Performance Analysis of Transport Layer Protocol in IoT Environment

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ABSTRACT

IoT is currently an eternally emerging technology with sensors and actuators to upgrade and develop our day to day life. It promotes excellent opportunities for the direct integration of physical world into the digital based system. Communication is the vital segment of IoT based networks in divergence nature. To thrive an optimized communication, fixing an efficient transport layer protocol which suites for IoT contexts. A large number of new protocols are developed to improve the efficiency of communication and in usage, however, TCP and UDP are focused as the spine of Transport Layer Protocol. In this paper, we introduce a basic logical model to assess the execution of TCP and UDP protocols by using different metrics in IoT context and various experiments are conducted to provide the relative assessment among the transport layer protocols which are TCP and UDP to prove which protocol is most suitable for constraint IoT environment.

Key words: Internet of Things (IoT), User datagram protocol (UDP) , Transmission control protocol (TCP), logical model

1. INTRODUCTION

IoT provide a very intelligent connection between objects including people and virtual things, which provide a meaningful communication over the internet. This technology enables each and every product to connect with one another and exchange data over the web. The technology roadmap of IoT is growing tremendously from supply chain to physical world web. An IoT transforms those gadgets from being conventional to smart by using its underlying technology including ubiquitous and pervasive computing, embedded gadgets, communication technology, sensor networks, internet protocols and packages[1].IoT smart devices are anticipated to attain 212 billion entities deployed globally by the give up of 2020.

[2]. By 2022, M2M traffic flows are anticipated to represent up to 45% of the whole Inter-internet site visitors [2], [3], [4]. Besides these predictions, McKinsey international Institute reported that the quantity of related machines (units) has grown 300% over the past five years [5].It is gambling an amazing role in monetary growth for commercial enterprise and producing a splendid impact in international economy. Boom of IoT in healthcare application and correlated IoT based totally services consisting of telecare, m-health, tracking and prognosis are efficiently taken. The entire annual monetary impact caused by the IoT is estimated to be in the range of $2.7 trillion to $6.2 trillion through 2025[5].To accomplish the entire functionality of IoT, we need exact protocols with best performance metrics. In this paper, we have given a relative assessment among the protocols TCP/IP and UDP/IP to show which protocol is most suitable for IoT environment. Traditionally, Wide area network (WANs), UDP is fundamentally utilized for ongoing applications, for example, voice and video. Additionally, it supplies limited transmission

delay for disregard association setup process, stream control, Retransmission and Error control [6].In the meantime, more than 80percent of the WAN assets are involved by Transmission Control Protocol (TCP) movement. Rather than UDP's straightforwardness, TCP receives one of a kind stream control mechanism with sliding windows. Henceforth, the Quality of Service (QoS) of constant applications utilizing UDP is influenced by TCP movement and its stream control mechanism at whatever point TCP and UDP share a similar system assets.[7].Multimedia applications are more favor on the web and applications have special constraints to handle data over web. To optimized protocol can be fixed based on its attempt of energy utilization through its communication interfaces, based on perception and regulate the flow control on network traffic. To determine the best suitable protocol for IoT environment, two important transport layer protocols viz. TCP and UDP should be selected. To estimate the performance of the TLP protocols, several runs of simulation can be made using NS3 simulator. The rest of the paper is systemized as follows: Section II analysis the performance of current Transport layer protocols and its standards. Section III discusses the Performance metrics used in IoT. Section IV presents the formulation of proposed node scenario in IoT. Section V analysis the Performance of TCP, UDP, SCTP and DCCP with various metrics in IoT pragmatic scenario. Finally, Section 7 presents a summary and concludes this study.

2. PERFORMANCE ANALYSIS OF TRANSPORT LAYER PROTOCOLS

The transport layer protocols, TCP and UDP are well suited for efficient streaming and communication over unreliable network. However, they require a better performance in IoT environment. IoT is very excellent technology and it discloses unimaginable number of possibilities. There are many challenges in realizing IoT is with wireless network because it has packet loss and performance degradation. The layers of transmission control protocol is shown in figure 1.

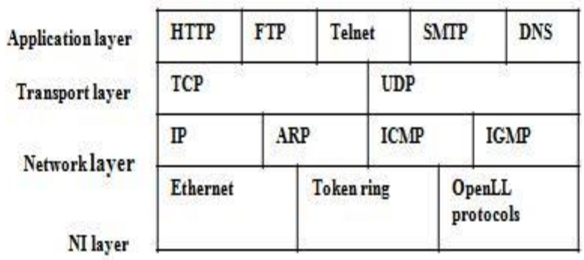

Figure 1 Layers of Transmission control protocol

2.1. Transmission Control Protocol

TCP/IP is the engine for networks and the web. It provides a communication service over the heterogeneous networks. Transport layer provides an end-to-end data transfer by delivering data to its remote node. The author demonstrates the version of end to end postpone, packet delivery ratio and throughput is carried out with various packet sizes and under TCP and CBR traffic conditions [8]. An enormous amount of applications are supported simultaneously. The frequently used protocol in transport layer is TCP. The unique feature of TCP is error recovery, reliability and flow control. The applications that are based on TCP are Telnet and Ftp.It is mainly based on streamed data transfer.TCP form segments by grouping of bytes, it reaches destination by IP layer and TCP decides the segmentation and transfer data to other nodes. The sequence number is assigned for each packet transmitted and it gets Acknowledgement is not received; it transmits again by using the sequence number the packets can be rearranged in destination.The conventional TLPs performed inadequately in remote conditions. TCP accept that all bundle misfortunes occurring in any system are because of system blockage [9], Flow control is a credit assignment strategy for TCP and it is essentially in light of byte number. The communication mechanism of TCP/IP is shown in figure 2. Customary TLP (TCP) misconstrues route or connection disappointments, medium conflict, and high piece mistakes as clog and summons congestion control (CC) mechanisms, which result in superfluous retransmissions and loss of throughput [10].

