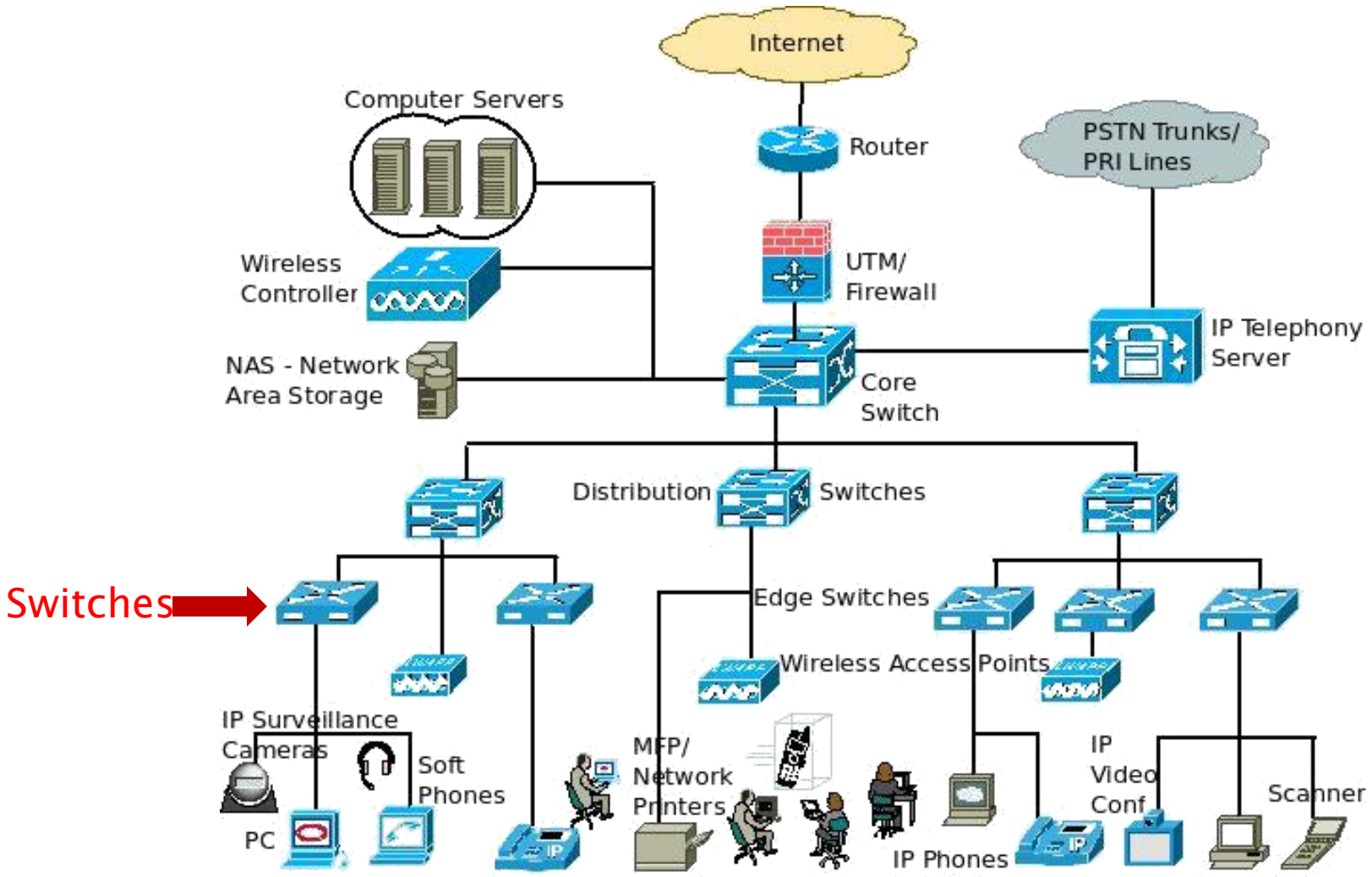
# Limitations of Current Networks

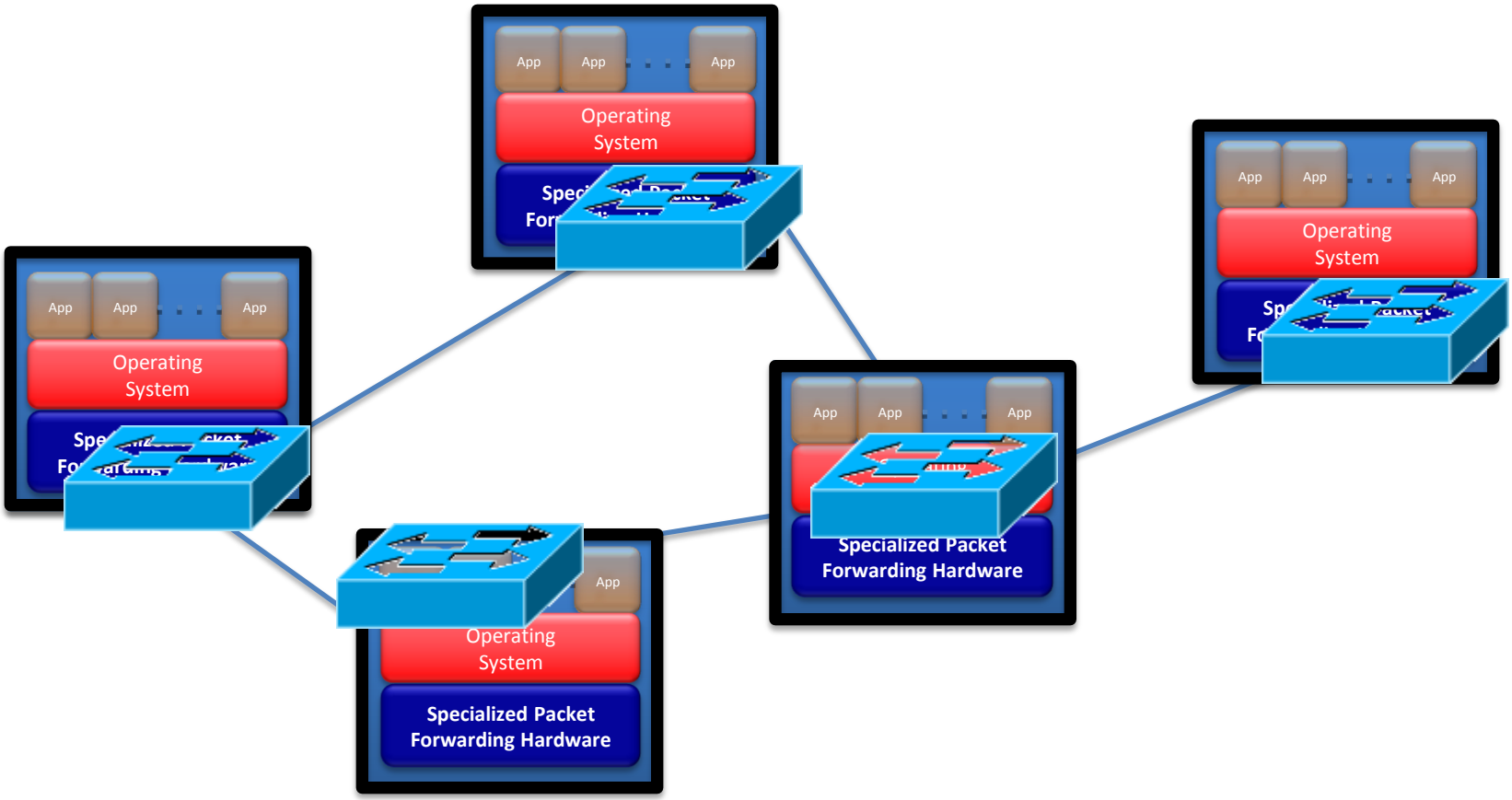


# Limitations of Current Networks

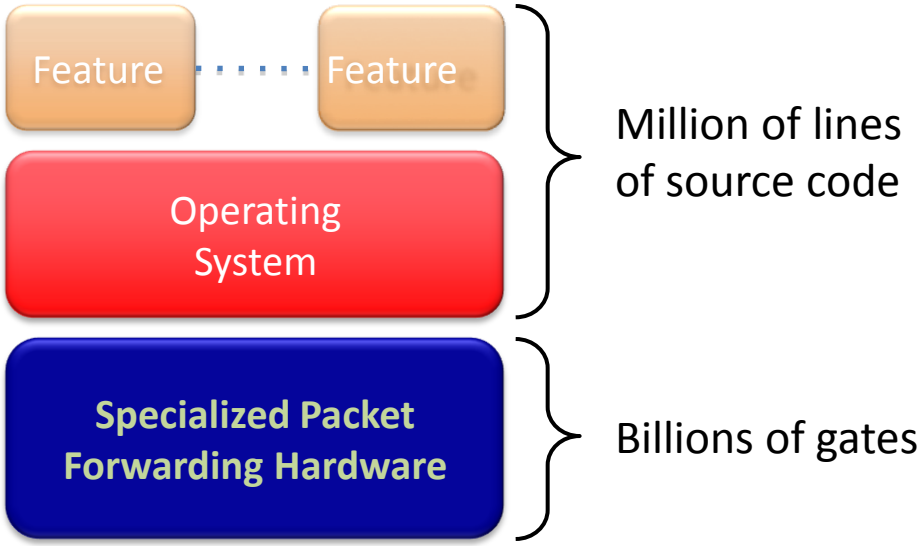
- **Enterprise networks are difficult to manage**
- **“New control requirements have arisen”:**
  - Greater scale
  - Migration of VMS
- **How to easily configure huge networks?**

# Limitations of Current Networks

- **Old ways to configure a network**



# Limitations of Current Networks




Many complex functions baked into infrastructure

*OSPF, BGP, multicast, differentiated services, Traffic Engineering, NAT, firewalls, …*

