Performance Analysis of Routing Protocol in Delay Tolerant Network

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***Abstract*— Delay tolerant networks (DTNs), are characterized by their lack of connectivity, resulting in a lack of instantaneous end-to-end paths. Ad Hoc routing protocols in such challenging network fails to accomplish the task of routing, as these protocols has a strategy to first establish the path and then send the actual data. In case of DTN, where there is lack of end to end connectivity, routing protocol must have store and forward strategy. With the use of store-carry-and-forward strategy DTN carry multiple copies of packets, stored them in buffer and forward to intermittent nodes which has the reliable connection with the destination. From simulation we conclude that Epidemic routing protocol give better result in term of packet loss and Overhead ratio. Average latency is higher in PROPHET routing protocol than others. Message delivery ratio of Spray and Wait protocol is better than other routing protocol if here we take number of L copies is Equal to 10. Delivery probability of Max Prop and Spray and wait routing protocol give excellent result as compare to others. Simulation result successfully carried out with the help of Opportunistic Network Environment (ONE) simulator**

***Index Terms*— Delay tolerant network, Routing in DTN, routing protocol, ONE simulator**

I. INTRODUCTION

The Internet has been a large use toward interconnecting communication devices across the world. It has done this by using a homogeneous set of communication protocols, called TCP/IP protocol suite. The research toward Delay Tolerant Network (DTN) is developed from the Mobile ad-hoc Network, MANET. In which the connectivity between two nodes always guarantee. MANET is the network in which all the nodes are intermittently and sparsely connected but this kind of sufficient facility not provide in DTN. In MANET, the protocols used such as Ad hoc on demand distance vector (AODV), Dynamic source Routing (DSR), do not work in proper manner because these protocols require fully connected path or active path to make connection between source and Destination.

MANET use the routing scheme in which its first establish a path between two nodes then after its transfer the messages on setup path until the transmission become over. This thing not possible in Delay Tolerant Network. DTN is wireless network which designed for the interplanetary Internet; this is a communication system which used to provide internet-like services in interplanetary distances to support of deep space exploration [1]. DTN is known as challenged network because there's no any connectivity between two or more nodes. DTN determine to handle routing and make enhancement in research area, where connectivity between the wireless nodes are intermittent over time because of small transmission range. Furthermore, the end to end connectivity path between source and destination does not take place due to disturbed connections. DTN not insure the reliable communication for messages transmission between two or more relay nodes. DTN is also known as opportunity network [8] because the interconnected nodes always finding the opportunity to transmit messages from source to Destination. DTN has more messages transmission probability then the MANET.

II. DELAY TOLERANT NETWORK

The architecture of DTN implements a new way to make effective communication even if there's no any end-to-end intermittent connectivity take place. We already know that in DTN network no possibility of fully connected network at every time.so the nodes itself find out the best path make connectivity and try to transmit all messages to the relay nodes which make communication and try to increase the nodes meeting connectivity. DTN introduces a new layer [15] which is define as a Bundle layer, added between the application layer and transport layer. This bundle layer improves a store-carry-and-forward strategy in which a node can store and carry messages in its own storage location and forward these messages to other connected nodes where they are available [15]. Due to intermittent behavior of DTNs, nodes use store-carry-and-forward method where nodes arrange packets in its buffer for a long period and forward it more to improve the delivery reliability of packets. In the store-carry-and-forward strategy nodes are store the incoming message in the buffer if the storage buffer is not a desired destination then messages are flooded in the network and again broadcast and in the network at the end delivered it to the destination. Figure 1 shows the bundle layer between the application and Transport layer. DTN is most useful for those Applications whose time requirement is higher in hours or also in days like Sensor based Network, Satellite Network, and Terrestrial Wireless Network with moderate delays and periodic connectivity, under water acoustic network with moderate delays and frequent interruption due to environmental factors.

