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RESEARCH ARTICLE

Comparing Stream Control and Datagram Congestion Control with Traditional Transmission Control Protocol

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Abstract- At the Transport Layer in Internet model, Transmission Control Protocol provide host-to-host connectivity. There are many other protocols under TCP like SCTP (Stream Control Transport Protocol) and DCCP (Datagram Congestion Control Protocol) which provides more features. DCCP is unreliable transport layer protocol designed to provide congestion control and suitable for time delivery of data. SCTP is another reliable transport layer protocol which provides reliable transfer of data with congestion control mechanism. SCTP also provide other features like multi-streaming and multi-homing. This paper provides the comparative study of these three protocols.

Keywords: Congestion control, TCP, DCCP, SCTP, Multi-streaming, Multi-homing

I. INTRODUCTION

The Transmission Control Protocol provides reliable transmission of data at transport layer in an IP environment. It offers reliability by providing connection –oriented and end to end reliable packet delivery through internetwork. TCP provides services to many applications such as file transfer, world wide web, email, multimedia, communication many more[1]. TCP acts as a standard transport protocol for Internet and is suitable for wired network and gives bad performance in case of wireless networks applications where time delivery of data is more important than reliability UDP(User Datagram Protocol) is used. TCP plays very important role in data transfer in MANETS[21]

Services Provided by TCP:

1. Connection orientation and point to point communication: TCP provides connection-oriented service in which an application must first require a connection to a destination, and then use the connection to transfer data. These are three phases in TCP connection establishment, data transfer and connection termination phases. It performs three way handshaking [2]. Connection establishment is shown in fig1.

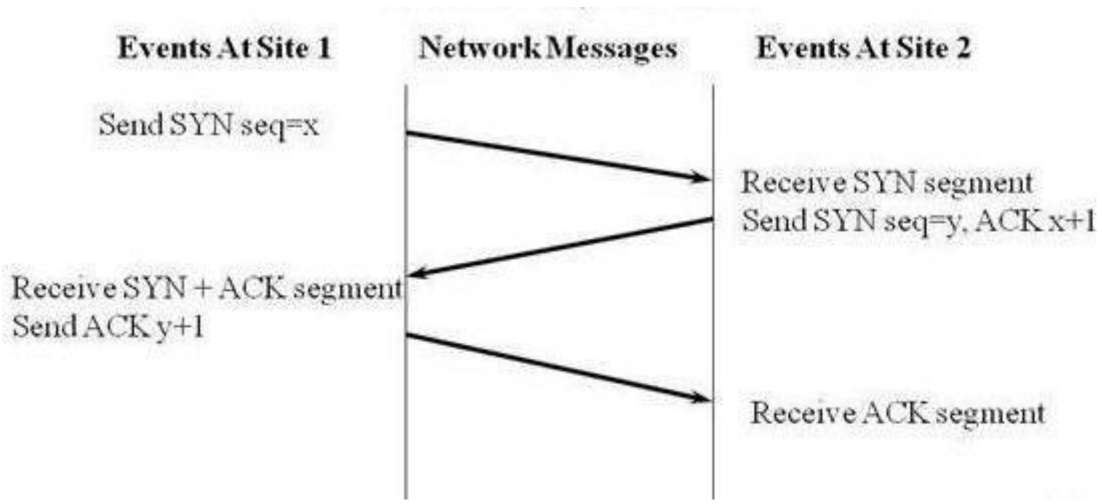

Fig.1: TCP Connection Establishment

2. Complex reliability: TCP guarantees that the data sent across a connection will be delivered exactly as sent, with no data missing or out of order. In order to provide reliability, TCP must recover from datalost. TCP uses the Positive Acknowledgment Retransmission (PAR) scheme for achieving reliability. In PAR scheme, data is only sent after getting acknowledgement from previous data sent as shown below[2].Connection termination is shown in fig2.

