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Software-Defined Networking

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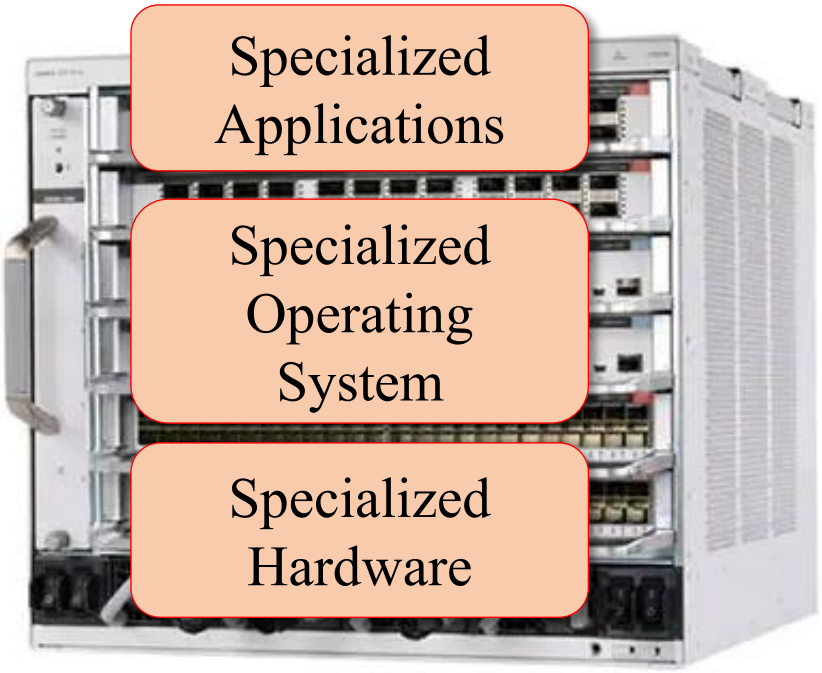
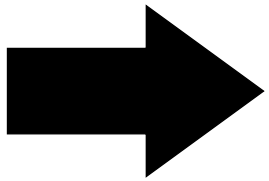
The Original SDN

Includes slides from courses taught by Mohammad Alizadeh (MIT), Jennifer Rexford (Princeton), Nick McKeown (Stanford), and Raj Jain (Washington).

