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A STUDY OF DYNAMIC PREDICTION BASED MULTI-QUEUE (DPMQ) DROP POLICY IN FERRY BASED PROTOCOLS FOR DISCONNECTED MOBILE AD HOC NETWORKS

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ABSTRACT

Delay Tolerant Network (DTN) is an approach to address the technical issues in heterogeneous networks that may lack continuous network connectivity. The issues that are related to DTN are delivery probability, overhead, latency and drop rate. To improve message delivery probability and reduce network overhead, routing protocol and buffer management has to be selected efficiently. This scheme is used to decide which message to be transmitted when two nodes come within the transmission range and to decide which message to drop when buffer overflow occurs. This effort improves delivery probability of a message by choosing probabilistic type of routing protocol called as Prophet and a new buffer management policy called as Dynamic Prediction based Multi Queue (DPMQ) drop policy. This routing protocol forwards the message only when the encountered node has the highest probability of reaching the destination than the sending node. The DPMQ drop policy classifies the buffer into three queues such as LPQ, HPQ and DCQ based upon the delivery prediction. This buffer management policy along with Prophet Routing performs well by reducing overhead and latency while improving delivery probability for a global village scenario.

Keywords: delay tolerant networks, prophet, buffer management, opportunistic network, opportunistic network environment (ONE).

1. INTRODUCTION

Delay Tolerant Network is also referred as the Intermittently Connected Mobile Network. One of the major problems in routing messages is the absence of a complete end-to-end path from the source to the destination. When no path exists to connect a source with a destination, network partition is said to occur. Most of the nodes in a DTN are mobile; the connectivity of the network is maintained by nodes only when they come into the transmission ranges of each other.When end-to-end path could not be established, store and forward approach is used, which is capable of storing the messages to be delivered to the destination in the intermediate node's buffer until contact occurs with other node. If a node has a message to send but it is not connected to another node, it stores the message in its buffer until an appropriate communication chance arises. In these challenging environment, well-known ad hoc routing protocols such as Ad hoc On-demand Distance Vector and Dynamic Source Routing fail to establish routes. This is due to these protocols try to establish a complete route and then, forwards the actual data. Majority of forwarding and routing techniques uses Store-Carry-Forward mechanism to transfer the message to the destination node. A common method used to improve the delivery probability of a message is by replicating more copies of the message with the hope that one will succeed in reaching its destination. The Epidemic routing protocol floods the message via multiple paths to reach their destination which increases network overhead. The other routing protocols such as Prophet, Max Prop, and Rapid, use the information about the network depending upon the scenario to forward the message to the encountered node which reduces the number of replicas of the messages.

Buffer is a limited resource; it suffers from high drop rate. The messages stored in the buffer must be organized and prioritized by a buffer management policy in such a way that it should improve delivery probability and reduce overhead in the network.

In this study, a new buffer management policy called as Dynamic Prediction based Multi-Queue drop policy is used. It classifies the buffer based on delivery prediction of the messages into three queues such as Low-Prediction Queue (LPQ) which holds lower priority messages, High-Prediction Queue (HPQ) which holds medium priority messages and Destination-Connected Queue (DCQ) that contains high priority messages. The messages are forwarded from the buffer in the order of DCQ, HPQ followed by LPQ messages. The drop sequence takes place in the order of LPQ, HPQ tailed by DCQ messages. It improves delivery probability of the message and reduces the network overhead. The result proves that DPMQ policy improves message delivery probability and reduces network overhead.

The remainder of paper is organized as follows: section 2 briefly explains the existing buffer management policies. Section 3 gives the details of proposed buffer management technique. Section 4 provides the simulation and results. Section 5 describes the conclusion of the paper.

2. EXISTING BUFFER MANAGEMENT POLICIES

When buffer overflow occurs and a new message has to be inserted, a buffer management policy is essential to choose which message to be dropped to free up space for new incoming message.

