Software Defined Network Overview

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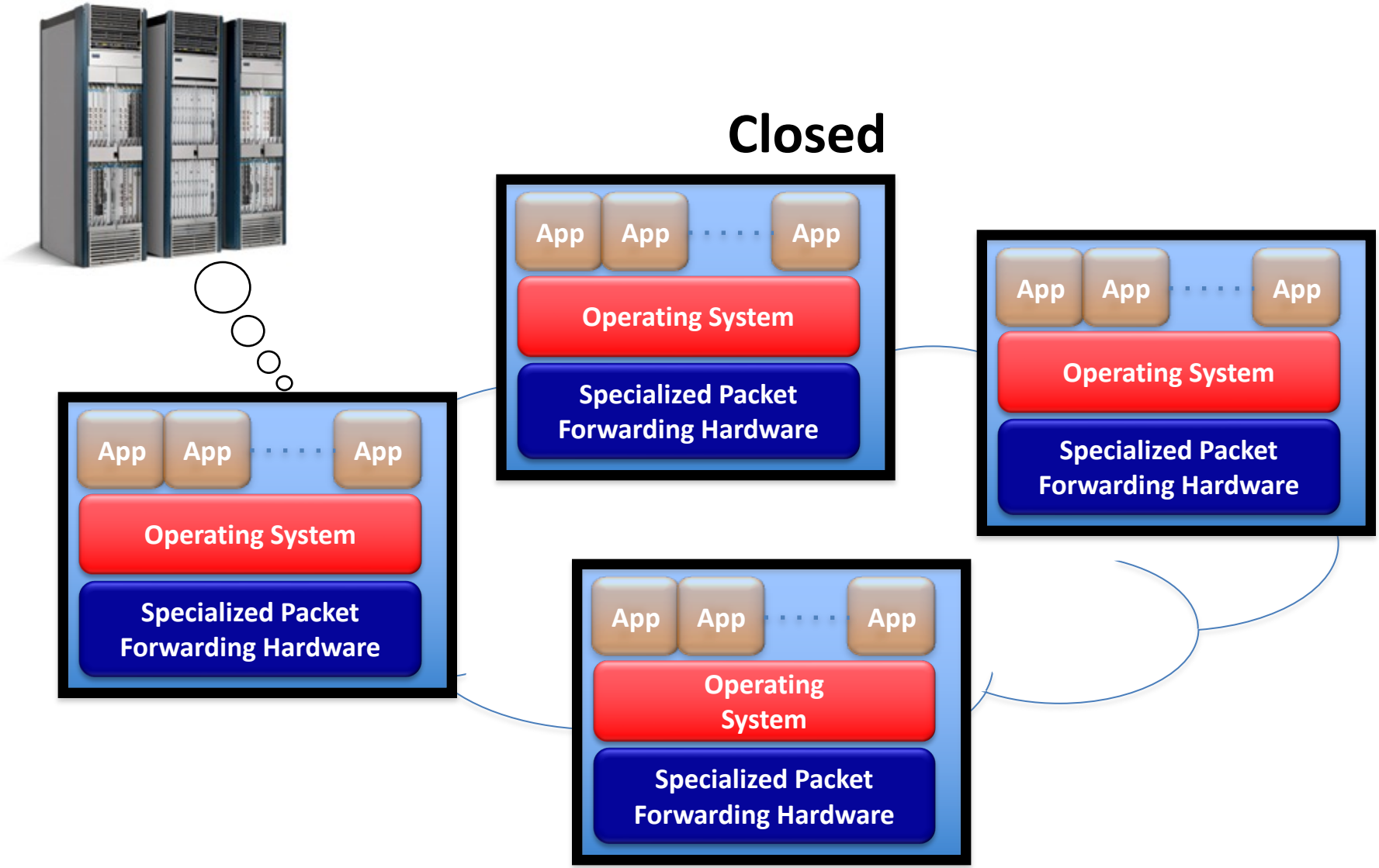
Spring 2024

Why Software Defined Network

Traditional Computer Networks



The Ossified (僵化) Network

Control Plane: Routing, management, access control, VPNs, …

App ····· App

Operating System

Million of lines of source code

6000+ RFCs

Data Plane: Packet forwarding

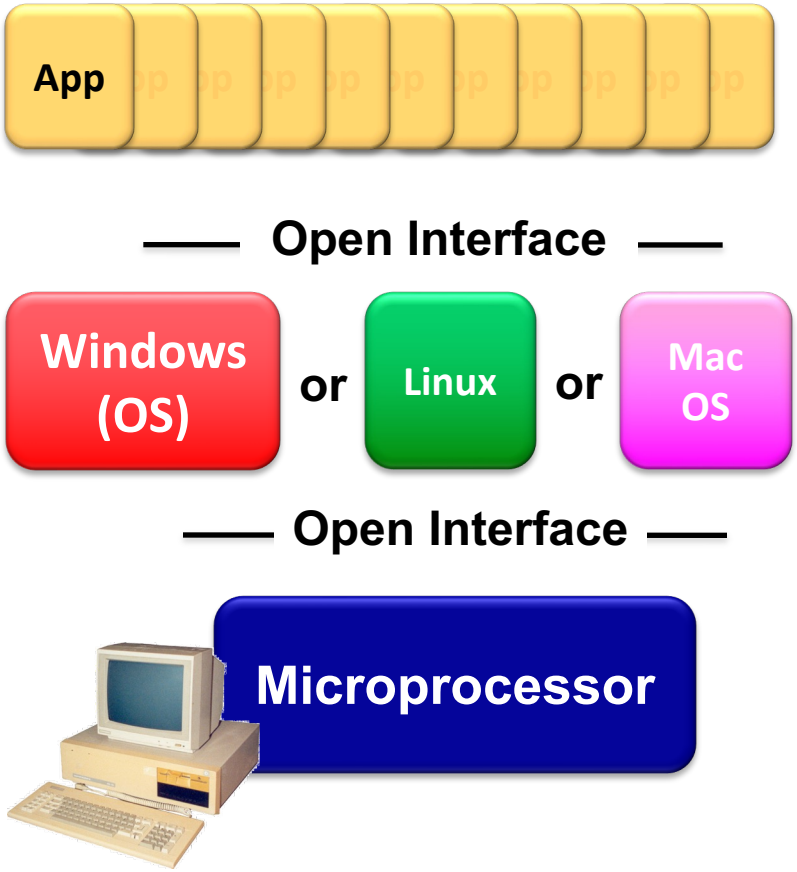
Specialized Packet Forwarding Hardware

Billions of gates

Bloated（臃肿）

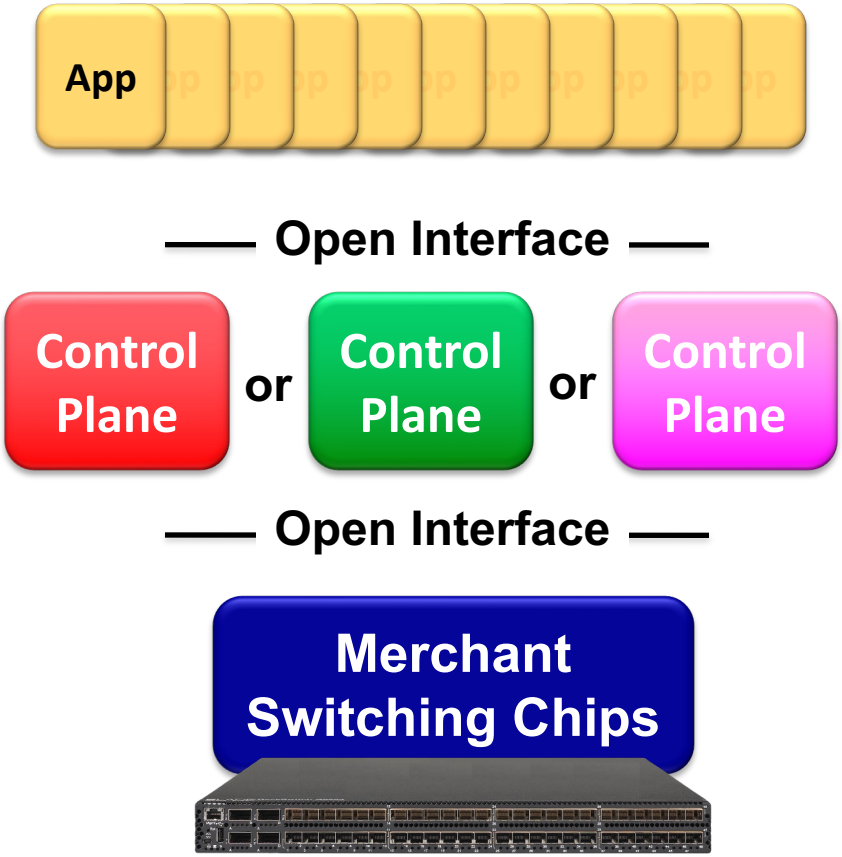
Many complex functions baked into the infrastructure

