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Research paper

Performance Comparison between TCP and UDP Protocols in Different Simulation Scenarios

Fahad Taha AL-Dhief[1], Naseer Sabri[2], N. M. Abdul Latiff[1], Nik Noordini Nik Abd. Malik[1], Musatafa Abbas Abbood Albader[3], Mazin Abed Mohammed[4], Rami Noori AL-Haddad[5], Yasir Dawood Salman[6], Mohd Khanapi Abd Ghani[7], Omar Ibrahim Obaid[8]

[1]Faculty of Electrical Engineering, Department of Communication Engineering, Universiti Teknologi Malaysia, UTM Johor Bahru, Johor, Malaysia
[2]Computing and Information Technology, Sohar University,
[3]CAIT, Faculty of Information Science and Technology, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia,
[4]Planning and follow up department, University headquarter, University of Anbar,
[5]Faculty of Information Science and Technology, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia,
[6]Human-Centered Computing Research Lab, Universiti Utara Malaysia, Kedah, Malaysia,
[7]Biomedical Computing and Engineering Technology (BIOCORE) Applied Research Group, Faculty of Information and Communication Technology, University Teknikal Malaysia Melaka, Malaysia
[8]Department of Computer, Collage of Education, AL-Iraqia University, IRAQ
**Corresponding Author Email: fahadtaha37@yahoo.com*

Abstract

User Datagram Protocol (UDP) and Transmission Control Protocol (TCP) are a transportation layer routing protocols which are considered of the core protocols of the internet protocol suite. The behaviour of these routing protocols with different network metrics and scenarios is still not very clear. Therefore, this paper presents a comparison of the performance of both TCP and UDP to precisely determine which of these protocols is better. Network Simulator version 2.35 (NS2) is utilized to analyse and evaluate the performance for both TCP and UDP protocols varying in the packet size and the bandwidth. In this study, we have used two scenarios, in the first scenario the bandwidth has been changed with fixed packet size and in the second scenario the packet size has been changed with fixed bandwidth to precisely verify the performance of these protocols. These protocols were examined in terms of the rate end-to-end delay, rate throughput, packet delivery ratio, and packet loss ratio

Keywords: *UDP, TCP, Different simulation scenarios, NS2*

1. Introduction

A computer network is a service that uses to share audio, video and photo and other data between the laptops, computers and any smart devices can connect to the network. It is also used to share the network resources like the printer. TCP and UDP protocols are approved to work on transport layer of a network. They handle with the data differently [1]. TCP uses a connection oriented way to handle the data thus provides a very reliable way of handling messaging or information where it guarantees the delivery of the message. If there is some error in the transmission, the packet will be automatically re-sent over the network [2]. UDP utilizes a simple transport model with a minimum of protocol technique. Computer applications with the UDP can transmit messages, in this situation, indicated as an datagrams, and also can send voices and videos [3]. In [4], the authors have been presented a performance comparison among UDP and TCP in MANET to evaluate the conduct of DSDV, DSR, and AODV protocols. They implemented the comparison between the protocols using NS2 to analyze protocols performance, where the results have shown that TCP in some mobility models is outperformed the UDP in terms of throughput. Also, the DSDV has shown lowest delay in all simulation for UDP. This study [5] has provided performance assessment among DSR and AODV protocols in the mobility paradigm with UDP and TCP traffic sources. The results have been referred that the performance of AODV protocol is outperformed the performance of DSR protocol in the high mobility environments. Moreover, in [6] the authors have provided a performance comparison among UDP and TCP for TORA and OLSR in various mobility conditions. The authors used NS2 simulator to evaluate and analyze protocols performance based on the various performance measures like throughput, packet delivery percentage and end-to-end delay. The results have referred that TCP is outperformed UDP in terms of the throughput. Furthermore, TORA protocol in UDP is outperformed TCP in the PDR. However, there are many comparisons of routing protocols but still, there is a need to carefully study the protocol performance in several scenarios. For instance, an improper routing protocol for the specific network scenario result in degraded performance of that network. Wherein in [7], the authors have presented a comparison between OLSR and LAR protocols for detecting the forest fire and results showed that LAR has outperformed OLSR. In this regard, a review of routing protocols has been presented in the surveillance of the forest fire and study the performance of those protocols in this disaster [8]. Moreover, a comparison among DSDV, AODV, and DSR has been presented with a different number of nodes in [9].