Disaggregation





App

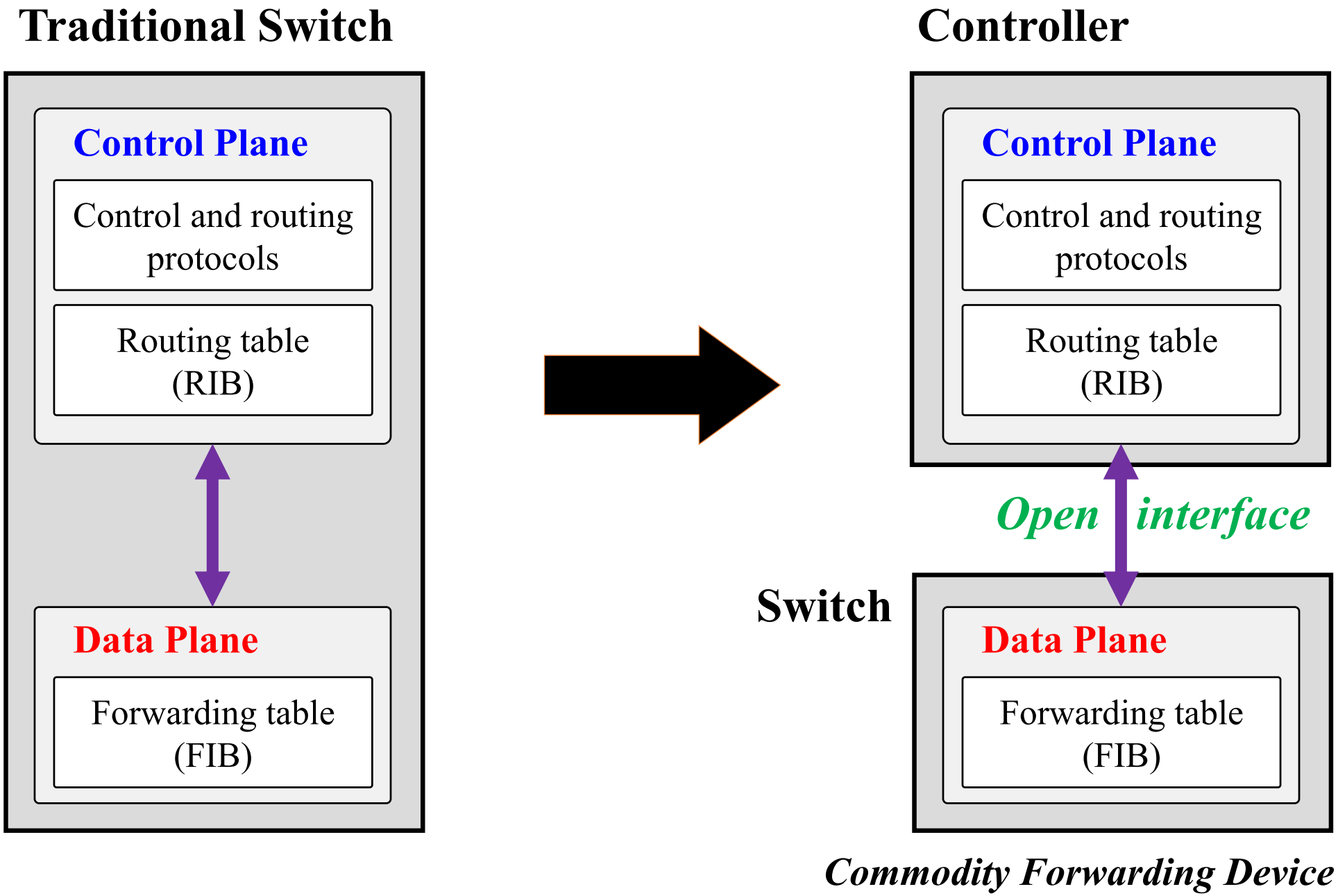
Open Interface

Network OS

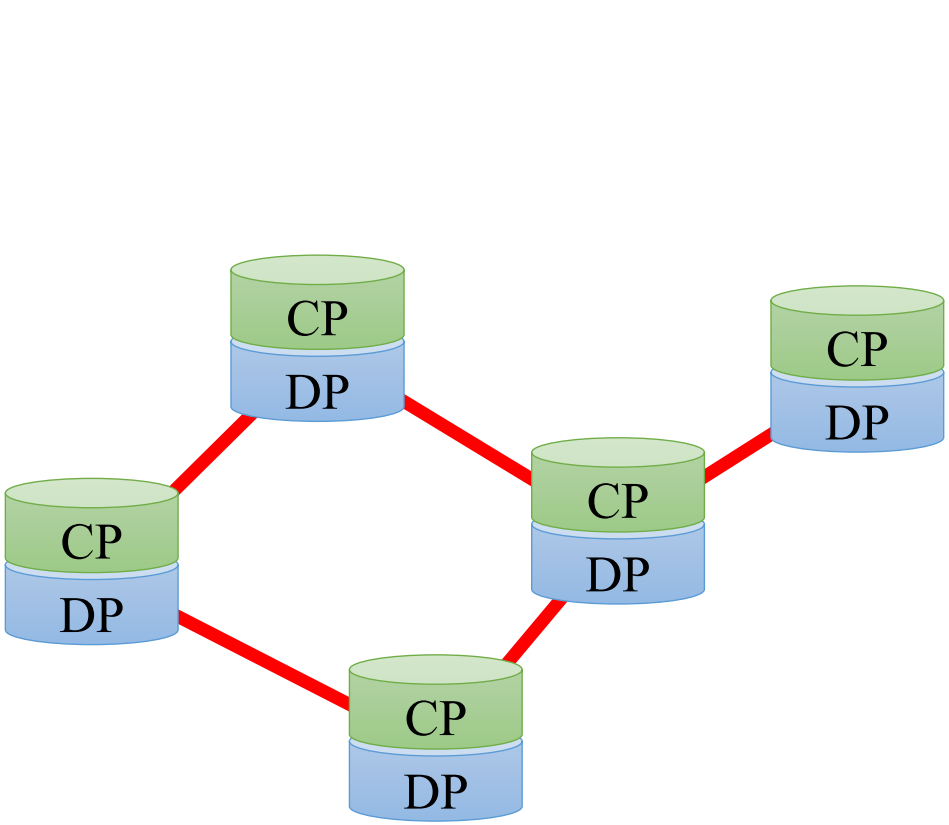
Open Interface

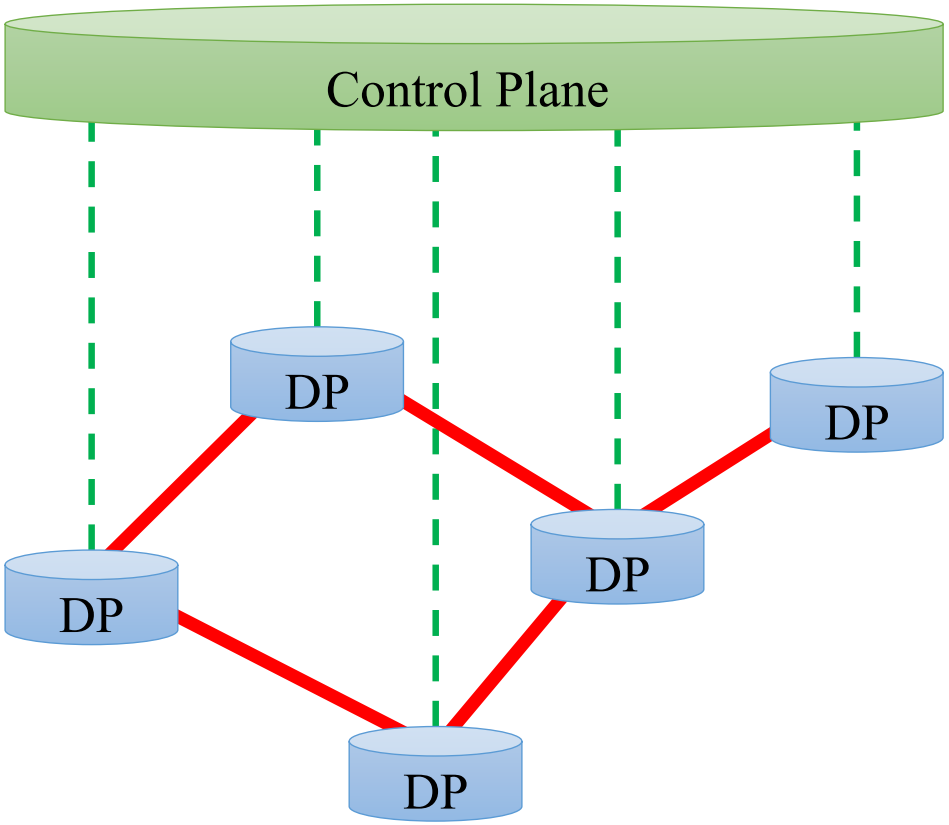
Switching chip

Disaggregation