An industry with a "mainframe-mentality"（大型机心态）, reluctant to change



Vertically integrated
Closed, proprietary
Slow innovation
Small industry

Horizontal
Open interfaces
Rapid innovation
Huge industry



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Open interfaces
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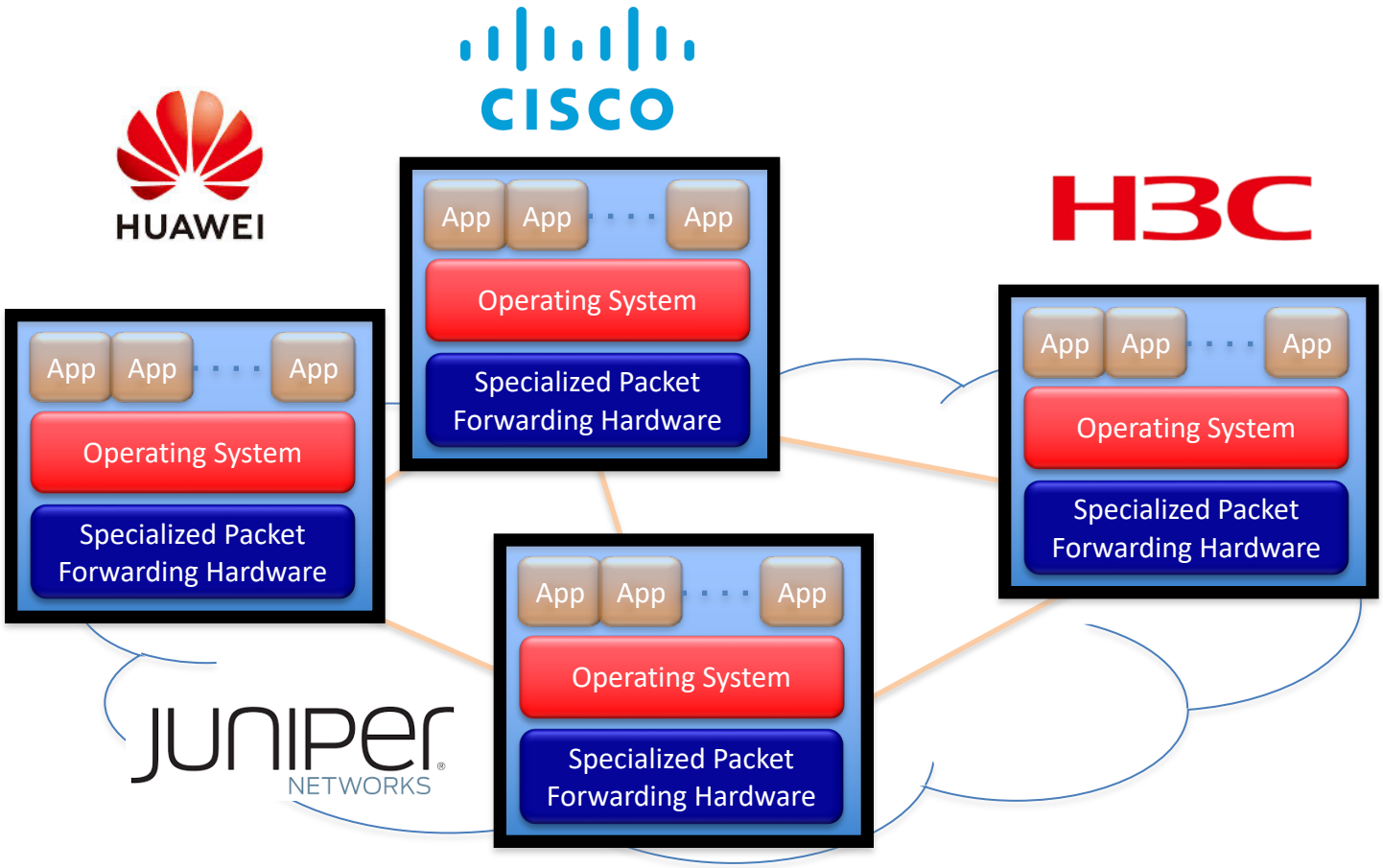
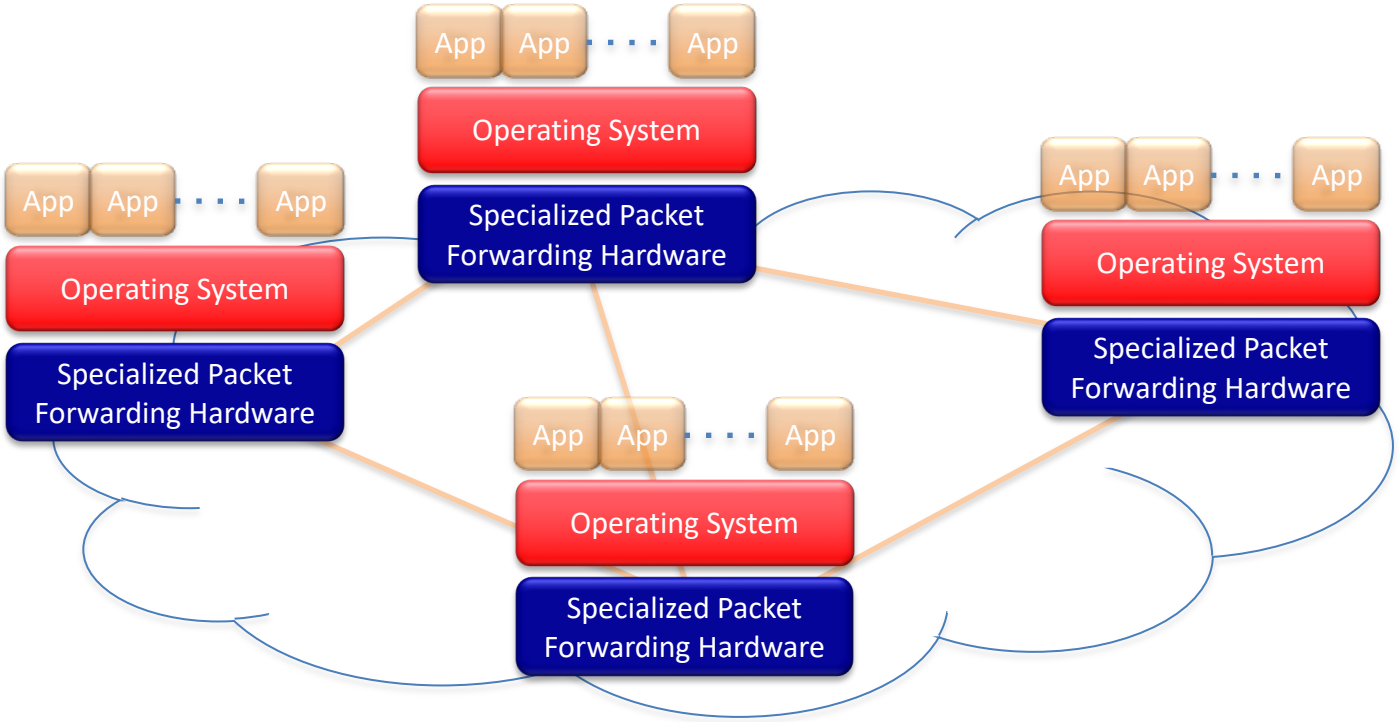
Software Defined Network (SDN)



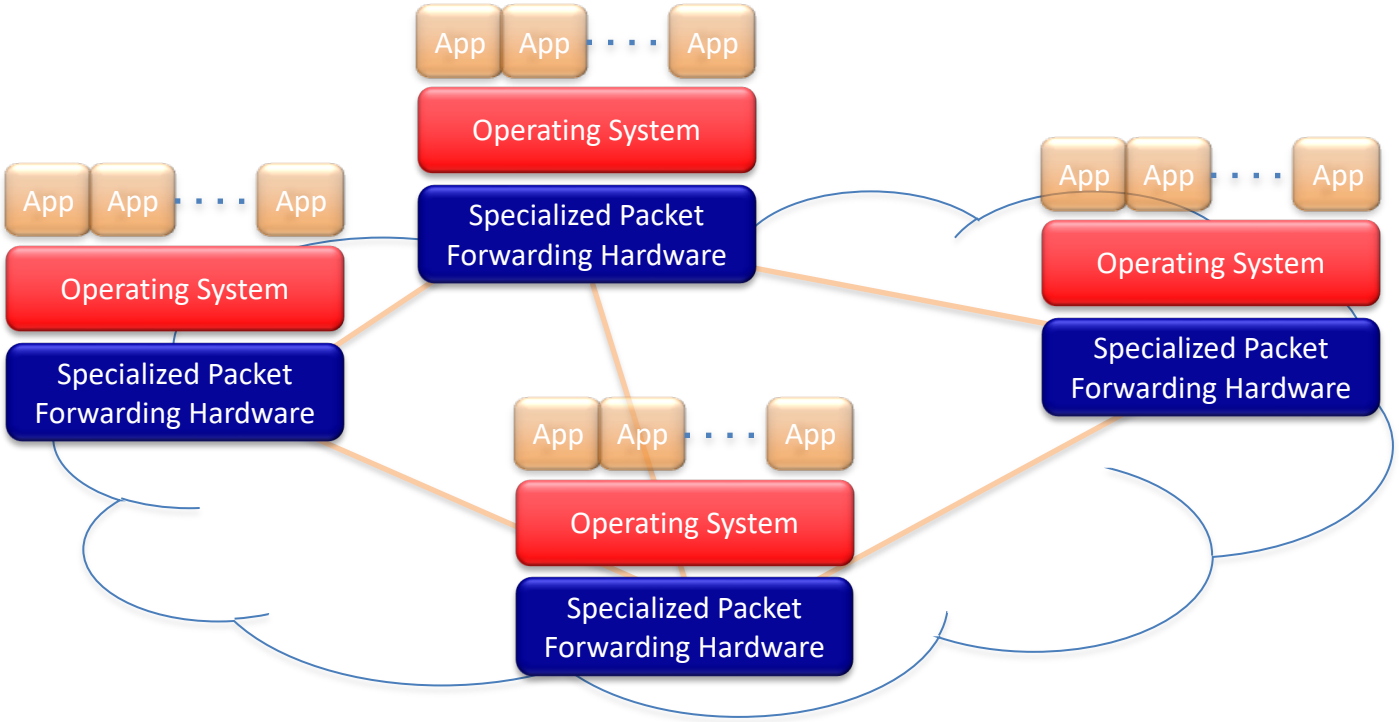
Software Defined Network (SDN)

- Open the box: decouple the control plane and data plane



Software Defined Network (SDN)

- Make the control plane centralized



Software Defined Network (SDN)

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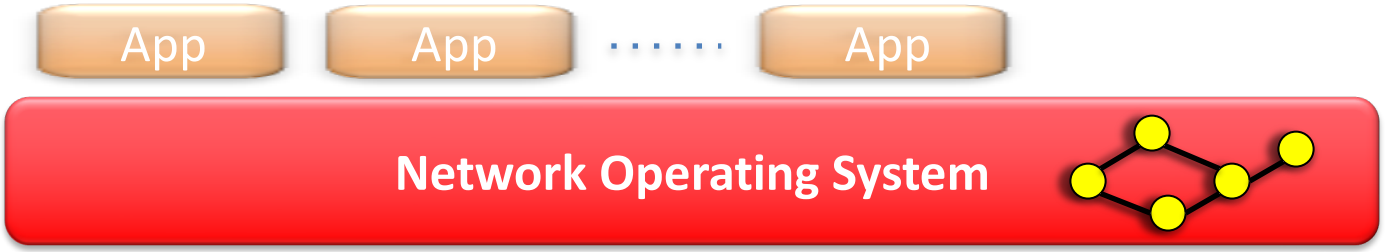
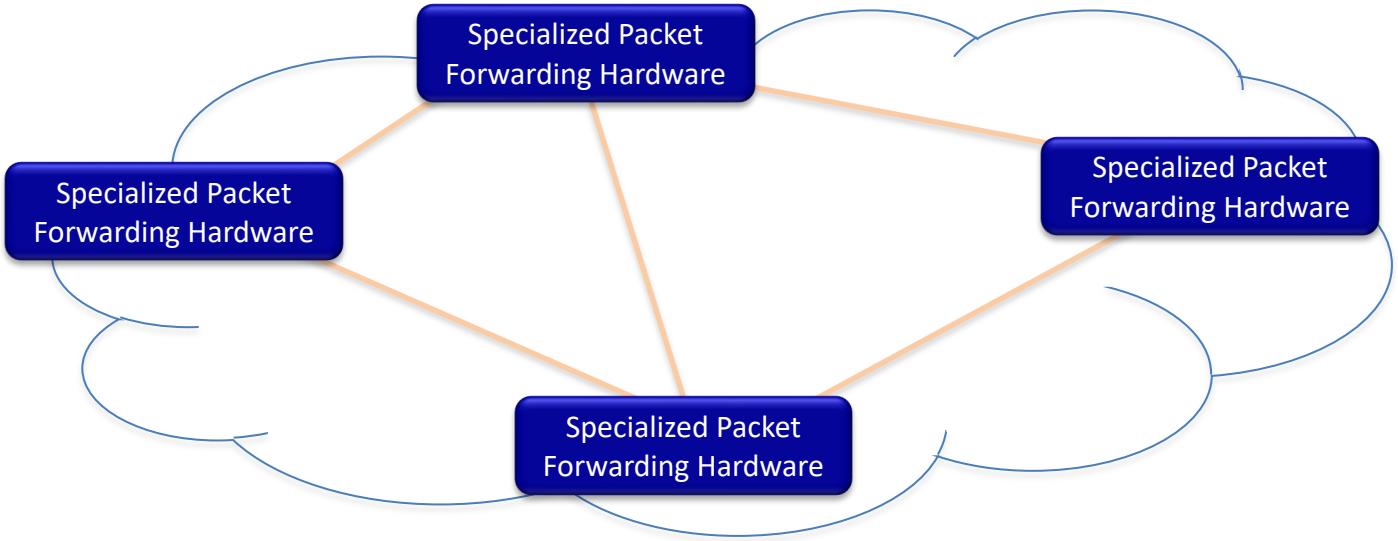
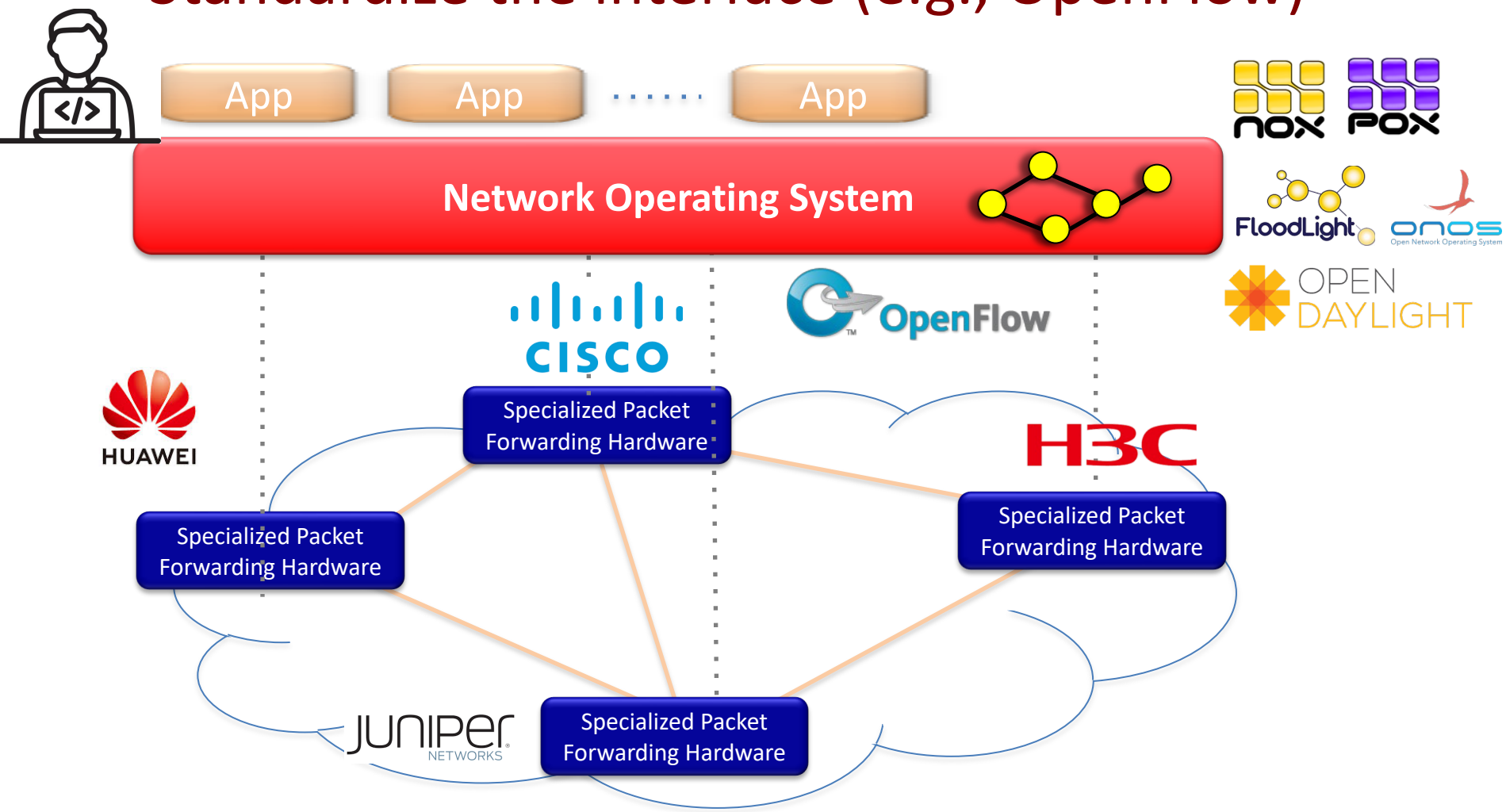


