OFELIA: A Distributed OpenFlow Testbed

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Why Another Testbed?

- PlanetLab
  - Distributed overlay testbed
- Emulab
  - Single site, freedom to configure own topology/use own VMs
- GpENI
  - Programmable network testbed, mainly for clean-slate experiments
- And many others …

- OFELIA testbed:
  - Distributed testbed
  - Flexibility to add own processing to switches/routers
  - Hardware support for efficient clean-slate experiments (OpenFlow)
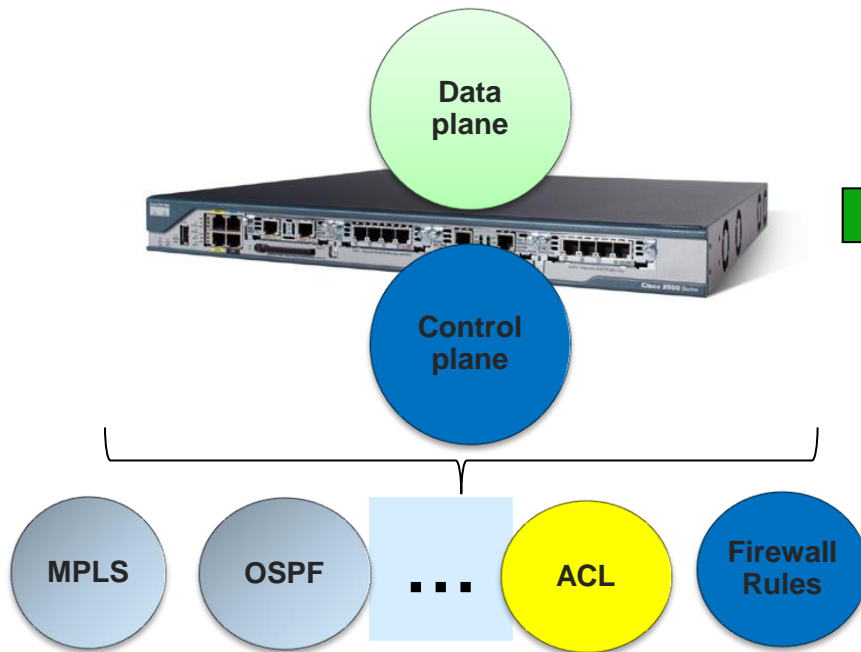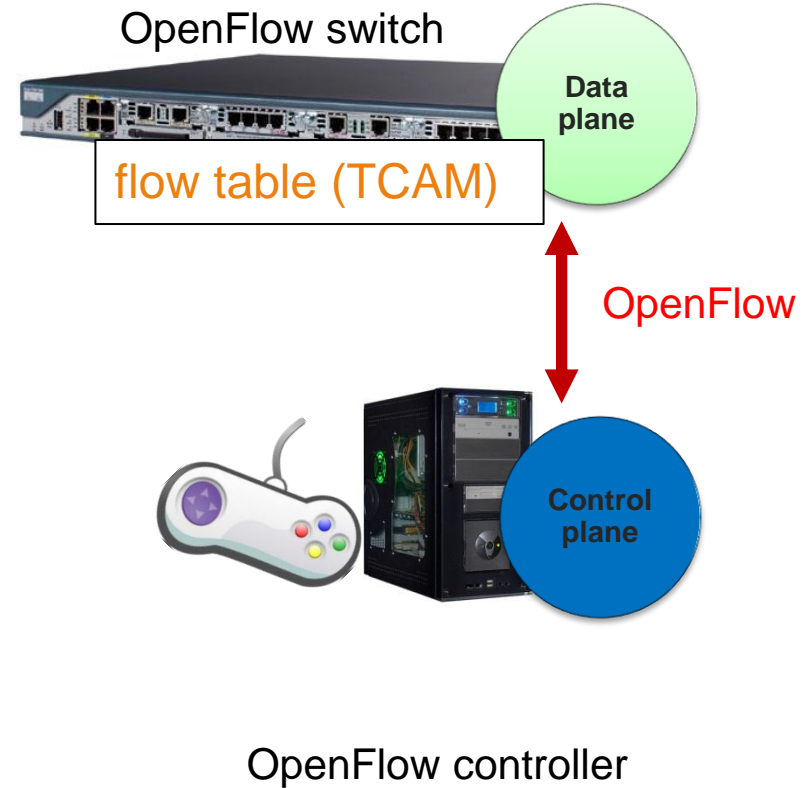 - Federation with other testbeds