Cannot dynamically change according to network conditions

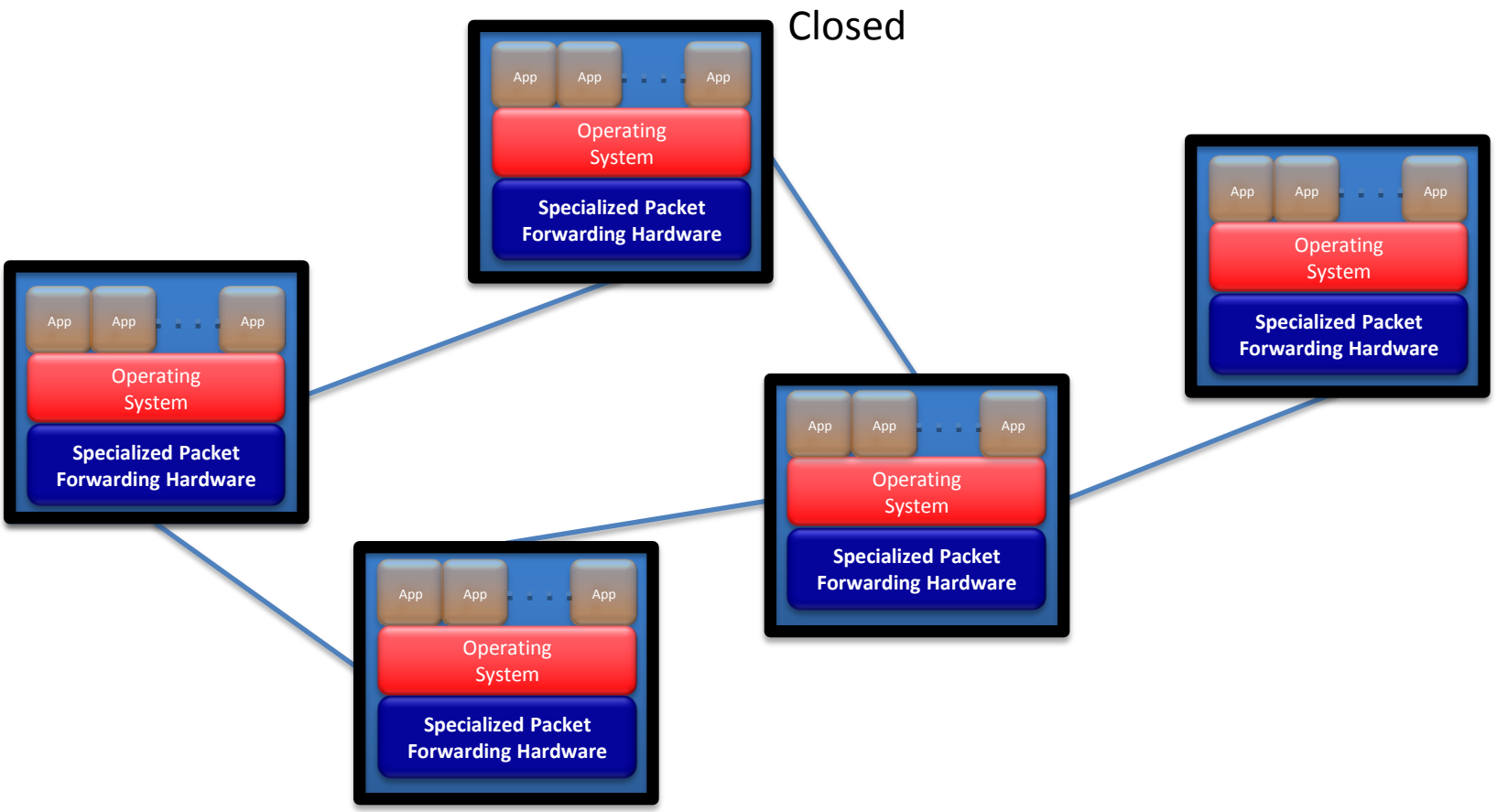
# Limitations of Current Networks

- **No control plane abstraction for the whole network!**

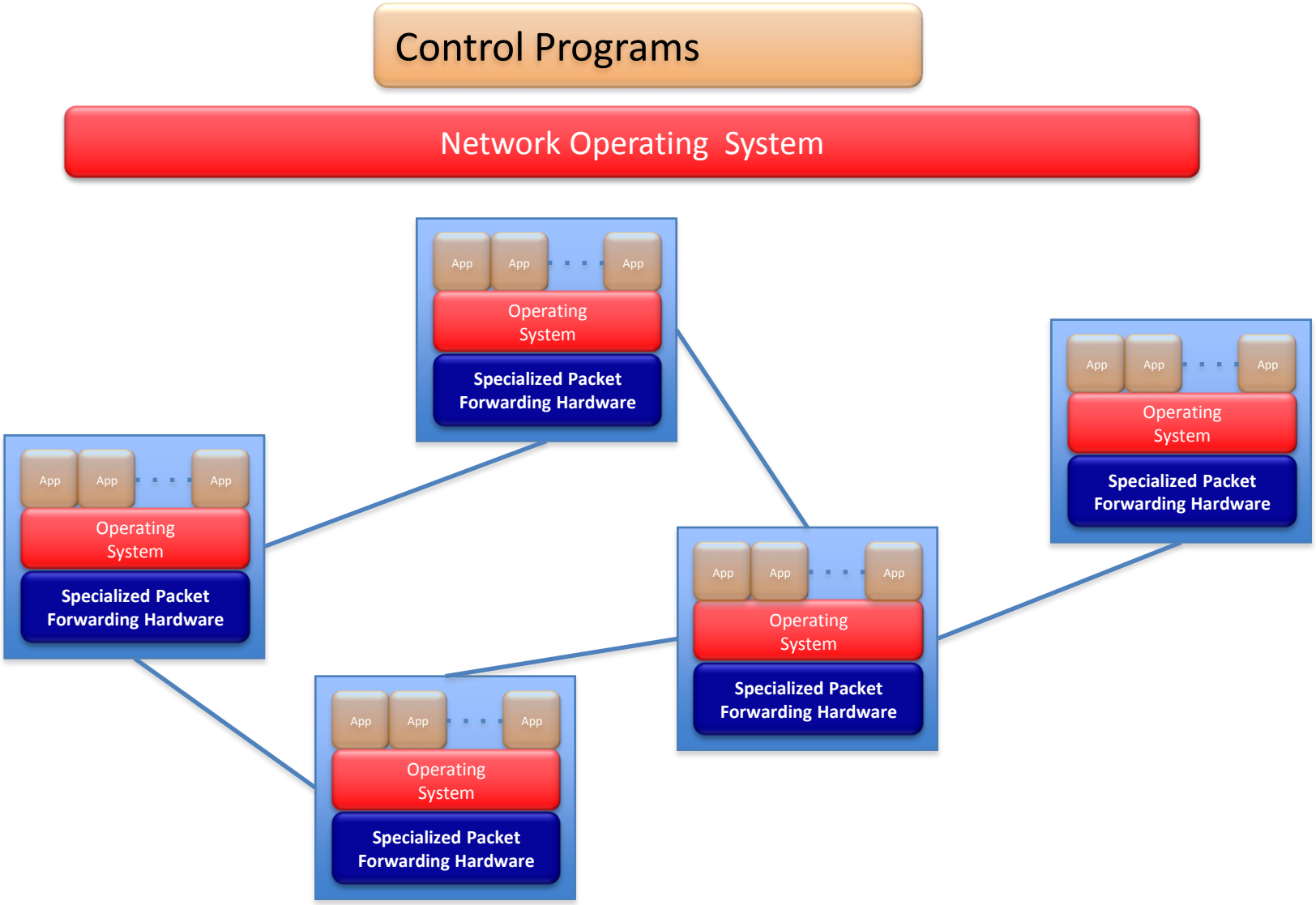
- **It's like old ti**  **there was no OS…**

