PERFORMANCE EVALUATION OF MOFO BUFFER MANAGEMENT TECHNIQUE WITH DIFFERENT ROUTING PROTOCOLS IN DTN UNDER VARIABLE MESSAGE BUFFER SIZE

Anita Rani[1], Sangeeta Rani[2], Harminder Singh Bindra[3]

[1]*Student,* [2]*Teaching Associate, Computer Sci. & Applications Department, Chaudhary Devi Lal University, Haryana, India*

[3]*HOD IT Department, Malout Institute of Management & Information Technology, Punjab, India*

Abstract

Delay Tolerant Networks (DTNs) uses the store-carry-forward scheme for the delivery of the messages, with this way data transmission can be successfully done despite of the absence of continuous end-to-end paths. The opportunities of message forwarding in such types of networks usually are limited due to the absence of contemporaneous paths. In such networks, the "store-carry-forward" methodology is used for the transmission of the messages to be delivered to their intend destinations in a hop by hop manner. It arises many problems like how to schedule the messages, how to drop the messages in the buffer due to the impulsive nature of the nodes. It also arises many challengeable situations like short contact durations between the two nodes, limited storage capacity of nodes and so on. This paper evaluates the performance of MOFO buffer management technique with three routing protocols i.e. Epidemic, Prophet and MaxProp under variable message buffer sizes (5MB to 40MB). Such evaluation can improve the performance of the opportunistic networks by reducing the overhead ratio, enhancing the delivery rate, minimizing latency average and hop count average in a certain degree. So four performance evaluation metrics namely delivery probability, latency average, overhead ratio and hop count average are used in this study. This study uses ONE (Opportunistic Network Environment) simulator for the performance evaluation of the MOFO buffer management technique and routing protocols. The evaluation results shows that the performance of different protocols can benefit to optimizing the performance of delay tolerant networks in terms of delivery probability, Latency average, Overhead ratio and Hop count average of messages with the increase in message buffer size. Finally, this study suggested that which routing protocol is most suitable with MOFO buffer management technique.

Keywords: *Delay Tolerant Networks, Buffer Management, Routing Protocols, MOFO, Epidemic, Prophet, MaxProp*

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1. INTRODUCTION

In the present day scenario, rapid rise in the heterogeneous networks has been seen in the wireless communications. The heterogeneous network may be termed as the network, which connects computers and such other devices, which uses different operating systems and communication protocols. Delay Tolerant Network approach addresses the issues that provide communication in the heterogeneous networks. In Delay Tolerant Networks (DTN), there is frequency of disruptions is much higher, as end to end path is not available all the time. Due environment nature of delay tolerant networks like underwater, ocean sensor, deep space, delays can further be extended. In such demanding networking situations, to obtain data delivery researchers have proposed a technique in which the messages is stored into the buffers of the intermediary nodes until it is forwarded to the destination. Thus, in order to obtain the higher delivery probabilities of the messages and reliable communication in such challenging networks, many approaches have been adopted. Several issues like increasing the delivery ratio or minimizing the delivery delays, optimizing resources usage etc. has been the main focused area of the researchers to achieve message delivery probability. Moreover, to increase delivery probability, multiple copies of the messages into the network is done. This arrangement of long-standing storage and duplication results in high storage overhead on the network. Therefore, efficient buffer management policies are required, which decides that what messages must be dropped, while node buffers are overflowed [2].

In this paper, we have evaluated the performance of MOFO buffer management technique with Epidemic, Prophet and MaxProp routing protocols under variable message buffer size. The performance metrics chosen for the evaluation of these routing protocols is delivery probability, overhead ratio, hop count average and latency time average. The tool used for the simulation is Opportunistic Network Environment. Simulation setup for the study is given in the Table-1 in Section 4.

2. BUFFER MANAGEMENT TECHNIQUES

Buffer Management technology is a fundamental approach that manages the various resources among different situations as per the technique used. An efficient buffer management technique decides at each step that which of the messages is to be dropped first, when the buffer is full likewise which messages are to be transmitted, when bandwidth is limited. Some of the popular buffer management techniques are as follows:

2.1 Drop Least Recently Received (DLR)

In DLR technique as the name implies, the message which is staying for a long time in the buffer will be dropped first. As it has the less probability to be conceded to the other nodes [2].

2.2 Drop Oldest (DOA)

In DOA technique, the message with the shortest remaining life time (TTL) is dropped first. The idea behind dropping such messages is that the messages whose TTL is small, then these are in the network from a long period of time and thus has the high probability to be already delivered [2].

