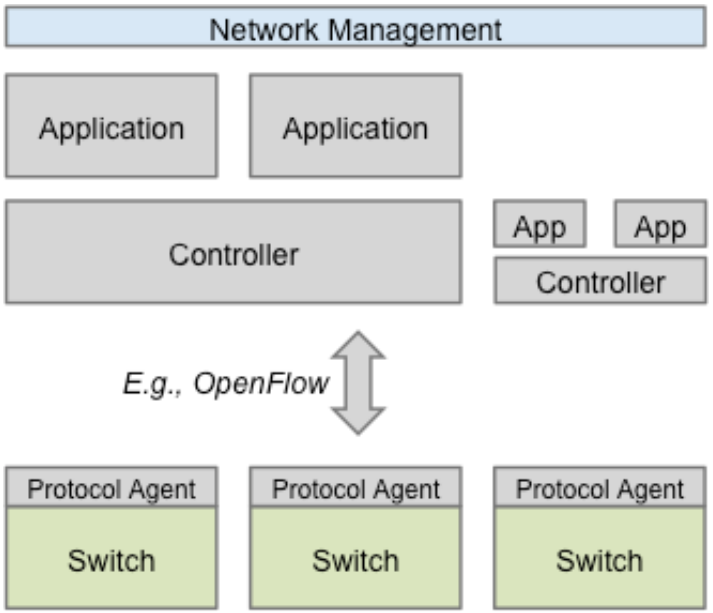
Motivation

Specialized controller/app coupling



On-demand Network Programmability

- Application-triggered network connectivity and path setup
- Emergency first responder assistance
  - Bandwidth
  - Priority
  - Best path (or all)



Research on:

1. Network data model
2. Application-aware control
3. Centralized control policy

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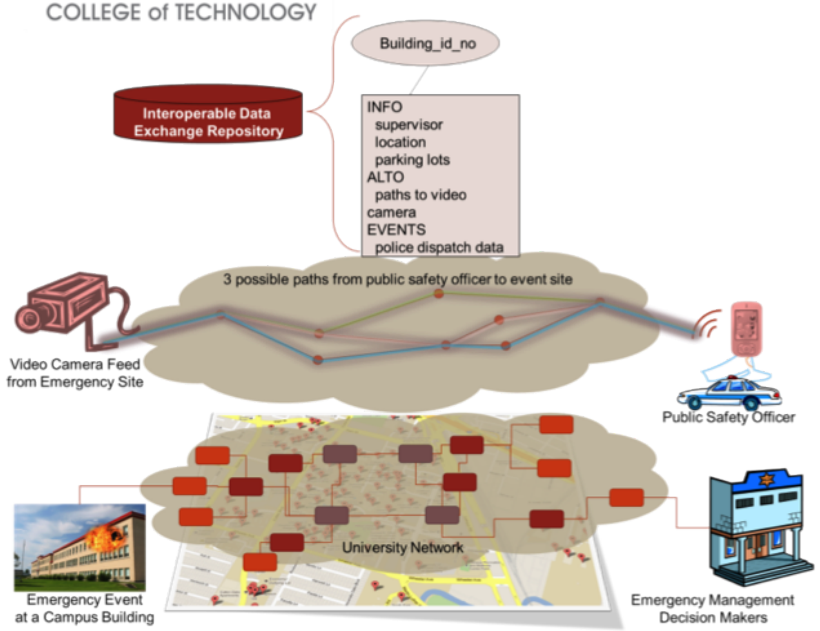
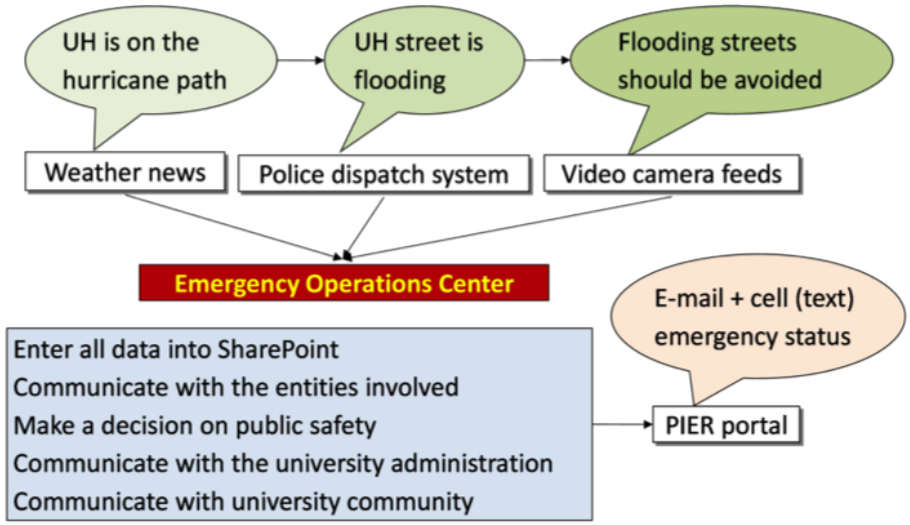
Emergency Management: Interoperable Data Exchange and Dynamic Network Setup

University of Houston: Huy Vo, Deniz Gurkan, Anand Arun Daga
Infoblox: Sandhya Narayan, Stuart Bailey

Project sponsored by Infoblox





EMERGENCY OFFICER

View emergency management portal, **publish** police dispatch emergency events on the **MAP server**

Update/Publish other information on events and buildings related to emergency on the **MAP server**

Delete emergency events when necessary from the **MAP server**

PUBLIC SAFETY OFFICER

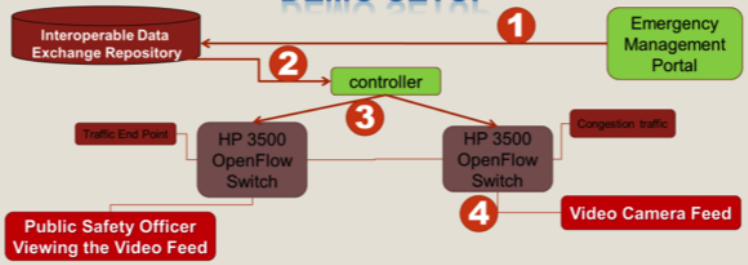
Subscribe to emergency events and related information feeds on the **MAP server**:
e.g., view video camera feeds around an emergency site as soon as there is a police dispatch of an event at the site