Some of the existing buffer management policies are as follows:

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a) Drop-Oldest (DOA)

DOA drops the message from the buffer which has shortest remaining time-to-live value.

b) Drop-Last (DL)

In DL drop policy, the message that resides at the last position of the buffer is dropped out

c) Drop-Front (DF)

The message that is present in the front of the buffer is dropped first.

d) Drop-Largest (DLA)

It selects the largest size message from the buffer to drop.

e) Evict Most Forwarded First (MOFO)

The message which has been forwarded for more number of times will be dropped first.

f) T-Drop

The size of the message that lies between the specified threshold values is dropped initially.

g) E-Drop

In E-DROP policy, the message that has equal or larger size than that of the incoming message is dropped from the buffer

h) N-Drop

Each time when a message is forwarded, forward count is incremented. When the count exceeds the value 'N', then the message is selected to get dropped from the buffer.

i) Evict Most Favorably Forwarded First (MOPR)

In MOPR, each message in the buffer is linked with a forwarding predictability FP, which is assigned to 0. Each time when the message is forwarded, the value of FP is altered and the message with highest FP value is dropped.

j) Optimal buffer management policy

It drops the message based on global knowledge of the network. Global knowledge is obtained from the number of replicas of a particular message stored in different nodes in the network.

3. PROPOSED WORK

A. Scenario setting

The scenario considered here is a global village scenario which is created with three disconnected networks each containing of 15 nodes. In order to establish communication with the disconnected network, ferry node is used which can receive, carry and forward message from the partitioned network. Local ferry is used to travel in a dynamic path within a cluster by using shortest path depending on the number of neighbors for each node. Local ferry moves within the cluster to collect and deliver messages that are destined to the same cluster. Global ferry is used to travel in a static path to connect the clusters. Global ferry collects the messages from each cluster that is destined to another cluster and delivers it to the appropriate destination cluster. If global ferry does not meet the destined node in the cluster then the message will not be delivered. To overcome this problem, a stationary gateway is used in each cluster which forwards the messages destined to another cluster to the global ferry and receives the message that are destined to itself from the global ferry.

B. prophet

Routing protocol of probabilistic type is chosen so that the traffic will come with different probabilities. Prophet is a probabilistic routing protocol which forwards the message to a node by utilizing its encounter history and transitivity. It uses the routing metric called delivery predictability, $P_{(a,b)}$ € [0,1] which is maintained at each node for all the known destinations where the delivery probability lies between 0 to 1. A node forwards the message to its neighbour only if the neighbour has higher delivery probability for the destination of the message.

C. Buffer management

In order to improve the utilization of the buffer, local buffer is classified into 3 queues such as Low-Prediction queue (LPQ), High-Prediction queue (HPQ) and Destination-Connected queue (DCQ) as shown in Figure-1. The messages are stored in the buffer based on the delivery prediction of the message to its corresponding queue. *DCQ* holds those messages that have higher delivery probability of reaching the destination node or path to the destination is available. HPQ contains messages that have medium delivery probability to reach the destination node. LPQ holds messages that have lower delivery probability of reaching the destination node.

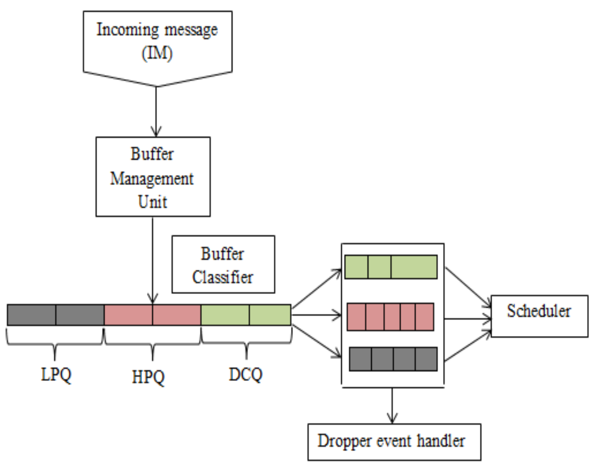

Figure-1. Dynamic prediction based Multi-Queue Architecture.

The size of each queue is changed dynamically depending upon the incoming message and messages that are present in the particular category due to fluctuations in

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network connectivity. The messages are forwarded from the buffer in the order of DCQ queue then HPQ queue and then from LPQ queue since DCQ holds the higher priority messages. Dropper Event Handler is called, when a node's buffer runs out of space to accept a new message from the new node. It is invoked to drop a message from the queue which creates a space for new message. Initially, the drop event checks if there are any messages present in the LPQ queue, if available, then drops the message and terminates. This is because LPQ queue contains the lower priority messages. If LPQ queue is empty, then checks for the presence of any messages in HPQ queue if available, then it drops and terminates. And if the HPQ queue is empty subsequently terminates and discards the relay messages.

