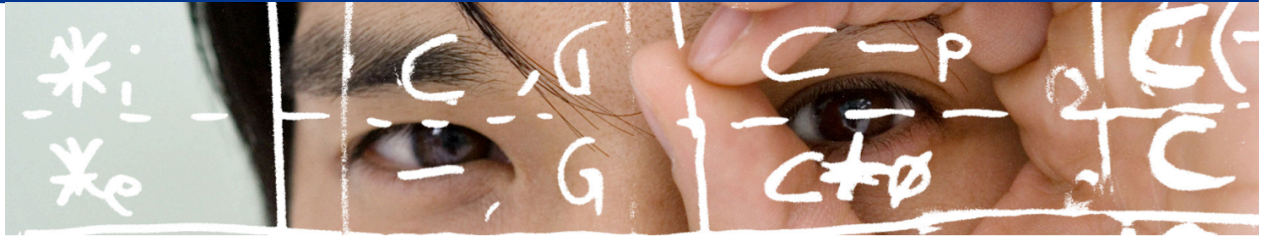


# SDN/OpenFlow

Performance UI, Winterschool, Zurich



[www.openflow.org](http://www.openflow.org)

# SWITCH

Kurt Baumann  
[kurt.baumann@switch.ch](mailto:kurt.baumann@switch.ch)

Zurich, 08. March 2013

## Outline

- SDN to OpenFlow
- OpenFlow a valid technology ☺
  - Basic Concept
  - How it works
- GÉANT OpenFlow Facility (GN3-JRA2T5)

# SDN

## **Software Defined Networking (SDN)**

is transforming networking architecture.

In the **SDN architecture**:

- Control and data planes are decoupled.
- Network intelligence and state are logically centralized.
- The underlying network infrastructure is abstracted from the applications.
- ...
- and OpenFlow, is the first standardized interface designed specifically for SDN

Source: ONS Whitepaper: "Software-Defined Networking – The new Norm for Networks, 13. April 2012



## **OpenFlow Basic Concept and how it works**

Source: OpenFlow tutorial, ONS, Santa Clara Marriot, April 16, 2012



# OpenFlow in a Nutshell

“OpenFlow is created and hosted at the University of Stanford in 2008 for evangelizing and supporting the OpenFlow Community”

## What it is:

- An open standardized interface approaching SDN architectures
- L2 communication protocol - gives access to the forwarding plan of a network switch, router. ([www.openflow.org](http://www.openflow.org))

## Motivation:

- The improvement of research and innovation in networking,
- To encourage networking vendors to implement OpenFlow to their switching products.

## Basic Idea:

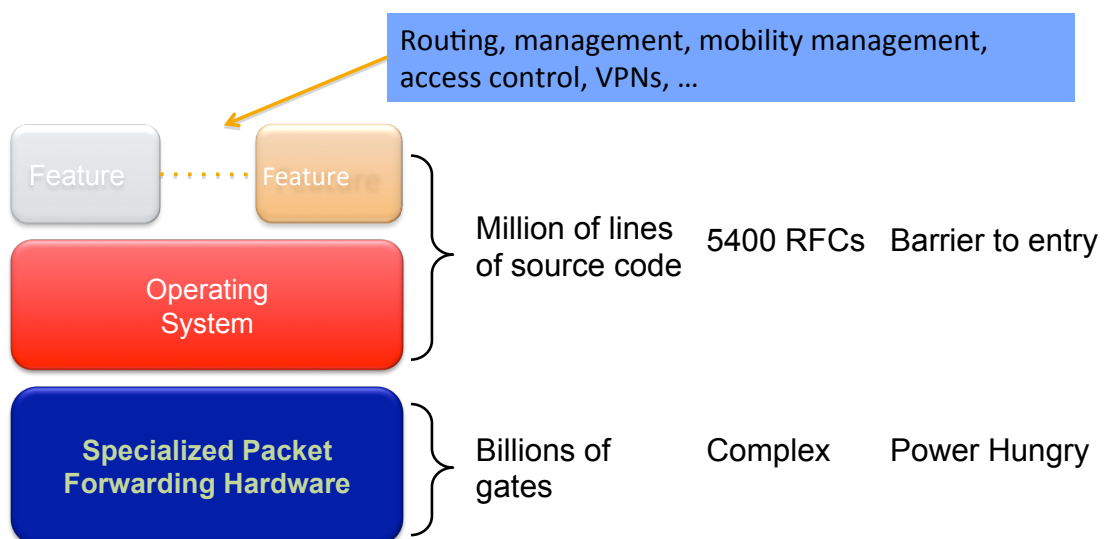
- OpenFlow, is based on an Ethernet switch with an internal-flow table and a standardized interface to add and remove flow entries.
- Delivering a shared data & forwarding plane and a sliced, user-managed control plane at L2.

