Routing in the Future Internet

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Graduate Course (Slideset 10a)

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Outline

1. Assignment of final works for course approval
2. Software Defined Networks (SDNs).
3. Open APIs:
   - OpenFlow
   - JUNOS SDK
   - Cisco ONE
   - OPENER
   - .....
4. Outsourcing to the Cloud and its impact on routing, etc.

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Final Works (15 hs/person)

Multi-point BGP sessions for Traffic Engineering

Mauricio and M. Barreto:

- Identify scenarios and/or use cases in which multi-point BGP sessions can add value...
- How do you imagine multi-point BGP sessions would be?
- What can be done with them? ... be creative!
- Analyze the options in two contexts. .. intra-AS multi-point sessions and the challenges toward inter-AS multi-point sessions...
- Examine the possible strengths in the enterprise arena...
- Benchmarks vs. LISP-based TE...

Final Works (15 hs/person) (cont.)

Examine the problem of Route Leaks and propose solutions...

A. Valdés and E. Cota:

- Examine the state-of-the-art.
- Split the analysis in two contexts: Dealing with route leaks in BGPSEC vs. the Overlay approach...
- Can route leaks be stopped in either of these contexts?
- Be creative ...

Final Works (15 hs/person) (cont.)

EID Prefix Authorization

F. Rodriguez and L. Vidal:

- Analyze the requirements for global EID prefix authorization in the DDT.
- Analyze the expected level of security in the authorizations, including considerations such as the right to register an EID prefix, and the right to claim the presence of an EID at an RLOC.
- To this end, consider the potential coupling with a RPKI and/or ROA-like infrastructure and the protocols needed.
- Analyze the challenges posed by mobility (especially, in the context LISP-MN where the goal is to keep complex operations off the ITRs implemented in the mobile terminals).
- Be creative ...

Final Works (15 hs/person) (cont.)

The iBGP, Route Reflection and Overlay puzzle ...

Emiliano, N. Antoniello, and José:

- During the course we examined these solutions in isolation ...
- Identify the requirements and highlight the considerations toward their coexistance (iBGP, RRs, iPSP).
- Recommendations toward their coexistence with special focus on the following aspects: scalability, data paths, avoiding black holes and loops.
- Be creative ...

Final Works (15 hs/person) (cont.)

Software Defined Networks (SDNs)

Juan, Edgardo, and Fernando

- Identify a set of problems in the IMM (at least 3) that cannot be suitably tackled by legacy routing and switching (preferably involving i/eBGP).
- Based on that, define at least 3 use cases for SDNs.
- Identify the requirements and highlight how SDNs can help in these areas.
- Develop the ideas for such SDN apps and how they can be used.
- Define the new command-set needed and or the services that shall be exposed through the API.
- Be creative ...

Final Works (15 hs/person) (cont.)

Assessment ...

- Be creative ... I wouldn't like to read a 20 page doc that lacks good ideas...
- Would you like to read and/or comment on other people's work before my evaluation?

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Drivers

The router/switch arena is rapidly transforming...

Three ongoing (and overlapping) trends:

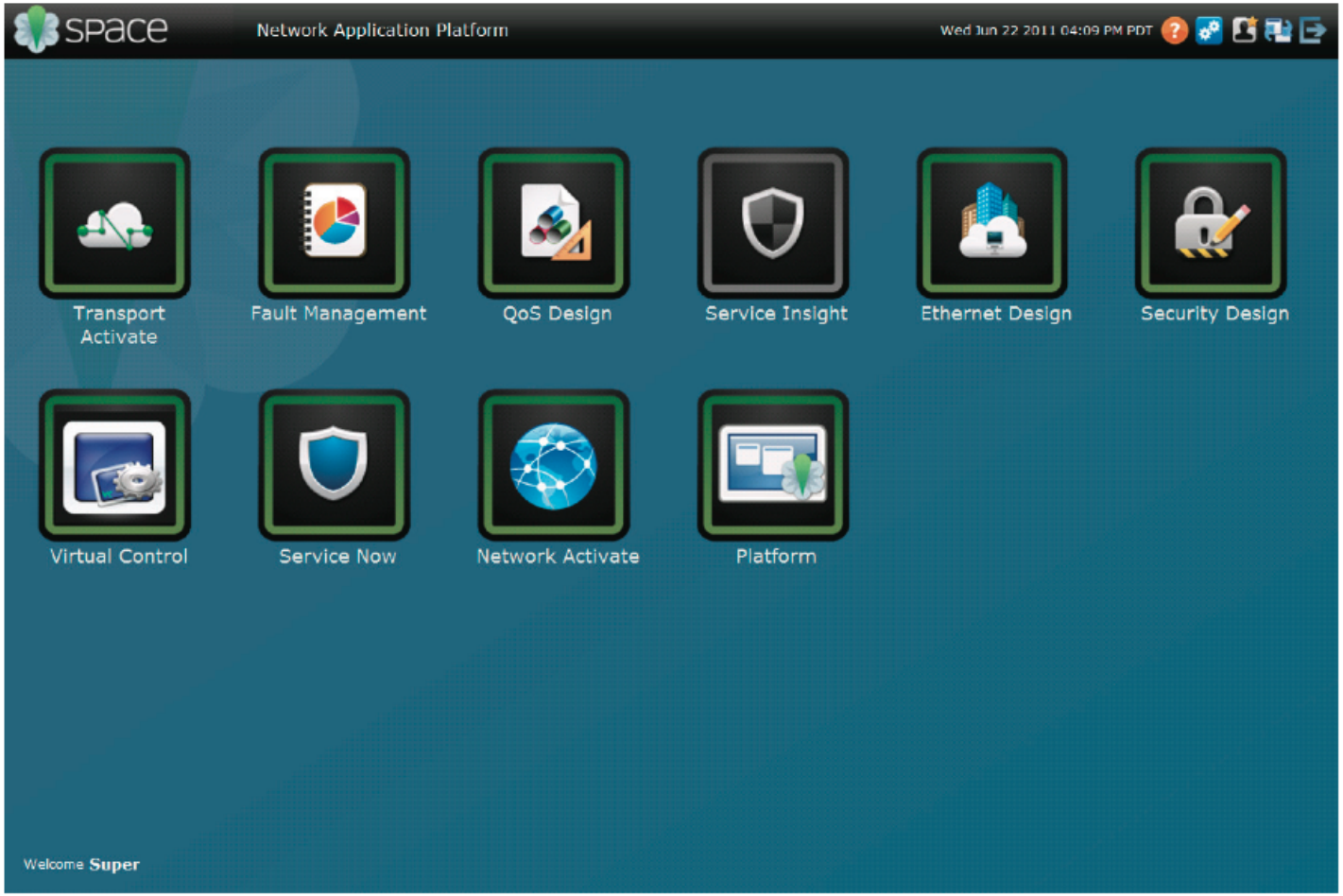
1. Trend toward **open** and **programmable** network devices
   - Allowing researchers and network operators to flexibly experiment with innovative applications and traffic management paradigms on the same hardware that is currently available on operational carrier-grade networks.
2. Trend toward **coordinated cross-layer network operation**
   - ... so as to keep pace with consumers bandwidth and energy requirements.
3. Trend toward **IT and networking convergence**
   - ... the limits between cloud and networking will blur