This work [10] addresses a comparative study between the performance of UDP and TCP tunnel connections in OpenVPN. Two scenarios have been simulated to test two mechanisms of VPN tunnelling. The results have shown that the tunnel of UDP uses the link better than TCP tunnel and give improved transfer in terms of the speed and the time. However, there is still a need to clearly study the performance of UDP and TCP in different network metrics and scenarios. Thus, this paper provides the performance comparison among UDP and TCP to precisely study the performance of these two protocols with different packet size and bandwidth.
The remainder of the paper as follows: Section 2 shows a comparative study of UDP and TCP behaviours. Section 3 presents the simulation scenarios. Section 4 shows the performance metrics. Section 5 is about the network metrics for the simulation. Section 6 discusses the simulation results for UDP and TCP. Finally, Section 7 presents the conclusion of the paper.

2. Comparison Study between TCP and UDP

TCP is represented as a connection-oriented protocol, TCP presents end-to-end communications. Moreover, when the communication is created among the transmitter and receiver, the data can be send over that communication. While the UDP is a simple connectionless protocol. UDP does not constitute a dedicated end-to-end communication among the transmitter and the receiver before the real communication takes place. However, the data is being transported in one trend from the transmitter to the receiver with no need to verifying the receiver case. [11, 12]. Figure 1 shows the segment fields of TCP and UDP.

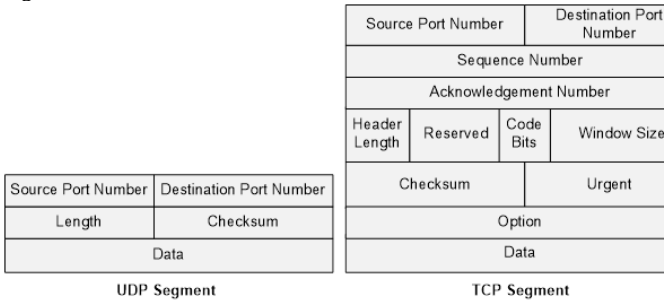

Fig. 1. The Segment Fields of TCP and UDP

The UDP and TCP are various on the basic operations and applications. The differences in the data transmission, the TCP presents ordered and reliable delivery of data from the user to the server and vice versa. UDP considered as a connectionless protocol and does not provide the reliable delivery for the data. UDP and TCP are various from each other in terms of the basic features for the data transmission [13]. However, TCP is more reliable comparing to the UDP, where TCP uses the retransmissions and the message acknowledgment if there is some loss in the packets. Therefore, there is no losing data in the network. While in the case of UDP does not guarantee that the data has arrived to the receiver or not. Also, in UDP there is no retransmission, timeout and message acknowledgment. TCP transmits the messages in an order and these messages are received in the same order at the destination. If the packets of the data reach in the wrong order, TCP can reorder the data packets. Whilst in UDP, the sequence of the message is not maintained over the transmission. TCP records the data as a stream of bytes and sending the message as segments. The messages in UDP are sending as datagrams in the network. So, both of TCP and UDP have various approaches of sending and receiving the data [14,15,16]. Figure 2 shows a comparative among TCP and UDP.

TCP	UDP
Keeps track of lost packets. Makes sure that lost packets are re-sent	Doesn't keep track of lost packets
Adds sequence numbers to packets and reorders any packets that arrive in the wrong order	Doesn't care about packet arrival order
Slower, because of all added additional functionality	Faster, because it lacks any extra features
Requires more computer resources, because the OS needs to keep track of ongoing communication sessions and manage them on a much deeper level	Requires less computer resources
Examples of programs and services that use TCP: - HTTP - HTTPS - FTP - Many computer games	Examples of programs and services that use UDP: - DNS - IP telephony - DHCP - Many computer games

Fig. 2. The Comparison between TCP and UDP [17,18]

3. Simulation Scenarios

We have utilized NS2 simulator in this study to evaluate and analyze the behavior of both TCP and UDP protocols. This simulation has been presented two wired scenarios to carefully verify the behavior of these protocols. Where in the first scenario the bandwidth is varied from 0.1 Mb/ms to 0.5 Mb/ms and the packet size is fixed at 64 bytes. While in the second scenario the packet size is varied from 800 bytes to 1000 bytes and the bandwidth is fixed at 0.3 Mb/ms. Simulation parameters shows in table 1. The nodes number in this study is 8 and the simulation time is 64 second in both scenarios [19,20]. Figure 3 illustrates the wired simulation environment.

