Hands-on Workshop on
Open vSwitch and Software-defined Networking

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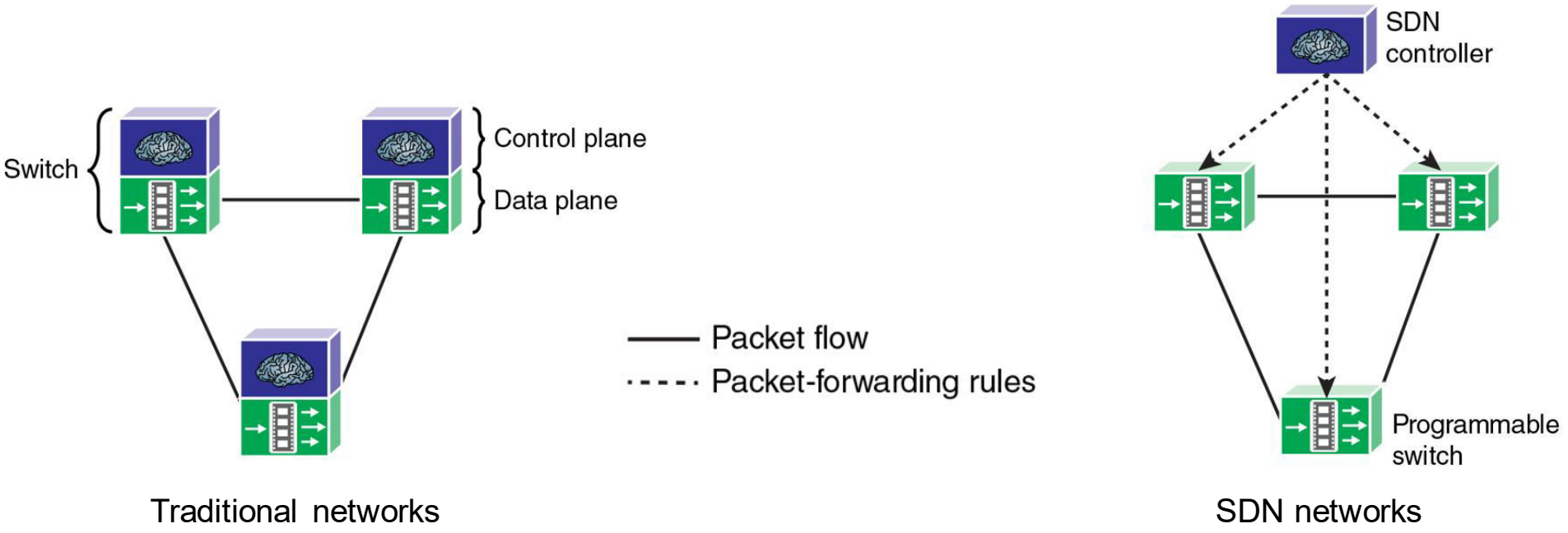
SDN Concepts, Controllers, Flow Tables