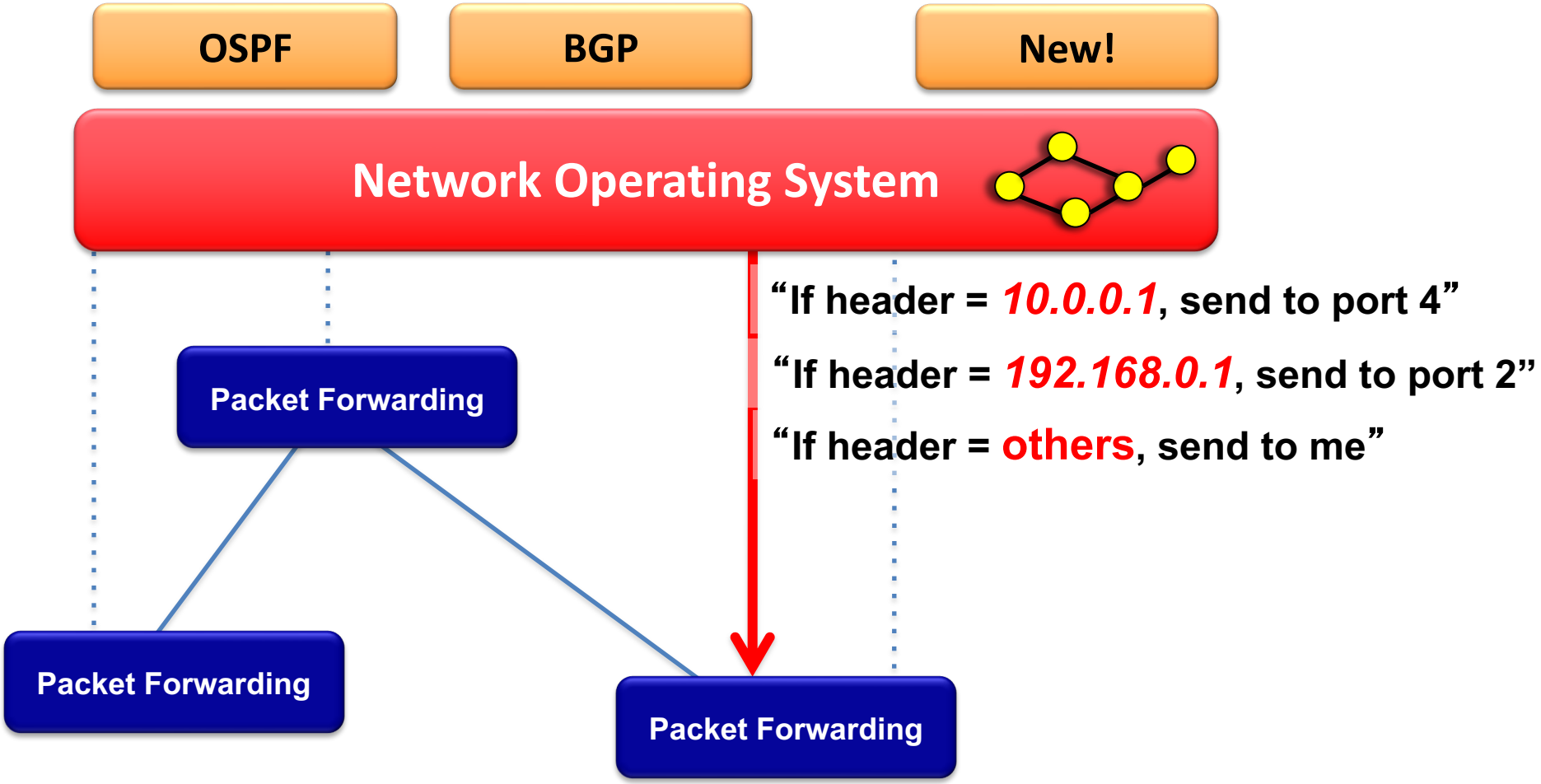


Software Defined Network (SDN)

- Standardize the interface (e.g., OpenFlow)

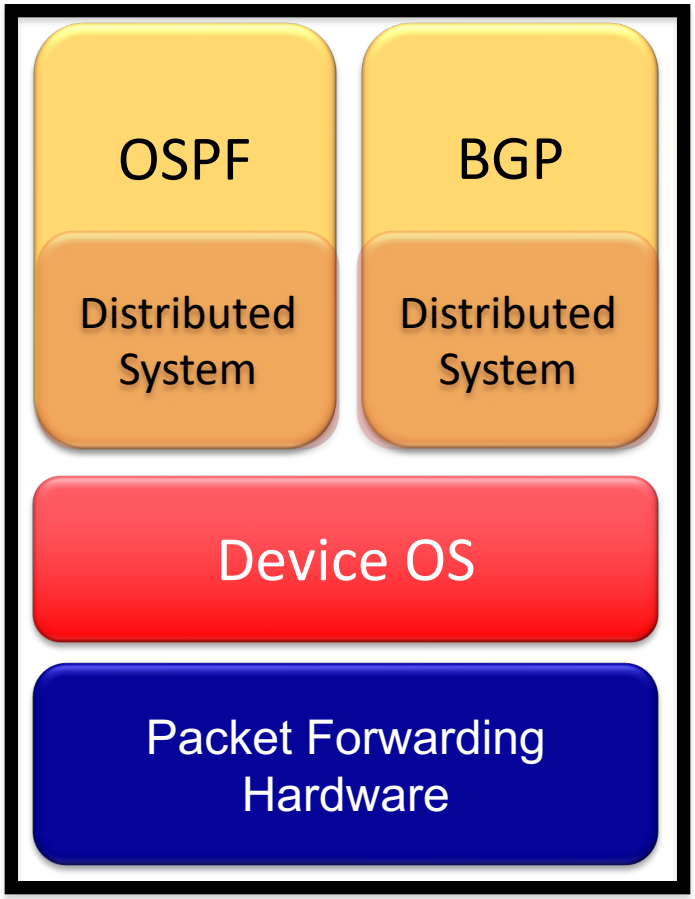


SDN Example

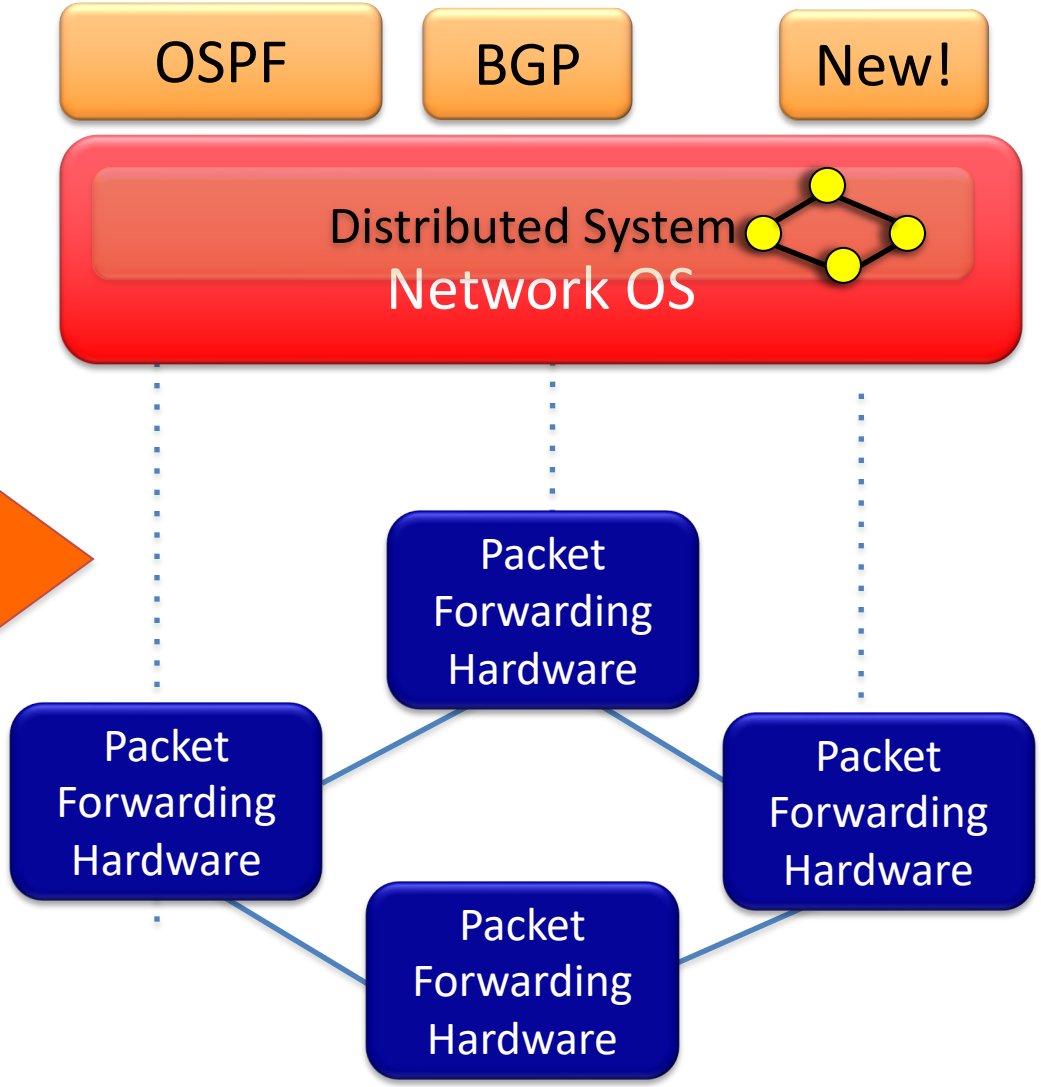

OSPF
BGP
New!
Network Operating System
"If header = 10.0.0.1, send to port 4"
"If header = 192.168.0.1, send to port 2"
"If header = others, send to me"
Packet Forwarding
Packet Forwarding
Packet Forwarding

