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Buffer based Analysis of Congestion Control in Delay Tolerant Network

Amardeep[1*], Devendar Gahlot[2], H S Bindra[3]

[1]Dept. of Computer Science, Gopichand Arya Mahila College, Abohar (Punjab)
[2]Dept. of Computer Science, Govt. College of Engineering, Bikaner (Rajasthan)
[3]Dept. of Information Technology, MIMIT,Malout (Punjab)

[*]*Corresponding Author: – amardeepaziz@gmail.com*, (M) +91 9888490735

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Abstract **-** In this fast changing era, information or data sharing is one of the key requirement of human and machines. Networks are designed so as to provide this facility of data sharing to the humans or machines. The networks which work under the adverse circumstances (i.e. intermittent connectivity) are termed as Delay Tolerant Networks. In the Delay Tolerant Networks, Congestion is the key area which needs to be addressed by the researcher and the community. In this paper we have proposed a novel technique for buffer management to avoid / remove the congestion in Delay Tolerant Networks. This approach for buffer management contemplates the size of message and the rest of the TTL of message for buffer management and for convenience of new approaching message at every node. Through the simulative results obtained in this study we found that the approach proposed and evaluated in this work is providing better delivery probability of the messages.

Keywords **:** Delay Tolerant Network; Time to Live; Delivery Probability; Overhead Ratio; Congestion Avoidance

I. INTRODUCTION

A network can be defined as a few (two or more) computer systems which are linked together via cable /and/or wireless and also has the capacity to share software and hardware resources among a number of users. TCP/IP protocol is the main communication language or protocol of the internet. Such a thing might also be used as a communication protocol in a private network (either internet or extranet). It also makes use of the client-server model of the communication in which the requests are made by computer front and users (client) the services are provided by another computer (server) from the network [1,2]. This communication is primarily point-to-point, meaning host node is connected to another host node of another computer in the network. It also provides reliability of message during transmission process. TCP/IP protocol offers simple naming and addressing scheme. It works on four layers as shown in the blow figure 1.

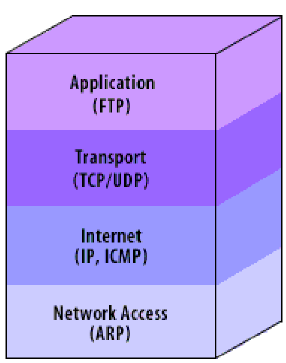

Figure 1: The TCP/IP Model

The advantages of the TCP/IP protocol are (i) It operates independently of operating system (OS) [3]. (ii) It is based on client/server architecture. (iii) It can be used to establish connection between two or more computers. Whereas the disadvantages of TCP/IP protocol are (i) It is very complex to setup and manage as it has large number of computer / paths / routers. (ii) It only allows sending / receiving data within its network.

The TCP/IP protocol is not working satisfactorily with existing and newly emerging wireless networks as used in military wars, deep ocean, deep space, floods, storms etc. the result of this is excessive delay, bandwidth node, restrictions mobility and shortage of power. Because of such circumstances, there is no end to end path between the source and its destination which makes connectivity not possible. Many networks which have been intermittently connected are already under research example include: Wireless Sensor Networks (WSNs), Exotic Media Network (EMNs), Mobile Ad-hoc Networks (MANETs) etc [4, 5, 6]. For correspondence amongst ICNs and web, we utilize the new idea i.e. gateway. As appeared in below figure 2, the door goes about as an interface and believers the web convention parameters, as per the ICNs prerequisites parameters. It is additionally conceivable that a gateway has its own particular storage. Since there is a plausibility that the association between two ICNs takes quite a while, the door holds the message until the point that it is conveyed to the following hop. For the best possible association and usefulness under these testing conditions specialists were pushed to build up another systems administration idea [7].

