

PERFORMANCE EVALUATION OF TCP AND DCCP PROTOCOLS IN MOBILE AD-HOC NETWORKS (MANETS)

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ABSTRACT: *Flow control, end-to-end (EED) delay, throughput, and energy consumptions are important factors of real-time and multimedia communication in mobile ad-hoc networks (MANET's). It has a characteristic of the dynamic flow of data communication among the various users without using wired technologies. Due to this dynamic structure of MANNETS, most of its energy is consumed in route searching and packet retransmission. In addition, a problem of energy consumption may also occur due to network congestion and traffic flow control. In general, UDP is used for real-time communication but this protocol is unable to control the traffic flow properly. Therefore, a new protocol is developed for this purpose called datagram congestion control protocol (DCCP) used in those networks, which has an increasing number of multimedia traffic, and real-time flow. In this research work, major performance metrics with the issue of power usage of the TFRC and TCP like DCCP protocols are evaluated.*

Keywords: TFRC, TCP, DCCP, MANET, MRTP, CCID2

1. Introduction. In MANNETS energy plays a vital role to state outlives duration of a mobile ad-hoc network during communication. MANNETS dynamically communicate data among the various users without using wired technologies. Due to this dynamic structure of MANNETS, most of its energy is consumed in path demanding and packet retransmission [1].

Use of satellite networks is increasing with time particularly its usage in homes and small business environments has increased many folds, whereas in past it used mostly in environments like oil/gas/mining based remote locations, military and governmental organizations. It has increased the efficiency of recently develop protocols like datagram congestion control protocol (DCCP) which are used in today's high speed networks having an increasing number of multimedia traffic and real time data flow. The basic aim of developing DCCP is used to control such flow in a proper way and provide flow control which is not available in User Datagram Protocol (UDP) [2].

TCP is network aware communication protocols mainly develop for transferring data packets on Internet securely. TCP is the basic means to carry data over Internet Protocol (IP) reliably, because in TCP, a connection is established first before sending data, thus TCP is a connection-oriented protocol [3].

The two most commonly used Transport layers in today's networks are UDP and TCP. However, the nature of services of these two protocols is different from each other. TCP provides reliable service of data transfer with a slow speed. It is connection oriented service while the UDP is connection less service, and provide speedy communication without guaranteed delivery of data. DCCP provides self-congestion control mechanism which facilitates to select the best and required application. DCCP commonly use these two techniques such as CCID2 (TCP like) and CCID3. DCCP is not reliable like TCP but DCCP has the congestion control mechanism like TCP. DCCP is suitable for supporting multi congestion mechanisms and a connection runs between two end points and this consists of two half connections (HC). One HC consists of data packets which are sent by the HC sender in one direction with corresponding ACK sent by HC receivers. For each end point a specific HC is held and it is known as

feature location and other one is a remote feature of the connection. DCCP is message congestion delivery protocol. TFRC is suitable for streaming media files [4]. UDP is an unreliable and connectionless protocol because there is no acknowledgement, retransmission and timeout mechanisms involve during the communication. Apart from this, it also uses all the available bandwidth.

UDP is congestion less protocol and there is no regeneration of those packets which are lost during communication process. A new congestion control mechanism TFRC is used for internet video streaming and other multi-media applications, which provides average rate of traffic such as a TCP/IP sender, without bringing any variations in data rates. Basically, the TFRC response function is not suitable for Multi-hop networks therefore for the successful deployment of TFRC over multi-hop wireless networks it must be adapted to handle the unique challenges of these networks [5]. DCCP commonly uses multiple congestion control algorithms and much efficient when it is chose for user applications as identifier (CCID) [6]. DCCP is particularly design to carry multimedia traffic where we need speedy data transfer instead of reliable data transfer.

1.1 Mobility. Data gram congestion control protocol provides basic support for multi homing and mobility through a technique which is use for delivering end-point connection from one node to another. Only on one side of the connection DCCP supports the mobility while the other side of the connection should remain constant. During communication when one endpoint is moving it should inform other endpoint about its movement. (using Mobility Adept Feature) and when it updates its IP address it will inform the other about its new IP address by sending DCCP-Move packet which consist of updated IP address of the moving peer to fixed peer.

