8 : Software Defined Networks

IT4506 – Computer Networks

Level II - Semester 4

Overview

- In this topic we discuss the Software Defined Networks.

Intended Learning Outcomes

- At the end of this lesson, you will be able to;
  - Define Software Defined Networks.
  - Explain the Control plane, Data plane and Management plane.
  - Discuss the evolution of switches and control planes.
  - Describe the SDN architecture and Open flow.
  - Summarise usage of SDN in real world.

List of sub topics

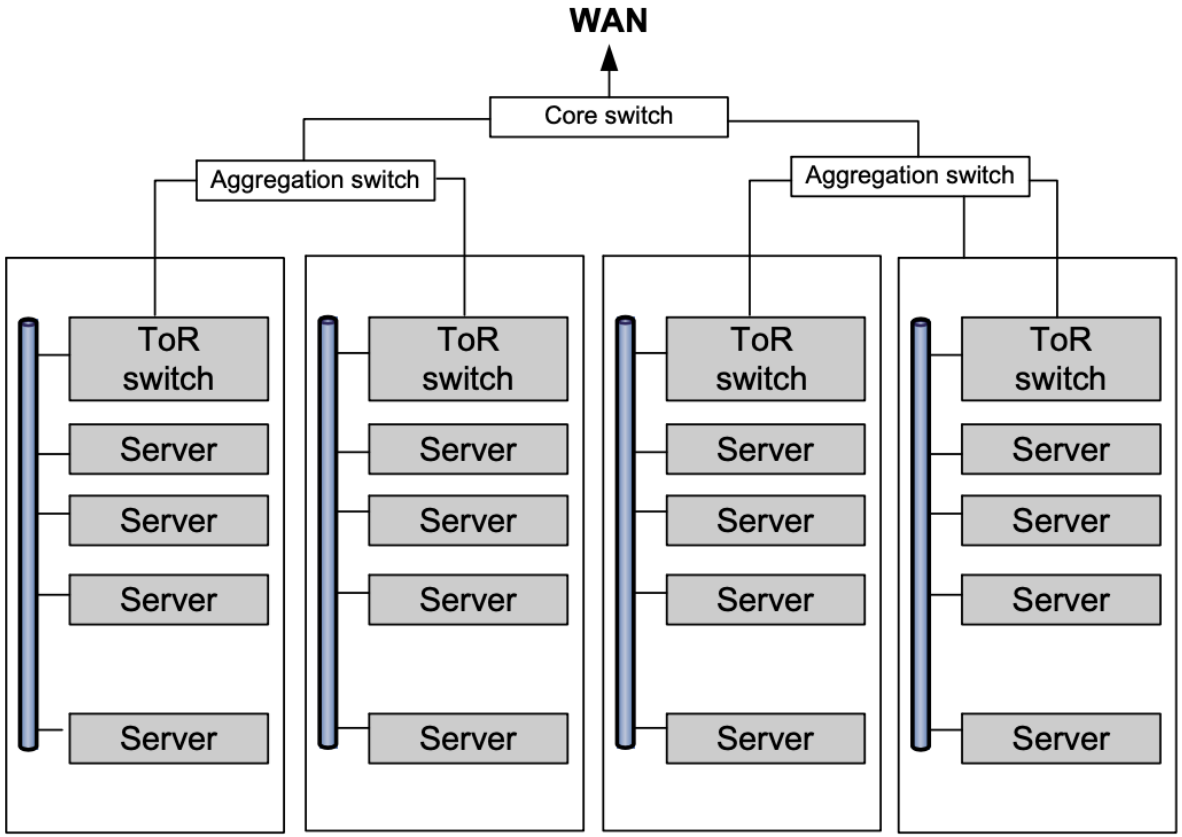
8. Software Defined Networks
    - 8.1 Control and data planes
        - 8.1.1 Traditional Switch Architecture
        - 8.1.2 Evolution of Switches and Control Planes
            - 8.1.2.1 Simple Forwarding and Routing Using Software
            - 8.1.2.2 Hardware Forwarding and Control in Software
            - 8.1.2.3 Moving Control Off of the Device
    - 8.2 Overview of SDN architecture
        - 8.2.1 Main Components
        - 8.2.2 Introduction to OpenFlow
        - 8.2.3 An example SDN use case - Data Center Orchestration

Modern Data Center

- Host complex and more heavily subscribed web services.
- Data centers served as environmentally protected warehouses housing large numbers of computers that served as compute and storage servers
- These warehouses were protected against environmental disasters.
- They have redundant power systems.
- They are designed with duplicate capacity at disparate geographical locations.
- The large numbers of servers are physically arranged into highly organized rows of racks of servers.