Table 1. Simulation Parameters

Parameters	Values
Simulator	NS 2.35
Number of Nodes	8 Nodes
Simulation Time	64 Sec
Protocols	TCP and UDP
The Bandwidth in 1st Scenario	0.1, 0.2, 0.3, 0.4, 0.5
The Packet Size in 1st Scenario	64
The Bandwidth in 2nd Scenario	0.3
The Packet Size in 2nd Scenario	800, 850, 900, 950, 1000

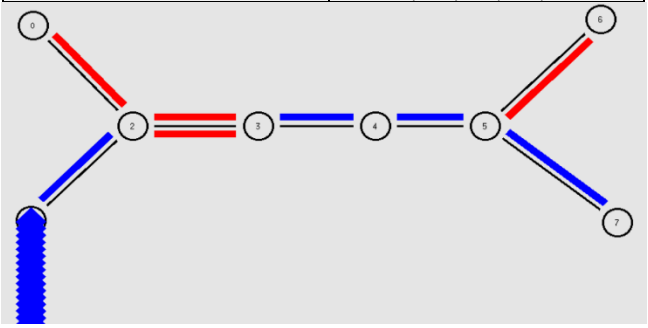

Fig. 3. The Simulation Environment

4. Performance Metrics

In our comparison, we have utilized various network behavior metrics among UDP and TCP. These metrics are applied to evaluate and analyze protocols performance [21,11].

4.1 Packet Delivery Ratio (PDR)

PDR is the percentage of data packets transported to the destination to those produced by the sources. PDR is calculated as follow:

$$\text{PDR}\ (\%) = \frac{\sum \text{No of packet received}}{\sum \text{No of packet sent}} * 100 \qquad (1)$$

4.2 Average Throughput (TP)

It is the bytes successfully received number and it is calculated as follow:

$$TP = \text{No. of Bytes Received} * 8 * \text{Simulation Time} * 1000 \text{ kbpsb} \quad (2)$$

4.3 Average End-to-End Delay (e2e delay)

It is the mean time of the successfully transmitted data packet over the network from the source to the destination. It is computed as follow:

$$\text{e2e delay} = \frac{\sum \text{arrive time} - \text{send time}}{\sum \text{number of connection}} \quad (3)$$

4.4 Packet Loss (PL)

It is the difference among the data packets transmitted and the data packets received. It is calculated as follow:

$$PL = \text{No. of Data Packets Sent} - \text{No. of Data Packets Receive} \quad (4)$$

5. Network Metrics

In this our simulation, there are two various kinds of network parameters which are varying through the simulation experiments:

• Bandwidth: It is the data number that transfer from the source to the destination.

• Packet size: A packet is the unit of data which is routed between the source and destination.

6. Simulation Results and Discussion

In this simulation, we have analyzed and compared the TCP and UDP protocols utilizing NS2 in two scenarios. The first scenario has been simulated in different bandwidth and in the second scenario we have used different packet size. According to the results obtained in the first scenario, the performance of both protocols has been much different from each other. Where in Figure 4 the TCP has achieved 700.71 of throughput and UDP has achieved 687.1 that means TCP receives data more than UDP. Figure 5 indicates the behavior of the protocols in the e2e delay, where TCP has been achieved average e2e delay to 0.62018 sec and UDP has been achieved 0.98376 sec. It is obvious, there is no huge difference between the protocols in e2e delay. In terms of PDR as shown in Figure 6, the behavior of TCP showed much better than UDP, where TCP has been obtained 100% of the network and UDP has obtained 4.04 of PDR. However, TCP has 0% of PL and UDP has 95.96 as shown in Figure 7. Therefore, the results in the first scenario have shown that TCP is much better than UDP in terms of all performance measures.