(The functional viewpoint)



Disaggregation + Centralized Control

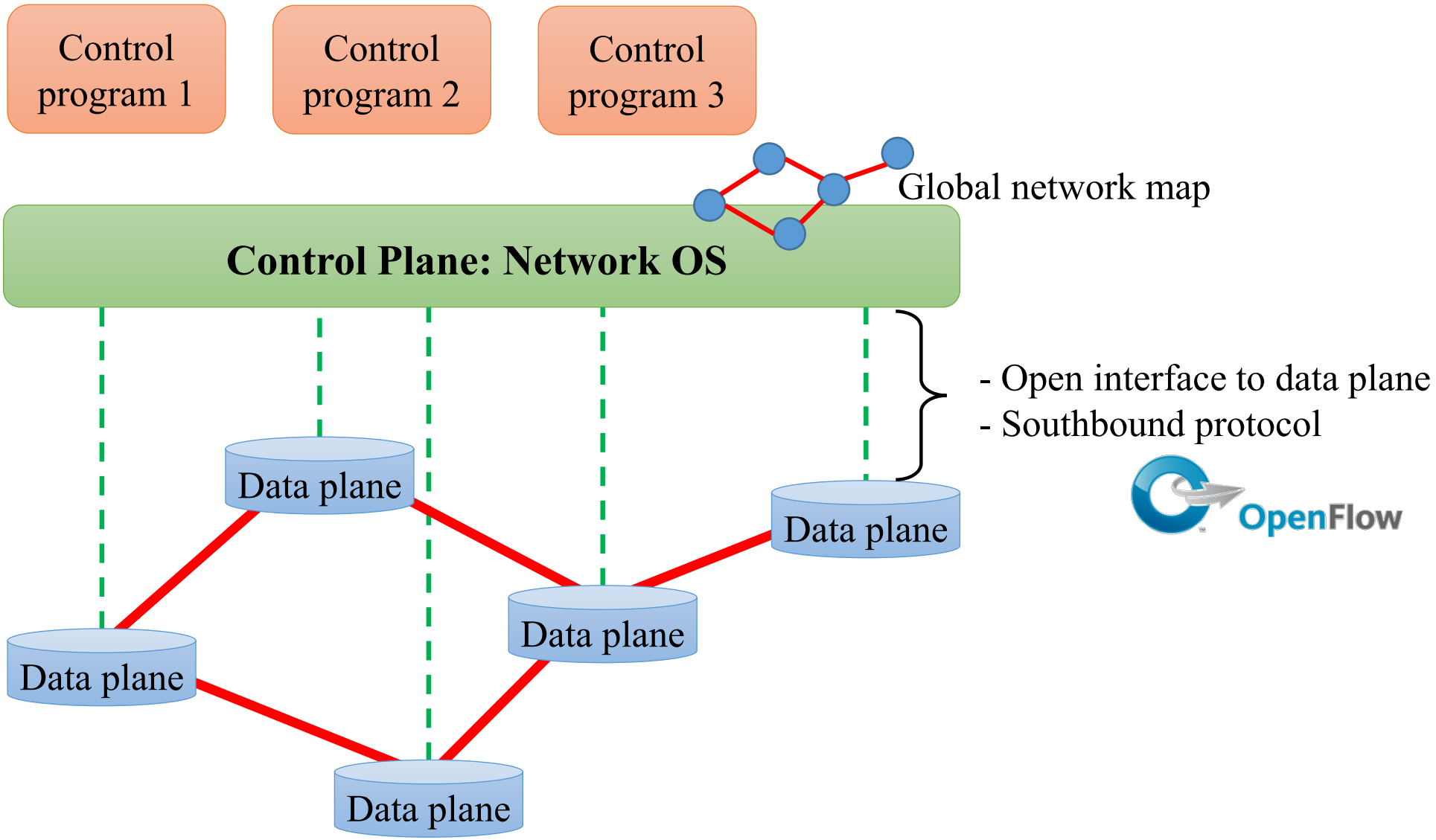




CP → Control Plane

DP → Data Plane

Software Defined Network



Open Networking Foundation (ONF)