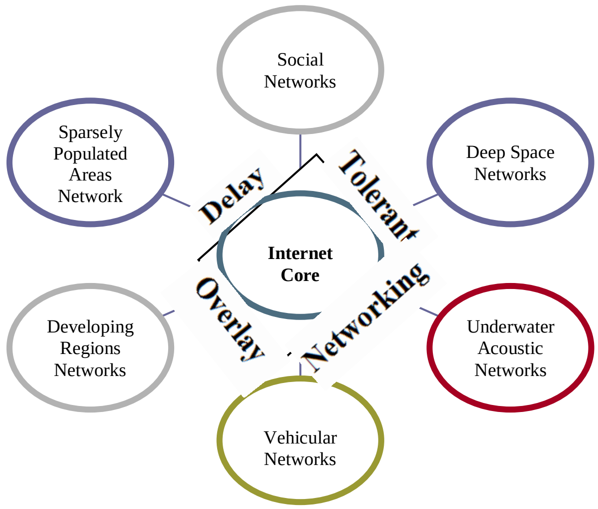

Figure 2 : Delay Tolerant Networking

An infrastructure less wireless network is usually intermittently connected. It helps to support the proper functioning of one or more wireless applications which operate in a stressful environment. The stressful environment in turn indicates delaying excessively and continues existence of un-guaranteed end to end path between a particular destination and its source rendering traditional routing protocols unable to deliver message between hosts/sending/receiving hop. As a result, there is a problem of link disruption.

Problems associated with intermittently connected network during data transmission for both sender and receiver included (i) Lack of connectivity indicating no end to end path between the destination and its source. (ii) Long or variable delay occurs due to absence of an end to end path between source and destination nodes, long propagation delays between them also contribute to end to end path delay. (iii) Asymmetric bidirectional data rate can be somewhat dealt with in the conventional protocol. But If the asymmetric is larger, then it can't be overcome easily.

I.I Delay Tolerant Network

A part of networking dealing with problems in disengaged or distributed especially without end to end connection is known as delay tolerant network (DTN). It aims to have practical working in extreme distance as in space interchange or on an interplanetary scale. In such circumstances, the long latency usually measured in hours or days becomes obvious. In certain networking situations the functioning of the present internet protocol is not satisfactory. An example includes the scenarios where the quality of lake water is to be taste in some rural area. Another example could be a space mission to Mars. Network passage can be blocked by amendments or retransmission of the complete packet due to bit error owner transmission links.

I.II The Architecture of DTN

The structure of DTN is planned to contain network connection disruption by means of a technique to deal with heterogeneity. The architecture grasps the ideas of intermittently connected networks that may experience the ill effects of regular allotments and that might be involved in one or more different arrangement of protocols or protocol families.

Beneath the applications but above the transport layers of the networks on which it is hosted, there exists a bundle layer as shown in the below figure no. 3, known as end to end message overlay. Gadgets that execute the bundle layer are known as DTN nodes [8]. The bundle layer shapes an overlay which utilizes diligent capacity to enable battle to network interruption. It incorporates a hop-by-hop exchange of reliable delivery responsibility and voluntary end-to-end acknowledgement. Various demonstrative and administrative features are likewise included. For interoperability, it utilizes an adaptable naming plan fit for general naming grammar. And furthermore security nodes are planned as choices went for ensuring framework from unauthorized use.

Original Five Layer Internet Protocol Stack		DTN Protocol Stack Including Bundle Layer
		Application
Application		Bundle
Transport		Transport
Network		Network
Link		Link
Physical		Physical

Figure 3: Protocol Stack of Internet and Delay Tolerant Networks

II. CONGESTION CONTROL IN DELAY TOLERANT NETWORK (DTN)

The congestion in DTNs is difficult to control because of two reasons: (1) Episodic Connectivity, i.e., constant assurance of end-to-end connectivity is not possible between nodes, and (2) there can be subjectivity in communication latencies as a result of delay due to high propagation and also due to intermittence connectivity. As a result, the traditional congestion control mechanism cannot work in DTN environment.