Current Trends

(1st Trend) Openness and Programmability

- OpenFlow
  - Before OpenFlow there was almost no way to experiment and test new protocols, algorithms, and novel paradigms in a realistic fashion
- JUNOS Space and JUNOS SDK
- CISCO ONE
- ...

JUNOS Space


space
Network Application Platform
Wed Jun 22 2011 04:09 PM PDT
Transport Activate
Fault Management
QoS Design
Service Insight
Ethernet Design
Security Design
Virtual Control
Service Now
Network Activate
Platform
Welcome Super

Current Trends (cont.)

(1st Trend) Openness and Programmability (Cont.)

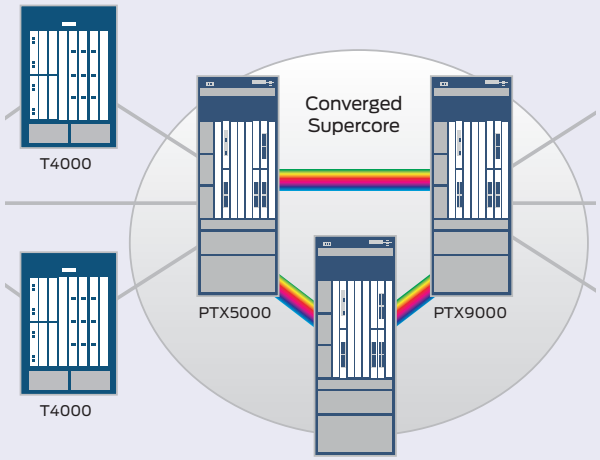
- ...
- Cisco $\Rightarrow$ embarked in a profound restructure of its IOS
- Open source router: Quagga

... the strategy of router/switch vendors is to open their OSs to third-party developers and let them become part of the innovation process

Current Trends (cont.)

(2nd Trend) Cross-layer interactions

- Still challenging since operators traditionally manage their IP and transport network separately (in total isolation)
- Take advantage from openness and programmability
  - Work toward synergetic deployments and operations of IP and transport (Ethernet/optical) networks.
  - The key is to devise cost-effective ways both to orchestrate the operation of L3 and L2/L1 networks, and to manage their corresponding traffic, (e.g.: JUNIPER's PTX – hybrid nodes)



