Software Defined Networking

Group 4:

- Alexander Nunez
- Joseph Ayoka
- Pablo Ruiz
- Md Zahidul Islam

Introduction

What is Software Defined Networking (SDN)?

- SDN is a type of network management that allows for dynamic, efficient, and centralized network configuration.
- SDN is a way of giving developers control of how the network gets configured, instead of leaving it to protocols.
- A SDN can be modeled by 3 layers: Application layer, control layer (controller), and infrastructure layer(switches, forwarding devices)

Introduction

How does a SDN work?

- The most substantial part of a SDN is the SDN controller (found in the control plane)
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- At the lowest layer of an SDN are forwarding devices that enable communication throughout the network. They make up the SDNs datapath.
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- SDN applications are created with the needed SDN requirements and desired SDN behavior, explicitly specified.
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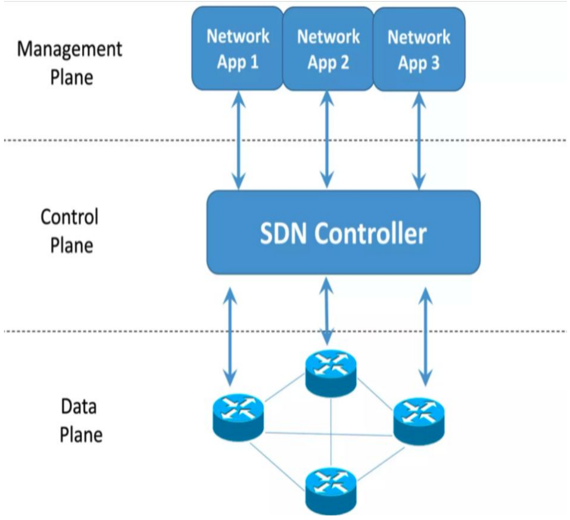
- Two interfaces are used by the SDN controller to control the network.
  - Northbound interfaces: These are interfaces between SDN apps and the controller. Through this interface apps can specify network behavior and requirements.[1]
  - Southbound Interfaces: This interface gives the controller programmatic control over all forwarding devices, forwarding operations, and other services.[1]



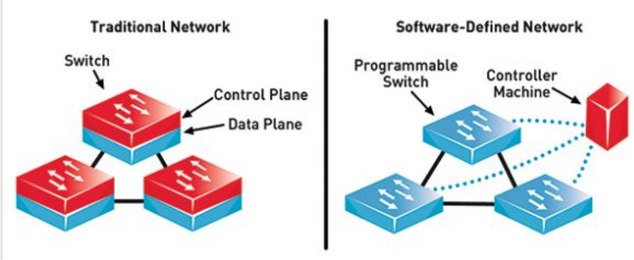
Examples of APIs:

OpenFlow (SBI)
OpFlex (SBI)
REST (NBI)

Motivation

Why create a Software Defined Network?

- ❖ Demanding applications that a traditional network cannot handle/deploy quickly without manual and costly configurations.
- ❖ You want an easily configurable network that can quickly adjust to bottlenecks and application needs.[1]
- ❖ You want centralized control of the network.
- ❖ You want many services that provide control of:
  - ➢ How devices are connected and topology graphs implemented(Topology service)[1]
  - ➢ Information on network device capabilities (Inventory service)[1]
  - ➢ Data on the statistical function of the network (Statistics service)[1]
  - ➢ Information about hosts on the network (Host tracking)[1]
- ❖ You want automation of Network services.

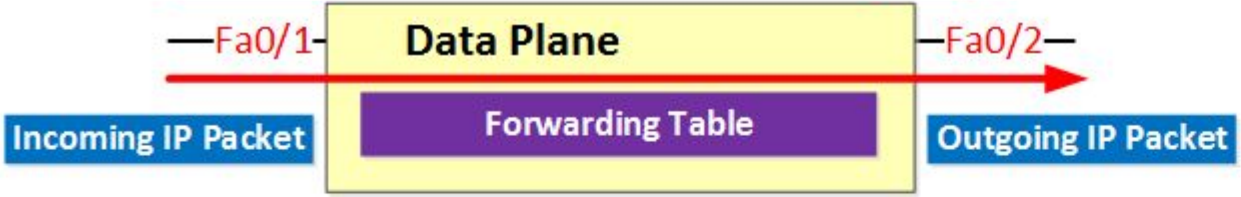


Traditional network issues that SDN helps address

- ❖ Distributed network control → Centralized network control
- ❖ Non-programmable network → Programmable network
- ❖ Static/Manual configuration → Automatic configuration
- ❖ Protocols → APIs