Outline

- Motivation
- OpenFlow introduction
- OpenFlow applications
- OFELIA testbed
- Conclusion

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OpenFlow: Control/Data Plane Separation

Traditional approach

OpenFlow approach

OpenFlow switch

Data plane

flow table (TCAM)

Data plane

Control plane

OpenFlow

MPLS OSPF . . . **ACL** **Firewall Rules**

Control plane

OpenFlow controller

OpenFlow: Flow-Based Switching

- Flow table: If rule matches incoming packet, take an action

Rule	Action	Stats

Packet + byte counters

1. Forward packet to port(s)
2. Encapsulate and forward to controller
3. Drop packet
4. Send to normal processing pipeline

Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport
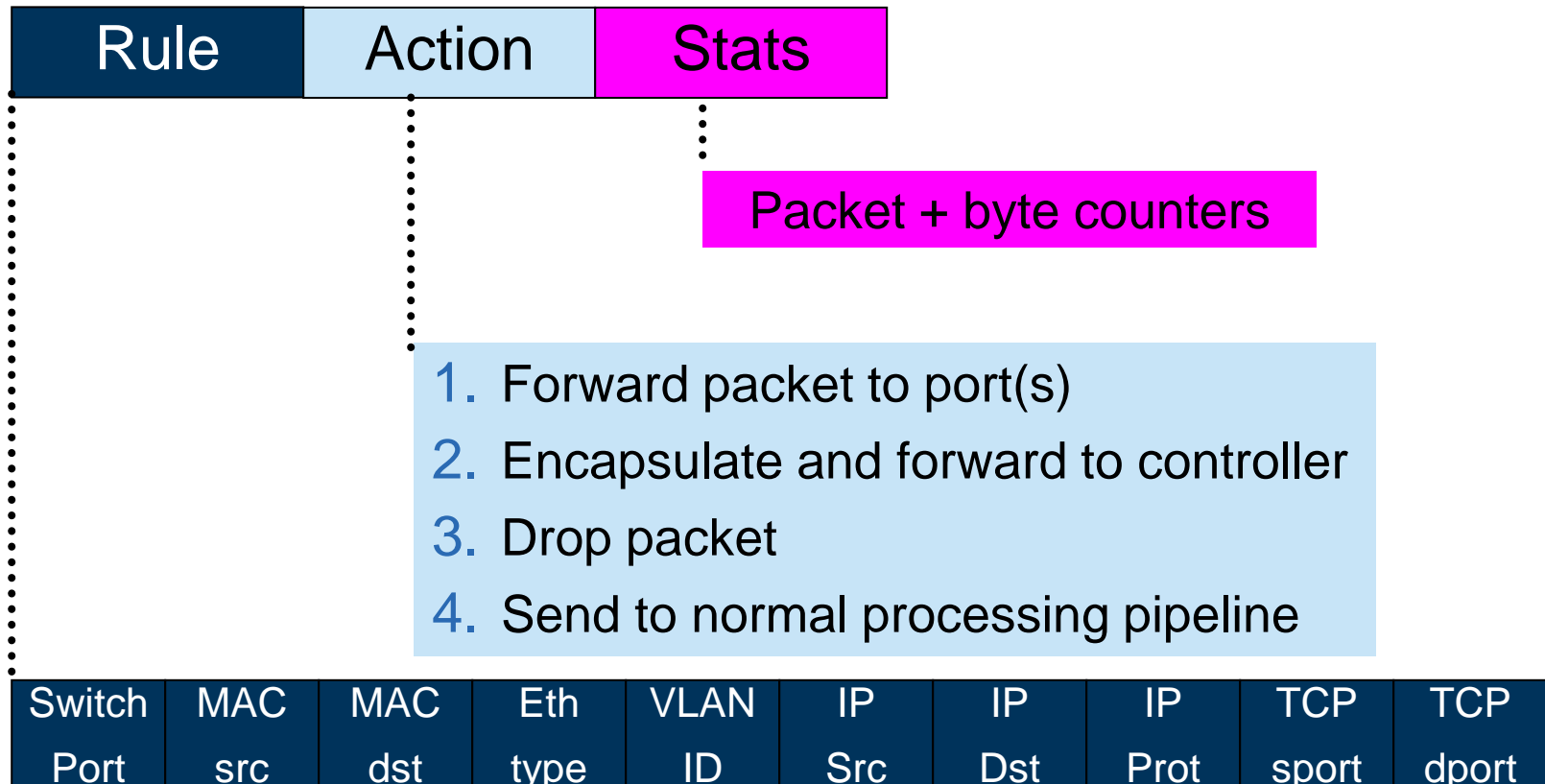
OpenFlow: Status

