Efficiency Analysis of Enhanced Epidemic Routing Protocol of Delay Tolerant Networks using Improved Buffer Management

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Abstract

Delay tolerance network (DTN) has been proposed as a solution to build the network infrastructure via intermittently connected mobile nodes by adopting store, carry and forward paradigm. Accordingly, the node stores the incoming messages in its buffer, carries it while moving and forward or deliver when comes within the transmission range of other nodes. When a message is generated at the source node, it is stored in the buffer until a suitable contact opportunity occurs. At this contact opportunity the message copy is forwarded to the next intermediate node depending upon the availability of buffer space at the next node. If the buffer space is available then the message is forwarded to the node and if the buffer space is not available in the next hop node then the space is created at the next hop node using some buffer management scheme. There are certain cases in which some messages which are removed from the node to accommodate new messages again arrive at the node through some other node which in turn initiate the process of removal of the message from the buffer to accommodate this message. This leads to the circular loop of the message removal and accommodation and hence the overhead associated with the routing protocols get increased and the delivery probability gets reduced. In this paper we have proposed and analyzed the efficiency of the mechanism to deal with this message removal and accommodation loop. The results given in this work clearly show that the extension applied to the Epidemic routing protocol has significant impact on the performance of the routing protocol and hence it is to be applied in the working environment.

Keywords: *Delay Tolerant Networks, MANETs, Time to Live (TTL), PROPHET, Routing Protocol*

1. INTRODUCTION

Delay Tolerant Networks (DTN) comprises of mobile devices like vehicles. Without focal center, there is correspondence between the mobile devices in DTN. There might be such conditions in the system when there is absence of persistent availability in long separation remote territory systems (e.g. interplanetary, Deep Space Communication, Tactical Military Applications, Acoustic Networking). Such sorts of tested systems may bring undesirable conditions like undesirable long deferral, cushion limit confinements, asset constraints, high error rates, discontinuous ways. Versatile Adhoc Networks don't perform well to control these undesirable circumstances. To manage these tested system conditions, the need to propose another model for the specialists is arise and that system is named as Delay Tolerant Network (DTN). Data access in DTN may enable deceptive gatherings to encroach customer secrecy. Then again, precision in execution results is wanted in the dependable system for best outcomes and support purposes. A few steering calculations were proposed for DTNs in the writing. In steering conventions, plans issues, for example, security, trust and protection have been considered in not very many of them. DTNs are extremely open to conduct of noxious hubs due to their properties, for example, low hub thickness and discontinuous ways between the hubs.

Delay Tolerant Networking covers a wide range of systems designed to work in challenging environments that traditional routing protocols from the Internet and MANETs would scuffle to perform in. From inter-planetary networks [1] designed to tolerate the noise and delays experienced by communication across astronomical distances, accounting for occlusion of satellites and planned communication windows, to military [2] and disaster recovery scenarios [3], animal tracking [4], and connecting regions of the world without infrastructure [5].

2. RELATED WORK

Delay tolerance network (DTN) [6] has been proposed as a solution to build the network infrastructure via intermittently connected mobile nodes by adopting store, carry and forward paradigm. Accordingly, the node stores the incoming messages in its buffer, carries it while moving and forward or deliver when comes within the transmission range of other nodes.

DTN routing protocols [15, 7, 8] can be either single copy or multi copy. In single copy protocols, [9] the node forwards the unique copy of the message along a single path. These protocols consume fewer network resources but suffer unbounded delivery delay. The multi copy routing protocols forwards redundant copies of each message along multiple paths resulting reduced delivery delay and increase the delivery ratio. Despite improving network throughput, the multi copy protocols galvanizes the

Eminent amount of network resources including buffer space, energy, bandwidth and processing power. The resource consumption [10] can be curbed by forwarding the