Data Plane

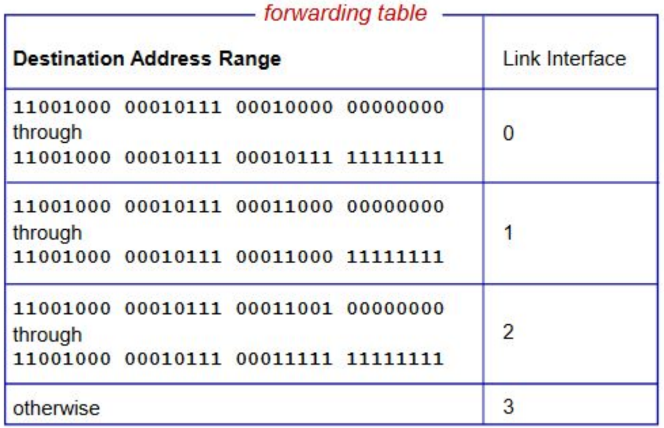
- The data plane does not change fundamentally in an SDN controlled network.[2]
- It remains distributed throughout the network with each switch containing its own hardware based data plane.
- Speed is critical for the data plane since packets should be switched as fast as possible so a hardware accelerated system is the most efficient option.
- The traditional forwarding tables would now be replaced by flow tables which allow the network to be more intelligent and adaptable.
- The new flow tables would be updated by the external SDN controller rather than by built in control plane hardware.[3]



Data Plane Representation. [4]

Data Plane

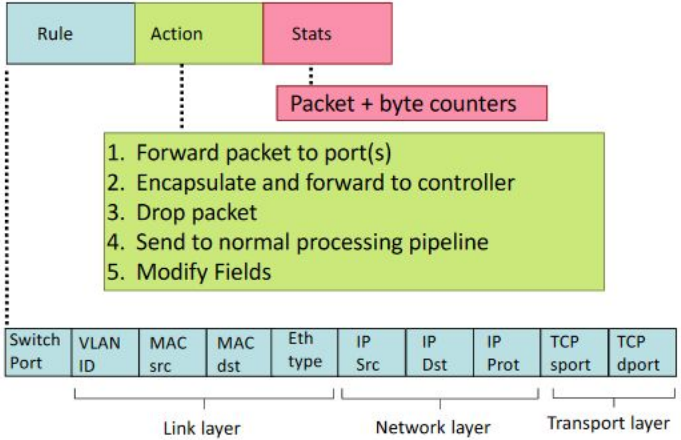
- **Flow Tables:**
  - Search each packet for a match to a given pattern/rule provided by the controller.
  - Any part of each packet’s header or data payload can be searched.
  - If the pattern matches perform the specified action (eg. forward, drop, modify, etc.).
  - Keep track of how many packets and/or bytes satisfied that rule.



forwarding table

Destination Address Range	Link Interface
11001000 00010111 00010000 00000000 through 11001000 00010111 00010111 11111111	0
11001000 00010111 00011000 00000000 through 11001000 00010111 00011000 11111111	1
11001000 00010111 00011001 00000000 through 11001000 00010111 00011111 11111111	2
otherwise	3

