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A Novel Approach For DTN Routing Based On Estimation Status With Delivered List Update

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Abstract

Delay tolerant networks (DTNs) characterize a class of networks that suffer from frequent and long-duration partitions. Buffer management schemes greatly influence the performance of routing protocols when nodes have limited buffer space. The excessive increase of a single message's copies will exhaust nodes' buffer space and reduces the probability of other messages to be buffered and forwarded and leads substantial decrease in delivery ratio. The paper proposes an enhanced routing algorithm for delay tolerant networks. The technique developed to buffering decision is based on transmission status of messages, including the total number of copies in the network and the dissemination speed of a message. Routing provides more priority to the messages destined to the contact node. When buffer overflow occurs, messages that have larger estimated number of copies and faster dissemination speed are replaced prior to and forwarded posterior to other messages. The delivered messages are deleted from the network with the update of buffer summary vector. The Simulation result proves that buffer management scheme based on estimation status remarkably improves delivery ratio with relative lower overhead compared to other existing buffer management schemes.

Keywords: *Delay Tolerant Network, Buffer Management, Summary Vector, Intermittent Connectivity.*

1. Introduction

The TCP/IP protocol helps reliable communication over the internet by establishing an end to end path between the source and destination of communication. However, this communication paradigm is not suitable to challenged networks such as interplanetary and deep-space networks in which communications are subject to delays and disruptions. Maintaining a stable data path in spite of intermittent connections is a difficult task. These challenged networks which suffer from these types of connections are generalized as Delay Tolerant Networks. DTN is designed so that the temporary or intermittent connection problems, limitations and anomalies have least possible adverse impact in communication. It allows the regional networks with varying delay characteristics to interoperate by providing mechanisms to translate between their respective network parameters.

DTN is represented by a graph G = (V, E), where V denotes the set of network nodes and E denotes the set of edges or links. G is a time-varying graph which shows a snapshot o1f network connectivity at a certain point in time. An edge in G may stay connected for a period of time and then become disconnected. When a node comes in the range of other node, it gets connected. Figure 1 represents a DTN of five nodes (A, B, C, D & E) with B & C connected by an edge.(B-C). The nodes get connected when one node is coming in the range of other node. Here, B & C comes in contact and forms an edge.

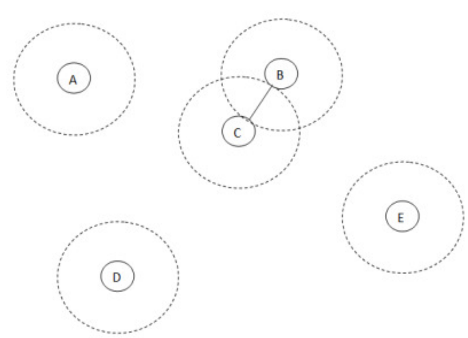

Fig. 1 DTN Topology

DTN utilizes the communication opportunities arising from node movement to forward messages in a hop-by-hop way, and implements communications between nodes based on the manner of storing–carrying–forwarding transmission. To deal with the unpredictability in connections and network partitions, many routing protocols adopt flooding-based schemes to improve the message delivery, where a node receives packets, stores them in their buffers, carries them while moving, and forwards them to other nodes when they encounter each other. DTN operates above the transport layer protocol and the router handles the message aggregates as bundles.

Many of existing routing schemes assume the nodes have infinite buffer space and do not consider the contention for buffer space between nodes. However, in many wireless networks, nodes are limited in their buffer space. Even if a node have large buffer space, it is not feasible to share the buffer for all messages in the network. Most of the nodes share only a limited part of buffer to the external traffic when it acts as a relaying node. Thus, the way the buffers are managed will significantly affect the performance of routing protocols in DTNs, especially in environments where intermittent connectivity and long latency require the data to be stored for a long period throughout the network. Hence, an enhanced routing algorithm associated to buffer management will increase the delivery ratio and overhead of nodes during message transmission.

The excessive multi-copies spraying in the network causes serious congestion and exhaust nodes' buffer space can create a stage in which no more messages can be transmitted. This influences the performance of transmission dramatically. Therefore, the buffer management plays a very important role in the transmission, and the limited buffer in each hop should be used reasonably. How to design an efficient and effective buffer management strategy in opportunistic networks becomes a crucial issue.

The paper proposes an efficient buffer management scheme that minimizes the redundant copies of messages circulate in the network. A prioritized scheme is introduced to deal the messages so that the nodes can efficiently utilize the contact time between nodes without much dropping rate. The proposed enhancement for buffer management is to provide highest priority to messages which is destined to the connected node if it is not delivered. The remaining messages are prioritized based on the replicated copies and dissemination speed. When buffer overflow occurs, messages that have larger estimated number of copies and faster dissemination speed are replaced prior to and forwarded posterior to other messages. The delivered messages are deleted from the network with the update of buffer summary vector.