2.3 Drop Front (DF) FIFO

This technique drops the messages on the basis of the order in which they entered into the buffer, for example the first message that entered the queue will be the first to be dropped [3].

2.4 Drop Largest (DLA)

In Drop Largest (DLA) buffer management technique message having large size will be selected in order to drop [2].

2.5 MOFO (Evict Most Forwarded First)

MOFO attempts to maximise the propagation of the messages through the network by dropping those messages that have been forwarded the maximum number of time. In such way the messages with lower hop count enables to travel further within the network [3].

2.6 DL-Drop Last

The newly received message is first removed simply.

2.7 MOPR (Evict Most Favorably Forwarded First)

MOPR maintains the value of each message in its queue. Thus each time when a message is replicated the value in the message is increased based on the predictability of the message being delivered, thus the message with the highest value is dropped first [3].

2.8 SHLI (Evict Shortest Life Time First)

This technique uses the timeout value of the message, which indicates that when it is no longer useful, such that a message with the shortest remaining life time is dropped first [3].

2.9 LEPR (Evict Least Probable First)

This technique works by a node ranking the messages within its buffer based on the predicted probability of delivery, the message with the lowest probability is dropped first [3].

This study evaluates the performance of MOFO buffer management technique on the basis of metrics, delivery probability, overheads ratio, latency time average and hop count average.

3. ROUTING PROTOCOLS USED

3.1 Epidemic Routing protocol

In DTN, among all the routing protocols, Epidemic routing protocol is the leading protocol. This protocol is flooding based in nature as all the nodes continuously replicate and transmit the messages to the adjacent nodes that do not already have a copy of the message. Using this protocol, when a node comes into the contact of other node, it checks whether the new node has the copy of this message or not. If it does not have, then the new message is forwarded to that node. This protocol uses the summary vectors for this task. The node exchanges their summary vectors when they comes in the communication range of each other to decide which message have not been seen by that node. Host request for a copy of a message which it has not seen yet. The receiving host has the complete autonomy to reject or accept the message [6].

3.2 PRoPHET Routing Protocol

Epidemic routing protocol is a resource hungry protocol because it makes no attempt to remove the replications deliberately that would be unlikely to increase the delivery probability of the messages. Such type of strategy is more effective if the opportunities of delivering the messages encounters between the nodes are purely random, but in realistic circumstances, meeting of nodes are rarely totally random. Data Mules such as human beings moves in the society and have higher probabilities of meeting the certain Mules than others. The PRoPHET (Probabilistic Routing Protocol using History of Encounters and Transitivity) protocol used an algorithm that attempts to use the non randomness of the real-world encounters by maintaining the set of probabilities for a successful delivery to the known destinations in DTN [4].

3.3 MaxProp Routing Protocol

MaxProp routing protocol is a flooding-based protocol by nature. In MaxProp if a contact is occurred, then all the messages not held by the contact will be replicated and transferred. The MaxProp routing protocol intelligently determines that which messages should be transmitted first and which of the messages should be dropped first. Here an ordered queue is maintained by this protocol based on the destination of each message, ordered by the probability of a future transitive path to that particular destination. When two nodes meet each other, firstly, they exchange their estimated node meeting likelihood vectors. Preferably, each node will have an up to date vector from every other node. With these 'n' vectors at hand, the node can compute the shortest path on the basis of a depth-first search where path weights indicate the probability that the link does not occur [5].

4. SIMULATION SETUP

The performance of MOFO buffer management technique with different routing protocols is analyzed through simulation using the Opportunistic Network Environment (ONE). The ONE simulator is an agent based discrete event simulation engine. The main functionality of the ONE consists of the modeling of the node movement, inter node contacts using various interfaces, routing, message handling and application interactions. The simulator is configured using text based configuration files that contains the simulation, event generation and reporting parameters. This file also has the defining parameters for the nodes like the storage capability, transmit range, bit rates as well as the routing model to use. Table 1 summarizes the simulation configuration used for the current analysis.

5. PERFORMANCE METRICS

The following are the performance metrics used for the analysis:

Table -1 Simulation Setup of the Study

Parameter	Value
Total Simulation Time	43200 seconds
World Size	4500x3400 meters
Movement Model	Map Based Model
Buffer Management Technique	MOFO
Routing Protocols	Epidemic, Prophet, MaxProp
Node Buffer Size	5, 10, 15, 20, 25, 30, 35, 40 (in MBs)
No. of Nodes	50
Interface Transmit Speed	560 kBps
Interface Transmit Range	30 meters
Message TTL	90 minutes
Node Movement Speed	Min.=1.9 m/sec, Max.=3.9 m/sec
Message Creation Rate	One message per 15-30 sec
Message Size	250KB to 2MB

5.1 Delivery Probability

The delivery probability is the amount of the fraction of all the created packets that are successfully delivered to its destination. This is the ratio of the total number of packets that are delivered to their destinations against the total number of packets that are created. Thus this is a direct measurement of how reliably packets are routed in the network by a routing protocol under consideration [6].