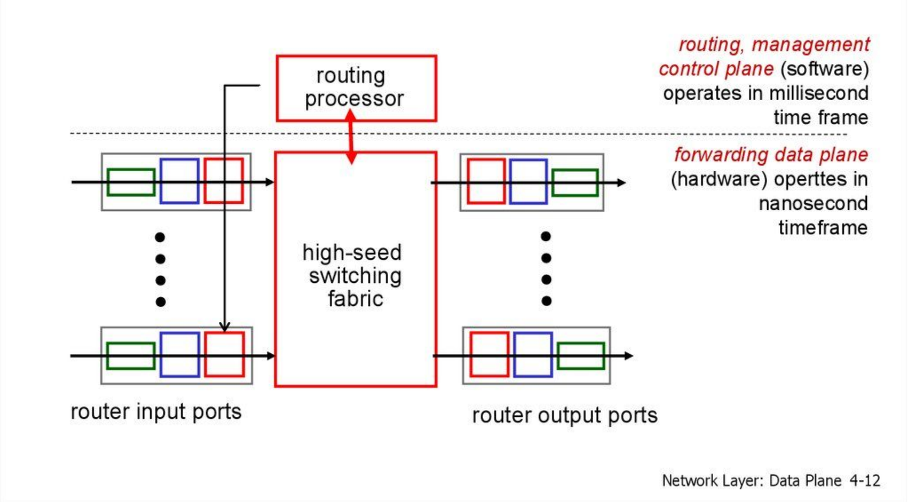
Forwarding Table Representation. [4]



1. Forward packet to port(s)
2. Encapsulate and forward to controller
3. Drop packet
4. Send to normal processing pipeline
5. Modify Fields

Flow Table Entry Representation. [4]

Data Plane

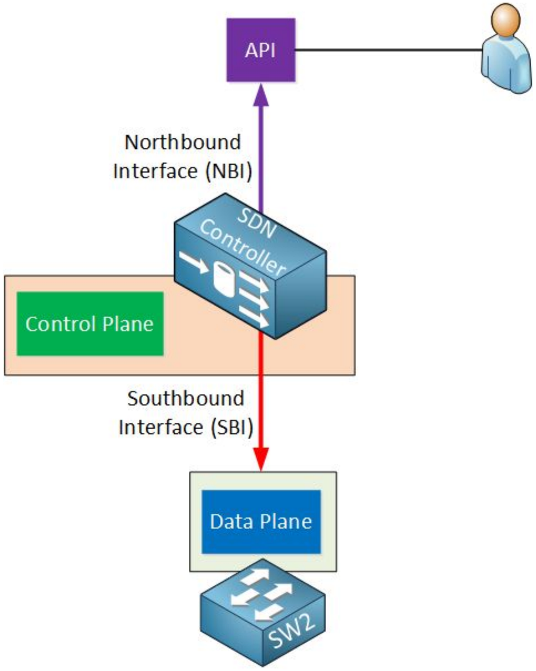


routing, management control plane (software) operates in millisecond time frame

forwarding data plane (hardware) operttes in nanosecond timeframe

Network Layer: Data Plane 4-12

Traditional Router Structure. [4]



SDN Router Structure. [5]

Communicating with the Data Plane

- Since the control plane and data plane are not physically connected on the same piece of hardware they need a means of communication.
- Communication can be achieved through a software interface (API) which can be referred to as the Southbound Interface (SBI).
- The most common SBI in use is the OpenFlow an open-source SDN protocol maintained by the Open Network Foundation.[4]

OpenFlow Protocol Logo. [6]

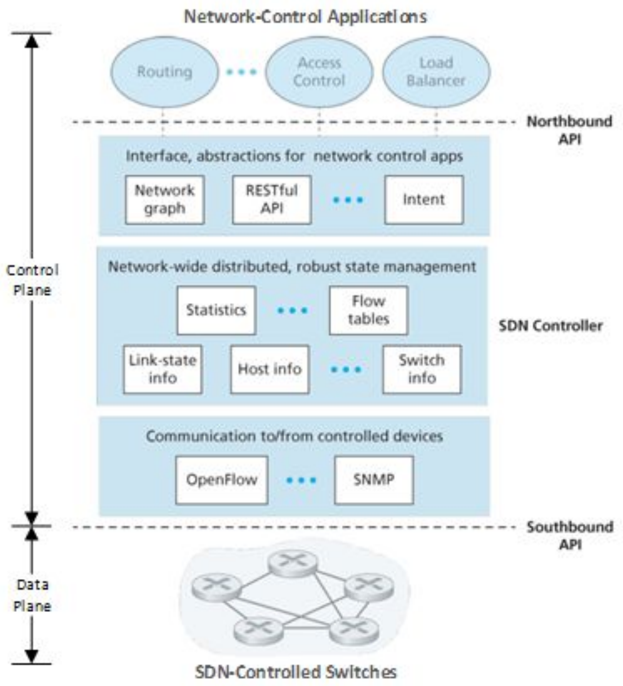
Control Plane [4]

Control plane consists of two components:

- an SDN controller.
- a set of network-control applications.