- Versions
  - 1.0: Header fields are fixed
    - But could be interpreted differently for clean-slate experiments
  - 1.1: some extensions
    - GMPLS support, multiple flow tables / pipelining, etc.
    - No IPv6 support yet
  - 2.0 (planned): bit matching, arbitrary header fields
- Implementations:
  - Reference switches: Software, NetFPGAs, 48-port Broadcom switch
  - Commercial switches available from NEC, HP Curve, …
- Controller software: NOX, SNAC, TREMA
- Testbeds: e.g., on campus of Stanford University
- Newly founded Open Network Foundation (ONF)
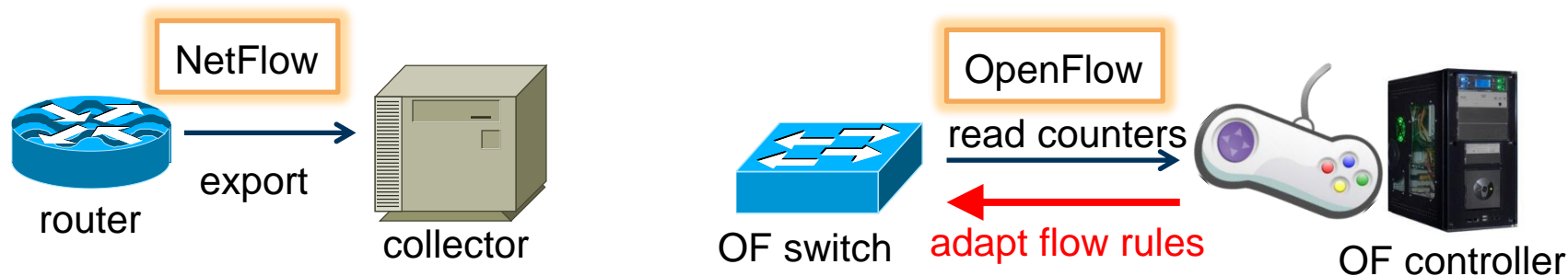
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OpenFlow: Applications

- Experiments at the flow level, e.g.
  - User-defined routing protocols
  - Content-centric networking
  - Energy management
  - VOIP mobility and handoff

  - Experiment-specific controllers
  - Static or dynamic flow-entries

- Experiments at the packet level
  - Forward all packets to the controller (slow)
  - Fast: Redirect flows through programmable hardware (NetFPGA)
  - Modified routers, firewalls, NAT, congestion control…

- Explore alternatives to IP
  - E.g., new naming + addressing schemes
  - Header format is fixed but can be interpreted differently

Leveraging OpenFlow for Network Measurements

NetFlow

OpenFlow
read counters
adapt flow rules

export
router
collector
OF switch   OF controller

Granularity: src/dst IP, src/dst port   AS … subnet…   5-tuple…   host/app

"expand"   "drill down"

- Leverage OpenFlow hardware for "edge" measurements
  - Change granularity "drill down" or "expand" rules
  - On-demand adaptation initiated by controller
  - Logic runs on controller: flexibility + reaction!
- *Online Measurement of Large Traffic Aggregates on Commodity Switches*, Jose and Yu and Rexford, Hot-ICE'11
  - Application: heavy hitter detection