Modern Data Center…(2)

- Typical data center network topology



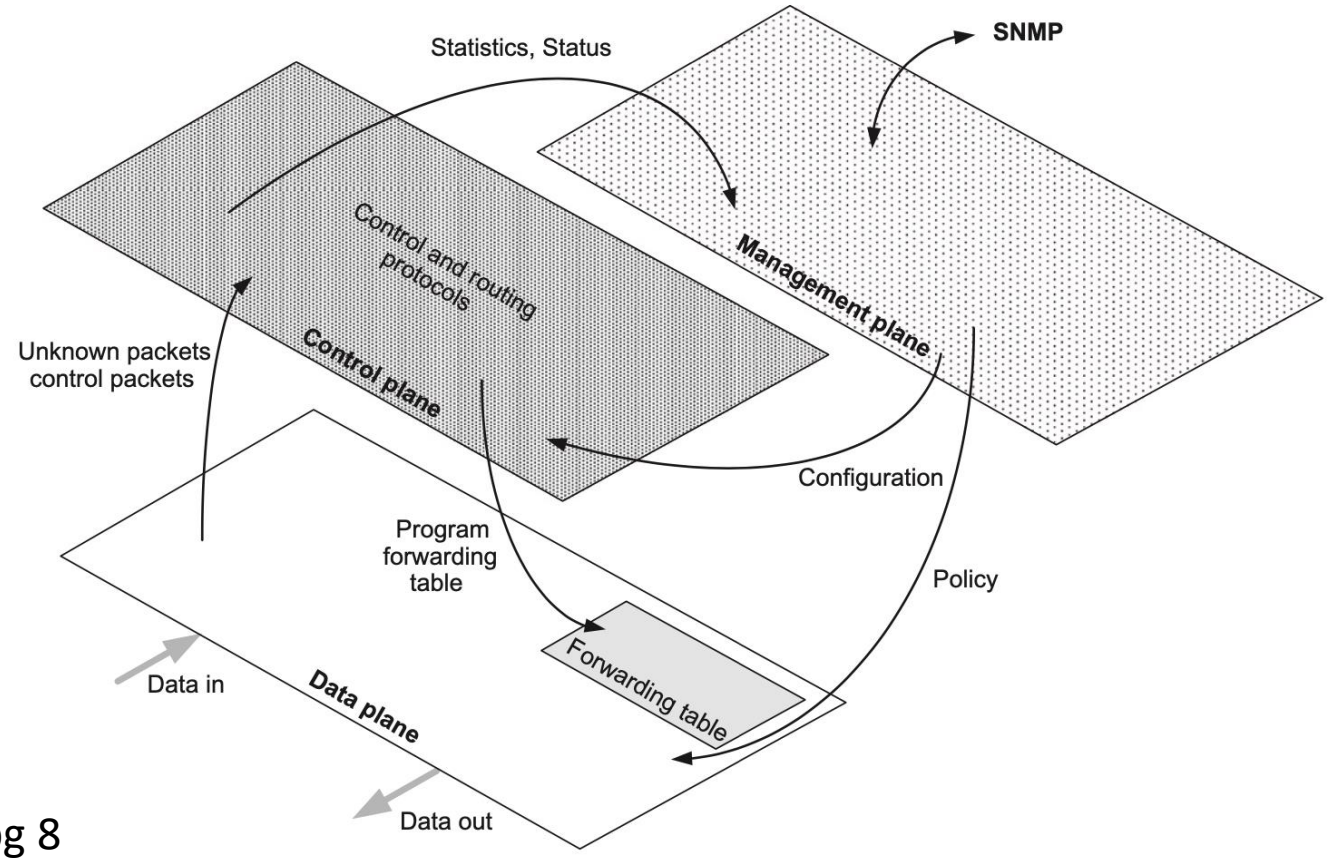
Ref 1: pg 6

Traditional Switch Architecture

- Switching functions are traditionally segregated into three separate categories.
- Common to represent each of these categories as a layer or plane.
  - Control planes
  - Management planes
  - Data planes

Traditional Switch Architecture...(2)

Roles of the control, management, and data planes.



