Software Defined Networking

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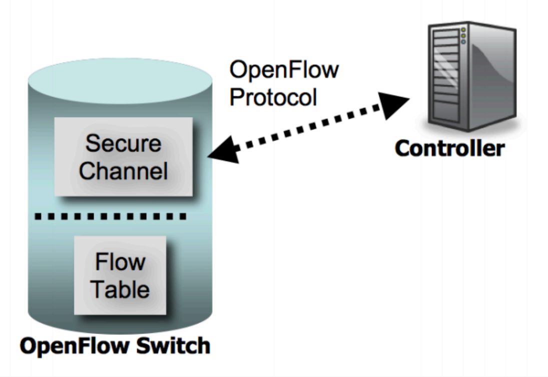
In this course, you will learn about software defined networking and how it is changing the way communications networks are managed, maintained, and secured.

This Module: The Control Plane

- Three Lessons
  - Control Plane Basics (OpenFlow 1.0 and Beyond)
  - SDN Controllers
  - Using SDN Controllers to Customize Control
- Programming Assignment (and Quiz)
- Quiz

OpenFlow Protocol Specification



- OpenFlow controller communicates with switch over a secure channel
  - OpenFlow protocol defines message format
  - Purpose of control channel: update flow table
  - Logic is executed at **controller**

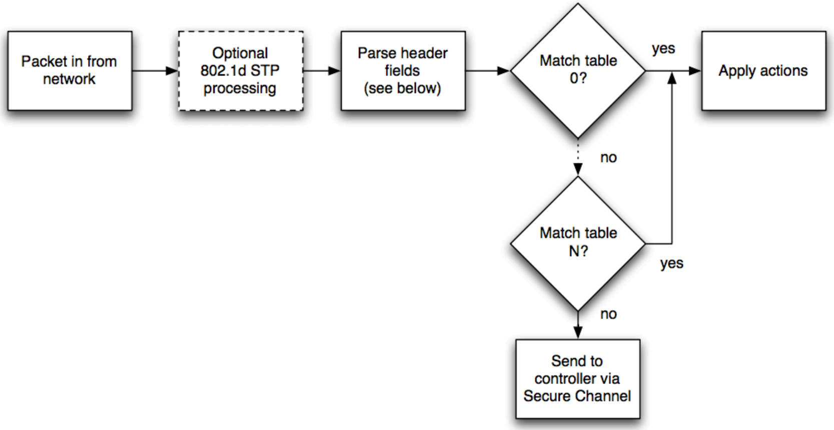
https://www.opennetworking.org/images/stories/downloads/sdn-resources/onf-specifications/openflow/openflow-spec-v1.0.0.pdf

Switch Components

- **Flow table:** Performs packet lookup
  - All packets compared to flow table for **match**
  - **Actions** depend on match being found
  - If no match, traffic is sent to controller

- **Secure channel:** Communication to external controller

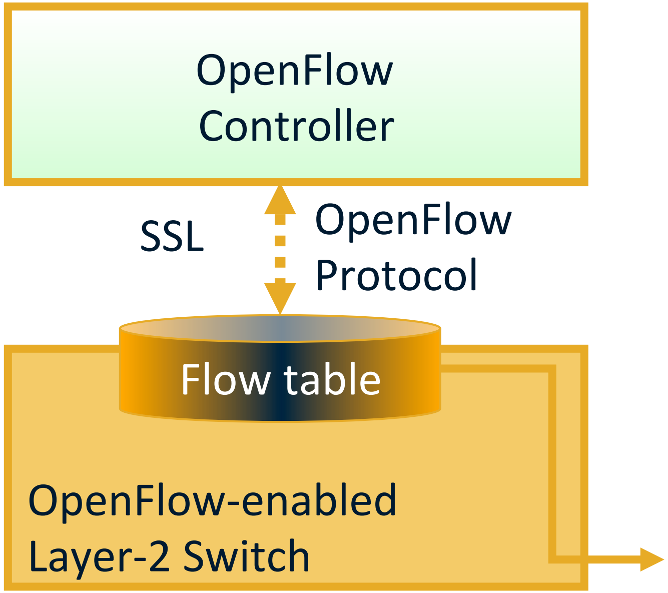
Matching (OpenFlow v. 1.0)


Packet in from network
Optional 802.1d STP processing
Parse header fields (see below)
Match table 0?
yes
Apply actions
no
Match table N?
yes
no
Send to controller via Secure Channel

- Packet header fields matched against one of N tables
- If no match, packet is sent to controller
- Otherwise, switch performs action

https://www.opennetworking.org/images/stories/downloads/sdn-resources/onf-specifications/openflow/openflow-spec-v1.0.0.pdf

Match: Fields in Lookup (v. 1.0)



- 12-tuple (also, VLAN priority and ToS)
- Support for wildcard matching

Matches subsets of packet header fields

Switch Port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Dst	IP Prot	TCP sport	TCP dport

