Performance Evaluation of TCP and UDP Protocols under EPLAODV Routing Protocol in Emergency Situations

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Abstract

Mobile ad hoc networks (MANETs) can easily be deployed in a disastrous situation. Mobile routing protocols provide efficient routing strategies in such situations to share critical and emergency-related information. Many researchers have designed various energy and link-aware routing protocols but research still needs improvement. This study focuses on and evaluates the performance of TCP and UDP transport layer protocols under the EPLAODV routing protocol in an emergency. Various emergency-related scenarios are designed and simulated in the NS-2 environment. Network traffic load, node mobility, and simulation time are the main parameters. It is observed from the results that the TCP performs better than UDP under EPLAODV in an emergency situation.

Keywords—AODV, EPLAODV, TCP, UDP, Energy Efficient

1 Introduction

THE MANET is a collection of nodes that group together to form a network. MANET is a decentralized network that provides better telecommunication services without a permanent base station [1]. The MANET can easily be deployed in an emergency situation where the wired network devices are not responded to due to the occurrence of a disaster, and the destroyed network does not support sharing emergency-related information such as the medical report of disaster victims [2]. The first responders and their skilled supervisors have been deputed to the disaster-affected areas, to launch rescue and relief operations for disaster victims. Response, recovery, mitigation, and the preparedness are main activities of disaster relief and rescue operations to evacuate people [3]. The first responders such as doctors, nurses, policemen, firefighters, ambulance drivers, and media personnel are sharing bi-directional critical information to reduce infrastructure losses and save the lives of people. The first responders share multime-dia messages such as videos, voice calls, WhatsApp, and text messages with their supervisors to show the actual situation at the disaster site.

During rescue operations, the first responders change their positions, and the topology of the ad-hoc network changes dynamically. In such type of emergency situation, the deployment of a robust ad-hoc network is essential, which addresses the routing strategies that help to improve the network lifetime [4]. In an emergency-related situation, the uses of well-designed energy-efficient routing protocols are important, because the mobile nodes face limited coverage area, memory, residual energy, and battery charging problems [5]. The energy-efficient routing protocols determine the path to the destination based on the residual energy of nodes. The energy consumption amongst the participating nodes is properly balanced by well-designed routing, to maximize network lifetime [6].

The MANET routing protocols are divided into three types such as reactive, proactive, and hybrid [7]. The proactive type discovers the predefined routes. Each node of the network maintains its routing table and saves the routing information of all other nodes. During the occurrence of topological changes, the routing table updates its route periodically. The proactive type protocols determine the routes with less

ISSN: 2523-0379 (Online), ISSN: 1605-8607 (Print)
DOI: https://doi.org/10.52584/QRJ.2001.05

latency and consume more bandwidth during the route setup process. The reactive-type protocols discover their routes to the destination when required. The reactive type protocol does not maintain the routing information. The path discovery and its maintenance are phases of reactive routing protocol [8]. During the path discovery phase source node initiates and floods the RREQ packet to its neighbor nodes. Mobile nodes broadcast RERR control packets to their neighbor nodes informed about link failure. Hello, packets are broadcast to the neighbors periodically to check the status of the node. The hybrid rout-ing protocols combined the features of proactive and reactive routing protocols. AODV, DSR, and TORA are the main types of reactive routing protocols [9].

AODV routing protocol is designed based on the Bellman Ford Algorithm [10]. AODV reactive routing protocol is more appropriate in disaster scenarios due to its topological changes. The mobile nodes move easily within the transmission range of the network. AODV discovers the route between source to destination when required. The routing protocols discover the feasible route by the broadcasting of control packets. The source node starts the route setup process, which broadcast RREQ control packets to its neighbors. The broadcast ID and latest sequence number are included with the RREQ control packet during the route setup process. The intermediate nodes re-broadcast RREQ packets to their neighbor nodes when the destination was not found. This route setup process is continued until the destination node received the RREQ control packet. The destination node unicast route reply (RREP) controls packets along with the reverse path to discover a feasible route to the destination. The EPLAODV routing protocol chooses energy and link-aware routes during route setup. The routes are determined based on link quality, node energy, and traffic priority. High and low-priority traffic are the two types of network traffic. For the broad-casting of emergency-related information such as voice calls and real-time video in high-priority traffic, the EPLAODV routing protocol selects high-energy nodes with high SNR values in route setup. The usual traffic type EPLAODV chooses the moderate energy nodes with moderate SNR value for sharing emergency-related information such as text and location information.

