Introduction to OpenFlow

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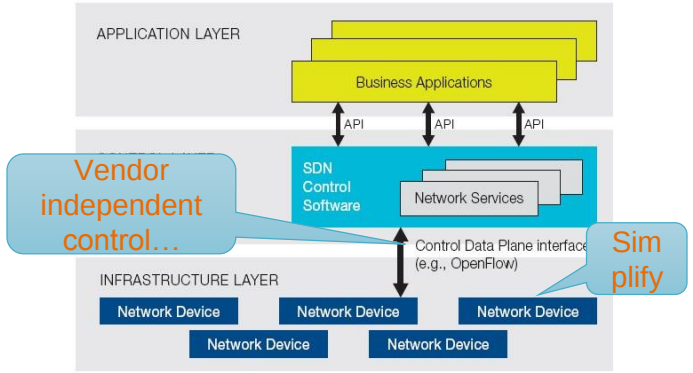
SDN vs. OpenFlow

ONF Definition

- SDN performs Software Defined Forwarding
  - Controls data forwarding through open API
- SDN provides Management Abstraction
  - Can make more advanced applications



Logical View of SDN architecture

Currently Implemented with OpenFlow

OpenFlow is Misunderstood to be Equivalent to SDN

- No requirements for the use of OpenFlow within an SDN
- OpenFlow is one of SDN protocols but most popular

Version	Date	Characteristics	Organization
OpenFlow 1.0	2009.12	MAC, IPv4, single flow table	OpenFlow Consortium
OpenFlow 1.1	2011.2	MPLS/tunnel, multiple flow tables, group table	OpenFlow Consortium
OpenFlow 1.2	2011.12	IPv6, Config., extensible match support	ONF
OpenFlow 1.3	2012.9	QoS (meter table)	ONF
OpenFlow 1.4	2013.10	Optical port monitoring and config. (frequency, power)	ONF
OpenFlow 1.5	2014.12	Egress table, pkt. type aware pipeline, flow entry stat trigger	ONF

OpenFlow

❖ Definition

- A communication protocol that gives access to the forwarding plane of the network switch or router

❖ Features

- OpenFlow is similar to an x86 instruction set for the network
- Separation of control plane and data plane
  - The data path of an OpenFlow switch consists of a Flow Table, and an action associated with each flow entry
  - The control path consists of a controller which programs flow entry in the flow table
- OpenFlow has an internal flow-table, and a standardized interface to add and remove flow entries

❖ Components

- OpenFlow controller
  - Process packet match, instruction & action set, pipeline processing
- OpenFlow switch
  - Secure channel, flow table

OpenFlow History

❖ USA NSF FIND (Future INternet Design) Program

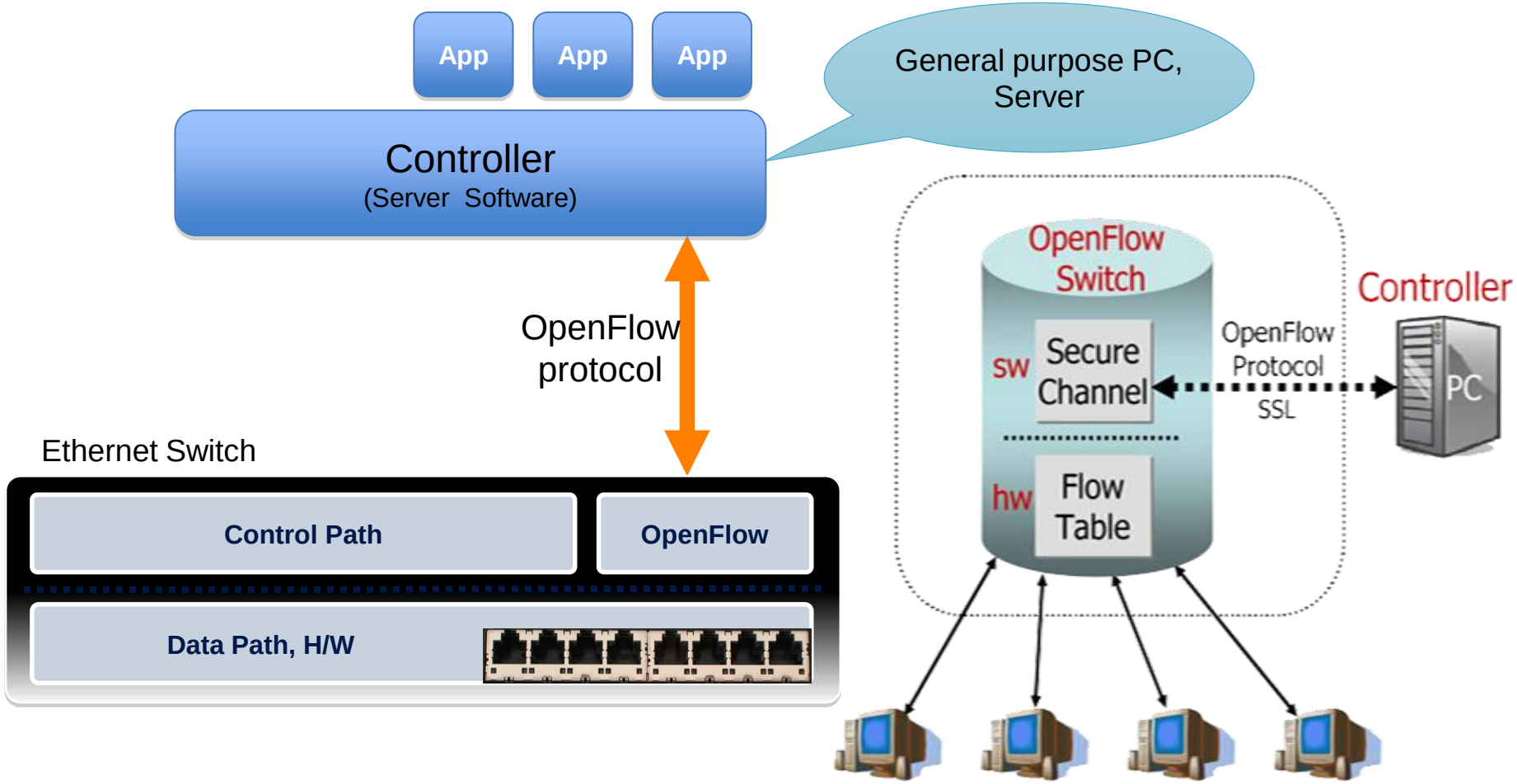
- 2006, Stanford and Berkley University
- SANE(clean-slate Security Architecture for Enterprise Network) project
- Ethane project