Actions: Forward/Drop

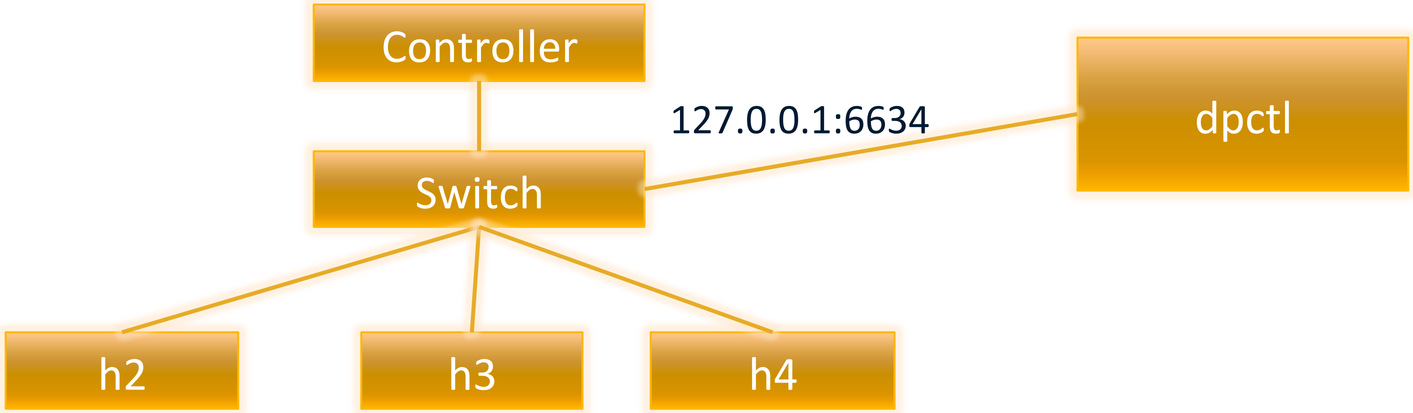
- **Forward**
  - **ALL:** Send out all interfaces, not including the incoming interface.
  - **CONTROLLER:** Encapsulate and send to the controller.
  - **LOCAL:** Send to the switch's local networking stack.
  - **TABLE:** Perform actions in flow table. Only for packet-out messages.
  - **IN PORT:** Send the packet out the input port
  - **Optional:** Normal forwarding, spanning tree
- **Drop:** A flow-entry with no specified action indicates that all matching packets should be dropped.

Optional Actions: Modify/Enqueue

- **Modify:** Option to modify packet header values in the packet (e.g., VLAN ID)
  - Set VLAN ID, priority, etc.
  - Set destination IP address

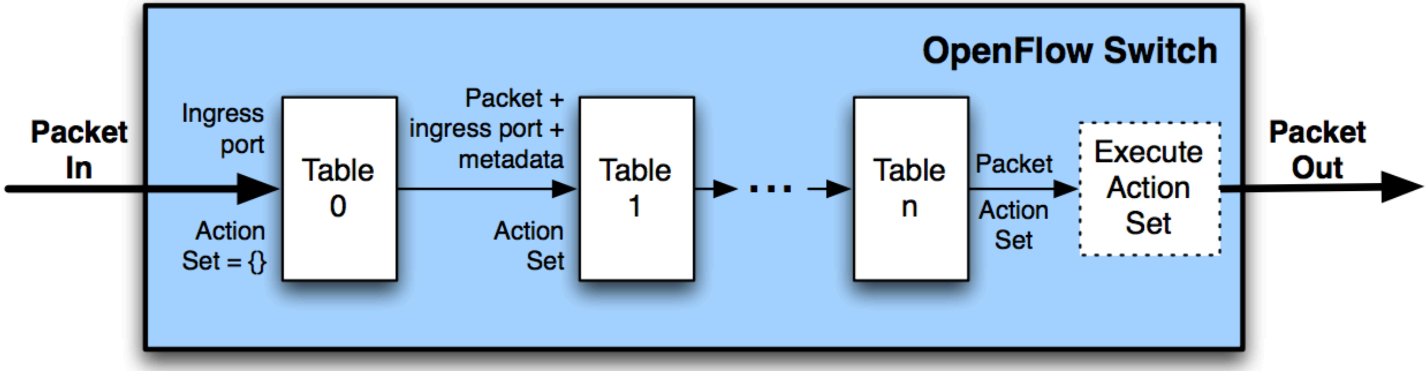
- **Enqueue:** Send the packet through a queue attached to a port

Example: dpctl Control Channel



- `$ sudo mn --topo single,3 --mac --switch ovsk --controller remote`
- `dpctl` to communicate with switches
  - Switches listen on port 6634
  - Can inspect flow table entries, modify flows, etc.

OpenFlow (v. 1.3) Enhancements



- **Action set:** Set of actions to be performed on each packet.
- **Group:** A list of action sets
- Each table updates fields, modifies action set

Action Group Options

- Execute all action sets in a group
  - Useful for implementing multicast: One packet is cloned for each action set in the group

- Indirect groups
  - Execute the one defined bucket in the group. Useful for pointing multiple flow entries to a common action (similar to RCP optimizations)

Example Actions

- **TTL:** Decrement, copy inwards/outwards
- **MPLS:** apply MPLS push action to packet
- **QoS:** apply QoS actions (e.g., set_queue) to the packet

OpenFlow: Other Details

- Metering and traffic monitoring
- Control channel details
  - Encryption
  - Handling control messages from multiple controllers
- More details on the ONF page: https://www.opennetworking.org/sdn-resources/onf-specifications/openflow

Other SDN Control Architectures

- Juniper’s Contrail Controller (Linux)
  - XMPP as control plane
  - L2 and L3 virtual networks
  - Contributions to OpenDaylight
- Cisco’s Open Network Environment
  - Centralized software controller
  - Programmable data plane
  - Ability to provide virtual overlays

Summary: Control Plane Basics

- OpenFlow Switch Components
  - Secure channel
  - Flow tables (match and action)
  - (New) Group tables
- OpenFlow Protocol is evolving
- `dpctl` connects directly to a switch to poll, manipulate, etc.
- Next lesson: SDN Controllers

This Module: Introduction

- Needs and Expectations
  - Determine if this course applies to you
  - Identify whether you have the necessary prerequisites
  - Learn how much time commitment each module will require
- Course Overview