SDN Benefits

RFC 2328:
245 pages



Dijkstra's Algorithm:
4 pages



SDN in Practice

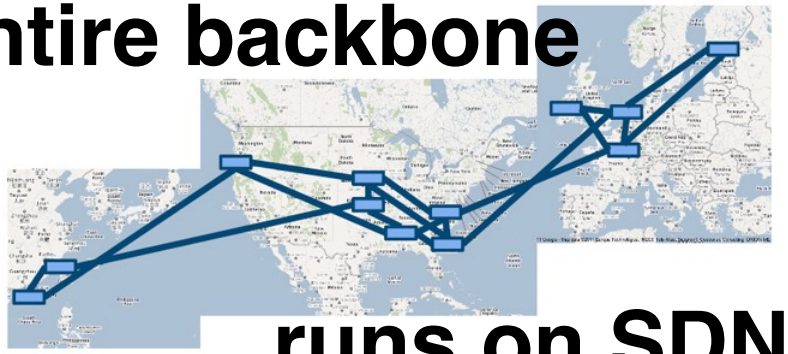
SDN: A Major Trend in Networking

OPEN NETWORKING FOUNDATION

Deutsche Telekom · facebook · Goldman Sachs · Google · Microsoft · NTT Communications · verizon · YAHOO!

Google

Entire backbone



runs on SDN

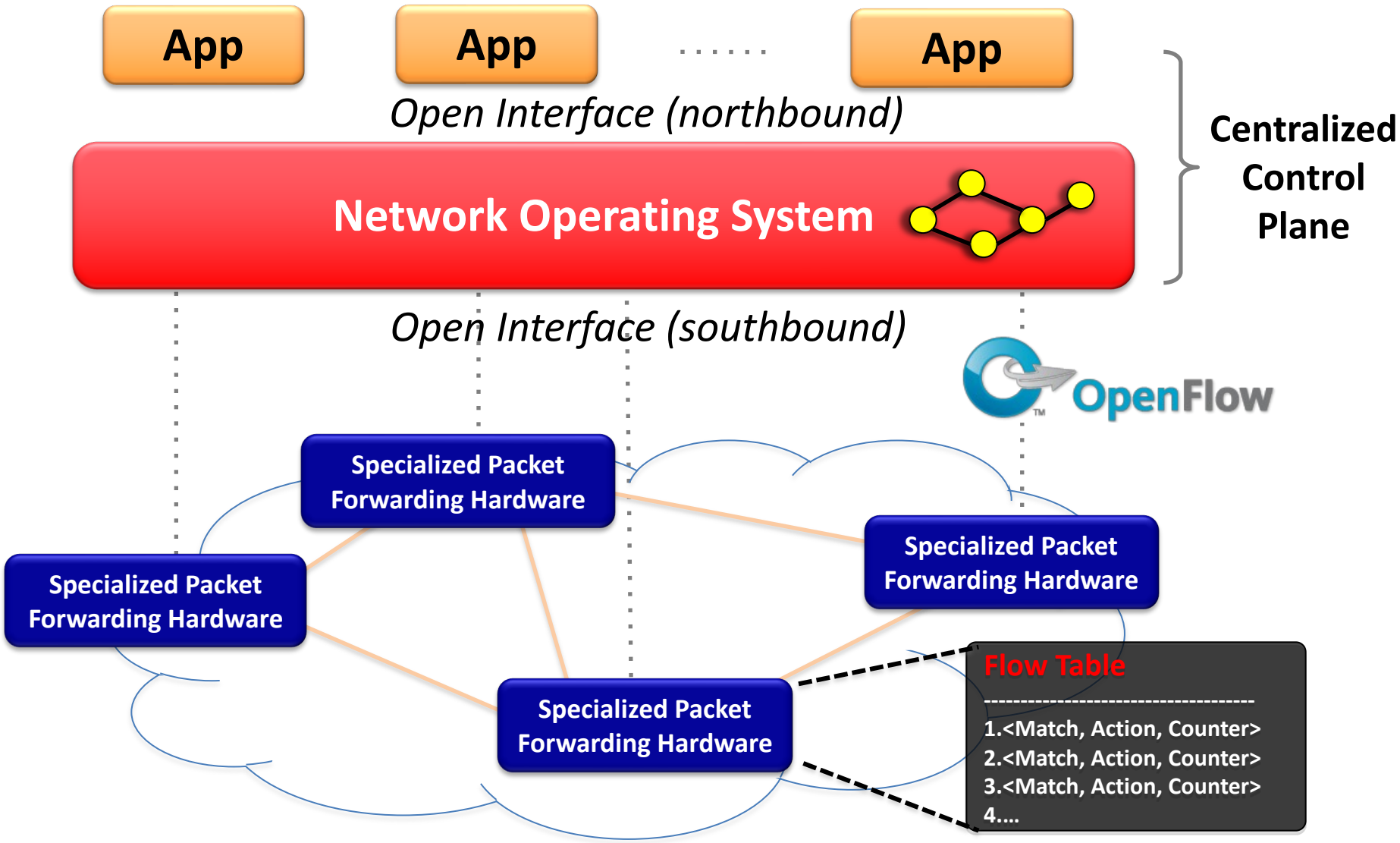
nicira

Bought for $1.2 x 10^9 (mostly cash)

SDN in Google

OpenFlow

Software Defined Network (SDN)



OpenFlow

- *2008: the paper "OpenFlow: enabling innovation in campus networks" in ACM SIGCOMM Computer Communication Review*
  - "This whitepaper proposes OpenFlow: a way for researchers to run experimental protocols in the networks they use every day."

OpenFlow: enabling innovation in campus networks

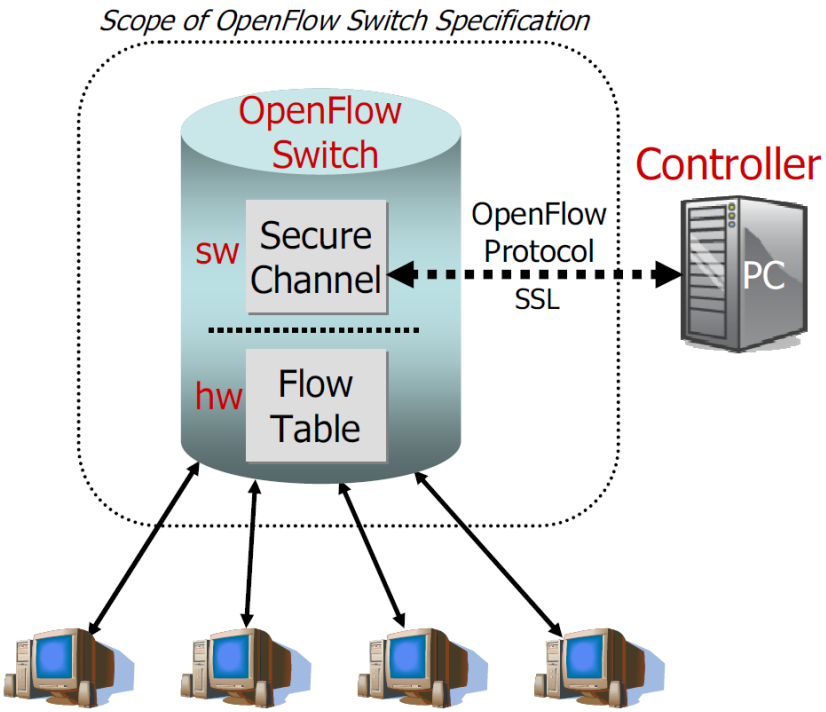
N McKeown, T Anderson, H Balakrishnan… - ACM SIGCOMM …, 2008 - dl.acm.org

This whitepaper proposes OpenFlow: a way for researchers to run experimental protocols in the networks they use every day. OpenFlow is based on an Ethernet switch, with an internal flow-table, and a standardized interface to add and remove flow entries. Our goal is to …