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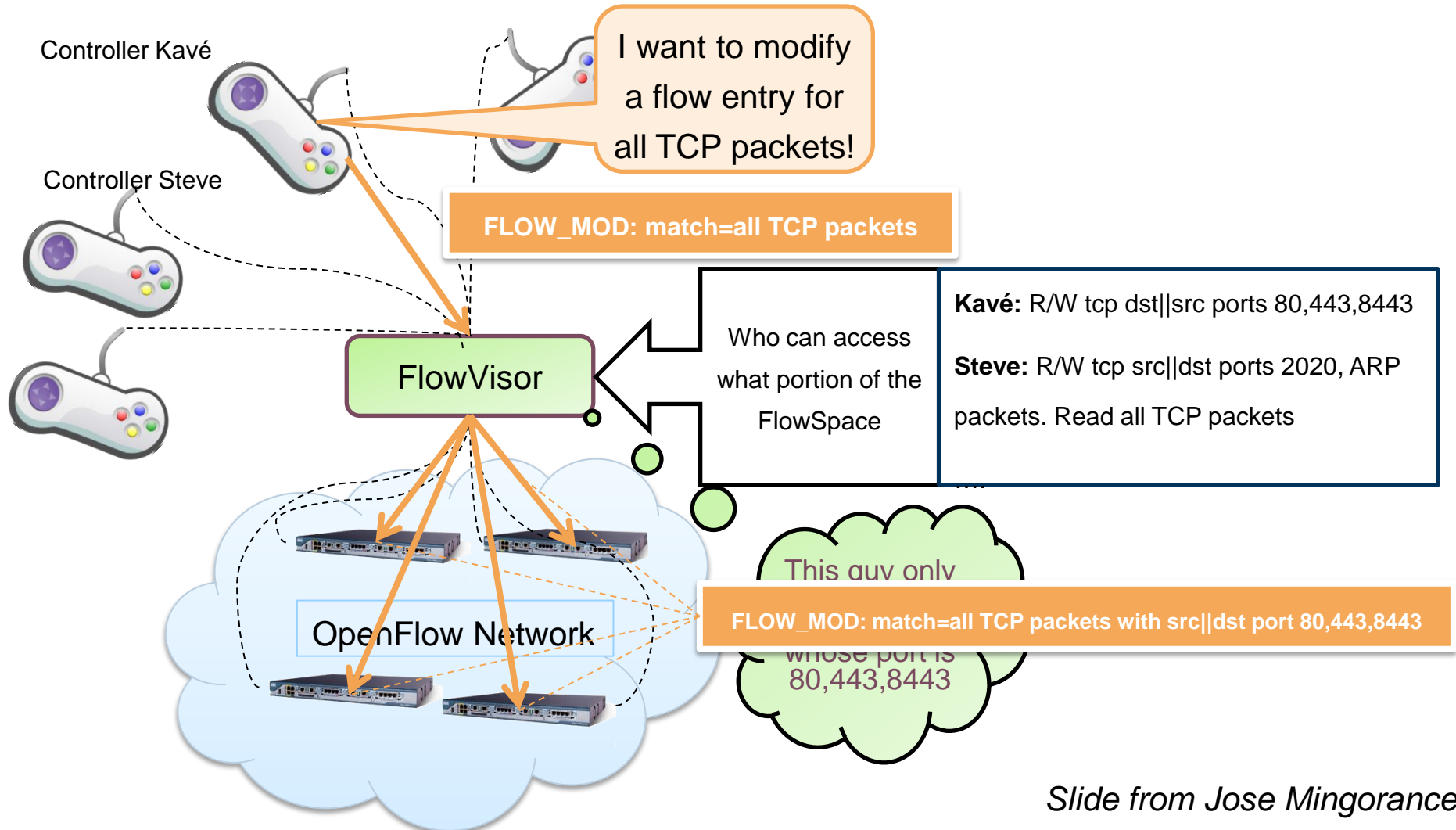- OpenFlow applications
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OpenFlow Testbed