Ref 1: pg 8

Traditional Switch Architecture…(3)

- Data plane
  - Consists of the various ports that are used for the reception and transmission of packets.
  - It assumes responsibility for packet buffering, packet scheduling, header modification, and forwarding.
  - If an arriving data packet's header information is found in the forwarding table it may be subject to some header field modifications and then will be forwarded without any intervention of the other two planes.
  - All the packets cannot forward in this manner. If the header information is not available in the forwarding table or if the packet is belong to some other control protocol, then in it has to process by the control plane.

Traditional Switch Architecture…(4)

- Control plane
  - Main responsibility is to keep the forwarding table updated. So that the data plane can forward packets based on it.
  - It need to process number of control protocols which affect the forwarding table.
  - These control protocols are responsible for managing the active topology of the network.
  - Control protocols are sufficiently complex so they required general purpose microprocessors and accompanying software in the control plane.

Traditional Switch Architecture…(5)

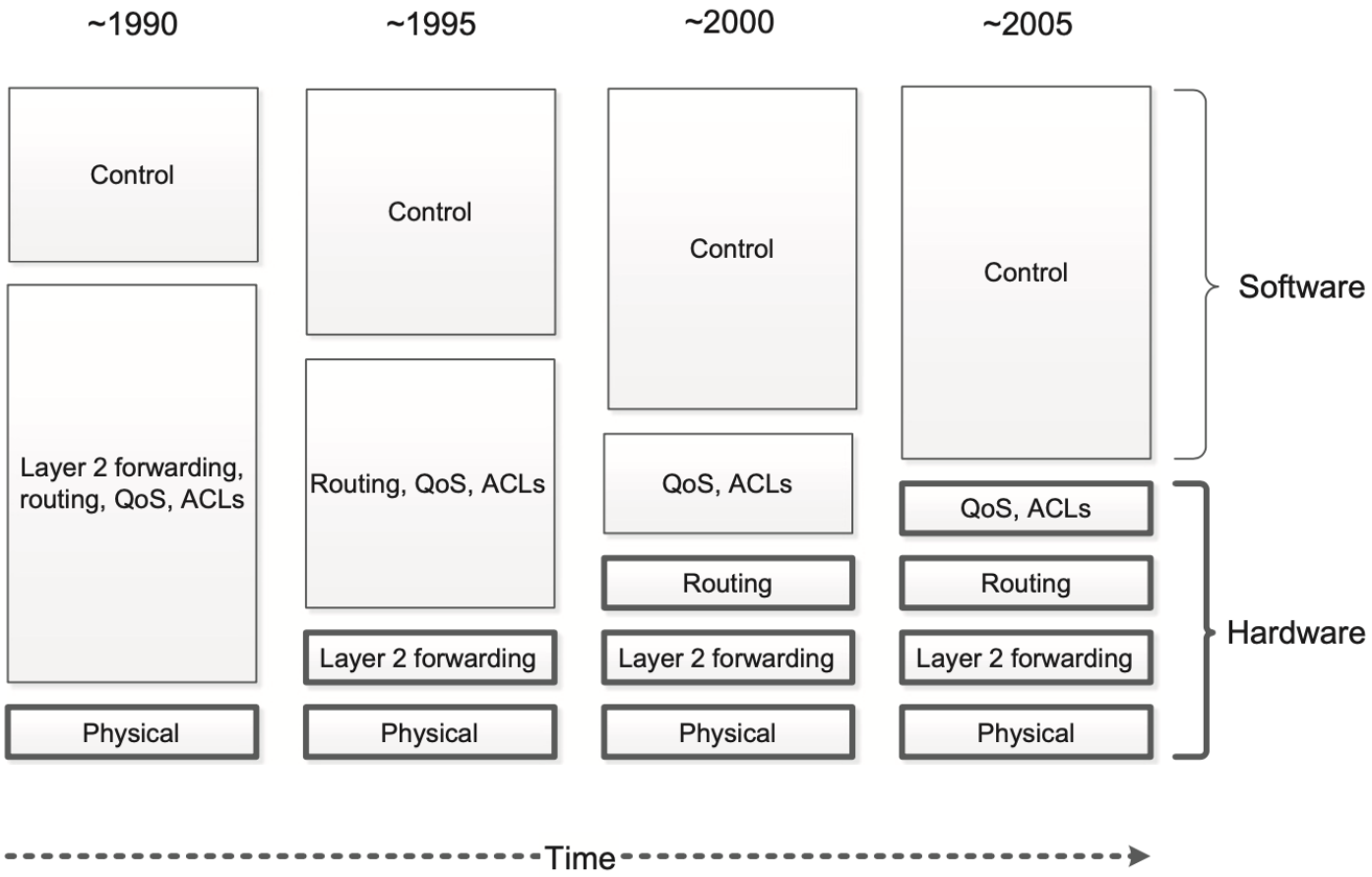
- Management plane
  - Network administrators configure and monitor the network using this plane.
  - It extracts information from or modifies data in the control and data planes.
  - Network administrators use some form of network management system to communicate with the management plane in a switch.