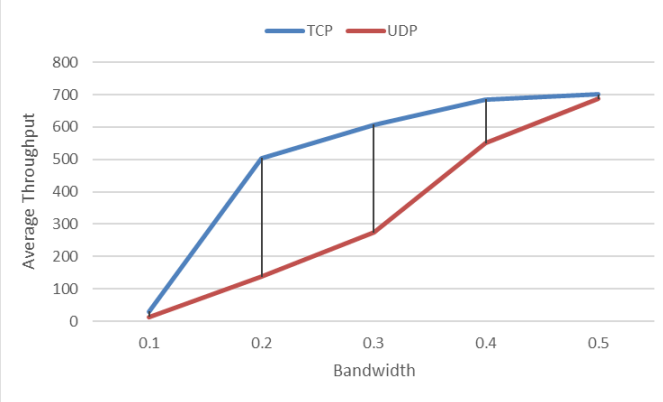

Fig. 4. TP versus Bandwidth

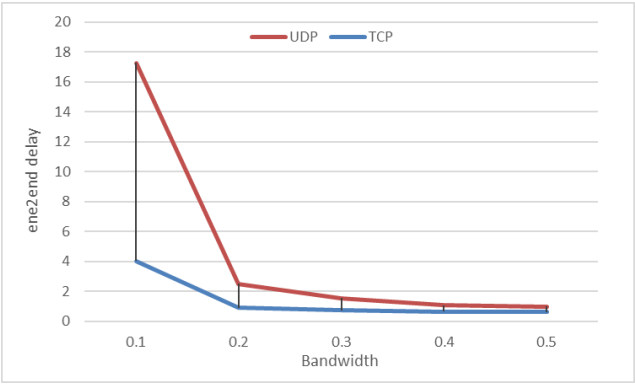

Fig. 5. e2edelay versus Bandwidth

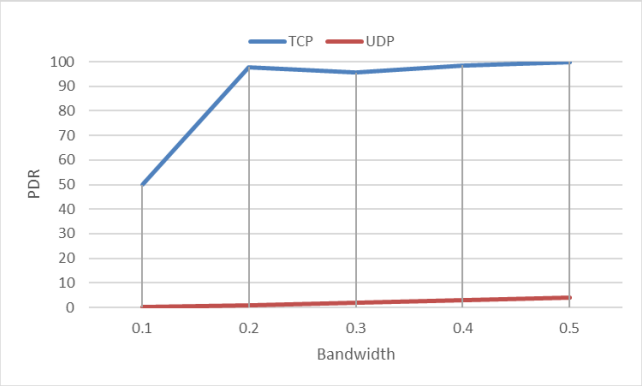

Fig. 6. PDR versus Bandwidth

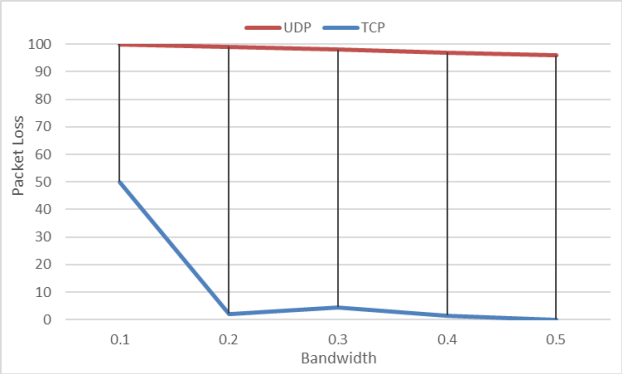

Fig. 7. PL versus Bandwidth

In the second scenario, it has been used different packet size in both protocols. The results have shown that the behavior of TCP is outperformed behavior of UDP in mean throughput as shown in Figure 8, where TCP has 580.67 of throughput and UDP has 302.67. Figure 9 shows the performance of the protocols in average e2e delay, TCP has achieved 0.93883 sec and UDP has achieved 2.84602 sec. Thus, TCP performance is faster than UDP in send and receive the data. In Figure 10, the performance of TCP is outperformed UDP in the PDR, where TCP has been achieved 95.7 value of PDR and UDP has achieved 3 of PDR. However, Figure 11 illustrates the behavior of the protocols in PL, TCP has achieved 4.74 of PL and UDP has achieved 97 value of PL. Therefore, the results in the second scenario have shown that TCP is much better than UDP in terms of all performance metrics.