The existing techniques make the decision to store/drop is only after the data transfer. In this proposed solution the nodes identify the priority before the data transfer so that only high prioritized messages will be transmitted and hence it reduces the dropping rate. The proposed methodology also removes the delivered messages from the network nodes before the TTL expires. The method is suitable when the nodes in DTN network are limited by the memory and power. The improved delivery ratio, latency and overhead ratio shows a very good enhancement in terms of buffer management.

2. Existing System

DTN routing transfer the data in a basic store - carry forward method. Basic Epidemic routing [1] forwards all the messages which it possesses to the entire contact node as a bundle. This contact node in turn will forward the messages it has with the ones which it received from other nodes to the next contact node and so on. This leads to spread each message in the network and eventually reach the destination. In this scheme, the protocol assumes infinite storage space in nodes and hence there is no contention of buffer in nodes. So, by epidemic routing, the number of copies of each message is increased largely in the network. Thus each message consumes a lot of buffer space and it can lead to a state in which no message can be accepted and delivered to the destination application. This is because the buffer space is always limited and when it gets overflow [2], all incoming message will be discarded. This works well till there is no buffer overflow. So it is better to limit the redundant copies in the network and by that the other messages will get more chance to reach the destination.

When the buffer overflows, the nodes discard incoming messages and it leads to a state in which no more messages can be forwarded. Many proposed schemes introduced remedies for this state by different replacement and scheduling algorithms. Most of the protocols are implemented based on the basic algorithms like DL - Drop Last (Drop tail), DF- Drop Front, DO- Drop oldest, DY- Drop Youngest, Drop random and HBD – History Based Drop.

3. Issues Identified in Existing Methodologies

Many proposed routing schemes for DTNs assume nodes have infinite buffer space and do not consider the case where there is a contention for buffer space on network nodes. However, in many wireless networks, nodes are limited in their buffer space. Even if a node have large buffer space, it is not possible to share the limited part for external traffic when it acts as a relaying node. Thus, the way the buffers are managed will significantly affect the performance of routing protocols in DTNs, especially in environments where intermittent connectivity and long latency require the data to be stored for a long period throughout the network. Hence, an enhanced routing algorithm associated to buffer management will increase the delivery ratio and overhead of nodes during message transmission.

From a detailed survey conducted on the existing method, it is identified that existing protocols suffer from the following weaknesses.

a. There is no restriction in the creation of redundant copies of messages in the network.
b. Most of the existing system has large message dropping rate.
c. In most of the existing system, there is no reasonable queue strategy for message scheduling.
d. Most of the existing system does not utilize the buffer efficiently.
e. Most of the existing system drop the message after sending and hence not utilize the contact time efficiently.
f. The delivered messages also circulated in the network until the TTL expires.
g. Most of the methods do not consider the occupancy of replicas of delivered messages in nodes other than the destination node. So the delivered message replicas will be circulated within the network till the TTL expires.
h. Another issue identified with current system is that prioritization of message is based only on the number of replicas and dissemination speed. It does not consider the destination node availability with contact node [3]. So, the message may be discarded from the contacted destination node because of the higher replicated copy.

4. Proposed System

Message transfer in DTN is done using the Storage-carry-forward paradigm. Buffer management schemes greatly influence the performance of routing protocols [4] when nodes have limited buffer space. From a network-wide viewpoint, the excessive increase of a single message's copies will exhaust nodes' buffer space. This reduces the probability of other messages to be buffered and forwarded and leads substantial decrease in delivery ratio. It proposes a buffer management scheme based on estimated status of messages [5], including the total number of copies in the network and the dissemination speed of a message. Messages with larger estimated number of copies and faster dissemination speed are dropped while buffer overflow [6]. Dissemination speed of message is measured with the rate to drop the message. The acceptance of message is done according to the message priority and the free buffer space. The delivered messages are deleted from the network with the update of buffer summary vector on each contact. High priority is given to the message destined to the contact node and the one with less number of copies and dissemination speed. The proposed buffer management scheme improve delivery ratio with relative lower overhead ratio compared to other buffer management schemes.

4.1 Buffer Management

Because of intermittent connectivity in the network, a node could not get accurate global status about a particular message. It uses statistical learning to estimate the dissemination status of a message when nodes encountered. Paper introduces two metrics to measure the priority of a message [7], including the number of message copies and the dissemination speed of a message. Message that has smaller replication number is assigned higher priority. If messages have the same replication number, message with lower speed of dissemination is assigned higher priority.