1.2 Congestion Control Mechanism. In DCCP, there are two HC (half connections) and these HC are run by various congestion control mechanisms, and each one of these mechanism is denoted by 1-byte CCID: a number from 0 to 255. Presently assigned numbers to CCIDs are shown as following.

Table-1: DCCP Congestion Control Identifiers

CCID	Meaning
0 – 1	Reserved
2	TCP – like Congestion Control
3	TFRC Congestion Control
4 – 255	Reserved

CCID has a server priority feature and fresh connection starts with CCID 2 for both connection terminals, in case of unacceptable packet loss, it brings mandatory change CCID options on its first packet that it sends on the link toward the destination node [7].

1.3 Faster Restart Congestion Control. If an application send its data and it has no data to send for at least no acknowledge from the respective in a network, then it will wait for at least four round trip time (RTT) after expiring that time the connection will goes “idle”. If we use Faster Restart mechanism in that condition a ping message (bit) must send by the transport layer, on each RTT in order to get continuous RTT sample and an idea about dropped packet rate.

1.4 Congestion Control Framework. When we use DCCP for congestion control framework it provides an option of congestion control mechanism to an application, there are several applications that might prefer TFRC congestion control, avoiding TCP’s abruptly halving the sending rate in reply to congestion while others might prefer a more active TCP-like probing for available link bandwidth. Congestion Control Ids (CCIDs) make the choice with standardized congestion_control mechanism. CCIDs of a connection are negotiated at connection startup [8].

1.5 Datagram Congestion Control Protocol (DCCP). The DCCP offers bi-directional and end to end connection between sender and receiver for congestion-control untrusted segments. It is best suited for those type of programs which transmit a large amount of information with high speed and where there is no need of reliability and security.

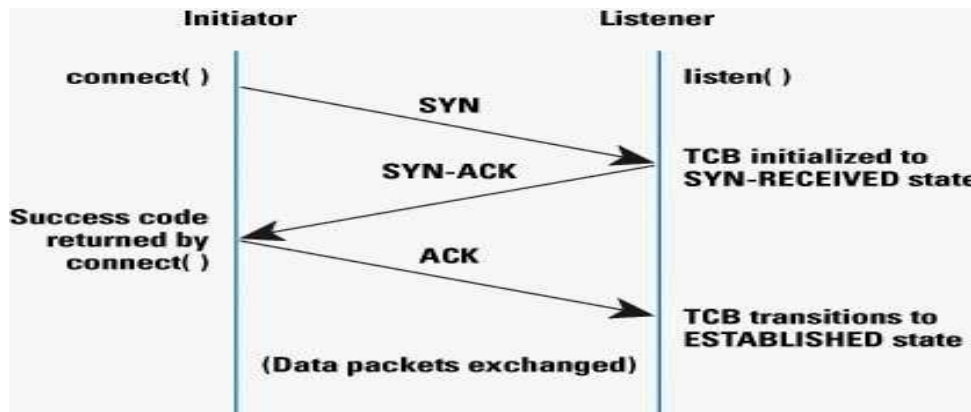


Figure-1: DCCP connection establishment

It specifies, how to decompose an application data into packets that can be transmit on the networks, (transmit packets and received packets) from the network layer. Moreover, it also monitor flow control which means to offer error-free transmission of data and control resending of those packets which were dropped or lost during communication it also handle the ACK of all those data packets which are received. In the Open Systems Interconnection (OSI) communication system, TCP encompasses several parts of the Transport Layer, and some parts, of Session Layer.

For instance, web server for sending HTML files to client system uses HTTP protocol. The HTTP program layer ask the TCP layer to establish a link for sending data packet. The TCP break large data file into small data files (packets), and assign a serial numbers to them and forwards these small data packets to IP layer for sending one by one. The packets which are break down in to small packets will have same source and destination IP address whereas these data packets are on different paths. The TCP program layer on the client side wait unless each and every data packet is received on the destination side, and then give acknowledgement of those packets which are received on destination side and asks for the retransmission of those packets which were lost or not received on the destination side (based on missing packet numbers). Finally, the small data packets are combine in a data file and then transmitted to the destination end.