Hybrid and Programmable Nodes

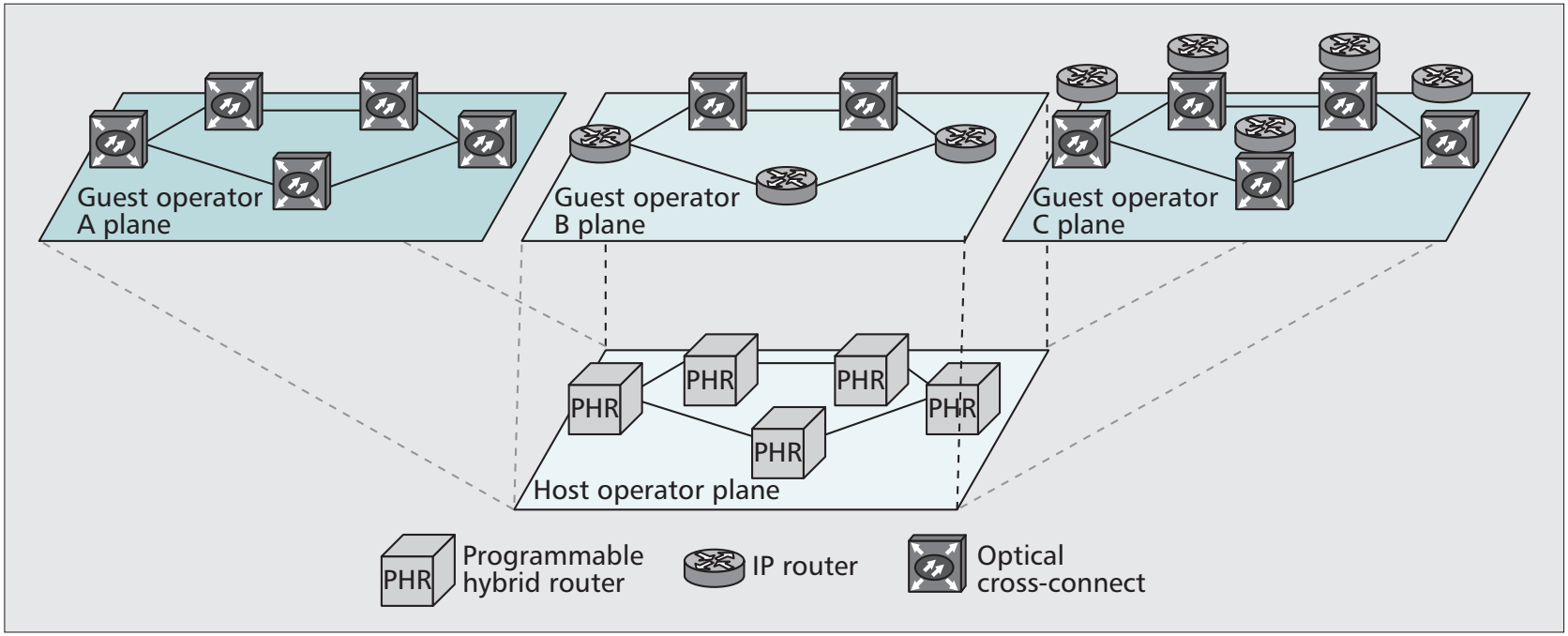
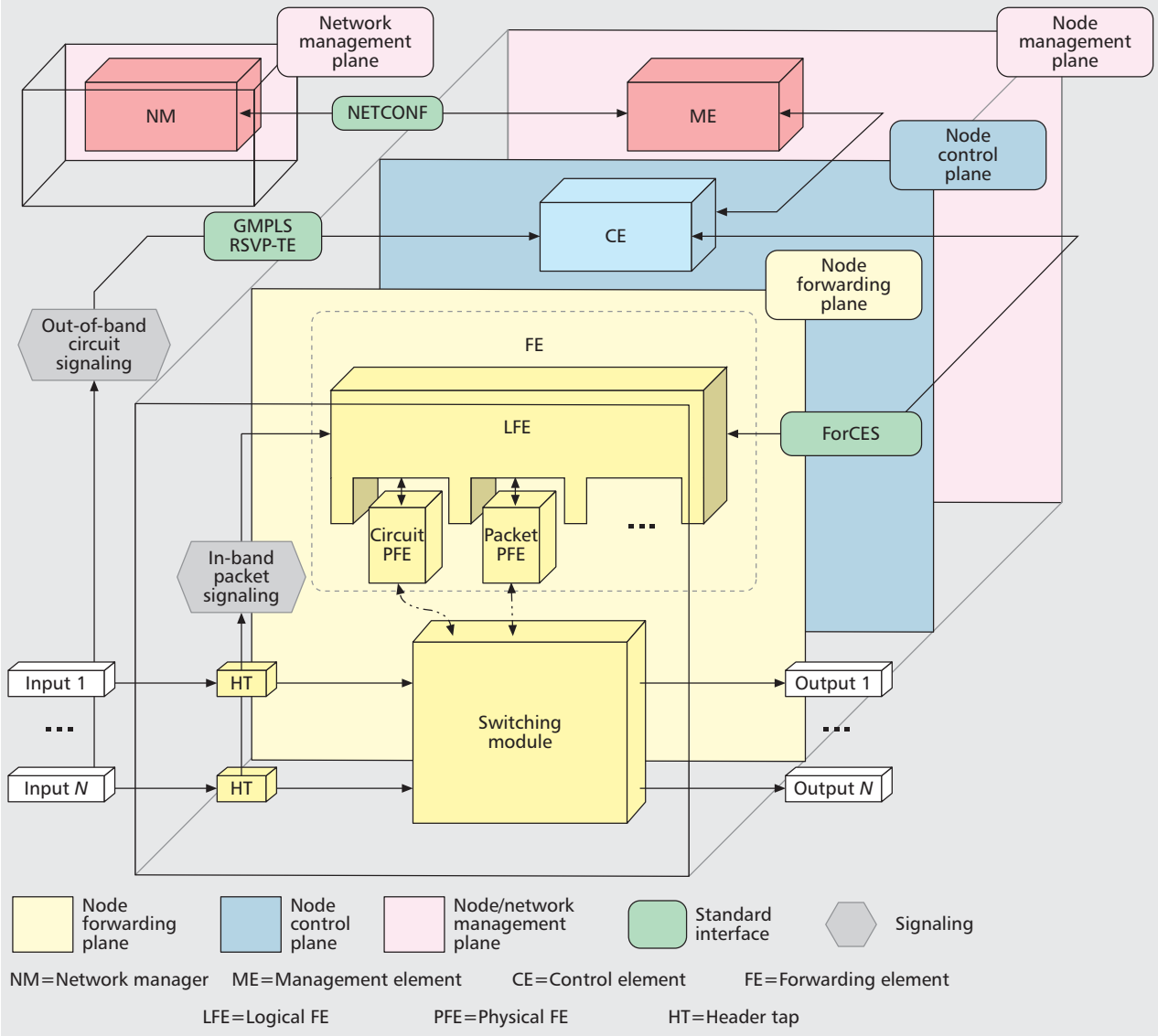