OPENFLOW CONTROLLER

Subscribe and/or **search** events to program and provision the network accordingly

Push flows to the OpenFlow switches to assign priority or pick best paths

DEMO SETUP



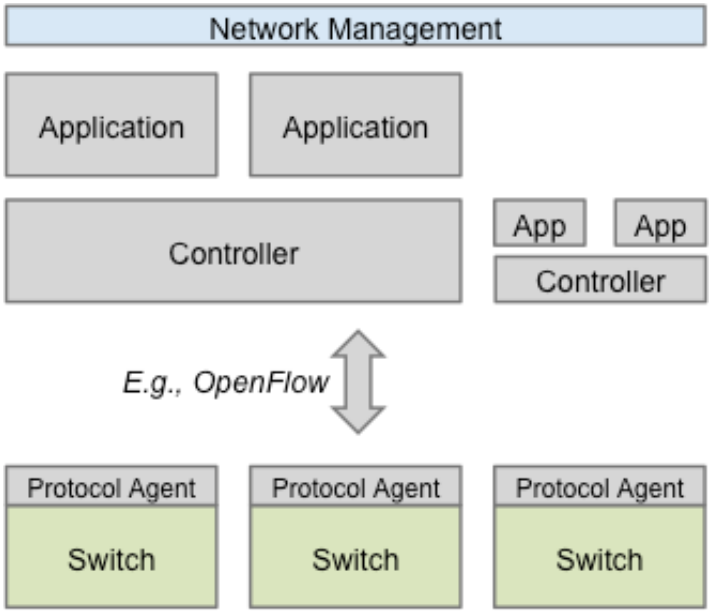
1 Emergency event is published to a building site
2 Controller is subscribed to events at flow-controlled sites
3 Controller pushes flow definitions for high quality video transmission
4 Public safety officers view video feeds at high quality

Network Functions Virtualization

- Application-triggered “network function call”
- Firewall rule offload to forwarding plane
    1. DPI the flow → identify
    2. If safe → offload to network as flow rule
    3. Track only state of session

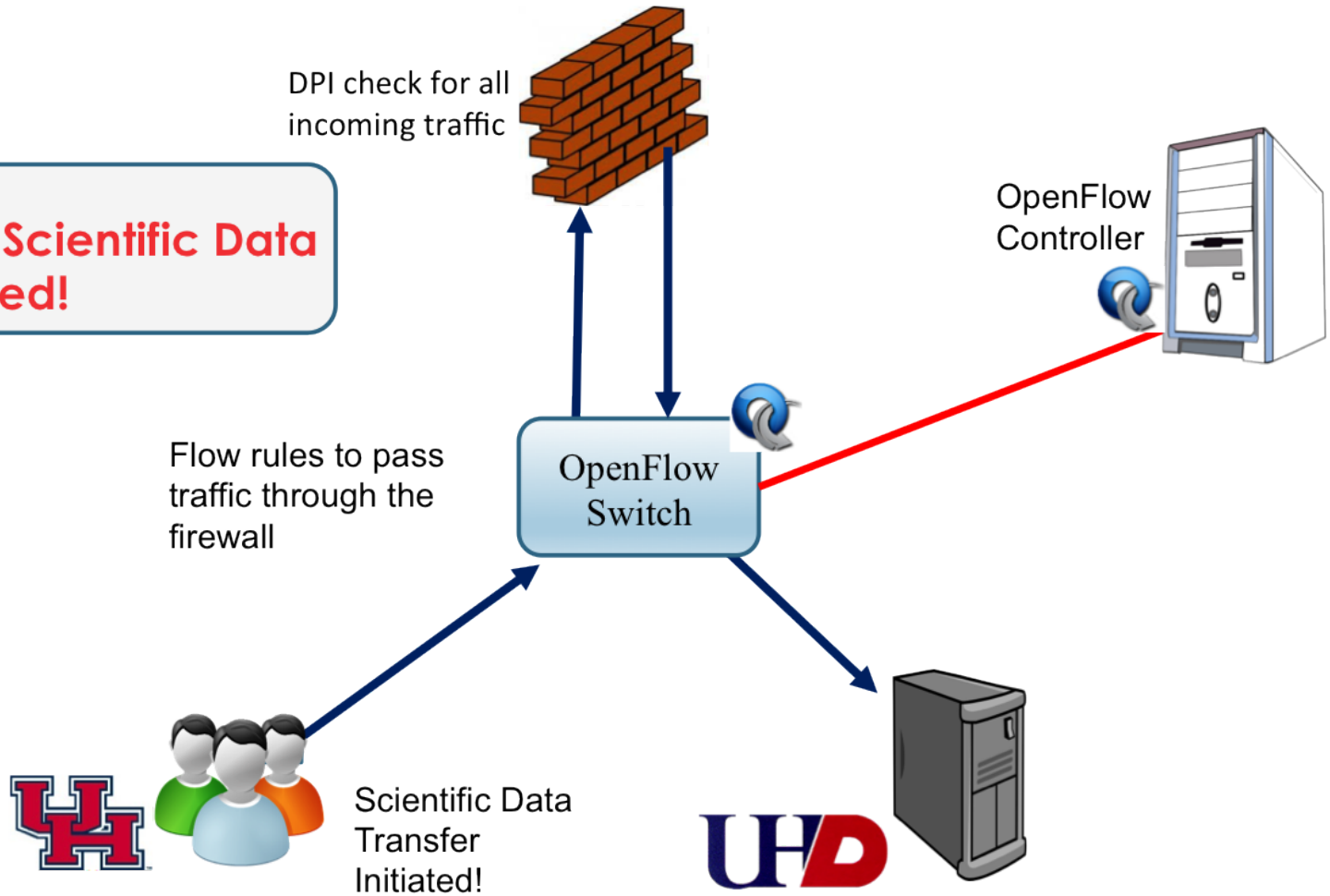
Research on:

1. Time/energy savings
2. Network abstraction
3. Network measurements



Service Chaining

Enterprise Traffic + Scientific Data firewalled!