After Resending and reordering of those data packets, which reached at destination can introduce latency in a TCP stream. Time sensitive applications like voice over IP (VoIP) and streaming video generally depend upon UDP way of transport which reduces latency and jitter (variation in latency) which need no reordering and no resending of the missing data packets toward the destination end. TCP provides guarantee for message delivery, which means that a message send through TCP protocol is to be delivered at client side successfully in the same order in which the sender sent it. If a data packet is dropped during communication then TCP recovered and resent that message, which is handled by TCP protocol itself.

Packets are lost when link breakages occur during communication, due to this TCP decrease its transmission rate and enhance the retransmission timeout (RTO), which display a low throughput because when the transmission time is increase then message take more time for transmission. If link failures occur TCP save its state till a new route is provided or the old path is reestablished. However, if link failures happen regularly, in that condition, TCP would switch to this state repeatedly so it will not send any new data and will wait until establishment of a new path, in addition it will also slow down the transmission speed of data [9].

Apart from successful delivery of data packets, TCP also guaranteed for order delivery of data packets, where the order of data will be same as send by the sender. The data will be send to client in the similar order as sent from server, it is also possible that the message which we send are not in order when they arrived on the other side of the network during transmission. TCP protocol is responsible for sequencing and ordering of the data. While UDP does not provide any guarantee that the message should be in same order or sequence as it is send from sender. Datagram packets may arrive in any order it may be in order or out of order. Therefore, TCP works better in case of those applications, which give preference to the sequence of data, though there are some UDP based protocols use sequence number for reliability and ordering of data during data transfer. DCCP is a new type of transport protocol that belongs to the family of TCP/UDP, which uses congestion-control mechanism with untrusted data transmission. DCCP is used for time-sensitive applications, like streaming media and telephony, which prefers timeliness on

reliability. So, DCCP is used in those conditions when we need speedy communication instead of reliable communication.

1.6 Packet of DCCP. The DCCP packet contains DCCP header and application data field. The DCCP header has three fields such as Generic Header of 12 or 16 bytes in length, the additional fields depends on data type of data, and the options (optional) field. The DCCP application data area is depends upon the nature of the data which is send from source to destination.

2. Review of Literature. Performance of TCP-TFRC for controlling transfer rate of scalable video streams is evaluated when it is used in mobile network, and with the help of Scalable Video Coding (SVC), the stream were encoded by using extension of the H. 264 / AVC standard. Decision of adding or removing a layer is based upon the TFRC during variable channel conditions of the mobile networks [10].

In [6], the simulation results compared with each other in the presence and in the absence of TFRC-based adaptation. In DCCP we had Congestion control mechanism and it is suitable for multimedia application. These multimedia application give preference to timely delivery of data over order delivery of data there is also less amount of security viable, we cannot use DCCP for those applications which need high security. Such type of applications include streaming media, multiplayer and online games. Basic objective of these applications is that old message rapidly becomes stale so that receiving fresh message is preferred to retransmitting those messages, which are lost [12]. The advancement in the TCP-Friendly Rate Control (TFRC) mechanism control congestion through DCCP intended to be use with real-time traffic, which aimed to enhance its performance for long delay (primarily satellite) links [13]. Rapid-developing Internet programs such as streaming media and telephony favored timely delivery of data reliability. Unfortunately, UDP has no congestion control mechanism, UDP applications must implement congestion control mechanism by their own which is a hard or risky task rendering congested control network useful for a specific interval. A congestion controlled technique is designed to make it possible to provide the facility of these application safely which is an unreliable protocol of the transport layer. The result of DCCP, which is based on the foundation of UDP was added to the mechanism which was essential to control the congestion efficiently. It is considered that all these techniques will perform similar to that of TCP's, but for the design of the DCCP they have reconsidered almost all of the aspects of the TCP which includes cumulative acknowledgment and with no reliability in the structure. In [14], it has been discussed that for the QOS of some applications like multimedia and some real time applications needs hard requirements which does not supported by the current infrastructure of the existing networks. In MANETs link failures and continuous topology changes leads to some destructive amount of data lose due to which the quality of received media is affected very badly. In such station there are usually many paths between sending and receiving nodes. For situation like this, we need a new type of protocol in which we had control over series traffic jams and link frailer and to improve multipart transportation of real-time multimedia data.