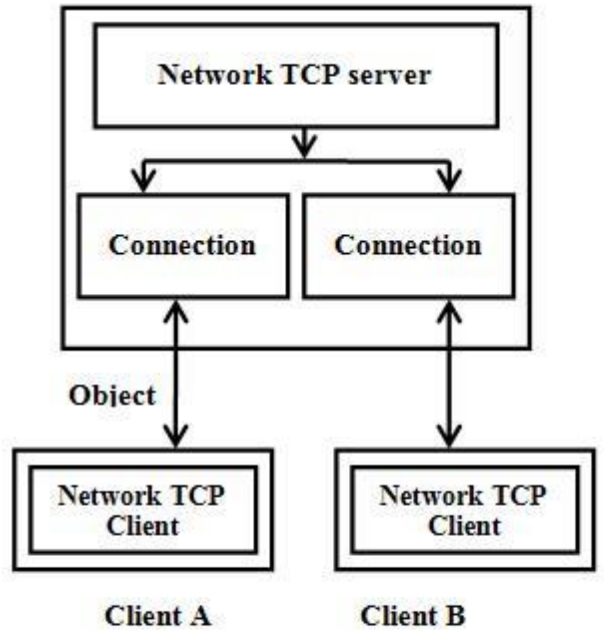

Figure 2 Communication mechanism of TCP/IP

2.2. User Datagram Protocol

UDP is a tunneling standard. It provides a best-effort delivery service defined with the IP network layer protocol. It is a packet-switched communication protocol, which interconnects the set of computer channels. The communication mechanism of UDP/IP is shown in figure 3.The development of a new reliable UDP based protocols are recently getting more attention but most of these new protocols have yet to be implemented in real applications [11]. This protocol provides a flexible way to transmit the real-time data from source to destination in the mode of individual datagram; the data packets do not send any acknowledgements. It is a basic and simple protocol on the top of IP layer. In order to improve wireless network reliability, several UDP based protocols have been developed for various purposes. The different types of protocols developed make it difficult to select the most suitable protocol for use in specific applications such as IoT and such an evaluation on the throughput and efficiency of these protocols would be helpful in these circumstances [11].UDP doesn‟t have any error detection mechanism. It is commonly called as a light-weight protocol originally intended for sample applications to short information exchange. It is a best effort protocol and faster because error recovery, retransmission, Acknowledgement is not attempted. In this protocol, the packets are sending separately and it tests for honesty just on the off chance that it arrived. The User Datagram Protocol (UDP) gives a temperamental connectionless conveyance benefit utilizing IP to transport messages between machines e.g. [12]. It doesn't have any requesting of messages and no following associations. It doesn't have any stream control mechanisms. By applying queuing model, UDP packet loss can be analyzed including UDP audio stream and internet [13].The comparison of TCP/IP and UDP/IP is shown in table 1.

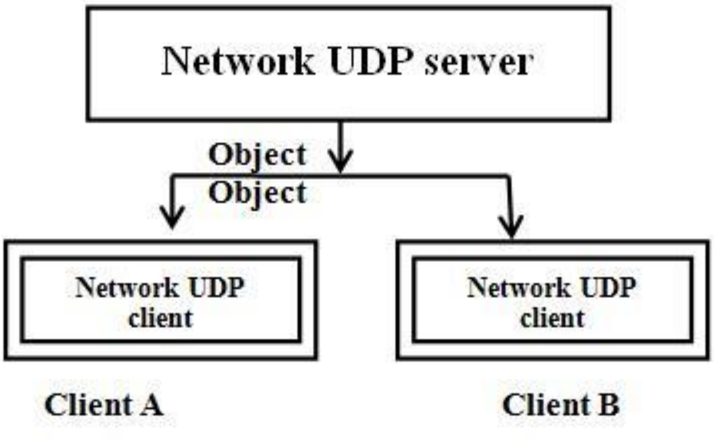

Figure 3 Communication mechanism of UDP/IP

2.3. Stream control transmission protocol

TCP is the base of SCTP[14]. In SCTP, the message is transmitted in the form of streams instead of single data packet. Likewise the messages are received in the form of streams and it is considered as the single operation. The two remarkable feature of SCTP are Multistreaming and Multihoming. Integration between the two end points is in the form of „association‟

.Multihoming is characterized as the capacity of an association to support various IP locations at a given end point. In multihoming, it results in noteworthy survivability of the session because it permits more than one address and accepts the re-routing of packets in the case of failure and also it gives a substitute way to retransmission and it comes about a noteworthy of the session even however utilizing different IP address just a single address is utilized for information trade [15], though Multistreaming speaks to requested stream of messages, it

might long or short with sole affiliation and diverse streams.The ability of SCTP to transmit a few autonomous streams of chunks in parallel referred by the term multistreaming, inside an association or affiliation [16].The messages contain control flag for grouping, Segmentation, rearrange and assembly. The stream loss occurs, stream identifiers and stream sequence numbers are included in the data packet, which permits the sequence of messages on a Single stream basis, and it eliminated the head-of-line hindrance between surges of messages. SCTP provides a mechanism for architecting the order of delivery of packets. SCTP is used for broader application. It is a reliable transport layer protocol working over the connection-less network service such as IP. The nature of SCTP is connection oriented but it is a wider concept when work with TCP connection. The functional View of the SCTP Transport Service is shown in figure 4.

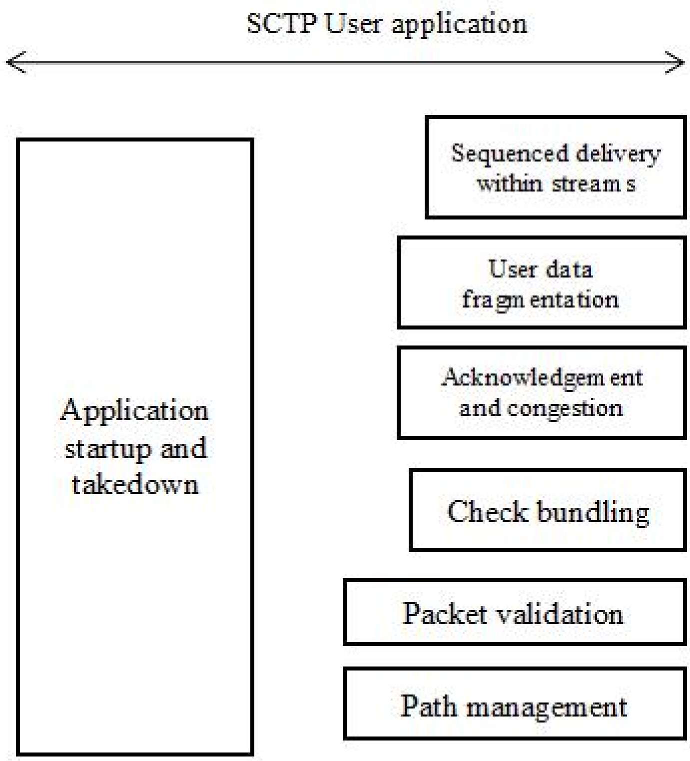

Figure 4 Functional View of the SCTP Transport Service

The transport service of SCTP is divided into many numbers of functions (1) Association start up and takedown, The SCTP user initiated an association through request. During the initialization the cookie mechanism is involved to protect against synchronization attacks. SCTP closes a connection through an association on request from the SCTP user. It is generally called shutdown. The end point performs a shutdown process. (2)The sequenced conveyance inside streams, the stream is utilized for client messages that are assigned by the top layer protocol. During the Start-up time, the SCTP user indicates the number of streams supported by an association. The number of streams confirmed with remote end user. The client messages are incorporated with stream numbers, SEND, RECEIVE messages. Sequence number can be assigned to each transmitted message by the SCTP at the sender side. On the receiver side, the SCTP user conforms the message received are in sequence within given stream.**(**3)User Datagram fragmentation, SCTP conforms the path MTU by which it sessions the user message to guarantee that the SCTP packet passed through the lower layer. At the receiver side, the fragmented messages are reassigned into the messages before passed on to the SCTP user.(4)ACK and Congestion avoidance, the transmission

sequence number (TSN) is assigned to each user data fragment or unregimented message by SCTP. In a stream level TSN is autonomous even if the gap in the sequence on the other end, it acknowledges all TSNs received.