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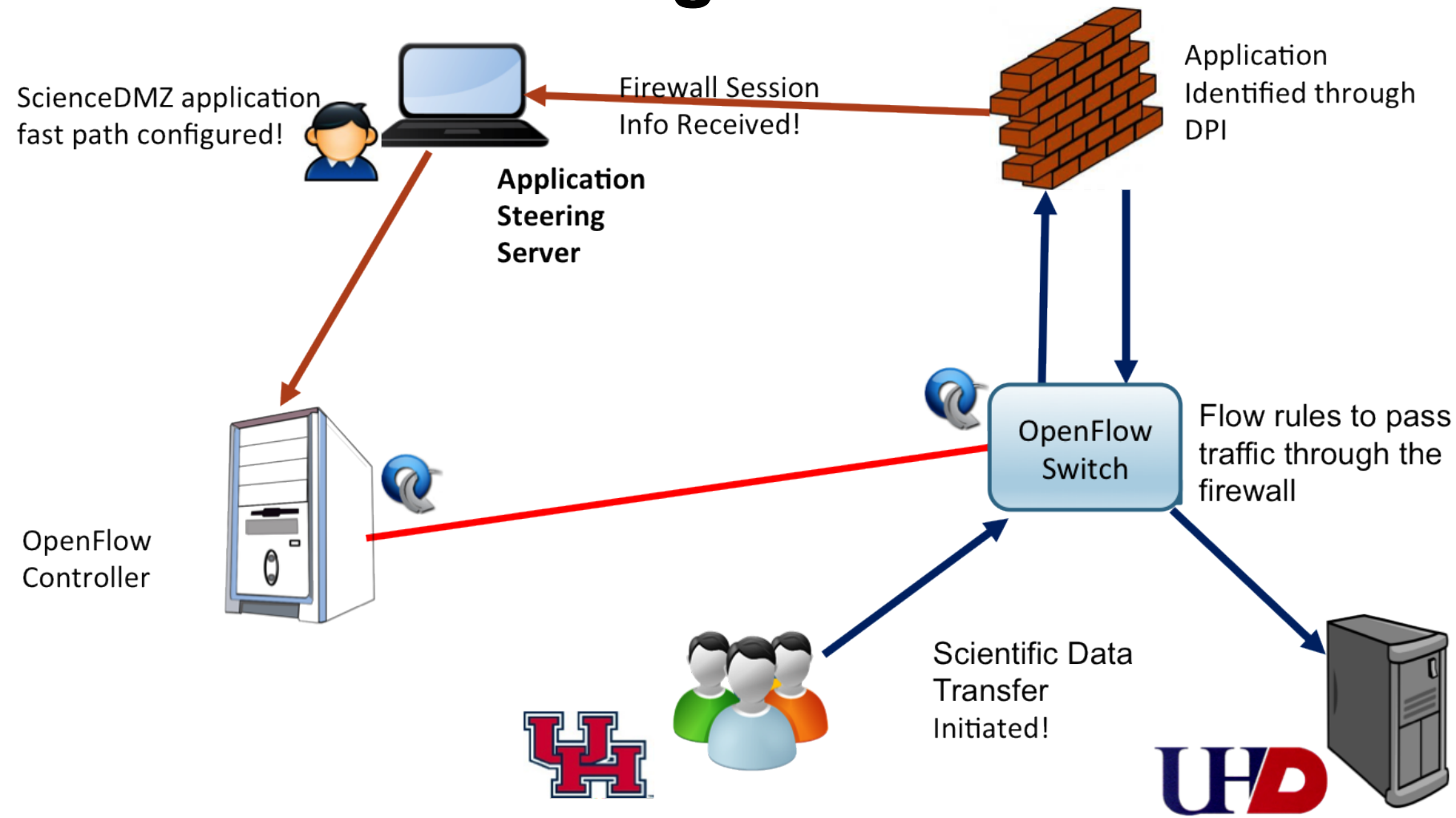
Service Chaining cont.



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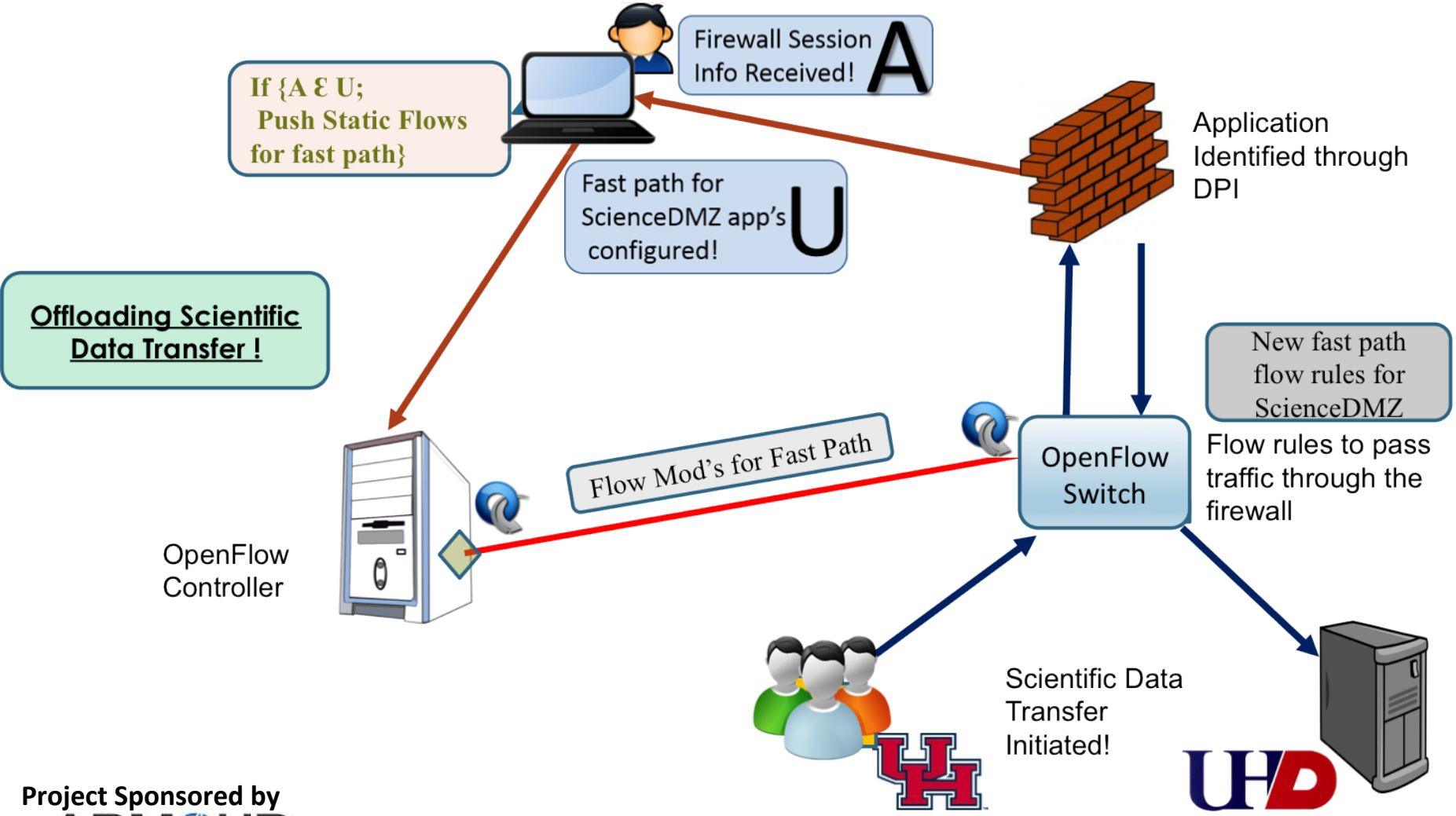
Service Chaining cont.