Evolution of Switches and Control Planes

- Simple forwarding and routing using software
  - In early days of networking almost everything except the physical layer was controlled using software.
  - In side the bridges, switches and routers, softwares were used to perform almost all the tasks.
  - Originally hardware vendors write their own software to perform functionalities the devices.
  - Over time most of the basic functions moved from software into hardware.
  - Now most forwarding and filtering decisions implemented entirely in hardware.

Evolution of Switches and Control Planes...(2)

- Simple forwarding and routing using software



Ref 1: pg 24

Hardware Forwarding and Control in Software

- Bridging (Layer Two Forwarding)
  - Basic layer two MAC forwarding of packets is handled in the hardware tables.
- Routing (Layer Three Forwarding)
  - To keep the high-speed links and to route packets at link speeds, layer three forwarding functionality is implemented in hardware tables.
- Advanced filtering and prioritization
  - General traffic management rules (ACLs) are handled via hardware tables located in the hardware.
- Control
  - Used to make broader routing decisions and to interact with other devices in order to converge on topologies and routing paths implemented in software that runs autonomously inside the devices.

Moving Control Off of the Device

- Control software is the intelligence that determines optimal paths and responds to outages and new networking demands.
- SDN is about moving that control software off of the device and into a centrally located compute resource which is capable of seeing the entire network and making decisions which are optimal, given a complete understanding of the situation.
  - SDN separate the network activities by
    - Forwarding, Filtering, and Prioritization - Forwarding responsibilities, implemented in hardware tables, remain on the device.
    - Control - Complicated control software is removed from the device and placed into a centralized controller.
    - Application - Applications are run above the controller.

Overview of SDN architecture

- Fundamental Characteristics of SDN
  - Plane separation - Separation of the forwarding and control planes.
  - Simplified device and centralized control - When the management and control software is running in a centralized system, the devices get simplified.
  - Network automation and virtualization
    - Distributed state abstraction - provide a global network view
    - Forwarding abstraction - allows to specify the necessary forwarding behaviors without any knowledge of vendor specific hardware
    - Configuration abstraction - defines the goals of the network without considering how it is implemented in the physical hardware.
  - Openness - Open SDN is standard, well documented, and not proprietary.