DCCP is newly under develop untrusted transport protocol with end-to-end congestion control on bi-directional, unicast connections of datagrams [15]. It was tried to sketch out a short overview of DCCP and Motivate the Protocol [16]. DCCP is a type of networks which Offer that wireless data services provide its services universally in wireless networks. The TCP congestion control mechanism in wireless data networks can oversight a wireless channel problems or a shutdown for traffic jam on the path. In this document, we have planned to introduce ACK Pacing algorithm for long continuous lost periods as a hand-off. By facing ACK Packets send, it will stop us from sending data rashly and it will keep us safe from false time out appearance. One important feature that is related to ACK pacing algorithm is that pace ACK packet activate the route which is restructured for fresh faster path. The ACK pacing algorithm also used for nodes in hybrid network or it also implemented on hybrid networks nodes. Results of simulation show that the ACK pacing algorithm enhanced TCP compared to many TCP other changes that proved from the simulation results. The ACK Pacing algorithm display good features during a long phase of loss [17]. As the clear bandwidth available is not equal to that of traditional fixed-wire telephone modems, users observed that GPRS was much worse [18]. In the portable wireless networks TCP faces some difficulties in case of performance. In this environment the mobility of nodes are high which causes high error rate due to the unwanted packets which leads to some disturbance in the network. In the paper [19], devise role of different network structures of the TCP and Ad-hoc networks are highlighted well. Apart from energy consumption issue, our research has also pointed out the following three problems in the behavior of TCP.

- a. Identification of the error techniques in the protocol.

- b. The error recovery
- c. Protocol strategy

It shows that the optimization of the transport layer protocol (TCP) movement is evaluated in depth. In which different parameters are investigated, which includes traffic of the TCP that ultimately observe the controlling of flow, which is helpful for the better results. As it is clear that an end to end simulation of all these methods have been observed but still it is not giving us an end to end real signaling in this simulation. According to these problems, if an encryption of the IP payload is present then it is not suitable for these methods [20].

The freezing approach of the TCP in this scenario has been evaluated which plays an important role without the need of adding more mediators like base stations for the controlling of traffic flow. DCCP establish a secure connection setup, teardown, Explicit Congestion Notification (ECN), congestion control and features negotiation. DCCP provides a way to have access to congestion control mechanisms without having to impose them at the application layer. It allows for flow-based semantics like in TCP but does not provide reliable in-order delivery. Sequenced delivery within multiple streams as in the Stream Control Transmission Protocol (SCTP) is not provided by DCCP. DCCP work better for those applications which need timely delivery instead of reliable delivery of data that may become baseless to the receiver if reliable in-order delivery is used combined with network congestion avoidance, such applications include streaming media, multiplayer online games and internet telephony. Basic feature of these applications is that old message quickly become stale so that getting new message is preferred to retransmit dropped packets [21]. Some changes is carried out in the TCP-Friendly Rate Control (TFRC) congestion control mechanism from the DCCP. Initially, the amount of reply messages in one round trip time (RTT) was optimized in our suggested algorithm as compared to the existing available standard of using one RTT which is dependent on the delay of the link. The given improvement here can be achieved with the help of our proposed changes in the different stages of controlling congestion and the results are prepared in the NS2 simulation software which is implemented in the Linux that gives a modified version of the DCCP. It is declared that the variable results an improved slow start performance and a minimize data loss as compared to standard DCCP while bringing overhead remains acceptable.

MRTP removes the dependency from the multimedia data for short range, which increases the performance of the given network including the queuing performance enhancement of the network.

