Comparative Study on the Performance of TFRC and SCTP over AODV in MANET

Shahrudin Awang Nor, Omar Dakkak

InterNetWorks Research Laboratory
School of Computing
College of Arts and Sciences
Universiti Utara Malaysia
shah@uum.edu.my, oaldakkak@gmail.com

Abstract. This study aims for comparative study on the performance of two transport protocols in MANET environment, i.e. TFRC and SCTP. As one of the features in TFRC, fairness attracts real time applications, whereas multi-homing and multi-streaming features in SCTP attract multimedia applications to use it as their transport protocol instead of TCP and UDP. However, the challenge faced by TFRC which uses additive increase is to adjust the sending rate during periods with no congestion which may lead to the short term congestion that can degrade the quality of voice applications. On the other hand, SCTP faces challenges in the best-effort network. The simulation study is conducted in two scenarios; the first one is without the presence of background traffic which is single traffic, while the second one is with the presence of background traffic, which is non-single traffic. In the simulation using *ns-2* simulator, the mobility of the nodes is set random and the traffic type is CBR. In both scenarios, SCTP has better performance in terms of throughput, whereas TFRC has less delay than SCTP. AODV was chosen as a routing protocol for TFRC and SCTP with throughput and delay as the performance metrics.

Keywords: Performance evaluation, TFRC, SCTP, AODV, MANET

1 Introduction

A Mobile Ad hoc Network (MANET) is a self-arranging network that uses wireless links to connect itself together. Due to the MANET environment, sensors keep moving freely and arrange themselves randomly. MANET is capable to perform well in a full independence style, or can be linked to large scale Internet network. Due to the minimum configuration as well as the rapid deployment that it has, MANET is suitable to be used for military operations, emergency medical situations and disasters.

Tremendous efforts also have already done for Transmission Control Protocol (TCP) in MANET. Consequently, an end-to-end Delay-Based Loss Discrimination mechanism for TCP over a wireless ad-hoc network is proposed [1] **.** A survey has been done about open issues that TCP faces in MANET, as well as recent studies to

improve MANET performance [3]. More research would be needed for TCP-Friendly Rate Control (TFRC) as defined in RFC 5348 and Stream Control Transmission Protocol (SCTP) as defined in RFC 4960 in MANET because they are more modern protocols compared to TCP that definitely requires further research. TFRC is defined in RFC 5348 and SCTP is defined in RFC 4960.

This paper is organized as the following: Section 2 reviews briefly the reviews the related works related to the study. Sections 3 describes the experiment design explaining the scenario and declare all the parameters value, then followed by simulation in Section 4. Section 5 shows the results and discussion. Finally, Section 6 concludes the paper and recommends the future works.

2 Related Works

There are a lot of work have been done to improve the TFRC and SCTP in MANET. However proposing new mechanisms for TFRP and SCTP are beyond the scope of this research.

The TFRC limitation is discussed by Ha et al. in [2]. The target for their research is to identify the reason why TFRC keeps sending rates with non-similar averages. The reason is because of the loss and delay rate estimation which affected these rates. However, this study was not conducted on MANET.

The limitations of an equation-based congestion control of TFRC is discussed in [3]. The target for the research was to check why TFRC keep sending rates with non-similar averages. The reason was because of the loss and delay rate estimation which affected these rates.

There is a study [4] on the performance of TFRC on MANET in terms of throughput fairness and flexibility when comparing to TCP flow. The study showed the ability to keep the smoothness for TFRC with less throughput rates. The study also included static and dynamic simulations. Two to seven nodes were created for static case. For dynamic case, 50 nodes were created for 600 m × 600 m and 60 nodes for 1500 m × 300 m. The aim was to get visions on TFRC in MANET with Dynamic Source Routing (DSR) as a routing protocol, and without routing protocol.

A comparison study [5] between TFRC and TCP in MANET over Ad hoc On-Demand Distance Vector (AODV) and DSR in terms of throughput, delay and jitter, the traffic is CBR with random mobility with three speeds (5, 10, 15), the conclude of the study that even though DSR gives better performance for TFRC (in terms of throughput) and the same performance for TCP, but both TFRC and TCP better to use AODV because DSR causes much more jitter and that affects the performance badly especially for multimedia applications.

A comparison study [6] is conducted to measure the performance of SCTP and User Datagram Protocol (UDP) over MANET using Network Simulator (*ns-2*) [7]. The traffic type is CBR, with 12 nodes, the distance between them is 240m with packet size 1000bytes the routing protocols is AODV. It was found that SCTP is better than UDP in terms of throughput and jitter while UDP is better in terms of delay only.