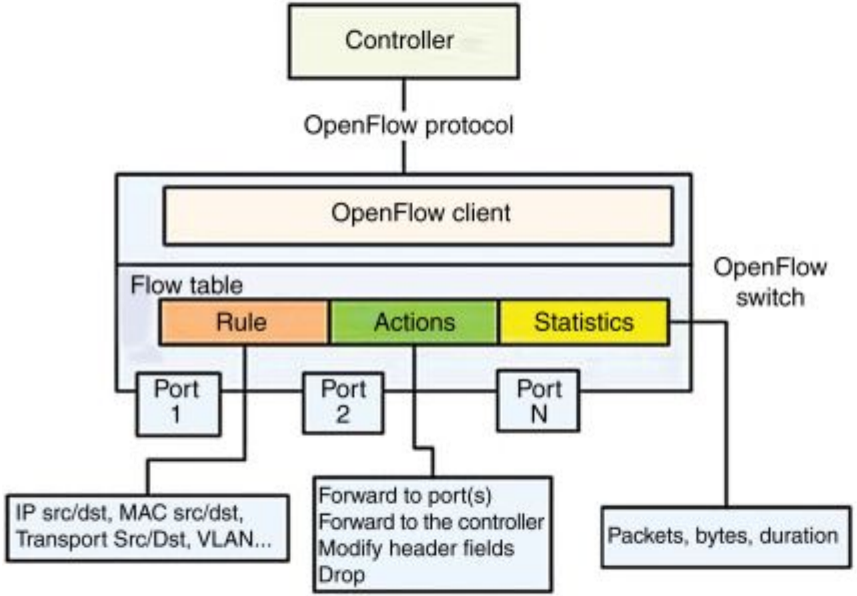
Functions of the Controller:

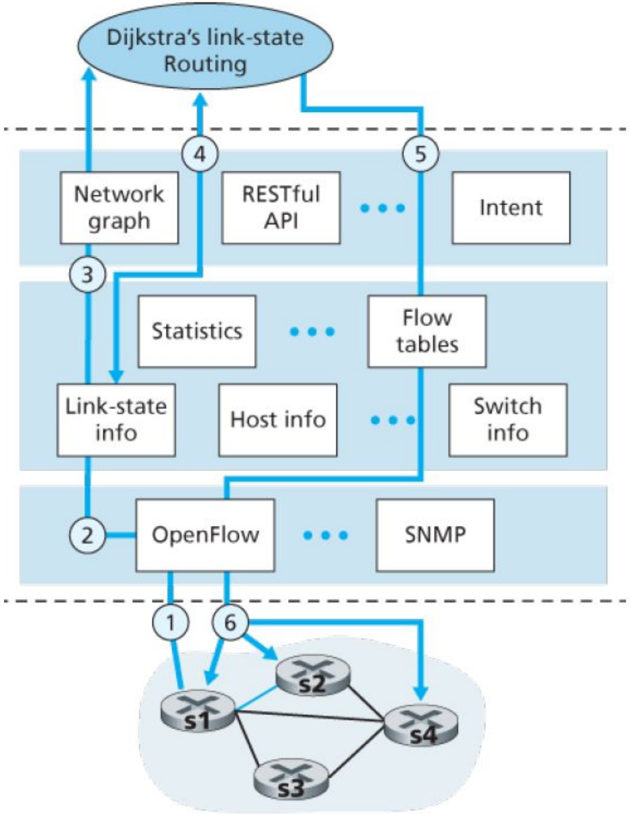
- Getting information from the underlying controlled devices. (**Openflow**)
- Maintaining the information (**Database**).
- Allowing the information to network-control applications. (**REST API**)