## Regulation of the SDN (OpenFlow) Standards:

- Open Network Forum (ONF) ([www.opennetworking.org](http://www.opennetworking.org))



## The Network Industry today



# OpenFlow Controller

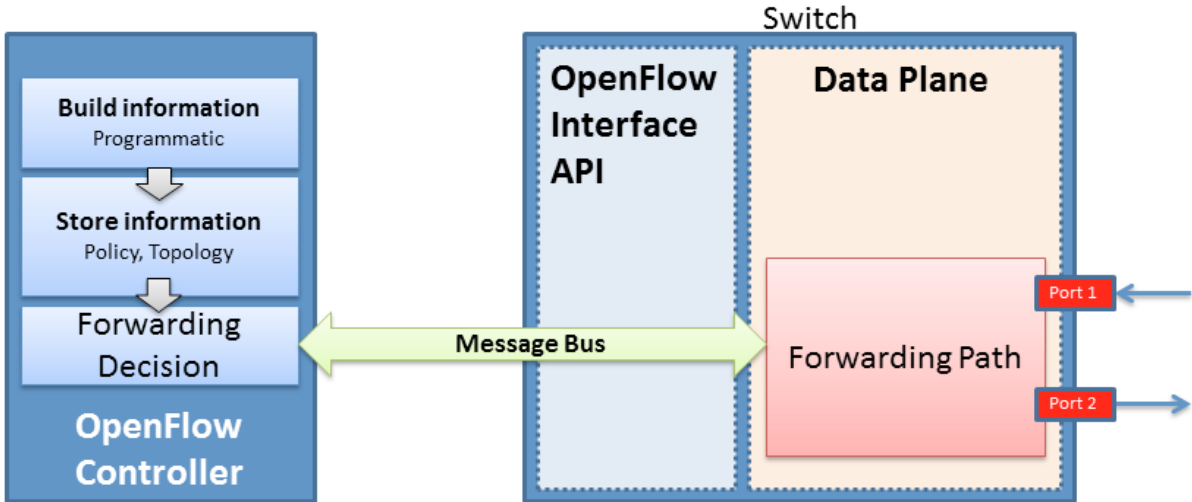
OpenFlow Protocol (SSL/TCP)



© 2013 SWITCH

## OpenFlow Basics: Entities / Functionalities

### Externally controlled Switch

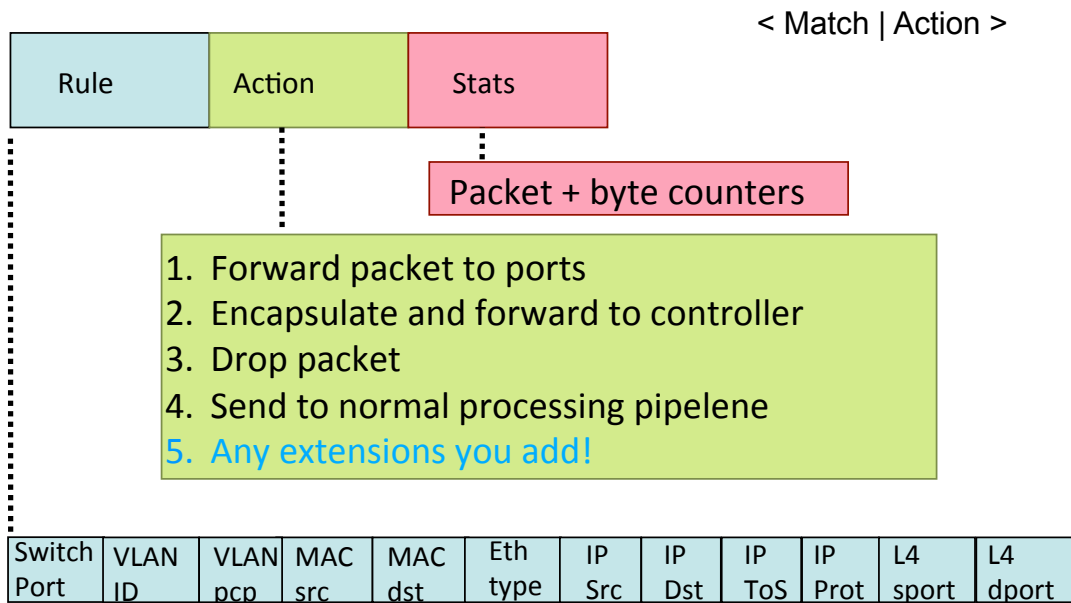


BRAD HEDLUND .com

© 2013 SWITCH

# OpenFlow Basics

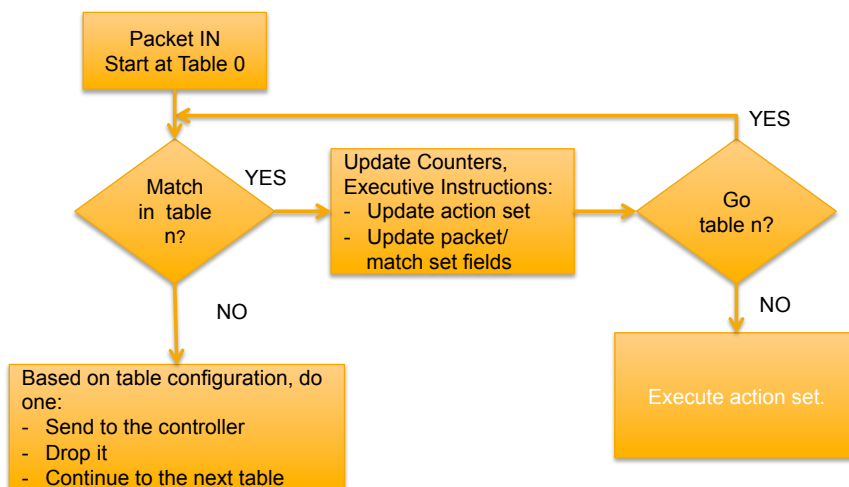
## Flow Table Entries OF v1.1



+ mask what fields to match



## Packet Flow



# OpenFlow – Rule Examples (1)

## Switching

Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport	Action
*	*	00:1f:..	*	*	*	*	*	*	*	port6