There is also a research [8] to study the performance for SCTP and TCP over MANET. The simulations were performed for three combination of multihoming/mobilitycases–No Multihoming, Mobile; Multihoming, Mobile; and Multihoming, Stationary nodes. The study showed that the behavior of SCTP and TCP in MANETs is similar, but TCP outperforms SCTP in most cases because of extra overheads present in SCTP.

3 Experiment Design

For the purpose of running the experiment, a network topology has been created in a network simulator. A simulation environment has been selected instead of setting up an actual network with real equipment due to the ease of varying different parameters of the environment and observing the results compared these results in each protocol for specific node's positions type together *ns-2* has been selected in this project due to its versatility and ease to use. Also, the fully functional *ns-2* is an open source tool that can be used freely. Figure 1 shows the topology whereas Table 1 shows the simulation metrics.

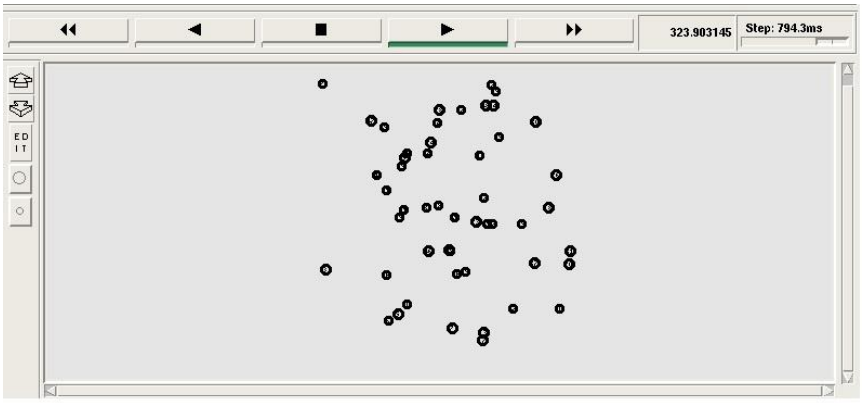

Fig. 1. Simulation topology.

The first set of experiments was carried out in TFRC with mobility positions where random movement for the nodes simulates the movements of the people. This experiment had been implementing in two modes. The first mode is when there is no background traffic is running. It is called No Background, i.e. when two nodes are transferring data to each other using TFRC, the other nodes are just moving randomly without sending or receiving any data. The second mode is when there is a background traffic is running. It is called With Background, i.e. when two nodes are transferring data with TFRC, some of the other nodes send and receive packets using UDP. UDP is selected as a default transport protocol for the background traffics.

In the previous modes, the simulation was executed in three different speeds for each mode, also the simulation was repeated 10 times to get the most accurate results. Same as for SCTP, the first set of experiments was carried out in mobility positions

where random movement for the nodes simulates the movement of the people. Same as for TFRC, this experiment is also implemented in two modes, the first mode is called No Background, and the second mode is With Background. UDP is as a default transport protocol. In the previous modes the simulation was carried out in three different speeds for each mode with 10 times of simulation.

4 Simulation

Firstly, in the mobility nodes position, the number of total nodes is 50. In both With Background mode and No Background the pause time is 0 (p=0), while the speed in m/sec of the nodes is (s=5) for the first simulation, (s=10) for the second one and for the last one (s=20). In No Background mode the total of nodes are 50 as mentioned earlier, two nodes transferring data using TFRC at the first time then using SCTP, while the other 48 nodes are just moving. For the With Background mode, there are two nodes transferring data using TFRC at the first time then using SCTP, while there are eight nodes sharing the wireless channel using UDP and the rest of nodes are just moving without sending any packets.

So the previous scenarios simulated the performance for throughput and delay for TFRC and SCTP with packet size 1000 bytes, packet rate is 0.01 Mbps, the traffic type is CBR [5], the simulation area is 1000 m × 1000 m while the simulation time is 500 seconds, the routing protocol is AODV, *ns-2* version is 2.32, and this simulation is in MANET environment as mentioned before.

Table 1. Simulation settings.

Parameters	Settings
Application	CBR
MANET routing protocols	AODV
Transport Protocols	TFRC, SCTP
MAC Protocols	802.11
Simulation Time	500 sec
Nodes number	50
Mobility model	Random waypoint
Packet size	1000 bytes
Packet sent rate	0.01 Mbps
ns-2 version	2.32

5 Results and Discussion

This section presents the result of the experiments based on throughput and delay as performance metrics. Throughput refers to how much data is transferred between two locations. It is used to measure the performance of hard drives, memory, as well as the Internet and other computer networks [9].

Throughput has been used in this project as a metric to compare the performance of the TFRC and SCTP streams. Throughput was measured by computing the amount of data transferred between the nodes.