Control Plane Overview

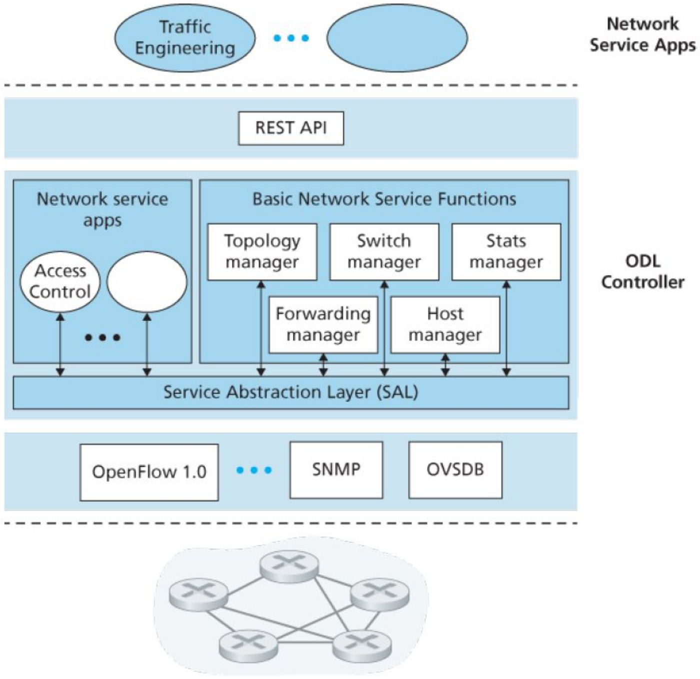
Control-Data plane Interaction [4,7]



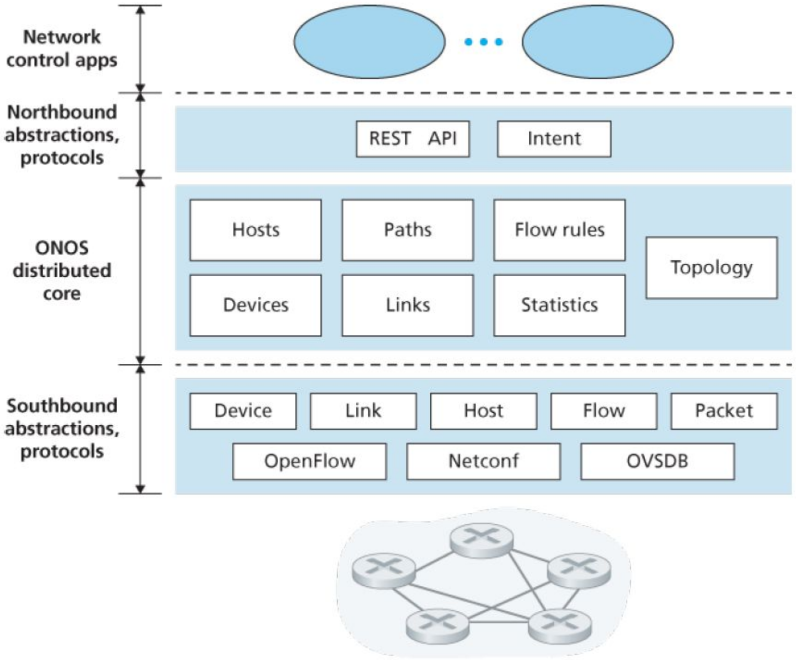


SDN Controllers [4]

OpenDaylight (ODL) controller



ONOS controller



Key points on Control Plane

- Logically centralized.
- Decoupled from the data plane.
- For performance, scalability, and/or reliability reasons,
  - The logically centralized SDN Controller can be distributed.
  - Several physical controller instances cooperate to control the network and serve the applications.