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



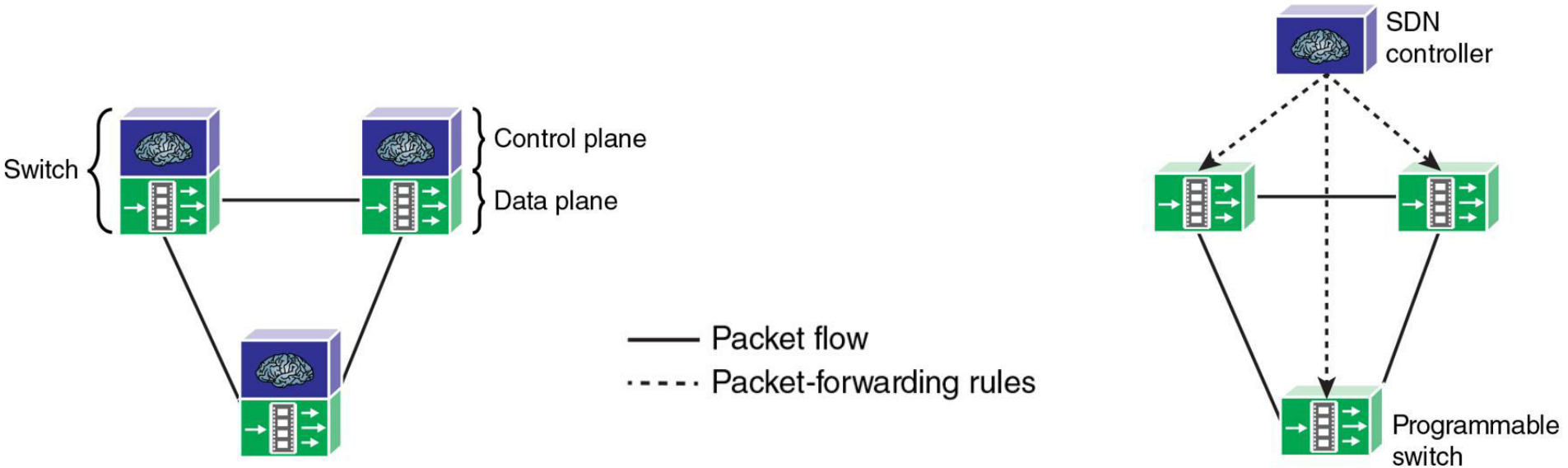
Traditional networks

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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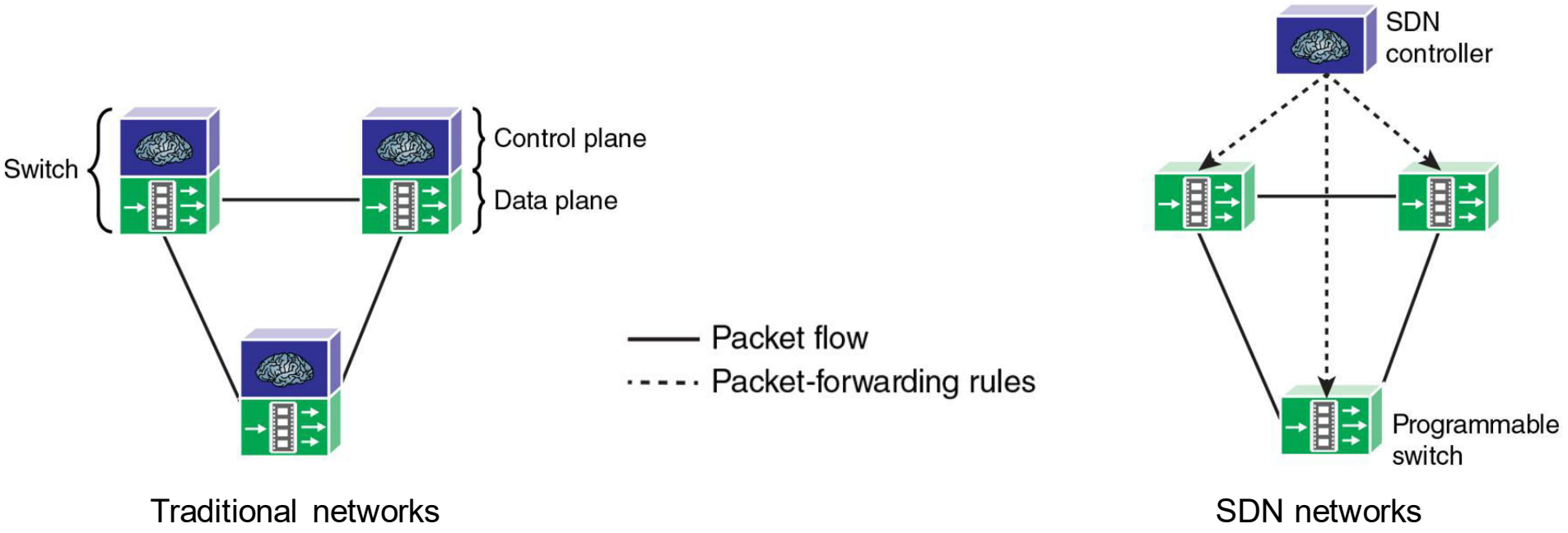
Plane Separation – Data Plane

- 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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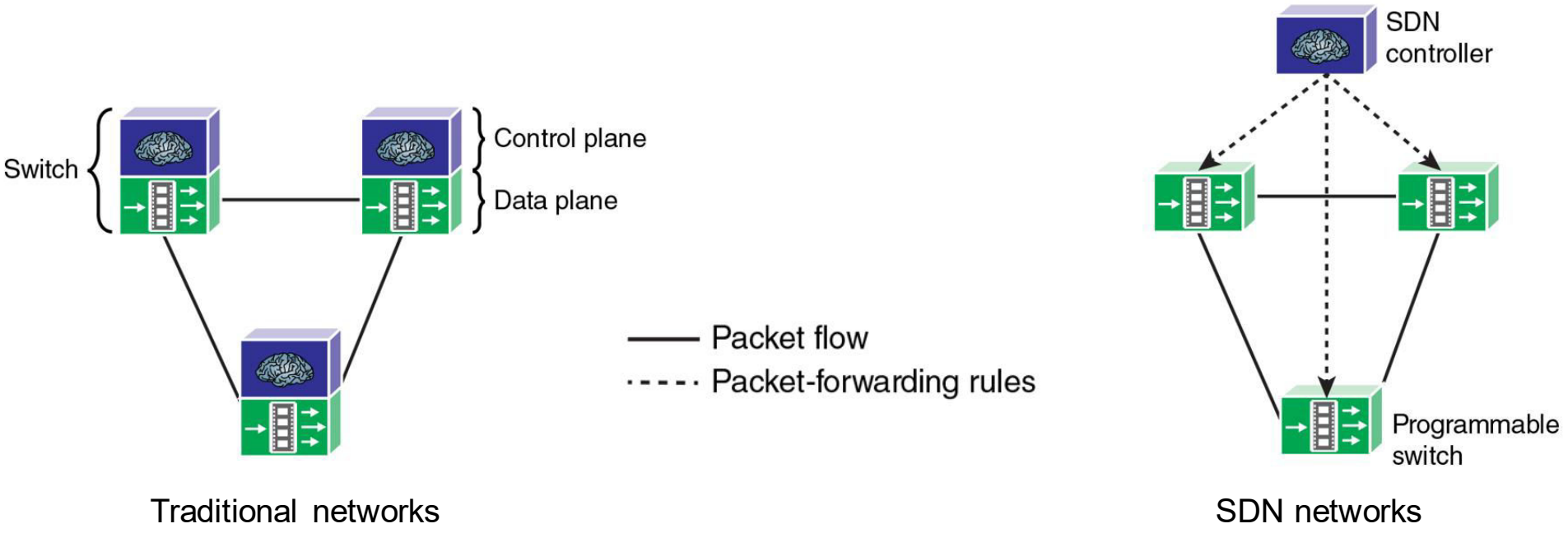
Plane Separation – Control Plane

