High-speed Networks, Cybersecurity, and Software-defined Networking Workshop

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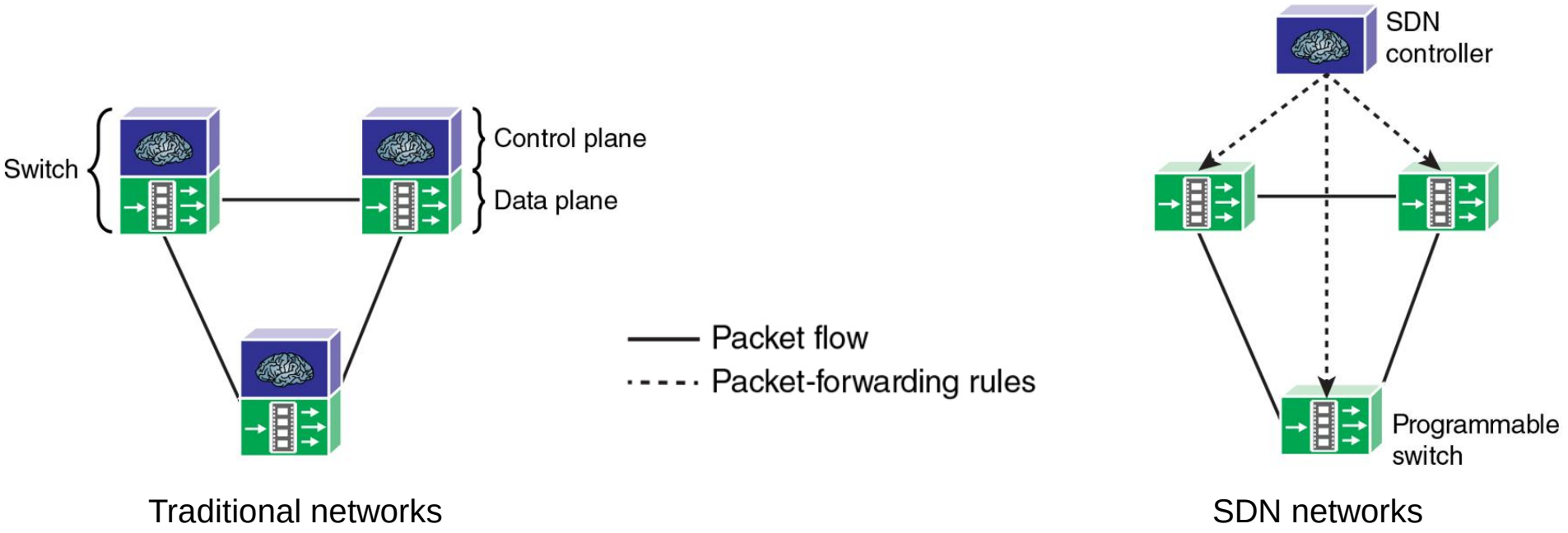
Lab 4: SDN Concepts, Controllers, Flow Tables

Plane Separation

- The first fundamental characteristic of SDN is the separation of planes
  - Data plane, implemented in the device
  - Control plane, implemented by a centralized controller