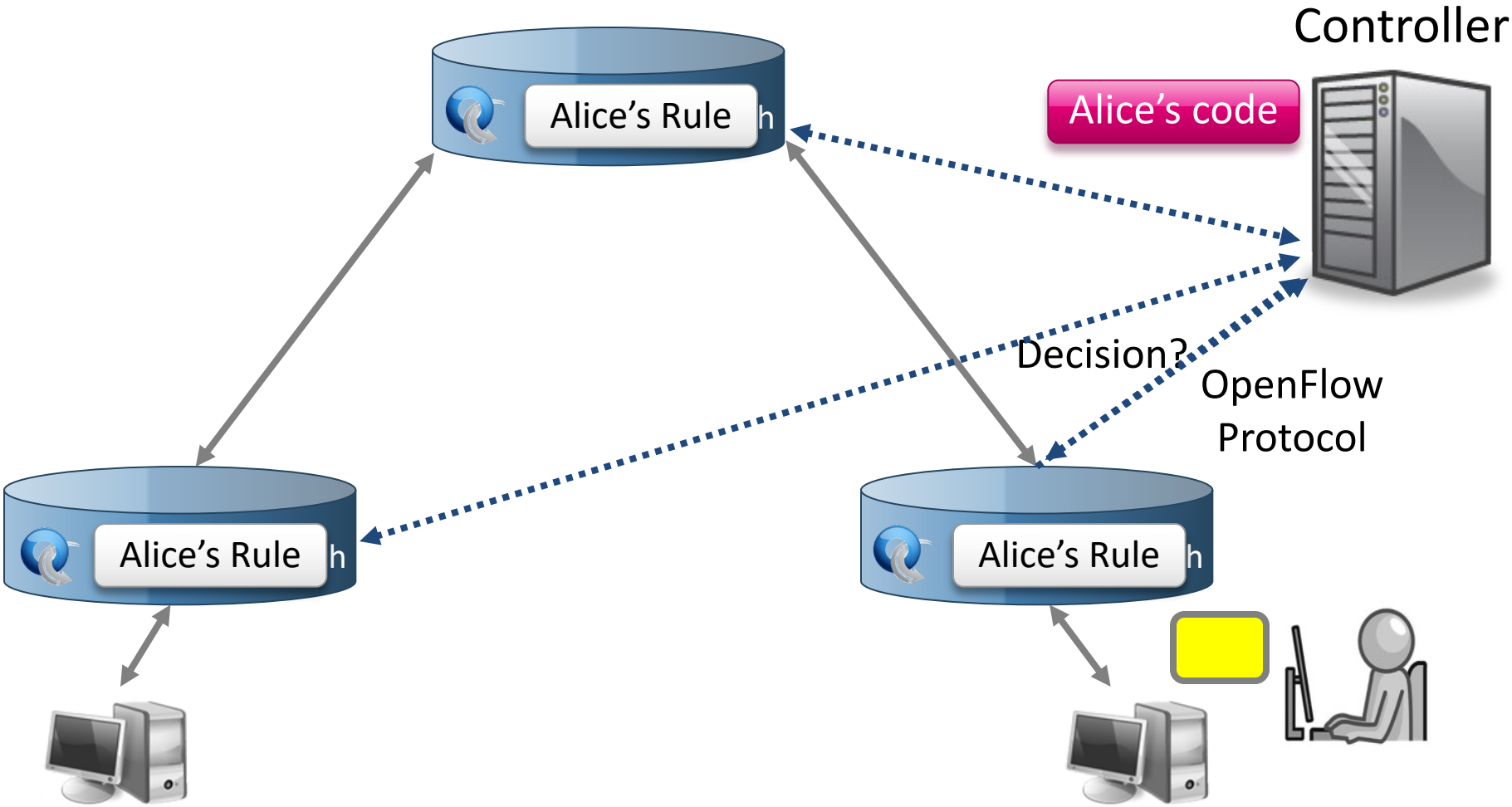
☆ 99 被引用次数：10835 相关文章 所有 91 个版本

OpenFlow

- Original purpose: make it easy for experiments
  - Not practical to experiment with new network protocols
  - Not practical to persuade vendors to provide an open, programmable platform on their switches and routers
  - Most modern switches and routers contain flow-tables that run at line-rate to implement firewalls, QoS, etc.

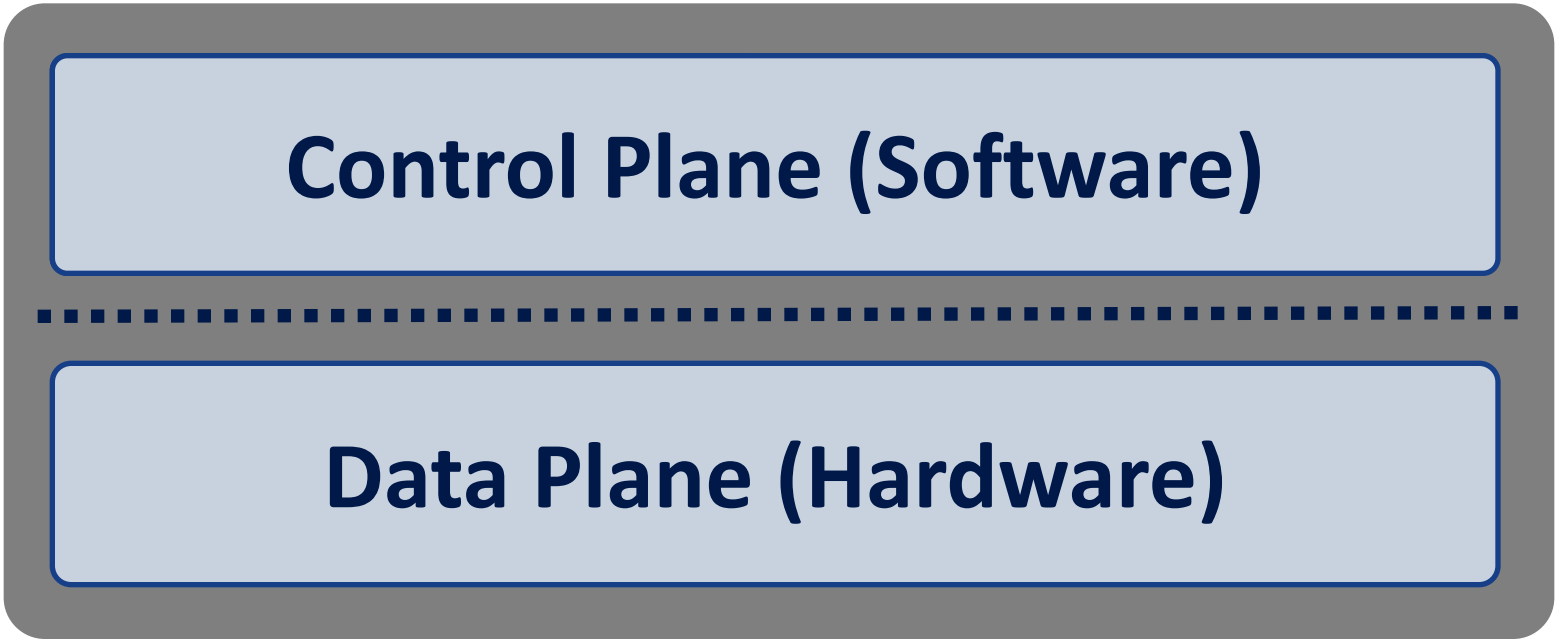


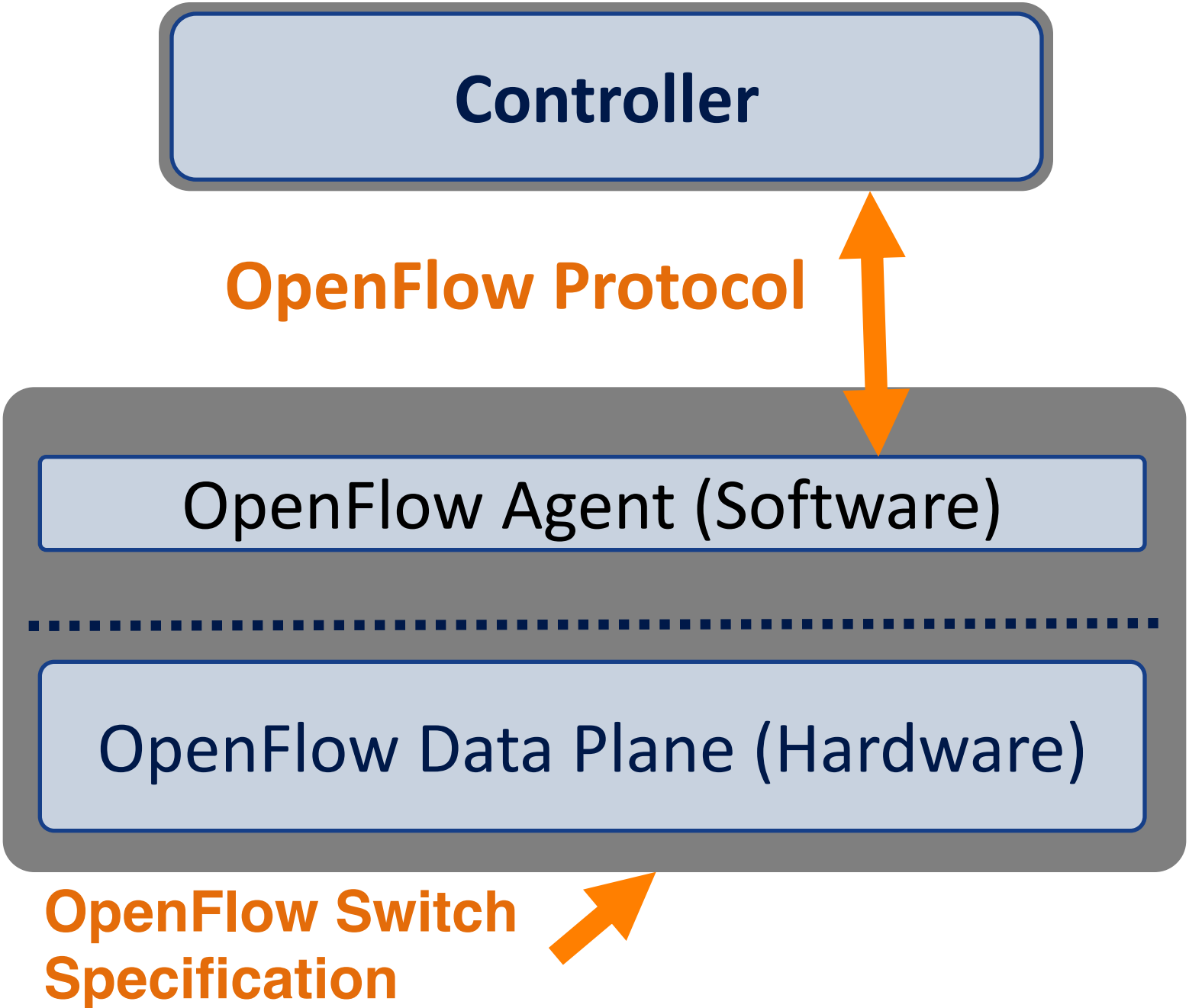
OpenFlow Example

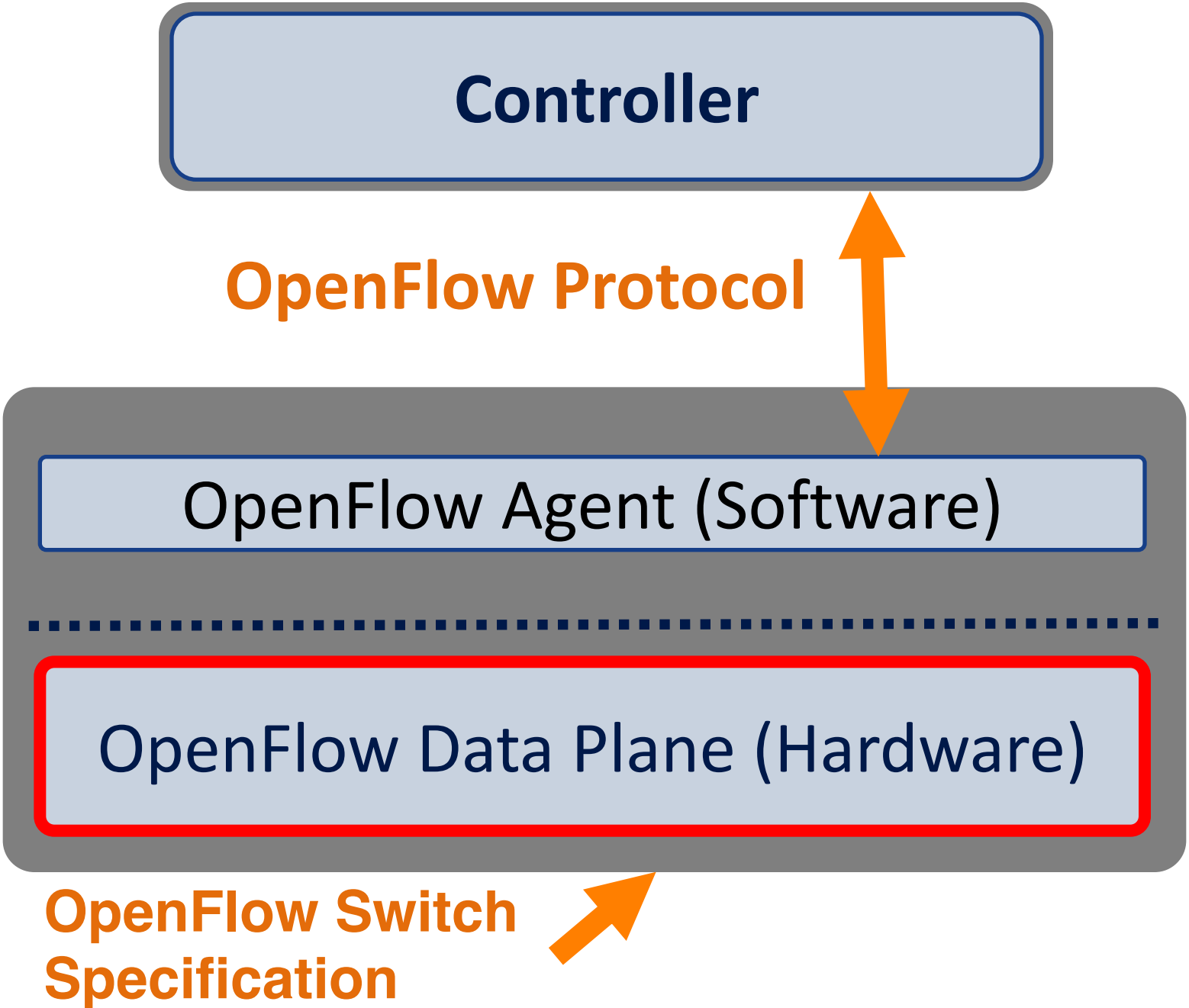


OpenFlow offloads control intelligence to a remote software

The Role of OpenFlow in SDN




Controller
OpenFlow Protocol
OpenFlow Agent (Software)
OpenFlow Data Plane (Hardware)
OpenFlow Switch Specification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OpenFlow Agent (Software)
OpenFlow Data Plane (Hardware)
OpenFlow Switch Specification

