Abstract—In a line with the noteworthy growth of the networks (e.g., networks properties and features,) the design of the network become more complex and maybe we cannot achieve these properties and features with the traditional architecture of the networks (e.g., architecture of dedicated monolithic routers and switches that implement both data and control plane.) In some cases, we need to take more complex decisions for routing process and security and managing the network flow and prevent some of the undesirable issues, with relying on the old architecture of the networks we can’t make these decisions. The way we can go through to make these properties of the network easy to achieve is making a change in the ordinary network architecture, making it \_the architecture\_ easier to be configured and be modified and by the way enhance its performance. Making use of the SDN (software defined network) is a great way to get benefit of the desired features of the expected and desired network architecture. SDN is a very rising architecture in today’s networks that is been adapted by a very influential technical institution (e.g., Google that uses SDN to manage the data center from inside and between data centers from outside).

**What is SDN (software defined network)**

SDN is the separation of the control plane and data plane. Control plane (i.e., the area where the routing protocols is performed) functions is performed by the SDN controller and network-control applications network, and the data plane (i.e., the area where the forwarding decision is performed) function is performed by the network routers and switches. This separation makes the process of modifying the network state and protocols done in an easier way than the old architecture (with monolithic data and control plane.) Also, we should mention that this separation allows more security options (i.e., firewall) that we can now achieve by SDN, simply by defining which packets from which sources will be dropped and another function this article will cover like traffic control.

SDN forwarding function is done in a different way. As we learned from the traditional routing algorithms, the packet forwarding decision depends only on the destination IP address (i.e., 3rd layer address). In SDN forwarding scheme, the forwarding decisions depends on many fields not only the IP address, and these fields not only from the IP layer (i.e., but it can also be from data link layer and/or transport layer.) fields from 2nd later like source and destination addresses and from 4th later like source and destination port. And this forwarding decision is done using protocols like OpenFlow protocol that depend on the “match-plus-action” scheme that will be discussed.

**SDN and router-based network**

The main difference between the SDN and monolithic data and control plane architecture is that the SDN dedicate the control plane function to some hardware devices (i.e., SDN controller that deliver configuration data to the underlying routers, and the network-control applications which perform the routing algorithms and network state updates and packet flow decisions.) leaving the only function performed in the network router and switches is the data plane functions which is not the case in the other architecture which the two planes are merged and done in the routers and switches.

Network-control applications

Control plane

App2

App1

App3

Northbound APIs

Data

plan

data

plan

Data

plan

Control

plan

Control

plan

Control

plan

Device 1

Device 2

Device 3

Southbound APIs

SDN

Controller

Data plane

Device

2

Device

1

Device

3

Traditional architecture

SDN architecture

**SDN architecture**

This discussion will be divided into two parts as the SDN consists of two main parts (i.e., the data and control plane.) First, we will talk about control plane and control plane components and the functionality of each component as a part of interactive cooperative system.

Control plane is divided into two parts, the SDN controller and the network-control application:

* Network-control application: the part of the control plane that is responsible for the routing function. These applications take the network information (e.g., the links states and the nodes states form the SDN controller and perform the defined routing algorithm (e.g., Dijkstra algorithm) to determine the shortest path also it is triggered by the SDN controller if there is any change in the network state, in this case the applications make the decision depending on the changes in the network state and pass the appropriate decision to the SDN-controlled routers. We will notify that the SDN controller does not do any routing processes, it is the job of the applications and the SDN controller transfer this routing information to the SDN-controlled routers. Other function the is performed in the applications is the control access (i.e., firewall) that provide the network with some security by defining which packets will be forwards and which will be dropped, and this decision can be performed depending on several information (e.g., the source IP address, and this mean not to receive any data from this host.) The IP address is not the only way to control the access, it can be controlled using the TCP/UDP source and/or destination ports to prevent any date transmissions between hosts and a specific port in transport layer, we will discuss this in more detail when we talk about OpenFlow protocol. Other function done in network-control applications is the load balancing of the network by defining the action taken by matching in the flow table (i.e., tables used by the SDN-controlled routers to determine the action taken by the matching of an incoming data header with an entry of the table) in the SDN-controlled routers. It is done by destitute the routes to a single destination over multiple paths, and this service make use of the counter entry (i.e., entry in the flow table that determine the number of matchings that is done on a specific entry in the table) of an entry in the flow table. By considering the Above graph, we can say the application1 may be the control access application and application2 is the routing and application3 is the traffic controller. Of course this not the only applications can be provided from the SDN architecture, many services can be added to the network and this is one of the most advantage for the SDN over the traditional architecture that we can easily and add and remove modules to enhance the network without making changes in all network parts, for example we do not need to make any change in the routers configuration if we change the routing algorithm used or add a new service to the network, all we do is make the new changes in the control plane (i.e., the network-control application) add pass this change information and parameters the routers of the network through the SDN controller. Changing the routers configuration is not simple, any change in the network that need special router configuration to each router is very complicated problem and it becomes harder if the router is manufactured in different places. So, it is reasonable to make a radical change in the old network architecture, and of course SDN provide an accepted solution to this issue of adding new features and overcome this constrains.
* SDN controller: As comes to mind that the controller plays the role of a link between the controlled-application network and the SDN controlled devices (i.e., The SDN controller defines the data flows between the centralized control plane and the data planes on individual routers and switches.) The controller does the complex functions in the network (with the help of the controlled applications); the controller receives different messages from the SDN-controlled devices (using southbound APIs) and process these messages which may be a message to notify the controller that there is a failed router in the network, or in other scenario may be a message carrying an information of a change in a link in the network. The controller deals with the incoming messages be determining which type is this message and who sent it and by the way the SDN controller can gather the information that will help in determining to which application that the parameters taken from the messages should be passed (using northbound APIs). When the controller receives the message and determining its type, it extract an information from this message that help the application module to handle the issue concerned with this message. And in the other direction, the SDN controller receive the results of the processing done int the application and populate these information in the devices .When we talk about SDN abstraction, we must mention the role that the controller plays to take off the responsibility of constructing the routing table (i.e., flow table) from the SDN-controlled routers. The SDN-controlled routers only are concerned with the execution of the forwarding process depending on the flow table that the controller deliver to it after it has been computed by the routing application (i.e., The controller populates flow tables.) We must mention here that it can be seen that the SDN controller is only one device that control all this functions in the SDN network, but in fact the SDN controller is a combination of many devices that are seen as only one device (i.e., SDN controller is logically centralized but physically distributed.) And this distribution come with many advantages (e.g., distribute the incoming message from either application or the devices over many servers and fault tolerance.) These advantages reduce the delay time in the connection between the application and the devices and make that connection more reliable.

The second part in the SDN architecture is the control plane and it consists of the SDN-control devices the deal with the observed network operation. After talking about the controller and application, we can conclude thar these devices do not make and type of processing in the network, all its function is to deliver the network state information to the controller and receive the changes and the commands from it and perform the data forwarding depending on this information.

Before talking about how actually the control plane and data plane cooperate together, we should first understand how the controller and the SDN-controlled devices talk to each other.