III. RELATED STUDIES

In Delay Tolerant Network, Hua et. al. (2010) proposed a technique dependant on path avoidance [9]. In the computer network, the custom congestion control component is made more likely that there are contemporaneous such as occurring in the same period of time, end to end path and the response data can be conveyed to source node on regular intervals. These necessities cannot be possible in DTN environment. Congestion avoidance mechanism is used to enhance the task and make use of node stockpiling and it separates the DTN nodes into various states and embraces comparing procedures to control of the data delivery in neighborhood extension to maintain a strategic distance from congestion. This new method is called PA mechanism . This new mechanism has three components i.e. Storage Management, Node State and Path Avoidance. APEA stands for Adaptive Parameter Estimation based congestion Avoidance strategy and this strategy deals with buffer management and packet receiving policy [10]. To analyze the result of APEA strategy the researcher used the simulator ONE. At the point when the network winds up plainly congested, we consider dropping packets with more hops and bigger latency first. They utilized the data contained in the node itself to evaluate the average latency and the average hop count of entire network. At that point, we utilize the estimation qualities to figure the need weight of every bundle. At that point, they utilized the estimation qualities to figure the priority weight of every packet. Packets with additional hops and bigger latency relate to lesser priority weights. At a point when the network becomes congested, they delete the packet with least priority weight first. Opportunistic Network Based Congestion Control Strategy was proposed by Zhang (2014) [11]. In opportunistic network, the moving of nodes isn't arbitrary yet constrained by time and space. Nodes can travel repeatedly in a few areas. Therefore we can say that in a particular node if the encounter probability is high with the goal then its neighboring node encounter probability will be high too. For a particular node, both encounter probability node its neighbor encounter probability node are high. The message processing in the opportunistic network embraces the repetition procedure in the congested node. In this protocol, there is very less probability that message is sent to the congested node. There can be misuse of the messages at the neighboring node. The neighboring node will get the exchanged message probably, when the probably of the moved neighboring node is high. Exploratory outcomes demonstrate that technique called DATM is used to enhance the rate of message entry and decrease the end-to-end delay to some extent**.** In 2015 Patil and Penurkar proposed an algorithm such as Congestion Avoiding Strategic Epidemic Routing Algorithm which is used to control the congestion problem in a node [12]. In the DTN there is the critical issue of the congestion such as there is the loss of the packets and there is no assurance of end to end connection. After the congestion there is chance of highest priority messages will be dropped and it is not pleasing in a DTN to drop high priority messages .Therefore we will use some kind of proposal so that priority message drop should be less by bringing more feasible element of congestion rendering. In sensitive applications high priority messages should not be dropped because they are very important but even then they are discarded when the node is congested. To overcome this problem researcher proposed a CASE routing algorithm. The researcher carried out their research in ONE simulator which is a discrete event based simulator. It is clear from the experiment that the size of the buffer has impact on the delivery probability. The said CASE directing calculation will attempt to maintain a strategic distance from the congestion before it happens. There is the likelihood of expanded number of packet drops yet the delivery probability may be expanded as a result of the lessened overhead ratio due to the network not being congested.

Buffer Management is an essential methodology that deals with the different assets among various circumstances according to the strategy utilized [13]. An effective storage administration strategy chooses at each progression that which of the messages is to be dropped first when buffer is full moreover which of the messages are to be transmitted, when data transmission is constrained. There are various buffer management techniques commonly used in DTN i.e. *Drop Least Recently Received (DLR), Drop Oldest (DOA), Drop Front (DF) FIFO, Drop Largest (DLA), MOFO (Evict Most Forwarded First) etc.* Bindra and Sangal, In their paper they have projected another message cancellation approach for multi-duplicate routing plans [14]. This plan utilizes the affirmation technique to expel the futile bundle from the system, keeping the hubs from the buffer flood issue and maintain a strategic distance from exchange of pointless message reproductions in this manner loosening up the assets of the nodes. They have discussed down the buffer occupancy of the nodes under the expanded DTN Routing Protocols. The multi-duplicate directing plans accomplish higher conveyance probability when contrasted with the single duplicate routing plan [15]. This change is accomplished at the expense of higher asset usage i.e. multi-duplicate routing protocol requires more storage space, more data transmission, acquire more overheads and expend other essential system resources. Commitment of this work is the cancellation of pointless imitations of the messages which are as of now conveyed to the expected goal. Bindra, H S has broken down the evacuation and convenience of messages at the node, and saw that there are sure cases in which a few messages that are expelled from the node to suit new messages again touch base at the node through some other node, which thus starts the procedure of expulsion of the message from the buffer to oblige this message [16]. This prompts the round circle of message deletion/settle down which thusly expands the overhead connected with the routing protocol and brings down the delivery probability.

