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PERFORMANCE EVALUATION OF TCP, UDP, AND SCTP IN MANETS

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ABSTRACT

The number of applications that are using ad-hoc interface is increasing continuously. This effect on diverse quality requirements such as delay, bandwidth, jitter, and reliability. Transmission Control Protocol (TCP) allows two hosts to establish a connection and switch streams of data. User Datagram Protocol (UDP) is a connectionless protocol that is used mainly for low-latency applications. In-Stream Control Transmission Protocol (SCTP) we can transmit several data streams between two endpoints when a network connection established at the same time. Due to the various constraints such as mobility, flexibility, and reliability, TCP and UDP don't perform well in ad hoc networks. This paper gives the performance evaluation of TCP, UDP, and SCTP regarding various quality metrics using ns2. Simulation results prove that SCTP performs better than TCP and UDP regarding throughput, jitter, loss rate, packet delivery ratio, and end-to-end delay in ad hoc networks.

Keywords: MANETs, multi-streaming, performance, SCTP, TCP, UDP.

1. INTRODUCTION

Nowadays interactive applications are among the most popular services in the Information and Communication Technologies world. The main reasons for this are, increase in various devices that support different data applications. In recent years, there is also increase in some users from professional to personal. Increase in the processing speed, capabilities of devices, and the global applications of mobile networks designed for data communications results in high data rate services. These make data transmission as a potential area to work.

TCP acts as a byte-oriented protocol as its acknowledgment and flow control depends on the byte number rather than packet number. Each packet or segment is identified by a data octet number, although data communicated over the internet are in small or large parts. UDP cannot ensure ordered data transmission and reliability in the TCP fashion. This may be because of many issues like out of order arrival of the datagram's, or data duplications, or may be misplaced or lost without notification. The main reason that makes UDP more efficient and faster is avoiding the checking overhead from every packet arrival. UDP performs well in the scenarios in which confident delivery is not essential. Applications that are time sensitive frequently uses UDP, as dropped packets are considered equivalent to delayed packets. UDP Connectionless nature also benefits servers that respond minor requests from a massive number of clients also. Unlike TCP, UDP provisions packet broadcasting. In SCTP message transmissions carrier in the form of a stream instead of individual data packets and hence, considered as a single operation (J. Rosenberg *et al.*, 2005). Similarly, the reception of the exact message also viewed as a single transaction. Multi-homing and Multi-streaming are the two unique features of SCTP that deliver reliable data simultaneously (Vivekananda, G. N *et al.*, 2017).

Reliability and content delivery can categorize possible ways of data transfer. The reliability category differentiates between transmission with full reliability, no reliability, and partial reliability. Reliability can be achieved through missing or misplaced data retransmissions, which may further lead to delays in transmissions. For partial reliability, retransmissions are attempted in a limited number, thereby regulating the delaying of remaining streams and not transmitting outdated data. Four possible categories of data deliveries are reliable, unreliable, ordered, and unordered that are possibly used by SCTP mechanisms (R.Fracchia *et al.*, 2005). The objective of this paper is to ascertain that SCTP performs better regarding the delay, throughput, controlled packet loss and an increase in packet delivery ratio maintaining reliability in ad hoc networks when compared to UDP and TCP in data transmissions.

Overhead comparison of protocols

Transport Protocol Data Unit (PDU) headers-TCP-PDU consists of 20 bytes of a length of the header without options, and UDP-PDU header has 8 bytes of header whereas SCTP-PDU consumes 12 bytes length of standard header along with its headers. For example, if data header chunk of SCTP has 16 bytes, then SCTP-PDU can carry a single data chunk, i.e.,28 bytes which will be the total header size, which is 40% greater than the TCP-PDU header without using the options.