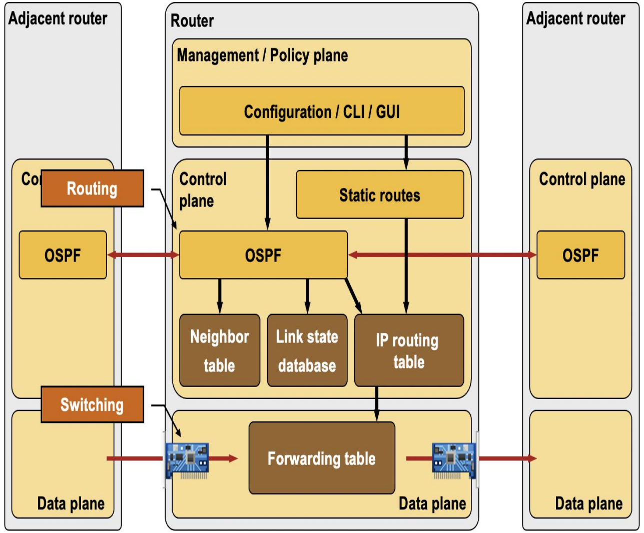
Management Plane

The management plane is the third plane in Software defined Networking

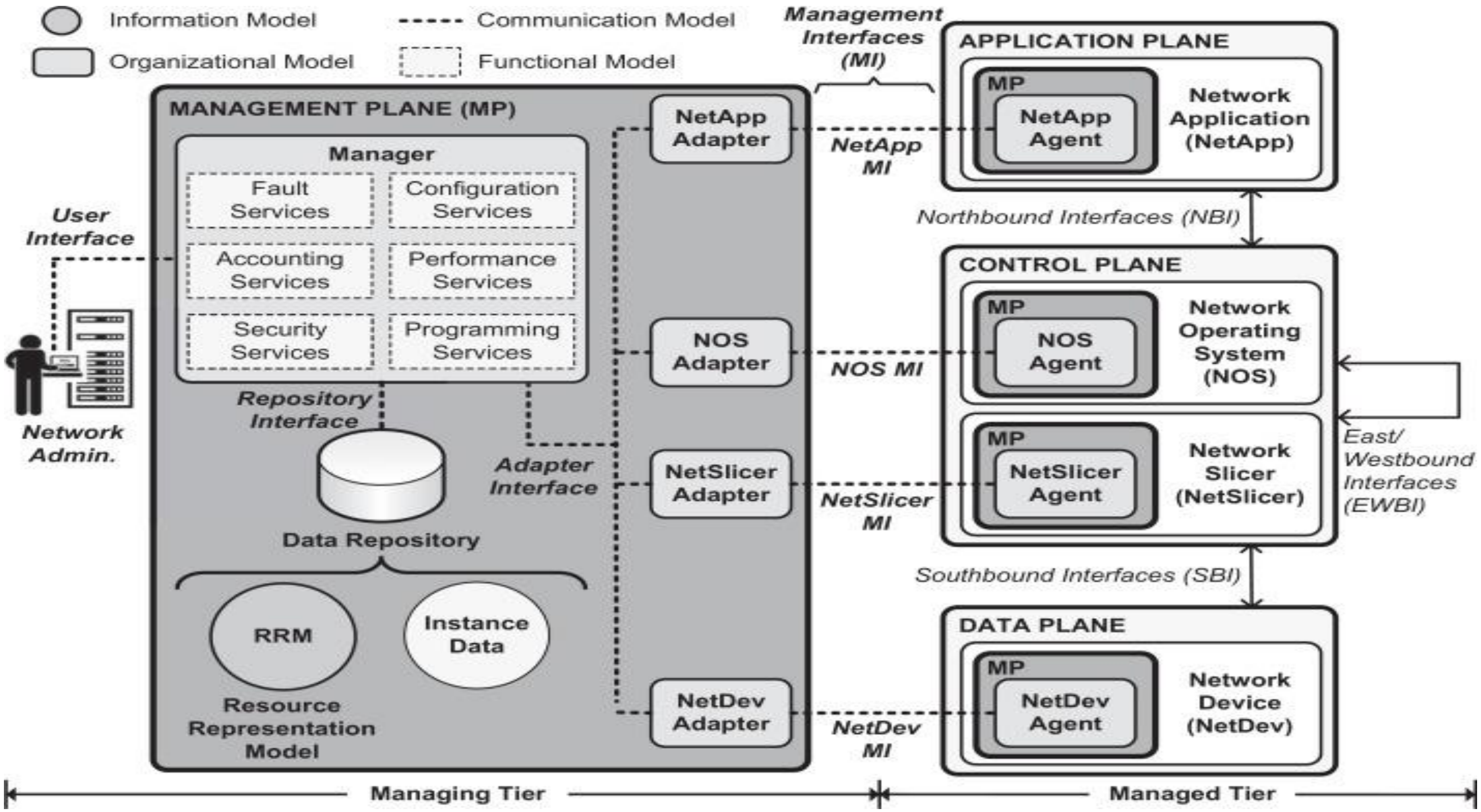
- ❖ The least talked about and most straightforward amongst the other planes in SDN.
- ❖ Contains traffic which is used by the Network admin to control/manage the network.