Both Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) are supported by the AODV routing protocol [11]. TCP protocol uses the SYN-ACK mechanism to establish the network connection before sending the data to the destination. TCP is a transport layer protocol that ensures reliable data transfer, and bi-directional communication and provides congestion control features. The application agent of TCP is FTP and the CBR is the application agent of UDP protocol. The UDP supports the unidirectional flow of data from source to destination. No acknowledgment is received during the successful transformation of data packets. The UDP is considered unreliable because the protocol is not responsible for successful data delivery [12]. The rest of the paper organizes as follows: Section 2 gives the overview of related work. Section 3 describes the route setup process of the EPLAODV routing protocol. Section 4 presents the simulation and results, a comparative analysis of TCP and UDP under the EPLAODV routing protocol, and Section 5 consists of concluding remarks.

2 Related Work

Raffelsberger et al. [13] proposed a MANET routing protocol in realistic emergency response scenarios. The author evaluates the performance of multiple routing protocols for MANET. A disaster area mobility model and a wireless shadowing model are used in the simulation to recreate realistic first responder motions in a mixed indoor/outdoor environment. The simulation findings reveal that nodes have different connectivity characteristics which are prob-lematic for state-of-the-art MANET routing methods. Kaur et al. [14] proposed an energy-efficient algorithm EMAODV that is based on AODV. The authors introduce an automatic update mechanism, which updates the information of other nodes during the route setup process. The algorithm reduces transmission delay during the transmission of messages. The proposed algorithm added a new field power dissipation factor (PDF) to optimize battery lifetime. The PDF has decremented during the route setup process nodes with minimum routing cost are selected to find feasible routes from source to destination. Manaseer et al. [15] proposed a model for Emergency Centres setup. In the proposed model fire stations, emergency rooms are constructed at the disaster site by rescue teams as part of disaster-recovery efforts. This research proposes a novel model for the distribution of rescue stations and centers. This model fulfills the requirements which influence the decision to adopt ad-hoc networks for getting the best communication performance level. Arepalli et al. [16] designed a geospatial framework for smart cities. The proposed framework helps to understand and handle disasters. The author focuses on the design of smart cities which minimizes the risk of disaster-related losses. In this age of development, most people live in cities, and the population of cities increases continuously. In an emergency situation, population fluctuations increase the risk of losses such as loss of human lives, property, and the environment. Smart cities are a rapidly expanding trend in many emerging nations. These cities' infrastructure is being redesigned to achieve smart city aims. Li et. al. [17] proposed an energy-efficient routing algorithm EAODV. The algorithm considered limited node energy and low node mobility during the route setup process. EAODV enables an interrupt update strategy when the node moves out of the communication range. The algorithm discovers the route dynamically and switches to a more energy path to improve network lifetime. Channa et. al. [18] the authors proposed and provide a dependable routing approach that finds the shortest paths between all reliable nodes. The suggested routing technique detects packet forwarding misbehavior in an active route owing to a network fault or congestion and re-routes packets through another trust-worthy route. Comprehensive simulations are used to assess the proposed strategy's performance in terms of PDR, End-to-End Delay, and routing overhead. Chaudhary et al. [19] studied AODV routing protocol under TCP and UDP traffic. Through simulation, it has been observed that the behavior of TCP in multi-hop wireless networks is variable. Despite several studies on TCP's shortcomings on MANET, traffic and mobility scenarios play a crucial role in assessing their performance. The simulation shows that CBR outperforms TCP in terms of throughput and routing overhead. AODV was in a position to address connection failures quickly, improving packet delivery per-formance. Kumar et al. [20] analyzed three routing AODV, DSDV, and DSR. This study addresses MANET routing techniques on mobile Ad-hoc network performance. The authors examined the performance of MANET routing methods using TCP traffic. The performance evaluation of routing protocols is carried out under TCP traffic patterns using PDR, Throughput, and Jitter. The PDR and throughput of DSDV are better as compared with AODV and DSR routing protocols. Sharma et al. [21] proposed a P-AODV routing algorithm which is a priority-based routing scheme. The authors added priority as a new field. The mobile nodes are divided into high and low-priority traffic. The priority is advertised in Hello packets and stored in the neighbor table. The high-priority nodes are selected in the route setup process. A controlled re-route discovery mechanism is introduced to minimize re-route discovery and avoids the broadcasting of control packets. Chaudhary and Singh [22] investigated and analyzed the perfor-mance of DSR, DSDV, and AODV routing protocols under CBR and TCP traffic. This study analyzes the behavior of TCP traffic under various network conditions. The paper presents the behavior of routing protocols in emergen-cies. The simulation results show that in the variable node mobility speed, the PDR of AODV under CBR performs better than TCP. Yadav et al. [23] authors characterize and compare the performance of TCP and UDP protocols for AODV and DSR routing protocols. This research article used a network simulator to perform an experimental anal-ysis of the working mechanism and functionality of two available on-demand routing protocols (AODV and DSR).