In Message-based vs. Byte-based transmission, Chunk acts as basic transmission units in SCTP. SCTP sender covers every Application-PDU (A-PDU) in a single chunk. A-PDU is delivered similarly from the SCTP receiver as it is received. SCTP boundaries preserve message during transmission and delivery (R.Stewart*et al.*, 2004). Similar to UDP, the sender sends a message in only one operation in SCTP, and the receiving application receives the exact message that is processed in one operation. In contrast to this mechanism, byte-based transmission is followed by TCP. TCP sender does not maintain message A-PDU boundaries. For instance, we can add the end portion of one A-PDU with the beginning part of another A-PDU as the bytes fit into one single TCP-segment during transmission. Similarly, a TCP

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receiver provides all or some of an A-PDU to the application receiving it, with one system call. Diverse features acceptance in TCP, UDP, and SCTP are shown in Table-1.

Table-1. TCP, UDP and SCTP protocols comparisons in MANETs.

Feature	TCP	UDP	SCTP
Protection against blind DDoS attacks	No	N/a	Yes
Dynamic address Manipulation	No	N/a	Yes
Reliable data transfer	Yes	No	Yes
Partial-reliable data transfer	No	No	Yes
Application PDU fragmentation/bundling	Yes	No	Yes
Ordered data delivery	Yes	No	Yes
Unordered data delivery	No	Yes	Yes
Full-duplex data transmission	Yes	Yes	Yes
Flow and congestion control	Yes	No	Yes
Selective acknowledgments	Optional	No	Yes
Explicit congestion notification Support	Yes	No	Yes
Multi-streaming	No	No	Yes
Multi-homing	No	No	Yes

There are various problems in UDP and TCP that SCTP could help to mitigate. TCP is point-to-point protocol, and it is inflexible in the fashion that it changes application data (PDU) into network data. UDP can't perform reliable transmission and ordered delivery of packets. SCTP can figure out many of these complications. The particular throughput of a network can be improved as SCTP data can be reassembled out of order. Thus large chunks of data can be moved without interruptions. An efficient handshaking mechanism is presented in SCTP than TCP has. Hence secure key exchanges can be potentially improved. Mechanisms to prevent Distributed Denial of Service (DDoS) attacks by using four-way handshake is present in SCTP. SCTP has extensive addressing support, as it has point-to-multipoint transport. This is suitable for distribution of media over Internet Protocol (IP) and the purpose why Internet Protocol Television (IPTV) in TCP is hard and inefficient. Thus SCTP can be more elegant than TCP and UDP. SCTP can balance buffering, and can directly access data by navigating the contents using Round Trip Time (RTT) and Retransmission Time Out (RTO). Thus better enhancements in data transmission can be achieved.

The organization of the rest of the paper is as follows. Section 2 gives the studies of TCP, UDP, and SCTP in wired and Mobile Ad hoc Networks (MANETs) scenarios. In section 3, results of simulations and analysis of them concerning TCP, UDP, and SCTP using various metrics are presented. Finally, the paper is concluded by its future work in section 4.

2. BACKGROUND

In wired scenarios, (Lee, 2004) SCTP experimentation results using high-speed WANs (widearea networks) are presented. In (Rajesh Rajamani, 2002) paper, web traffic for TCP and SCTP performance is compared. Multi-homing and multi-streaming features of SCTP are studied using NS2 in (M.Fields, 2003). These aspects prove that they have gained over TCP in firm scenarios. Particularly, in multi-streaming, they state the number of optimal streams and describes how they affect the performance of a network.

In wireless scenarios, slow start, and congestion avoidance processes, congestion window and the round trip time to develop an analytical model, by which we can predict the performance of SCTP in (Li Ma, 2005). In (D. Emma, 2006) SCTP has analyzed in packet level over wireless, wired and complex scenarios. Authors consider the real environment to measure SCTP jitter and throughout in the heterogeneous networks.