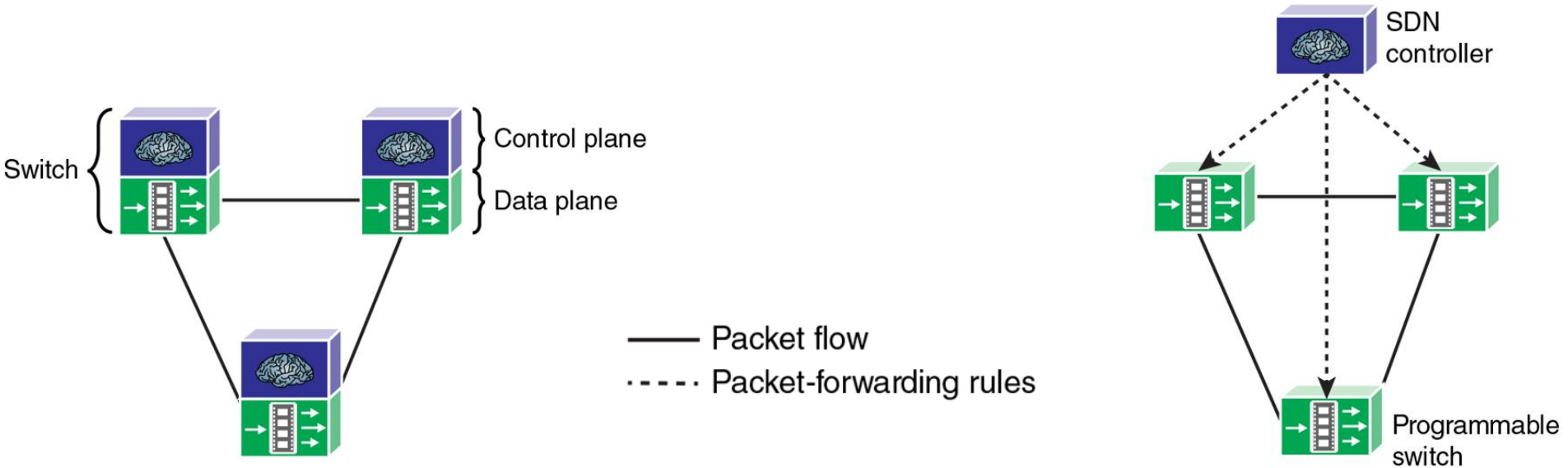
Traditional networks

SDN networks

W. Stallings, “Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud” Addison Wesley, 2017.

Plane Separation – Data Plane

- The data plane implements forwarding functionality (logic and tables for choosing how to deal with incoming packets)
  - Forwarding based on MAC address, IP address, VLAN ID, etc.
- The data plane may forward, drop, consume, transform, replicate an incoming packet



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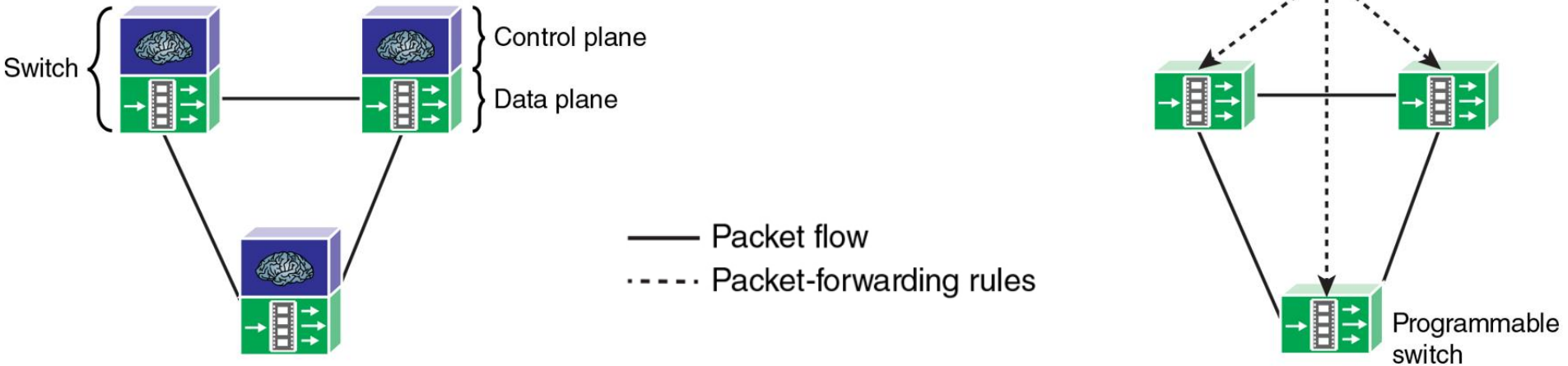
Plane Separation – Data Plane

- It determines the correct output port by performing a lookup in the address table in the ASIC (very high-speed hardware, operating at terabits per second)
- Special-case packets (e.g., routing advertisements) that require processing by the control plane are passed to that plane