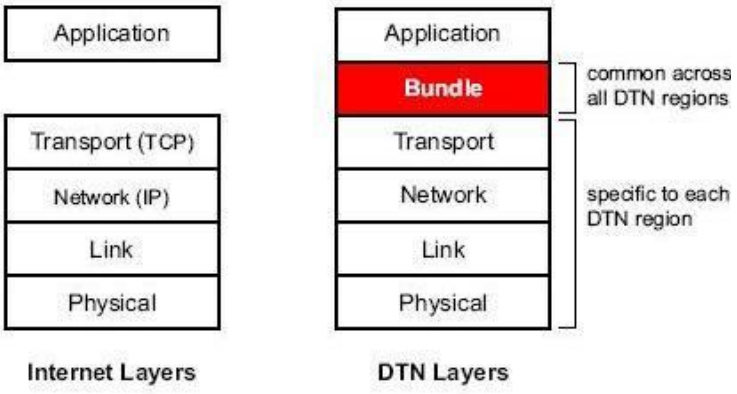

Figure 1: Layer in DTN [15]

III. DTN ROUTING PROTOCOLS

(1) DIRECT DELIVERY ROUTING PROTOCOL

Direct delivery is one of the basic and simple routing protocols in DTN network. Direct delivery is simplest routing protocol which use simple hand to hand message transmission scheme. Source generally grasps all the data until the destination of transmitted data come in the contact. Data handled in FIFO (First In First Out) based queue and overhead ratio in this strategy will be always zero.[11] This scheme is also related to flooding strategy so there's no doubt if its transmit so many messages to the destination and also we know that flooding scheme not require any kind of information about network topology. In this protocol all the messages are delivered to only desire destination because in it there's no any intermittent or relay node employed. The messages only delivered to destination when it has the details regarding Destination where the no. of messages delivered. Also in this strategy require the direct path connected between the Source and final Destination.

(2) Epidemic Routing Protocol

Epidemic routing protocol designed for sparse and mobile networks in which connectivity between Sources to Destination not occurring at the same time because of this reason this protocol more suitable with store-carry-and-forward approach. Like Direct Delivery routing protocol, Epidemic routing protocol also based on flooding strategy in DTN network so in it also large no. of messages forward from one end to another. Main purpose carried by this protocol is maximizing the rate of message delivery, minimize message latency and minimize the total resources consumed in message delivery. [10] In this routing approach same no. of multiple message copies forward between nodes gives fastest transmitting messages in the DTN network which provide optimum delivery time. As compare to Direct Delivery routing protocol, Epidemic protocol give guaranteed transmission of messages between source and destination with using algorithm but considering the irrespective of delivery delay.

(3) PROPHET Routing Protocol

To give better design development and improve performance of probability of messages delivery and minimize the use of network resources in Epidemic routing protocol a new type of routing protocol has proposed known as PROPHET. [4] The probabilistic routing protocol using history of encounter and transitivity (PROPHET) is one of the forwarding related routing protocols. The basic assumption policy in PROPHET is that the movement of node's in network is not random but in a repeating nature. In PROPHET number of nodes visit different location so many times and because of this reason the pattern will be repeat in future. In PROPHET all nodes use probabilistic metric which known as delivery predictability to move messages to reliable node. [4] The delivery predictability is high which define that it is more suitable in condition than other nodes to transfer messages to desire Destination. In this type of routing protocol each node of network has knowledge of delivery predictability of every other neighbours to reach at the Destination and when number of random nodes comes in contact with each other than list of nodes exchanged with another network nodes and also carry all information to decide network node to which message transmitted to which node in DTN network.

(4) Max Prop routing protocol

Max Prop is one of the forwarding based routing family protocols which worked with limited number of messages to transmit from source to destination with correct location of them. In this routing protocol arrangement of routing nodes in buffer is define in two set of arrangement. In starting first scheme the stored messages in buffer based on low to high hop count information. Then after first phase arrange messages in the term of high to low cost. Buffer in these two arrangements employed from both ends in which front side of buffer used by first arrangement and another end of buffer used by second arrangement. In this protocol each

node in network arranges set of probability to meet all other neighbour nodes and also make such a scenario to exchange the values to other intermittent or relay nodes. Between source and destination the value of probability calculated which useful to identify cost of path. When the storage location means buffer is full by number of messages then Max Prop protocol drops the messages which with higher cost path and at the other side this protocol provide higher priority to new coming messages and transmit them first with the low hop count. Max Prop maintains an order-queue based on the destination for each messages, ordered by the estimated likelihood of a future transitive path to that destination [19]. Each node in a Max Prop routing protocol has routing information and these all information updated on the base of information obtained by other intermittent nodes and all the messages are ordered and transmitted according to cost to reach from source to destination.