Delay in the network means the time or period for data traveling through the network from the source to the destination, or between the specifying how long the data will take to arrive at the destination [9]. The delay can be measured also by computing the time between the start and receive times. A proposed novel model from [10] for delay Table 2 and Table 3 show the throughput and delay for TFRC and SCTP in both scenarios.

Here are the results from the simulation as shown in No Background case and With Background case as follow:

a) Throughput

Table 2(a). TFRC Vs SCTP (No Background).

Speed	TFRC	SCTP
5 m/sec	1.12746 Kbps	192.9018 Kbps
10 m/sec	1.24691 Kbps	11.519401 Kbps
20 m/sec	3.75151 Kbps	11.519401 Kbps

Table 2(b). TFRC Vs SCTP (With Background).

Speed	TFRC	SCTP
5 m/sec	1.22977 Kbps	0.760022 Kbps
10 m/sec	1.234185 Kbps	22.7223 Kbps
20 m/sec	3.48778 Kbps	22.47461 Kbps

Simulation showed that the throughput of SCTP in No Background is much higher than TFRC in TFRC No Background, while TFRC is increasing more than SCTP depending on the speed. The throughput of SCTP is almost steady if the nodes move faster, but still the big pros for SCTP for its throughput performance. Due to multihoming, SCTP is able to send the data through another path and that leads to decrease the possibility of losing retransmitted data, thus the throughput has rare chance to lose data during large chunks. Figure 2 shows the difference between both protocols in this case.

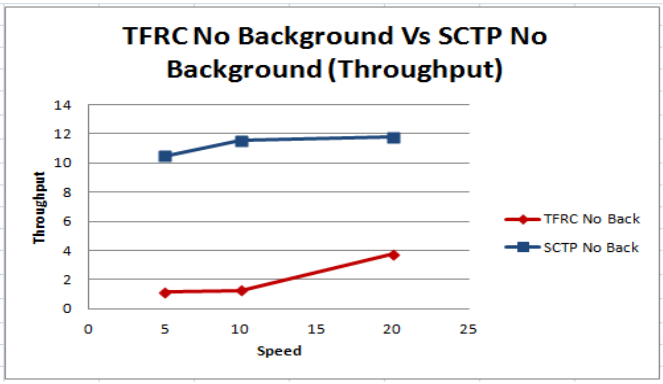

Fig. 2. TFRC No Background Vs SCTP No Background (Throughput).

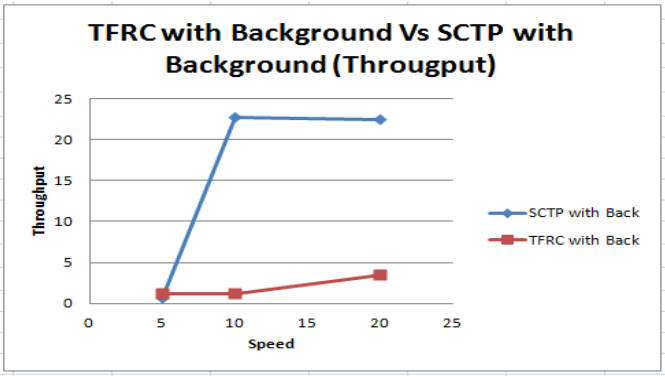

Fig. 3. TFRC With Background Vs SCTP With Background (Throughput).

b) Delay

Table 3(a). TFRC Vs SCTP (No Background).

Speed	TFRC	SCTP
5 m/sec	192.9018 ms	78.58746 ms
10 m/sec	146.4647 ms	79.52767 ms
20 m/sec	33.5109 ms	160.363 ms

Table 3(b). TFRC Vs SCTP (No Background).

Speed	TFRC	SCTP
5 m/sec	167.7439 ms	153.7292 ms
10 m/sec	159.2331 ms	221.4257 ms
20 m/sec	43.4757 ms	254.9968 ms

Simulations show that the throughput of SCTP in With Background is much higher than TFRC in TFRC With Background case except the first case in SCTP when the speed is 5. When the throughput of TFRC is increasing more than SCTP depending on the speed, the throughput of SCTP is almost stay steady if the nodes move faster except the first case, but still the big pros for SCTP in the throughput performance. The main reason is because SCTP has longer delay time than TFRC due to the four handshake rather than three handshakes in TFRC. In addition, SCTP sends more packets and that can cause more queuing delay which increases the total delay. Figure 4 shows the big difference between TFRC and SCTP in this case. When the speed is increased, the delay of TFRC becomes less, while SCTP performance badly affected as much as speed increasing. Figure 5 shows the increasing speed between TFRC and SCTP. In this case, at speed 5, the delay almost is the same, then the speed is begin growing. TFRC is going down too deep while the delay rate of SCTP becomes higher.