❖ OpenFlow

- 2007, Stanford University
- 2008, OpenFlow Consortium
- 2008, Nicira Networks released NOX platform.
- 2009, OpenFlow Spec 1.0
- 2009 MIT Tech. Review → SDN as one of 10 emerging technologies
- 2011 March, ONF (Open Networking Foundation) was born
- 2012 ONF released OpenFlow 1.3
- 2013 ONF released OpenFlow 1.4
- 2014 ONF released OpenFlow 1.5
- At the end of 2017, ONF merges with ON.LAB

How Does OpenFlow Work?

❖ OpenFlow Switch and Tables



Current Status of SDN Products and Solutions

❖ Controller Vendors

	Solutions	OpenFlow version	
Controller	NOX	OpenFlow 1.3	C++ API
	POX	OpenFlow 1.1	Python version of NOX, Python API
	Floodlight	OpenFlow 1.3	BigSwitch joined OpenDaylight but left it on June 2013
	Ryu	OpenFlow 1.4	Python API
	OpenDayLight (ODL)	OpenFlow 1.3	2014.2
	ONOS	OpenFlow 1.4	2014.12
Switch	Open vSwitch	OpenFlow 1.3	Developed and maintained by NICIRA
	Ericsson soft switch	OpenFlow 1.3	Compatible with Mininet Controller: NOX 1.3

❖ Switch Vendors

- NEC: released OpenFlow 1.3 switch and controller… 2013.9
- HP: released OpenFlow 1.3 data center switch … 2013
- Centec Network, China: released Open SDN switch with OpenFlow1.3 support (implemented on Open vSwitch) … 2013.4
- Brocade, OpenFlow 1.3 switch … 2014.6~

OpenFlow Protocol Format

❖ Protocol Layer

- OpenFlow control message relies on TCP protocol
- Controllers listen on TCP port 6633/6653 to setup conn. with switch
  - 6633/6653 became the official IANA port since 2013-07-18
- OpenFlow message structure
  - Version
    - Indicates the version of OpenFlow which this message belongs
  - Type
    - Indicates what type of message is present and how to interpret the payload (version dependent)
  - Message length
    - Indicates where this message will be end, starting from the first byte of header
  - Transaction ID (xid)
    - An unique value used to match requests to response

OpenFlow Message Structure

Bit Offset	0 ~ 7	8 ~ 15	16 ~ 23	24 ~ 31
0 ~ 31	Version	Type	Message Length	
32 ~ 63	Transaction ID			
64 ~ ?	Payload			

OpenFlow Protocol Messages

C: OpenFlow Controller AM: Asynchronous message CSM: Control/Switch Message
S: OpenFlow Switch SM: Symmetric Message

Category	Message	Type	Description
Meta Info. Configuration	Hello (SM)	C → S	following a TCP handshake, the controller sends its version number to the switch.
	Hello (SM)	S → C	the switch replies with its supported version number.
	Features Request (CSM)	C → S	the controller asks capability of a switch, including port speed, supported tables and actions.
	Set Config (CSM)	C → S	configures various settings to switch including flow expirations, MTU and etc.
	Features Reply (CSM)	S → C	the switch replies with a list of ports, port speeds, and supported tables and actions.
	Port Status	S → C	enables the switch to inform that controller of changes to port speeds or connectivity.
Flow Processing	Packet-In (AM)	S → C	a packet was received and it didn't match any entry in the switch's flow table, causing the packet to be sent to the controller.
	Packet-Out (CSM)	C → S	instructs a switch to send a packet out to one or more switch ports.
	Flow-Mod (CSM)	C → S	instructs a switch to add a particular flow to its flow table.
	Flow-Removed (CSM)	S → C	a flow timed out after a period of inactivity.

OpenFlow Communication

❖ Connection Setup