- 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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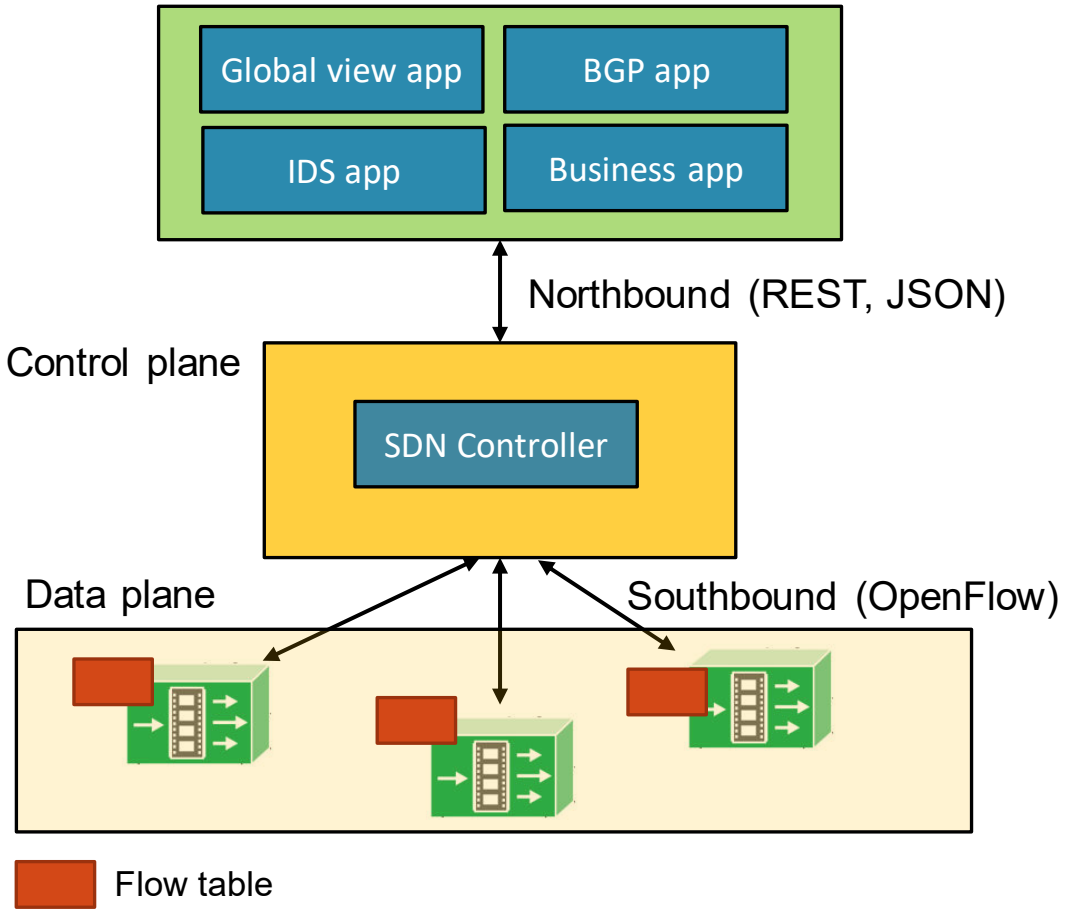
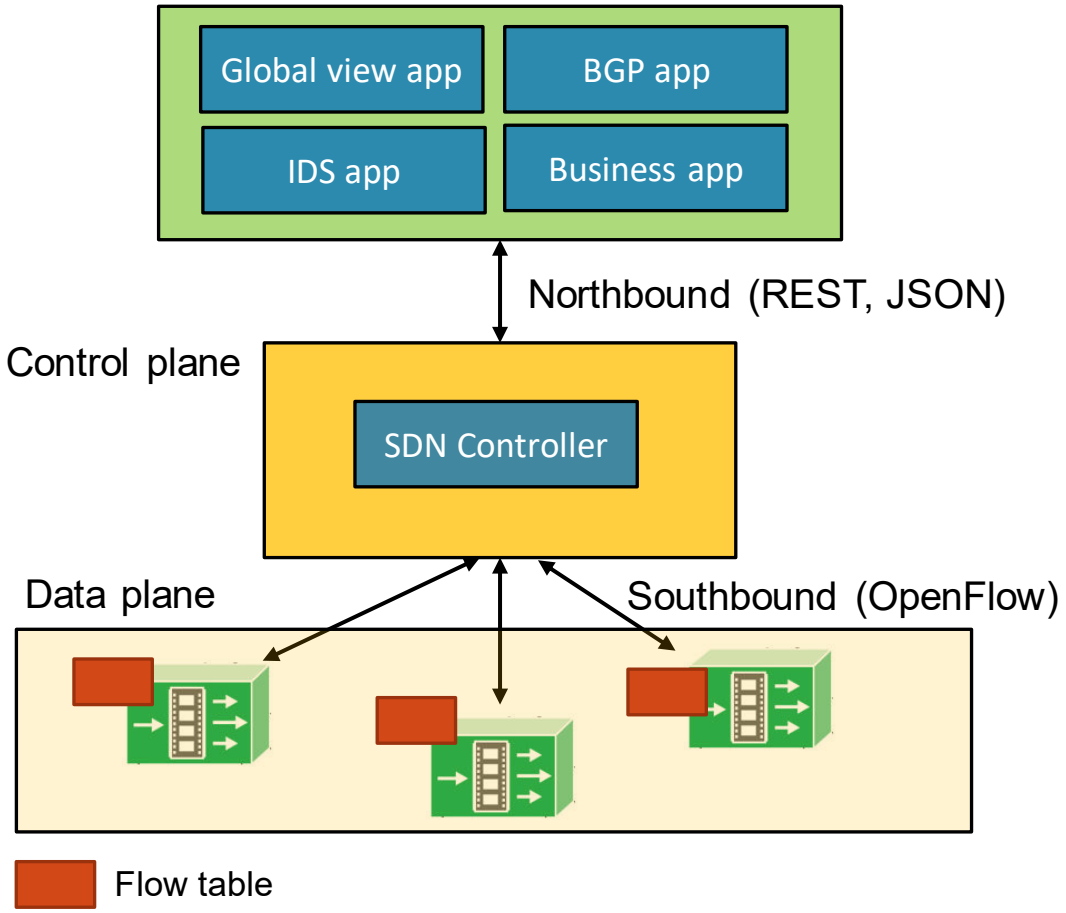
SDN Operation