Overview of SDN architecture…(2)

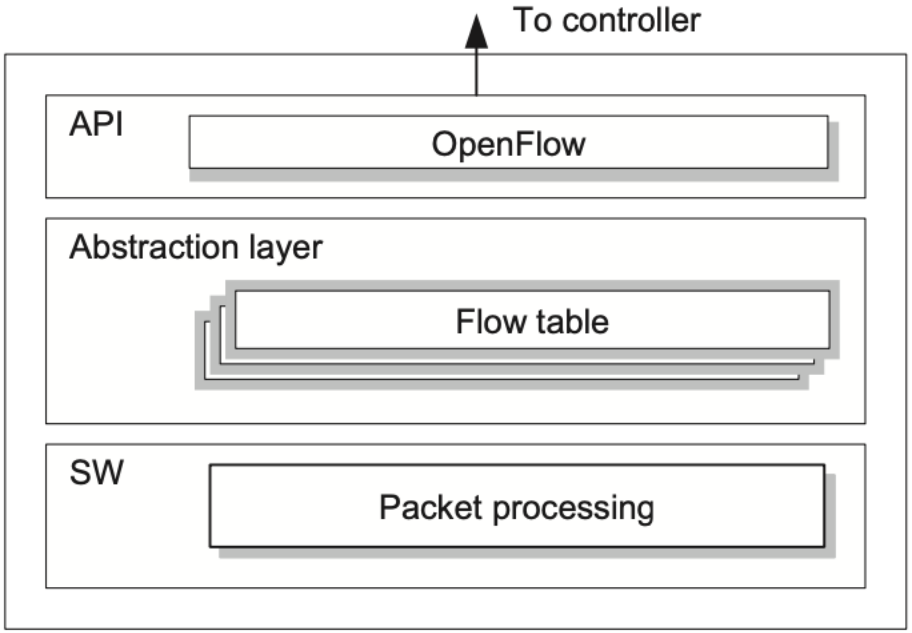
- The centralized software-based controller in SDN provides an open interface on the controller to allow for automated control of the network.
- In Open SDN
  - Northbound API - allowing software applications to be plugged into the controller, and thereby allowing that software to provide the algorithms and protocols that can run the network efficiently.
  - Southbound API - is the OpenFlow interface that the controller uses to program the network devices.

Main Components

- SDN Devices
  - It should composed of an API for communication with the controller, an abstraction layer, and a packet processing function.
- SDN Controller
  - Controller maintains a view of the entire network, implements policy decisions, controls all the SDN devices that comprise the network infrastructure, and provides a northbound API for applications.
- SDN Applications
  - SDN applications run above the SDN controller, interfacing to the network via the controller's northbound API.

Main Components...(2)

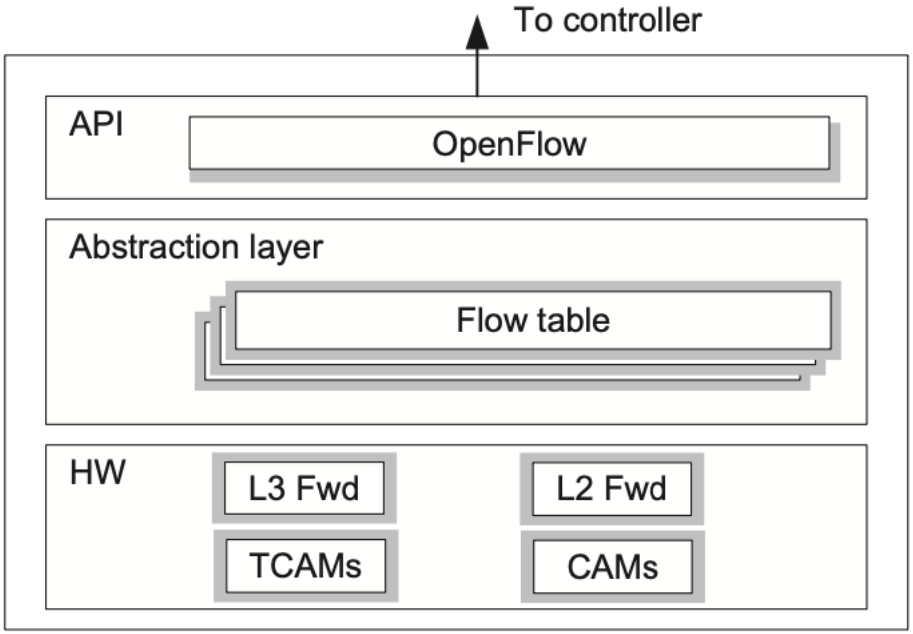
- SDN software switch anatomy.