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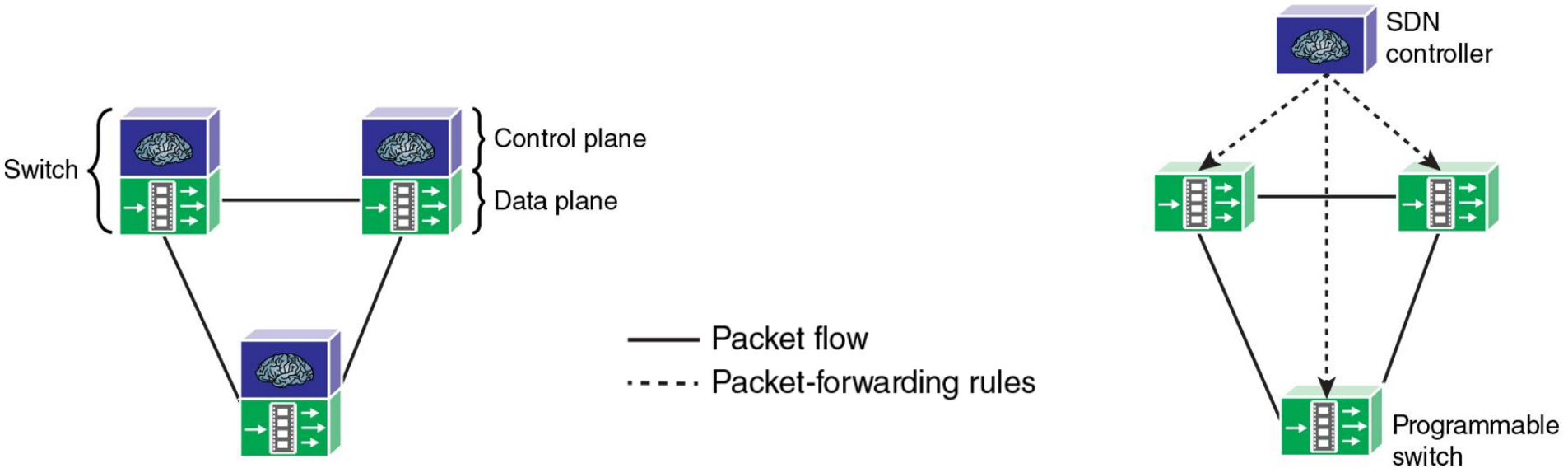
Plane Separation – Control Plane

- The algorithms used to program the data plane reside in the control plane
- Many protocols / algorithms require global knowledge (for example, OSPF, BGP)
- The control plane is moved off of the switching device, onto a centralized controller