## Flow Switching

Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport	Action
port3	00:20:..	00:1f:..	0800	vlan1	1.2.3.4	5.6.7.8	4	17264	80	port6

## Firewall

Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport	Action
*	*	*	*	*	*	*	*	*	22	drop

# OpenFlow – Rule Examples (2)

## Routing

Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport	Action
*	*	*	*	*	*	5.6.7.8	*	*	*	port6

## VLAN Switching

Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport	Action
*	*	00:1f:..	*	vlan1	*	*	*	*	*	port6, port7, port9

Details see: OF Switching Specification  
<http://www.openflow.org/documents/openflow-spec-v1.1.0.pdf>

# OpenFlow Implementations

- **Hardware Vendors**

- Commercial -> NEC, HP, Pronto, Toroki, IBM, Pica8
- Experimental -> Juniper, Cisco

- **Software**

- **OF switches**

- Stanford's software reference design (user-space implementation)
- Open vSwitch (user-space and kernel module implementation)
- NetFPGA-based switch (hybrid solution based on Stanford's ref. sw)

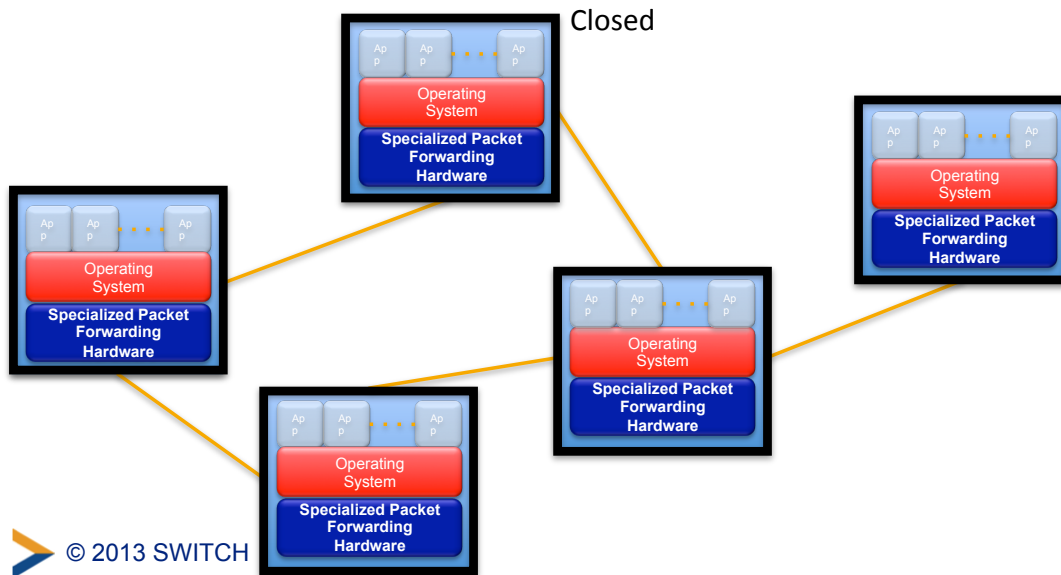
- **OF controllers**

- NOX
- Beacon
- Trema (modular framework for developing OF controllers)
- Other NOX-based implementations
- NEC Programmable Flow
- FlowVisor (Proxy Controller for slicing)