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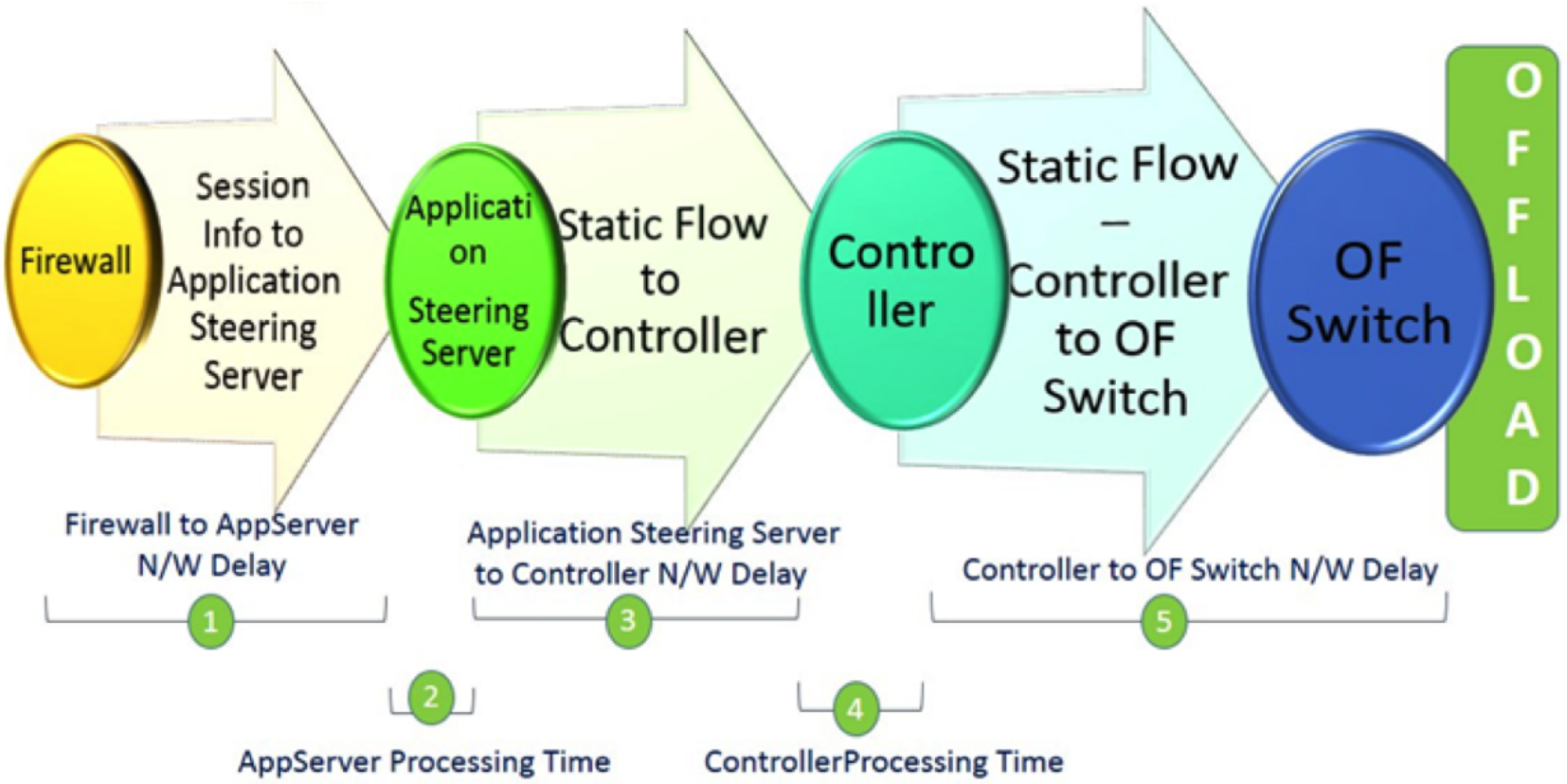
Measurement Points