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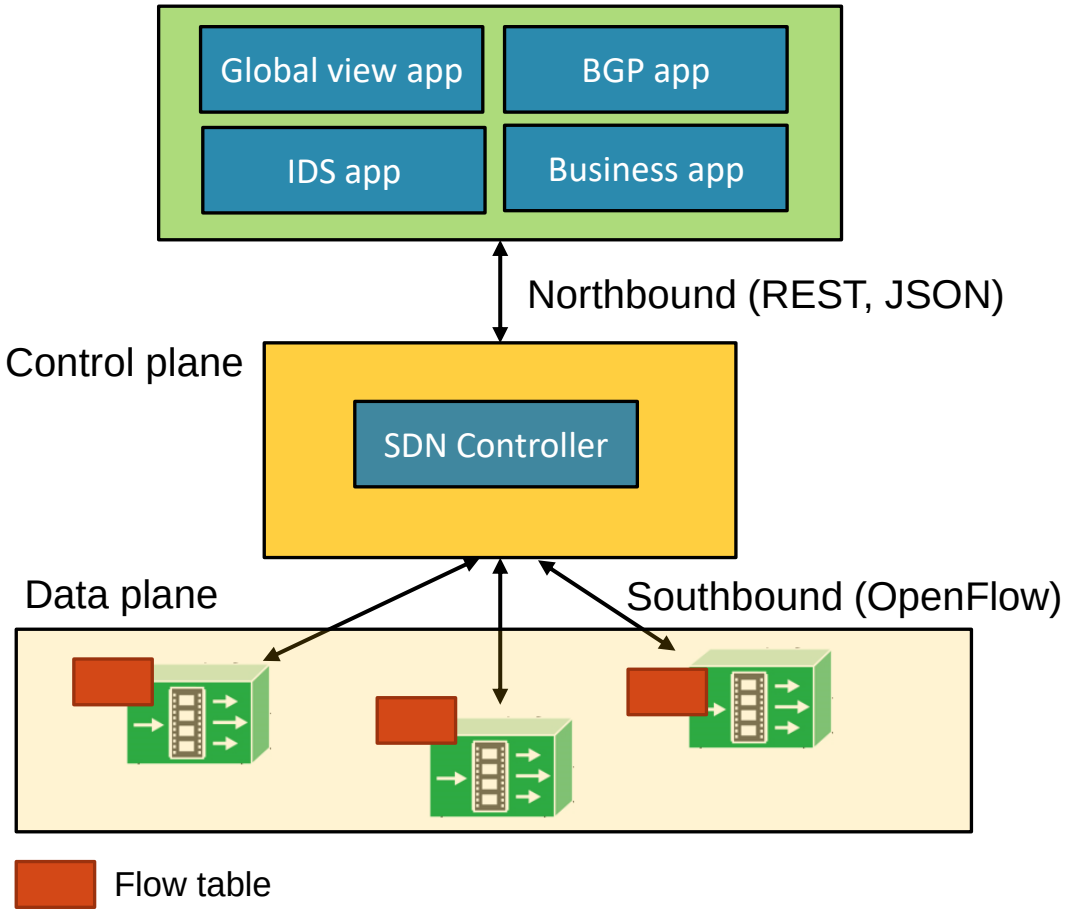
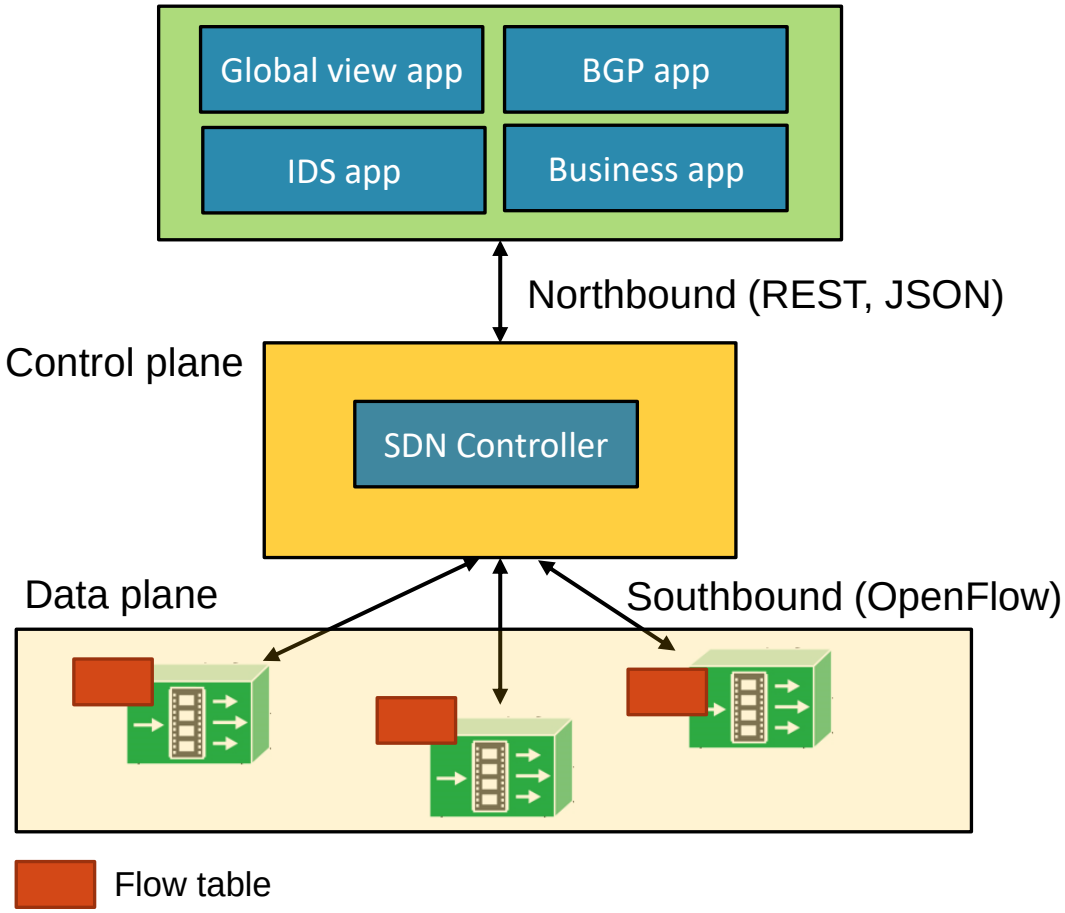
SDN Operation