3 EPLAODV

The energy priority and link-aware ad-hoc on-demand distance vector (EPLAODV) [24] routing protocol determines energy-efficient and link-aware routes in the route discovery process. The EPLAODV chooses feasible routes based on node residual energy, traffic priority, and link quality parameters. The protocol divides network traffic into two categories such as high priority traffic and low-priority traffic. For sharing of emergency-related information such as voice calls and videos, EPLAODV routing protocol selects high-energy nodes with good SNR, whereas nodes having moderate residual energy are selected for normal traffic such as WhatsApp, numerical, graphical, and textual information. The route discovery process of EPLAODV is discussed below.

Fig. 1. and Fig. 2. show the route discovery process of high-priority traffic in EPLAODV routing protocol. The node N_s initiates the route discovery process when demanded. For the exchange of emergency-related information, the source node initiates to discover energy-efficient routes by assigning traffic priority into the newly created priority field of the RREQ control packet then broadcasts to its neighbor nodes such as n_1, n_3, and n_5. As the intermediate nodes n_1, n_3, and n_5 receive RREQ packets, the nodes compare their node residual energy with energy threshold The. Suppose that the residual energy level of nodes n_1, n_3, and n_5 is greater than the threshold value such node is selected and makes a reverse path entry, and broadcasts the RREQ packet to its one-hop neighbors. In another case, each node drops the RREQ packet. The good energy level intermediate node n_1 which is broadcasts an RREQ packet to node n_2, similarly node n_3 broadcasts the RREQ packet to node n_4, and node n_5 broadcasts the RREQ packet to node n_6. The intermediate nodes n_2, n_4, and n_6 compare their energy levels with energy threshold value The. The node n_2 is dropped and does not accept the RREQ packet due

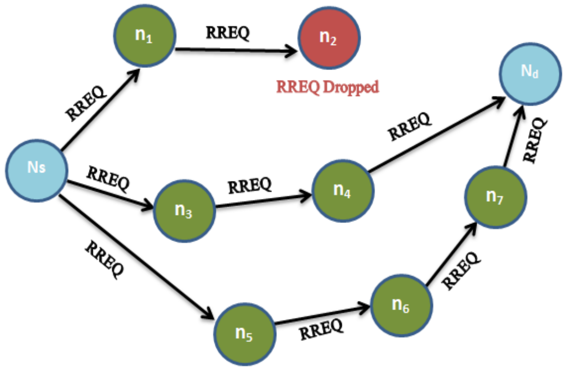

Fig. 1: Broadcasting of RREQ packet [24]