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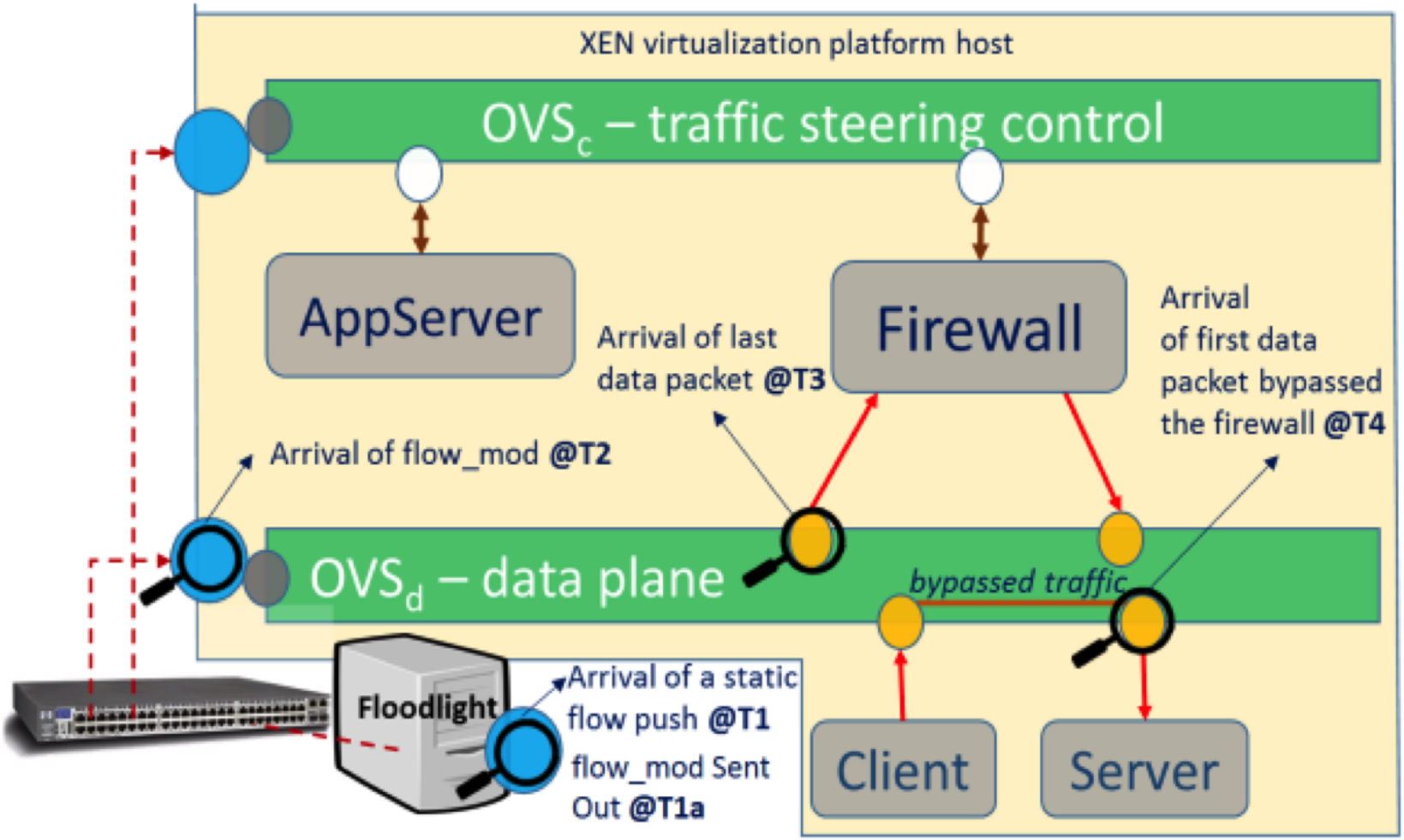
Offload - Justification?



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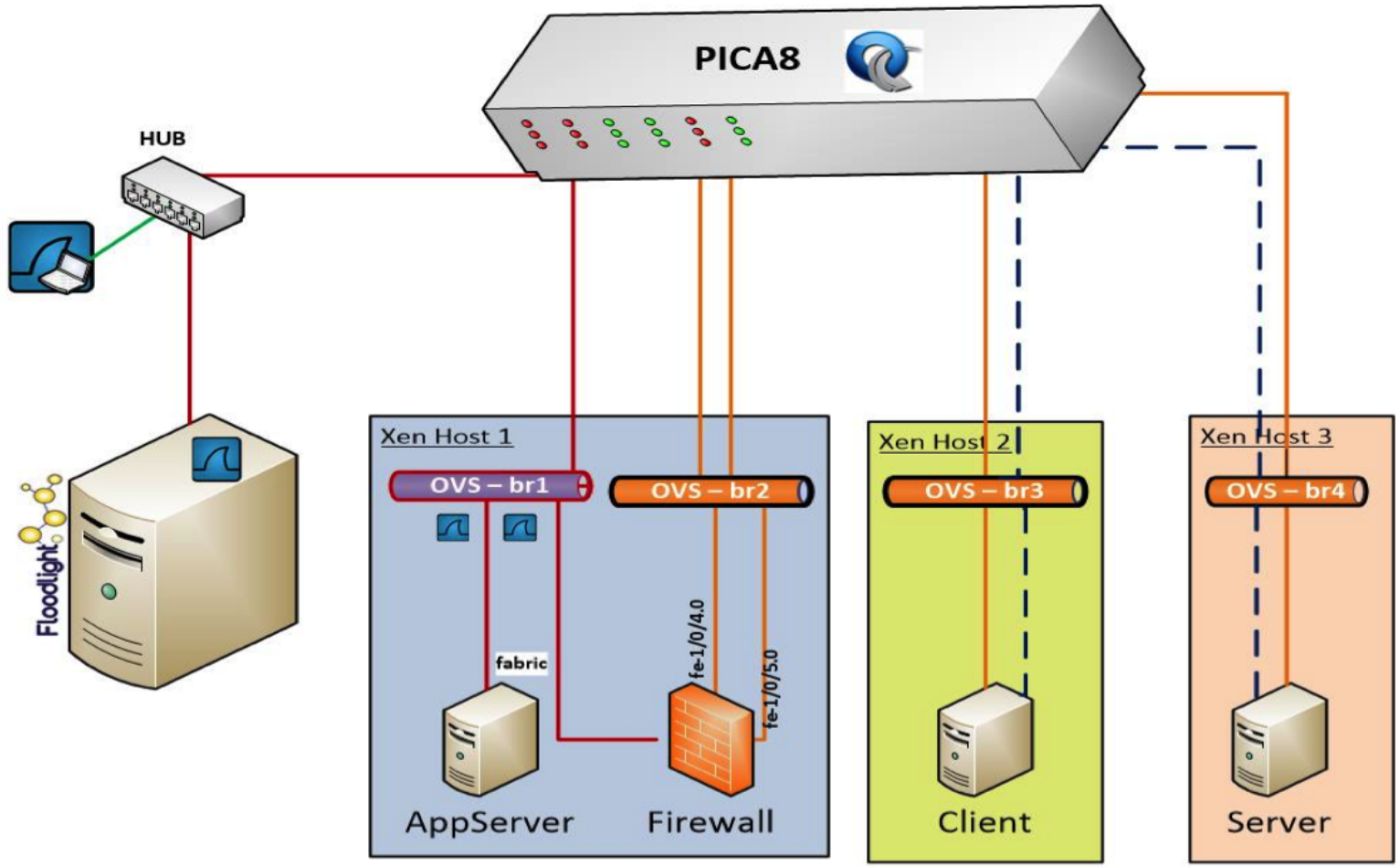
Better measurement scenario



