Performance Comparison of File Transfer Protocol Service Between Link State and Distance Vector Routing Protocol in Software Defined Network

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Abstract. Software-Defined Network (SDN) is a new concept in computer networks where the network control function is separated from the data forwarding function (data plane). The control plane and data plane which are separated from each other is the answer for faster, more flexible, and secure internet service. File transfer protocol (FTP) is an internet protocol that runs at the application layer that is used to exchange data between server and client. Open Shortest Path First (OSPF) is a routing protocol for internet networks that belongs to the Interior Gateway Protocol (IGP) group and uses the Link State Routing algorithm (LSR). Routing Information Protocol (RIP) is a type of Distance Vector Routing protocol that is still used today. This study aims to compare the performance of FTP services using OSPF and RIP on SDN networks and conventional networks. The research was conducted with direct implementation on the device with a planned topology. The measurement results show that FTP using OSPF routing has better results than using RIP. FTP that runs on SDN also has a better quality of service value compared to conventional networks.

1. Introduction

Software-Defined Network (SDN) is a new technology on computer networks, where this technology separates the function of the data Forwarding (data plane) with the network control (control plane) which can be programmed. With the SDN, a network infrastructure could have centralized control and more efficiency in the configuration of a network. The separate Control Plane and Data Plane make the network architecture more flexible, cost-effective, and innovative [1, 2]. As shown in Figure 1, it appears that one of the most important things in SDN is the centralized controller, which runs the routing protocol algorithm. In conventional networks, routing protocols are run on each router, so the routing process is determined by the router itself. Research on routing protocol or types of service performance in SDN has been carried out such as using the RIP [3-5] or OSPF routing protocol [6-11]. The research of FTP service on conventional networks is also carried out using various simulations such as bandwidth analysis using [12], FTP over p2p [13], or compare the performance of HTTP services with FTP on simulations using Opnet [14]. Most research is usually done by using a simulator or emulator.
The study aims to compare the performance of FTP services using OSPF and RIP on SDN, as well as on conventional or traditional networks. The research was carried out with direct implementation on the device with a planned topology. Upload and download scenarios on FTP servers, to see whether OSPF and RIP routing protocols could run on FTP services with good results on SDN and conventional networks.

2. Research Method

2.1 Software Defined Network (SDN)
In conventional network technology, where the control plane and the data plane are made in one device, but on the SDN network has two advantages. First, the control plane and the data plane are separated. Second, each device's control plane is put together and put together in a centralized controller. So the controller could control many devices at one command.

As shown in Figure 2, the control plane is centered in the control layer. The centralized controller manages all network devices at the infrastructure layer. Various services in the application layer could run on SDN, through various APIs provided.

The separation between the control plane and the forwarding plane, where the control plane contains RF Client, Quagga, RF Server, and RF proxy, while the forwarding plane uses OpenFlow which is responsible for connecting the Control Plane and the Data Plane. Openflow has become a standard in SDN-based research [15-18].
The function of each block in figure 3 are as follows:

a) RF client functions as a daemon in the VM, it’s a function to detect the changes in Linux ARP and routing tables. When there is a routing update, the routing information is sent to the RF Server.

b) RF Server is a standalone application that holds central control connected to the RF Client. Where RF server makes mapping between RF clients with interfaces, the appropriate switches, and ports.

c) RF Proxy is an Application Controller (POX controller) that forward protocol policies from the RF Server to the data plane.

2.2 Routing Protocol

Open Short Path First (OSPF) is a routing that uses the link-state algorithm, which works effectively on large scale networks. OSPF requires information on the weighting of each link on the network obtained from neighboring nodes. Routing Information Protocol (RIP) is a type of routing protocol that is effective in small scale networks and uses distance vector routing protocols as a reference in determining its path. The OSPF protocol is one of routing Interior Gateway Protocol (IGP) for the internet that is used to distribute routing information across interconnected networks. OSPF collects information for all paths to be passed from an existing router. To determine the shortest path, OSPF requires weighting each link on the network. RIP is one type of routing protocol that is effective in small scale networks and uses distance vector routing protocols as a reference in determining its path. Currently, RIPv2 also supports Ipv6 [19].