In (Chukarin, 2006) evaluation of wide area networks protocol performance is performed and found that SCTP can be TCP-friendly and its introduction did not degrade the performance of the existing protocol. In (James Noonan, 2002) presenters explored standard SCTP and Mobile IP interactions. In (Changqiao, 2015) SCTP is proved as, it can be an efficient transport protocol intended for HTTP traffic, and it could help to reduce the user-perceived latency and improve throughput. Authors presented that few types of research are being carried out on in SCTP layer-4 handover and MPEG media over SCTP in (HMO.Chughtai, 2009).

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The success of using a new protocol resides when it is implemented in various applications of an operating system (HP.La Monte, 2015). Thus SCTP is implemented in Linux kernel project thatis integrated into the Linux 2.5 Kernel.

3. RESULTS AND ANALYSIS

Simulation throughout in this paper is classified based on TCP, UDP, and SCTP in ad hoc networks. The simulation parameters are as shown in Table-2. The topology is as shown in Figure-1. Data rates are maintained with a maximum of 10 Mbps. The total simulation time is 100 sec. For the simulation of TCP, a window size of TCP is varied to increase the data rate and uses the File Transport Protocol (FTP). For UDP, Constant Bit Rate (CBR) is used,and the rate is varied. SCTP also uses CBR traffic in HTTP and packet intervals are varied.

The network simulator NS-2, version 2.35 is used for simulation. NS-2 supports TCP, UDP, and SCTP traffic with FTP, CBR and HTTP applications. Simulations for TCP, UDP and SCTP traffic is presented in ad hoc networks. Consider a topology with ten nodes, with upward and downward links.

Table-2. Simulation parameters.

No. of nodes	10
Area size	1500m X 950m
Mac type	MAC / 802_11
Propagation	Two Ray Ground
Antenna	Omni Antenna
Simulation time	100 sec
Traffic source	CBR
Data rate	250 Kbps (Min) 10 Mbps (Max)

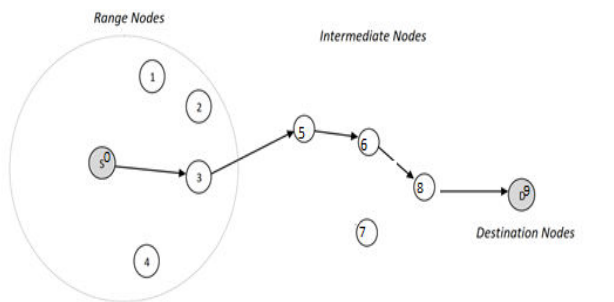

Figure-1. Topology illustration.

Various metrics are calculated for performance evaluation as follows:

End-to-end delay is given by the time that a packet takes to travel from source to destination in the network.

Jitter is the difference in delay from a packet to the next packet. It measures the first order derivative of delay variations. The causes of jitter can be due to queuing delay variations, cross traffic in the network, the bursty behavior of the end-user or end host, etc.

Packet loss may arise due to the packet fails to reach its destination. Packet loss causes loss of information if the transmission protocol does not have packet retransmission, or may originate delay if the transmission protocol implements packet retransmission.

Throughput is the rate at which a network sends or receives data. It is some network connections with a real capacity of channels and rated regarding bits per second (bits/sec).

Packet delivery ratio determines the number of packets delivered from the source to the destination based on sent and received packets.

Simulation of TCP, UDP, and SCTP in MANETs Environment

Jitter, End-to-end delay, Packet delivery ratio, Loss rate and Throughput are calculated in TCP, UDP, and SCTP protocols with varying data rates, window sizes and simulation times.

Jitter

Jitter is higher concerning TCP and UDP. The delay difference from one packet to next packet is prohibitively greater than SCTP as shown in Figure 2. Average data loss is higher in the case of the UDP and TCP than that of SCTP. The reason is that SCTP feature accepts both unordered and orderly delivery of packets and supports maximum path transmission unit discovery, which can't be supported by UDP and TCP.