5.2 Overhead Ratio

The overhead ratio is calculated using the following equation:

Overhead ratio =
(Number of relayed messages – Number of delivered messages) / Number of delivered messages

Here, the term relayed messages refers to the messages that have been forwarded by the source to an intermediate node to be forwarded towards the destination. This number is a measure for the number of packets or copies of packets that have been inducted into the network. The number of delivered messages refers to the total number of created packets that are successfully delivered to the destination. The overhead ratio also shows the amount of the network resources required to deliver a packet from source to its destination [6].

5.3 Latency Average

The latency measured here is the time that elapses between the creation of a message and its delivery at its destination. This study considers the average of the latency of the packets over the entire simulation time. This is the time as calculated for the delivered packets only. In most protocols, it is desired that the value of latency time average is low. In the DTNs environment the latency is acceptable at some extent [6].

5.4 HopCount Average

It is the mean hops which a message takes to reach its destination

6. RESULTS AND DISCUSSION

6.1 Delivery Probability

The delivery probability of MOFO buffer management technique with Epidemic, Prophet and MaxProp routing protocols under variable message buffer size is shown in Chart 1.

1. The Chart shows that the delivery probability of all the three routing protocols under MOFO buffer management technique increase as the message buffer size increases.

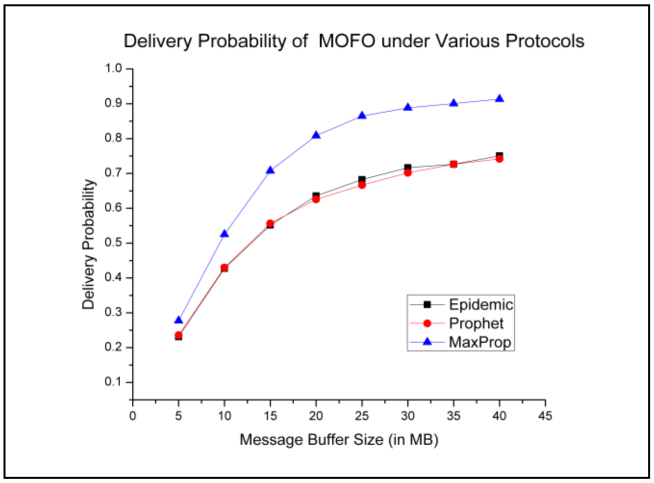

Chart- 1: Delivery Probability

2. The overlapping lines of Epidemic and Prophet shows that delivery probability of Epidemic and Prophet are same at a particular message buffer size
3. Whereas the delivery probability of MaxProp is much higher than Epidemic and Prophet routing protocols at all the message buffer sizes.

6.2 Overhead Ratio

The overhead ratio of MOFO buffer management technique with Epidemic, Prophet and MaxProp routing protocols under variable message buffer size is shown in Chart- 2.

1. The Chart 2 clearly demonstrate that the overhead ratio under all the three protocols falls sharply as the message buffer size increased from 5MB to 10MB.

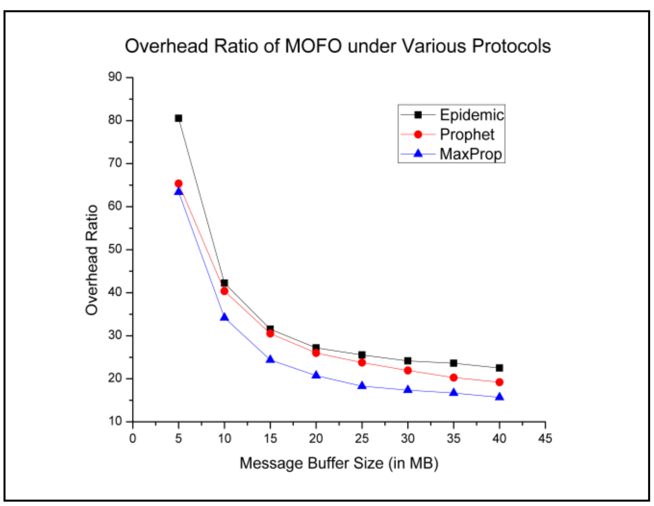

Chart- 2: Overhead Ratio

2. As the message buffer size increased further, the decline in overhead ratio under all the three routing protocols continues very slowly.
3. Overhead ratio under MaxProp is lower than Epidemic and Prophet routing protocols.
4. Overhead ratio under Epidemic is much higher than Prophet and MaxProp at 5MB, but becomes equals with Prophet from 10MB message buffer size.