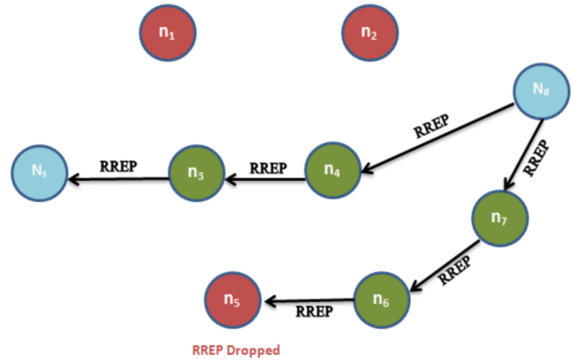

Fig. 2: Unicasting of RREP control packet [24]

to insufficient node energy level. The selected nodes n_4 and $n6$ make reverse route entries in their routing tables and broadcast the RREQ packet to nodes N_d and n_7 respectively. This process is continued until the RREQ packet reaches node N_d.

The destination node Nd updates the priority field of the RREP control packet and unicasts to nodes n_4 and n_7. The nodes n_4 and n_7 compare their residual energy, compute their SNR of the uplink, and sets the priority value in the priority field of the RREP packet. The protocol selects energy-efficient nodes with good SNR values. Low-energy nodes with bad-quality links are avoided during the route discovery process. A separate SNR threshold value Th_{snr0} and Th_{snr1} is set for time critical and normal traffic respectively. Assume that nodes n_4 and n_7 are energy efficient with good link quality which accepts RREP control packets and makes a forward path for the source node and then unicast RREP control packets to its one-hop neighbors namely n_3 and n_6. The node n_3 accepts the RREP control packet and makes a forward path entry to the source and unicasts it to the source node N_s. At the other end node, n_5 is dropped and does not accept the RREP control packet due to insufficient energy level and low-quality link. The EPLAODV selects a feasible and energy-efficient path N_s - n_3 - n_4 - N_d for the sharing of data packets from source to destination. For low-priority route setup source node set priority field of extended RREP packet of EPLAODV is 1. EPLAODV routing protocol uses the same route discovery process as used for high-priority setup. During the route setup process, the energy and SNR threshold is checked for low priority to find a new route.

4 Simulation Environment

Table 1 shows the simulation parameters of the energy-efficient EPLAODV [24] routing protocol. The routing algorithm is implemented in the NS-2 environment. For the simulation setup, Ubuntu 14.04 was installed on a third-generation Intel core family core i7 desktop PC with a 3.9 GHz and 32GB RAM. NS-2 version 2.35 was configured to simulate various emergency-related scenarios which are designed for the performance evaluation of routing protocol. The routing protocol compares two different traffic patterns such as UDP and TCP. The voice and video traffic is represented by UDP traffic and the other traffic is represented by TCP traffic. These traffic patterns are evaluated under node mobility speed, simulation time, and network traffic load parameters. The simulation results have been discussed in the next section.

4.1 Performance Evaluation

Section 4.1 consists of simulation results and the comparison of UDP and TCP traffic patterns by using EPLAODV. The performance evaluation of EPLAODV is presented in terms of PDR, energy consumption, and End-to-End Delay. The PDR of a network under variable traffic load is shown in Fig. 3. The TCP is reliable in data transfer and provides a 100% success ratio during the broadcasting of data packets. The PDR of UDP traffic is significantly dropped because the UDP is an unreliable and connectionless protocol, and do not provide retransmission of data packet. It is observed from the results that the PDR of TCP traffic is stable with the increase in traffic load. The UDP traffic reduces PDR when the traffic load increases gradually because, when the traffic load is increased more active connections are established, the network became more congested, and more data packets are lost. It is observed from the results that the TCP performs better than UDP in terms of PDR.