- A non-profit consortium promoting networking through SDN
- Formed in 2011
- By 2020, ONF grew to over 200 member companies
- Standardizes SDN protocols and architectures
- Proposes SDN-based solutions for Cloud, Datacenters, 5G
- OpenFlow, P4, Conformance Test

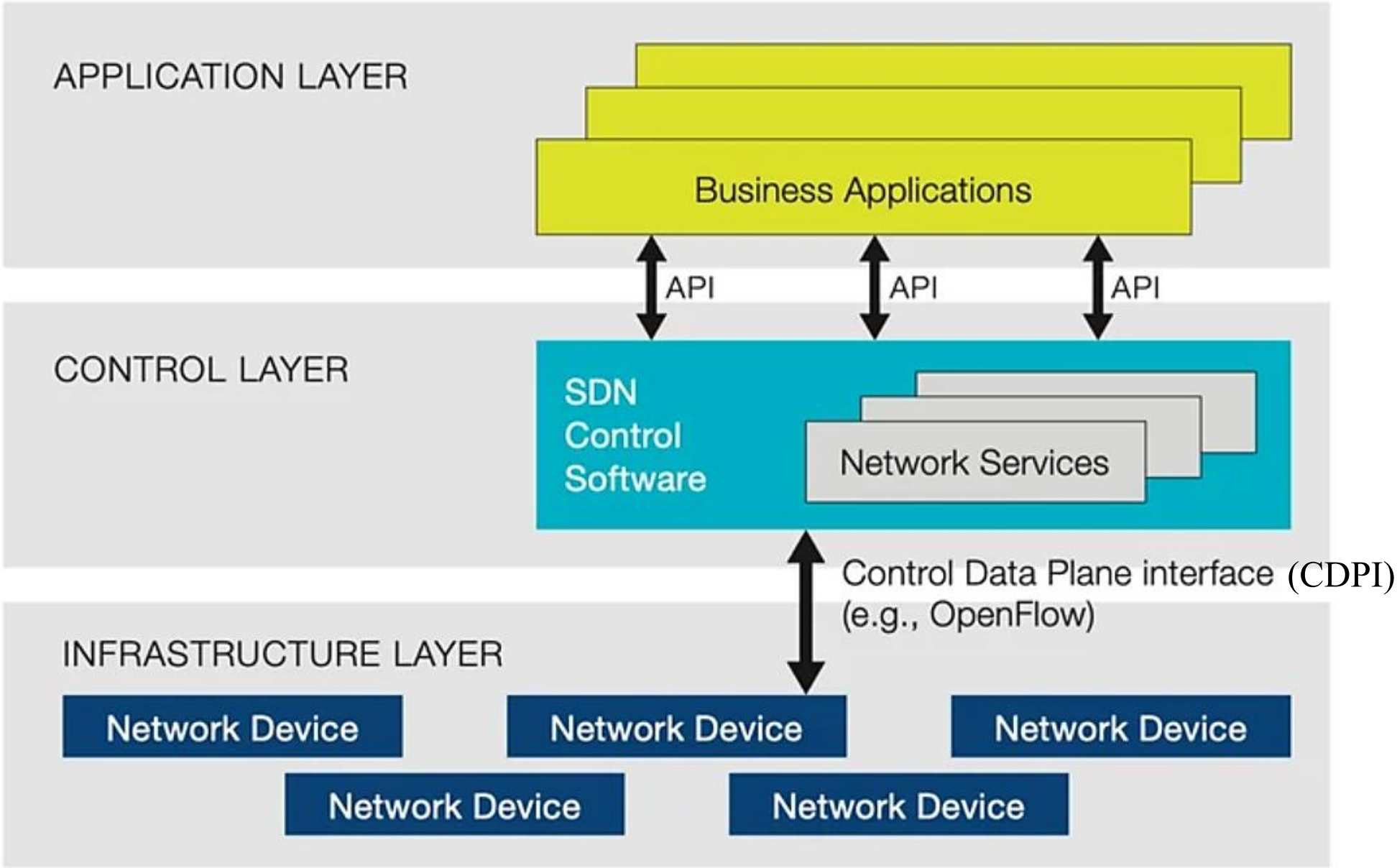
The original definition of SDN

A network in which the control plane is physically separate from the data plane.

and

A single (logically centralized) control plane controls several forwarding devices.