OpenFlow Rule = Match + Action

Match

Header	Data

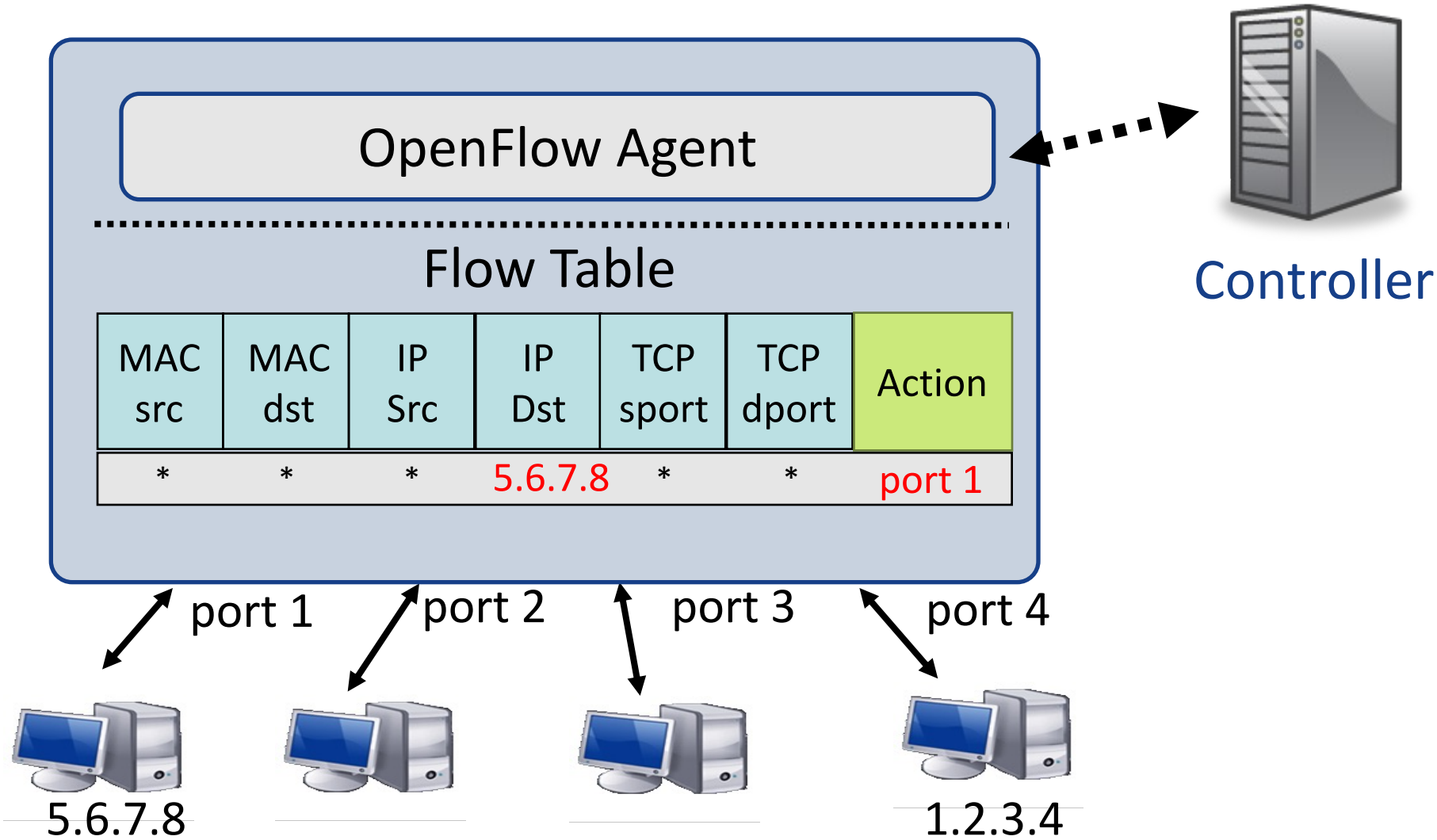
1000x01xx0101001x

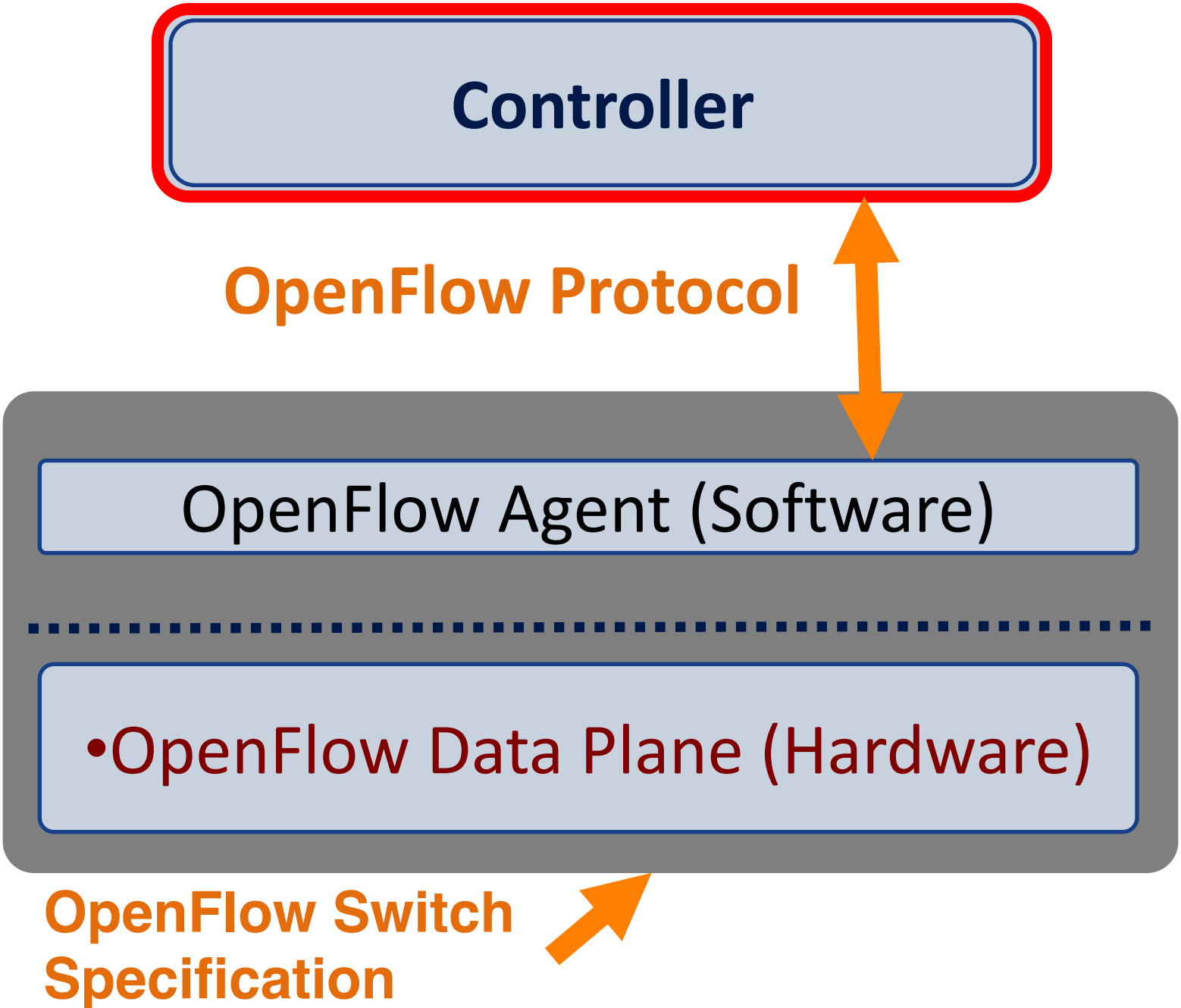
- Match on any header, or new header
- Allows any flow granularity

Action

- Forward to port(s), drop, send to controller
- Overwrite header with mask, push or pop
- Forward at specific bit-rate

OpenFlow Rule Example

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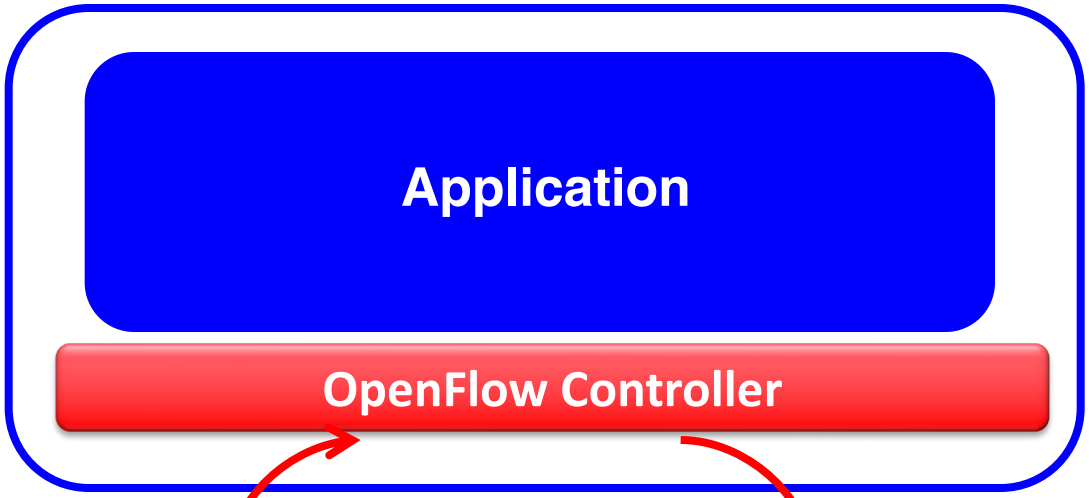
OpenFlow Controller