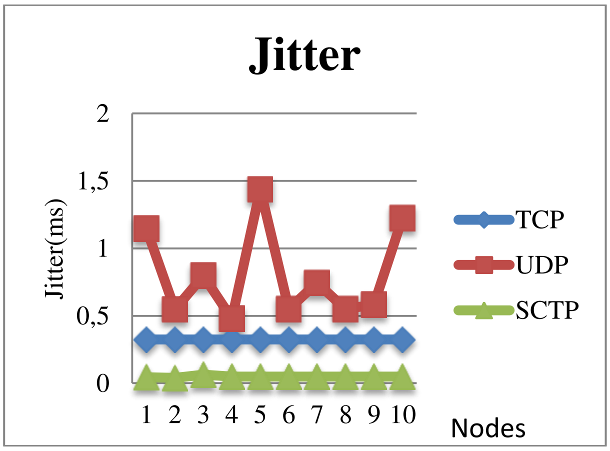

Figure-2. Jitter in TCP, UDP, and SCTP.

End-to-end delay

It is clear that end-to-end delay is higher concerning TCP and UDP as the average amount of data loss is prohibitively greater than SCTP as shown in Figure-3. Average data loss is higher in the instance of TCP than that of SCTP, for all the information reporting intervals considered. The reason is that TCP is byte oriented protocol and the delivery of each byte is to be assured by it whereas SCTP is stream-oriented protocol and it is associated with the provision of streams of bytes

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rather than an individual byte, and hence, the latter involves relatively minor overheads.

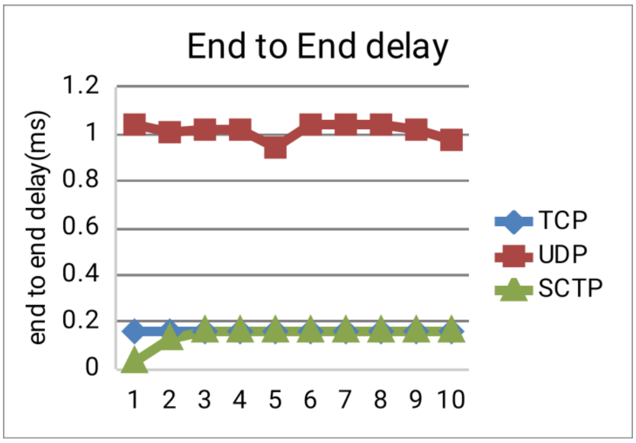

Figure-3. End-to-end delay in TCP, UDP, and SCTP.

Packet delivery ratio

TCP protocols transmit data from a source to a destination only through a dedicated path and hence when congestion occurs the probability of data loss is high. In the UDP, packets may get lost as it is a connectionless protocol. Dropped packets in SCTP are less compared to the TCP and UDP as shown in Figure-4. SCTP transmits data through all the available paths along with systematic and unordered deliveries, and hence, if data is lost in one way due to congestion or any other reason, the same data which is traveling over other paths may reach the destination successfully, thus lessening the extent of dropped packets.

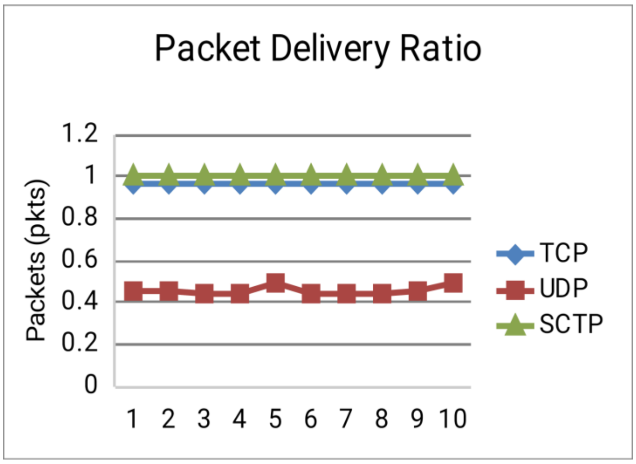

Figure-4. Packet delivery ratio in TCP, UDP, and SCTP.