- Basic components (bottom-up)
  - SDN switches (e.g. Open vswitches)
  - Controller (e.g., ONOS controller)
  - Applications (e.g., OpenFlow, forwarding)



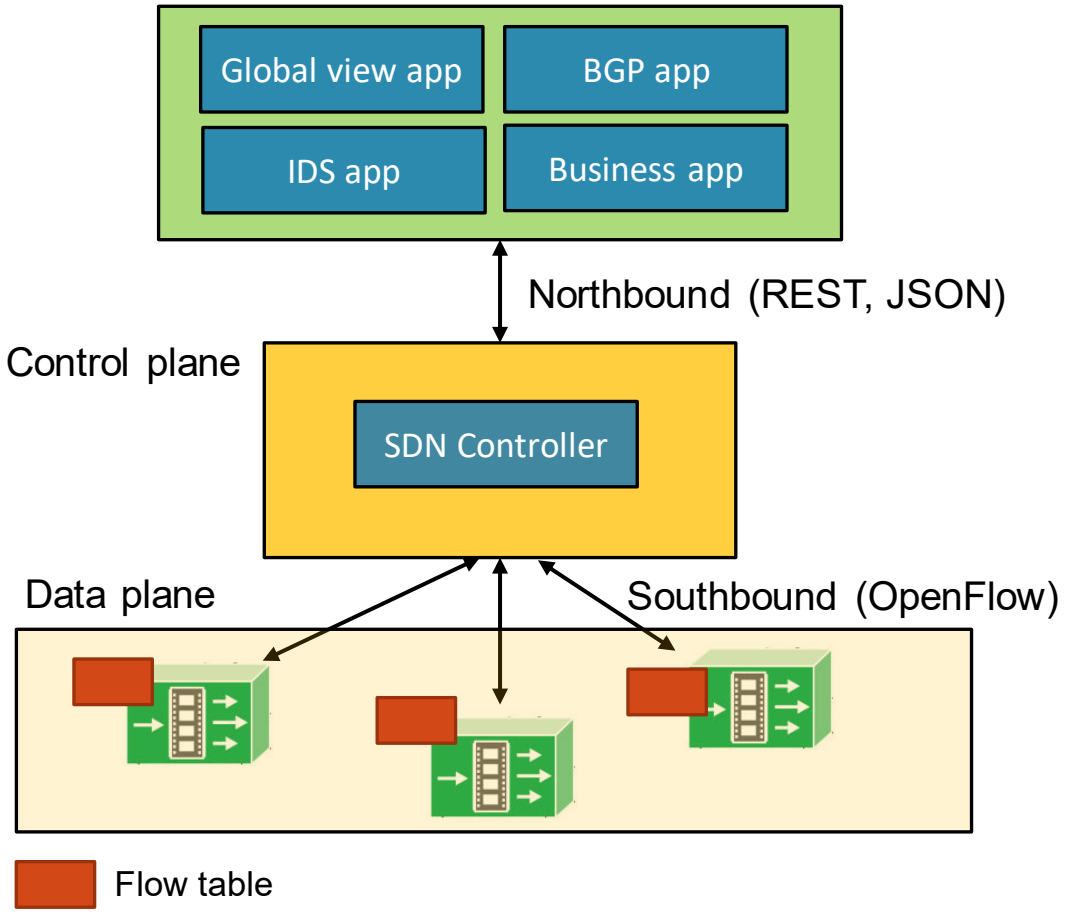
SDN Operation – Switches

- SDN devices contain forwarding functionality
- Forwarding information is stored in flow tables
- The flow tables reside on the network device and consist 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