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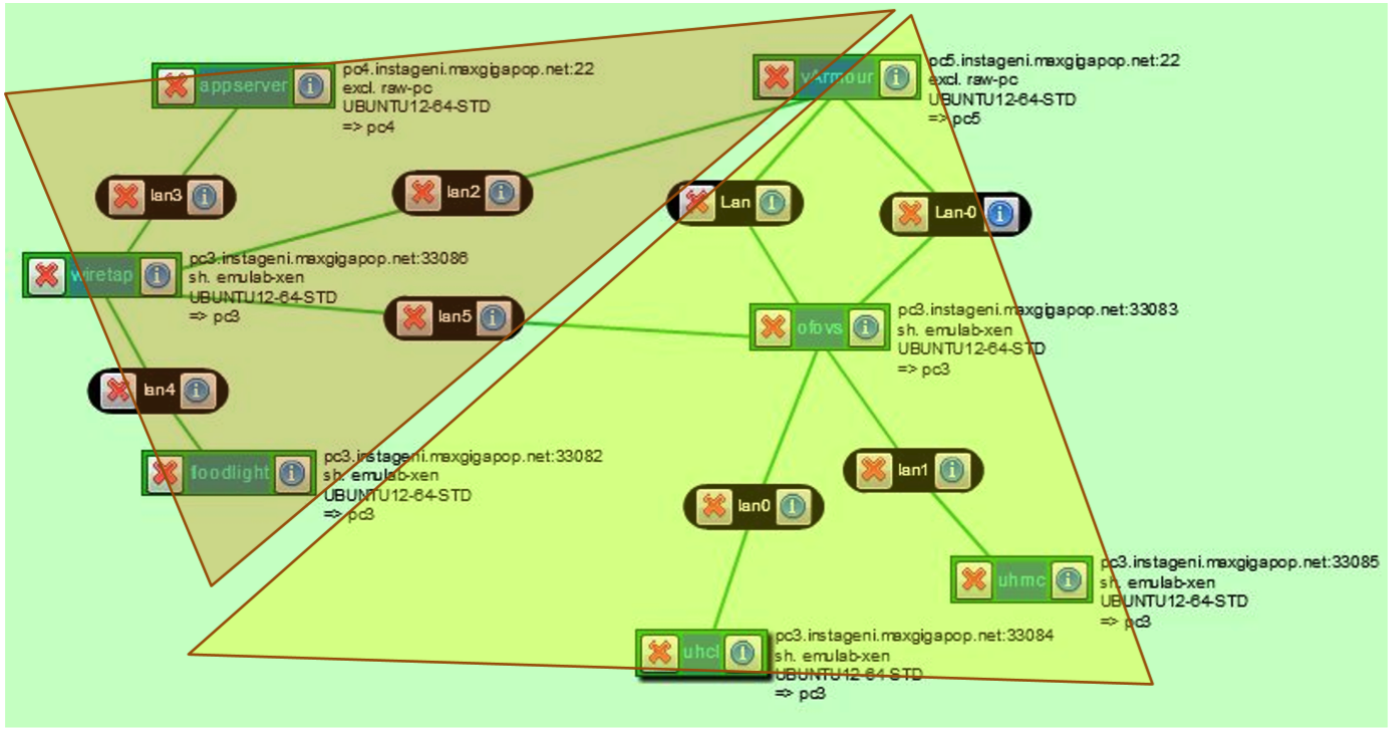
Fabric Network
Measurement Points
Data Network
Wire Tap
Offloaded Path