Wilkes with the EDSAC, 1949

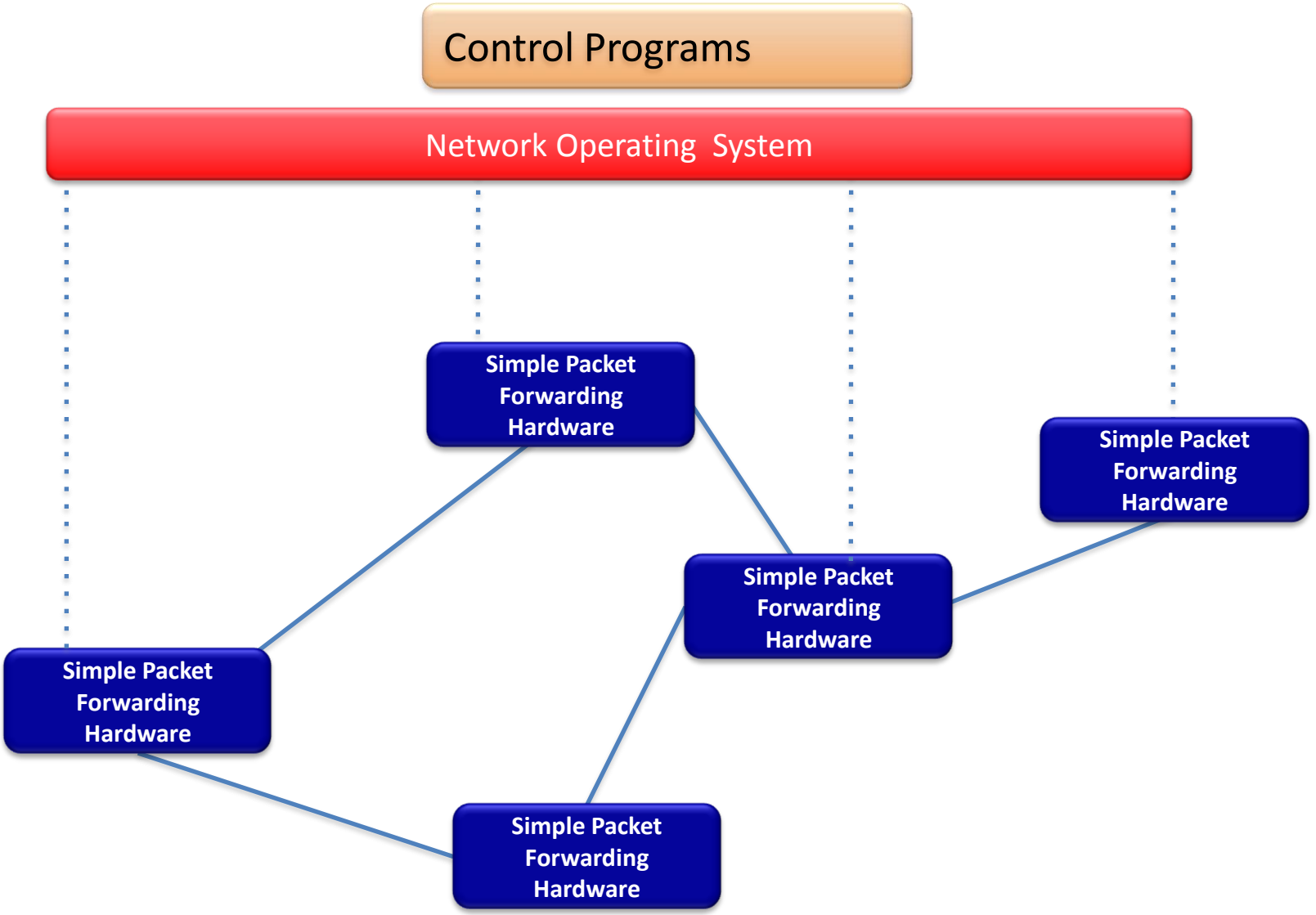
# Idea: An OS for Networks



# Idea: An OS for Networks

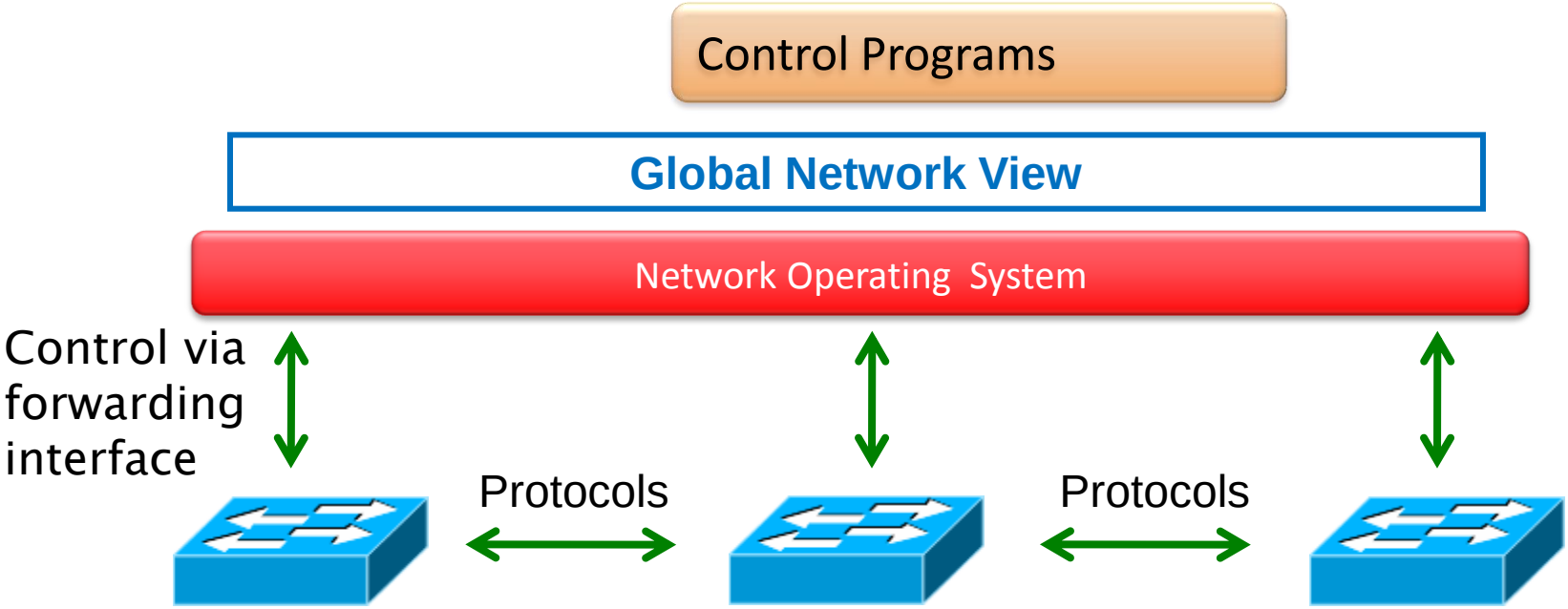


# Idea: An OS for Networks



# Idea: An OS for Networks

## Software-Defined Networking (SDN)



# Software Defined Networking

- **No longer designing distributed control protocols**

