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Exercise 1

1. Motivation for SDN

   a. Please explain the problems current, large-scale production networks experience.
      Solution:
      Current Problems:
      i. Immaturity of the current products backs the above statement
      ii. Certain new challenges and ability of the existing system to in-coporate them.
      iii. SDNs key characteristics include programmability, automation and central control, configuration and policy management. If the large scale production doesn't want to achieve these goals, its better not to invest on this technology.
      iv. The separation of the control and data plane opens up a key challenge of maintaining a carrier grade service within this framework.
      v. Security is one of the key challenges of the SDN. How can the SDN be safeguarded from malware attacks.

      Large-scale production networks:

      vi. Google follows a Hybrid SDN deployment to connect their data servers and it is most successful large scale SDN deployment.
      vii. Amazon also uses software defined WAN to support their global operations with flexibility and high availability.

2. History of SDN

   a. What goals did the historical networking techniques discussed in the lecture (e.g., active networking) have?
      Solution: Opening up the network control to everyone instead of just the network administrator. To achieve this goal, fully programmable API is to be introduced. Active networks allowed the co-existence of legacy router with active routers.

   b. What means did they propose to achieve these goals?
      Solution: Programmability of the network nodes could be achieved through two models:
      i. Capsule model: Code to be executed at nodes was carried in band data packets
      ii. Programmable router/switch model: Code to be executed at nodes was carried in out-band-data packets

c. Why did they fail?
    Solution: These models were proposed in 90's when there wasn't enough infrastructure (cloud, data centers). The cost of hardware was way too expensive than present day. Apart from these, one of the key challenges were the programmability of end-user. Security was the main concern of not introducing programmability as they OS/Network security during 90's weren't that popular when compared to the present day.

d. What are their intellectual contributions that are similar to SDN?
    Solution: Two major intellectual contributions of Active networks is the programmability of network functions (remotely) and network virtualization through de-multiplication of packets according to their header.

3. Software-defined Networking - Basics

    a. Please briefly describe the main characteristics of SDN
        Solution: The main characteristics of SDN are divided into four parts:
        i.   SDN separates the control plane from the data plane .
        ii. A centralized controller and view of the network:
             SDN consolidates the control plane, so that a single software control program controls multiple data-plane elements. . The SDN control plane exercises direct control over the state in the network's data-plane elements (i.e. routers, switches, and other middleboxes) via a well-defined Application Programming Interface (API).
        iii. Open interfaces between the devices in the control plane and the data plane.
        iv. Programmability of the network by external applications:
             SDN decouples network resources with underlying hardware components and hence opens the concept of network virtualization.

    b. What does a Network Operating System do in the context of SDN?
        Solution: Network Operating System is a piece of software which implements an operating system oriented to computer networking. If the OS principles are applied to a SDN controller, it could be extended for network virtualization techniques.