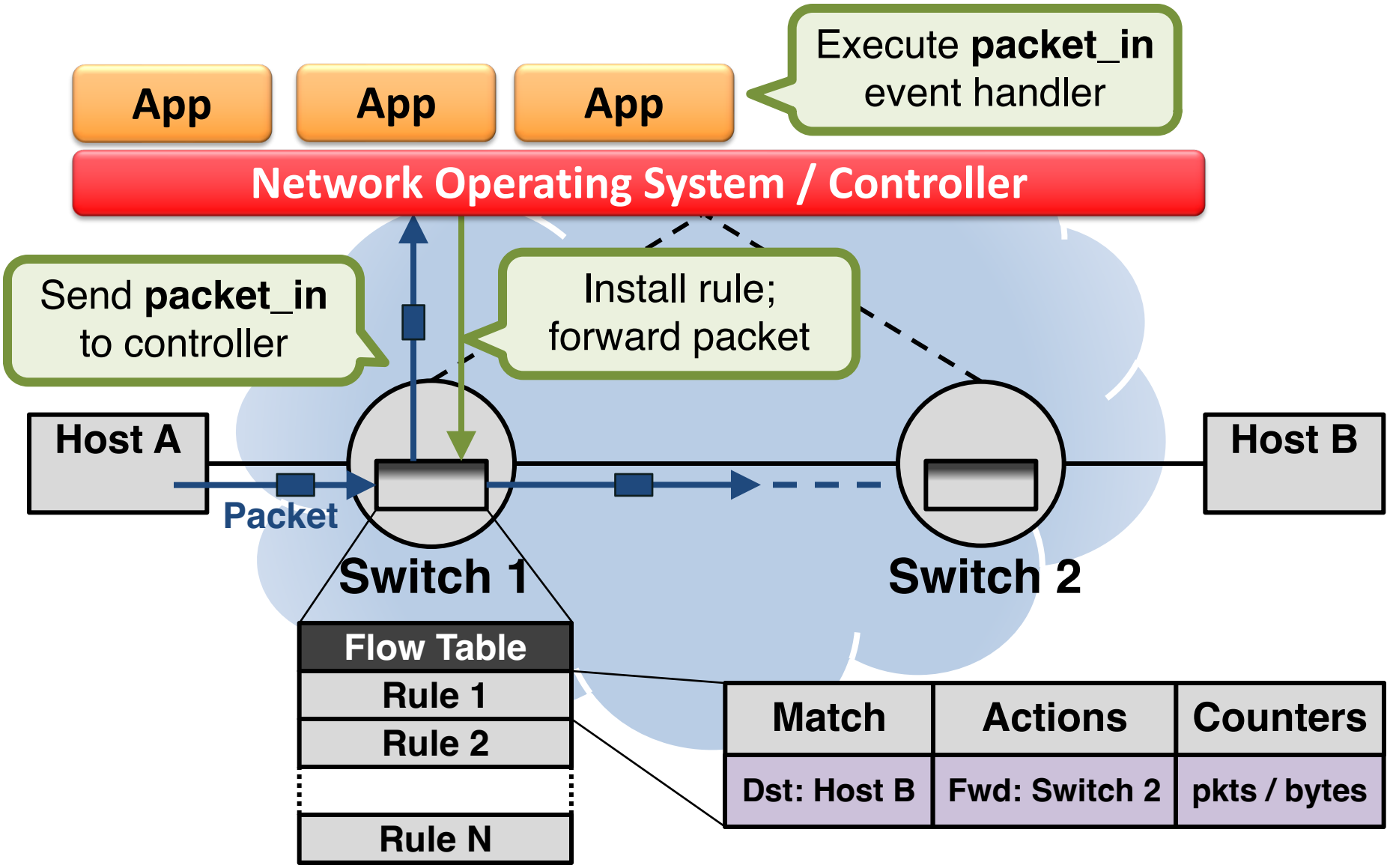
Events from switches

Topology changes,
Traffic statistics,
Arriving packets

Commands to switches

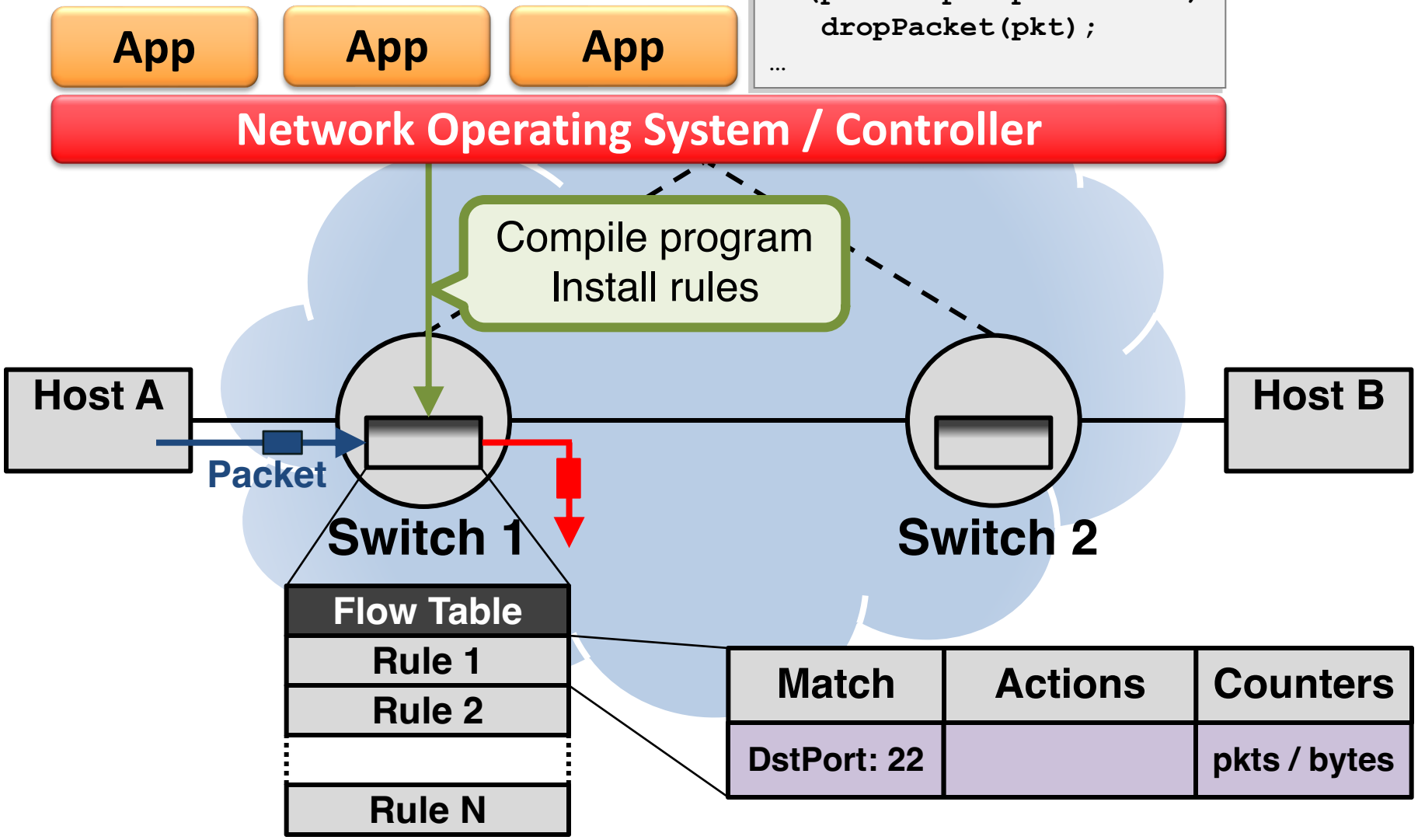
(Un)install rules,
Query statistics,
Send packets

Example: Reactive Control



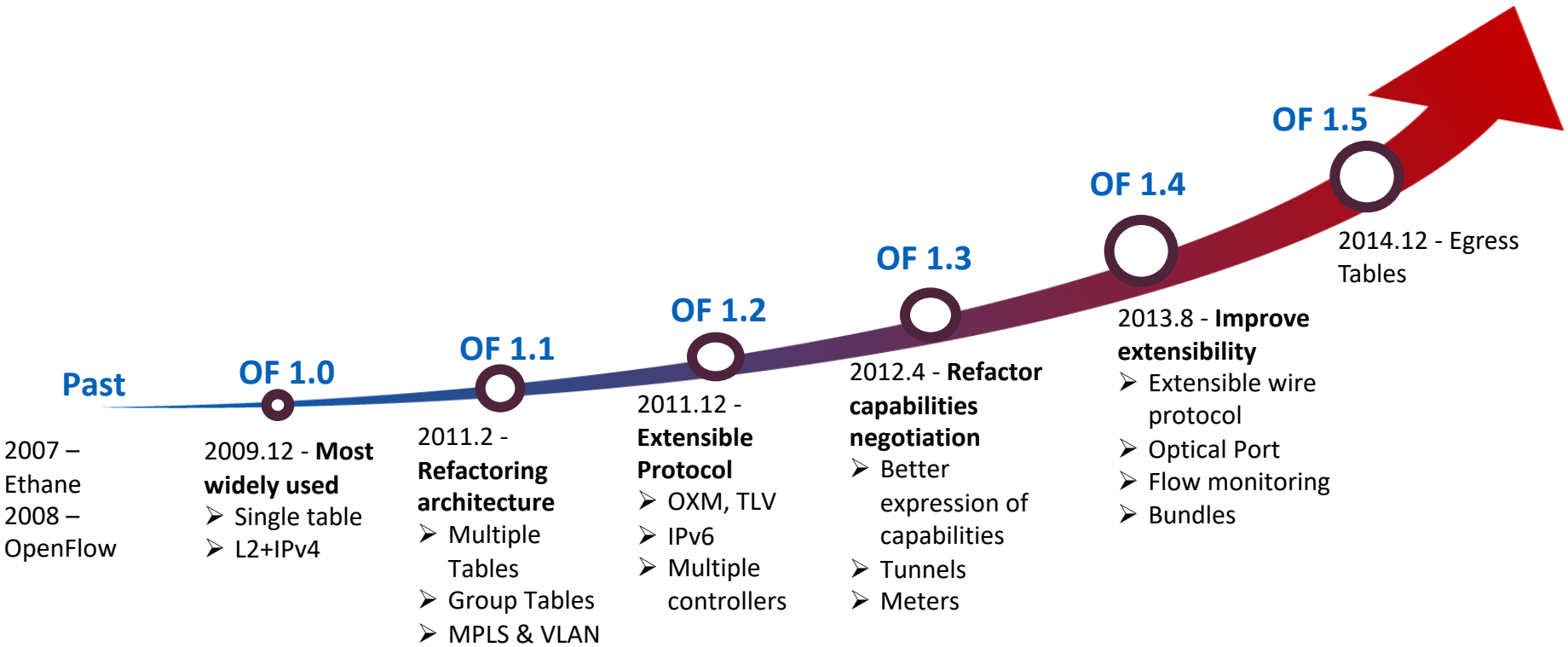
Example: Proactive Control

```
firewall.c
if(pkt->tcp->dport == 22)
    dropPacket(pkt);
…
```



OpenFlow Versions

Version	Date	Statistics	Matches	Actions	Instructions	Ports
OF 1.0	Dec 2009	Per table/flow/port/queue	**12/**	13/	1	8
OF 1.1	Feb 2011	Group/Action bucket	**15/**	32/	0	8
OF 1.2	Dec 2011	--	**36/**	51/	5	8
OF 1.3	Jun 2012	Per flow meter	**40/**	58/	6	8
OF 1.4	Oct 2013	Optical port properties	**41/**	59/	6	8