- **Much easier to write, verify, maintain, …**
  - An interface for programming

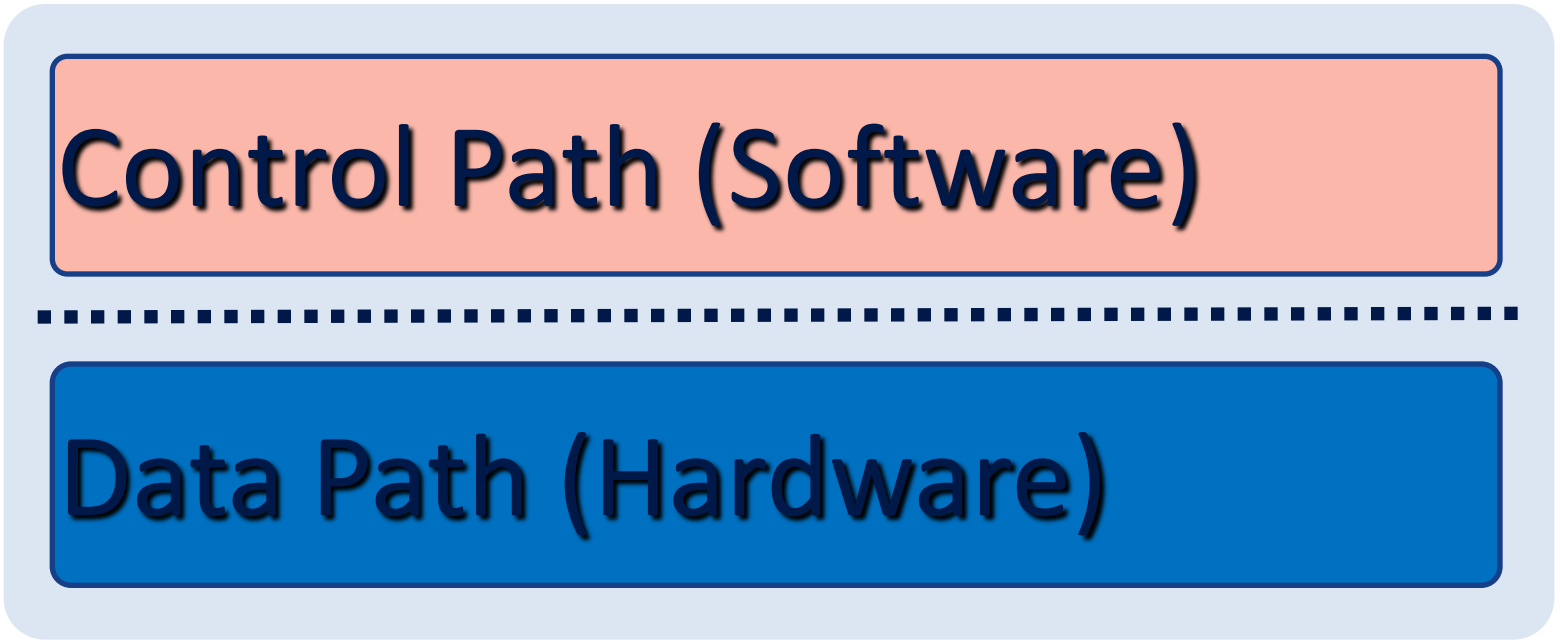
- **NOS serves as fundamental control block**
  - With a global view of network

# OpenFlow

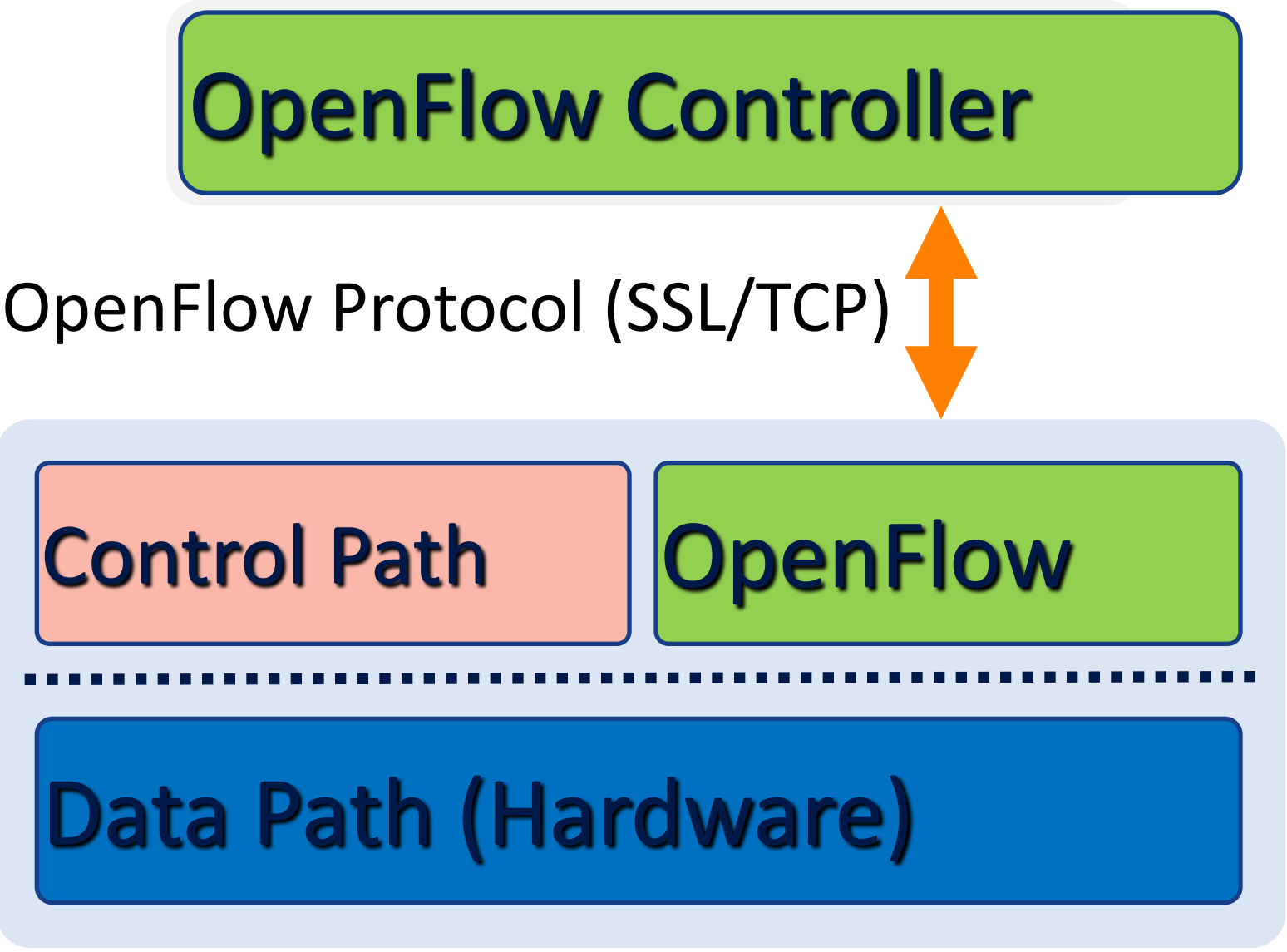
- **"OpenFlow: Enabling Innovation in Campus Networks"**