2.3 File Transfer Protocol (FTP)

File Transfer Protocol (FTP) is an internet protocol that runs at one application layer, it’s a function to exchange data between servers and clients in a network. FTP before sending data, communication session will occur first in the transport layer using TCP. Usually, FTP uses two ports, port 20 and 21. Port 21 is used to “listen” and port 20 for the data line. FTP provides users access to a large number of concurrent accesses by computer. In this research, the FileZilla application is used to implement the FTP server and client.
3. System Model

3.1 Network Topology Design

The hardware and software are used in this study consisted of 2 laptops, each of which was used as a controller and FTP client, 5 switches as data planes, and some software with the specifications are listed in table 1.

| Component                | Specification                                      |
|--------------------------|----------------------------------------------------|
| Controller device        | Intel(R) Core(TM) i5-6200HQ CPU @ 2.30GHz, RAM 12GB, NVIDIA GeForce 920M |
| Forwarding plane         | 6 Switch TP-Link WR1043ND v1                       |
| Router                   | 5 Mikrotik RB951Ui-2nd, RAM 64 MB                 |
| Operating system         | Ubuntu 12.04 LTS 32 bit & Ubuntu 12.10 Quantal 64 bit (Mininet) |
| Virtual machine          | Vmware                                             |
| Emulator                 | Mininet                                            |
| Openflow Controller      | POX controller                                     |
| FTP software             | FileZilla                                          |
| Routing engine           | Quagga                                              |

The first network topology design is implemented on a conventional network using five Mikrotik RB951Ui routers that function as data planes as well as control planes. Figure 4 shows a FileZilla-based FTP server and FTP client on the other side. Topology is designed to provide several routing alternatives, so the OSPF and RIP routing protocols could determine the best route. On conventional networks, it does not have a centralized controller like the SDN network, because the device itself regulates where the data flow must be sent.

![Figure 4. Conventional Network Topology](image)

In the second scenario is designed SDN-based network topology. In figure 5, a computer is functioning as a control plane with route flow software installed in it. The data plane function uses 5 conventional switches that are adjusted to support SDN. Openflow is used to connect between the control plane and the data plane. Unlike the conventional network, SDN simply uses a switch as a data plane for a different network.
Figure 5. SDN Network Topology

3.2 Measurement Parameters

The examination in this study uses the ITU G.1010 standard as in Table 2. The measured test parameters are throughput, delay, and packet loss. Using FTP services from server to client. The test scenario is comparing OSPF and RIP routing protocols in conventional and SDN networks. Network conditions are adjusted to real conditions by adding background traffic from 0 Mbps to 100 Mbps. The test is conducted 30 times for each measurement point and the average measurement results are taken.

Table 2. Measurement parameters [20]

| No | Parameter   | ITU-T G.1010                           |
|----|-------------|----------------------------------------|
| 1  | Throughput  | NA                                     |
| 2  | Delay       | Preferred <15s, acceptable < 60 s      |
| 3  | Jitter      | NA                                     |
| 4  | Packet Loss | 0%                                     |

Throughput is the rate of data that is successfully delivered to the receiver over a communication link during a certain observation time. Throughput is measured in bits per second (bps). The higher throughput means better network performance. The formula to measure the throughput is written as below.

\[
Throughput = \frac{R_s}{L_o}
\]  

(1)

Where:
Rs = The data that are successfully received by the receiver.
Lo = length of observation time.

Delay is the time taken by data to travel across the network from sender to receiver. Delay is measured in the second unit. The higher delay cause quality of service in the network more unacceptable The formula to measure the delay can be written as below.

\[
Delay = Tr - Ts
\]  

(2)

Where:
Tr = The time when data is received
Ts = The time when data is sent
Packet Loss is defined as the percentage of data fail to reach it’s intended destination during transmission. Several reasons cause packet loss in a communication network, such as network congestion, software bugs, the problem with network hardware, and security threat. Packet loss and throughput are opposite on each-other, high packet loss causes low throughput at receiver. The formula to measure packet loss can be written as below.

\[
\text{Packet loss} = \frac{Pt - Pr}{Pt} \times 100\%
\]  