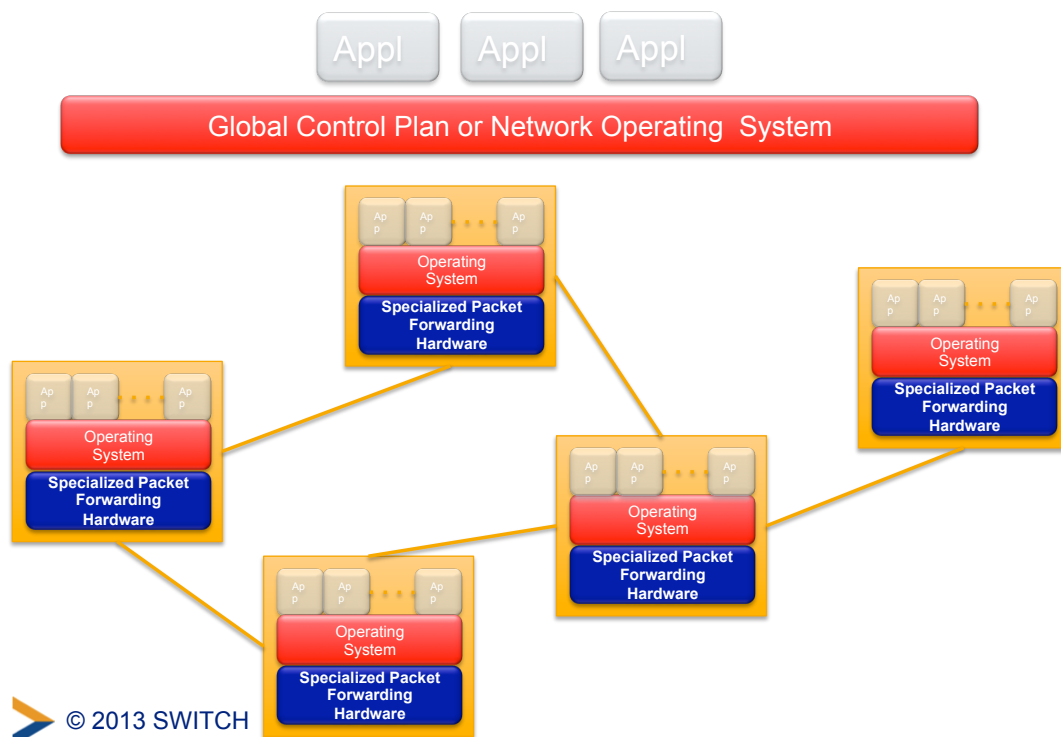
## SDN/OpenFlow Application

Source: OpenFlow tutorial, ONS, Santa Clara Marriot, April 16, 2012