Ref 1: pg 67

Main Components...(3)

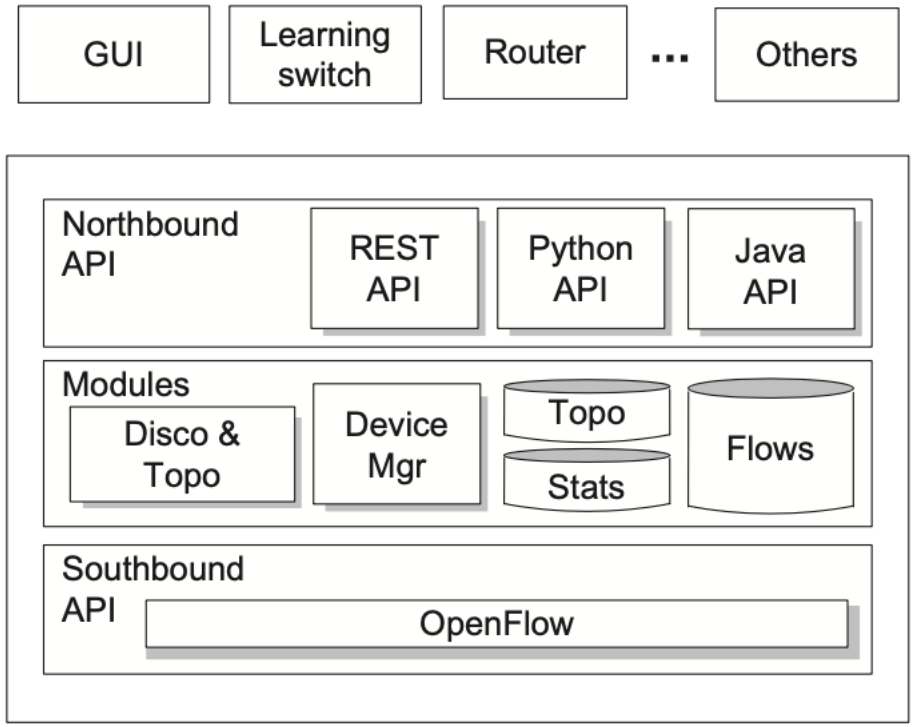
- SDN hardware switch anatomy.



Ref 1: pg 67

Main Components...(4)

- SDN controller anatomy.



Ref 1: pg 72

Introduction to OpenFlow

- OpenFlow is one of the technologies used for SDN.
- OpenFlow defines both the communications protocol between the SDN data plane and the SDN control plane.
- It does not describe the behavior of the controller itself.
- An OpenFlow system consists of,
  - OpenFlow controller - communicates to one or more OpenFlow Switches.
- The OpenFlow protocol defines the specific messages and message formats exchanged between controller (control plane) and device (data plane).
- The OpenFlow behavior specifies how the device should react in various situations, and how it should respond to commands from the controller.

An example SDN use case - Data Center Orchestration

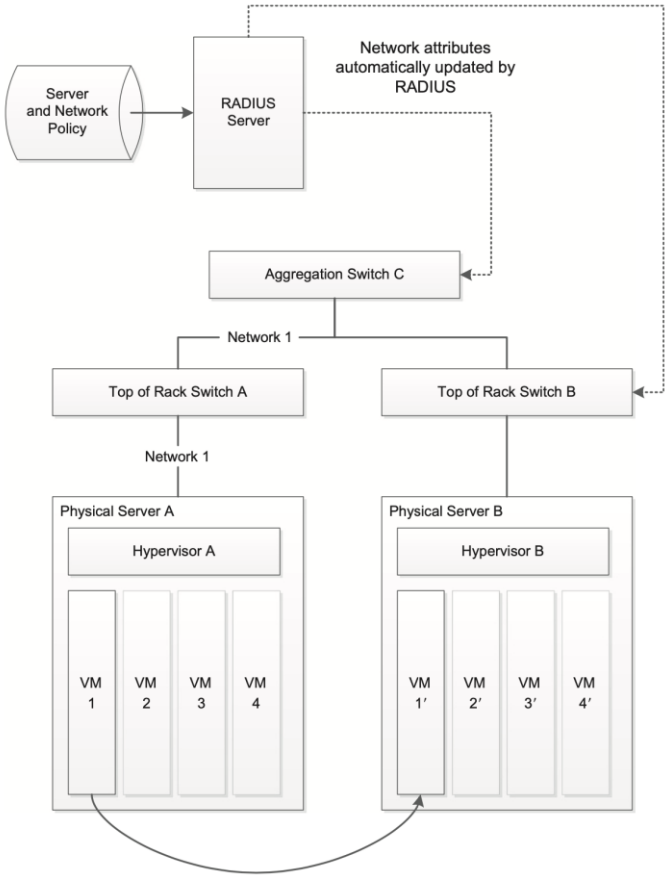
- Data center implementation using SDN is still in work in progress.
- Some organisations are using SDN technologies such as Open SDN and Overlays as pilot projects in their data centers.
- Data Center SDN Implementations,