(5) Spray and Wait (SaW) routing protocol

Spray and Wait protocol also named as SaW protocol in DTN network which is flooding based routing protocol in which this protocol forward number of copies of same messages from source to destination for increase message probability and delivery ratio without having the knowledge of network topology and nodes mobility pattern. This routing protocol is describe in two different phase which is most popular and define as Spray phase and Wait phase. SaW routing protocol developed to limit the flow of multiple copies of messages in Epidemic routing protocol by adding number of L copies of messages which indicate maximum allowable copies of the messages in the network. In the Spray section L copies of messages are initially forward to L intermittent relay nodes. While in Wait section when destination not able to meet at spray phase, the L nodes take number of messages copies and perform direct transmission. This scheme controlled by parameter L which define function of node density, there distribution and mobility profile. [8] In the spray phase, messages in the source responsible for 'spraying' and when the intermittent nodes receive the no. of messages from source then after it's enter into Wait phase, where intermittent nodes hold that messages until the destination directly come in the contact with relay or intermittent nodes. The forwarding scheme is a contribution of always (Spray) and direct delivery (Wait) and we can also compare Spray scheme with Epidemic and Wait scheme with Direct delivery routing because these two phase provide same scenario like Epidemic and Direct delivery routing. SaW routing protocol able to reduce congestion in network and overhead ratio than Epidemic routing protocol.

IV. SIMULATION SETUP

The protocols mentioned in this paper are simulated using the Opportunistic Network Environment (ONE) Simulator. In the present work, we analyses the performance of five routing protocols namely Direct Delivery, Epidemic, PROPHET, Max Prop and Spray and Wait by varying number of nodes. Performance analysis carried out based on packet loss, average latency, delivery probability, message delivery ratio and overhead ratio and this simulation successfully done by the help of Opportunistic Network Environment (ONE) simulator. Table below specify the simulation parameter changes and work done with appreciate changed parameter in ONE simulator. Table 1 summarizes the simulation configuration for various network parameters. Before it we have to well known about metrics for performance comparison.

Performance Metrics

1) **Message delivery probability:** It is the probability of the messages that are correctly received by the destination within a given time period.
2) **Average latency:** It's defined as the measure of average time between messages is generated and when it is received by the Destination.
3) **Message delivery ratio:** It's defined as the ratio of total no. of messages delivered to their destination to total no. of created messages at source node.
4) **Packet loss:** It's defined as amount of packet dropped when packet travel from source to destination due to overloading and traffic congestion in the network.
5) **Overhead ratio:** It's reflects how many redundant packets are relayed to deliver one packet. It simply reflects transmission cost in a Network.

Table 1: Simulation parameters with varying in number of nodes

Routing Protocols	Direct Delivery, Epidemic, PROPHET, Max prop, Spray and Wait
No. of Nodes	10,50,100,200
Buffer size	10 MB
Speed (m/s)	1-5 (m/s)
Simulation time	43200 sec
Packet TTL	300 minute
Transmission Speed	2 Mbps
Movement model	Random way point
No. of L Copies in SaW	10

Using these simulation parameters we have some result for the network metrics which describe as below with the help of figure.

Figure 2 show that for the 10 nodes packet loss is same for all the routing protocols but for 50,100 and 200 nodes epidemic protocol has higher packet loss as compare to other protocols because in Epidemic routing protocol large number of same messages created in relay nodes and these all messages transfer at the destination so large number of messages dropped and packet loss become higher while for direct delivery protocol less number of packet loss as compare to other protocols because there's no any intermediate node in it so message directly delivered at destination so no packet dropped.