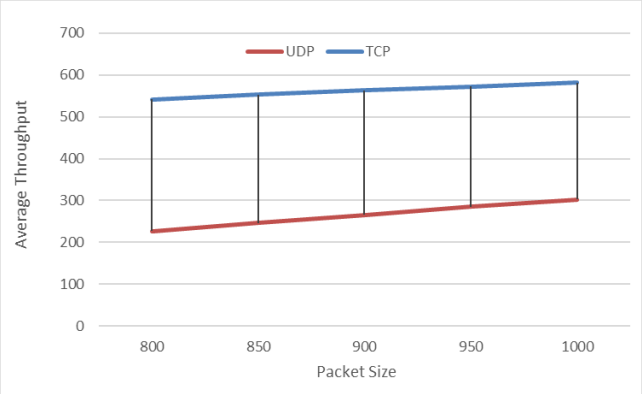

Fig. 8. TP versus Packet Size

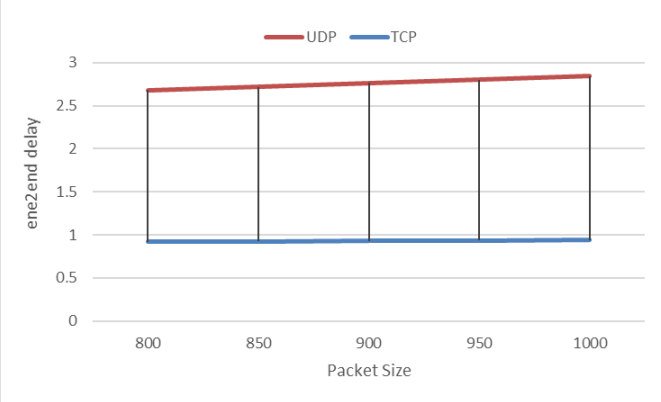

Fig. 9. e2edelay versus Packet Size

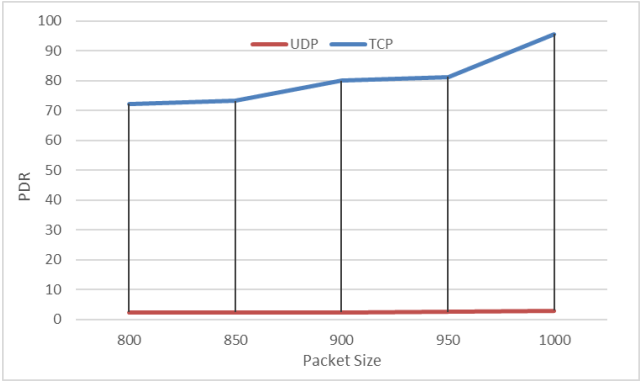

Fig. 10. PDR versus Packet Size

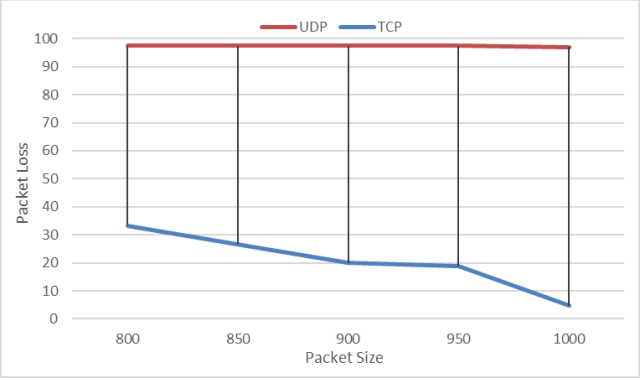

Fig. 11. PL versus Packet Size

7. Conclusion

TCP and UDP are a transportation layer protocols which are considered of the basic protocols of the internet. The performance of these protocols in various network parameters and scenarios is still not so clear. Therefore, in this paper, we have analyzed and compared the behavior of both TCP and UDP in two different scenarios to accurately determine which of these protocols is better. The simulation has been used NS2 to assess the behavior of TCP and UDP in varying packet size and bandwidth. These two protocols were measured in terms of the mean end-to-end delay, mean throughput, packet delivery percentage, and packet loss ratio. The results have shown that the performance of TCP is outperformed the UDP in both of the two scenarios. Therefore, this paper concluded that the TCP is more reliable and better than UDP in terms of all the performance measures. Future work includes the evaluation of the TCP with other layer protocols in other different scenarios such as changing the number of nodes or the simulation time.

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