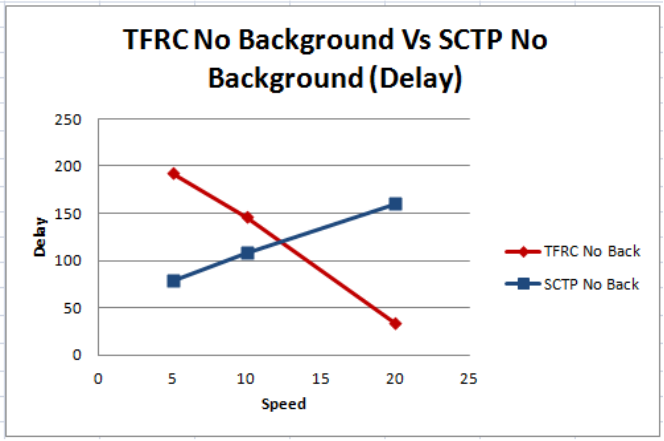

Fig. 4. TFRC No Background Vs SCTP No Background (Delay).

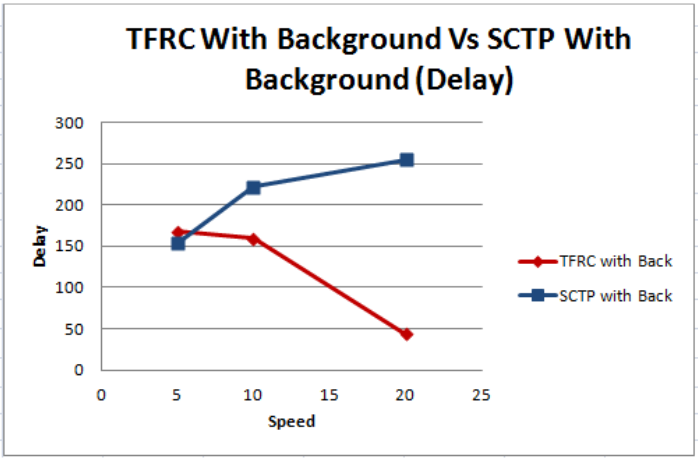

Fig. 5. TFRC With Background Vs SCTP With Background (Delay).

6 Conclusion and Future Work

The performance of TFRC and SCTP over AODV in MANET environment has been discussed. Two scenarios were used for this experiment, the first one is without background traffic, which is single traffic, and the second one is with the background traffic as well as the nodes are moving randomly. The experiments consider only AODV as a routing protocol. The results show that SCTP outperforms TFRC in terms of throughput, but TFRC is better in terms of delay. As a conclusion, SCTP is suitable for stored video applications which require higher throughput and can tolerate with delay. On the other hand, TFRC can work well for applications which require low delay such as IP telephony and video conferencing.

For future work, other routing protocols can be added to the simulation scenario for the performance comparison of TFRC and SCTP.

References

1. Habbal, A.M. and S. Hassan, *Delay-Based Loss Discrimination Mechanism for Congestion Control in Wireless Ad-Hoc Network*, in *Informatics Engineering and Information Science*, A. Abd Manaf, et al., Editors. 2011, Springer Berlin Heidelberg. p. 689-700.
2. Floyd, S., et al., *TCP Friendly Rate Control (TFRC): Protocol Specification*, 2008, in RFC 5348.
3. Injong, R. and X. Lisong, *Limitations of Equation-Based Congestion Control.* Networking, IEEE/ACM Transactions on, 2007. **15**(4): p. 852-865.
4. Chen, K. and K. Nahrstedt. *Limitations of equation-based congestion control in mobile ad hoc networks*. in *Distributed Computing Systems Workshops, 2004. Proceedings. 24th International Conference on*. 2004.
5. Zaini, K.M., et al., *An Interaction between Congestion-Control Based Transport Protocols and MANET Routing Protocols.* Journal of Computer Science, 2012. **8**(4): p. 468-473.
6. Tahir, H.M., et al., *Performance Comparison of SCTP and UDP over Mobile Ad hoc Networks.* International Journal of Computer Science Issues (IJCSI), 2012. **9**(4): p. 443.
7. *The VINT Project. The Network Simulator - ns-2*, http://www.isi.edu/nsnam/ns/, retrieved on 2nd October 2014.
8. Kumar, A., L. Jacob, and A.L. Ananda. *SCTP vs TCP : Performance Comparison in MANETs*. in *29th Annual IEEE International Conference on Local Computer Networks*. 2004. IEEE.
9. Demichelis, C. and P. Chimento, *IP Packet Delay Variation Metric for IP Performance Metrics (IPPM)*, 2002, in RFC 3393.
10. Habbal, A.M.M. and S. Hassan, *A Model for Congestion Control of Transmission Control Protocol in Mobile Wireless Ad Hoc Networks.* Journal of Computer Science, 2013. **9**(3): p. 335-342.