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message only to the nodes that are highly favorable to encounter its destination, for instance, PRoPHET [11] and Encounter based routing [12]. However, in real time scenarios each node has its own mobility region [13], speed, energy and buffer space.
The resource usage can be circumscribed by forwarding a message through observing the movement pattern of nodes. The protocols such as [14] Lindgren et al. (2004) and [7] Elwhishi et al. (2012) study social encountering pattern and transmission which occur only if the node has a high encounter rate with message destination. These protocols reduce delivery delay. However, there are some scenarios where such strategies could derail network throughput.
Despite efficient forwarding, a buffer scheduling is also required to reduce the impact of dropped message on the network through- put. Message drop event cannot be removed. However, selection of dropped messages is an important decision because a dropped message lost its opportunity to be delivered.
Prodhan et al. [8] (2011) proposed a TTL Based Routing (TBR). TBR has prioritized mechanism of schedule of messages to be forwarded to the neighbor, and the messages need to be dropped from the buffer. Whitbeck and Conan [16] (2010) proposed a new generic hybrid approach HYMAD that uses node knowledge of their local group topology to improve the performance of a simple DTN protocol.
A precious contribution is available on the DTN routing protocols. One of the area which needed to explore much more is to use of effective buffer management policies in DTN that aims to find how messages discard will influence the buffer overflow by selected an intelligent buffer policy. A few classical buffer management polices like Drop-oldest (DOA), Drop Random (DR), LIFO/DL, FIFO/DF are used for the DTN, but they are not appropriate for the optimal selection of the message from buffer overflow and also reduces the message's buffer time occupancy.
In another paper [22], a Queuing policy alleviated flooding attack for probabilistic delay tolerant network (PRED), which too doesn't need global knowledge about the network. It will discard the message with the maximum metric. This policy is used to eliminate security threats to some extend against malicious nodes. Heuristic congestion control for message deletion in DTN credit based congestion control (CCC) [17] based on the idea that the message that is not valid should be deleted first as in DOA and kept in junk for later use. In the future contact, the same message can't be replication from the encounter node and reduces the replication ratio, which carries out high performance by using the time-dependent credit.
Some works have been proposed recently, which deal with the problem of buffer congestion, e.g. Lifetime ASC (Ascending) [18] order drop policy assurances to the

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messages chosen to be discarded are those, whose remaining TTL expires nearer, Drop Largest (DLA), [19] large size message will be selected to drop. T-DROP [20] drop the message which lies in the threshold size range of buffer and E-DROP [21], it will drop the message of equal size from the node buffer when the node congested. All these schemes have some pros and cons and still more research findings in this area is ongoing.

3. PROBLEM STATEMENT

Overall communication in Delay Tolerant Networks is carried out using store-carry-forward scheme. When a message is generated at the source node, it is stored in the buffer until a suitable contact opportunity occurs. At this contact opportunity the message copy is forwarded to the next intermediate node depending upon the availability of buffer space at the next node. If the buffer space is available then the message is forwarded to the node and if the buffer space is not available in the next hop node then the space is created at the next hop node using some buffer management scheme. In this process some of the messages are removed from the buffer so as to accommodate the new message at the node. But if we analyze the removal and accommodation of the messages at the node, we observe that there are certain cases in which some messages which are removed from the node to accommodate new messages again arrive at the node through some other node which in turn initiate the process of removal of the message from the buffer to accommodate this message. This leads to the circular loop of the message removal and accommodation and hence the overhead associated with the routing protocols get increased and the delivery probability gets reduced. There is large number of schemes which manages buffers to accommodate the new incoming message but we did not found any scheme which deals with the issue mentioned above. So the research gap which we analyzed is the mechanism to deal with this message removal and accommodation loop is required.

4. METHODOLOGY

The basic communication model for the Epidemic routing protocols in Delay Tolerant Networks is shown in Figure 1. When the two nodes come in communication range of each other, the two nodes exchange the summary vector (list of messages in message collection). From the summary vector, the current node generates the list of messages to be requested from the other node. This list is exchanged to the other node. When the message arrives at the node, if the buffer space is available, the message is received by the node. But if the buffer space is not available, some messages from the message collection is

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removed depending upon the buffer management scheme being followed (generally FIFO). This freed space is used to accommodate the new message from the other node.