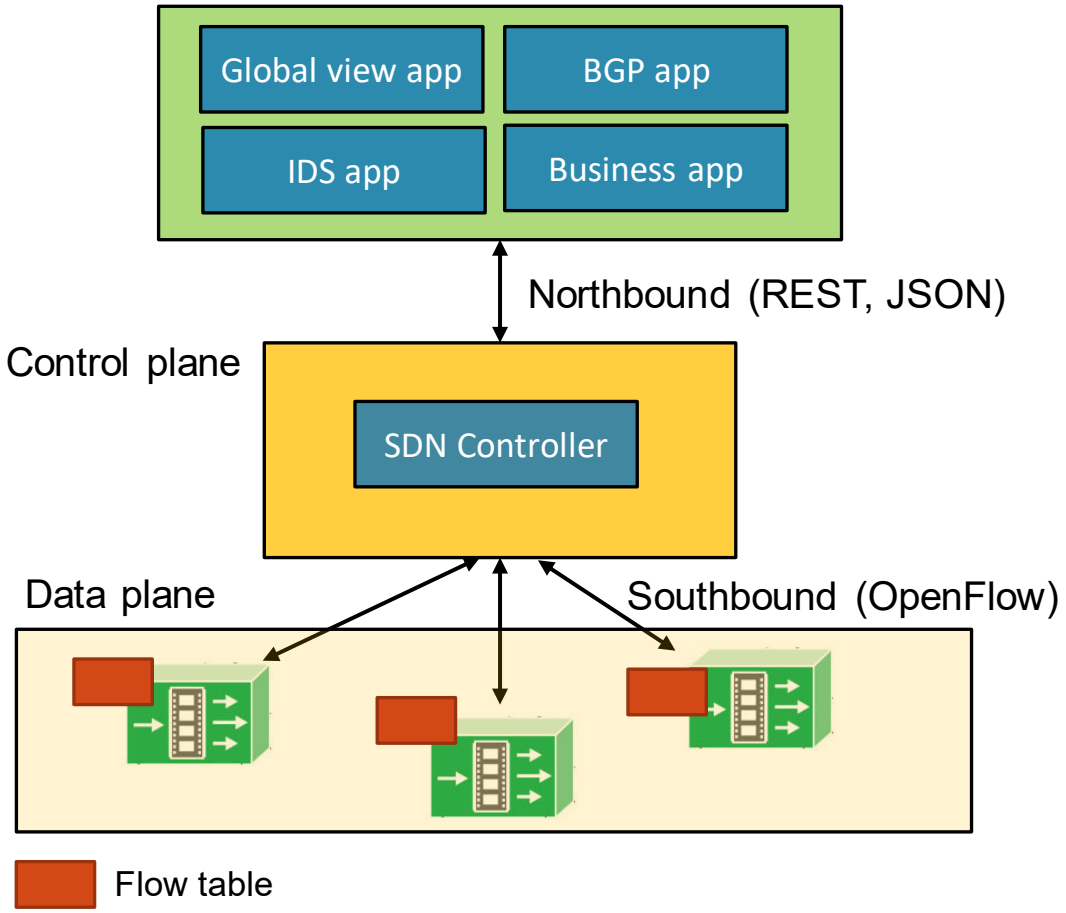
SDN Operation – Controller

- SDN controller implements control plane functionality
- It presents an abstraction of the network to the SDN applications running above
- It 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)