On GENI



Data Plane

Firewall Out-Of-Band

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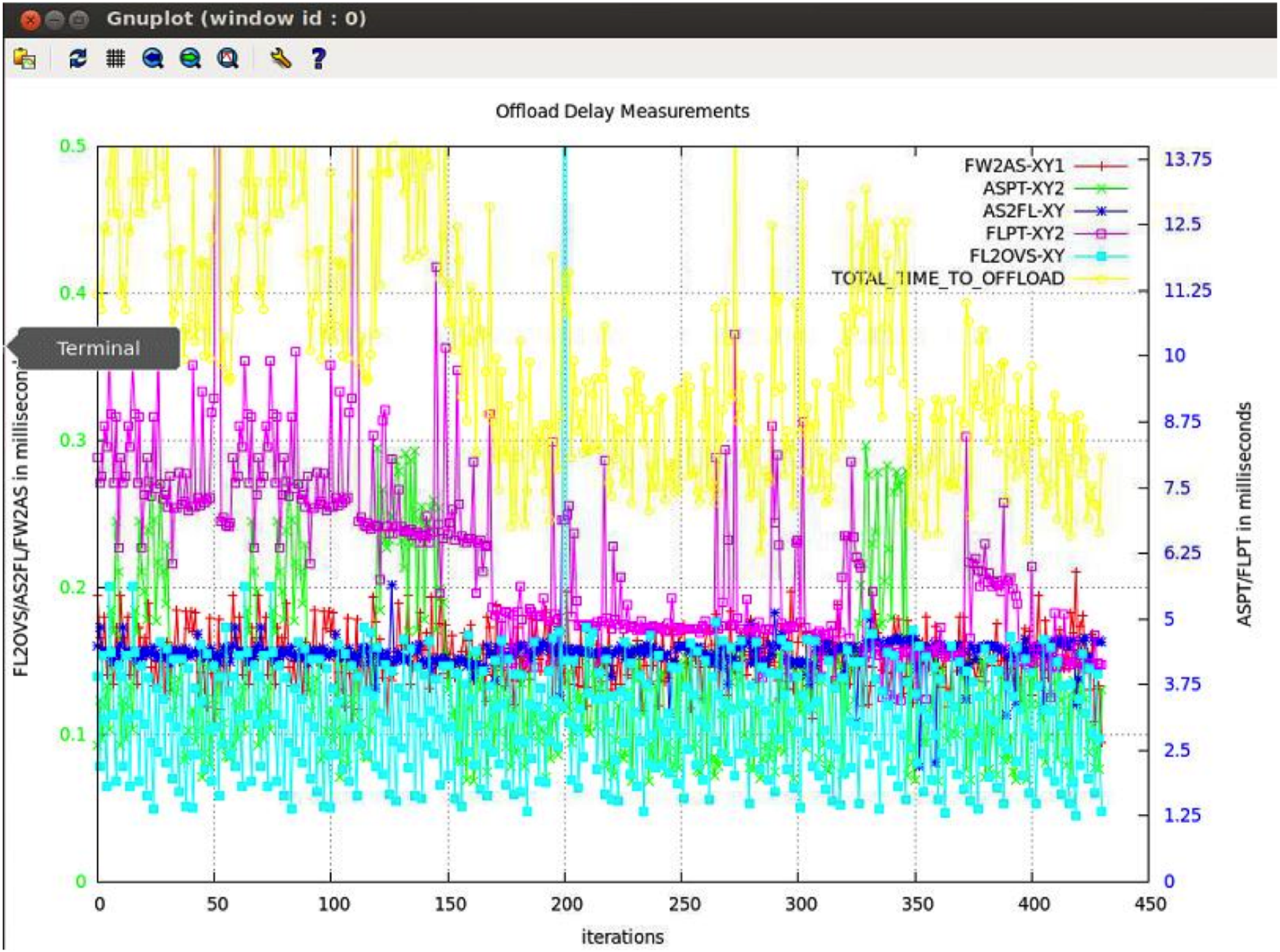
Gnuplot (window id : 0)
Offload Delay Measurements
FW2AS-XY1
ASPT-XY2
AS2FL-XY
FLPT-XY2
FL2OVS-XY
TOTAL_TIME_TO_OFFLOAD
Terminal
FL2OVS/AS2FL/FW2AS in millisecon
ASPT/FLPT in milliseconds
iterations
0
0.1
0.2
0.3
0.4
0.5
0
1.25
2.5
3.75
5
6.25
7.5
8.75
10
11.25
12.5
13.75
0
50
100
150
200
250
300
350
400
450

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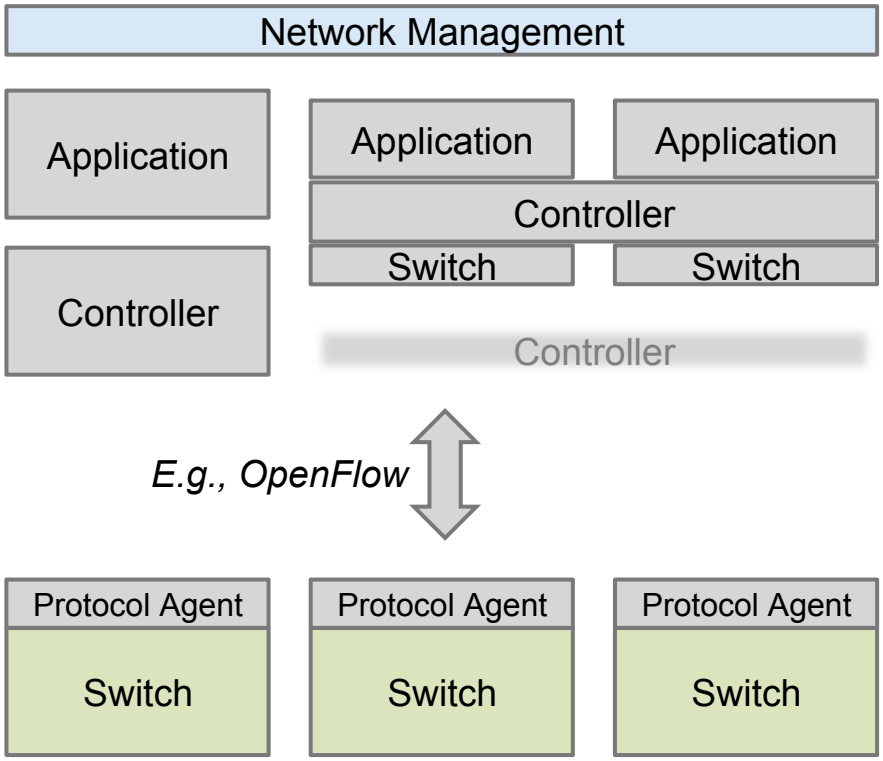
Motivation

Switching as a *software construct* for applications



Switch as a Software Construct

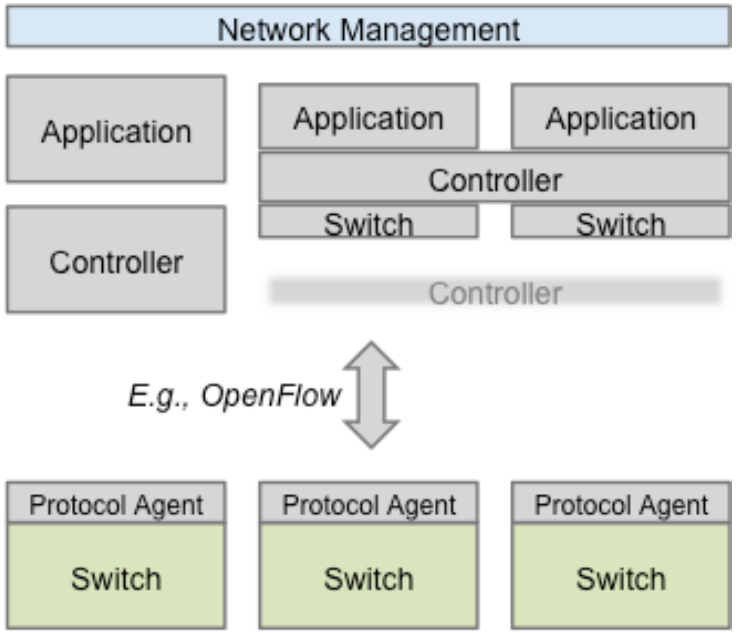
- Server industry ~--~ switch industry

→ approaching an understanding of the forwarding elements as a “software construct” rather than a “vendor box”