Loss rate

Due to noise and network congestion, few packets may get lost. To deliver high QoS and for successful transmission of packets, loss rate must be kept the minimum. The loss rate is very less in SCTP in comparison with the TCP and UDP, as in Figure-5. As SCTP can access the data through various paths and have multiple path deliveries, and as it preserves the message boundaries in the applications it performs better than TCP and UDP.

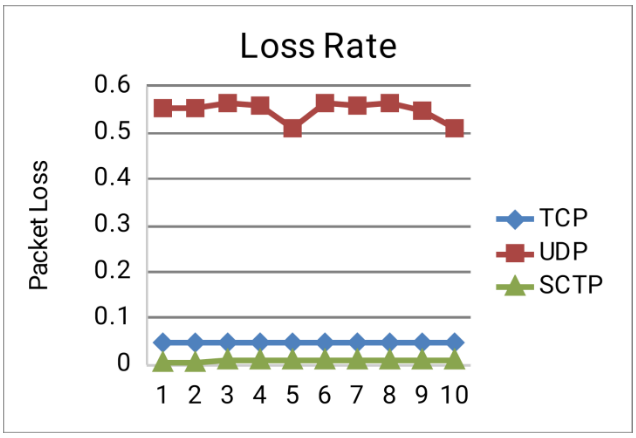

Figure-5. The loss in TCP, UDP, and SCTP.

Throughput

Throughput is calculated for the nodes between 0-9, with window size 50 and a data rate 5 Mbps, with different simulation times. Figure-6 shows the throughputs of all the considered protocols against versatile data reporting time intervals. Upon considering the individual performances, it is noticed that as the window size and data rates increases during various intervals the throughputs are better for the protocols, but overall functioning of SCTP is better than UDP and TCP in ad hoc networks.

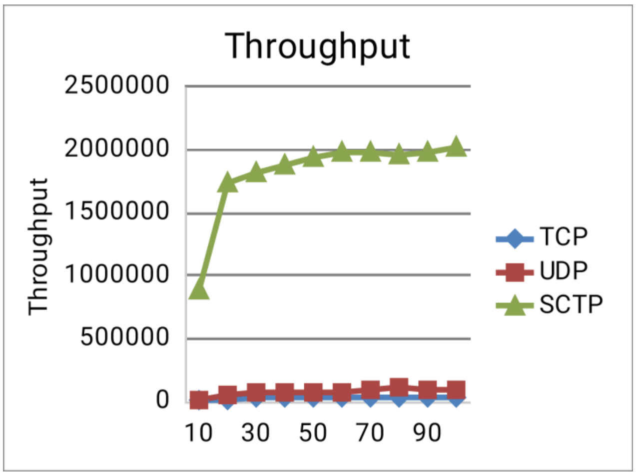

Figure-6. Throughput in TCP, UDP, and SCTP.

Simulation analysis

As TCP is a reliable protocol, which ensures in-order delivery of packets, the overheads involved are high, which results in underutilization of resources which is reflected in reduced performance. Also, it is found that UDP is far better than TCP for data delivery in ad hoc networks, as it can perform unordered data transmissions, but not reliable. SCTP has all the influenced characteristics that are present in TCP and UDP, which makes data transfer an efficient process.

The throughputs, loss rate, end-to-end delay, jitter, and packet delivery ratios of protocols TCP and UDP over ad hoc networks are not fair at broadcasting intervals when compared with SCTP protocol evaluations. Hence, from the arrived results it is concluded that SCTP can perform better in the ad hoc networks among the protocols considered.

The TCP performance is found to be reducedregarding average data transfers. UDP provides a second-best result for throughput next to SCTP when average performance is considered. Thus, on the whole, except for average throughput, UDP and TCP provide poor results concerning the metrics discussed. Thus by these scenarios, SCTP can be regarded as the efficient protocol for the ad hoc networks, which is shown in Table-3.