Fig. 4. shows the End-to-End Delay of the network. The Figure shows the End-to-End Delay of the TCP traffic which is less than UDP traffic. When the network load increases gradually the End-to-End

TABLE 1: Simulations Parameters

Parameters	Values
Mac Layer	IEEE 802.11
Coverage Area	1000 X 1000 Meters
Antenna Type	Omni Directional
Routing Protocols	TCP, UDP, EPLAODV
No. of Nodes	50
Packet Size	512 Bytes
Energy threshold for high-priority traffic	10 joule
SNR threshold for high-priority traffic	10
Node mobility speed	2m/s to 10 m/s
Traffic load	2 to 10 simultaneous connections
Data-Rate	11Mb
Mobility Models	Random waypoint
Traffic Type	CBR, FTP
Initial Energy	30 Joules
Buffer Size	50
Topology	Flat-grid
Simulation Time	1000 seconds

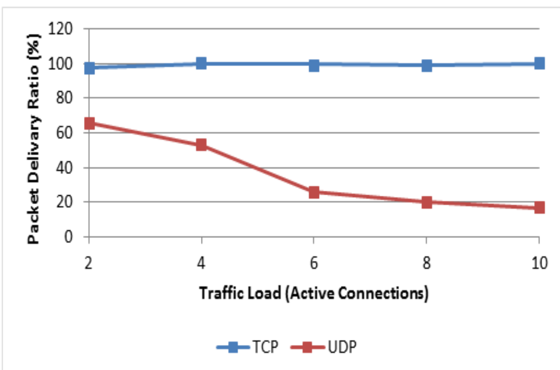

Fig. 3: PDR vs. Traffic load

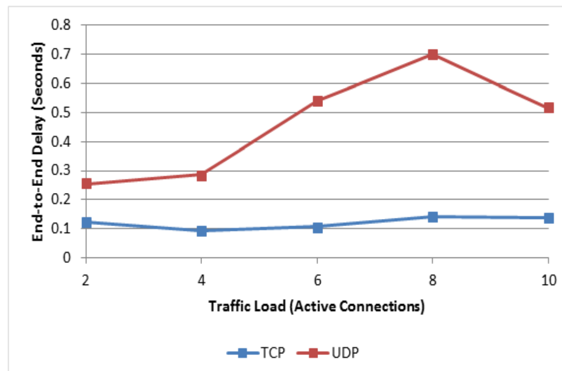

Fig. 4: End-to-End Delay vs. Traffic load

Delay of UDP traffic produces more network Delay. The network becomes more congested when more active connections are established simultaneously. During network congestion, the source node sends more data packets than the destination node handles such packets. The network congestion increases the End-to-End Delay of the UDP because the packets are buffered which drops packets. It is observed from the figure that the TCP performs better than UDP in terms of End-to-End Delay.

Fig. 5. shows the energy consumption of the network. The Figure shows that the energy consumption of the entire network increases gradually when the traffic load increases. As the traffic load increases, more active connections are established. Due to network congestion, the connections are disconnected. The source node sends more packets to establish a new connection, which may cause the consumption of node energy. It is observed from the results that the

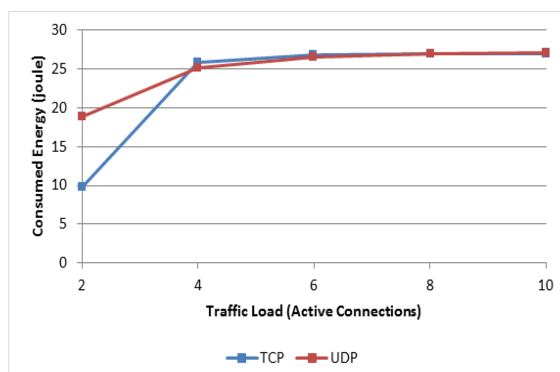

Fig. 5: Consumed energy vs. Traffic load

TCP performs better than UDP in terms of Energy consumption.