- ## EU FP7 project (FIRE)
  - 10 partners
  - OpenCall: +2 partners
- ## Goal: Distributed OpenFlow testbed
- ## 5 OpenFlow "Islands"
  - At IBBT, TU Berlin, i2CAT, University of Essex, ETH Zurich
  - Complementary strengths
- ## Connectivity via hub in Ghent
  - Current: OpenVPN connections
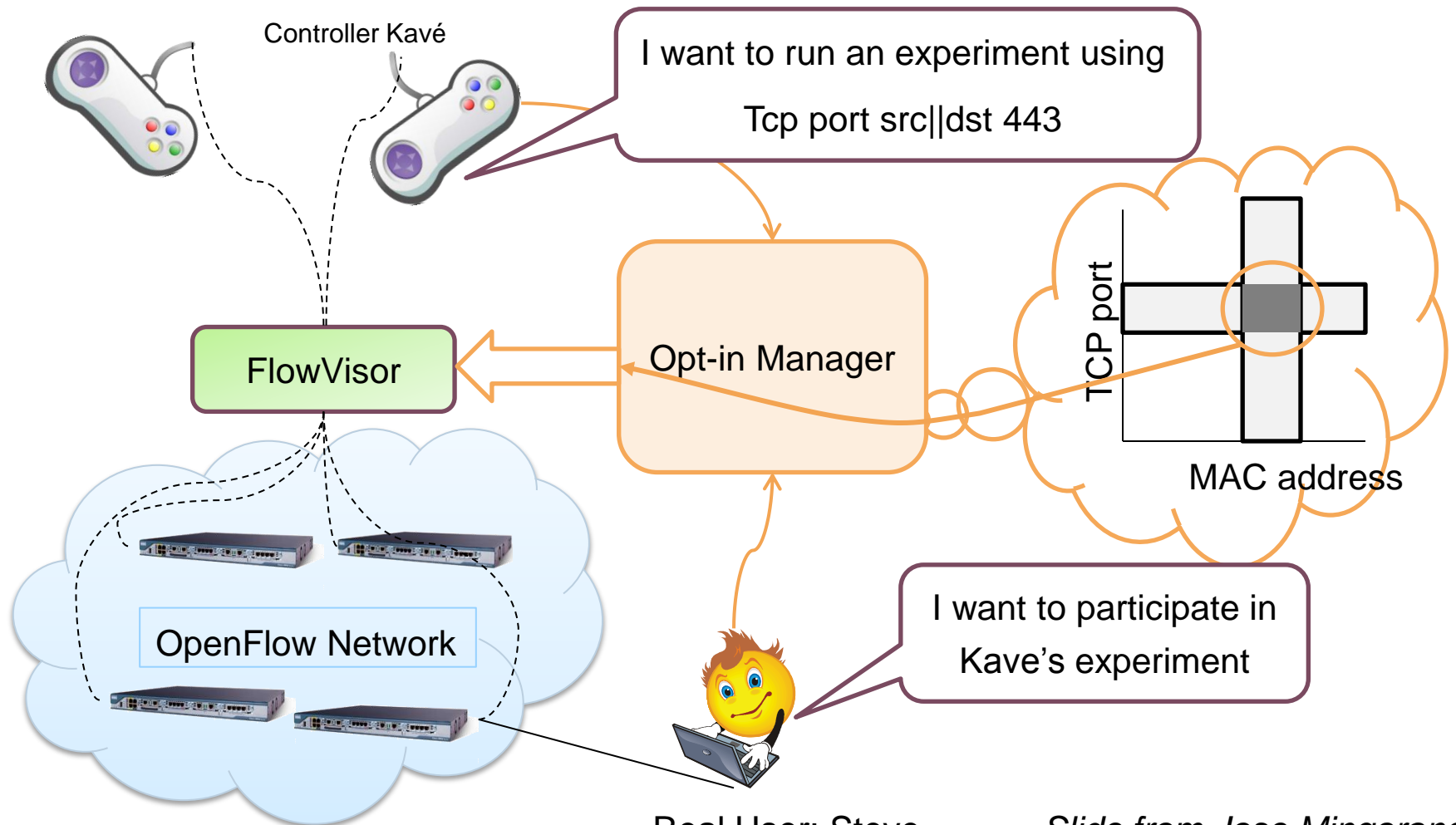 - Future: Dedicated layer-2 tunnels (1Gbps)

partner	L2	L1/optics	Wireless	emulation	US connections	MM source	User traffic
iBBT	X			X		X	
TUB	X		X				X
I2cat	X						
UEssex	X	X				X	
ETH	X				X		X

FlowVisor: How to Isolate Experiments?

Slide from Jose Mingorance

Opt-In Manager: How to Get Productive Traffic?