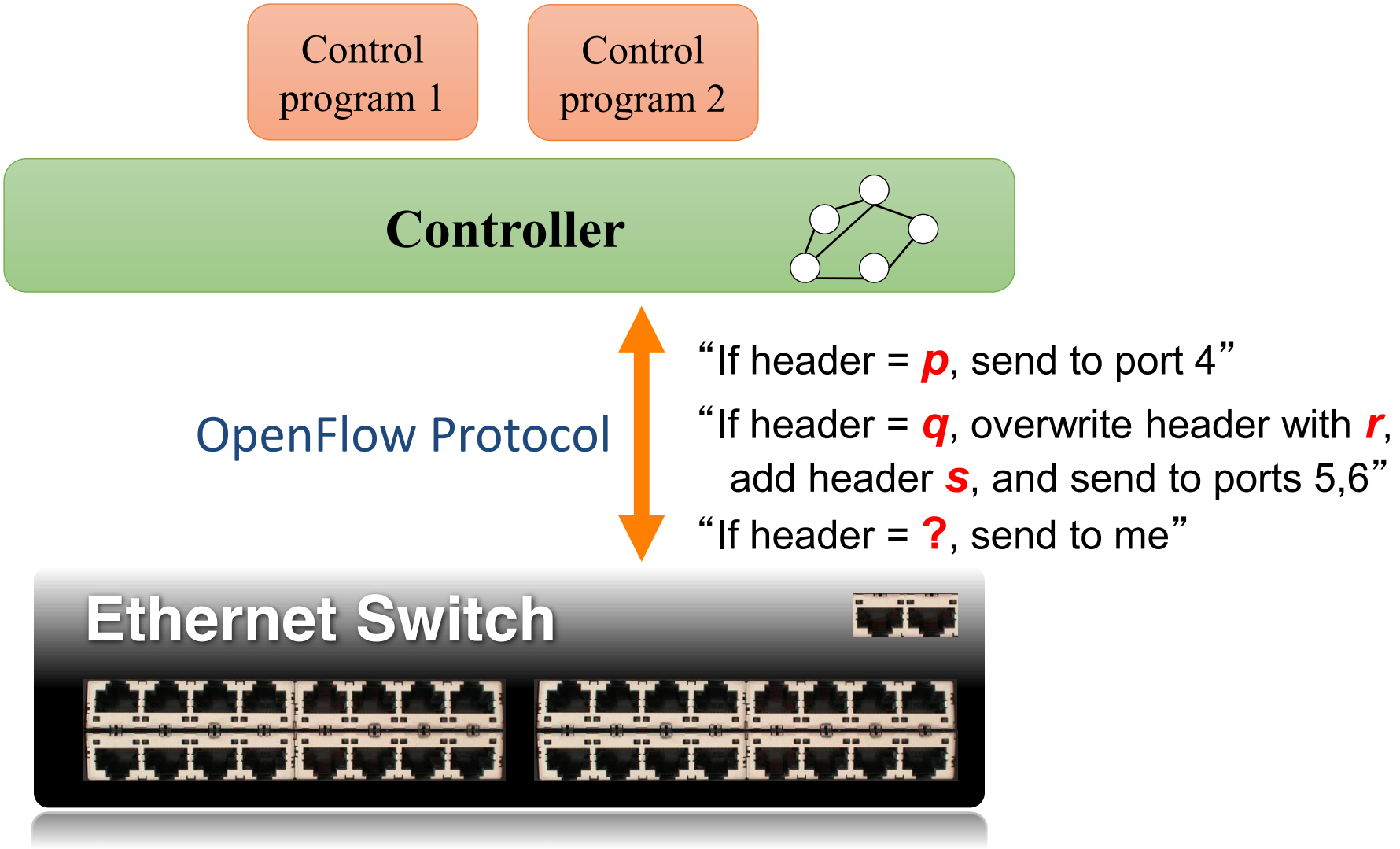
SDN architecture overview



Control to Data Plane Interface (Southbound protocol)