# Today we have Closed Boxes, Fully Distributed Protocols

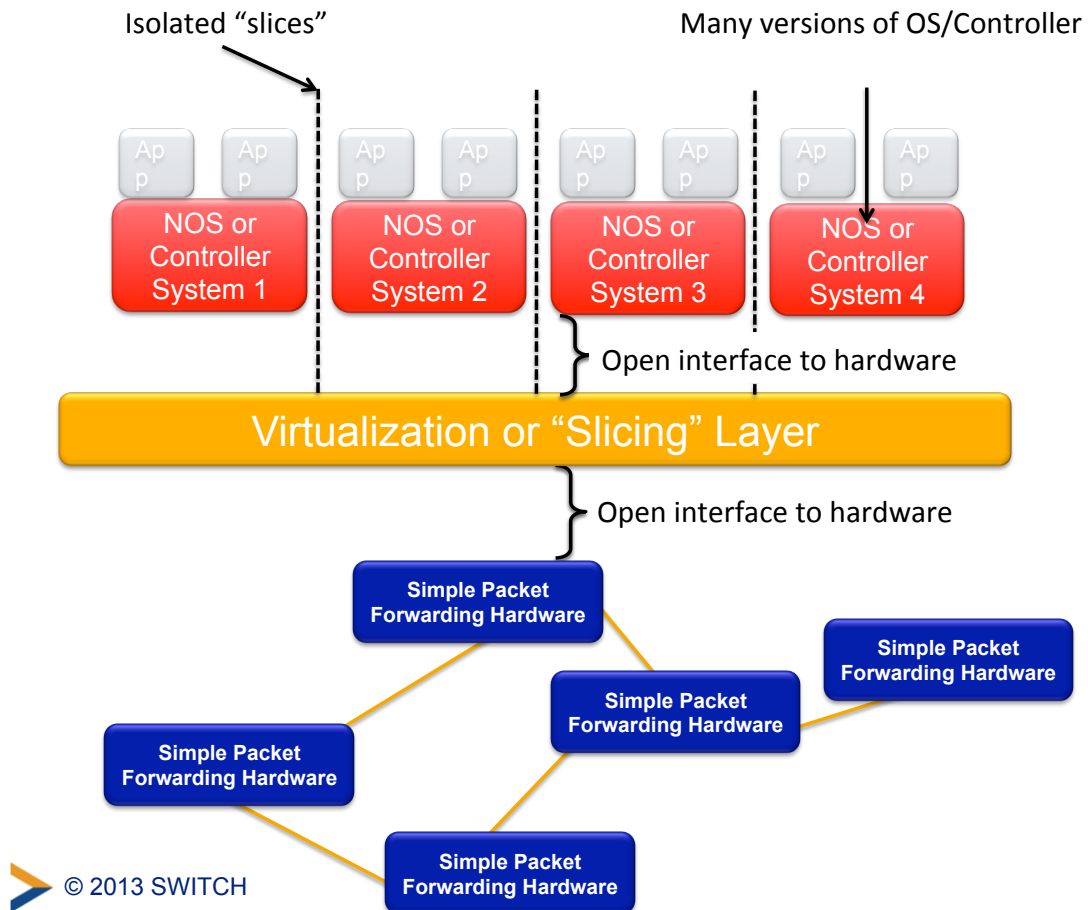
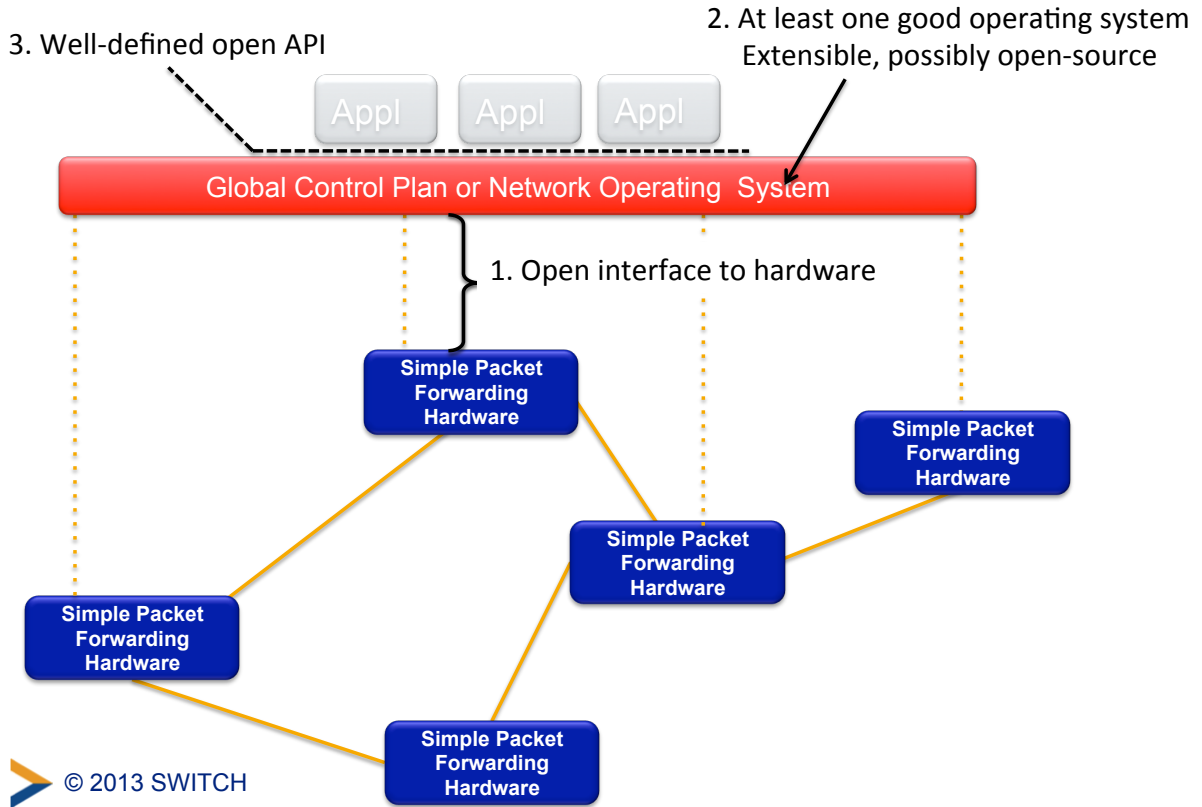