IV. PROPOSED FRAMEWORK

In any network, dispersing packets during correspondence is a vital matter that needs attention, likewise in DTN the problem of congestion, pertaining to packet falls or messages receiving deleted, is as vital concern as, creating the connection among nodes where end to end connection is not assured. In DTN the normal latency of the network and normal hop tally are equally fixed and each has some fix value. Our proposed framework for network congestion is based on congestion avoidance approach (proactive). Our research mainly focuses on buffer management policy. The buffer management policy normally cannot noticeably decrease the network overhead so we develop the new dropping policy which is based on size of the message and TTL of the message [17].

The node may be origin, target or any adjoining mid-way forwarding node between the origin and target. Each message has unique recognition can be created at any node and can differ in sizes. The epidemic router is utilized that is completely flooding based technique and thus enhances the possibility of congestion [18]. As per our proposed framework a threshold value for buffer occupancy is established and all the incoming messages are accommodated in the node's buffer normally until the threshold value is attained. When the space of the buffer comes near to the threshold value then there is a chance of congestion so there is a need of some mechanism to avoid congestion and hence our proposed framework becomes active. Once the framework becomes active it calculates the size of the incoming message. Messages having the largest size from the incoming message in the buffer node are recognized and selected. After that the time to live (TTL) value is obtained from the selected messages. A comparison of TTL value of the incoming messages and selected messages is performed. If any message in selected message has lower TTL value than the TTL value of the incoming message, the message with the lower TTL will be dropped otherwise the incoming message cannot be accommodated in the node's buffer

V. EXPERIMENTAL RESULTS

V.I Performance Metrics

Hence, distinctive performance metrics for examining the output of DTN protocols are delivery probability and delivery latency. Overhead is broadcast of the bundles outcome in added energy spending. As the movable nodes in DTN are energy controlled, the overhead measured as an added vital metric. The outcomes of different DTN Protocols are examined based on metrics like delivery ratio, overhead ratio, delivery probability under various circumstances. Beside these metrics the buffer consumption is observed and the impact of buffer size on outcomes is also examined. There are few classic performance metrics for examining the work of DTN Protocol such as Delivery probability, overhead ratio, buffer average time, hop count average etc.

V.II Delivery Probability

It is characterized as a ratio of the quantity of message really conveyed to the goal and the quantity of messages sent by the sender.

$$\text{Delivery Probability} = \frac{\text{No. of messages delivered to the destination}}{\text{No. of messages sent by the sender}}$$

V.III Overhead Ratio

It is characterized as the ratio of contrast between the aggregate number of handed-off messages and the aggregate number of conveyed messages to add up to number of conveyed messages.

$$\text{Overhead Ratio} = \frac{\text{No. of relay messages} - \text{No. of delivered messages}}{\text{No. of delivered messages}}$$

V.IV Hop Count Average

Hop count, characterized as the quantity of nodes a parcel crosses from source to goal. The final exchange to the goal node isn't viewed as a hop and along these lines Direct Delivery's hop count is dependably 0.

V.V Buffer Average Time

Buffer Average Time is the time that message spends in the node's buffer.

Table 1: Simulation Parameters

btInterface.transmitSpeed = 250k
btInterface.transmitRange = 45
Group.movementModel = ShortestPathMapBasedMovement
Group.router = EpidemicRouter
Group.bufferSize = 4M; 8M; 12M; 16M; 20M; 24M;30M
Group.waitTime = 300, 900
Group.speed = 0.5,1.5
Group.nrofHosts = 100
Events1.interval = 15,30
Events1.size = 250k,2M
Events1.hosts = 0,99
World Speed = 4500, 3400
MovementModel.warmup = 1000

The results obtained from the above mentioned scenario (Table No.1) of our experiment with different parameters are summarized below in the Table Number 2 to 5 and Figure Number 4 to 7.

Table 2: Delivery Probability in comparison to Normal and Proposed Technique

	Delivery Probability		
Buffer size	Normal	Proposed	Percentage
4 MB	0.1206	0.1168	- 3.15
8 MB	0.2016	0.2111	4.71
12 MB	0.2519	0.2864	13.70
16 MB	0.3046	0.3518	15.50
20 MB	0.3417	0.4039	18.20
24 MB	0.3876	0.4309	11.17
30 MB	0.4523	0.4943	9.28