The PDR of the entire network is shown in Fig. 6. with respect to the increase in simulation time. The TCP is a connection-oriented protocol that broadcast packets to the destination without any packet loss. The

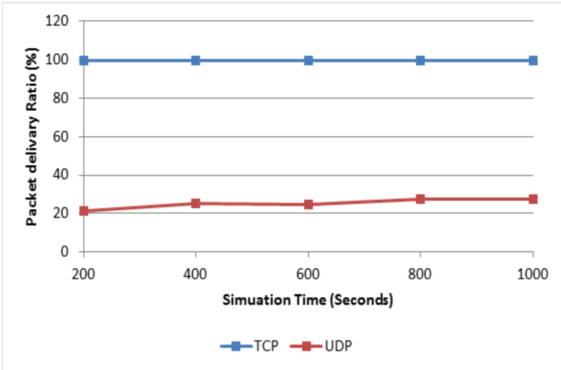

Fig. 6: PDR vs. Simulation time

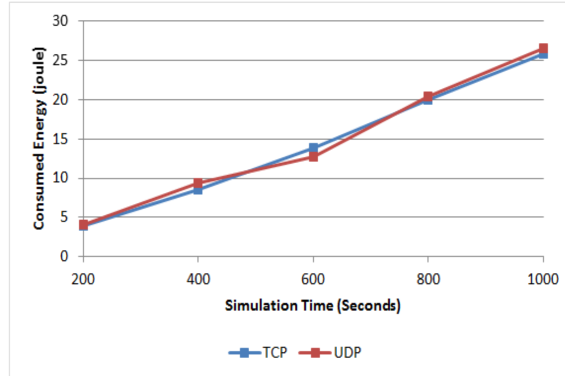

Fig. 8: Consumed Energy vs. Simulation time

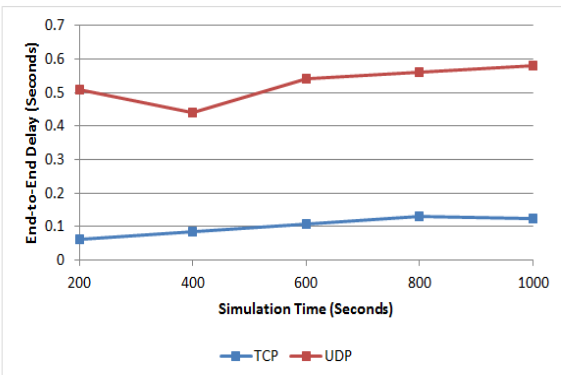

Fig. 7: End-to-End Delay vs. Simulation time

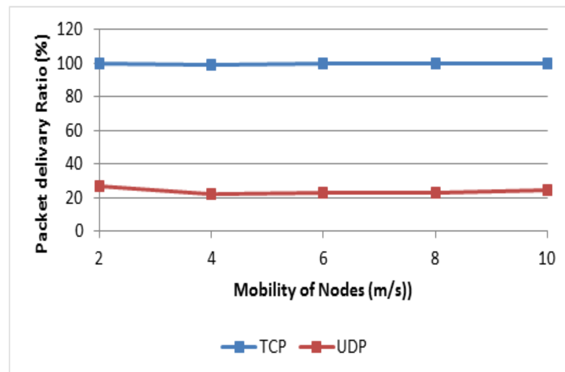

Fig. 9: PDR vs. Mobility of Nodes

TCP provides the re-transmission of packets which increases the PDR of the entire network whereas the UDP has a higher packet loss ratio which drops PDR up to 80% when the simulation time increases. It is observed from the results that the overall performance of TCP is better than UDP traffic.

Fig. 7. shows the End-to-End Delay of the entire network. The End-to-End Delay of the TCP traffic slightly increases when the simulation time increases. The UDP traffic produces more Delay as compared with TCP traffic. When the simulation time increases more packets are generated and buffered in the queue, which causes more End-to-End Delays. The TCP performs better with respect to simulation time.