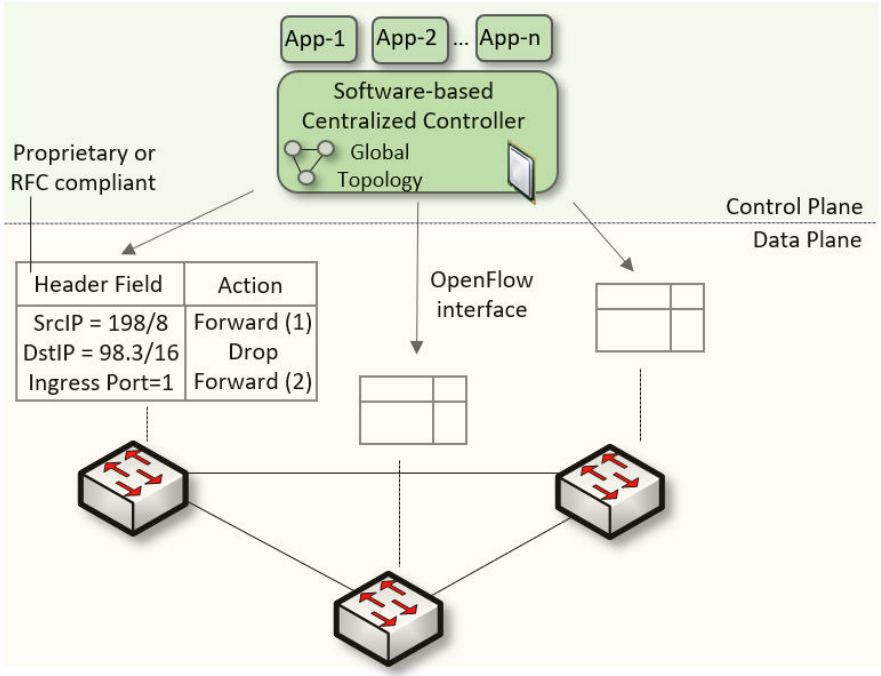
SDN Operation – Applications

- 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



Lab 4: Introduction to SDN

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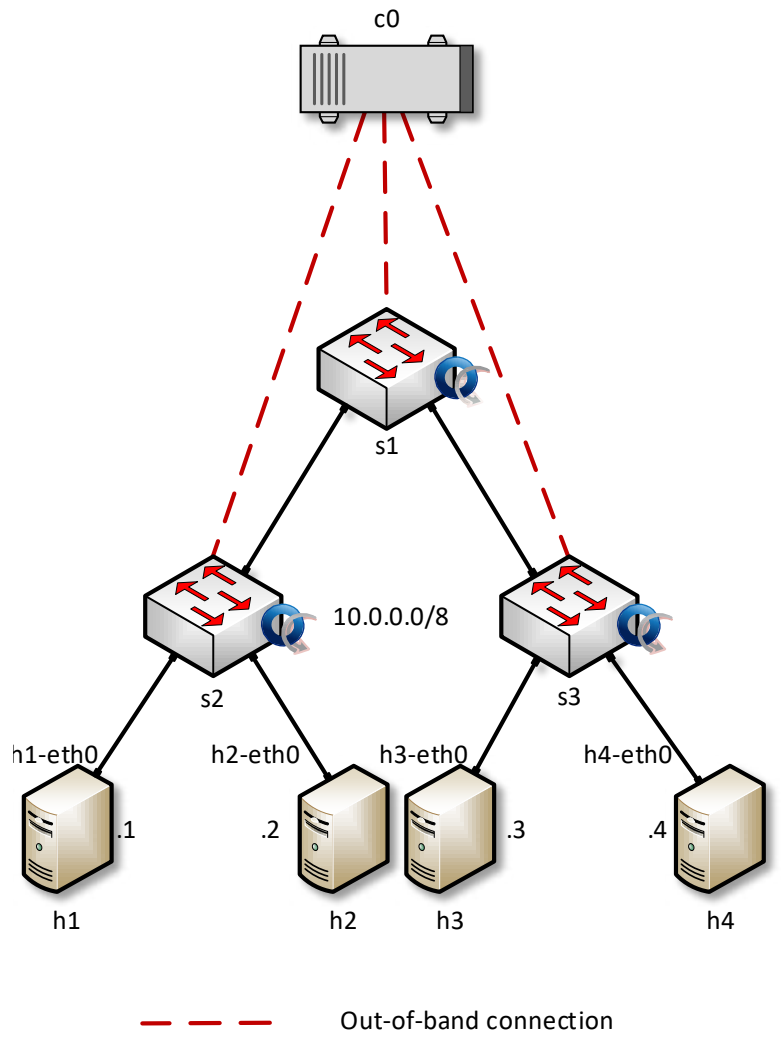
- The topology consists of:
  - The Open Network Operating System (ONOS) controller, an open source SDN controller
  - Open Virtual Switch (OVS) devices; OVS is an open source SDN switch
- Activities include
  - Run ONOS controller
  - Run simple SDN applications
  - Inspect flow tables
  - Interact with ONOS Graphical User Interface (GUI)



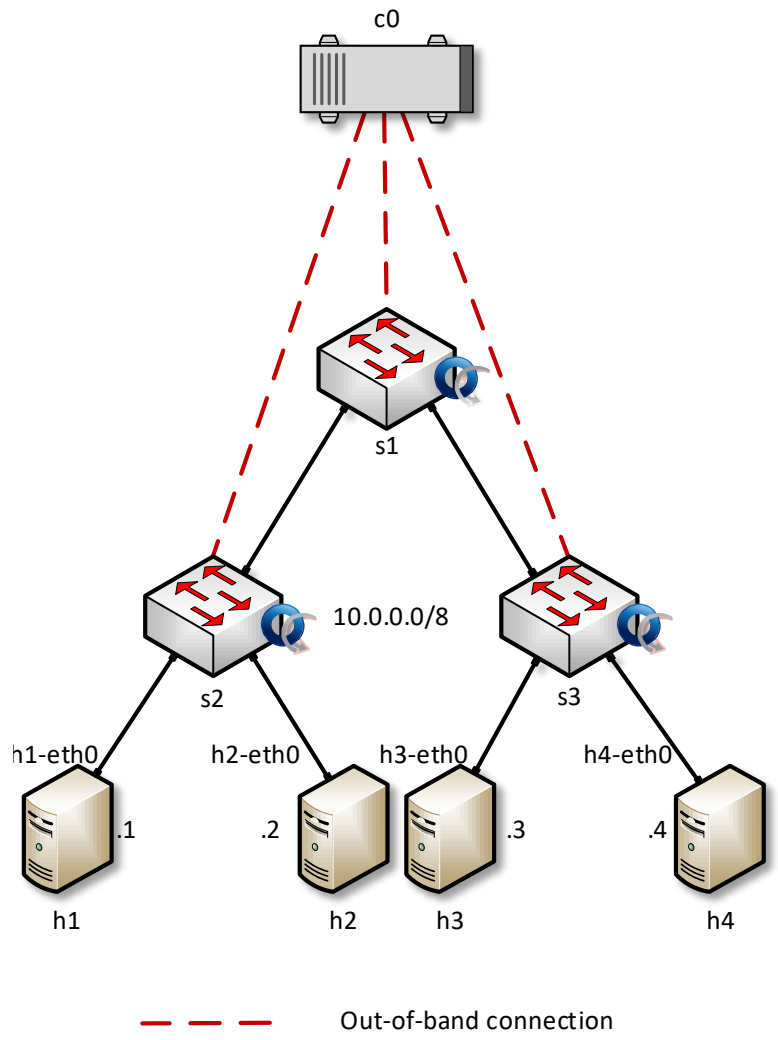
Activating the OpenFlow Application

Devices

```
sdn@admin: ~/SDN_Labs/lab4
File  Actions  Edit  View  Help
sdn@admin: ~/SDN_Labs/lab4
sdn@root > devices                                                    16:35:23
id=of:0000000000000001, available=true, local-status=connected 3m28s ago, role=MASTER,
 type=SWITCH, mfr=Nicira, Inc., hw=Open vSwitch, sw=2.12.0, serial=None, chassis=1, dr
iver=ovs, channelId=127.0.0.1:45148, managementAddress=127.0.0.1, protocol=OF_10
id=of:0000000000000002, available=true, local-status=connected 3m28s ago, role=MASTER,
 type=SWITCH, mfr=Nicira, Inc., hw=Open vSwitch, sw=2.12.0, serial=None, chassis=2, dr
iver=ovs, channelId=127.0.0.1:45152, managementAddress=127.0.0.1, protocol=OF_10
id=of:0000000000000003, available=true, local-status=connected 3m28s ago, role=MASTER,
 type=SWITCH, mfr=Nicira, Inc., hw=Open vSwitch, sw=2.12.0, serial=None, chassis=3, dr
iver=ovs, channelId=127.0.0.1:45150, managementAddress=127.0.0.1, protocol=OF_10
sdn@root >                                                            16:35:35
```