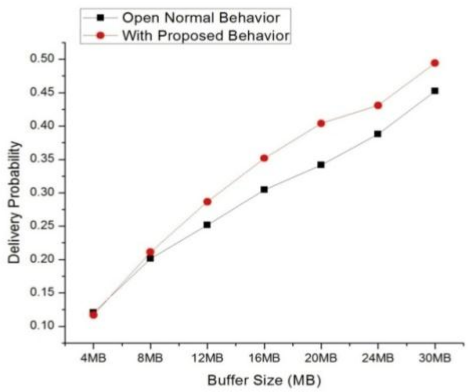

Figure 4: Delivery Probability in comparison to normal and proposed technique

From the data of Table 2 it is concludes that the delivery probability of the nodes increases from 3% to 18% (approximate) with different buffer size ranges from 4 Mb to 30 Mb when our proposed buffer management mechanism is implemented. The results in table also shows that the proposed mechanism gives improvement at various buffer sizes but the maximum percentage increase in the delivery probability is observed at 20 Mb buffer size and this increase is about 18%. At the smallest buffer size value 4 mb the proposed mechanism negatively impacted the delivery probability i.e. about 3% as compared to normal behavior. The results of the above table are also depicted in the above line graph (Figure 4).

Table 3: Overhead Ratio in comparison to normal and proposed technique

	Overhead Ratio		
Buffer size	**Normal**	**Proposed**	**Percentage**
4 MB	117.5260	141.1989	20.14
8 MB	123.7445	173.7560	40.42
12 MB	127.8229	170.3860	33.30
16 MB	120.2000	153.1357	27.40
20 MB	116.7739	136.2473	16.68
24 MB	103.5997	127.4810	23.05
30 MB	93.7625	105.6213	12.65

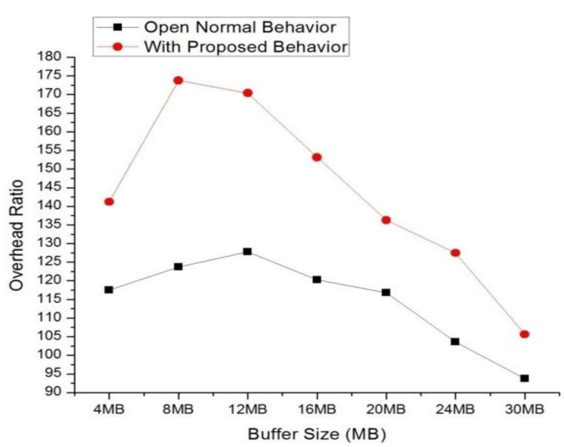

Figure 5: Overhead Ratio in comparison to normal and proposed technique

Table 4: Hop Count Average in comparison to normal and proposed technique			
	Hop count Avg.		
Buffer size	**Normal**	**Proposed**	**Percentage**
4 MB	4.9375	5.4247	- 9.87
8 MB	5.3396	5.4911	- 2.84
12 MB	5.1347	4.4671	13.00
16 MB	5.1258	4.0536	2.09
20 MB	4.8143	3.8771	19.47
24 MB	4.8088	3.4796	5.75
30 MB	4.3597	3.5133	- 19.4

From the facts and figures mentioned in Table 3, is can be analyzed that the overhead ratio of the proposed mechanism is high as compared to the Normal behaviour. But this increase in the overhead ratio is at the cost of increased delivery probability in case of our proposed mechanism. There is increase in overhead ratio as our mechanism removes the messages with larger size and less probability/time to get delivered and make space for the new incoming message which has higher chances of being delivered. The results in table also shows that the proposed mechanism gives improvement at various buffer sizes but the maximum percentage increase in the overhead ratio is observed at 8 Mb buffer size and this increase is about 40%. The results of the above table are also depicted in the above line graph (figure 5).

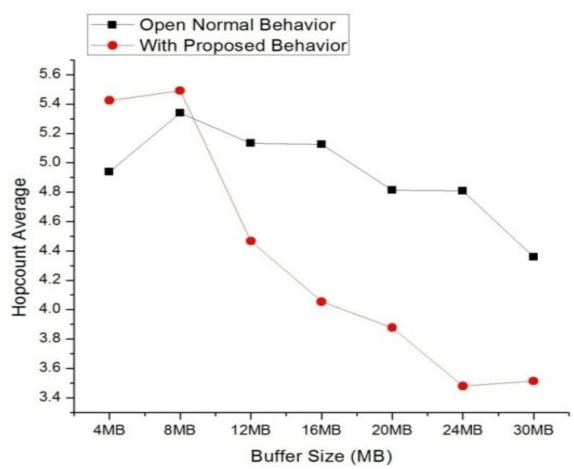

Figure 6: Hop Count Average in comparison to normal and proposed technique

From the facts and figures mentioned in Table 4, it can be analyzed that the hop count average of the proposed mechanism has improved as compared to the Normal behaviour. The results in table shows that the proposed mechanism gives improvement at various buffer sizes but the maximum percentage enhanced in the hop count average is observed at 20 Mb buffer size and this increase is about