- Basic components
  - SDN switches
  - Controller
  - Applications



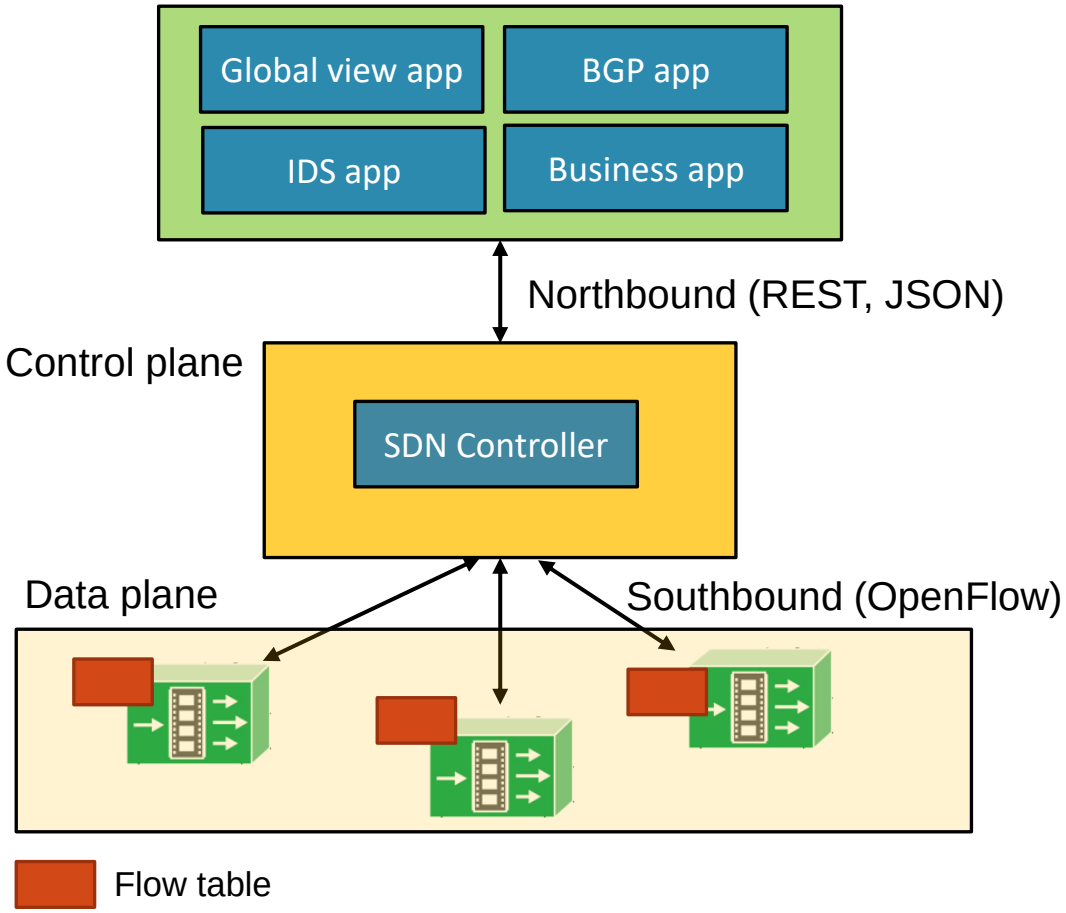
SDN Operation – Switches

- SDN devices contain forwarding functionality
- Forwarding information is stored in a flow table
- The flow table resides on the network device and consists of a series of flow entries and actions to perform when a packet matches an entry
- If the SDN device finds a match, it takes the appropriate configured action (e.g. forward)
- If it does not find a match, it can either drop the packet or pass it to the controller