6.3 Latency Average

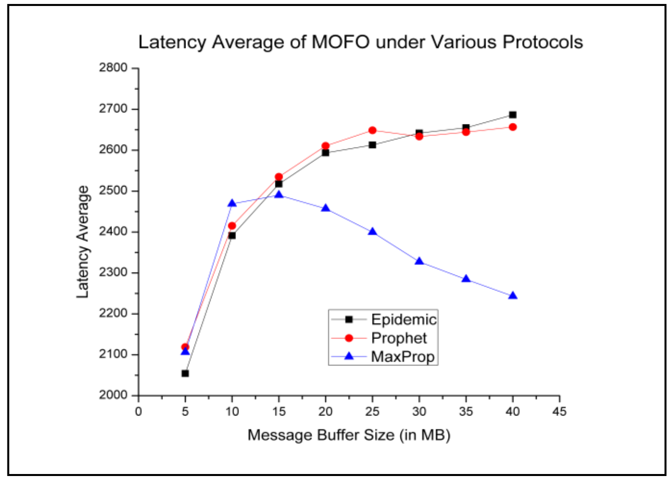

Chart- 3: Latency Average

The latency average of MOFO buffer management technique with Epidemic, Prophet and MaxProp routing protocols under variable message buffer size is shown in Chart- 3.

1. The Chart 3 depicts that the latency average under Epidemic and Prophet routing protocols increases with respect to message buffer size.
2. Whereas latency average under MaxProp increases up to 15MB message buffer size and then declines constantly with increasing message buffer size.
3. The latency average of MaxProp is higher than Epidemic and Prophet routing protocols up to 10MB message buffer size.
4. But as the message buffer size increased, the latency average under MaxProp drops significantly in contrast to Epidemic and Prophet routing protocols.

6.4 Hop Count Average

The hop count average of MOFO buffer management technique with Epidemic, Prophet and MaxProp routing protocols under variable message buffer size is shown in Chart- 4.

1. The Chart- describes that the hop count average of MOFO buffer management technique under all the three routing protocols increases as the message buffer size increases.
2. The hop count average of MaxProp is higher than Epidemic and Prophet routing protocols.
3. Hop count average of Prophet is equal with Epidemic up to 20MB message buffer size, thereafter it gets marginally lower than Epidemic routing protocols.

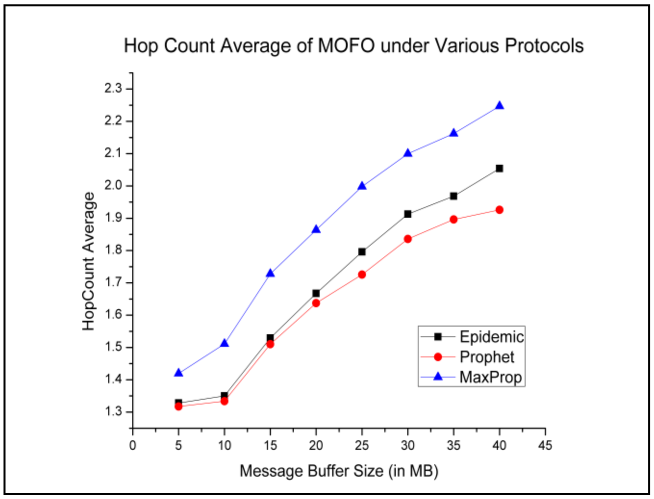

Chart- 4: Hop Count Average

7. CONCLUSIONS

This study evaluated the performance of MOFO Buffer management technique with Epidemic, Prophet and MaxProp routing protocols under variable message buffer sizes. The results show that there are clear benefits of increasing the message buffer size for the parameters Delivery Probability, Overhead Ratio in case of all the routing protocols under study. The Delivery Probability, Overhead Ratio and Latency Time Average of MOFO with MaxProp routing protocol gives the best results among the three routing protocols under study. Whereas for the performance metric Hop Count Average, MOFO with Prophet is better than the other two routing protocols.

In this study, MOFO buffer management technique with different routing protocols has been simulated on the ONE simulator. They have not been deployed on the real network. There may be a higher significance that this technique and protocols be tested out on the real network. This study assumes that all the nodes have unlimited energy. This study do not considers the energy loss of the network as the message buffer size increased for all the nodes. Such constraints should take into account, the energy spent for the network as the message buffer size increases.

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