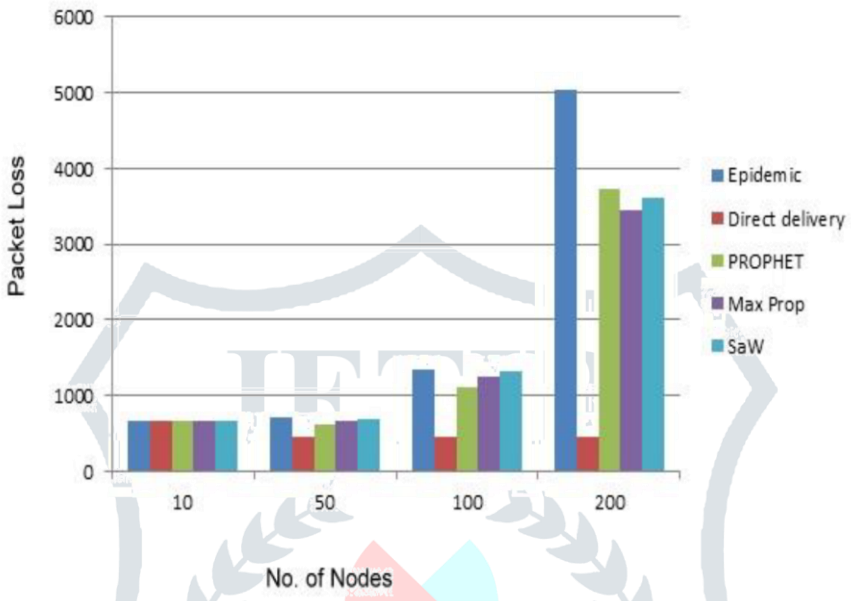

Fig. 2: packet loss v/s no. of nodes

Figure 3 shows that for the 10 nodes average latency is higher for max prop protocol than other and all other protocol have same value for 10 nodes. Average latency is higher for epidemic, Max Prop and Spray and Wait protocol than direct delivery and PROPHET for 50 nodes because when number of nodes increase average time of message delivered per message creation increase. Epidemic has higher value than other protocols and approx. same value for PROPHET, Max Prop and Spray and Wait protocol For 100 nodes and for 200 nodes PROPHET has higher value than other protocols because of large number of same messages delivered at the destination and average time also increase with it.

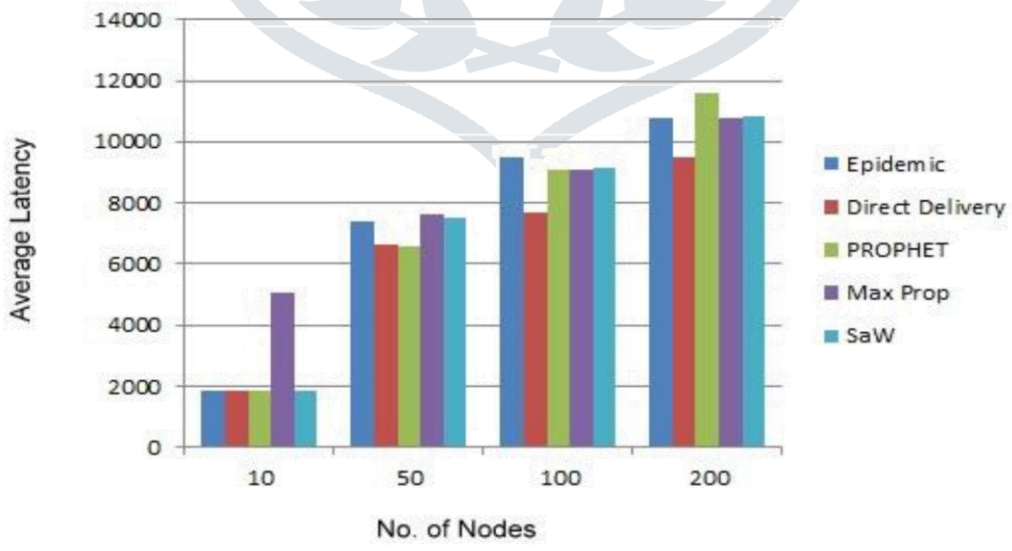

Figure 3: Plot for Average latency v/s No. of nodes

Figure 4 shows that for 10 and 50 nodes delivery probability is higher for Max Prop protocol than other protocols because of higher probability of the messages to deliver at the destination. Further for 100 and 200 nodes delivery probability is higher for