This work showed that an additional route, MRTP exceeded single flow RTP by a substantial margin [22]. It is assumed to add a small amount of changes in the proposed design of DCCP which is UDP-like foundation for congestion control that includes acknowledgment of the trusted information which makes the DCCP more suitable for other application design like online games, internet telephony and media streaming etc. In our proposed protocol i.e. DCCP, it is has been observed to offer best performance results in the above mentioned real time applications that is main point of motivation for choosing this protocol.

Finally, two new techniques used in order to demonstrate the result of the cross layer reaction. For this, we added user feedback in the Protocol. Mobile host can dynamically controlled by TCP stack on desire application. Moreover, we make a method to the use of the lower layers and coupling information for improving TCP Performance. These two mechanisms led minimal amendment to the mobile host and no modification to the sender or other entities network.

3. Proposed Methodology. In this research work, apart from other performance metrics, special consideration is devoted to the energy usage of the TFRC and TCP like DCCP protocols because in MANETs power composition is the core issue. All performance metrics are evaluated in NS2 by using Linux platform.

3.1. Performance evaluation metrics of TCP and DCCP protocols. The following tables are showing the performance of each protocol (TCP, and DCCP Mechanisms) of the mobile ad hoc network by using different performance metrics for five intervals. Table 3.2 listed the performance of the TCP which is calculated for Energy consumption along with other different metrics and it is very large as compared to DCCP two protocols (DCCP-TCP-like & DCCP- TRFC). The consumption of energy is different in each interval. Actually, energy consumption depends on end-to-end delay because in the case of TCP, large number of packets is dropped and these dropping packets are re-transmitted on the network, which causes delay on the data packets.

Table-2: Performance Table of TCP

Interval (sec)	EDE Delay (ms)	Throughput (bytes/s)	Dropped Packet (pkts/sec)	Energy Consumed (joules)
1	269.12	64.75	69532.21	1.57
2	300.57	70.05	67923.63	1.59
3	154.21	30.85	55104.58	1.39
4	612.69	21.78	51312.59	1.36
5	645.61	15.54	48649.78	1.33
Average	396.44	40.91	58504.56	1.45

The tables 3.3 and 3.4 are the result of DCCP sub protocols. The energy consumption of DCCP (TCP-like & TCP TFRC) 1.24 joules and 1.32 joules respectively, and it is very low as compared with TCP Protocol. DCCP – TCP-Like consumed a very small amount of energy during the communication. Other metrics measures such as Average (EED, Throughput, and Dropped packets) are also very small as compared to the TCP. Average EED of DCCP-TCP-Like is 40.6 ms, showing very small amount of delay on the network. The Average throughput is 18.66 bytes per second and average number of packets dropped (5858.59) in a unit sec is also small. Therefore DCCP is a much better for Multimedia file transmitting because there is no retransmission.

Table-3: Performance Table of DCCP-TCP- LIKE

Interval (sec)	EED Delay (ms)	Throughput (bytes/s)	Dropped Packet (pkts/sec)	Energy Consumed (joules)
1	60.78	27.65	10204.21	1.35
2	50.63	20.85	6314.54	1.28
3	35.46	18.67	4105.98	1.24
4	22.28	15.92	3097.75	1.29
5	33.84	10.21	5556.91	1.03
Average	40.6	18.66	5858.59	1.24

Although, DCCP-TCP-TFRC consumed a slightly higher amount of energy as compared to DCCP-TCP-LIKE. However, when we compare its energy consumption with TCP, in this case energy consumption is relatively small. DCCP-TCP-TFRC has dropped minimal number of packets as compared with DCCP-TCP-LIKE. The throughput of DCCP-TCP-TFRC is much smaller than TCP.