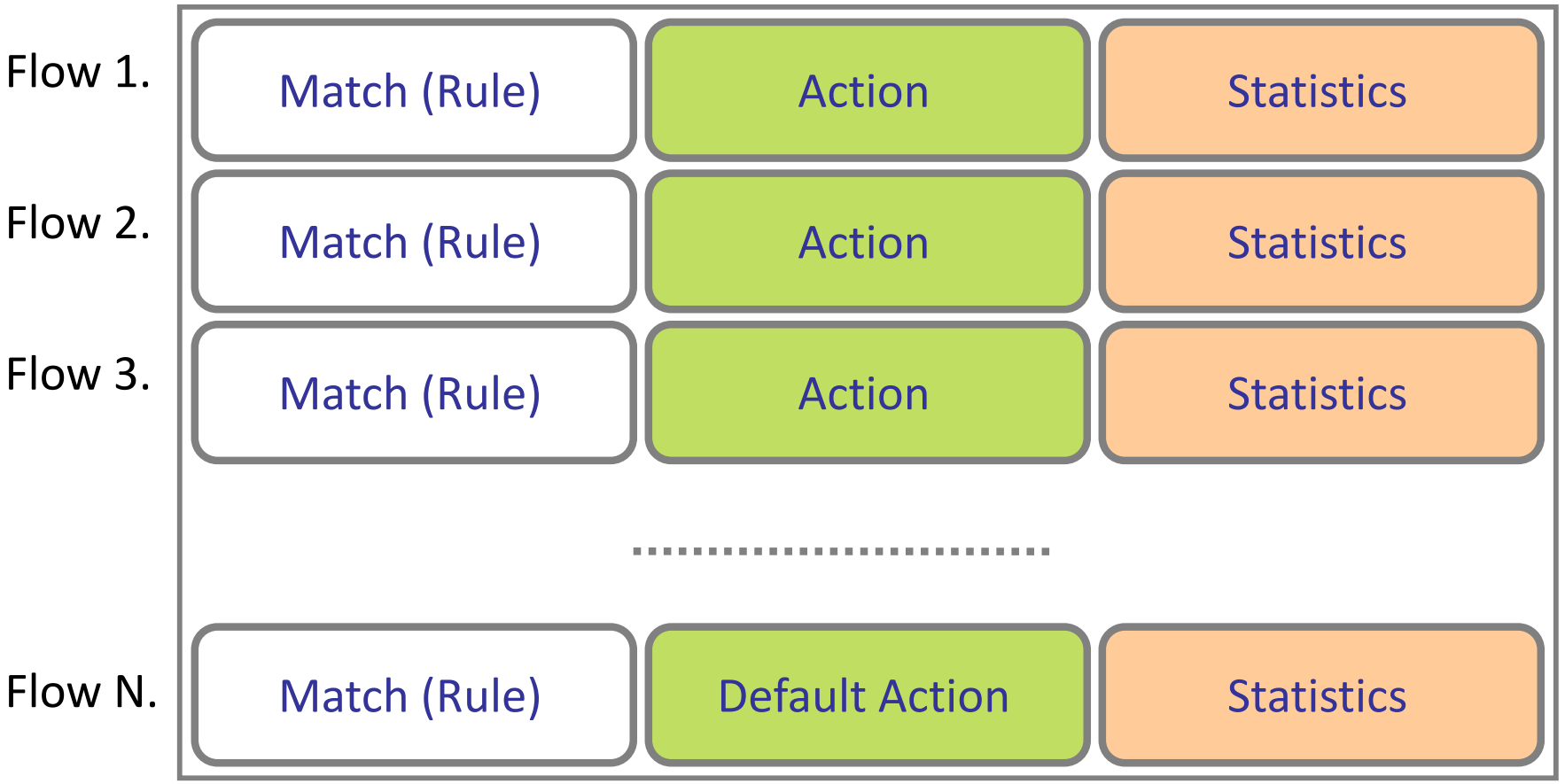
- Interface to forwarding plane
- To control, configure, and get status of devices
- The most famous one: OpenFlow
  - Open, vendor-agnostic
  - Last version: 1.5 (by ONF)
  - Based of adding/deleting flow table entries: if a packet matches a rule, then perform actions.
  - Easy to add to existing switches or new disaggregated switches
- Other southbound protocols: NETCONF, OVSDB, PCEP, SNMP.

OpenFlow Basics



OpenFlow Rules

Flow Table



Exploit the flow table in switches, routers, and chipsets

Infrastructure Layer (Data Plane)

- Forwarding devices that are controllable by an external controller
- Includes hardware and software (virtualized) switches
- Switch that implement and support OpenFlow: OpenFlow Switch
- Switch vendors very reluctant to support OpenFlow

Juniper MX-series

NEC IP8800

WiMax (NEC)

HP Procurve 5400

Cisco Catalyst 6k

PC Engines

Quanta LB4G

Control Plane

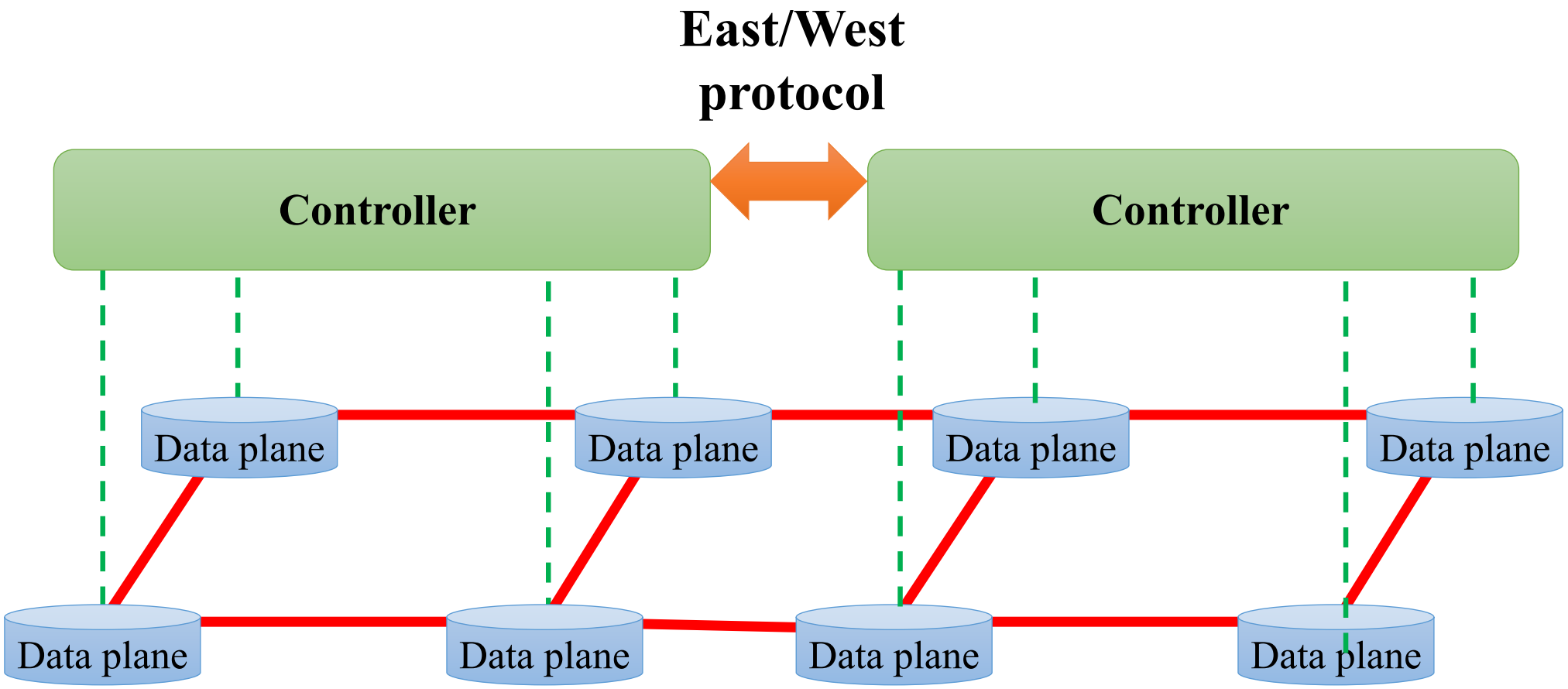
- Includes software controllers (NOS) running on servers
- Abstracts the infrastructure layer for applications
- Provides services to the application layer
  - Topology service
  - Inventory service
  - Statistics service
  - Host tracking
- Northbound API
- Famous controllers: *OpenDayLight, ONOS, RYU, FloodLight, POX*