4.2. Steps of Proposed Method

1. Creating and sending a new message:
   a. Application forwards information about new message to the router on the local host.
   b. Router creates a new message with number of replicas as '1' and payload as the provided information.
2. Assign high Priority to the new message i.e. replication count of 1.
3. For the remaining messages, assign the priority based on the number of replicated copies in the network and dissemination speed (No of Hops/(TTLinitial-TTL))of the message.
4. Messages with less number of replica is given high priority and for the same replicated number of messages, message with less dissemination speed is given high priority.
5. When two nodes meet:
   a. Exchange Summary Vector(MsgID, Replication_No,No:of Hops, TTLinitial, TTL,

DeliveredMsgIdList)

b. Delete the delivered messages from the buffer.

c. Combine the summary vector; assign high priority to the messages destined to the contact node if it is not delivered and sort the remaining messages by assigning priority.

d. Update the replication count of all messages and delivered list with respect to the summary vector of peer node.

e. Forward the high priority messages those are not already in the peer node's buffer. i.e. the peer node will have at least one message with lower priority than the non-existing message.

6. On receiving a message if the destination of the message is current node:

a. Update the delivered message list by adding current message id.

b. Forward the message to the intended application.

7. Store the message in its buffer, if it has enough free buffer

a. If the message size is more than the buffer size, reject the message.

b. Otherwise, make the room for message by removing the least priority message from the buffer and update the summary vector.

8. If the TTL expires for any message, delete it from buffer and update summary vector.

First of all, the ready list of messages to send is sorted in descending order according to their priority. When two nodes come in contact, they exchange the summary vector to identify the message to be sent and receive [8]. With the delivered list of messages updated in the node's summary vector, the nodes delete the delivered messages from it buffer and identify high priority messages to forward to the contact node. Message with most number of replicas on the network is given the lowest priority. Among the one with same number of replicas, the one having a higher dissemination speed is selected. If the highest priority of messages is lower than the lowest priority in peer node, the node forward messages so that peer node could contain incoming message in its free buffer. High priority message is send to the peer node if it exist at least one message which is high prioritized than the lowest priority message in the peer node. The peer node receives the incoming messages by removing the least priority message from the buffer and updates its summary vector.

5. Performance Evaluation

5.1. Experimental Setup

Proposed buffer management scheme evaluated and compared with epidemic routing protocol on the ONE simulator [9]. Result obtained is the graph showing the comparison of enhanced proposed Buffer Management method (EBM) with epidemic routing protocol.

Table 1: Simulation Parameters

Parameters	Value
Number of Nodes	40
Number of Groups	3
Transmission Range	10m
Transmission Speed	250k
Buffer Size	5MB-50MB
Message Size	0.5-1KB
Simulation Time	4200S
Message TTL	300m

5.2. Result Analysis

With ONE Simulator framework, we put together the important result parameters obtained in the report file with different configurations and available routing algorithms, to analyze and figure out performance impact [10]. The main intention is to figure out the impact on below major performance parameters, with varying network size and buffer size:

- Overhead Ratio
- Average Latency
- Delivery Ratio

Analysis 1: Impact on delivery ratio with varying network size or number of node

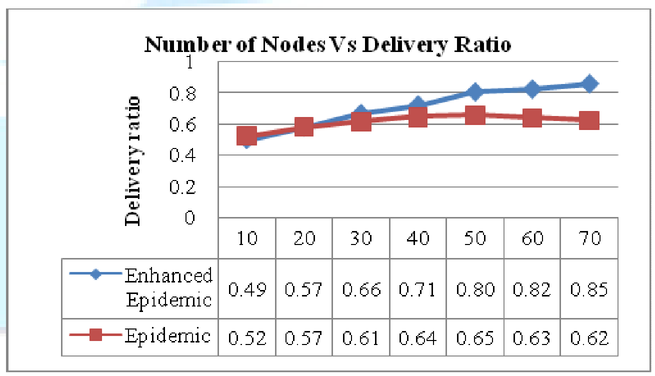

Fig. 2 Delivery Ratio with Varying Number of nodes.

It is obvious from the above graph that the delivery ratio of implemented routing algorithm outperforms the epidemic algorithm. It also shows that the delivery ratio increase with increase in number of nodes.

Analysis 2: Impact on overhead ratio with varying network size or number of nodes

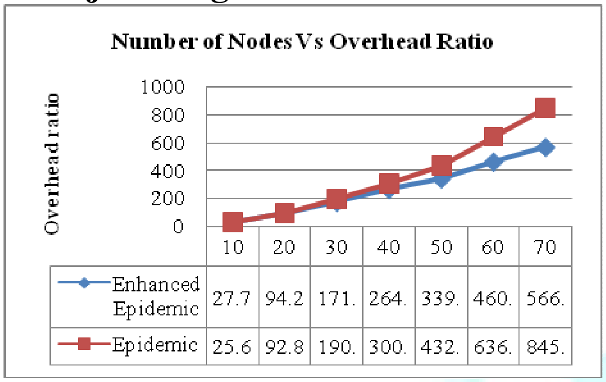

Fig. 3 Overhead Ratio with Varying Number of Nodes

The overhead ratio increases as the number of nodes. But the rate of increase is less than the epidemic with more number of packets deliveries.