Table-4: Performance Table of DCCP –TCP-TFRC

Interval (sec)	EED Delay (ms)	Throughput (bytes/s)	Dropped Packet (pkts/sec)	Energy Consumed (joules)
1	63.59	29.12	9231.52	1.28
2	55.94	23.34	5215.45	1.39
3	39.83	21.02	3196.83	1.32
4	24.71	17.65	2017.81	1.30
5	35.69	12.94	4542.76	1.31
Average	43.95	20.81	4840.87	1.32

The metrics used to evaluate the performance of the TCP and DCCP Protocols are:

a) Energy Consumption. It is the average amount of energy which is spend by all nodes on the network during the performance of protocols. Basically energy is consumed by different parameters on a network such as in the process of routing, congestion control algorithm of the transport protocol and data reporting intervals etc. Energy plays a vital role in the performance of protocols for the better performance and the consumption of energy must be in their lowest level. In MANET, a greater amount of energy is consumed on the route discovery process because the topology was changing continuously during the communication between the nodes. The following figure shows the energy consumption of TCP, DCCP-TCP-LIKE and DCCP- TCP- Friendly in each interval of time.

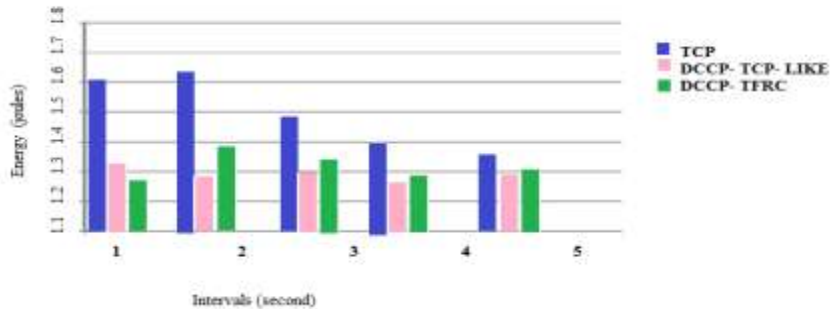


Figure-2: Energy Consumption in Each Interval

The figure shown below captured the average energy consumed by TCP and DCCP mechanisms. The average energy of TCP is 1.45 joules which is very high as compared with the DCCP identifiers. So the TCP consumed more energy on the mobile ad hoc network as compared with the DCCP protocol. TCP consumed more energy because it is a reliable protocol which retransmits the dropped packets during the transmission and the process of retransmission consumes more energy.

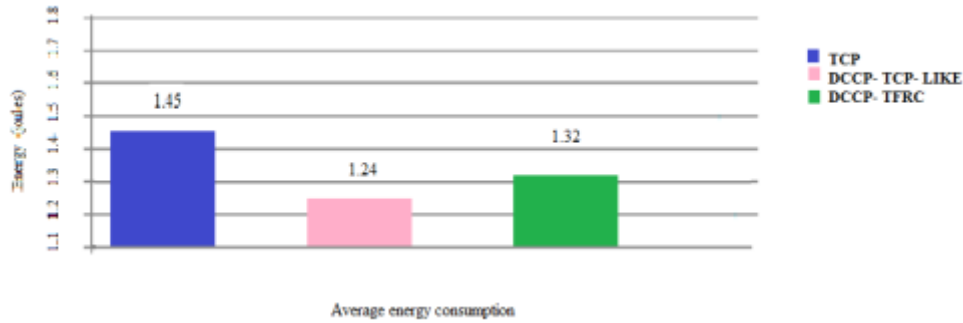


Figure-3: Average Energy Consumption.

b) End to End Delay (EED). EED is the amount of delay during transferring of data packets from sending to receiving node in MANET. EED is the combination of three delays i.e., Transmission, propagation and processing delay of data packet.

$$EED = \sum_{n=1}^N (r_n, s_n)$$

Where, S_n is the time require for the data packets to be send from source node, r_n is the time in which the destination node received the packet and N denotes the number of packet sent from source to target node. EED refers to the time taken by the packet to transmit from sender to receiver across a network.

The following figure finds out the EED of both protocols on the MANET in different time intervals. The EED of the TCP is greater than DCCP. The average EED of the TCP is 396.44 ms which is very high as compared with the DCCP. This delay may occur in different level of the network when packets are transmitted on the route from one node to another node.