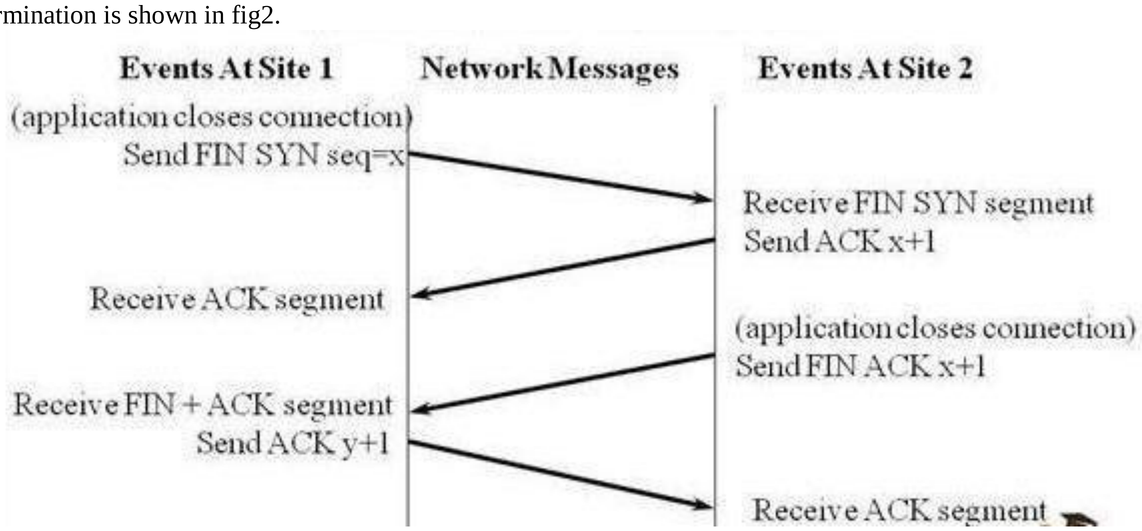

Fig.2: TCP connection termination

3. Full duplex communication: A TCP connection allows data to flow in either direction, and allows either application program to send data at any time. TCP can buffer outgoing and incoming data in both directions, making it possible for an application to send data and then to continue computation while the data is being transferred[2].

4. Stream interface: TCP provides a stream interface in which an application sends a continuous sequence of octets across a connection. That is, TCP does not provide a notion of records, and does not guarantee that data will be delivered in the same pieces at the receiving application in the same pieces that it was transferred by the sending application[4].

5. Congestion control: When the network performance fall by several orders due to retransmission of lost data many times leads to congestion. Congestion in a network or internet creates problems such as reduced availability and throughput for the end user. When there are so many incoming packets contending for the limited shared resources, such as the queue buffer in the router and the outgoing bandwidth, congestion may happen in the data communication. During congestion, large amounts of packet experience delay or even be dropped due to the queue overflow[3]. This will result in increasing packet loss rate and degradation of throughput. Congestion will also decrease efficiency and reliability of the whole network. At very high traffic, performance collapses completely and almost no packets are delivered. When a packet is dropped before it reaches its destination, all of the resources it has consumed in transit are wasted. As a result, many congestion

control methods are proposed to solve this problem and avoid the damage. Most of the congestion control algorithms[3] are based on evaluating the network feedbacks to detect when and where congestion occurs, and take actions to adjust the output source, such as reduce the congestion window. TCP uses many congestion control algorithms[3].