Functions of the Management Plane

- ❖ It is used to access and configure network operations.
- ❖ It allows protocols like SNMP, NetFlow, SSH and Telnet to monitor, maintain and troubleshoot the network.



SDN Architecture with Management Plane



Importance of Management Plane

- Allows the owner or Network Management System to fully interact and oversee the entire network system.
- Provides a means to ensure orderly running and smooth performance across the Network.
- Creates space for more flexibility in network infrastructure which can vary based on demand.

Network Security

- SDN implementation can enhance the security of a network due to the nature of having a centralized controller.[8]
- By continually collecting network statistics the controller could potentially detect threats ike DDoS attacks and prevent them by editing the flow tables in order to drop the malicious packets.[9]
- Moving Target Defense (MTD) algorithms can also theoretically be implemented in order to periodically change key features of the network to make it difficult for an attacker to understand the network configuration and reach its target.[10]

Conclusion

- **SDN Summary:**
  - Software Defined Networking is essentially the separation and centralization of the control plane for a network.
  - A centralized control plane with Northbound and Southbound Interfaces (APIs) for communication with the application layer and data plane respectively is more flexible and can react to network conditions faster and more efficiently.
- **Importance of SDN:**
  - With the rise of cloud computing and cloud services networks are becoming more complex and traffic patterns are changing.
  - Additional flexibility and troubleshooting capabilities are needed to meet these challenges.

Conclusion

- **Future challenges in SDN**
  - In Software Defined Networking, central controller is in charge of the whole network.
  - To avoid the collapse of the whole network, the central controllers need to be physically distributed with logical coordination between them.
  - The controllers need to be scalable to control and manage growing amount of controlled devices.
  - Open interfaces of the SDN network may bring new type of network attacks which need to be addressed in SDN framework.

References

[1] D. Kreutz, F. M. V. Ramos, P. Verissimo, C. E. Rothenberg, S. Azodolmolky, and S. Uhlig, “Software-defined networking: A comprehensive survey,” arXiv.org, 08-Oct-2014. [Online]. Available: https://arxiv.org/abs/1406.0440. [Accessed: 17-Nov-2021].

[2] K. Benzekki, A. El Fergougui and A. Elbelrhiti Elalaoui, "Software-defined networking (SDN): a survey", Security and Communication Networks, vol. 9, no. 18, pp. 5803-5833, 2016. Available: 10.1002/sec.1737 [Accessed 17 November 2021].

[3] A. Montazerolghaem, "Software-defined load-balanced data center: design, implementation and performance analysis", Cluster Computing, vol. 24, no. 2, pp. 591-610, 2020. Available: 10.1007/s10586-020-03134-x.

[4] J. Kurose and K. Ross, Computer Networking. Harlow, United Kingdom: Pearson Education Canada, 2016.

[5] "Introduction to SDN (Software Defined Networking)", NetworkLessons.com, 2021. [Online]. Available: https://networklessons.com/cisco/ccna-routing-switching-icnd2-200-105/introduction-to-sdn-software-defined-networking#Management_Plane. [Accessed: 20- Nov- 2021].

References Cont.

[6] “OpenFlow,” Open Networking Foundation, 15-Feb-2013. [Online]. Available: https://opennetworking.org/sdn-resources/customer-case-studies/openflow/. [Accessed: 17-Nov-2021].

[7] M. Cello, C. Degano, M. Marchese, and F. Podda, "Smart transportation systems (STSs) in critical conditions," in Smart Cities and Homes, Obaidat and Nicopolitidis Eds. Boston: Morgan Kaufmann, 2016, pp. 291-322.

[8] S. Scott-Hayward, G. O'Callaghan, and S. Sezer, “SDN Security: A survey,” 2013 IEEE SDN for Future Networks and Services (SDN4FNS), 2013.

[9] R. Braga, E. Mota, and A. Passito, “Lightweight ddos flooding attack detection using NOx/openflow,” IEEE Local Computer Network Conference, 2010.

[10] J. H. Jafarian, E. Al-Shaer, and Q. Duan, “Openflow random host mutation,” Proceedings of the first workshop on Hot topics in software defined networks - HotSDN '12, 2012.