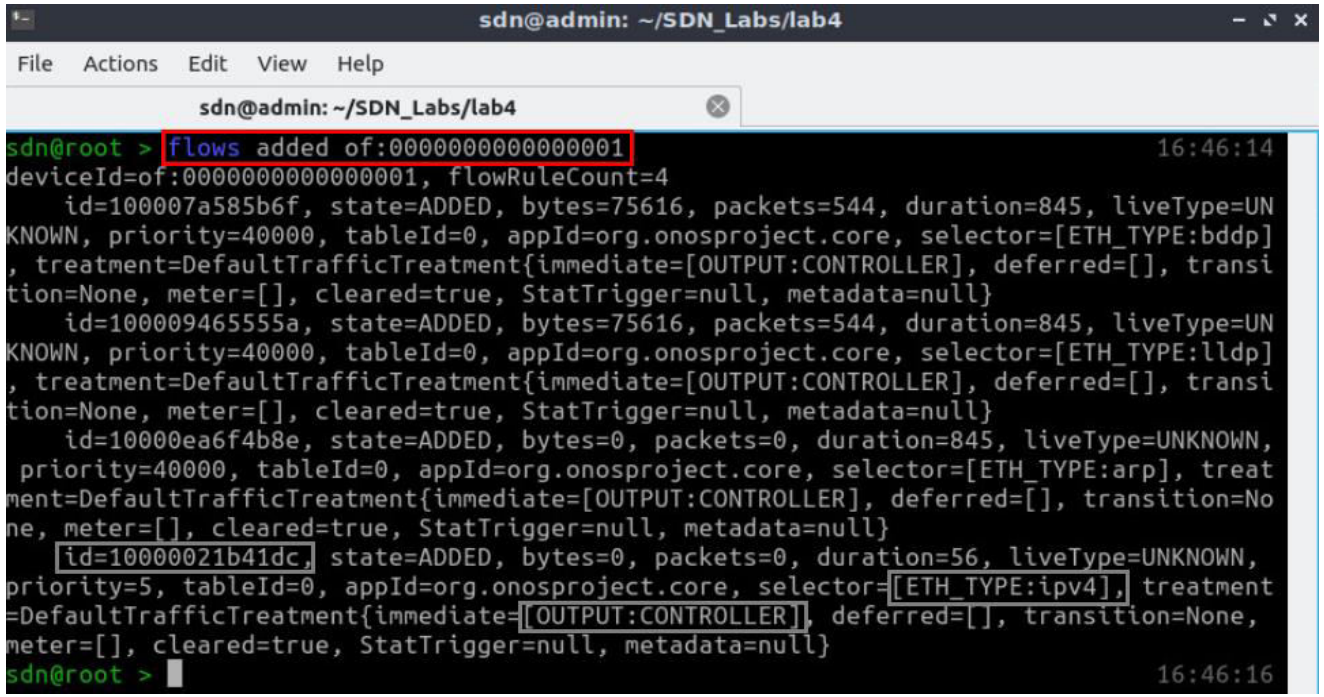
Hosts

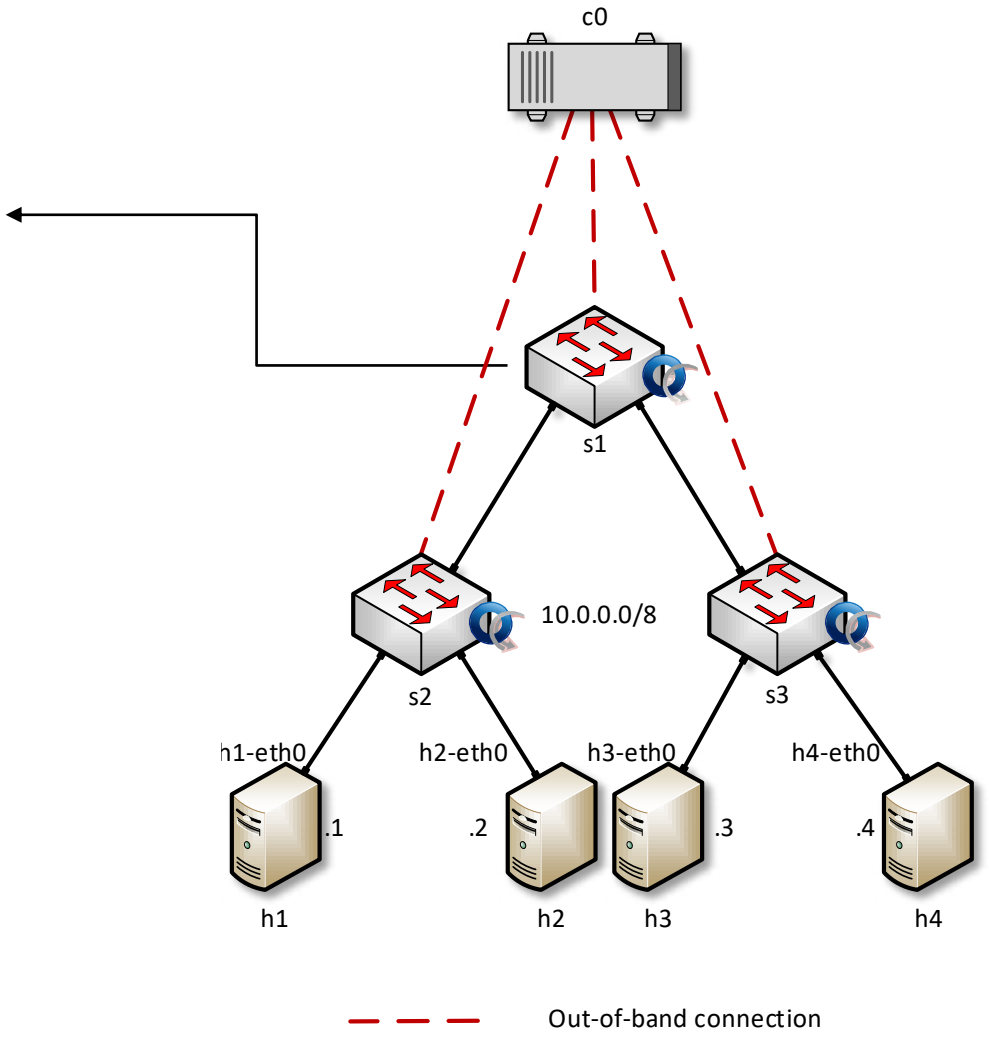
```
sdn@admin: ~/SDN_Labs/lab4
File  Actions  Edit  View  Help
sdn@admin: ~/SDN_Labs/lab4
sdn@root > hosts                                                      16:37:41
id=26:EA:BA:34:AA:D7/None, mac=26:EA:BA:34:AA:D7, locations=[of:0000000000000003/2], a
uxLocations=null, vlan=None, ip(s)=[10.0.0.4], innerVlan=None, outerTPID=unknown, prov
ider=of:org.onosproject.provider.host, configured=false
id=7A:4C:A7:9D:88:FF/None, mac=7A:4C:A7:9D:88:FF, locations=[of:0000000000000002/1], a
uxLocations=null, vlan=None, ip(s)=[10.0.0.1], innerVlan=None, outerTPID=unknown, prov
ider=of:org.onosproject.provider.host, configured=false
