PERFORMANCE COMPARISON OF SCTP AND UDP OVER MOBILE AD HOC NETWORKS

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Abstract

Countless researchers have put efforts to conduct researchs about the performance of the traditional transport control protocols (TCP) and user datagram protocol (UDP). Recently new transport protocol had been designed called Stream Control Transmission Protocol (SCTP). In this research, we will focus to study the effect of Mobile Ad Hoc Networks (MANET) on these two transport protocols SCTP and UDP and find out which one performs better over MANET. The transport protocol SCTP has more services and features compare to the traditional transport protocol. We also present some literatures on SCTP and UDP performance over MANET. The simulation parameters and the results of the simulation will also be discussed.

Keywords —*SCTP, UDP And Mobile Ad Hoc Networks*

1. Introduction

Currently the technology significantly goes forward and heavy data are being sent over the internet like multimedia applications. While processing the data, transport protocols play very essential roles. The traditional transport protocol UDP was designed for audio and video streaming application where the real time constraints are more important than the reliability. SCTP was designed with the goal of overcoming the limitation of the traditional transport protocol TCP. It also combines the function of the two older protocols TCP and UDP. SCTP ensure reliable, in sequence transport of messages with congestion control like TCP and preserving data message boundaries similar to UDP.

2. Mobile Ad Hoc Network

Historically, MANET have primarily been used for tactical network relate applications to improve battlefield communications/survivability. The dynamic nature of military operations means that military cannot rely on access to a fixed preplaced communication infrastructure in battlefields [8]. Pure wireless communication also has limitation in that radio signals are subject to interference and radio frequency higher then 100MHz rarely propagate beyond line of sight (LOS) [5].

MANET creates a suitable framework to address these issues by providing a multi-hop wireless network without pre-placed infrastructure and connectivity beyond LOS. Early ad hoc networking applications can be traced back to the DARPA Packet Radio Network(PRNet) project in 1972 [1],which was primarily inspired by the efficiency of the packet switching technology, such as bandwidth sharing and store-and-forward routing, and its possible application in mobile wireless environment.

In general, MANET are formed dynamically by an autonomous system of mobile nodes that are connected via wireless links without using the existing network infrastructure or centralized administration. The nodes are free to move randomly and organize themselves arbitrarily; thus, the networks wireless topology may change rapidly and unpredictably [9]. Such a network may operate in a standalone fashion, or may be connected to the larger Internet. MANET are infrastructure-less networks since they do not require any fixed infrastructure, such as a base station, for their operation. In general, routes between nodes in an ad hoc network may include multiple hops, and hence it is also appropriate to call such networks as ‘‘multi-hop wireless ad hoc networks’’. Each node will be able to communicate directly with any other node that resides within its transmission range. For communicating with nodes that reside beyond this range, the node needs to use intermediate nodes to relay the messages hop by hop. The ad hoc networks devices are battery powered. Therefore, the amount of spent energy by the routing protocol affects the bandwidth utilization. The longer the transport time, the less the throughput and the more the energy consumption. Accordingly, many studies have been dedicated to analyze its characteristics and/or propose new routing methods.

In MANET, the principal problem of these two transport protocols SCTP and UDP lies on link failure and link changes. SCTP which was designed for wired network suffers in wireless network and the same goes to UDP which was designed to carry multimedia data over the network. The nodes mobility nature of MANET could easily cause large loss of data sent over the network [6]. Due to this problem, we strive in this research to make a comparison between SCTP and UDP through simulation to analyze this problem and find out which one performs better. We will present a comprehensive set of simulation results and show the key factors that impact SCTP and UDP performance over MANET.

By examining the SCTP and UDP performance studied over MANET, some problems have been identified such as link failures and link changes in MANET can cause delay of the packet sends over the network [10]. These problems are part of the main causes of the SCTP and UDP performance degradation over MANET.

SCTP was designed for wired network and in mobile ad hoc network. UDP was designed to transport multimedia application over the network. This paper tries to compare the performance of SCTP and UDP over MANET.