- **Like hardware drivers**
  - interface between switches and Network OS

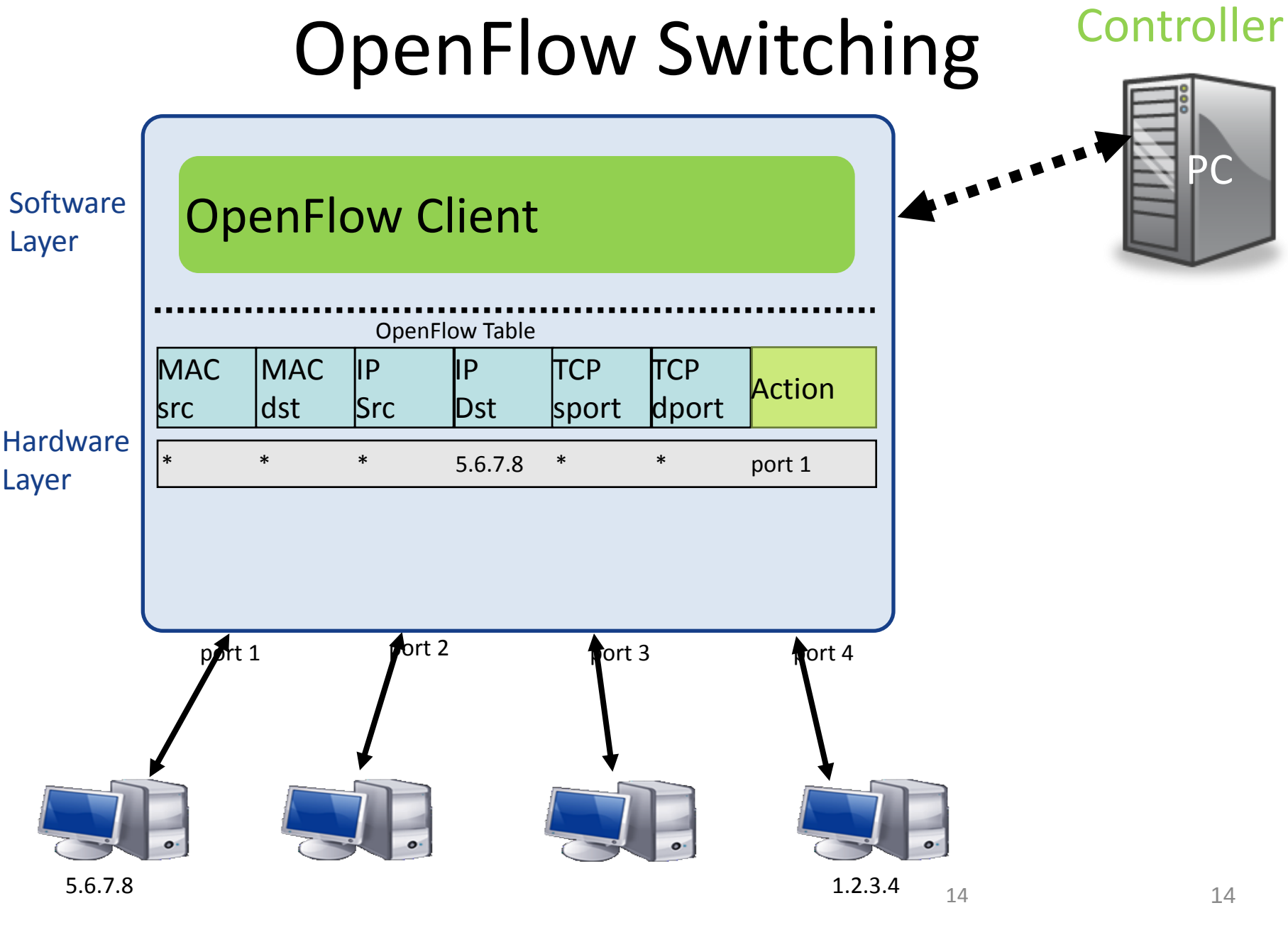
# OpenFlow



# OpenFlow


OpenFlow Controller
OpenFlow Protocol (SSL/TCP)
Control Path
OpenFlow
Data Path (Hardware)