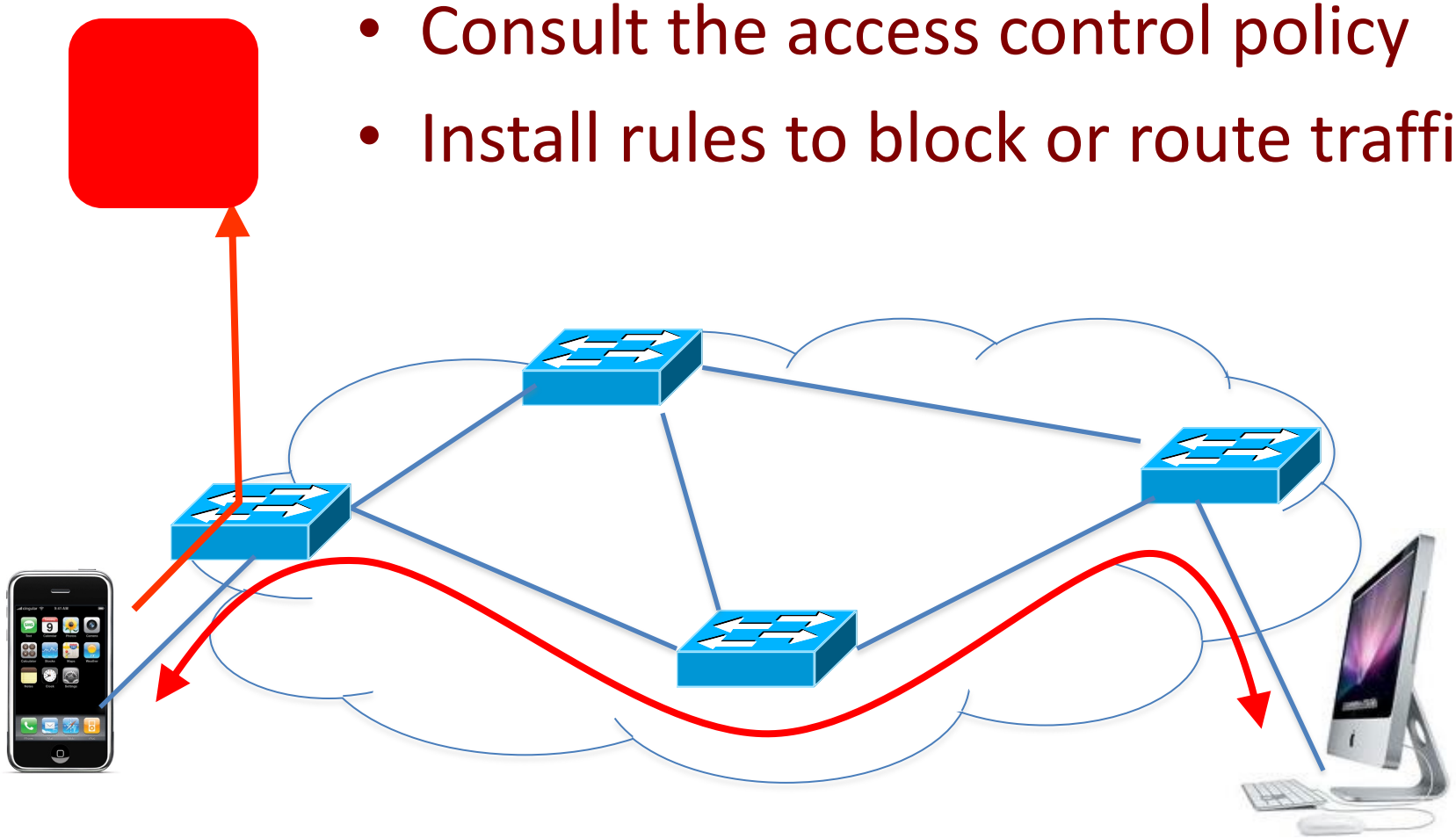
SDN vs. OpenFlow

- SDN ≠ OpenFlow
  - SDN is a general network architecture, OpenFlow is a protocol or standard
- OpenFlow is an interface protocol for SDN
  - Spoken by the controllers and switches
- OpenFlow is more than just a protocol
  - Also including switch specification
  - Can be seen as the de factor standard implementation of SDN: SDN/OpenFlow

SDN Applications

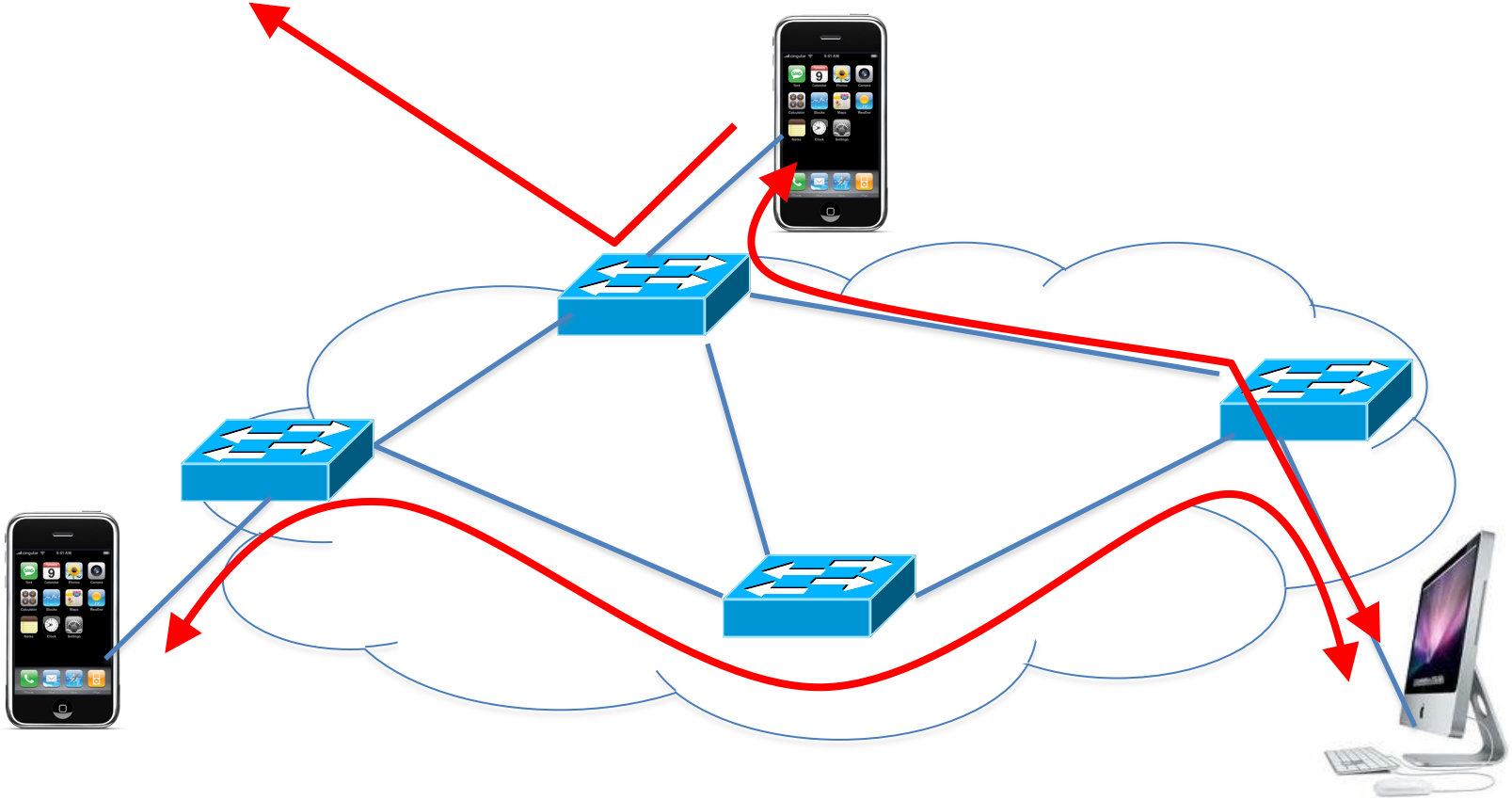
E.g.: Dynamic Access Control

- Inspect first packet of a connection
- Consult the access control policy
- Install rules to block or route traffic



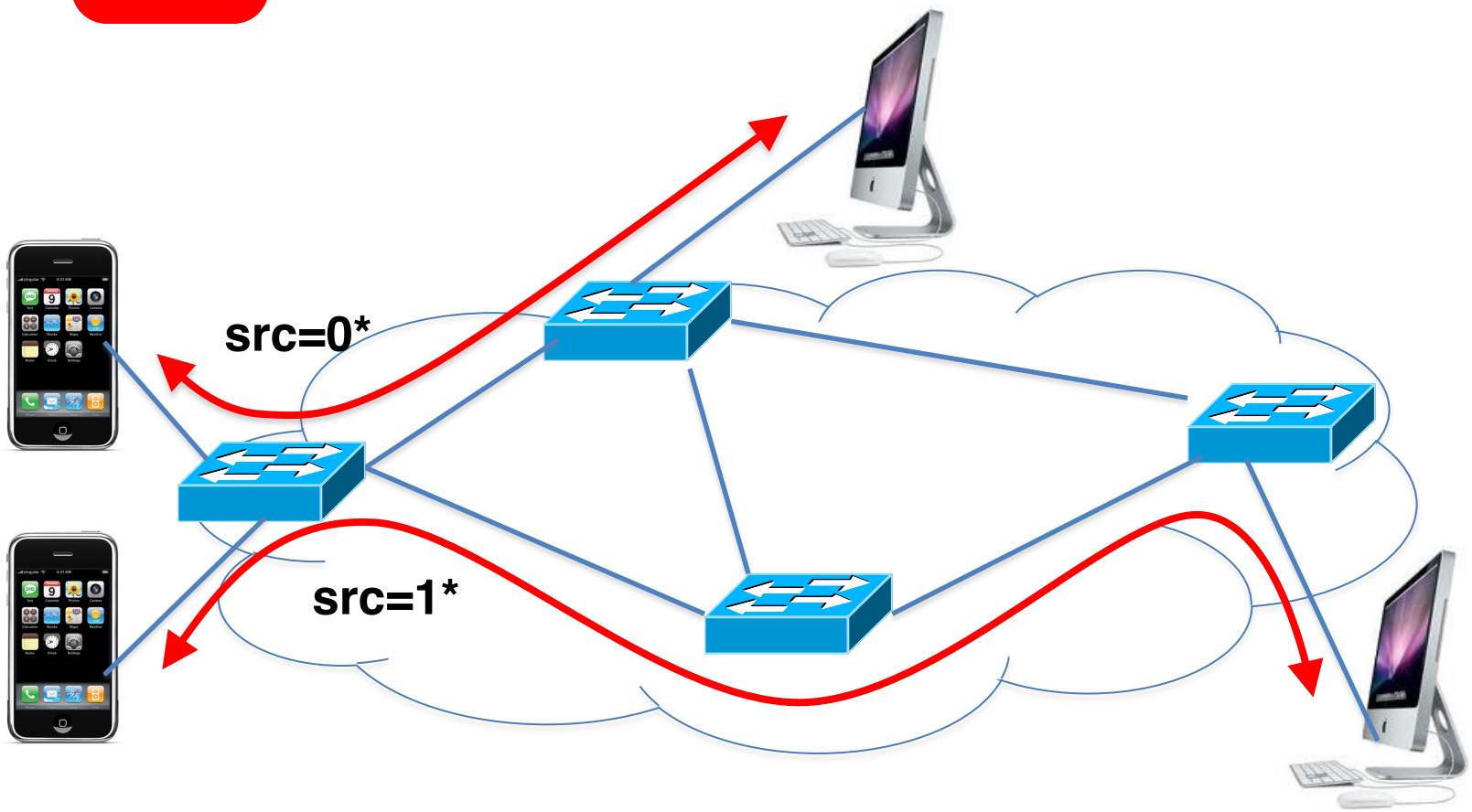
E.g.: Seamless Mobility/Migration

- See host send traffic at new location
- Modify rules to reroute the traffic



E.g.: Server Load Balancing

- Pre-install load-balancing policy
- Split traffic based on source IP



OpenFlow Applications

- **Routing**
- **Dynamic access control**
- **Seamless mobility/migration**
- **Server load balancing**
- **Network virtualization**
- Using multiple wireless access points
- Energy-efficient networking
- Adaptive traffic monitoring
- Denial-of-Service attack detection

Credits

[1] Jennifer Rexford, Course of Computer Networks, Princeton University

[2] McKeown et al., How SDN will shape networking, in Open Network Summit 2011