6. Packet Header: The size of TCP header is 20 bytes. TCP Segment consists of a source port, destination port, sequence number, acknowledgement number, data offset, reserved, urgent pointer, checksum for errors. Source port (16 bits) identifies the sending port. Destination port (16 bits) identifies the receiving port. Sequence number (32 bits) has a dual role. Acknowledgment number (32 bits) if the ACK flag is set then the value of this field is the next sequence number that the receiver is expecting [2]. This acknowledges receipt of all prior bytes (if any). The first ACK sent by each end acknowledges the other end's initial sequence number itself, but no data. Data offset (4 bits)specifies the size of the TCP header in 32-bit words. Reserved (3 bits)for future use and should be set to zero. Flags (9 bits) contains 9 1-bit flags. Window size (16 bits) the size of the receive window, which specifies the number of window size units. The 16-bit checksum field is used for error-checking of the header and data Urgent pointer (16 bits) if the URG flag is set, then this 16-bit field is an offset from the sequence number indicating the last urgent data byte. The TCP header padding is used to ensure that the TCP header ends and data begins on a 32 bit boundary. The padding is composed of zeros[2].Packet header is shown in table I.

Table I: Packet header

<table>
<tr><td colspan="8">SOURCE</td><td colspan="2">DESTINATION</td></tr>
<tr><td colspan="10">SEQUENCE NUMBER</td></tr>
<tr><td colspan="10">ACKNOWLEDGEMENT NUMBER</td></tr>
<tr><td>HLEN</td><td>RESERVED</td><td>U
R
G</td><td>A
C
K</td><td>P
S
H</td><td>R
S
T</td><td>S
Y
N</td><td>F
I
N</td><td colspan="2">WINDOW</td></tr>
<tr><td colspan="8">CHECKSUM</td><td colspan="2">URGERT POINTER</td></tr>
<tr><td colspan="9">OPTIONS(IF ANY)</td><td>PACDING</td></tr>
<tr><td colspan="10">DATA</td></tr>
<tr><td colspan="10">…</td></tr>
</table>

II. Literature Survey

Transport layer protocol is one of the important factor that can affect the QoS of many applications while transportation over the network. TCP provides better services for application like email and file transfer where reliability and in-ordered delivery is more important but if we consider multimedia application where time delivery of data with no delay is more important we prefer to use other transport layer protocols which provides many other features like congestion control, flow control, error control, multi streaming and multi homing.

Khalid et. al.[5] compares the simulation based study of UDP, DCCP, SCTP. For multimedia applications which are intolerant to time delay uses transport layer protocol UDP for communication. But UDP is an unreliable protocol and does provide congestion control which affects the QOS. DCCP is designed to provide congestion control but it is also an unreliable protocol. It is used for real time application which needs time delivery rather than reliability. SCTP provides reliable data transfer with congestion control. It also provides features like multi-homing and multi-streaming. The performance of these three transport layer protocols is analyzed in terms of performance metrics like packet loss, jitter, delay and throughput. By analyzing these performance measures it is found that the performance of DCCP and SCTP is much better as compared to UDP but DCCP gives much better performance then SCTP when compared in terms of throughput and packet loss. Comparing SCTP and DCCP with UDP in terms of delay and jitter shows that UDP has less delay and jitter as compared to SCTP and DCCP, but because of less throughput and large number of packet loss, UDP can badly degrade the quality.

Antonova et. al.[6] proposes how mobility and multi homing can be implemented in transport layer. Stream Control Transmission Protocol (SCTP), TCP Multi-Home Options (TCP-MH) and Datagram Congestion Control Protocol (DCCP) protocols were introduced and compared on the basis of mobility and multi homing features. TCP-MH provides only multi-homing not mobility with security problem. DCCP and SCTP both support mobility of only one point. SCTP is the most powerful as it provides multi-homing and mobility, also with using MobileIP, SIP, RSerPool or DDNS mobility of both endpoints can be managed.

Ikram et. al.[3] also provided the performance evaluation of TCP and SCTP. In the evaluation throughput, jitter and delay was compared. Performance of voice traffic is analyzed by applying Chunk- based Jitter Management algorithm. According to evaluation, it was seen that throughput is more in SCTP than TCP and delay is less in SCTP. In the case of jitter, it is more in TCP which degrades the quality of voice.