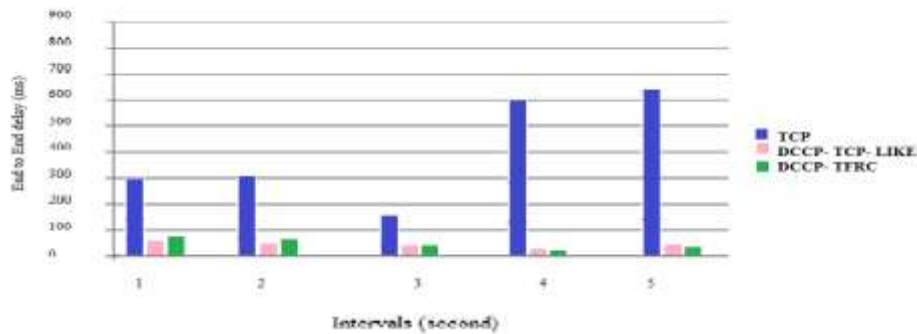


Figure-4: End to End Delay For Each Interval

The figure shown below reveals the average end to end delay of the two protocols (TCP & DCCP Mechanisms). In which the average end-to-end delay of TCP is much higher than the DCCP Mechanisms.

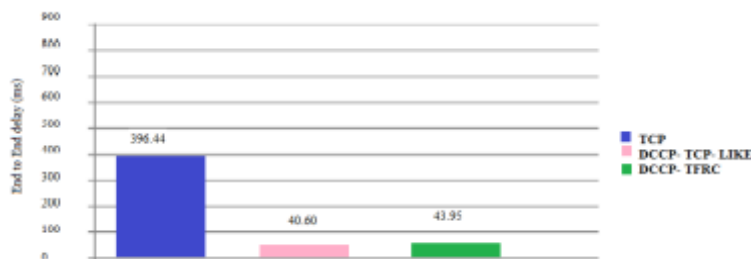


Figure-5: Average End to End delay

c) Throughput. Throughput is the number of packets received by the receiving nodes in a specific time interval. In a good congestion control algorithm, a large number of packets will be delivered successfully from source to destination nodes because in this case a very few packets are lost during transmission in specific period of time. Throughput is the average rate of successful packets delivery from source to destination over a communication medium. Throughput is commonly measured in bits per seconds (bps). The throughput of the TCP is greater than DCCP Agents because the TCP has the facility to retransmit the dropped packet on the network. TCP is generally used for the text file transmission but in the case of DCCP, reliability is a less concentrated issue due to which less throughput is observed as compared with TCP. The figure 3.7 plotted the throughput of TCP and DCCP Mechanisms on different intervals.

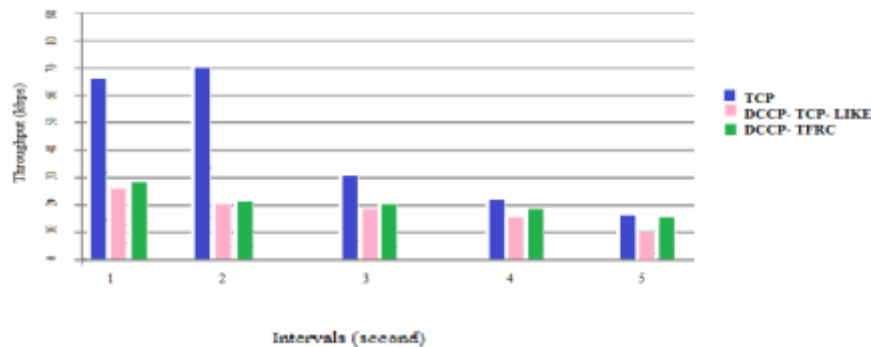


Figure-6: Throughput in Each Interval

According to the figure shown below, the average throughput of the TCP is more than the DCCP Mechanisms because it reliably retransmitted all the dropped or lost packets.