Spray and Wait protocol than others because limited number of same created copies transfers at destination by relay nodes and it has higher probability then other protocols where direct delivery has lower than others because no extra number of messages created and reached at the designation.

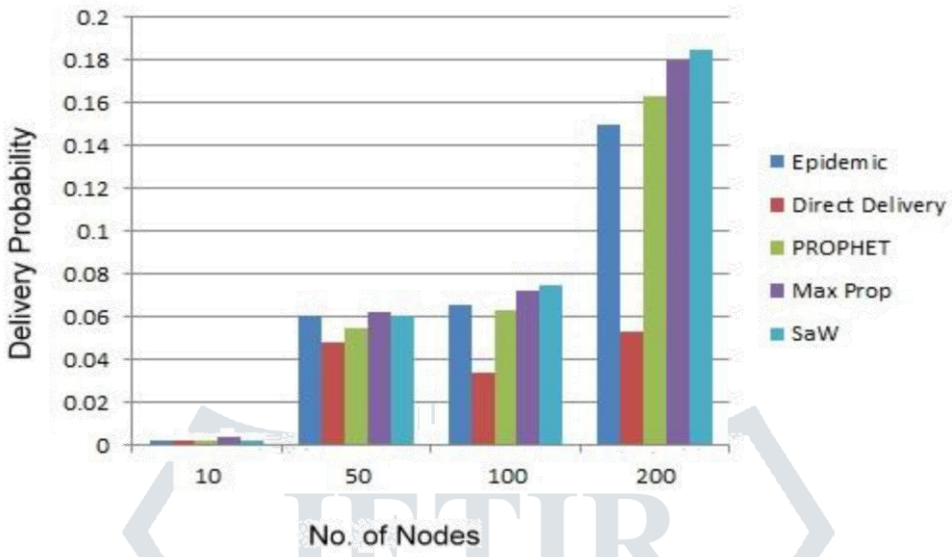

Figure 4: Plot for Delivery probability v/s No. of Nodes

Figure 5 shoes that Message delivery ratio is higher for Max Prop protocol than others for 10 nodes and for 50 nodes it's higher for epidemic and lower for direct delivery than others. For 100 nodes it's approx. same for epidemic and PROPHET but higher for Spray and Wait than others because most number of successful messages delivered at the destination further increase at 200 nodes, it's approx. same for Max Prop and Spray and Wait protocols because for larger nodes it's provide better efficiency to transfer messages at destination and lower for direct delivery protocol. Below figure and table show simulation result of Message delivery ratio for different protocols:

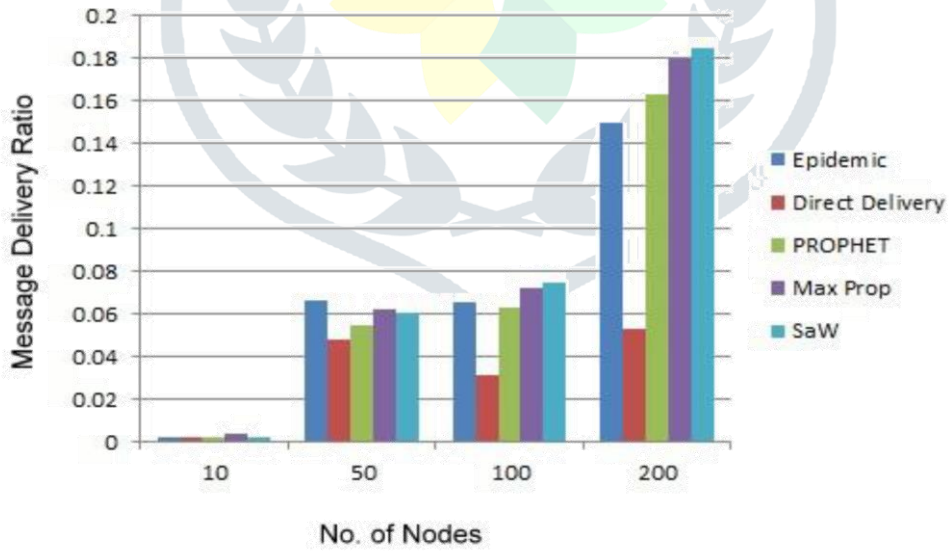

Figure 5: Plot for Message Delivery Ratio v/s No. of nodes

Figure 6 shows that Overhead ratio is higher for both Epidemic and Spray and Wait protocol which are flooding in nature and for 50 nodes, it's approx. same for Epidemic, Spray and Wait and Max Prop protocols and overhead ratio is higher for Epidemic than other protocols for 100, 200 nodes because of flooding type of behaviour which allow large number of messages to transfer at destination but one important thing is that overhead ratio is 0 for direct delivery for 10, 50, 100, 200 nodes because of no intermediate nodes in network between source and destination. Below figure and table show simulation result of Overhead ratio for different protocols:

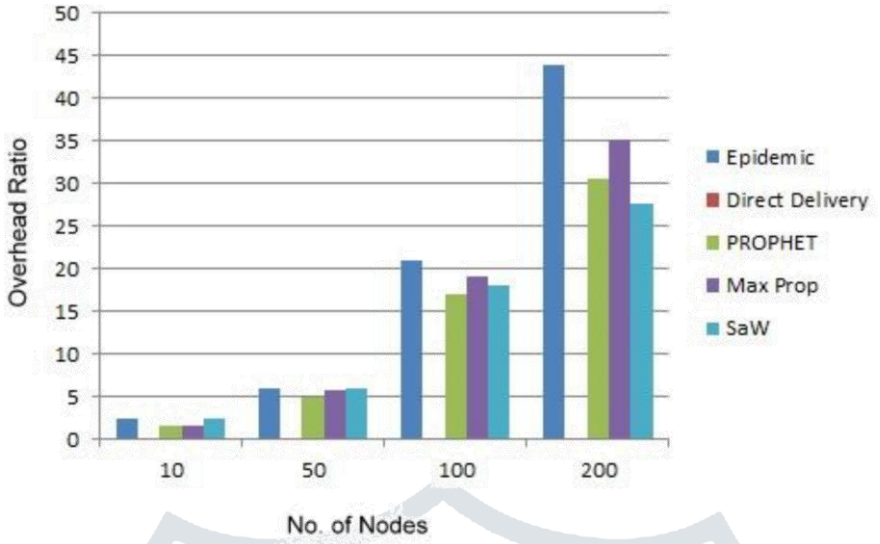

Figure 6: Plot for Overhead ratio v/s No. of Nodes

V. Conclusion

From the analysis carried out during this phase, we conclude in epidemic protocol packet loss is higher than other routing protocols due to large number of copies of same messages created in relay nodes. Spray and Wait protocol gives better result for message delivery ratio as compare to other protocols because when we use spray and wait protocol with selected number of copies then the probability to delivery of messages at destination through intermediate nodes is increase. Average latency of PROPHET is slightly higher at large number of nodes and Epidemic protocol has higher overhead ratio because of flooding type of its behaviour in which extra number of packets in intermediate node and transfer those to destination through it. Delivery probability is almost same for both Max Prop and Spray and Wait protocols with large number of nodes because for each node in network both protocols give the excellent result when probability is higher of messages to meet at the destination when number of nodes increase. We also conclude that direct delivery routing protocol is not more suitable for real time application because it's very poor to delivery probability and message delivery ratio. It's also pointed that Spray and Wait performed efficiently in all condition.

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