2.1. Stream Control Transmission Protocol (SCTP)

Recently several evaluations for SCTP performance have been carried out. SCTP performance was evaluated in MANET using the reactive routing protocols Dynamic Source Routing (DSR) and Ad hoc On-Demand Distance Vector Routing (AODV). Hoda Hassan [6] noted that although SCTP delivered a lower of its packets but yet the overall throughput achieved using SCTP is higher than that achieved with TCP. They also modified the retransmission and heartbeat algorithms in SCTP to improve protocol reaction to failure in routes [2]. Also in [2], they stated that the poorer performance of the SCTP is due to the overhead imposed by the protocol complexity and traditional features that are not well suited for MANET. It has been shown that SCTP suffers from the same problem as TCP when used in multi-hop ad hoc wireless networks. In [8], the simulation aim at studying the interaction of SCTP protocol with the underlying routing protocols such as DSR and AODV protocols using a two-factor full factorial experimental design with replication. The first set of simulation is performed without introducing background traffic. In that case, the two factors in our experiments are the routing protocol and the transport layer protocol using replications. In the second set of experiments only incorporated the AODV protocol. In the observation, average throughput for each combination of the protocols, SCTP has achieved higher throughput in all mobility scenarios of the two routing protocols. On the other hand, the difference in performance among the routing protocol is not so relevant. Beside that, we noted that TCP operates better on AODV than DSR. This can be due to the route shortening in DSR [3]. DSR attempts to shorten route when the sender and receiver move close to each other to improve transmission latency. As the sender and receiver move away from each other, DSR waits until a failure occurs to lengthen the route. This failure causes the loss of a number of packets and the latency of route discovery often result in repeated TCP timeouts. With SCTP, destination reachable is maintained through the use of heartbeat chunks that force the underlying routing protocol to continuously update its routing table.

SCTP is a Transport Layer protocol, serving in a similar role as the popular protocols namely TCP and UDP. Indeed, it provides some of the same service features of both, ensuring reliable in sequence transport of messages with congestion control like TCP and preserving data message boundaries similarly to UDP. However, differently to TCP and UDP, SCTP offers such advantages as multi-homing and multi-streaming capabilities.The main difference to TCP is the multihoming mechanism and the concept of several streams within a connection. Where in TCP, a stream is referred to as a sequence of bytes, an SCTP stream represents a sequence of messages and these may be very short or long.

The SCTP node must go through a setup procedure to establish a communication relationship by exchanging state information. This relationship is called SCTP association. The SCTP association is a broader concept than the TCP connection. SCTP can use more than one IP addresses to establish association. SCTP association uses four-way handshake and additional COOKIE mechanism for security (to prevent SYN flooding attack) in Fig.1.

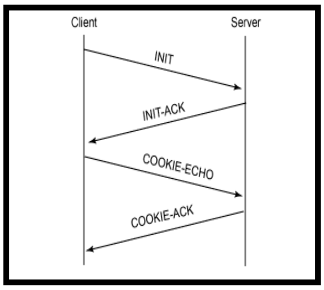

Fig. 1: SCTP four-way handshake.

In SCTP, a client initiates a connection with an INIT packet. The server responds with an INIT-ACK, which includes the cookie (a unique context identifying this proposed connection). The client then responds with a COOKIE-ECHO, which contains the cookie sent by the server. At this point, the server allocates the resource for the connection and acknowledges this by sending a COOKIE-ACK to the client. The SCTP message structure facilitates packaging bundled control and data messages in a single format. A common header is followed by one or more variable-length chunks, which use a type-length-value (TLV) format. Different chunk types are used to carry control or data information inside an SCTP packet.

2.2. User Datagram Protocol

User Datagram Protocol (UDP) is one of the protocols that are widely used in the internet. The services provided by UDP are unordered delivery of packets, connectionless service, full duplex connection and message boundaries preserving, no congestion control and packet delivery.

Multimedia communication involves blending voice and video traffic together with data traffic. Among different transport layer protocols, UDP offers a fast and efficient mechanism to handle voice, image, audio and video data traffic. Hence it is necessary to know the performance of UDP under various network conditions. The study of UDP performance will also provide an understanding of the adaptability of wireless networks to voice, video and data traffic. However, the wireless network performance is affected not only by the congestion, but also by other factors like environment, distance and protocol implementation. Different operating systems implement the protocols in different ways. In order to maximize the throughput of the wireless links, it is important to select an operating system with an efficient protocol implementation.