Table 1 Comparison of TCP/IP

Parameters	**TCP**	**UDP**
Reliability	Reliable and absolute guarantee	Unreliable and no guarantee
Connection	Connection oriented	Connection-less
Transmission	Segment transmission and flow control through windowing	No windowing and retransmission
Sequencing of packets	Segment sequencing	No sequencing and No Acknowledgement
Speed of transfer	Speed of TCP is lower than UDP	Speed of UDP is better than TCP
Acknowledgement	Acknowledgement for segments	No acknowledgement for segments

The timely acknowledgement is not received; the congestion avoidance function is responsible for sending the packets again. (5)Chunk bundling, Chunk contains the user data SCTP, control information and have the choice to request bundling of two or more user messages into sole SCTP packet. Assembling and reassembling of complete SCTP packet is done by chunk bundling(6)Packet validation, During the association startup, the verification tag is chosen by both sender and receiver end. Packets are discarded if the expected verification tag is not expected. Additional protection can be given by CRC32c.It protects from corruption and attack from the network.(7)Path management, The SCTP path management function select the destination address for each sending SCTP packet based on user instruction and find the reachability status of the eligible destination set. Some of the attractive feature of SCTP is Error-free, Non-duplicated data, discover path, sequence delivery of messages, optional bundling, network level fault tolerance and protection from attacks. The architectural view SCTP association is shown in figure 5.

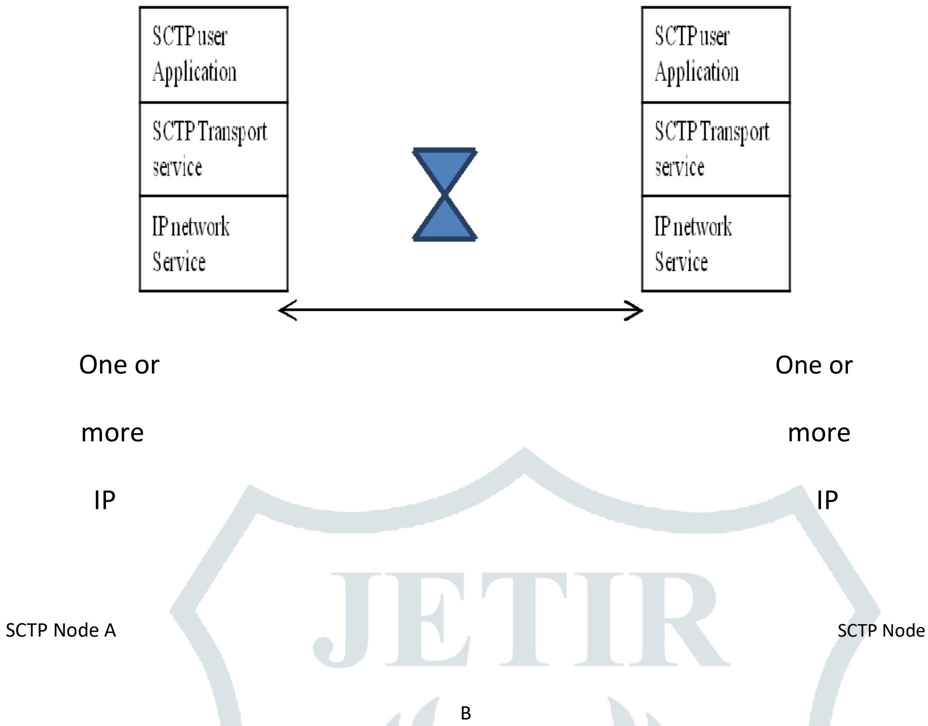

Figure 5 Architectural view SCTP Association

2.4. Datagram Congestion control protocol

UDP is the base of DCCP. This protocol mainly focused for handling the congestion effectively and efficiently. This can provide a more dependable transmission of data packets and transport layer protocol, which implements bi-directional and unicast connection with explicit congestion notification(ECN).DCCP is a rich content delivery over IP based t networks. The fundamental deficiency of the DCCP protocol is the lack of scalability [17].

Based on the type of data transmission, the specific schema can be selected for the efficient flow of data. Three way handshake mechanisms are used for high-level connection. The mechanisms are: Initiation, Data transfer and termination. Packet type, DCCP protocol implements a ten protocol types. New connection can be established using DCCP –Request after the initiation phase.

The advance of the association Eight bundle sorts are in picture ie, DCCP Request, DCCP Response, DCCP-Ack, DCCP-Data, DCCP DataAck, DCCP-closeReq, DCCP - close, DCCP-Reset, Other two information packets, for example, DCCP-Sync and DCCP-SyncAck are utilized for resynchronize after blasted of misfortune. There is no retransmission of lost packets and consequently DCCP is an inconsistent protocol [18].

2.5. States of DCCP

The client and server communication is done through nine states between the three phases. The states are LISTEN,CLOSED,REQUEST, RESPOND, PARTOPEN, OPEN,CLOSEREQ, CLOSING, TIMEWAIT[18],showm in figure 6.LISTEN -Server socket are passive listening state, REQUEST-initiate communication, RESPOND-After the listening state, Socket received the DCCP request from a client, PARTOPEN- It works with a mechanism such as Three-way handshake. When user send application data in this state, Ack number are included in all packets, OPEN –SERVER-OPEN and CLIENT-OPEN state can be established, CLOSEREQ-Request for close the connection and TIMEWAIT state can be enable, CLOSING-close the connection, TIMEWAIT-The destination enter into the TIMEWAIT state and the client has requested by server to hold TIMEWAIT state using the DCCP-CLOSEREQUEST packet type.

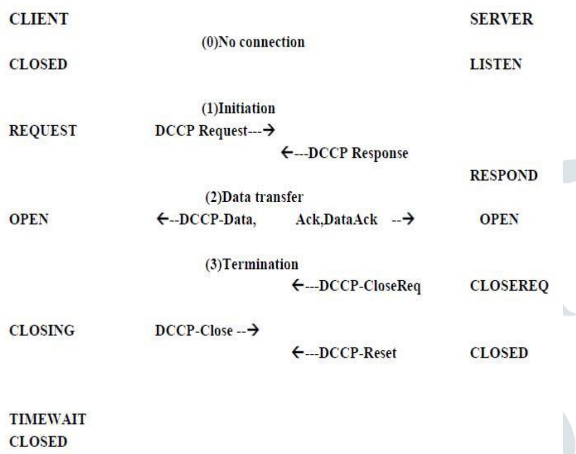

Figure 6 States of DCCP

The features of DCCP are reliable negotiation, provide explicit congestion notification (ECN) and optimal mechanism for all functions. The TCP-like Congestion control and TCP-Friendly rate control are two modular congestion control mechanisms.