4. SIMULATION SETUP AND RESULTS

The above mentioned protocols performance were analyzed through simulation using the Opportunistic Network Environment (ONE) Simulator (Keranen *et al.* 2009) which adds more realism to the simulations. At its core, ONE is an agent-based discrete event simulation engine. To make it suitable and efficient enough for simultaneous movement and routing simulation it uses time slicing approach, so the simulation time is advanced in fixed time steps. The simulations can contain any number of different types of agents, i.e., wireless nodes. The nodes are grouped into node groups and a one group shares a set of common parameters such as message buffer size, radio range and mobility model. Since different groups have different configurations e.g., creating a simulation with pedestrians, cars and public moving is possible. All movement models, report modules, routing algorithms and event generators are dynamically loaded into the simulator with different types of plug-in is made easy for users and developers. Creating a new class and defining its name in the configuration file is usually enough. Result collection and analysis are done through picturing, reports and post-processing tools. The elements and their interactions are shown in Figure-2. A detailed description of the ONE simulator is available in [8] and the ONE simulator project page [9] where the source code is also available.

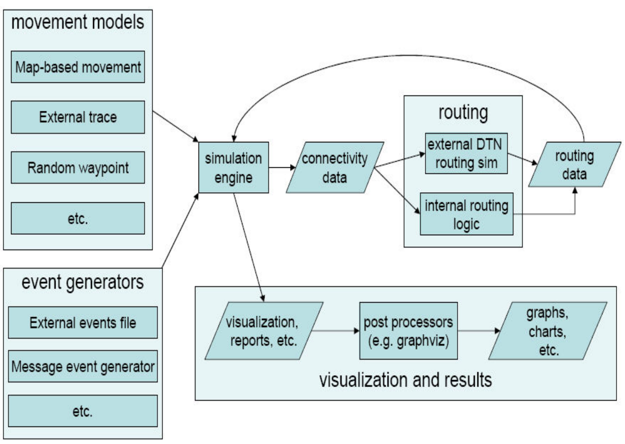

Figure-2. Overview of ONE simulator.

A. Simulation parameters

The Table-1 precises the simulation configuration used for the current analysis.

Table-1. Simulation parameters.

Parameter	Value
Simulation time	150 s
Simulation area	5400 X 5500 m
Routing protocol	Prophet
Movement model	Random waypoint
Buffer size	50 – 250M
Number of nodes	30, 60, 90, 120, 150
Transmission range	50 – 100 m
Transmit speed	0.1 – 10 m/s
Message size	500 KB – 1MB

B. Performance metrics

The metrics used for the performance analysis are as follows:

a) Delivery ratio: It is the fraction of number of messages delivered from the number of messages generated. It is defined as,

$$\frac{Number\ of\ messages\ delivered}{Number\ of\ messages\ generated}$$

b) Over head ratio: It is the average number of replicas per messages needed by the routing protocol to deliver the message to the destination. It is defined as,

$$\frac{Number\ of\ messages\ relayed\ - Number\ of\ messages\ Delivered}{Number\ of\ messages\ generated}$$

c) Average latency: It is the measure of average timebetween the creation and delivery of the messages to the destination. It is defined as,

Delivery time – Creation time

d) Buffer time average: It is the average time spends by all the messages in the buffer of a node.

The results presented here are obtained byrunning the simulations for a global village scenario as per the parameters defined in Table-1.

C. Results

a) Delivery Probability Vs Number of nodes

From Figure-3, message delivery probability of various routing protocols for a global village scenario is compared. In this, Delivery probability of Prophet with DPMQ policy is increased than that of other protocols since higher prediction messages are given first preference to get forwarded.