Most Internet-based real-time multimedia services employ user datagram protocol (UDP) as their transport protocol. Compared to transmission control protocol (TCP), UDP does not yield retransmission delay, which makes it attractive to delay sensitive applications. A UDP packet consists of a header and payload. UDP employs a cyclic redundancy check (CRC) to verify the integrity of packets; therefore, it can detect any error in the packet header or payload. If an error is detected, the packet is declared lost and discarded. UDP packet transmission in Internet is “best effort,” in which case network congestion yields packet loss. At the receiving host, packets are either perfect or completely lost. In contrast, wireless packet networks are characterized as low-bandwidth and unreliable, in which a considerable amount of packet losses are induced by both channel failure and network congestion. Depending on the environment, moving speed, and network loading, packet loss can be random or burst. Since UDP does not perform any error recovery, streaming multimedia over wireless networks can yield unpredictable degradation and poor video/audio quality. One of the inefficiency of UDP is that it fails to incorporate the properties of the wireless network, where a channel error only partially corrupts a packet. UDP discards a packet containing only a small part of corrupted data. As such, it also throws out error-free data within the packet. Indeed, the current and emerging multimedia coding technologies are focusing on providing error resilience so that the media decoder can tolerate a certain amount of channel errors. To support this feature, wireless systems should revise the UDP protocol to reduce or avoid unnecessary packet discarding

3. **The Experiment**.

In this research, we used network simulation tool to compare the performance of SCTP and UDP over Mobile Ad Hoc Networks. These simulation steps are divided into two stages, the pre-software stage and the software stage. Each goes through four phases and they are described in figure 2.

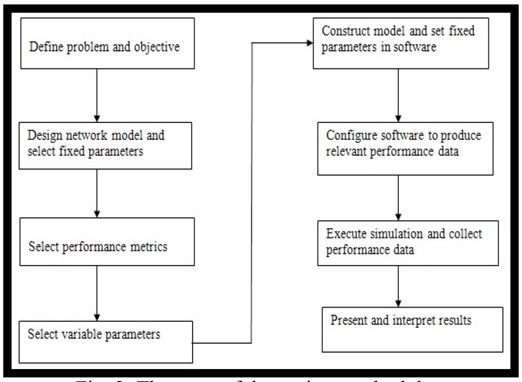

Fig. 2: The steps of the project methodology

3.1. Network Simulator 2 (NS-2)

NS-2 is the most popular simulation tool for network related research. it is also open source network simulators. It began as ns (Network Simulator) in 1989 with the purpose of general network simulation. Its wireless and mobile networking support extension is originally developed
by CMU Monarch group in the late 1990’s and later integrated in the mainline code. The primary purpose of this extension was to enable simulation of wireless networks, in particular multi-hop ad hoc networks. The support of sensor network simulation in NS-2 is also based on CMU Monarch extension with a small number of add-ons.

The programming it uses is C++ and OTcl (Tcl script language with Object-oriented extensions developed at MIT). The usage of these two programming language has its reason. The biggest reason is due to the internal characteristics of these two languages. C++ is efficient to implement a design but it is not very easy to be visual and graphically shown. It is not easy to modify and assemble different components and to change different parameters without a very visual and easy-to-use descriptive language. Moreover, for efficiency reason, NS2 separates control path implementations from the data path implementation. The event scheduler and the basic network component objects in the data path are written and compiled using C++ to reduce packet and event processing time. OTcl happens to have the feature that C++ lacks. So the combination of these two languages proves to be very effective. C++ is used to implement the detailed protocol and OTcl is used for users to control the simulation scenario and schedule the events. The OTcl script is used to initiate the event scheduler, set up the network topology, and tell traffic source when to start and stop sending packets through event scheduler. The scenes can be changed easily by programming in the OTcl script. When a user wants to make a new network object, he can either write the new object or assemble a compound object from the existing object library, and plumb the data path through the object. This plumbing makes NS2 very powerful.

3.2. Simulation Scenario

Our simulation scenario is that we designed the topology of 12 nodes and the distance between each node is 240m. We use CBR as traffic application of both protocols SCTP an UDP, the size of the packet sends from node 0 to node 11 is 1000bytes. We set the simulator start moving from node 0 while other nodes are fixed. The simulator starts running from 2.0 sec and stop at 159 sec.

3.3. Simulation Execution

In the completion of the simulation, NS and NAM trace output were created. The NAM output shows the movement of the mobile host and the traffic flow that generated during the movement of the mobile host. The trace file will display the output file. The next step is to analyze the NS trace file and the performance metrics to get all the details about what is happened when the simulations were running.

4. Performance Metrics Analysis

In this section, we describe the results of SCTP session and UDP session obtained from our experiments in different scenarios. The simulation starts with CBR traffic flow from the source node (0) to the destination node which is node (11). CBR placed on the application layer. SCTP and UDP are placed in the transport layer.

4.1. Throughput

Throughput is defined as the total successfully received packet to the destination or the aggregate throughput is the sum of the data rates that are delivered to all nodes in a network. It is also is the total number of packets received by the destination.