3. PERFORMANCE METRICS IN IOT

To estimate the performance of the protocol, the specific metrics are considered. The value of the metrics is determined by the quality of the system and suitable for the proposed scenario, the standard metrics are used to evaluate the performance of TCP and UDP in IoT environment.

End-To-End Delay

The end to end delay indicates the time taken to transmit the data packet across the network from source to destination. Typically, four components which are Transmission delay, Propagation delay, Processing delay and Queuing delay decides the total delay time. The end-to-end delay is calculated by using following formula.

EED=TD+PT+PD+QD

Throughput

Throughput may be decided through the average rate of source records packets shipping over network connection. It is the sum of statistics rates that are brought to all terminals within the network.

Throughput=received facts*eight/statistics transmission length

Energy Consumption

The median energy is consumed by the entire node of the network, is taken as a metric to find the performance of congestion control algorithm. It depends on several parameters such as routing protocols, Transport layer protocols, data from sensor with reporting interval and congestion control algorithm

Routing Load

Routing load may be calculated by means of wide variety of routing packets required to transfer the data packet from source to sink.

Mac Load

The medium range of MAC messages evolved for a success delivery of every information packet to the sink, the packet is unit of Mac load.

4. PROPOSED NODE SCENARIO IN IOT

IoT with transport layer protocols TCP and UDP have been simulated with different data reporting intervals and results can be plotted with the metrics and data reporting intervals. The individual performance of two protocols is analyzed.

Table 2 Transmission range of nodes

S.no	Node types	Range
1	Sink node(Node 0)	180m
2	Gateway(Node 1 t0 9)	180m
3	Normal node(10 to 79)	70m

The energy model of NS3 is used to study the characteristics of transport layer protocols. In this NS3 simulator, to the sink, node sends data in a periodic fashion, the total send and received packets will increase in reporting interval. So the overall simulation time is constant. Different metrics in IoT environment are set and default values are specified by NS3.The node transmission range has shown in the below table II.

The typical scenario over the proposed TLP protocols is to be implemented to estimate their performance depicted in the figure. There are 80 nodes in the proposed scenario with one base node and 70 nodes with minimum transmission range.9 gateway nodes are nominate to facilitate the information exchange between base node and normal nodes. The proposed node scenario of pragmatic environmemt of IoT is shown in figure 7.

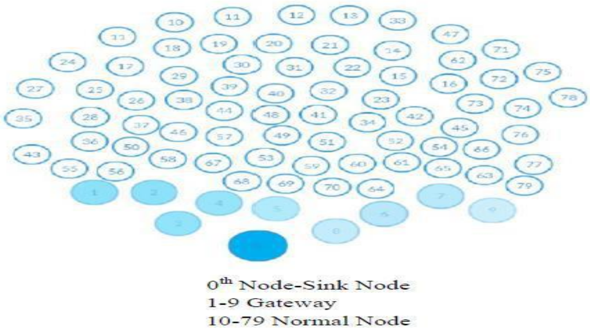

Figure 7 Proposed Node scenario

In simulated environment, 0th node is sink node. The nodes from 1 to 9 have high transmission range of all other nodes. Based on the other parameters, the transmission range of all other nodes and sink are set. The network simulator NS3 is used to study the characteristics of TLP. The node sent data to the sink in a regular fashion. By using the performance metric, calculate the performance analysis of TLP protocols such as TCP and UDP

5. PERFORMANCE ANALYSIS OF TCP, UDP, SCTP AND DCCP IN IOT

The protocols TCP, UDP, SCTP and DCCP have been simulated with different intervals with different performance metrics and the end results are plotted with the corresponding metrics concerned.

Table 3 performance of TCP for different interval with different metric

Interval (seconds)	EEE delay (ms)	Routing load (pkts)	Mac load (pkts)	Throughtput (bytes/sec)	Consumed energy (Joules)
1	242.01	26.32	62.27	60.17	1.67
2	270.87	27.40	70.74	61.09	1.60
5	110.08	54.60	122.04	20.52	1.78
10	580.10	74.62	140.72	13.54	1.55
20	622.88	92.30	181.38	8.87	1.69
Average	365.19	55.05	115.43	32.84	1.95

The table shows the average end to end delay of TCP is 365.19, which shows very high when compared to other protocols. UDP has very lower end to end delay, the average delay is 30.16.The following table III shows the performance of TCP for different interval with different metrics.

Table 4 performance of UDP for different interval with different metrics

Interval (seconds)	EEE delay (ms)	Routing load (pkts)	Mac load (pkts)	Throughtput (bytes/sec)	Consumed energy (Joules)
1	35.52	4.26	16.25	98.56	1.43
2	35.48	5.52	21.32	53.67	1.37
3	18.87	4.59	17.87	23.23	1.32
4	29.8	12.01	41.67	11.08	1.3
5	31.12	18.53	69.12	6.02	1.45
6	30.16	8.93	33.25	38.51	1.374

The routing load of SCTP is 74.912,it is very high when compared to other protocols.The average Mac load obtained by SCTP is 147.86,very high when compared with other protocols.The average Throughput of obtained by SCTP is 10.47 and it is better when compared with other protocols.The average energy consumed by SCTP is 1.42 and it is optimized when compared with TCP is shown in table V.

Table 5 Performance of SCTP for different interval with different metrics

Interval (seconds)	EEE delay (ms)	Routing load (pkts)	Mac load (pkts)	Throughtput (bytes/sec)	Consumed energy (Joules)
1	185	33.04	77.63	28.62	1.45
2	188.42	58.64	112.04	12.89	1.34
3	306	70.81	134.63	4.4	1.44
4	28	102.03	202.34	4.4	1.43
5	227.8	110.04	212.68	2.08	1.48
Average	187.04	74.912	147.86	10.478	1.428

The routing load of DCCP-TCP is 4.438,it is very low when compared to other protocols.The average Mac load obtained by DCCP-TCP is 18.204,very high when compared with other protocols.The average Throughput of obtained by DCCP-TCP is 13.708 and it is better when compared with other protocols.The average energy consumed by DCCP-TCP is 1.388 and it is optimized when compared with TCP shown in table VI.

The Performance Evaluation of Transport Layer Protocol in Constrained Environment of IoT

Table 6 Performance of DCCP-TCP for different interval with different metrics

Interval (seconds)	EEE delay (ms)	Routing load (pkts)	Mac load (pkts)	Throughtput (bytes/sec)	Consumed energy (Joules)
1	23.13	4.54	17.22	20.54	1.27
2	12.11	3.89	13.99	17.99	1.36
3	9.33	3.89	13.34	13.45	1.89
4	10.67	1.78	17.24	10.78	1.3
5	22.67	7.89	29.23	5.78	1.12
Average	15.82	4.438	18.204	13.708	1.388

End-To-End delay

The End-To-End delay is higher in the case of TCP, SCTP since the average amount of packet loss is higher when compared with UDP. TCP takes longer time to deliver the data whereas End-To-End delay is very low and constant in UDP and DCCP. Figure 8 shows the average performance of Both TCP and UDP.