Figure 1. *A programmable hybrid network owned by a host operator and three different instances of guest operator networks resulting from different configurations.*

- R. Cafini et al., "Standard-Based Approach to Programmable Hybrid Networks," IEEE Communications Magazine, May 2011.

Hybrid and Programmable Nodes



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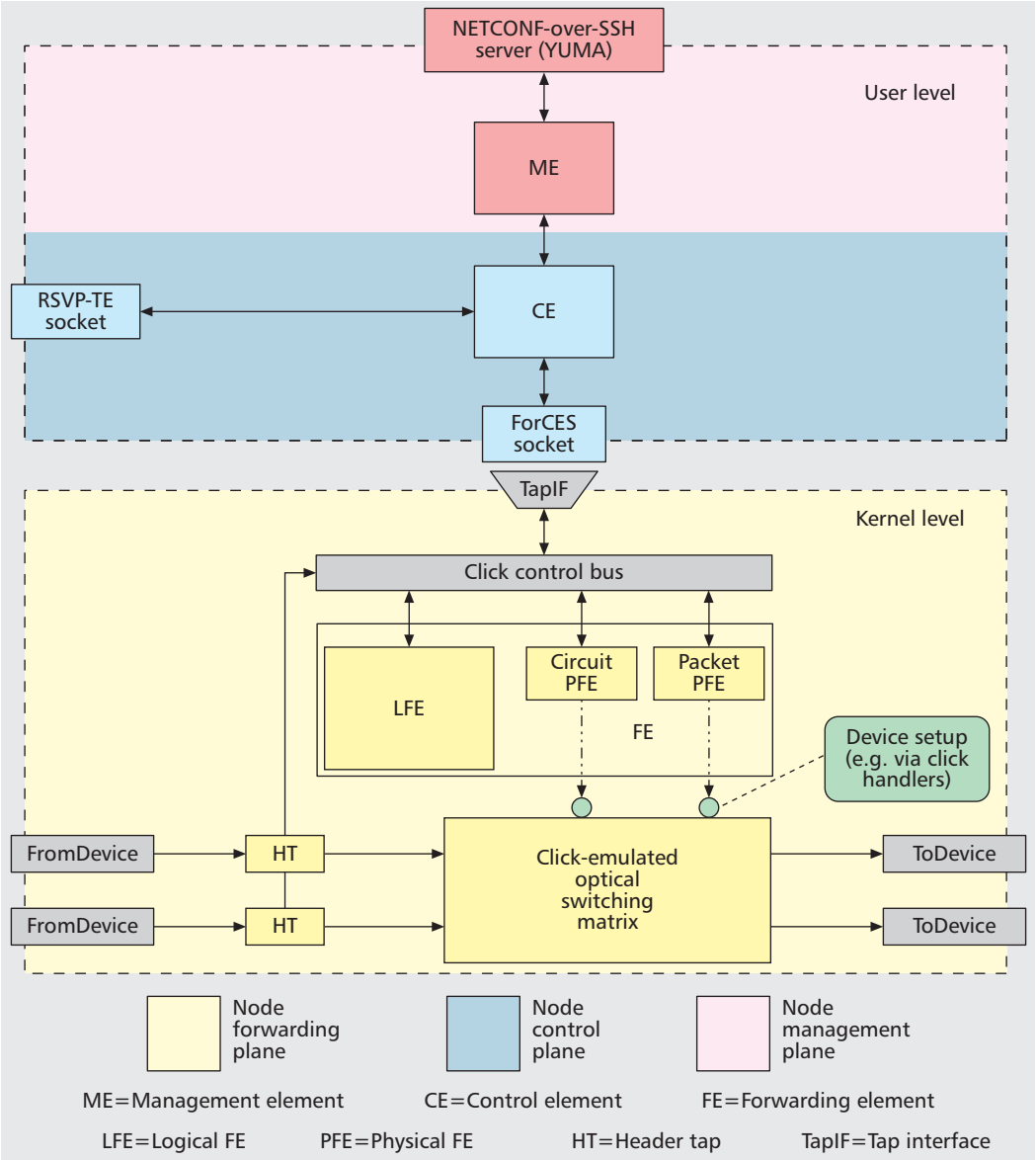
Hybrid and Programmable Nodes



