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Evaluating the Performance of Delay Tolerant in Network Routing Protocols

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Abstract – Delay-tolerant Network (DTN) is a network designed to operate effectively over extreme distances such as those encountered in space communications or on an interplanetary scale. In such an environment, nodes are connected intermittently, and determinations of the future node connections are not confirmed. In such network environment, the packet can be transferred by searching current efficient route available for a particular node. Due to the uncertainty of packet transfer route, DTN is affected by the variety of factors such as packet size, communication cost, node activity, etc. In the previous study, Effect of misbehaviour nodes in DTN has been analyzed. The primary goal of the study presented in this paper is to extend these works in an attempt to offer a better understanding of the behavior of different routing protocols with different strategies that depend on various amounts of Network parameters. In this paper, we discuss three DTN routing protocols Epidemic, PROPHET, and Spray and Wait. A special simulator will be used; that is Opportunistic Network Environment (ONE) to create a network environment.

Index Terms – DTN, ONE, epidemic, ProPHET, e, TTL.

I.INTRODUCTION

In recent year, the Delay Tolerant Network (DTN) environment has become popular in research and communication industry. DTN is an approach to computer network architecture that provides transmission from source to destination through complex network environment, which seeks to address the technical issues in heterogeneous network that may lack continuous network connectivity[1]. It provides transmission services in the very complicated network such as space networks, under-water networks, sensor networks, vehicular networks, mobile ad-hoc networks, military networks, inter-planetary networks, and low-cost networks. DTNs are categories by a large number of sparse nodes and by the appearance of uncertain network connectivity, network partitions, long and variable propagation delay, and high bit error rate of the transmission nodes[2].Because of these behaviors, packet delivery from source to destination can perform only through node mobility, which is indeed the primary way of communication in the network[3]. These nodes

are working on particular architecture, which runs on the store, carry and forward model. In the store, convey and forward model messages sent between the arrangements of hubs. At the point when a hub gets a message, it decides how to course the message further, and at that point figures out if or not it has availability to the picked next node destination(s). On the off chance that it does, the message is sent forward. However, if it does not have the network, rather than dropping the message, it will store it until the network gets to be accessible, so that when the system gets to be accessible, the sending operation is continued[4-5]. So, DTN is Delay-Tolerant Networking (DTN) architecture is intended to give correspondence in irregularly associated network by moving messages towards destination through the store, carry and forward network model that backings multi-routing calculation to get the best way towards it[6].

There are several routing protocols has been proposed for the store-carry-forward model and these protocols are categorized by the way for controlling message copies and making the forwarding decision[7]. Depending on the number of message copies, protocols can be classified into two type single copy and multiple-copy[8-9]. i) Single-copy routing protocols: only a single copy of each message exists in the network at any time. ii) Multiple-copy routing protocols: multiple copies of the same message can be generated and distributed into the network. Other than that, as indicated by whether the sending choice depends on the information got from the hubs' experiences or not, conventions can to be grouped into two classes: Deterministic and Non-deterministic[10].

In this paper, study focuses on multi-copy protocols in aspects of best performance. Epidemic[11], Spray and Wait[12] and ProPHET[13] are mostly used in delay tolerant network.

Epidemic protocol is flooding-based property, which helps to transmit multiple copies of a message continuously to next node for target delivery. It is more useful, when there is improper acknowledgment of network topology and node mobility [14]. The probabilistic routing protocol using history of encounter and transitivity (PROPHET) works with probabilistic matrix that is delivery probability of each node. In ProPHET Protocol, initially each node has $P(A,B) \in [0,1]$ at each node A to every known destination B. Messages are forwarded on the basis of higher delivery probability of the node. Spray and wait protocols controls to transmit continuous copies of a message by limiting the copy of a message. It has two phase spread and wait. First, copies of message spread by source and then wait for delivery report. Rest of the paper is presented as follows. To facilitate our study and make the paper self-contained, with its related work is described in Section 2. Performance analysis of protocol describes in Section 3. In last section, we conclude the paper.