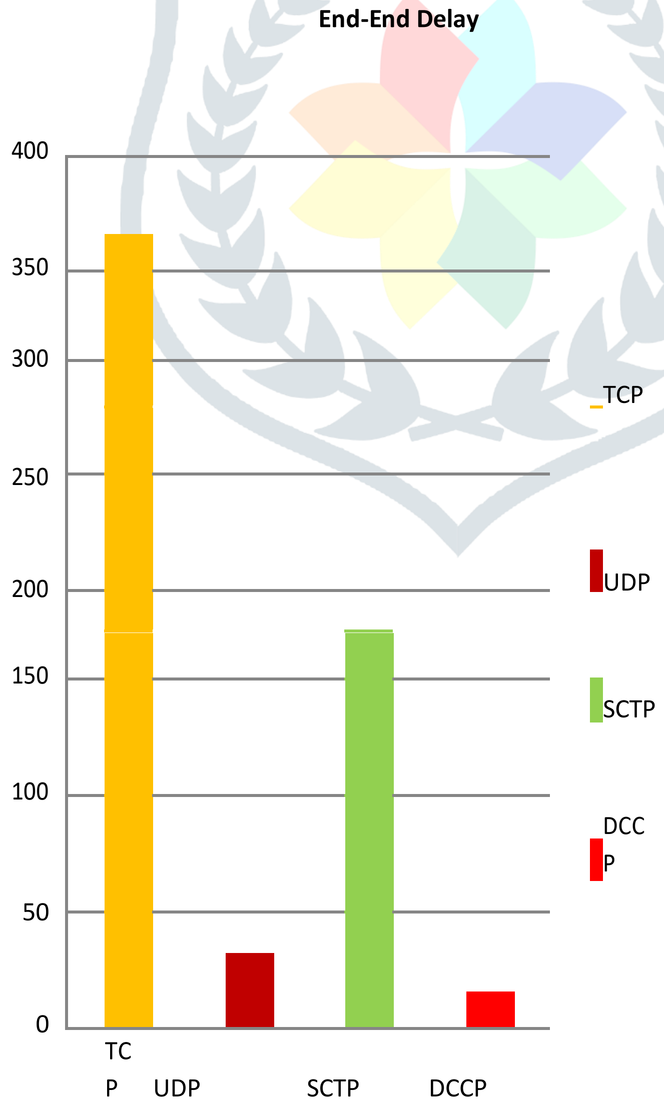

Figure 8 End-To-End delay of TCP , UDP, SCTP and DCCP with different intervals

Mac Load

The figure 9 represents the performance range of Mac load is same as that of routing load. The average Mac load of SCTP and TCP is higher when compared to UDP and DCCP. As a result, it yield a minimum Mac load level over TCP and SCTP

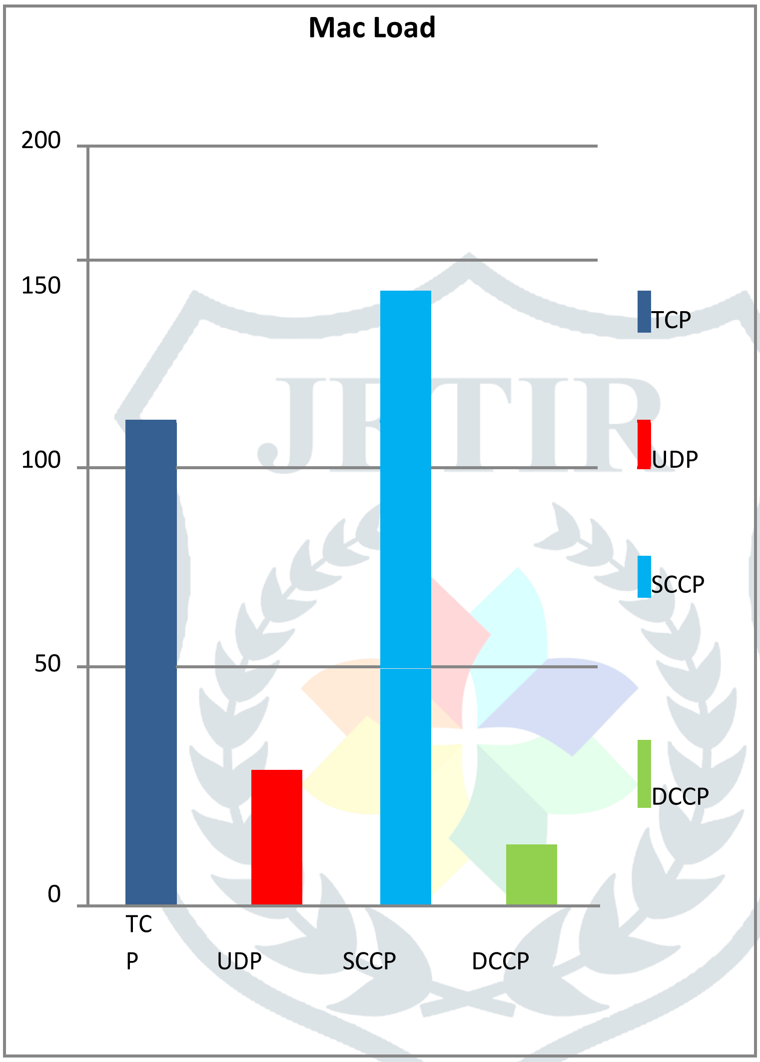

Figure 9 MAC load of TCP , UDP, SCTP and DCCP with different intervals

Routing Load

Routing load is higher for SCTP and TCP due to the additional overhead to optimized reliable transmission. The overhead caused due to the retransmission of packets since the analysis shows UDP and DCCP have only minimum routing load when compared toTCP. The average routing load of two protocols shown in figure 10 and UDP proves the good optimal performance over TCP and SCTP