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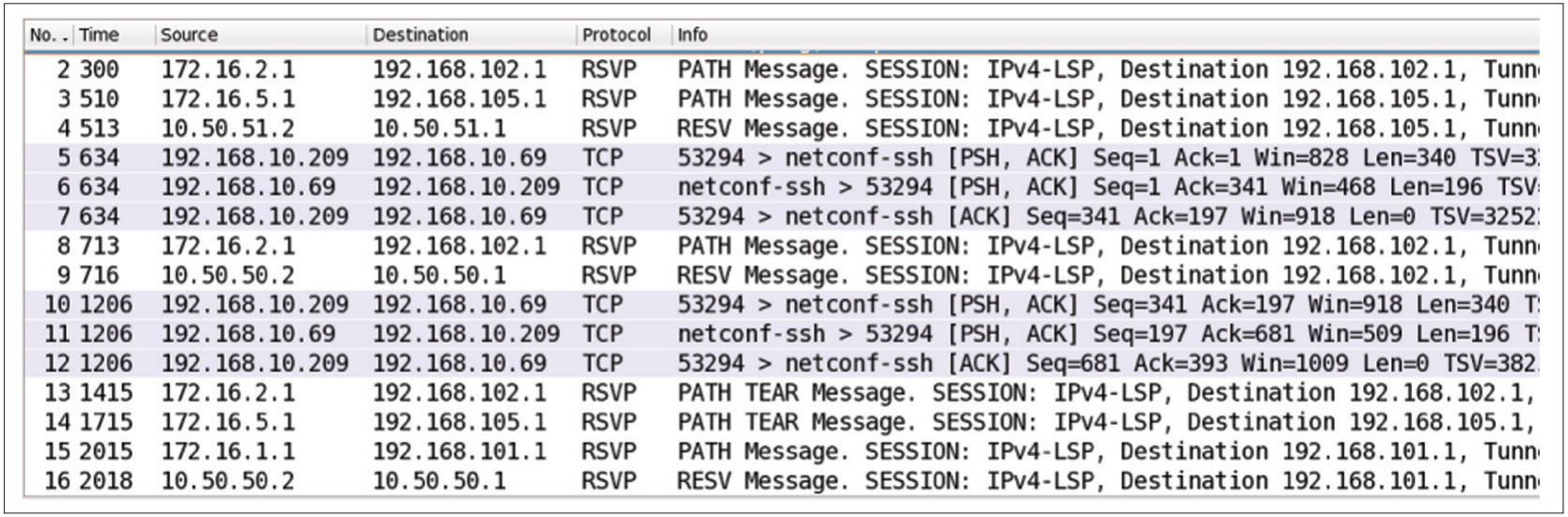

No. .	Time	Source	Destination	Protocol	Info
2	300	172.16.2.1	192.168.102.1	RSVP	PATH Message. SESSION: IPv4-LSP, Destination 192.168.102.1, Tunn
3	510	172.16.5.1	192.168.105.1	RSVP	PATH Message. SESSION: IPv4-LSP, Destination 192.168.105.1, Tunn
4	513	10.50.51.2	10.50.51.1	RSVP	RESV Message. SESSION: IPv4-LSP, Destination 192.168.105.1, Tunn
5	634	192.168.10.209	192.168.10.69	TCP	53294 > netconf-ssh [PSH, ACK] Seq=1 Ack=1 Win=828 Len=340 TSV=3
6	634	192.168.10.69	192.168.10.209	TCP	netconf-ssh > 53294 [PSH, ACK] Seq=1 Ack=341 Win=468 Len=196 TSV
7	634	192.168.10.209	192.168.10.69	TCP	53294 > netconf-ssh [ACK] Seq=341 Ack=197 Win=918 Len=0 TSV=3252
8	713	172.16.2.1	192.168.102.1	RSVP	PATH Message. SESSION: IPv4-LSP, Destination 192.168.102.1, Tunn
9	716	10.50.50.2	10.50.50.1	RSVP	RESV Message. SESSION: IPv4-LSP, Destination 192.168.102.1, Tunn
10	1206	192.168.10.209	192.168.10.69	TCP	53294 > netconf-ssh [PSH, ACK] Seq=341 Ack=197 Win=918 Len=340 T
11	1206	192.168.10.69	192.168.10.209	TCP	netconf-ssh > 53294 [PSH, ACK] Seq=197 Ack=681 Win=509 Len=196 T
12	1206	192.168.10.209	192.168.10.69	TCP	53294 > netconf-ssh [ACK] Seq=681 Ack=393 Win=1009 Len=0 TSV=382
13	1415	172.16.2.1	192.168.102.1	RSVP	PATH TEAR Message. SESSION: IPv4-LSP, Destination 192.168.102.1,
14	1715	172.16.5.1	192.168.105.1	RSVP	PATH TEAR Message. SESSION: IPv4-LSP, Destination 192.168.105.1,
15	2015	172.16.1.1	192.168.101.1	RSVP	PATH Message. SESSION: IPv4-LSP, Destination 192.168.101.1, Tunn
16	2018	10.50.50.2	10.50.50.1	RSVP	RESV Message. SESSION: IPv4-LSP, Destination 192.168.101.1, Tunn