Analysis 3: Impact on average latency with varying network size or number of node

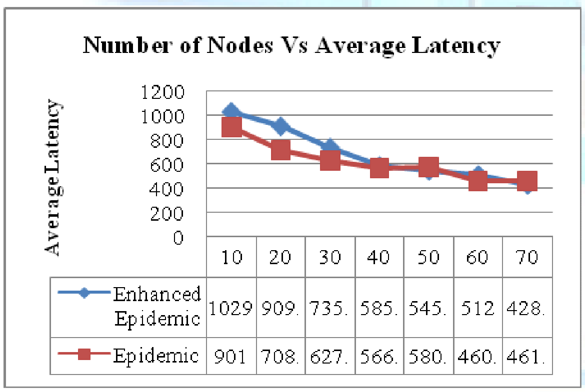

Fig. 4 Average Latency with Varying Number of Nodes

The average latency is reduced with increase in number of nodes. It gives the nearby performance in latency providing high delivery ratio.

Analysis 4: Impact on delivery ratio with varying per node buffer size

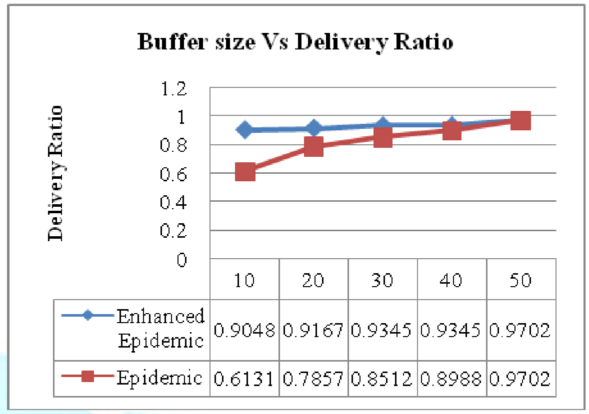

Fig. 5 Delivery Ratio with Varying Buffer Size.

Delivery ratio is very high compared to epidemic for the limited buffer and it provides the same performance with large buffer.

Analysis 5: Impact on overhead ratio with varying per node buffer size

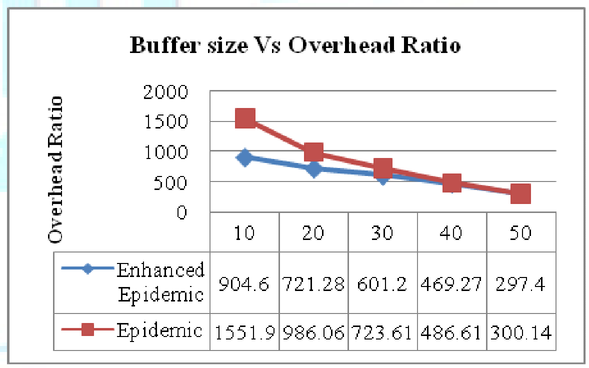

Fig. 6 Overhead Ratio with Varying Buffer Size

Overhead ratio is very small when it is compared with epidemic for limited buffer and it reduces as buffer size increases.

Analysis 6: Impact on average latency with varying per node buffer size

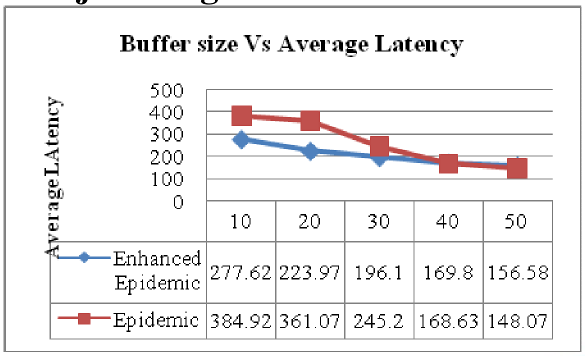

Fig. 7 Average Latency with Varying Buffer Size

Average latency reduces with increase in buffer size and it is very small compared with epidemic for limited buffer size.

6. Conclusion

Enhanced buffer management scheme improve the delivery ratio by identifying the message to the contact node & by deleting the delivered messages from the network nodes. From the result obtained it is proved that compared to the existing scheme, there is a 33% improvement in delivery ratio and overhead ratio with .07% increase in latency.

12. Future Work

Routing is implemented with a buffer management by considering only the message status. Routing can be improved by updating the node contact history details to identify the routing node and hence to improve the delivery ratio.

Table 2 :Contact Node Information

Field Names			
NodeId	Time of Contact	Duration	Frequency

A table of contact node information which contains the fields such as NodeId, Time of contact, Duration of contact and frequency of contact can be stored and updated after each contact. In this way we can effectively improve the message forwarding decision.

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