Zikina. Et. al.[8] also proposes video transport over heterogeneous network using SCTP and DCCP. On comparing these two on the basis of throughput, jitter and delay it is concluded that DCCP gives more throughput and less jitter and delay as compared to SCTP.
Rashid ali .et .al.[7] proposes the performance of Network redundancy in SCTP. Throughput and end-to-end packet delay are used as performance metrics to introduce the effect of factors like concurrent cross traffic, congestion control algorithms and SACK timers on multi-homing feature of SCTP. Based on extensive simulations, it is given that congestion control algorithm like RED gives less delay and improves throughput. If SACK timer of less millisecondis used with concurrent multipath transfer in SCTP gives high throughput and less delay is achieved.

Brak .et .al. [14] gives the performance evaluation of SCTP for smart grid environment and also provided the performance comparison between SCTP (with features of multi-streaming and multi-homing) and TCP. TCP is byte-oriented and does not provide features like multi-streaming and multi-homing. In terms of delay and throughput, SCTP is more feasible protocol for smart grid applications which relay on real time streaming.

M K Afzal .et .al[12] SCTP vs. TCP Delay and Packet Loss proposes the simulation based comparison of vital parameters of QOS like delay and effect of packet loss on throughput. Comparison is done using network simulator. SCTP and TCP shows similar delay in case of both single flow and competing traffic. With more throughputs we get more delay. In case of packet loss, SCTP performs better then TCP and gives more throughput.

B.Chellaprabha .et .al[17] gives the performance of datagram congestion control protocol dccp-tcp-like and dccp-tfrc on sensor network. It is found that the performance of DCCP_TFRC based protocol is better and more suitable than its counterpart considered in this work.

III. Other Transport Layer Protocols

1. DCCP(Datagram Congestion Control Protocol):

DCCP is a new transport protocol in the UDP/TCP family that provides an unreliable transmission with congestion control meant for applications like streaming media that prefer timeliness to reliability[9]. DCCP has been designed to incorporate the best features of both UDP and TCP, in addition to selective congestion control algorithms. It also implements reliable connection setup, tear down and feature negotiation.

- Packet Header: Generic header of DCCP if of 12 bytes but scalable up to 1020 as shown in table II.

Table II: Packet format

<table>
<tr><td colspan="3">SOURCE</td><td colspan="2">DESTINATION</td></tr>
<tr><td colspan="2">DATA OFFSET</td><td>CCVAL</td><td>CSCOV</td><td>C
CHECKSUM</td></tr>
<tr><td>RES</td><td>TYPE</td><td>X=1</td><td colspan="2">SEQUENCE NUMBER(HIGH BITS)</td></tr>
<tr><td colspan="5">SEQUENCE NUMBER(LOW BITS)</td></tr>
</table>

Source and Destination Port is 16 bit each and represent the relevant ports being used in the end points. Data Offset is 8 bit number of the 32 bit words from the start of the header to the start of the application area. CCVal 4 bits used to convey the half connection sender CCID. CsCov 4 bits determines which part of header are covered in the checksum.16 bits Internet checksum of the packet header Res 3 bits Senders should set these bits to zeros and the receiver should ignore. Type 4 bits Defines the type of the message. Extended Sequence Number 1 bit set to one to indicate the use of an extended generic header with 48-bit Sequence and Acknowledgement Numbers. Sequence Number24 or 48 bits identifies the packet uniquely in the sequence of all packets the source sent on this connection. Sequence Number increases by one with every packet sent. The four bit Type field, marks a difference from TCP. There are several packet types. This design increase the number of packet types available to 16.

- Connection Orientation of DCCP:Connection establishment in DCCP is accomplished by using three-way hand shake. In this three-way hand shake a connection establishment request DCCP-Request is sent by client to the receiver then a DCCP-Response is sent by server to the client and then finally an acknowledgment via a DCCP-Ack is sent by client towards the server[12].

- Un-Ordered Data Delivery of DCCP:DCCP is intended for the applications which require in-time delivery of data and reordering of data can cause delays which the multimedia applications cannot tolerate. So in DCCP data is not reordered because reordering can result in delay[12].