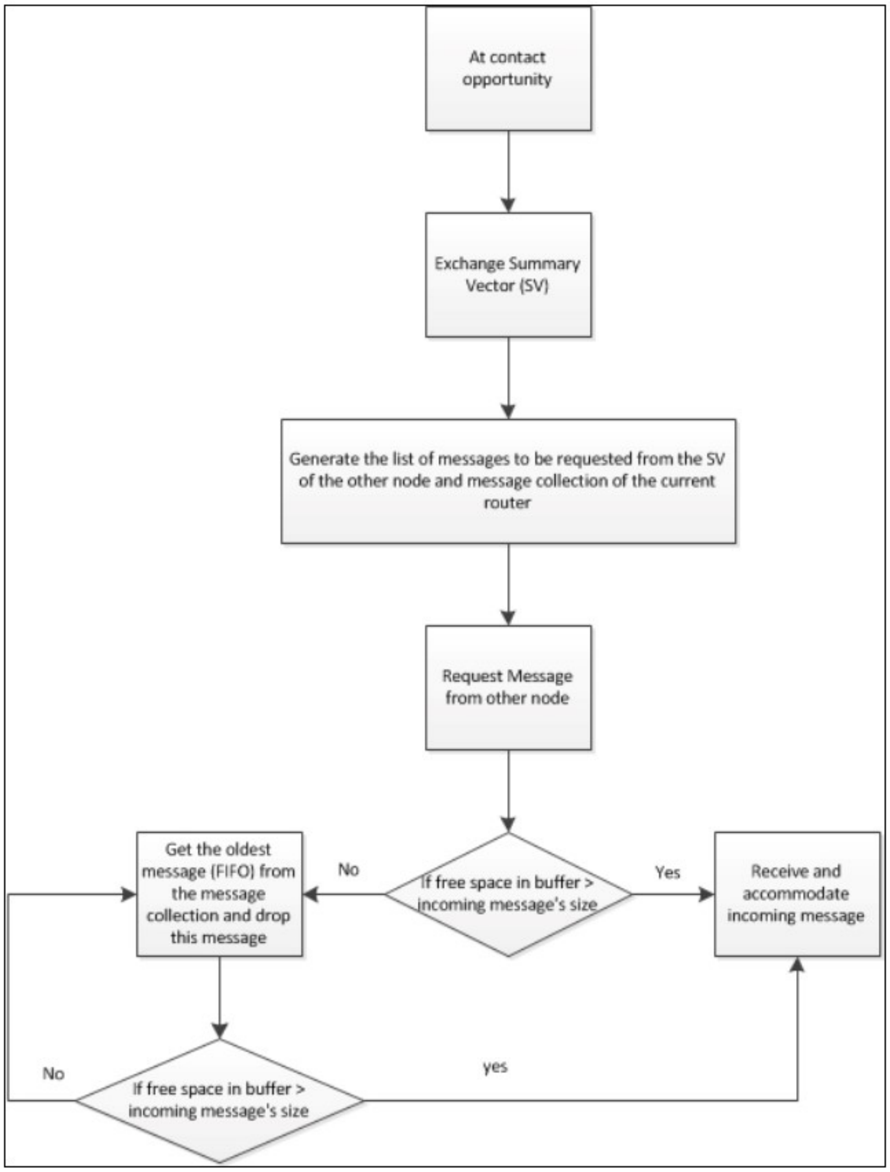

Figure 1: Normal behavior of router with Epidemic Routing Protocol in DTN

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But the drawback of this behavior is the message accommodation and dropping loop as mentioned in the research gap section. So the extension is applied to the normal behavior as shown in figure 2.