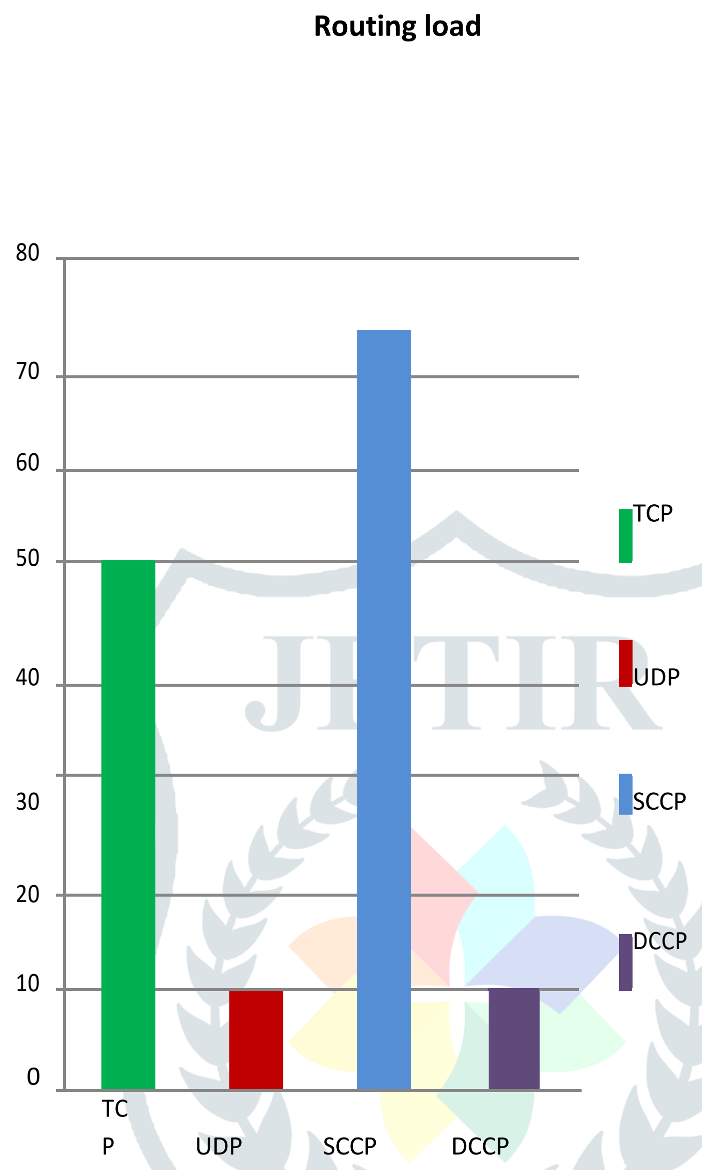

Figure 10 Routing load of TCP , UDP, SCTP and DCCP with different intervals

Throughput

The figure 11 shows the throughput of TCP , UDP, SCTP and DCCP with different intervals.TCP, SCTP, DCCP guarantees the convergence of all data bytes which it sends, whereas, UDP permits all the data packets send through all possible path, it increases the packet delivery ratio and throughput get increase. The following figure depicts the overall performance of the TCP, UDP, SCTP and DCCP, which conclude with the performance of UDP is better when comparing to all other protocols in terms of throughput.

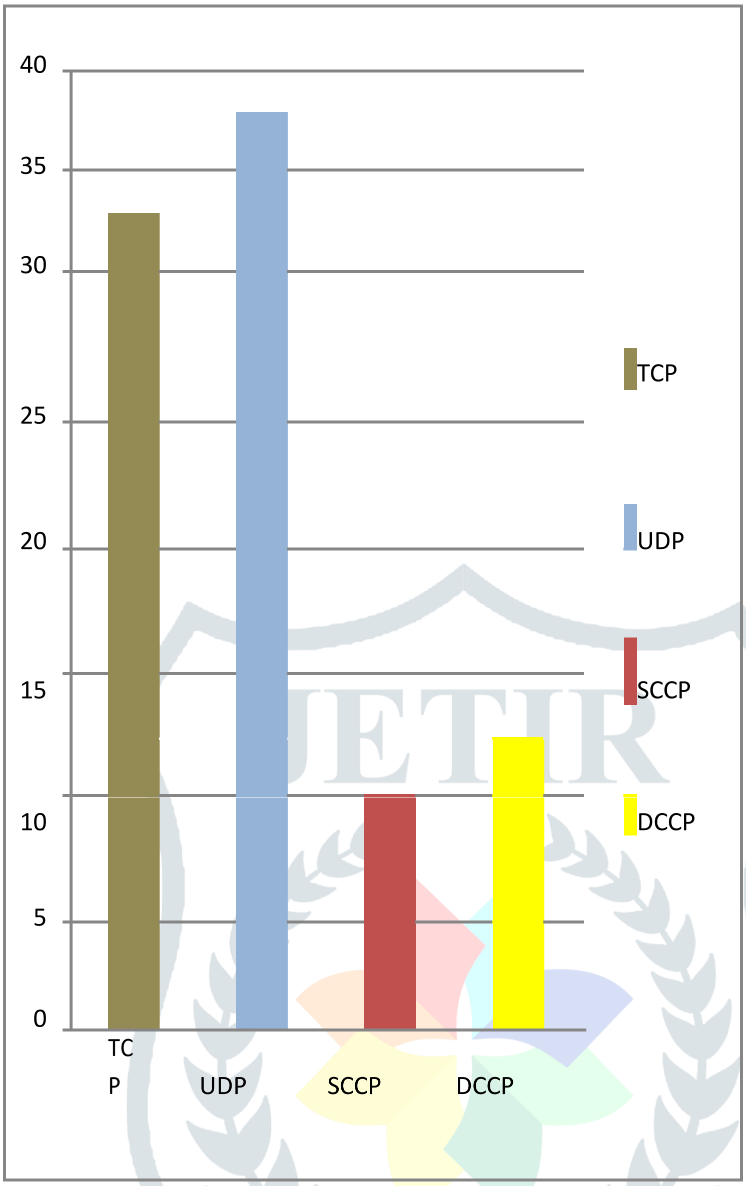

Figure 11 The Throughput of TCP , UDP, SCTP and DCCP with different intervals

Consumed Energy

The energy consumption is down when UDP moving towards the higher interval. The energy consumed in terms of joules. UDP consumes less energy when matched with TCP.TCP consumes maximum energy because it resends the data packets when it discarded, duplicated, corrupted or reordered. So UDP consumes minimum energy when compared to TCP.The consumption of energy is shown in figure 12.

The Performance Evaluation of Transport Layer Protocol in Constrained Environment of IoT