II.LITERATURE SURVEY

Yahui Wu et.al in “Performance Analysis of Multi-Frame Message Spreading in Delay Tolerant Networks" in 2013 has proposed a theoretical framework based on mean field limit to evaluate the epidemic-like multi-frame spreading algorithm for the first time. Also, the selfish behaviors can have the certain impact on the store-carry-forward communication mode, so we extend our model to the case that nodes are selfish. Simulations show the accuracy of our model. Numerical results show that the more bundles the message has, the lower the average delivery ratio will be. Also, the selfish behaviors can make the performance worse. Extensive numerical results show that the selfish behaviors can make the performance worse. Also, the degree of the impact of the selfish behaviors is related with other factors.

The paper “The Effects of Node Cooperation Level on Routing Performance in Delay Tolerant Networks (2009)” by Giovanni provides study about the effect of different degrees of node cooperation on the performance of routing protocols for delay tolerant networks. The Scientific depiction of the execution of epidemic and two-hops routing regarding expected packet delivery rate below the quality assumption of totally cooperative node behavior has analyzed. This characterization is employed to analytically characterize epidemic routing protocol performance in the presence of various degrees of node cooperation.

The results show that whereas epidemic routing provides the higher PDR performance below all investigated degrees of network cooperation; binary compass point routing can do the comparable performance, with the potential of considerably reducing message overhead. Binary compass point routing shows additionally the higher resilience to lower node cooperation levels amongst the thought of routing protocols. Finally, this paper recommends that even a modest level of node cooperation is comfortable to attain performance improvement with relation to the foremost negative state of affairs within which all potential forwarders drop messages.

Intermittently connected mobile networks are wireless networks wherever most of the time there doesn't have an entire path from the source to the destination. There are several real networks that follow this model, for instance, life pursuit device networks, military networks, conveyance ad hoc networks (VANETs), etc. during this context, standard routing schemes would fail. To manage such networks T. Spyropoulos et.al have prompted exploitation stream -based routing schemes in the paper “Efficient Routing in Intermittently Connected Mobile (2008).While stream-based schemes have a high chance of delivery, they waste plenty of energy and suffer from severe competition which may only degrade their performance. With this in mind, there are the variety of "single-copy" routing schemes that use only one copy per message, and thus, only scale back the resource needs of stream-based algorithms.

The article has performed a close exploration of the single-copy routing house so as to spot economic single-copy solutions that (i) may be used once low resource usage is important, and (ii) will facilitate improve the planning of general routing schemes that use multiple copies. This article has additionally proposed a theoretical framework that has been used to research the performance of all single-copy schemes bestowed and to derive higher and lower bounds on the delay of any theme.

X. Zhang, G. Neglia et.al within the paper, “Performance Modeling of Epidemic Routing(2007)” have developed a rigorous, united framework supported normal regardful Equations to review epidemic routing and its variations. These equations are often derived from parameters of Markova models below a natural scaling because the variety of nodes will increase. Whereas Associate in the nursing analytical study of Markova models is advanced and numerical resolution impractical for big networks, the corresponding lyric models yield closed-form expressions for many performance metrics of interest, and a numerical resolution quality that doesn't increase with the number of nodes.

Victimization this approach, there is a tendency to investigate however resources like buyers' area and power are often listed for quicker delivery, illustrating the difference between the assorted epidemic schemes thought-about. The final article has decided the elect of client management by complementing the forwarding models with Markova and quid buyer’s models.

III.PERFORMANCE ANALYSIS OF PROTOCOLS

The analysis is done for three DTN protocols Epidemic, Spray and Wait, and ProPHET. Performance of these protocols has evaluated with impact of numerous factors such as number of nodes per group, movement model as map-based movement or random movement of nodes, buffer size of packets, TTL of packets, transmission range of nodes, and speed of node movement on performance matrix as delivery probability, average latency and overhead ratio. Delivery probability is the ratio of the total number of messages delivered to the destination over the total number of messages created at the source. Average Latency is the measure of average time between messages generated and messages received by the destination node. The overhead ratio defines how many redundant packets are relayed to deliver one packet. It simply reflects the cost of transmission in a network. There are parameters and their values in Table 1, which has considered for evaluating the performance matrix of above mention protocols