Figure 4. *Capture of the RSVP-TE and NETCONF signaling messages in the experimental PHR validation.*

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Hybrid and Programmable Nodes

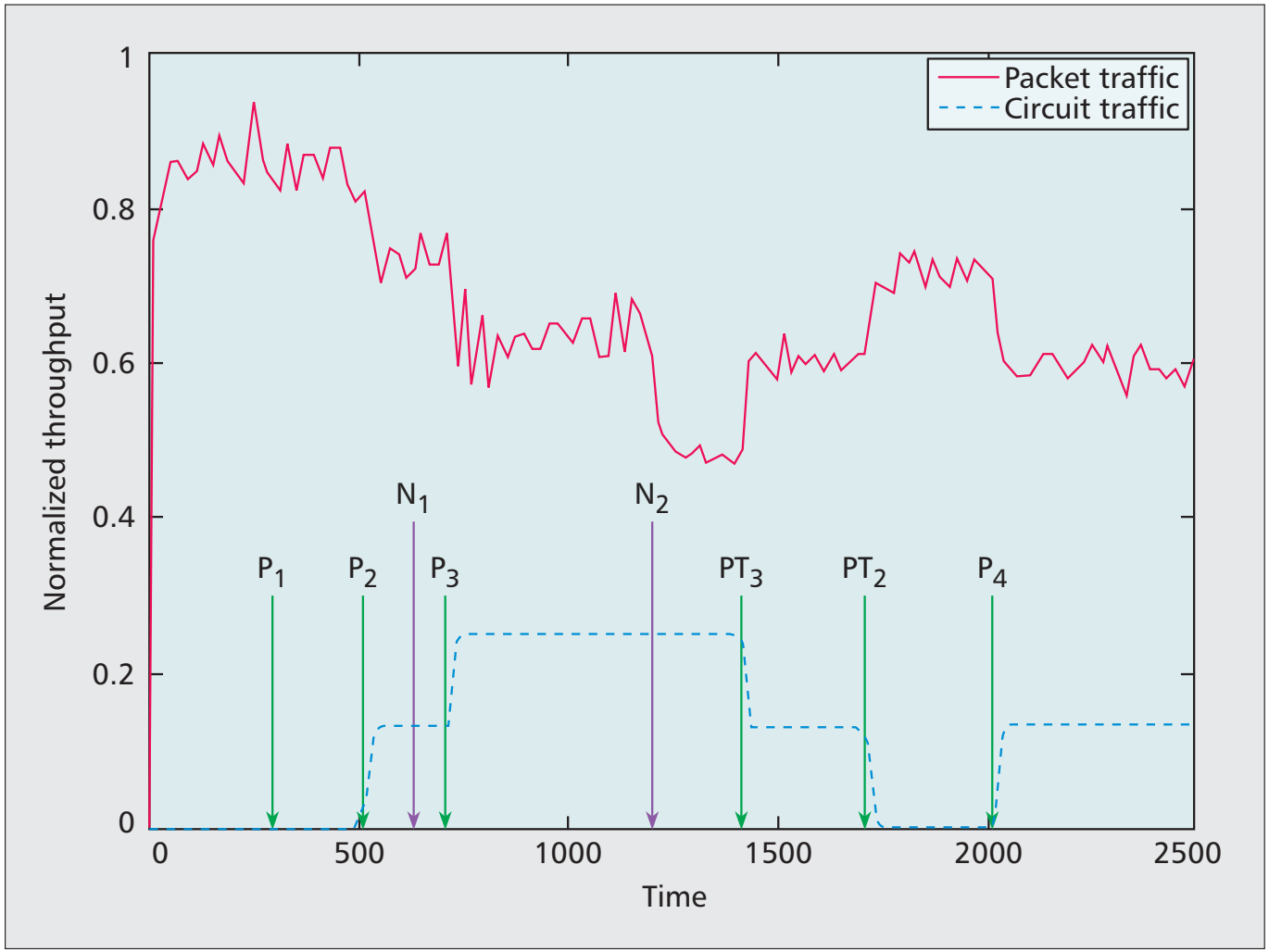

Figure 5. *Normalized throughput measured for packet and circuit traffic in the experimental PHR validation.*

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Current Trends (cont.)

(3st Trend) IT and Networking convergence

- Google, IBM, HP, etc.
- Telefónica, ...
- Alcatel, Cisco, etc.
- ....

... cross-stratum optimizations .... (DC + network)