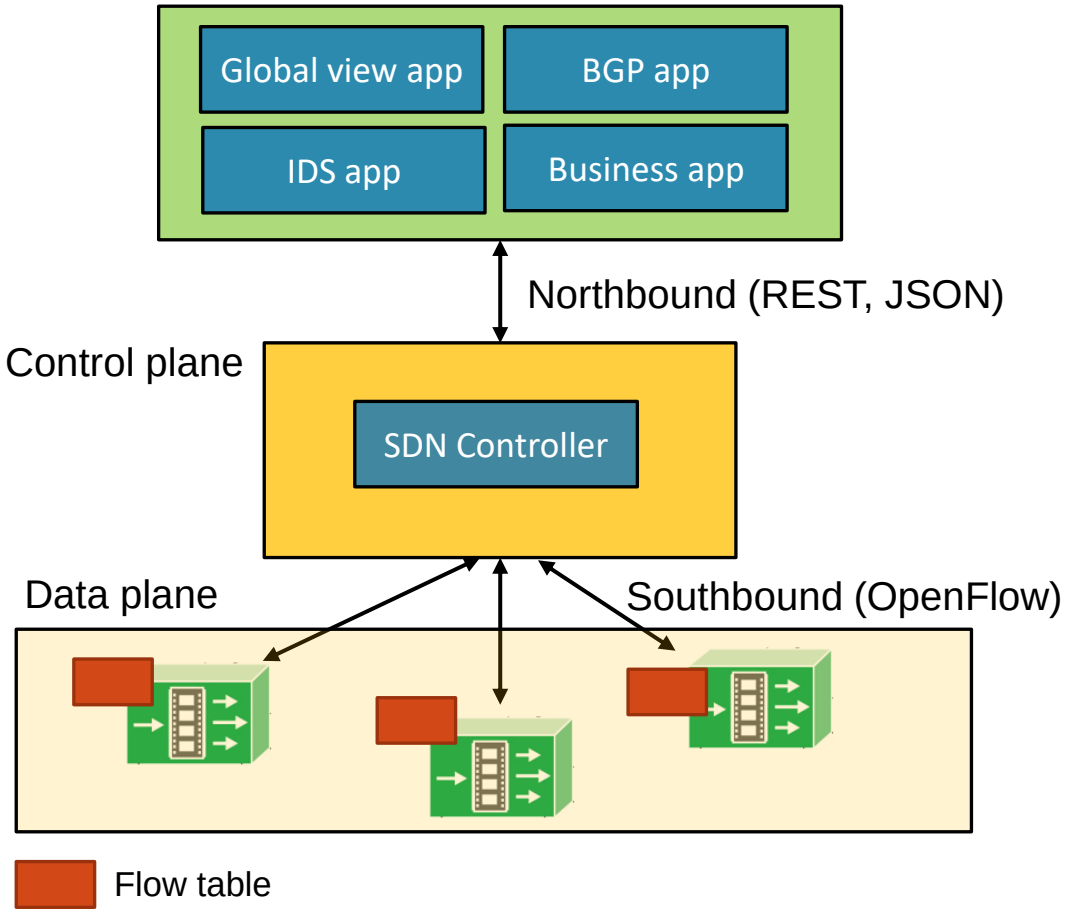
SDN Operation – Controller

- It implements control plane functionality
- It presents an abstraction of the network to the SDN applications running above
- The controller allows the SDN application to define flows on devices and to help the application to respond to packets which are forwarded to the controller by devices
- It maintains a view of the entire network (global network view)