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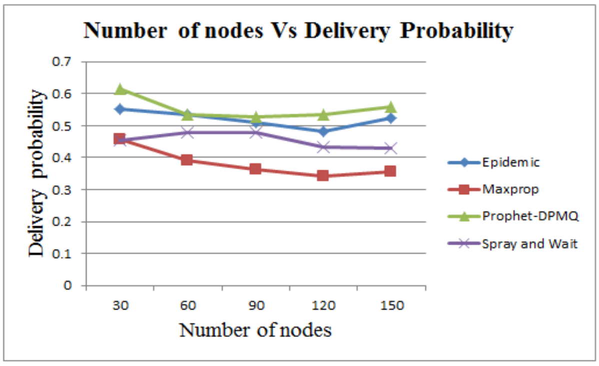

Figure-3. Delivery probability Vs. Number of nodes.

b) Overhead Ratio Vs Number of nodes

Comparison of Overhead ratio for various protocols is shown in Figure-4. In this, the overhead ratio of Prophet with DPMQ policy is reduced when compared with Maxprop and Epidemic. Since Spray and Wait uses only limited number of copies for transmission, overhead is low when compared to other protocols.

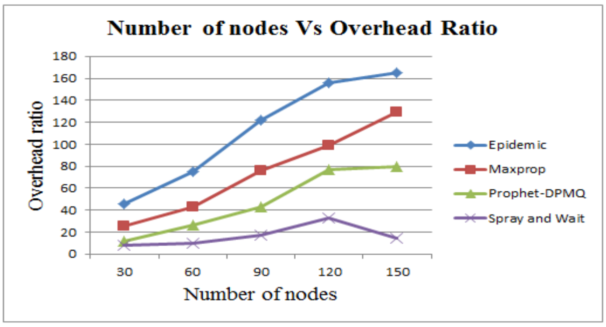

Figure-4. Overhead ratio Vs. Number of nodes.

c) Average Latency Vs Number of nodes

Comparison of Latency average for various protocols is shown in Figure-5. In this, latency of Prophet with DPMQ policy is increased than that of other protocols, because Prophet delivers the message to the encountered node only when the encountered has the higher probability of delivery than the sending node.

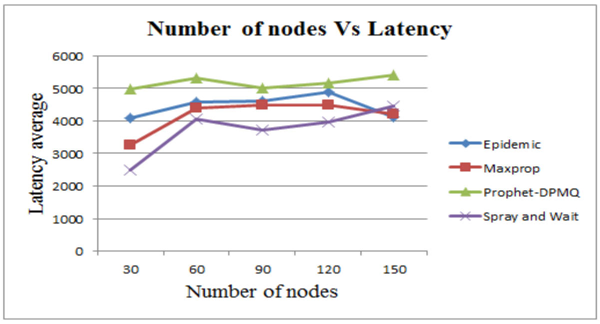

Figure-5. Average latency Vs. Number of nodes.

d) Buffer time average Vs Number of nodes

Comparison of Buffer time average for various protocols is shown in Figure-6. In this, Buffer time average of Prophet with DPMQ policy is less when compared to Maxprop and Epidemic because higher prediction messages are forwarded quickly than other messages in the buffer.

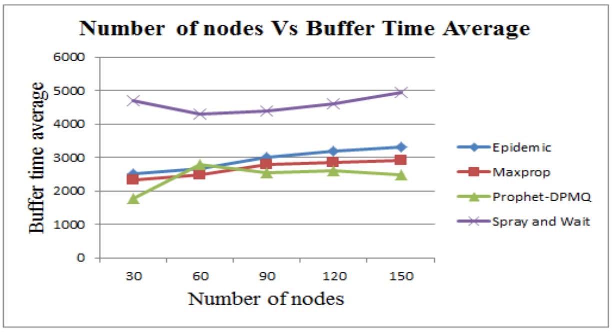

Figure-6. Buffer time average Vs. Number of nodes.

5. CONCLUSIONS

In this paper, Delay Tolerant Network suffers from limited buffer capacity. Existing buffer management policies like Drop-Oldest, Drop-Largest, E-Drop, T-Drop provides higher delivery probability but suffers from higher drop ratio. To overcome this problem, a new technique called Dynamic Prediction based Multi Queue Drop Policy is implemented in Prophet Routing protocol in which buffer is classified into three queues which holds lower priority, medium priority and higher priority messages based on delivery prediction. The messages are forwarded from the buffer in the order of higher priority messages followed by medium and lower priority messages. The drop sequence takes place in the order of lower priority messages followed by medium and higher priority messages. It improves delivery probability of the message and reduces the network overhead.

Future work will concentrate on combining the Dynamic Prediction based Multi Queue drop policy with other routing protocol. To improve the utilisation of buffer, message dropping can be carried out using the factors such as message size and time-to-live value instead of delivery prediction.

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