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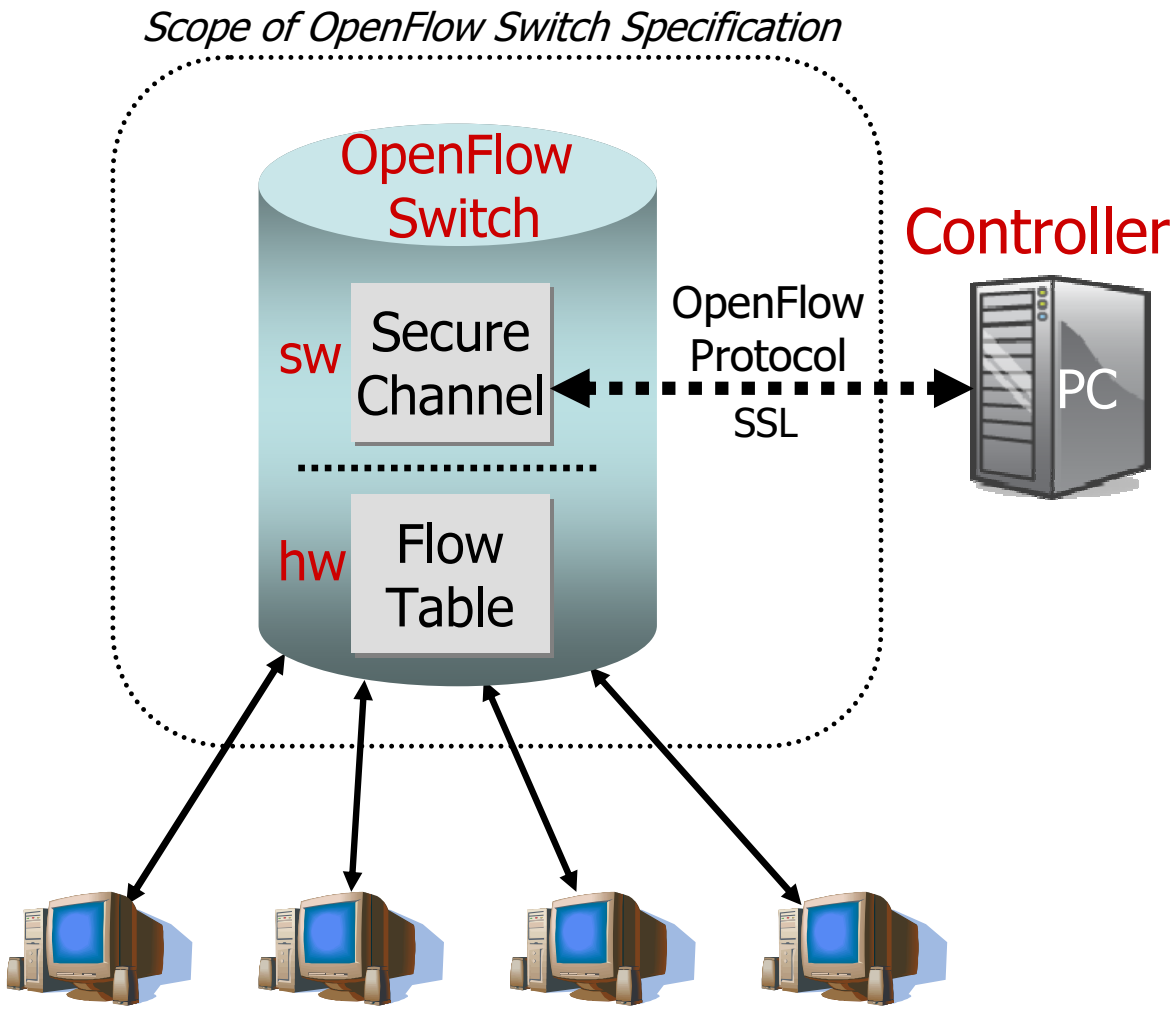
OpenFlow

- ... the Flow Table is controlled by a remote controller via a secure channel.



- N. McKeown et al., “OpenFlow: Enabling Innovation in Campus Networks,” ACM SIGCOMM Computer Communication Review, Volume 38, Number 2, April 2008.

OpenFlow (cont.)

In Port	VLAN ID	Ethernet			IP			TCP	
		SA	DA	Type	SA	DA	Proto	Src	Dst

Table 1: The header fields matched in a "Type 0" OpenFlow switch.