Fig. 8. shows the energy consumption of the network. The energy consumption of the entire network increases gradually when simulation time increases. The TCP and UDP traffic consume more node energy because more control and data packets are broadcast during the route setup process. The figure shows that the energy consumption of TCP and UDP is almost the same. It is also observed that the TCP performs slightly better than UDP in terms of energy consumption.

Fig. 9. shows the PDR of the network. The PDR of the TCP and UDP traffic remains almost stable with the increase in node mobility speed. The TCP produces more PDR as compared to UDP. The TCP produces 100% PDR with the change of node mobility speed because TCP supports the re-transmission of packets. The UDP is unreliable and does not establish a network connection before the broadcasting of packets. When the mobility of nodes increases more nodes join or leave the session which drops the PDR. It is observed from the figure that the TCP performs better than UDP.

Fig. 10. shows the End-to-End Delay of the entire network. The End-to-End Delay of the TCP traffic slightly decreases when the mobility of nodes increases. The UDP produces more Delay as compared to TCP with the change of node mobility speed. When the node mobility increases nodes may move out of the radio range which causes network failure. In the UDP packets takes more amount of time to reach the destination. The overall performance of the TCP is better than UDP in terms of End-to-End Delay.

Fig. 11. shows the energy consumption of the network. The energy consumption of the network de-

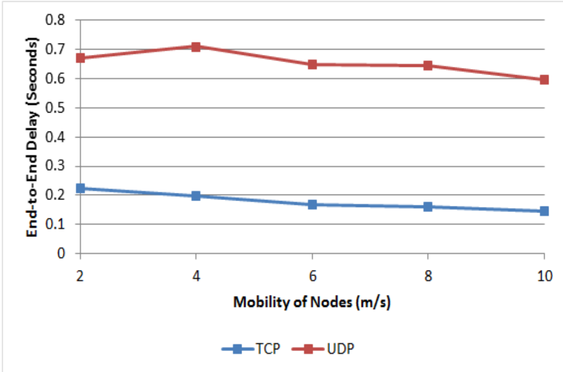

Fig. 10: End-to-End Delay vs. Mobility of Nodes

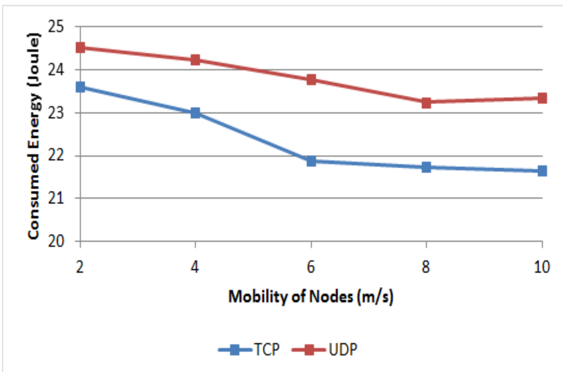

Fig. 11: Consumed Energy vs. Mobility of Nodes

creases gradually when the mobility of nodes increases. The UDP consumes more node energy as compared with TCP. When the node mobility increases more packets are dropped due to link failure which causes more energy consumption. It is ob-served that the TCP performs better than UDP.

5 Conclusion

This paper analyzed the behavior of TCP and UDP transport layer protocols under energy-efficient and link-aware EPLAODV routing protocols in an emergency situation. Both protocols are evaluated and simulated in terms of PDR, energy consumption, and End-to-End Delay. The TCP traffic drops less number of data packets and produces more PDR due to the retransmission of data packets. In all emergency scenarios, the End-to-End Delay and node energy consumption is better in the case of the TCP traffic pattern. It is concluded that the TCP produces better results as compared to the UDP protocol by varying simulation time, mobility of node, and network traffic load. It is also concluded that EPLAODV performs better with TCP traffic in an emergency situation. The future work is to compare the EPLAODV with other energy and link-aware routing protocols for TCP and UDP traffic in an emergency situation.

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