Application Plane

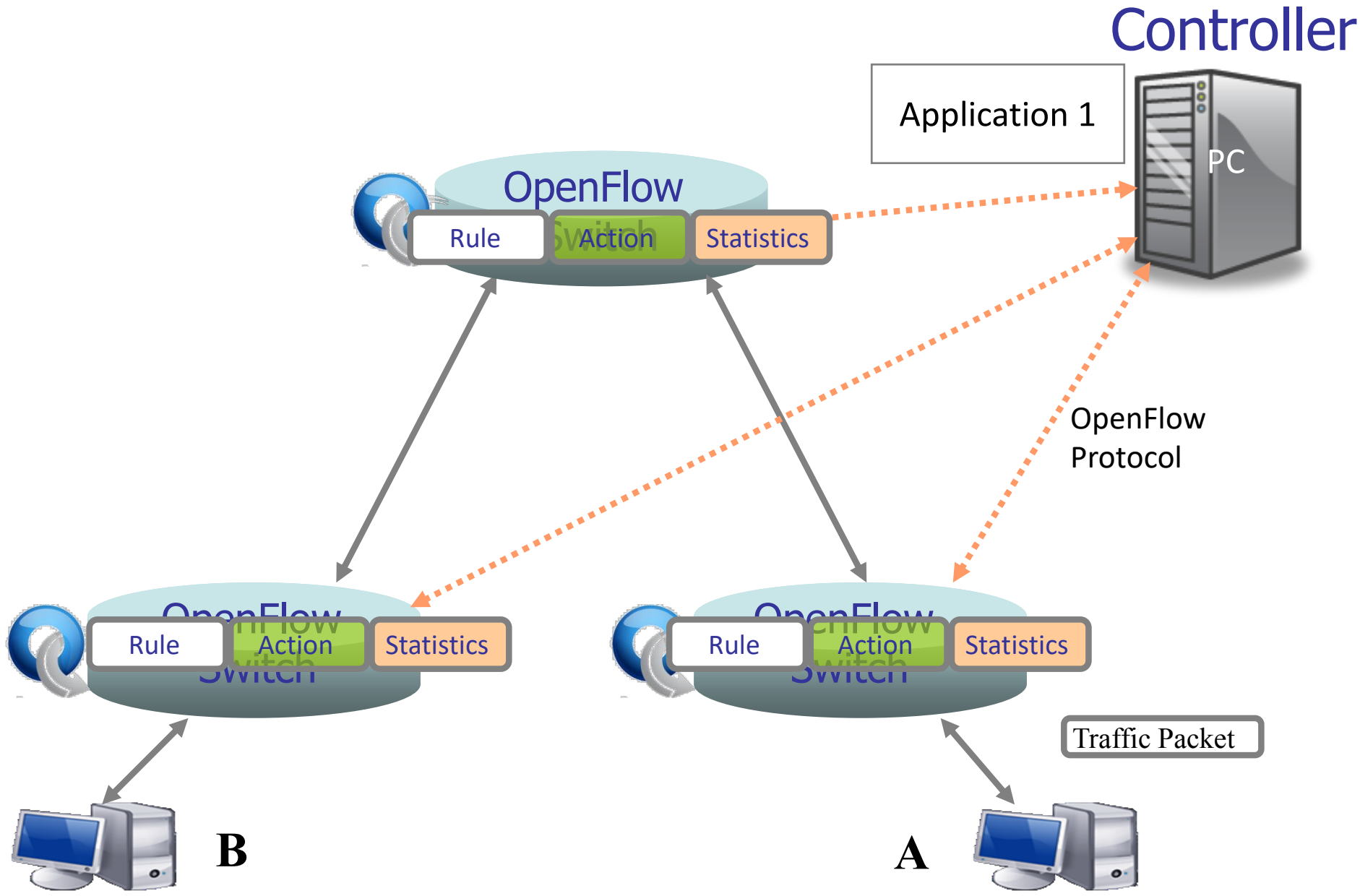
- Network features, services, protocols, applications