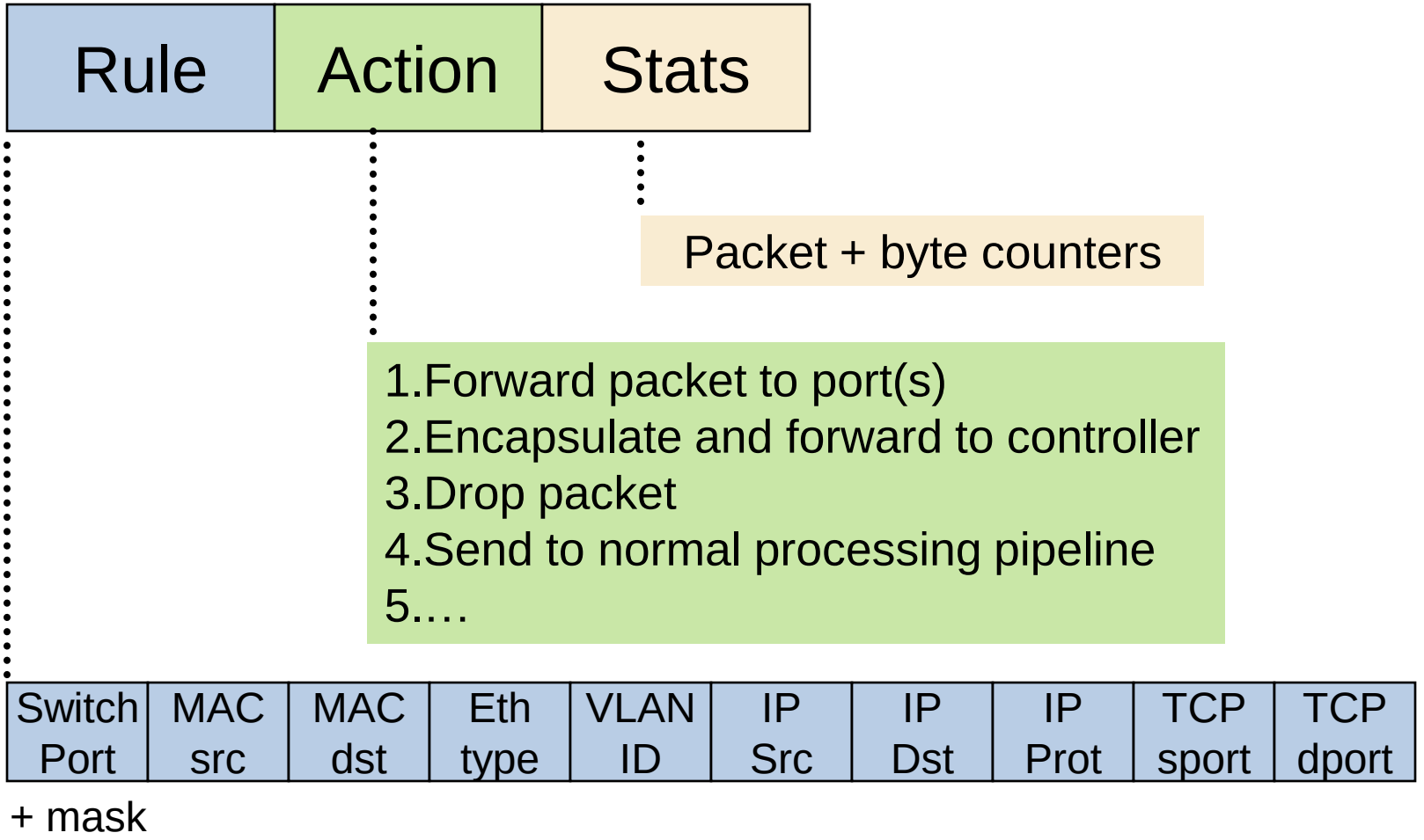
# OpenFlow Switching






14

# OpenFlow Table Entry



# OpenFlow Examples

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 |

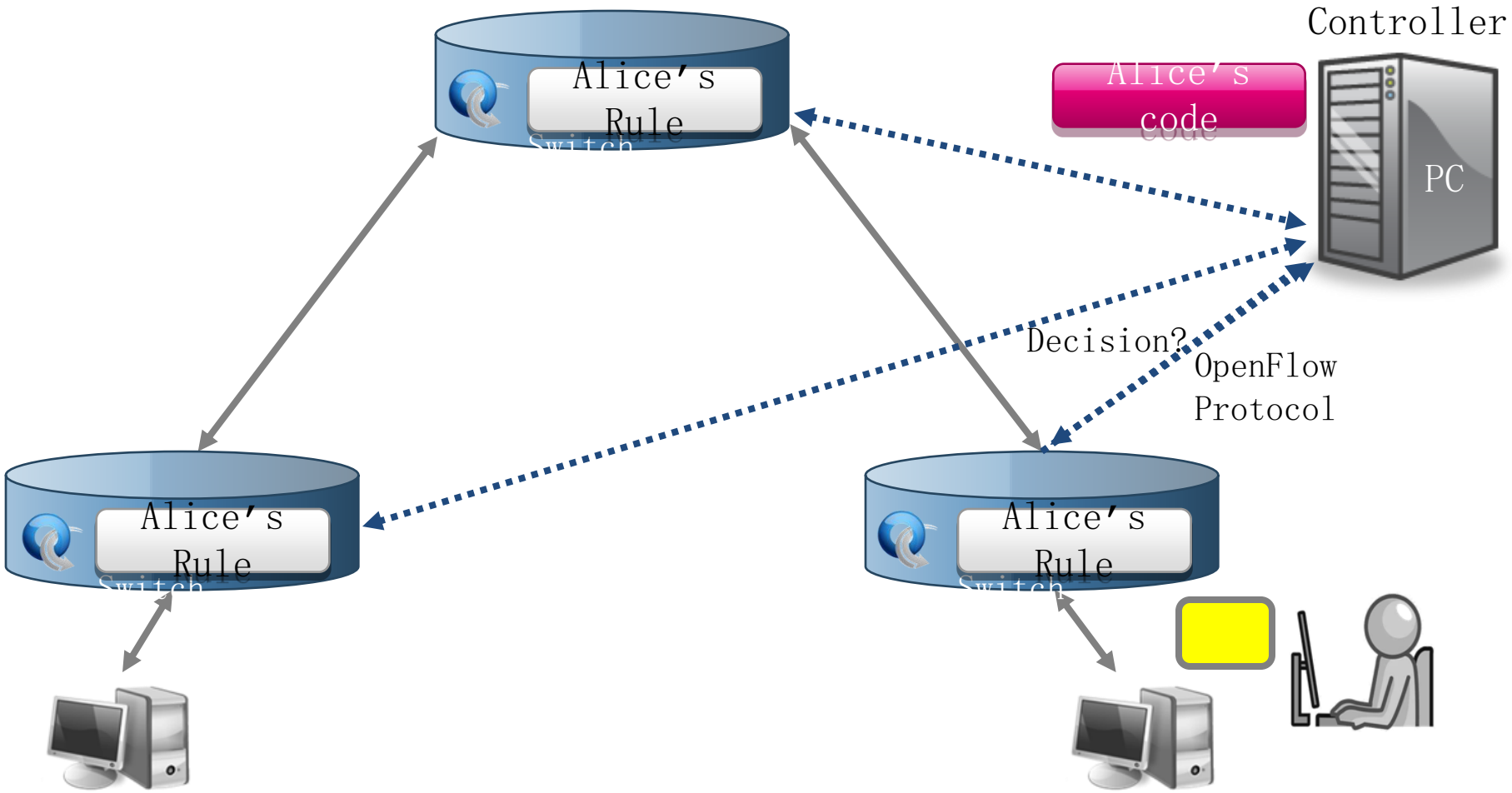
Routing

| 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 |

Firewall

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

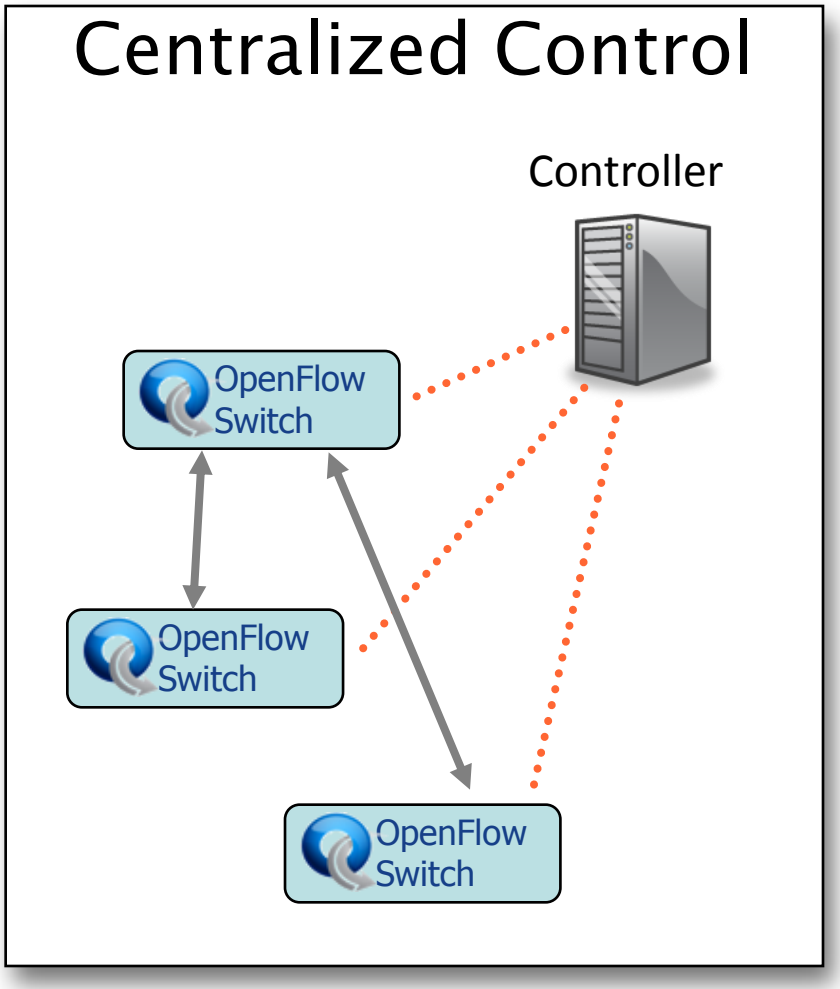
# OpenFlow Usage

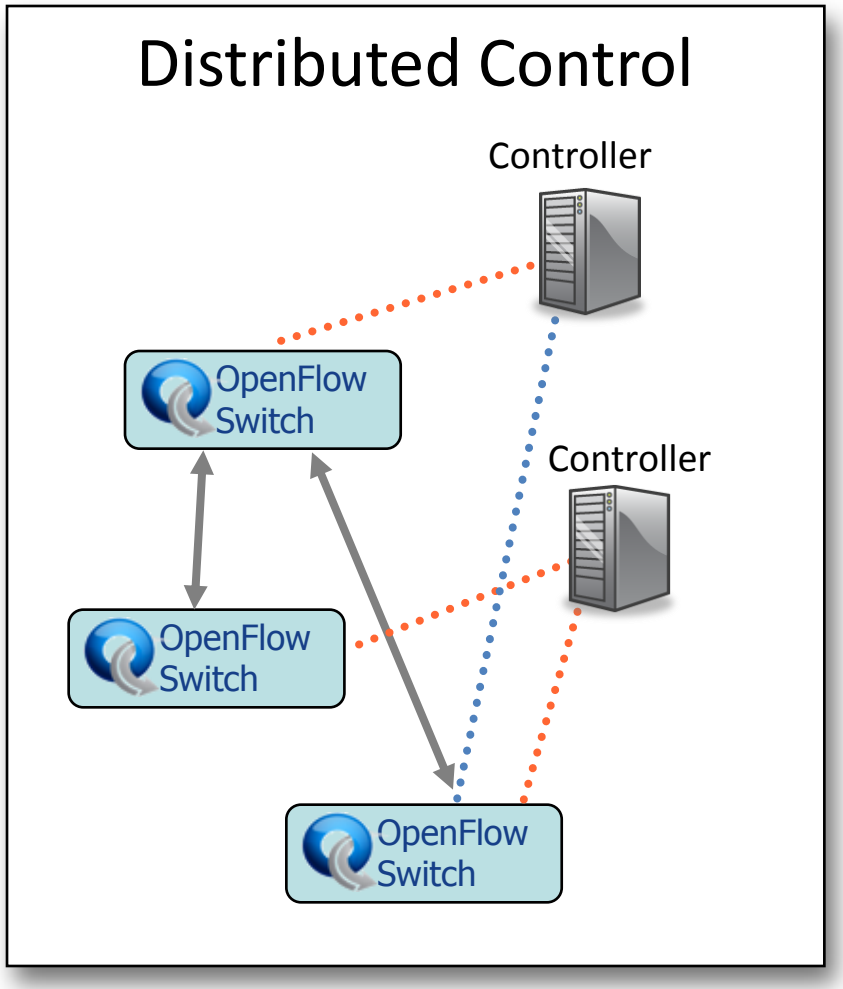



- Standard way to control flow-tables in commercial switches and routers
- Just need to update firmware
- Essential to the implementation of SDN

# Centralized/Distributed Control

- **"Onix: A Distributed Control Platform for Large-scale Production Networks"**



# Current status of SDN

- Hardware support

Juniper MX-series

NEC IP8800

WiMax (NEC)

HP Procurve 5400

Netgear 7324

PC Engines

Pronto 3240/3290

Ciena Coredirector

More coming soon…

# Current status of SDN

- Industry support
  - Google built hardware and software based on the OpenFlow protocol
  - VMware purchased Nicira for $1.26 billion in 2012
  - IBM, HP, NEC, Cisco and Juniper also are offering SDNs that may incorporate OpenFlow, but also have other elements that are specific to that vendor and their gear.