## “Software Defined Networking” approach to open it

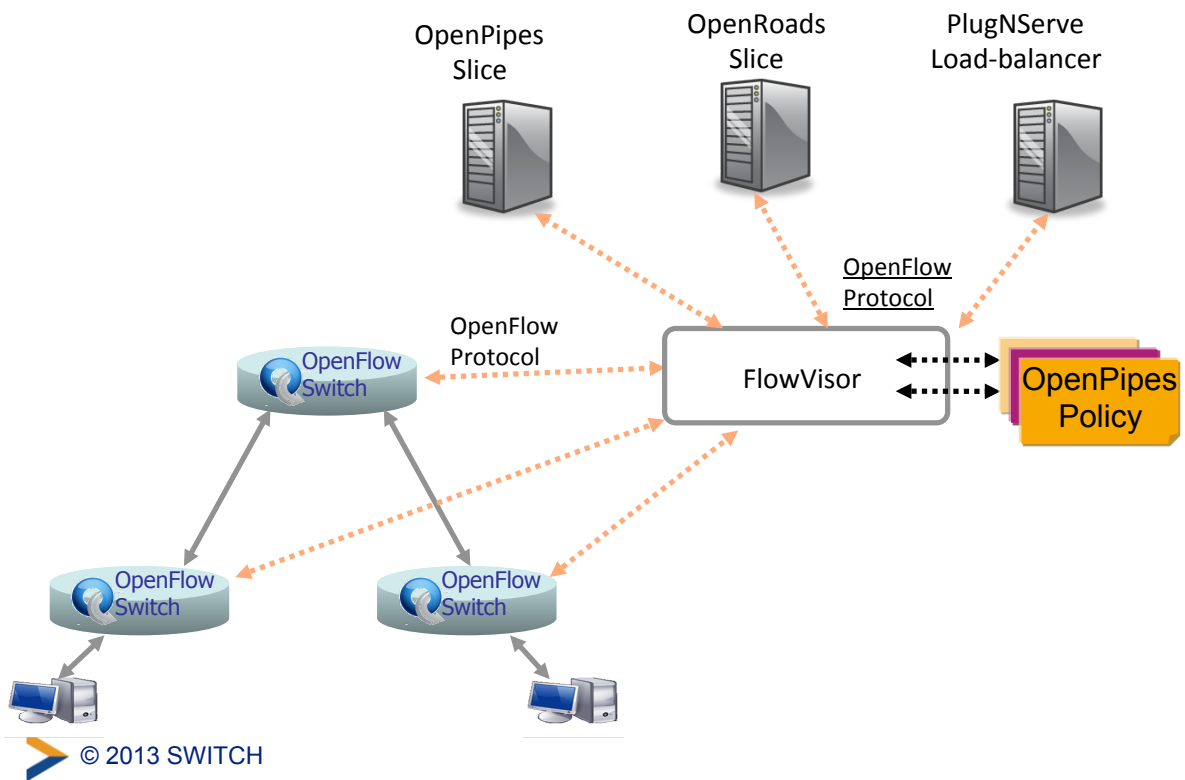




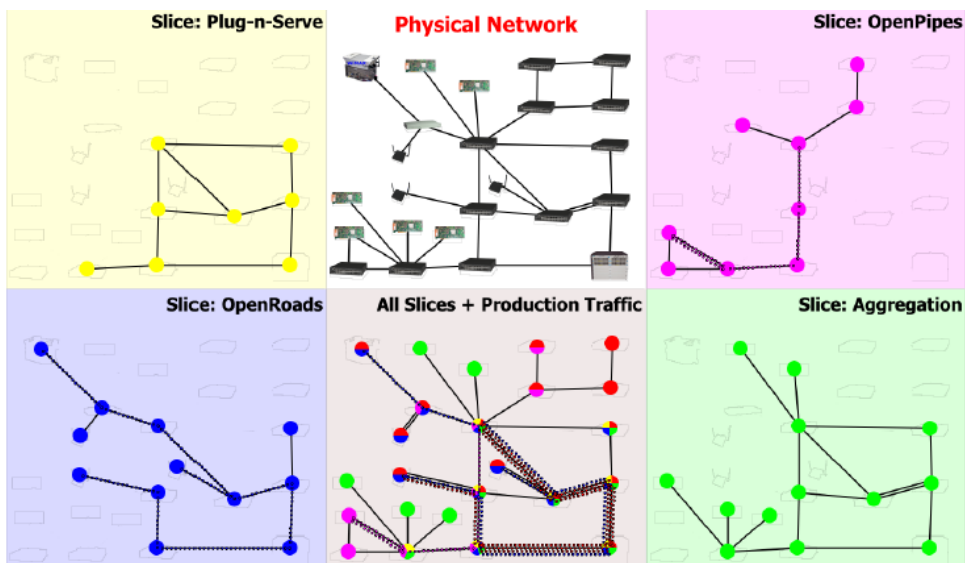
# The “Software-defined Network”



# FlowVisor Creates Virtual Networks

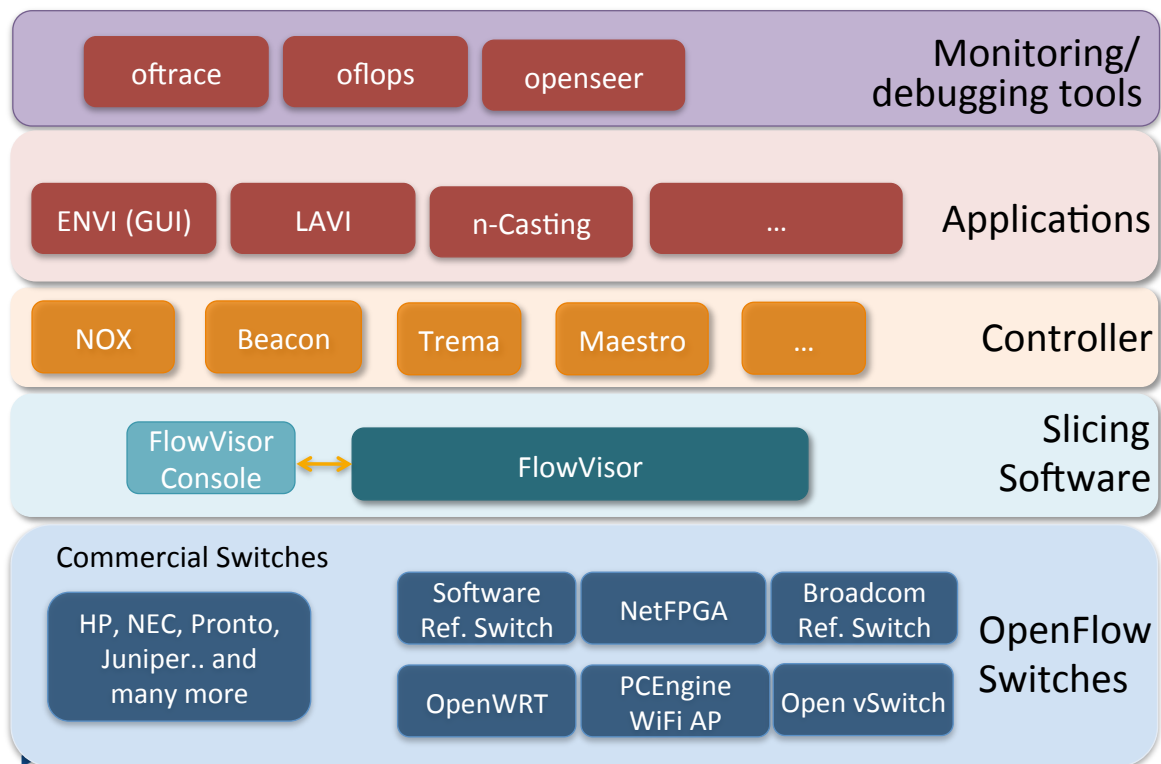


## Conclusion in Graphics



R. Sherwood, et. al, "Carving research slices out of your production networks with OpenFlow", ACM SIGCOMM Computer Communications Review, 40-1, 2010