- Routing protocols
- Security services, Firewall
- Dynamic access control
- Load balancer
- Network virtualization
- Energy-efficient networking

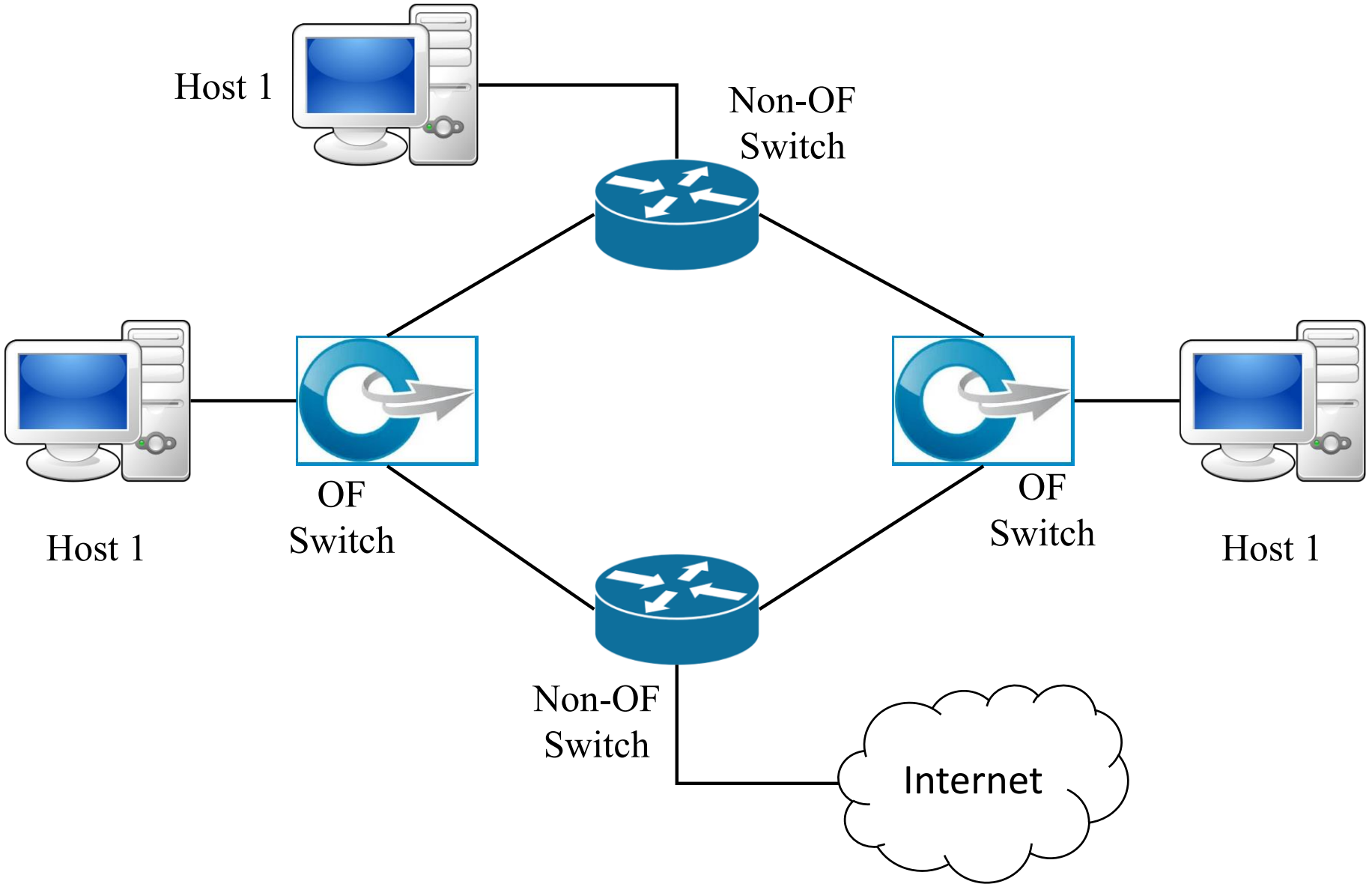
Distributed Control



OpenFlow usage example



Can we have both OF and Non-OF switches in a network?



SDN Concerns

- Single point of failure
- Scalability (The controller bottleneck)
- Security
- Delay
- Coexisting