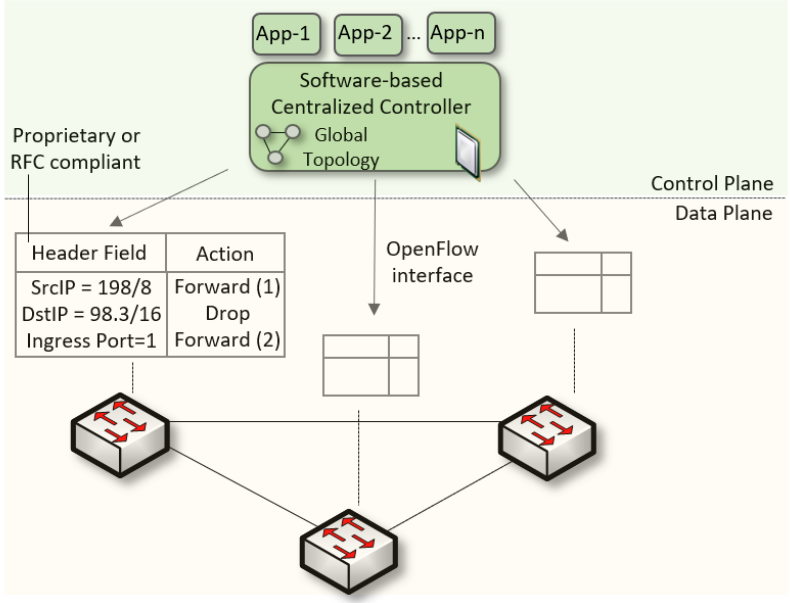
SDN Operation – Applications

- SDN applications are built on top of the controller
- Software applications can implement forwarding, routing, overlay, multipath, access control, etc.
- The application is driven by events coming from the controller and from external inputs
- External inputs could include network monitoring systems, Netflow, IDS, or BGP peers



Flow Tables

- Flow tables are the fundamental data structures in an SDN device
- They allow the device to evaluate incoming packets and take the appropriate action
- Flow tables consist of entries, each of which has match fields and actions
- OpenFlow explicitly specifies protocol headers on which it operates / matches

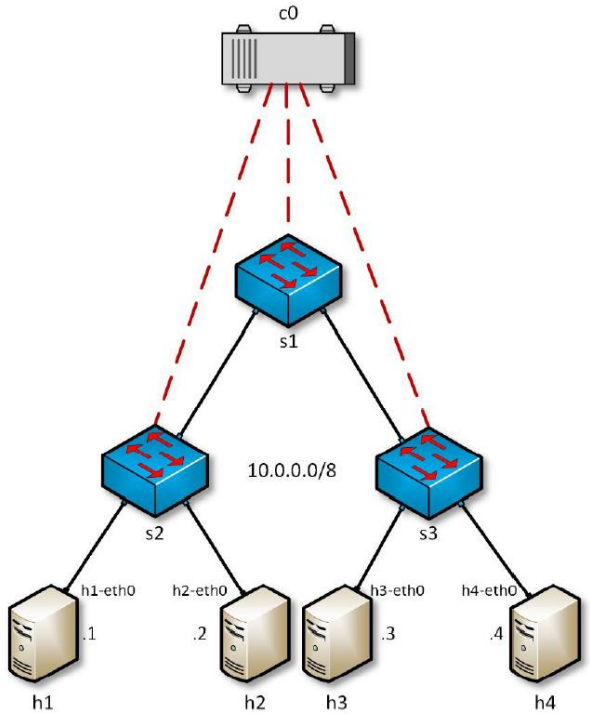


Version	Date	Header fields
OpenFlow 1.0	Dec. 2009	12 (Ethernet, TCP, IPv4)
OpenFlow 1.1	Feb. 2011	15 (MPLS, …)
OpenFlow 1.2	Dec. 2011	36 (ARP, ICMP, IPv6, …)
OpenFlow 1.3	Jun. 2012	40
OpenFlow 1.4	Oct. 2013	41
OpenFlow 1.5	Mar. 2015	44

Bossart et al. “P4: Programming Protocol-Independent Packet Processors”
OpenFlow Switch Specs v1.5.1. Online https://tinyurl.com/y4j4a5eh

Lab 4: Introduction to SDN

- This lab is an introduction to SDN
- It permits students to run an SDN network composed of
  - The Open Network Operating System (ONOS) controller, an open source SDN controller
  - Open Virtual Switch (OVS) devices; OVS is an open source SDN switch
- Activities include
  - Run ONOS controller
  - Run simple SDN applications
  - Inspect flow tables



SDN network