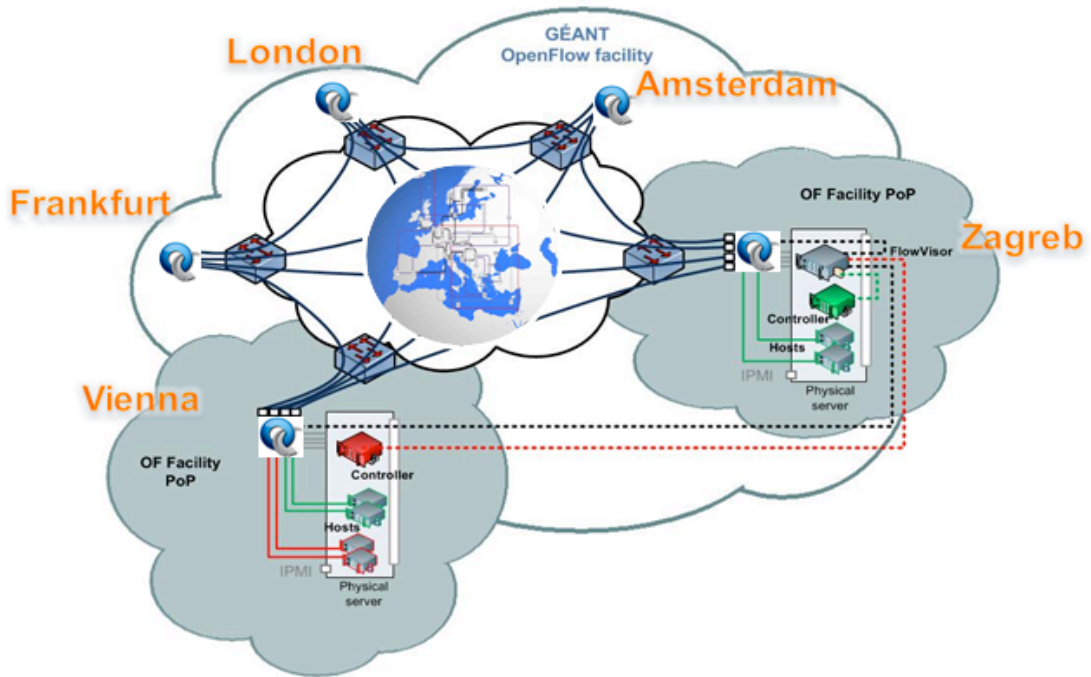
## The SDN Stack – in practice



## The Case of GÉANT – TaaS

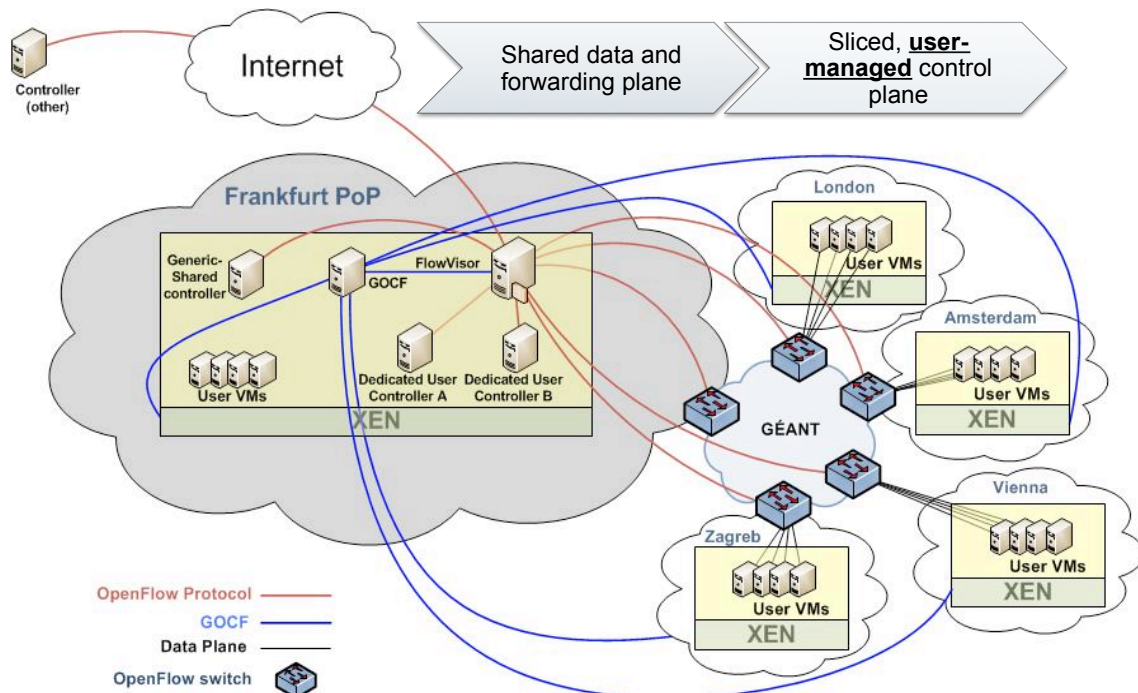
Source: – GÉANT JRA2T5 – GÉANT OpenFlow Facility Design, GN3-09-331/  
Joint Research Workshop JRA1/JRA2T5 in Utrecht NL, and Vienna AT.