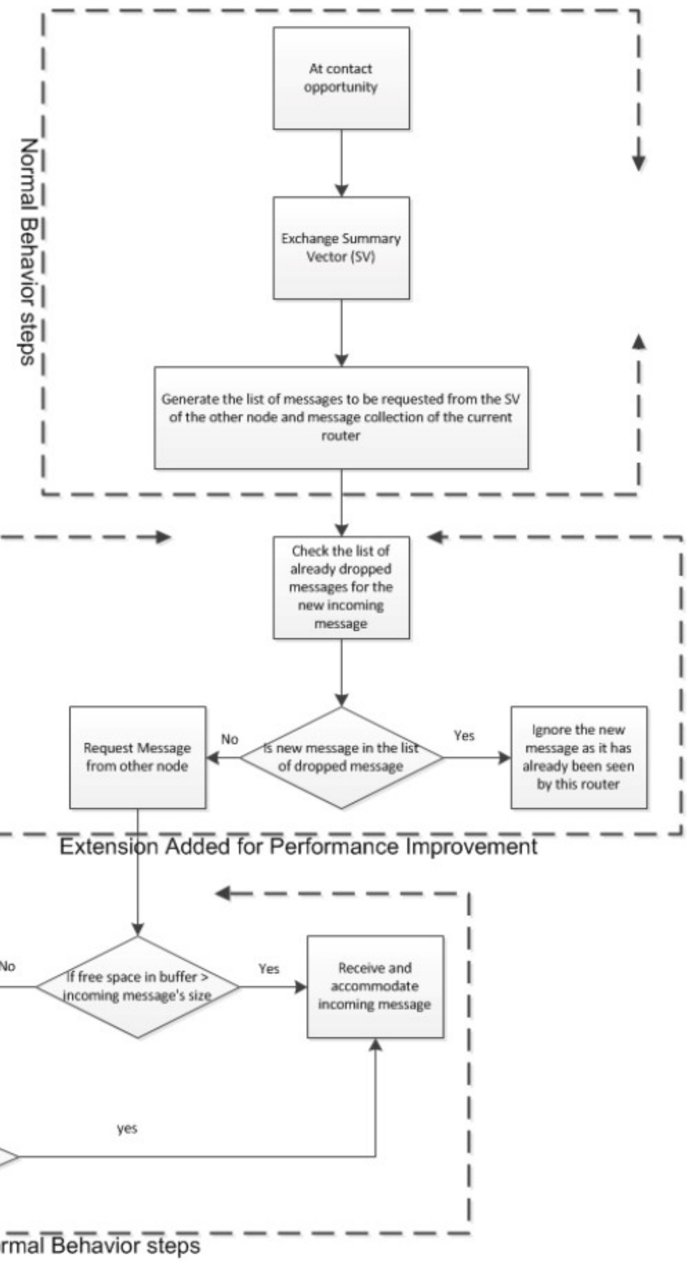

Figure 2: Extended behavior of router with Epidemic Routing protocol in DTN.

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In the extension applied, each node maintains the list of dropped messages. When a message arrives as the node, the routing module first checks the presence of the incoming message in the dropped message list. If the message is present in the dropped message list, the new incoming message is discarded as this message has already got enough time in the buffer for being forwarded to the other node. If the message is not present in the dropped message list, then the normal routing protocol routine proceeds.

5. RESULTS AND DISCUSSION

To analyze the performance of above stated routing protocol of DTN, simulations are executed using Opportunistic Network Environment (ONE) simulator (Kernen, Ott et al. 2009). For the simulative performance analysis epidemic routing protocol with ShortestPathMapBased movement model, we have varied the buffer size of the nodes in the varying node density in the specific network environment. The map based movement model used map of Helsinki city provided in ONE simulator.

Simulation setup

We have simulated a 12 hour period and evaluated the different metrics used to compare the performance of Epidemic Routing protocol under Normal Behaviour (defined in figure 1) and under the proposed extension (defined in figure 2). This routing protocol is implemented in a java based ONE (Opportunistic Network Environment) simulator. The flow model of the basic routing process as implemented in ONE is depicted in figure 1. Mobile nodes move according to the ShortestPathMapBased movement model. When the node moves to the selected destination, it waits at that location for a random period of time in between the lower bound and upper bound value (5 to 15 mins) of the wait period. It then selects random location in the scenario and moves to that location with the speed randomly selected between 30 and 50 km/h. Each of the mobile nodes buffer size is varied from 5 to 35 Mbytes and the performance metrics are studied under different buffer size scenario. Node's buffer works on FIFO strategy.

5.1 Impact on Delivery Probability

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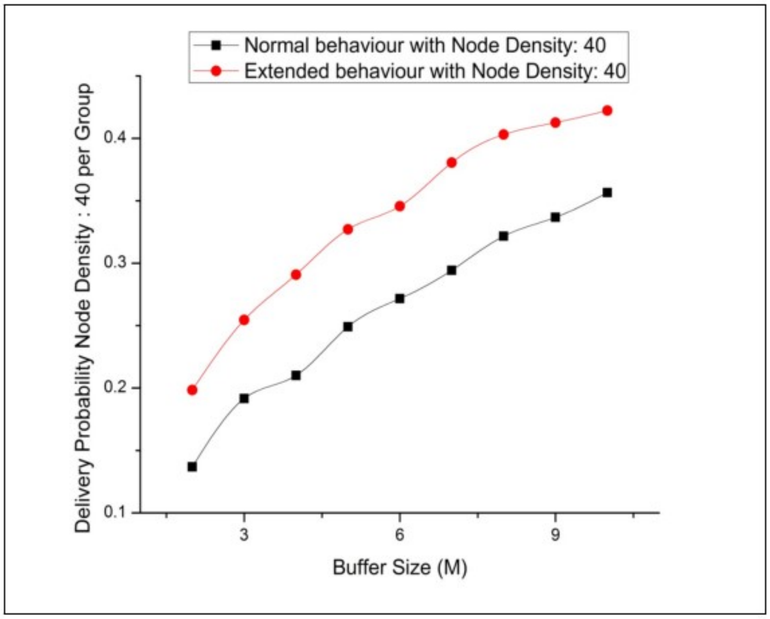