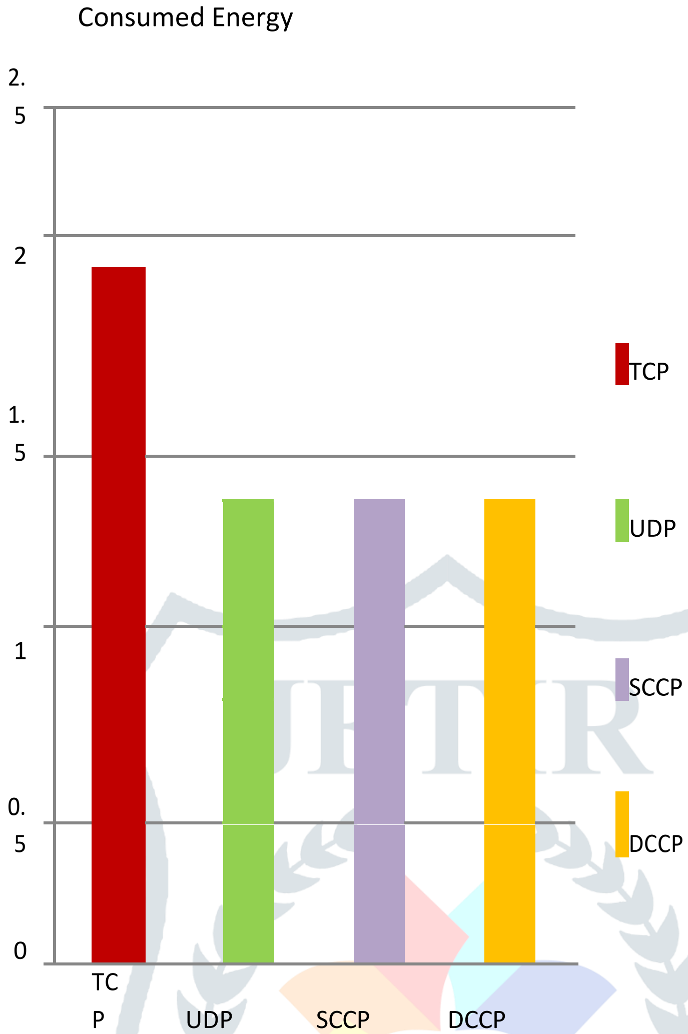

Figure 12 Consumed energy of TCP , UDP, SCTP and DCCP with different intervals

The conclusion can be made with TLP protocol analysis with existing framework of IoT, which satisfies the performance metrics such as End-to-End delay, Mac load, Routing load, Throughput and consumed energy in various aspects. The performance of individual protocols is shown in figures 13, 14,15 and 16 and UDP/IP proves that the more suitable protocol for IoT environment.