# Implementation over GÉANT (1)



© 2013 SWITCH

# Implementation over GÉANT (2)



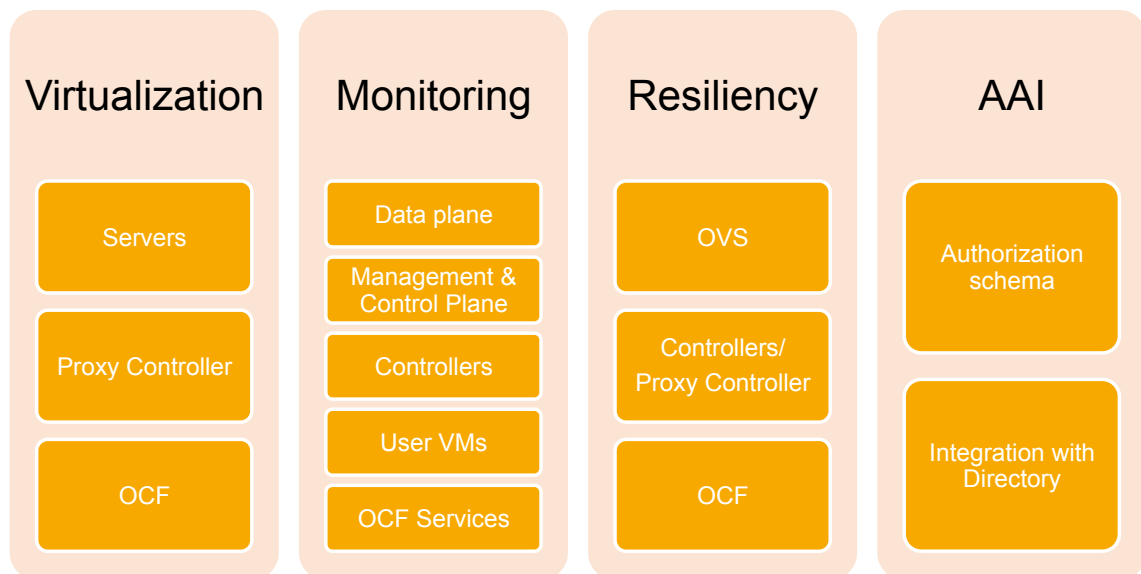
© 2013 SWITCH

# Design Principles

- **5 OpenFlow PoPs** interconnected with a full mesh of L2VPNs over GÉANT
  - Co-located with GÉANT PoPs
- **2 general purpose servers** per PoP for:
  - 1x Open vSwitch providing OpenFlow functionality
  - 1x XEN hypervisor delivering user VMs and hosting services
- Using OpenFlow v1.0 -> **VLAN-based slicing**
  - Limited capabilities for non-VLAN slicing for VLAN-based experimentation
- Orchestration software: FP7 **OFELIA Control Framework (OCF)**
  - Resource allocation and instantiation (per slice)
  - Authentication/Authorization (AA) and policy framework
  - Web-based user interface for slice access and management
  - Robustness, stability and scalability in terms of number of users, support for concurrent experiments and number of managed resources.
  - Monitoring of slices and the OCF components themselves



# Operations



Source: Layer 123, SDN& OpenFlow World Congress, Darmstadt, Presentation Application of SDN in Research Networks, Michael Enrico, Chief Technology Officer DANTE, Afrodite Sevasti, Chief Business Development Officer, GRNET, 24. October 2012, Darmstadt.

# Use Cases – Categories / Activities

- Using OpenFlow as a traffic engineering mechanism, managing backbone capacity and paths, for instance MPTCP and
- Using OpenFlow to deliver ‘vanilla’ layer 2 slices researching on layer 2 (and above) and experimentation on the actual data and control plane network technologies, for instance research on new protocols or capabilities
- Current activities on the OF Facility:
  - Contest Winner
    - “Improving resiliency and throughput of transport networks with OpenFlow and Multipath TCP” – Budapest University of Technology and Economics, MTA- BME Future Internet Research Group, 22.03.2013



## OpenFlow and Performance

Performance Tests:

On Mockup@grnet

Results:

- 1<sup>st</sup> Test – OVS mac forwarding without OpenFlow
- 2<sup>nd</sup> Test – MAC forwarding functionality provided by OpenFlow controller
- 3<sup>rd</sup> Test – OFV mac forwarding OF enabled & VLAN tagged frames.



# References

- OpenFlow – [www.openflow.org](http://www.openflow.org)
- OpenFlow – White paper:  
• <http://www.openflow.org/documents/openflow-wp-latest.pdf>
  
- SDN(OpenFlow) activities Internet 2
- <http://www.internet2.edu/network/ose/>
- OFELIA: <http://www.fp7-ofelia.eu/>
  
- GÉANT – GN3, JRA2 Multidomain Network Service Research, T5
- <https://intranet.geant.net/sites/Research/JRA2/pages/home.aspx>
  
- Standards of OpenFlow: Open Network Forum (ONF)
- <http://www.opennetworking.org>
- SDNRG (IRTF) - <http://irtf.org/sdnrg>
  
- JGN-X: RISE – <http://www.jgn.nict.go.jp>
- Deployment and Operation of Wide-area Hybrid OpenFlow Networks
- [http://hiroshi1.hongo.wide.ad.jp/hiroshi/papers/2013/Kanaumi\\_e96-b\\_1\\_108.pdf](http://hiroshi1.hongo.wide.ad.jp/hiroshi/papers/2013/Kanaumi_e96-b_1_108.pdf)

 © 2013 SWITCH

***Thank you for your attention!***

**Questions?**

 © 2013 SWITCH