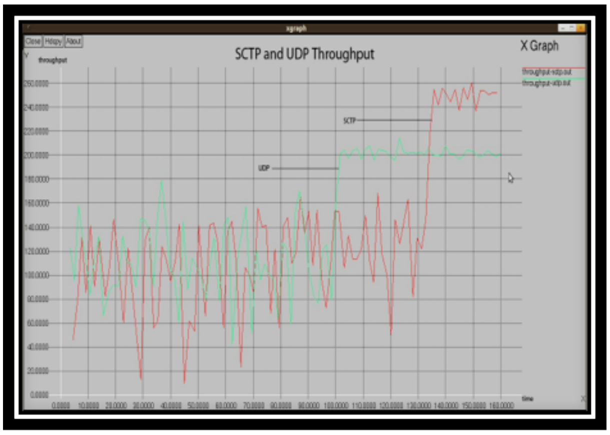

Fig. 3: The average throughput for SCTP and UDP over MANET

From figure 3, the throughput under SCTP is greater than under UDP transmission.

4.2. Jitter

We can see the comparison between SCTP and UDP base on Jitter in figure 4. The result shows that SCTP is lower than UDP, meaning that SCTP lower change the time between packets arriving, caused by network congestion timing drift, or route changes.

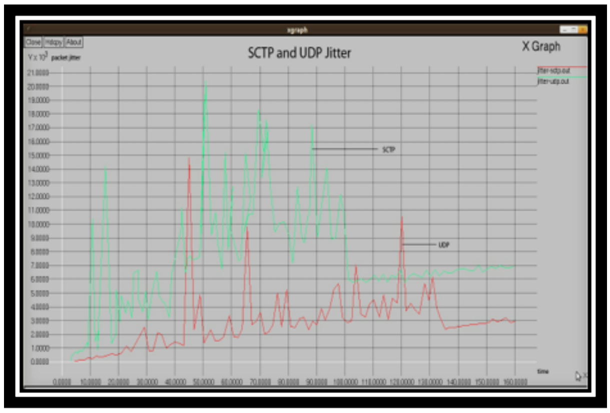

Figure 4: The average jitter for SCTP and UDP over MANET

Based on figure 5, SCTP performance is better for delay than UDP.

4.3. Delay

Delay includes all the possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times. It is also the average end-to-end delay of data packets from senders to receivers. The performance of delay for SCTP is better than UDP.

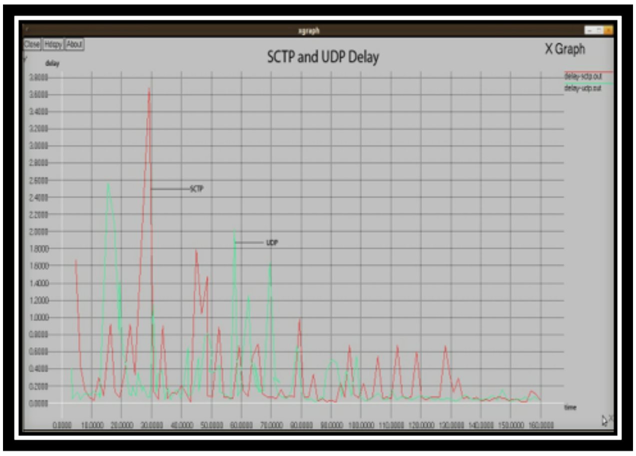

Figure 5: The average delay for SCTP and UDP over MANET

5. Result

In this section, we have compared the transport protocol SCTP with the traditional transport protocol UDP over MANET, the performance metrics we have used are Throughput, Jitter and Delay. The results in table 1 have shown that SCTP outperforms UDP in all cases except in Jitter due to the more features of SCTP protocol.

Table 1 : Result of SCTP over UDP Performance

Performance metric	**SCTP Result**	**UDP Result**
Throughput (kbps)	260.672	219.184
Jitter (ms)	10525.1	20413.3
Delay (ms)	3.67967	2.56428

The results have shown that SCTP is more stable than UDP. We have run both protocols SCTP and UDP in the simulation over AODV routing protocol and we have found that SCTP still outperforms UDP. Although SCTP performs lower in Jitter, yet its overall performance is higher than UDP. Furthermore, SCTP has added features like Multi-homing and Multi-streaming [10]. Multi-homing allows SCTP to send data even though the primary path is broken and the Multi-streaming is a mechanism that allows several data to be transferred through one connection and avoid the head of line blocking [7].

6. Conclusion

In conclusion, using the two transport protocols we have found that SCTP performs better than UDP except in Delay. The performance metrics such as Throughput, Jitter and Delay results are also illustrated in the graph showed above.

Acknowledgment

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