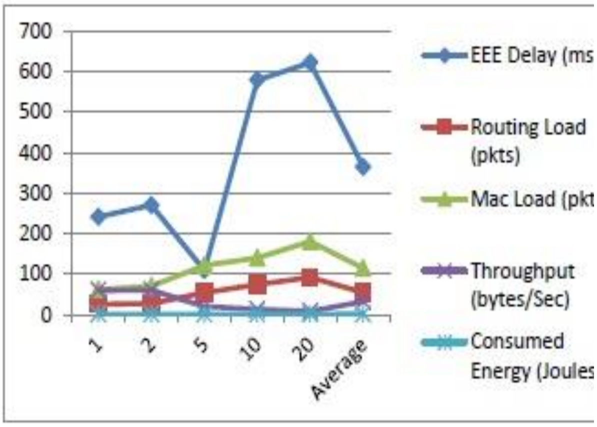

Figure 13 Performance of TCP

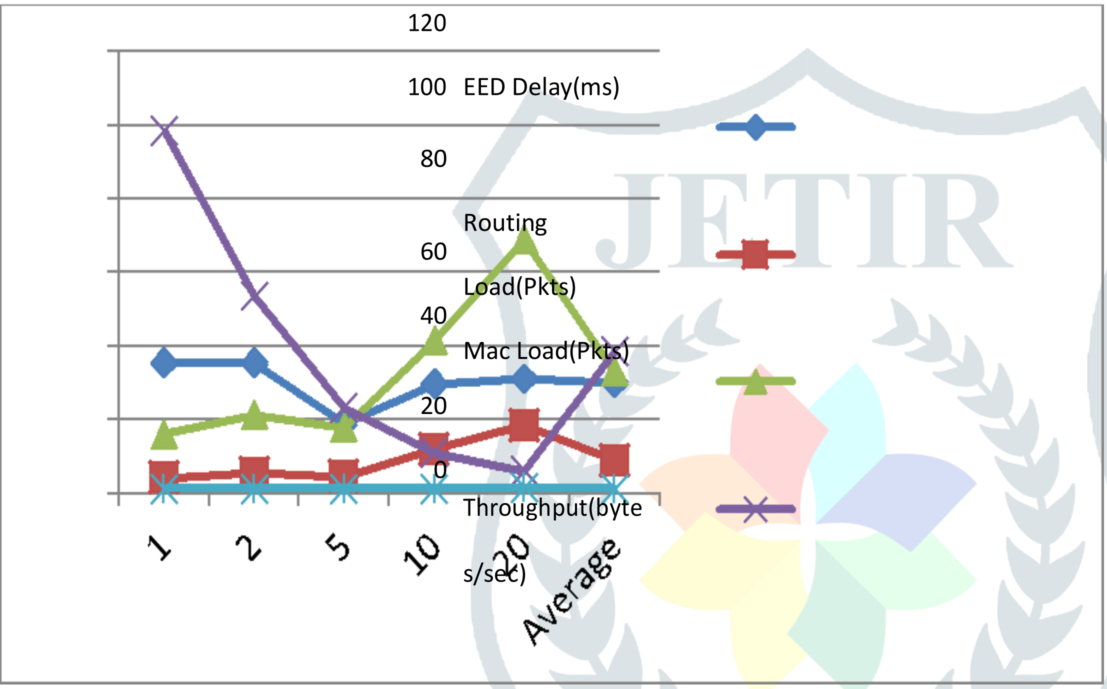

Figure 14 Performance of UDP

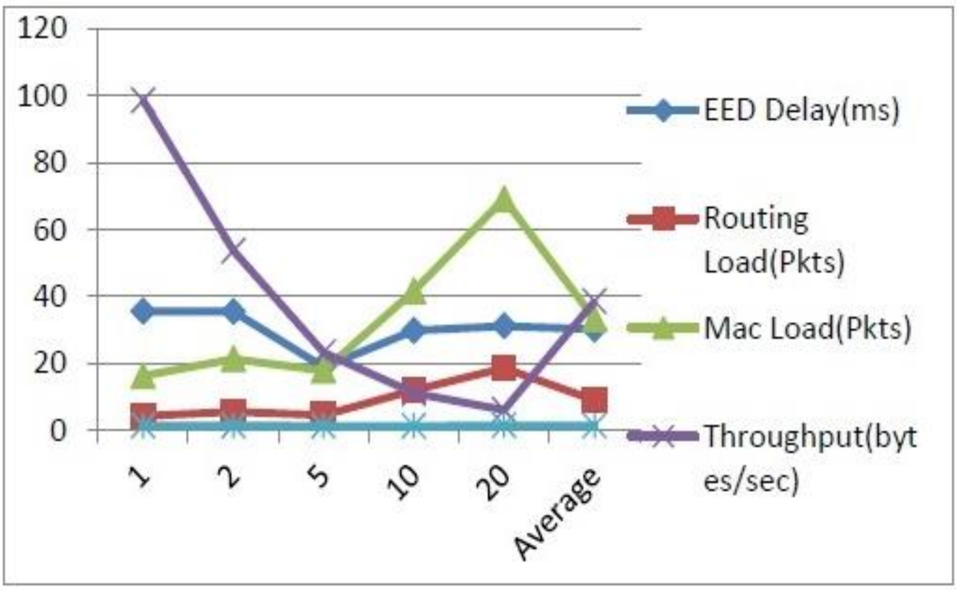

Figure 15 Performance of SCTP

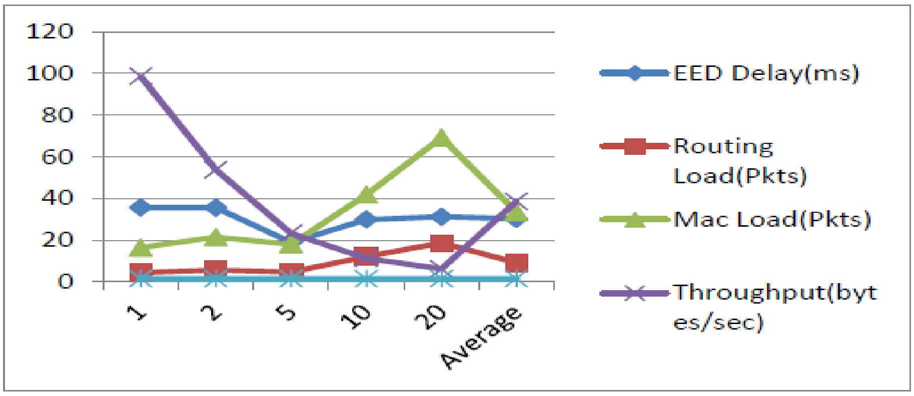

Figure 16 Performance of DCCP-TCP

6. CONCLUSIONS

The work outlines the performance of TCP and UDP protocols by using different metrics in a constraint environment. The nodes in our simulated environment are placed like mesh fashion. Several runs of simulations are made with different protocols. Performance is assessed on the basis of simulation results obtained under a pragmatic scenario. The surveyed upshot have shown that the UDP is more flexible and provide persistent performance level in terms of End-to-End delay, Mac load, Routing load, Throughput and consumed energy in various aspects. So UDP can be the effective transport layer protocol in the constraint environment of IoT.

REFERENCES

[1] Ala Al-Fuqaha, Mehdi Mohammad, Mohammed Aledhari, and Moussa Ayyash, Internet of Things: A Survey on Enabling Technologies, Protocols, and Application

[2] J. Gantz and D. Reinsel, “The digital universe in 2020: Big data, bigger digital shadows,

and biggest growth in the far east,” *IDC iView: IDCAnal. Future*, vol. 2007, pp. 1–16, Dec. 2012.

[3] D. Evans, “The Internet of things: How the next evolution of the Internet is changing everything,” CISCO, San Jose, CA, USA, White Paper, 2011

[4] S. Taylor, “The next generation of the Internet revolutionizing the way we work, live, play, and learn,” CISCO, San Francisco, CA, USA, CISCO Point of View, 2013.

[5] J. Manyika*et al.*, *Disruptive Technologies: Advances that Will TransformLife, Business, and the Global Economy*. San Francisco, CA, USA:McKinsey Global Instit., 2013.

[6] Taha Ahmed Al-Radaei and Zuriati Ahmad Zukarnain,Comparison Study of Transmission Control Protocol and User Datagram Protocol Behavior over Multi-Protocol Label Switching Networks in Case of Failures

[7] Tsuboi, T., H. Ueda and H. Kasai, 2005. Designing MPLS path protection networks for

reduced TCP goodput degradation. http://sciencelinks.jp/jeast/ article/200514/000020051405A0415504.php

[8] Barinderpal Singh and Rahul Hans, TCP and UDP Based Performance Analysis of AODV, DSR and DSDV Routing Protocols Under Different Traffic Conditions in Mobile AdHoc Networks

[9] Fu, Z., Greenstein, B., Meng, X., Lu, S., 2002. Design and Implementation of a TCP-friendly Transport for Ad hoc Wireless Networks.*ICNP.02: Proceedings of the 10th IEEE International Conference on Network Protocols*, pp. 216-225. 2002.

[10] Sakhile M. Ncanana, PragasenMudali, Murimo B. Mutanga, Siphamandla L. Nxumalo, and Mathew O. Adigun, Evaluation of Transport Layer Protocols overWirelessMultihop Networks

[11] MadzirinMasirap, MohdHarithAmaran, YusnaniMohdYussoff, RuhaniAbRahman and HabibahHashim,Evaluation of Reliable UDP-Based Transport Protocols for Internet of Things (IoT)

[12] D. Comer, "Internetworking with TCP/IP", vol.3: Client-Server Programming and Applications, Prentice Hall, New Jersey, 1993.

[13] J-C. Bolot, End-to-end Packet Delay and Loss Behavior in the Internet, In Proc. ACM SIGCOMM93, pp. 289-298, September 1993

[14] R. Stewart, Q. Xie, K. Morneault, C.Sharp, H.Schwarzbauer, T.Taylor, I.Rytina, M.Kalla, L.Zhang, V. Paxson. "RFC2960 - Stream Control Transmission Protocol ".October 2000.

[15] L. Budzisz, R. Ferrus, K.-J.Grinnemo, A. Brunstrom, F. Casadevall, "An analytical estimation of the failover time in SCTP multihoming scenarios", in: Proc. of the IEEE

Wireless Communications and Networking Conference (WCNC 2007), Hong Kong, 2007, pp. 3929– 3934.

[16] M. Fazio, A. Biundo, M Villari,. A. Puliafito, "An in-depth analysis of the SCTP behavior in mobile ad hoc networks", in: Modeling and Optimization in Mobile, Ad Hoc and Wireless Networks and Workshops, 2007 on Volume, Issue , 16-20 April 2007, Page(s):1

– 9

[17] C. Froldi, N. Fonseca, C. Papotti, and D. Manzato, " Performance evaluation of the DCCP protocol in high-speed networks," in Proceedings of IEEE CAMAD 2010, Miami, USA,

2010, pp. 41– 46.

[18] E. Kohler and M. Handly and S. Floyd, Datagram Congestion control protocol (DCCP) , IETF RFC 4330, LA, USA, 2006.

[19] P. Dayaker, Y. Madan Reddy and M Bhargav Kumar, A Survey on Applications and Security Issues of Internet of Things (IoT), International Journal of Mechanical Engineering and Technology , 8(6), 2017, pp. 641–648.

[20] Dr. Kavitha, C. Ramesh Gorrepotu and Narendra Swaroop, Advanced Domestic Alarms with IOT, International Journal of Electronics and Communication Engineering and Technology, 7(5), 2016, pp. 77–85.

[21] K. Nirosha, B. Durga Sri, Ch. Mamatha and B. Dhanalaxmi, Automatic Street Lights On/Off Application using IOT, International Journal of Mechanical Engineering and Technology , 8(8), 2017, pp. 38–47.

[22] John Singh. K, Sagar G. V, Sushmita Lenka, Belwin Edward. J, Jacob Raglend. I and Stephen Olatunde Olabiyisi, A Case Study: Usb Device Charging and Fitness Monitor with Smart Safety Shoe and Iot, International Journal of Mechanical Engineering and Technology 8(10), 2017, pp. 719–728.

[23] S.Palanivel, A.Umamakeswari, S.Thiyagarajan and S.Rajarajan, A Key Establishment Management for Wireless Sensor Network and Iot Environment, International Journal of Mechanical Engineering and Technology 8(8), 2017, pp. 640–648.