Performance matrix has been analyzed with respect of no of nodes. Fig 1 shows that the performance matrix such as delivery probability, average latency and average overhead of DTN protocols. In fig 1, buffer size is 50MB, transmission speed is 250k, TTL is 120 and transmission range is 10.these parameters values are mentioned in table 2.In this scenario, no of nodes vary. Graph of delivery probability vs. no of node shows that delivery ratio of the epidemic and ProPHET Protocol increase, but a little decrease in case of Spray and wait when no of nodes increase. The epidemic has the highest delivery probability. Latency increase for all these protocols but ProPHET has the lowest latency than others. The overhead ratio of epidemic and ProPHET increase, but it decrease in case of spray and wait. The overhead ratio of the epidemic is higher than other two protocols.

TABLE 1: LIST OF PARAMETERS AND THEIR VALUES

Parameter	Value
No of nodes	50,60,80,100,150,300,400
Buffer size	5,50,100,500
Transmit Speed	250
TTL	60,120,180,300,600
Movement model	Shortest path map based model, Random waypoint
Transmission range	1,5,10,20,50
Environment size	4500*3500
Packet generation rate	1-1.5,2-5,5-10,10-20

The next parameter is buffer size of the packet. Fig 2 shows the performance of DTN protocols on buffer size. Table 3 has different parameters and their values, which are used in fig 2. Delivery ratio of epidemic protocol is highest. In term of overhead ratio, epidemics has higher overhead ratio than other two protocols, but overhead decreases. Even, epidemic has lower latency. Spray and wait .Hence, epidemic has the best performance when the buffer size is increasing.

TABLE 2: PARAMETERS AND THEIR VALUES FOR FIG 1

Parameter	Value
No of nodes	50,60,80,100,150,300,400
Buffer size	50
Transmit Speed	250
TTL	120
Movement model	Shortest path map based model
Transmission range	10
Environment size	4500*3500
Packet generation rate	2-5

TABLE 3: PARAMETERS AND THEIR VALUES FOR FIG 2

Parameter	Value
No of nodes	50
Buffer size	1,5,50,100,500
Transmit Speed	250
TTL	120
Movement model	Shortest path map based model
Transmission range	10
Environment size	4500*3500
Packet generation rate	2-5