Table-3. Metrics evaluation results in ad hoc networks.

S. No.	Metric	TCP	UDP	SCTP
1	Packet loss rate (pkts)	Good	Average	Best
2	Packet Delivery Ratio (pkts)	Good	Average	Best
3	End-to-end delay (ms)	Good	Average	Best
4	Jitter (ms)	Good	Average	Best
5	Throughput (Kbps/ Mbps)	Average	Good	Best

4. CONCLUSIONS

We discussed the influence of the various protocols for performance evaluation in ad hoc networks, in this paper. In the IP networks, for transmission of signaling messages SCTP protocol was initially proposed. It had a significant impact on the research since its implementation. SCTP is now a well-known protocol, and this paper shows that SCTP has a great potential for applications in MANETs. Multi-streaming capabilities of SCTP can lead to various future works such as multipoint streaming with reliability in heterogeneous networks. One of the significant concerns for the SCTP based handover schemes is the development of more accurate handover policies. In this criterion evaluation of cross-layer designs would provide more depth to the analysis.

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REFERENCES

Changqiao Xu, Z. L., Jinglin Li, Hongke Zhang and Muntean. 2015. Cross-Layer Fairness-Driven Concurrent Multipath Video Delivery over Heterogeneous Wireless Networks. IEEE Transactions on Circuits and Systems for Video Technology. 25(7): 1175-1189.

Chukarin, A., & Pershakov, N. 2006. Performance Evaluation of the Stream Control Transmission Protocol. Paper presented at the IEEE Mediterranean Electro Technical Conference, Malaga.

D. Emma, S. L., A. Pescape, Giorgio Ventre. 2006. Measuring SCTP Throughput and Jitter over Heterogeneous Networks. Paper presented at the 20th International Conference on magnetism Advanced Information Networking and Applications, Austria.

HMO. Chughtai, S. M. and M. Yousaf. 2009. Performance Evaluation of Transport Layer Protocols for Video Traffic over WiMAX. Paper presented at the IEEE 13th International Multi Topic Conference, Islamabad.

HP. La Monte, Y., and Karl Knutson.2015. Linux Kernel SCTP: The Third Transport.

Vivekananda, G. N., & Reddy, P. C. 2017, February. ESCTP optimized unidirectional delay technique for the efficient video transmission in MANETs. In Electrical, Computer and Communication Technologies (ICECCT), 2017 Second International Conference on (pp. 1-5).IEEE.

J. Rosenberg, H. S. and G. Camarillo. 2005. The stream control transmission protocol (SCTP) as transport for the session initiation protocol (SIP).

James Noonan, P. P. a. J. M. 2002. A Study of SCTP Service in a Mobile-IP Network. Paper presented at the Information Technology & Telecommunications Conference, Ireland.

Lee, D. N. a. J.-K. 2004. Performance of SCTP over high speedwide area networks. Paper presented at the IEEE Conference on Cybernetics and Intelligent Systems, Singapore.

Li Ma, F. Y. and VCM. Leung. 2005. Modeling SCTP throughput in Integrated WLAN/cellular networks. Paper presented at the IEEE International Conference on

Communications, Seoul.

M. Fields, S. K. a. 2003.Experimental study of the SCTP compared to TCP.

R. Fracchia, C. C., CF. Chiasserini and M. Meo. 2005. WiSE Extension of SCTP for Wireless Networks. Paper presented at the IEEE International Conference on Communications, Seoul, South Korea.

R. Stewart, C. B., J. Pinkerton, S. Ganguly, H. Shah and V. Kashyap. 2004. Stream Control Transmission Protocol (SCTP) Remote Direct Memory Access (RDMA) DirectData Placement (DDP) Adaptation.

Rajesh Rajamani, S. K. a. N. G. 2002. SCTP versus TCP: Comparing the Performance of Transport protocols for web traffic. University of Wisconsin-Madison.