Controller Kavé

I want to run an experiment using
Tcp port src||dst 443

FlowVisor

Opt-in Manager

TCP port

MAC address

OpenFlow Network

I want to participate in
Kave's experiment

Real User: Steve

Slide from Jose Mingorance

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User VMs:
NOX, data sources/sinks
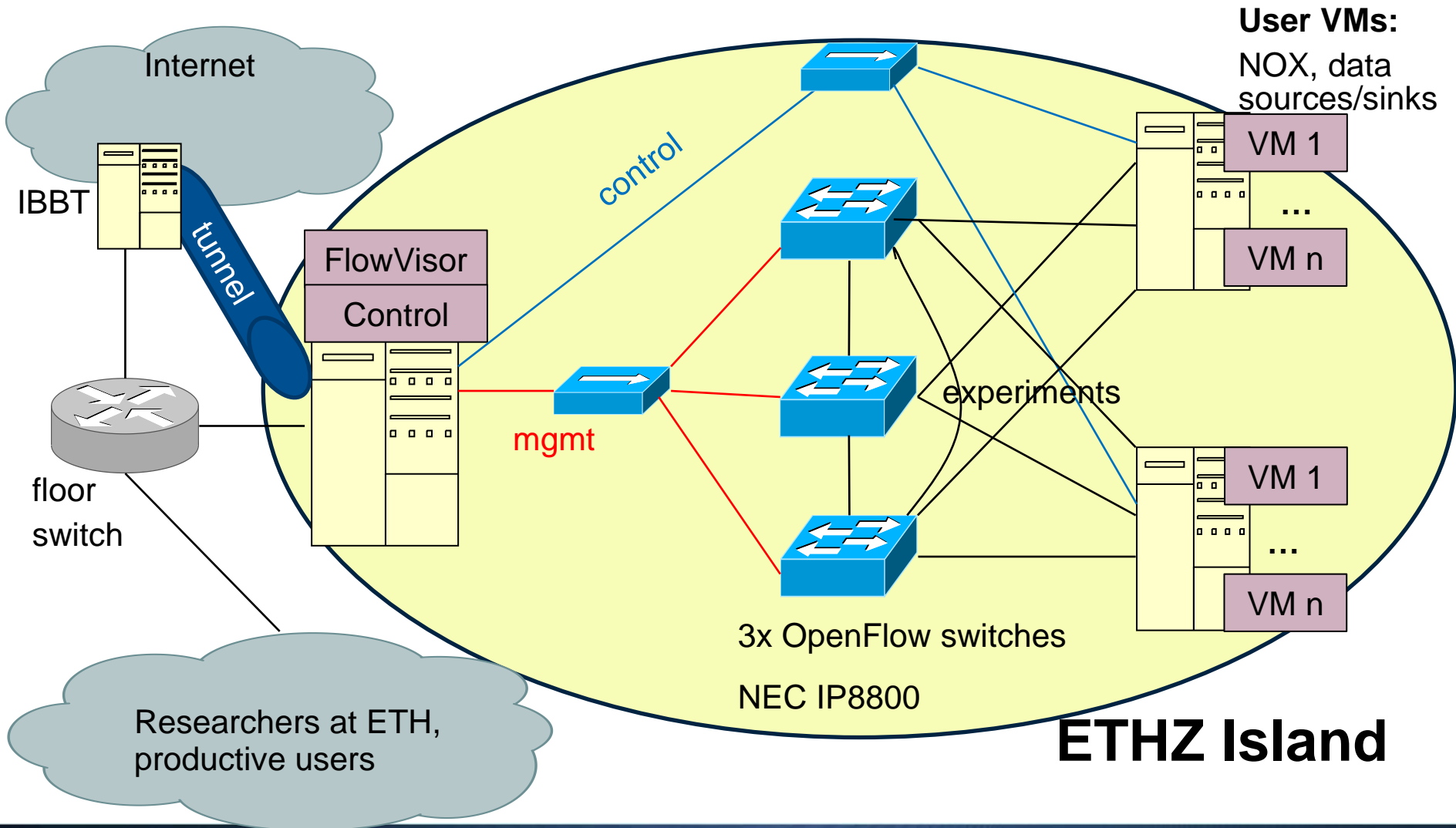
OFELIA – Status and Roadmap

- Phases
    - 1) OF controllers and switches in place, first local experiments ✓ concluded
    - 2) Connect islands and extend OF experimentation to wireless and optics
    - 3) Automate resource assignment and provide connections to other FIRE and non-European research facilities
- 2 OpenCalls
    - Additional funding for facility extensions or functional enhancements
    - Published in March 2011 and March 2012
    - Total budget 830,000 €; maximum of 200 € per partner funded experiment
- Summer School on OpenFlow related topics
    - November 7-11 (after IMC) in Berlin
    - http://changeofelia.info.ucl.ac.be

Summary

- OpenFlow
  - Standardized interface between switch controller and hardware
  - Flexibility: programm your own control plane
  - High performance: hardware support by vendors
  - Numerous applications: e.g., network measurement
- OFELIA
  - Distributed OpenFlow testbed
  - Heterogeneous Islands
  - One large Ethernet network
- Website: www.fp7-ofelia.eu