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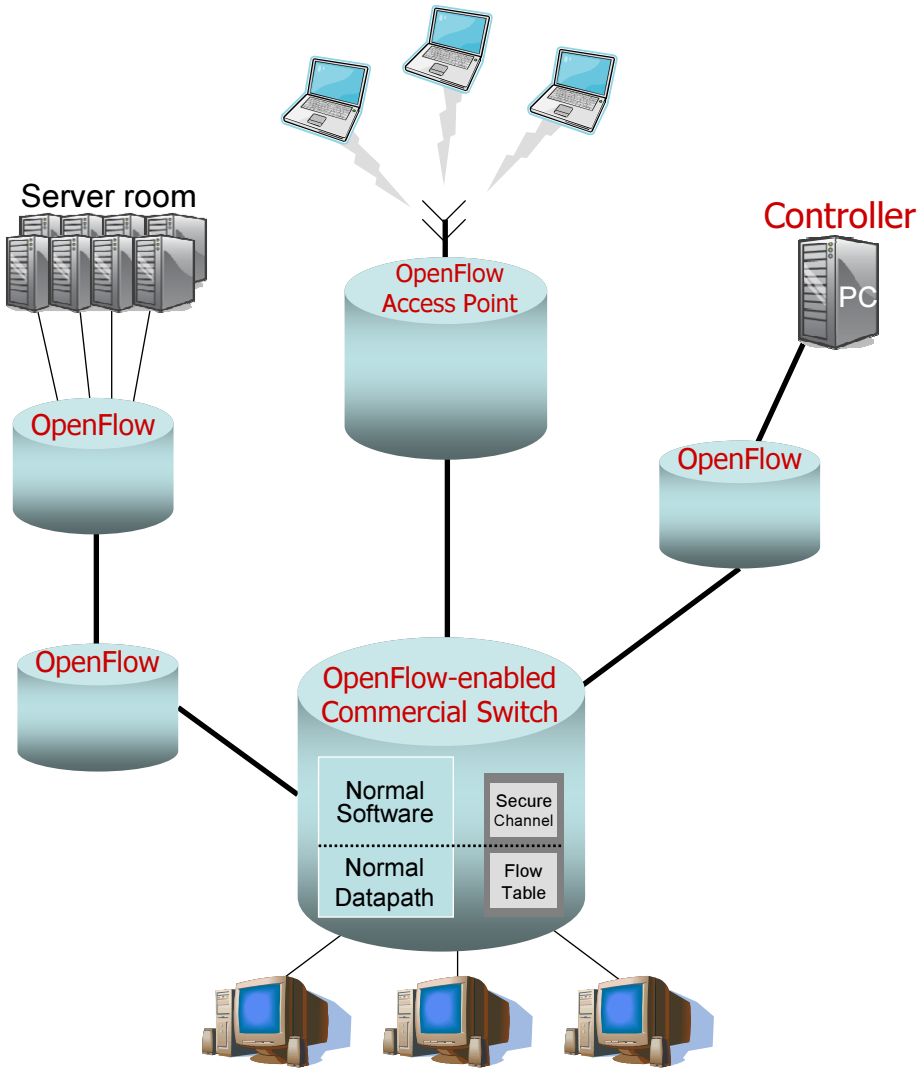
OpenFlow (cont.)

- Example of a network of OpenFlow enabled commercial switches and routers.



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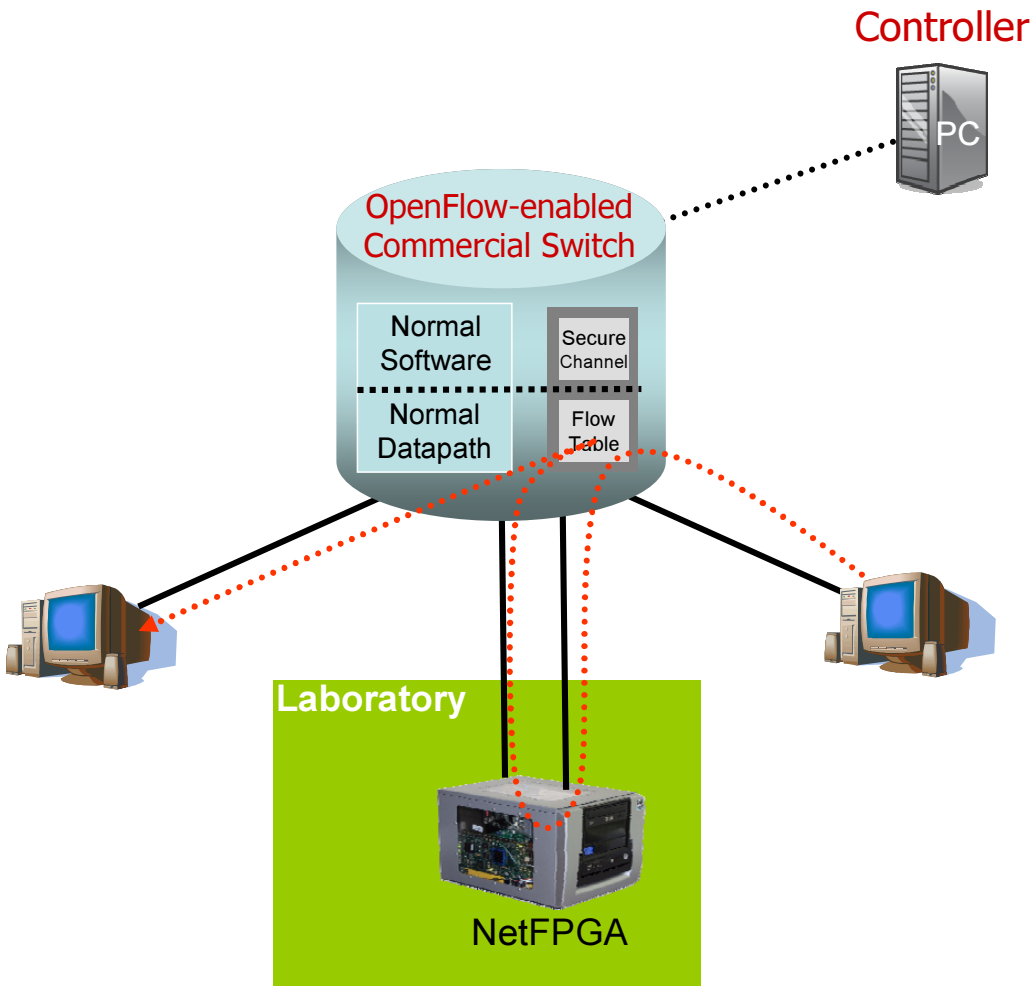
OpenFlow (cont.)

- Example of processing packets through an external line-rate packet-processing device (e.g., a programmable NetFPGA router).



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Questions?