- Un-Reliability of DCCP:DCCP is an unreliable transport layer protocol. DCCP is aimed for the real time applications in which delays are intolerable, so that's why DCCP does not retransmit dropped packets because the real time applications prefer to receive the most recent data then the older one[8].

- Flow Control and Congestion Control in DCCP:DCCP is not a flow control protocol in fact it is a congestion control protocol The flow control limits can affect the transfer rates. So DCCP does not make use of flow control which is separate from congestion control. The flow control is optional in DCCP. If required, flow control mechanism can be implemented on top of DCCP. DCCP is basically designed to provide congestion control. Two types of congestion control mechanisms are offered by DCCP named CCID 2[12]: TCP-like congestion control mechanism and CCID 3: TCP Friendly Rate Control (TFRC) congestion control mechanism. In order to make choice between these two mechanisms, congestion control IDs (CCIDs) are used. A particular CCID is negotiated during the connection startup between two endpoints[8].

2. **SCTP(Stream Control Transmission Protocol)**

SCTP is a reliable transport protocol operating on top of a connectionless packet network such as IP. It offers many features as acknowledged error-free non-duplicated transfer of user data, data fragmentation to conform to discovered path MTU size, sequenced delivery of user messages within multiple streams, with an option for order-of-arrival delivery of individual user messages, optional bundling of multiple user messages into a single SCTP packet, and network-level fault tolerance through supporting of multi-homing at either or both ends of an association[4]. The design of SCTP includes appropriate congestion avoidance behavior and resistance to flooding and attacks.

- Packet Format: It is shown in tableIII. The field verification tag is used by the receiver of a particular

Table III: Packet format

BITS 0-7	8-15	16-31
SOURCE PORT		DESTINATION PORT
VERIFICATION TAG		
CHECKSUM		
CHUNK N TYPE	CHUNK N FLAGS	CHUNK N LENGTH
CHUNK N DATA		

packet in order to validate the sender of that particular packet. The checksum field contains the checksum value of a particular SCTP packet. The Chunk type is used to identify the type of data available in Chunk data. The Chunk flags bits are dependent on chunk type, they are set to zero if not specified by the chunk type. The chunk length specifies the chunk size in terms of bytes. It includes size of chunk data, chunk flags, chunk type and chunk length fields. The field chunkdata is of variable length[15].

- Connection Orientation of SCTP:SCTP is connection oriented transport layer protocol. In SCTP, a connection is known as an association. When a process at host A wants to exchange the data from a process at host B, then first of all an association is established between each other [7]. After that data is exchanged between them, the association is terminated

- Multi-homing: One of the key features of SCTP is the support for multi-homing that is the destination nodes can be reached under the several IP addresses (multi-homed). A TCP connection is defined by a pair of transport addresses IP address and port number while in SCTP both sides of the association provides multiple IP addresses combined with a single SCTP port number. Thus each multi-homed node can be reached from another node using several paths[7].Multi-homing is shown in fig 3.