Where:
Pt = Transmitted data from sender
Pr = Received data at the receiver

### 3.3 Port Configuration

The port on the TP-Link WR1043ND v1 wireless router device is configured by separating the ports that are connected to the controller, port for configuration, and port for the Local Area Network. The configuration is conducted on WAN port which has been set before. The configurations in open vSwitch are dpid, IP controller, OpenFlow version. In this research using Open vswitch version 2.3.90, while the Open Flow (OF) version supports OF 1.0, OF1.1, OF1.2, or OF1.3. For the OpenvSwitch configuration as shown in Figure 6.

![Figure 6. OpenvSwitch Configuration](image)

To check the OpenvSwitch configuration results, can use the "ovs vscctl show" command, then the results are like in figure 7. From figure 7, we can see some information that we can check, such as the IP controller, interface of each ethernet port that has been set up to ensure that each port runs properly.

![Figure 7. Open Switch Configuration Results](image)
4. Results and Discussion
This section discusses the measurement results in a predetermined test scenario. Shown in figure 8 results of SDN implementation. Network conditions are adjusted to real conditions by adding background traffic from 0 Mbps to 100 Mbps with an addition every 20 Mbps each test. Adding background traffic is using the Iperf application. The bandwidth topology is set at 100Mbps according to gigabit ethernet device specifications.

![Figure 8. Results of SDN network implementation](image)

4.1 Delay
Delay is the time of sending packets from one source point to the destination point. The delay measured in this study is a one-way delay from FTP server to the client. The measurement results of delay in figure 9 show that conditions without background traffic, the smallest delay is owned by the OSPF protocol on the SDN network that is equal to 95ms, then followed by the RIP protocol on SDN of 97 ms. Delay in OSPF and RIP in conventional networks yields the same value, which is 105 ms. Adding background traffic to all protocols causes an increase in delay, which is near linear. Overall, the smallest delay is generated by the OSPF protocol on SDN, followed by RIP on SDN, OSPF on conventional networks, and finally, RIP on conventional networks. Overall, the delay value still meets the ITU-T G.1010 standard for data services.

![Figure 9. Delay measurement results](image)

4.2 Throughput
Throughput is a comparison between the number of packets received per observation time. By another definition, throughput is the average speed of data received by a node in a certain observation interval. Throughput measurements are conducted by providing background traffic from 0 Mbps (without background traffic) to 100 Mbps with an increase every 20 Mbps. In the initial condition without
background traffic, OSPF protocol in SDN provides the greatest throughput value, which is 93.4 Mbps, followed by RIP in SDN that is 84.2 Mbps, OSPF in conventional networks that are 82.5 Mbps, and RIP in conventional networks that are 80.5 Mbps. Adding background traffic causes a reduction value of throughput for all conditions. However, on 100Mbps background traffic, OSPF in SDN still has the best throughput value followed by RIP in SDN. OSPF and RIP in conventional networks have almost the same value. For overall results can be seen in Figure 10.

![Figure 10. Throughput measurement results](image)

### 4.3 Packet Loss
Packet loss is the percentage comparison between the number of packets that have failed to send and the number of packets that have been sent successfully. The greater the value of packet loss, of course, further reduce the value of network QoS. From the examination results that have been conducted for all scenarios, it is found that the value of packet loss is 0%. This means that almost no packet data is lost or failed. This reminds us that the FTP service uses TCP protocol instead of UDP. TCP has the characteristic to repeat sending failed packets until all packets arrive at the destination node.

### 5. Conclusions
In this study, we have succeeded in implementing the FTP service at SDN on conventional devices that exist today. The separation between the control plane and the data plane was successful and the FTP service was able to run well on SDN. QoS measurement results such as delay and throughput, show that FTP runs on SDN have a better QoS value compared to conventional networks. FTP services that use OSPF (link-state routing) routing on SDN have better results than using RIP (distance vector) on SDN. From four test scenarios, the routing protocol that has the best QoS in the sequence is the OSPF protocol in SDN, RIP protocol in SDN, OSPF protocol in conventional networks and finally RIP protocol in conventional networks.

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