Figure-7: Average Throughput

d) Dropping packets. The data packets, which are lost during transmission from source node to destination node, are called dropped packets. The dropping data packets have a huge influence on the performance of the network, as the loss of packets during transmission reduces the performance of the network. The reason for low performance is that only a small amount of data packets reached the receiving node. Those data packets which are dropped or lost during communication waste the bandwidth of the link and consume energy. If the lost packets are important, then they are retransmitted on the network. Therefore, in a better congestion control algorithm, dropping packets must be very few in number. The number of packets dropped from source to destination is much greater in the case of TCP, but on the other side, DCCP has a strong congestion-controlled mechanism which reduced the packet dropping problem from the network. In the figure shown below, the TCP dropped 58504.56 packets per second, which is a very serious issue for the Transport Control Protocol on the network, especially for time-sensitive multimedia applications. On the other side, DCCP plays a much more satisfactory role because the average number of dropped packets is negligible as compared to the TCP.

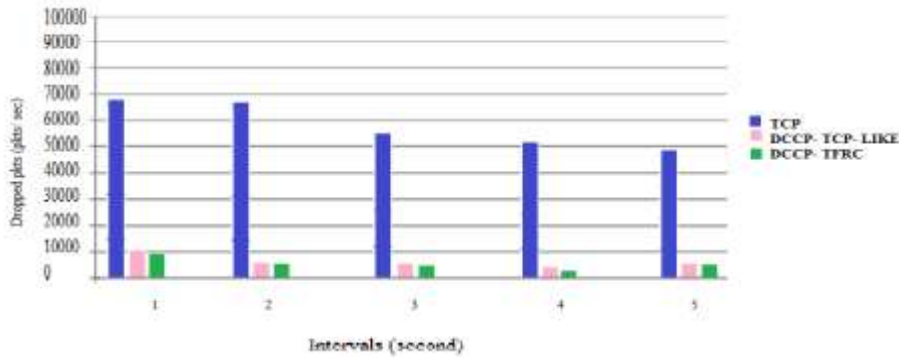


Figure-7: Number of Packets Dropped In Time Interval

TCP drops a large number of data packets as compared with DCCP mechanisms due to which the performance of TCP is very poor as compared with DCCP because DCCP mechanisms dropped a very small amount of packets during transmission.



Figure-8: Average dropped packets

Table-5: Average Performance of TCP & DCCP Mechanisms

S#	Metric	TCP	DCCP TCP Like	DCCP-TFRC
1	Energy (joules)	1.45	1.24	1.32
2	End to End delay (sec)	396.44	40.60	43.95
3	Throughput (kbps)	40.91	18.66	20.81
4	Packets dropped (pkts/s)	58504.56	5858.59	4840.87

The above table shows the average results of TCP and DCCP mechanisms. The average energy consumed by TCP protocol is 1.45 joules which is very high as compared with DCCP. The average end to end delay, throughput and dropped packets are 396.44 ms, 40.91 bytes / s and 58504.56 packets /s respectively. It is also very great number as compared with the DCCP sub protocols. A great number of packets are lost by the TCP during transmission which causes a bit higher delay because the reliability of the TCP maximized the EED in MANET. The throughput of the TCP is 40.91kbps which is greater than the DCCP Mechanisms because DCCP has slightly unreliable features. The retransmission process of TCP consumed a large amount of energy as compared with DCCP. TCP is a reliable

protocol, due to which its performance is poor as compared with DCCP, because DCCP is the combination of the features of TCP and UDP. Therefore its transmission rate is much higher than TCP and has low energy consumption of DCCP.

4. Conclusion. This study concludes that DCCP is better in performance than the Transport Control Protocol (TCP) in many ways when the results were compared after the evaluation of different performance metrics of the DCCP and TCP mechanisms. DCCP provided a congestion controlled mechanism with much better as compared with the TCP. Although TCP is a reliable protocol but during data transmission, huge number of packets are lost which affect the overall performance of TCP. On the other side, DCCP dropped a very small number of packets from sending node to receiving node during transmission. Therefore, it is concluded from the study that TCP has high throughput and due to its reliability, it provided better performance in the case of text file data packets and faced a relatively bit high problem in the multimedia file transferring. DCCP has the combined features of TCP and UDP. Therefore, it has good performance in both types of files transmission. Furthermore, it faces minor problem in the multi hopping network due to its new stage.

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