19%. At the buffer size value i.e. 4 mb , 8 mb, and 30 mb the proposed mechanism negatively impacted the hop count average i.e. about 10%, 3% and 19% respectively as compared to normal behaviour. The results of the above table are also depicted in the above line graph (figure 6).

Table 5: Buffer Time Average in comparison to normal and proposed technique

	Buffer time Avg.		
Buffer size	**Normal**	**Proposed**	**Percentage**
4 MB	746.4775	585.6361	21.55
8 MB	810.5541	578.2323	28.66
12 MB	862.4524	669.7285	22.35
16 MB	938.7309	785.9912	16.27
20 MB	1038.1208	906.8384	12.65
24 MB	1143.4596	1028.6697	10.04
30 MB	1301.5791	1192.4895	8.38

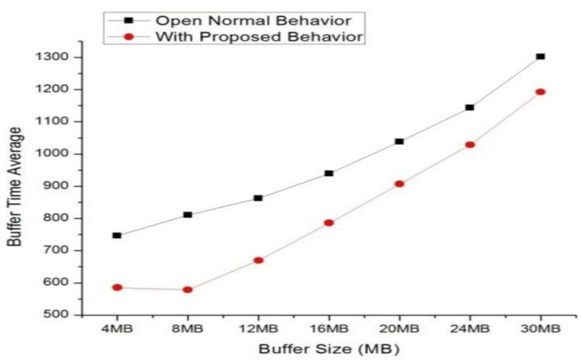

Figure 7: Buffer Time Average in comparison to normal and proposed technique

From the results obtained and shown in Table 5, it is evident that with the new proposed buffer management mechanism, the messages are now being delivered more quickly and staying for less time in buffer of the nodes. The results in table also shows that the proposed mechanism gives improvement at various buffer sizes but the maximum percentage increase in the buffer time average is observed at 8 Mb buffer size and this increase is about 28%. This means that the buffer is being now relaxed for accommodating the new incoming messages and hence contributes in higher delivery probability. The results of the above table are also depicted in the above line graph (figure 7).

VI. CONCLUSION

In this paper we proposed another Congestion Control structure in order to avert congestion in the Node's buffer. In this method to take care of the issue of congestion we utilized the size and TTL of the message. We have directed a trial by utilizing the ONE Simulator with epidemic protocol and shortest-path-map-based movement model. Simulation results demonstrate that delivery probability has made strides. The enhancement in delivery probability has been seen above 18 percent. The simulation results also show that to adjust a new message when an old message is dropped the overhead ratio increased which is natural. Buffer time average has fallen down when the proposed framework became active. The hop count average has also improved significantly.

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Authors Profile

Amardeep has obtained his Masters degree in Computer Application from PTU in 2005. Presently he is pursuing Ph.D in Computer Science from Tantaia University, Sri Ganganagar. He is working in Gopichand Arya Mahila College, Abohar, Punjab in Department of Computer Science. His field of research is Congestion Control in Delay Tolerant Network.

Devendra Gehlot received his Masters in Computer Application in 2006 and Doctorate in 2014 from Suresh Gyan University, Jaipur. He is presently working as Assistant Professor in Govt. Engineering College, Bikaner, Rajasthan. His field of research is computer programming and Networking.

Harminder S. Bindra received a Bachelor of Engineering degree in Computer Science & Engineering in 1999, and M.Tech. Degree in Information Technology in 2006. Since August 2009 he has joined as a research scholar in National Institute of Technology, Jalandhar. He obtained his PhD from Dr B R Ambedkar National Institute of Technology Jalandhar in 2015. His research interests are in Ad hoc Networks and Delay Tolerant Networks (DTNs).