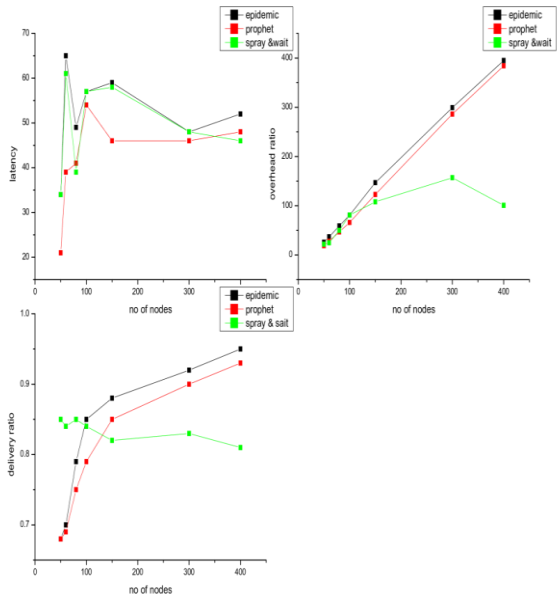

Fig. 1: Delivery Probability, latency and overhead ratio vs. no of nodes

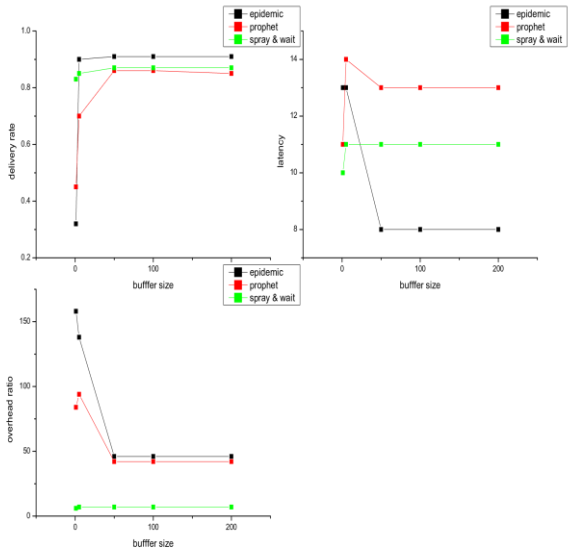

Fig. 2: Delivery Probability, latency and overhead ratio vs. Buffer Size

Performance matrix of protocols has analyzed on TTL time. Fig 3 has a graph of delivery, latency and the overhead ratio of DTN protocols on TTL. Table 4 has different parameters and their values, which are used in this figure. Delivery probability and latency increase, when TTL time increases. The overhead ratio of the epidemic and ProPHET Increase, it decrease in case of spray and wait for protocols. Spray and wait have higher delivery probability, but lower overhead and latency than other, because of limiting copy of message used by the spread and wait for protocols.

Hence, ProPHET has the best performance, when TTL increases because it depends on the probability of history encountered node. Performance of different protocols relies on message generation rate of packet has been shown in fig 4. Table 5 has different parameters and their values, which are used in the fig 4. Delivery probability of DTN protocols increases, but Latency decrease, while transmission range increases.

TABLE 4: PARAMETERS AND THEIR VALUES FOR FIG 3

Parameter	Value
No of nodes	50
Buffer size	50
Transmit Speed	250
TTL	60,120,180,300,600
Movement model	Shortest path map based model
Transmission range	10
Environment size	4500*3500
Packet generation rate	2-5

Overhead Ratio of epidemic and spray and wait decreases, but increase for prophet. Delivery probability of spray and wait is higher, but lower latency and overhead than others. In the scenario, where message generation rate increases, epidemic protocol has better performance than others, because its generate no of copies and spread to all nodes at random.

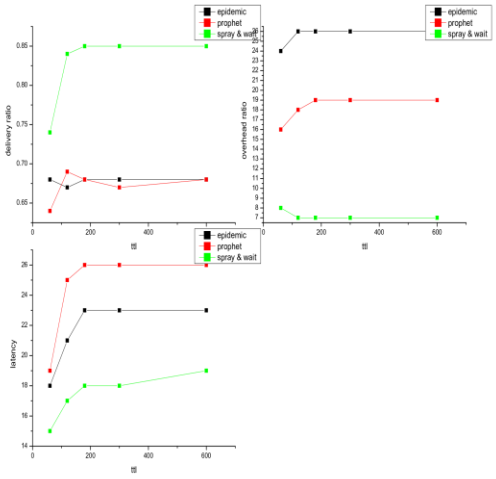

Fig. 3: Delivery Probability, latency and overhead ratio vs. Time to Live(TTL)

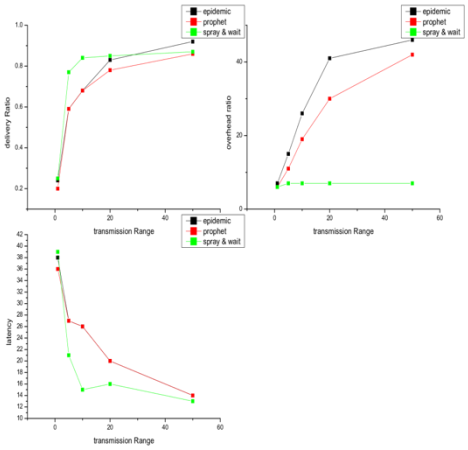

Fig. 4: Delivery Probability, latency and overhead ratio vs. transmission range

TABLW 5: PARAMETERS AND THEIR VALUES FOR FIG 4

Parameter	Value
No of nodes	50
Buffer size	50
Transmit Speed	250
TTL	120
Movement model	Shortest path map based model
Transmission range	1,5,10,20,50
Environment size	4500*3500
Packet generation rate	2-5

Table 6 show parameters and their values, those are used in fig 5, where two different movement model have been used. In fig 5, overhead ratio and latency of DTN protocols are higher in shortest path map based model than random way movement. Sprat and wait have highest delivery probability and lowest overhead ratio. In the case of overhead ratio, DTN protocols have lower overhead ratio in shortest path map based model than random way. Transmission range indicates movement speed of node.