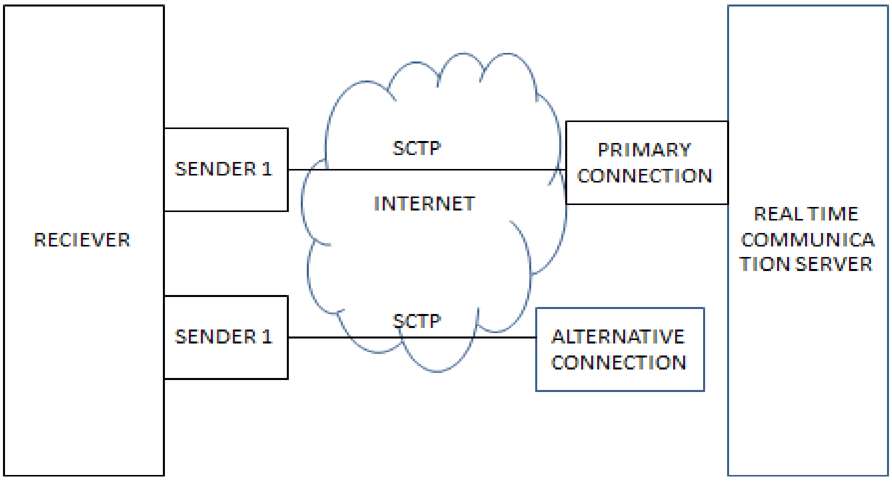

Fig.3: Multi-homing

- Multi-Streaming: Another key feature of SCTP is multi-streaming. It refers to the parallel transmission of messages over the same association between sender and the receiver. The stream independently carries fragmented messages from one end to the other. In TCP connection all bytes transmitted are delivered in strict transmission order. It is possible that protocol wastes its bandwidth due to the strict sequences of message delivery. The independent transmission of streams gives an advantage to SCTP over TCP and it achieves a cumulative throughput makes SCTP more robust against partial network failures than TCP[10].Multi-streaming is shown in fig 4.

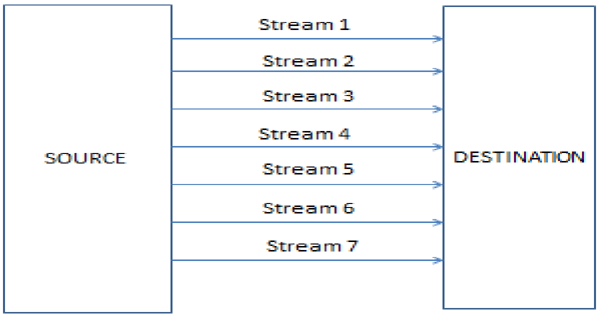

Fig.4: Multi-streaming

IV. COMPARISON

It is hard to conclude which protocol is better in all aspects than another. So the major trends which are observed are: (1) all these protocols provide high link utilization, (2) TCP and SCTP are similar to each other but SCTP is an advanced version of TCP used mostly used in multimedia applications. (3) DCCP and UDP are also similar unreliable protocols but DCCP provide congestion control. (4) Varying different parameters we can improve the performance of any protocol (5) all of the protocols have different features which are helpful in different applications. The following table summarizes our evaluation results:

Table IV: Comparison among TCP, DCCP and SCTP

Properties	TCP	DCCP	SCTP
Connection Oriented	Provides connection oriented service	Provides connection oriented service	Provides connection oriented service
Reliable Data transfer	Provides reliable data transfer	Provides unreliable data transfer	Provides reliable data transfer
Message oriented	It is byte oriented does not preserve any structure	It is message oriented.	It is message oriented and support framing of individual messages
Ordered data delivery	Yes	No	Yes
Unordered data delivery	No	Yes	Yes
Hand-shaking	3-way hand-shaking	3-way hand-shaking	4-way hand-shaking
Congestion control	Provides congestion control with more delay	Provides congestion control likeCCID-2, CCID-3 etc. with less delay	Provides congestion control with delay more than DCCP
Denial of services attack	Vulnerable to denial-of-service attack.	Resistant to denial-of-service attack.	Resistant to denial-of-service attack.
Header Size	20 byte	12 byte	12 byte
Full duplex	Yes	Yes	Yes
Flow control	Yes	It is optional because flow control gives more delay	Yes
Fragmentation	Yes	No	Yes
Multicasting	No	No	Yes
Multi-streaming	No	No	Yes
Multi-homing	No	No	Yes

V. CONCLUSION

From the study, we can clearly see that, TCP is reliable, connection-oriented protocol which provides congestion control but with increased delay. SCTP is an advanced version of TCP which provides some features of TCP as well as many others features too with more accuracy. DCCP is an unreliable, connectionless protocol like UDP but provide congestion control in communication. All these protocols can be used in different type of applications.

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