id=8E:0F:97:AC:3D:EB/None, mac=8E:0F:97:AC:3D:EB, locations=[of:0000000000000002/2], a
uxLocations=null, vlan=None, ip(s)=[10.0.0.2], innerVlan=None, outerTPID=unknown, prov
ider=of:org.onosproject.provider.host, configured=false
id=D2:19:CC:2E:E0:B7/None, mac=D2:19:CC:2E:E0:B7, locations=[of:0000000000000003/1], a
uxLocations=null, vlan=None, ip(s)=[10.0.0.3], innerVlan=None, outerTPID=unknown, prov
ider=of:org.onosproject.provider.host, configured=false
sdn@root >                                                            16:41:31
```



Activating the Forwarding Application

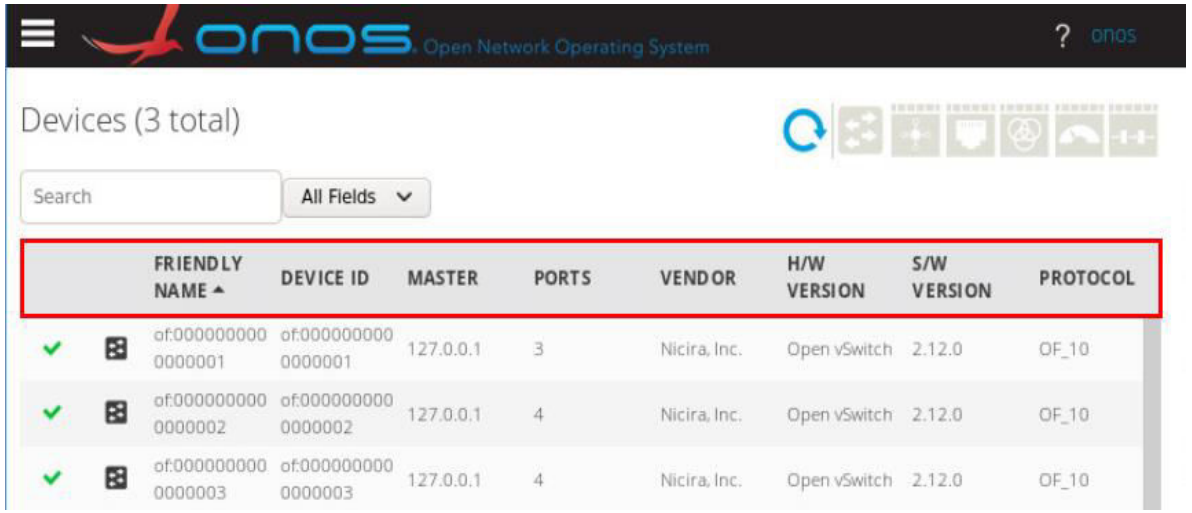
Flows on switch s1





ONOS GUI

Devices



Topology (ONOS GUI view)