TABLE 6: PARAMETERS AND THEIR VALUES FOR FIG 5

Parameter	Value
No of nodes	50
Buffer size	50
Transmit Speed	250
TTL	120
Movement model	Shortest path map based model, Random waypoint
Transmission range	10
Environment size	4500*3500
Packet generation rate	2-5

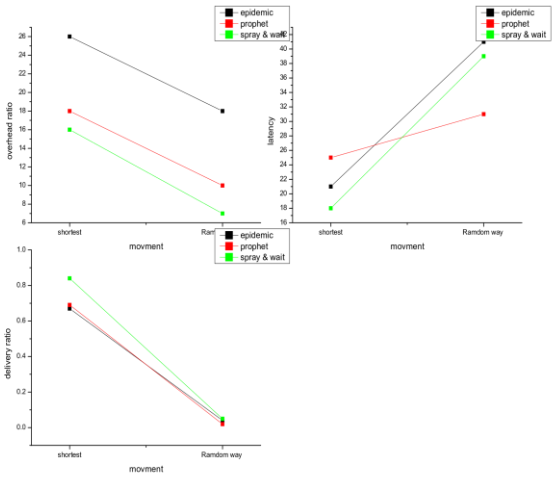

Fig. 5: Delivery Probability, latency and overhead ratio vs. Movment model

In the case of transmission range increases, the performance of protocols has been shown in figure 6.Table 7 has shown the parameters values, which are used in this figure.It shows that when transmission range increases, delivery probability and overhead ratio increase but latency decreases. The delivery probability of spray & wait is higher than others. The epidemic has higher latency and overhead ratio than others. The overhead of spray & wait is constant with transmission range. The performance of DTN protocols varies from movement models.

TABLE 7: PARAMETERS AND THEIR VALUES FOR FIG 6

Parameter	Value
No of nodes	50
Buffer size	50
Transmit Speed	250
TTL	120
Movement model	Shortest path map based model
Transmission range	1,5,10,20,50
Environment size	4500*3500
Packet generation rate	2-5

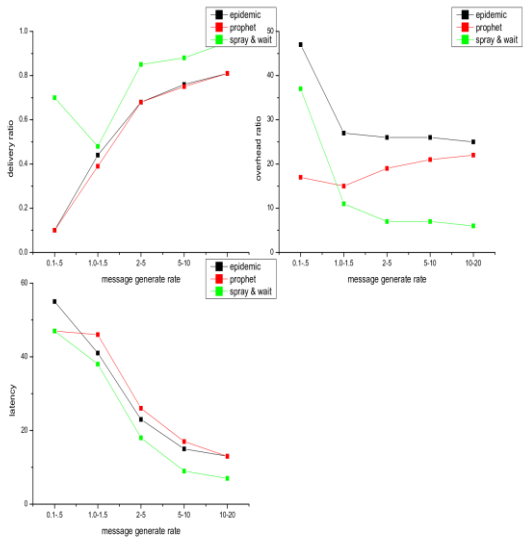

Fig. 6: Delivery Probability, latency and overhead ratio vs. message generation rate

IV.CONCLUSION

In this paper, the performance of DTN protocols has been analyzed. The performance of protocols has determined regarding numerous parameters such as delivery probability, latency and overhead ratio. Every protocol has its pros and cons. delivery probability of spray and waits protocol is greater than other protocols, but the overhead ratio of the epidemic is greater than other in all environments. The latency of spread and wait has low. Delivery rate is high, and latency is low of spray and waits for the protocol. Hence, spray and wait have better performance than others. This analysis of the performance of DTN protocols helps the researcher to learn better of these protocols in the different environment. Further, need to develop a protocol for DTN with the best performance, when malicious nodes occur.

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