Research on:

1. Network abstraction
2. Programmable header parsing
3. Fault-tolerant switch fabric
4. Efficient software switching:

parse – match – forward



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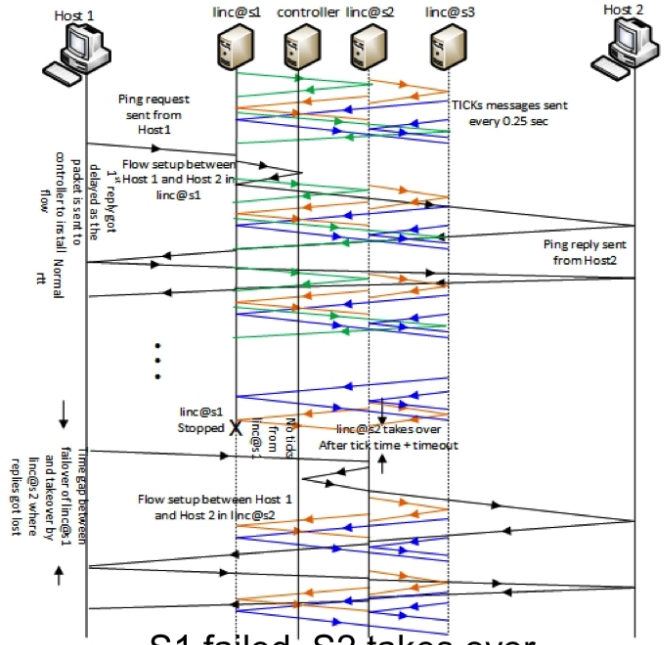
Packet loss during failover and takeover on Distributed OpenFlow Switch Architecture

Gandhimathi Velusamy and Dr. Deniz Gurkan

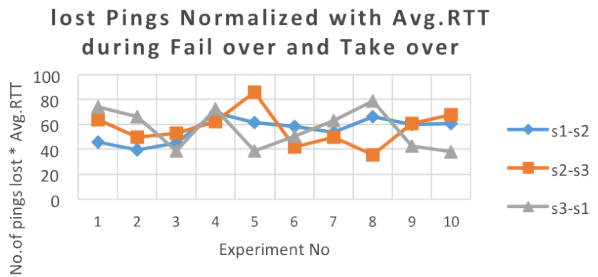
In collaboration with Dr. Sandhya Naraya

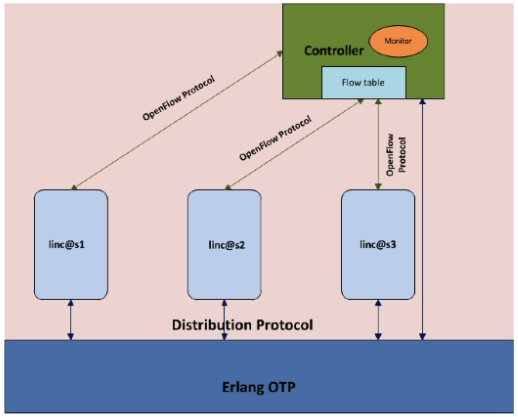
FLOWFORWARDING.ORG

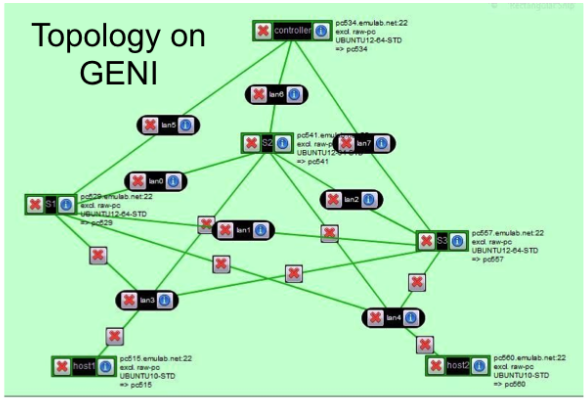
Infoblox

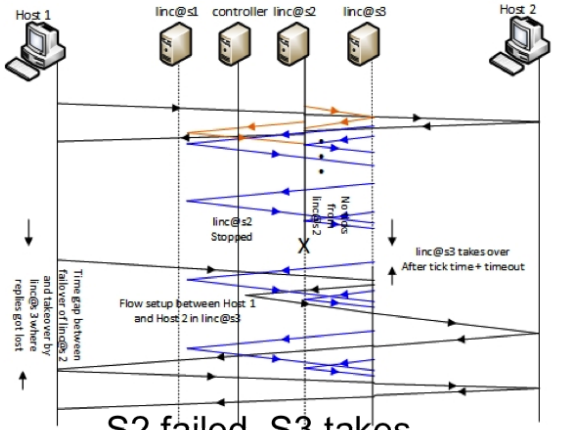


S1 failed, S2 takes over

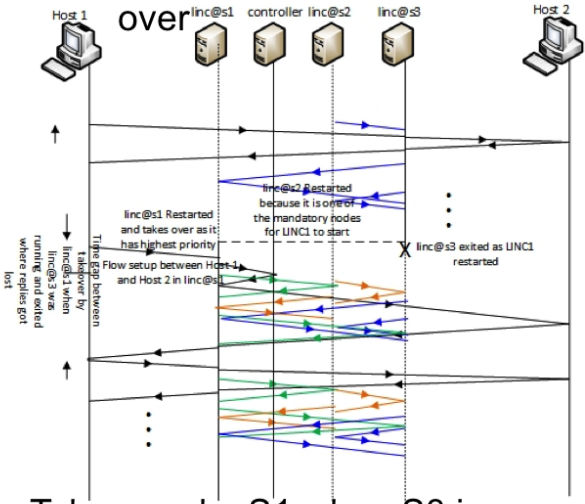








S2 failed, S3 takes over



Take over by S1 when S3 is running

Thank you

dgurkan@uh.edu