Enterprise	SDN Type	Description
Google	Open SDN	Has implemented lightweight OpenFlow switches, an OpenFlow Controller and SDN Applications for managing the WAN connections between their data centers. They are moving that Open SDN technology into the data centers.
Microsoft Azure	Overlays	Implementing Overlay technology with NVGRE in vSwitches, communicating via enhanced OpenFlow, creating tens of thousands of virtual networks.
Ebay	Overlays	Creating public cloud virtual networks, using VMware's Nicira solution.

Ref 1: pg 214

An example SDN use case - Data Center Orchestration…(2)

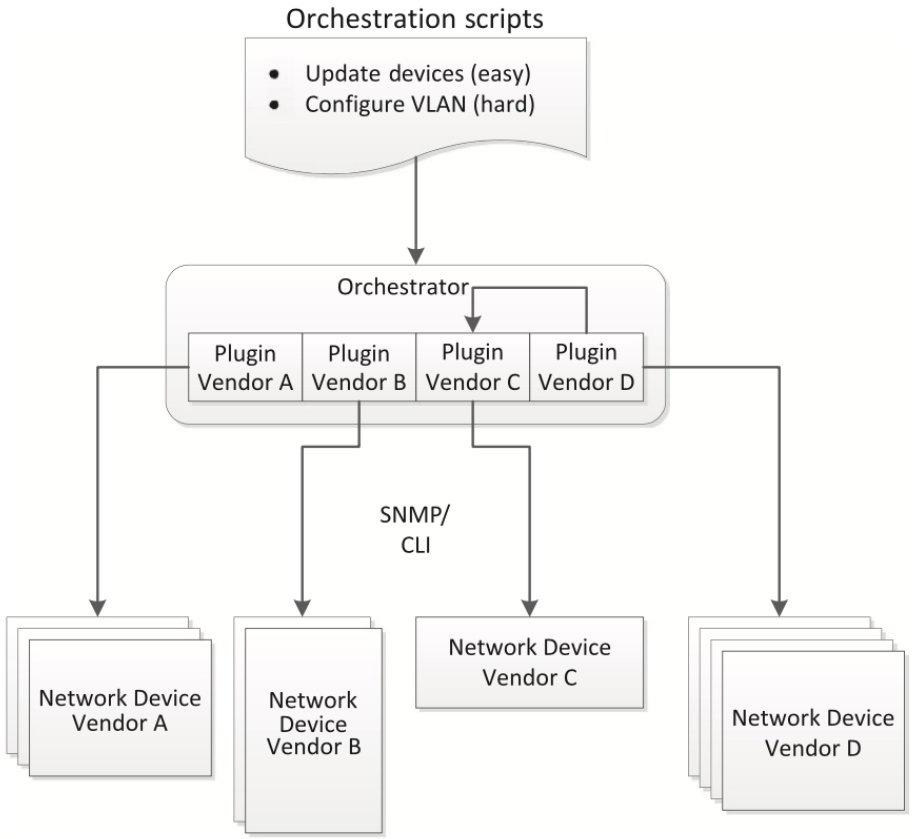
- Early attempts at SDN: RADIUS



Ref 1: pg 45

An example SDN use case - Data Center Orchestration…(3)

- Early attempts at SDN: Orchestration



Ref 1: pg 46

References

- Ref 01. Software Defined Networks by Paul Göransson, Chuck Black, Timothy Culver, 2nd edition, Elsevier