Figure 3: Delivery Probability of Epidemic Routing Protocol under Normal and proposed Extension with node density of 40 nodes per group

Similarly, at the node density of 40 nodes per group, the delivery probability improves by 31% i.e. it improves from 0.29 to 0.38 at 7 M buffer size (figure 3). Thus it is clearly evident from the figure 4.7 – 4.10 that the proposed extension when applied to the epidemic routing protocol have a great impact on the delivery probability of the protocol under the defined network scenario.

5.2 Impact on Overhead Ratio

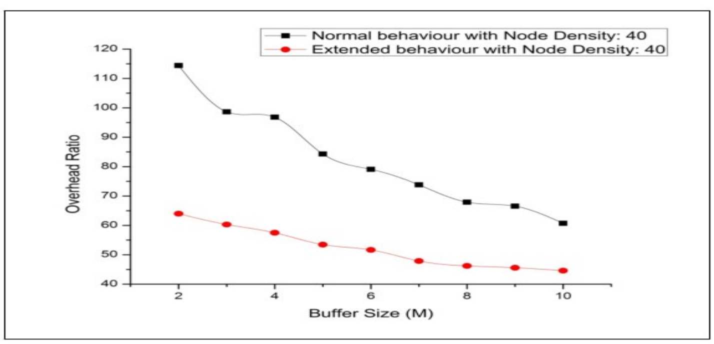

Figure 4: OverHead Ratio of Epidemic Routing Protocol under Normal and proposed Extension with node density of 40 nodes per group

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The response of the OverHead Ratio to the proposed extension of the buffer management at the node density 40 nodes per group is shown in figure 4. From the data shown in figure 4, it can be analyzed that the overhead ratio of the epidemic routing protocol with the extension applied has improved significantly. At 2 M buffer size this value drops from 114.42 to 63.98 i.e. 44% drop in the overhead ration. This improvement is the main contribution of our work which is very significant value. Similarly at 4 M buffer size over head ratio value improves by 41% at the same node density.

5.3 Impact on Average Latency

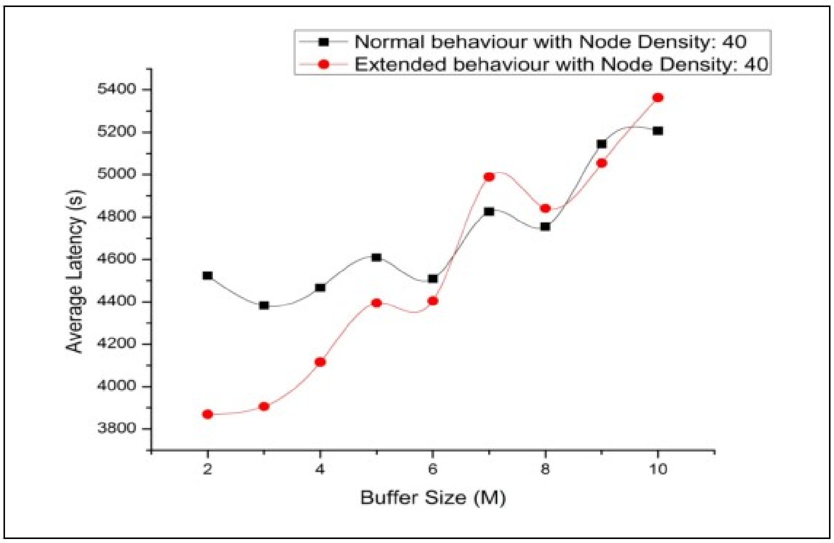

Figure 5: Average Latency of Epidemic Routing Protocol under Normal and proposed Extension with node density of 40 nodes per group

From figure 5, it is clear that there is no much drop or increase in the average latency of the epidemic routing protocol in the presence of the extension the protocol. This response of the routing protocol clearly shows that the replications of the packets which are avoided by the extension were really useless and were not contributing to the delivery of the data packets to the final destination. The packets which were earlier being delivered are still being delivered and hence there is no much change if average latency value.

5.4 Impact on Average Buffer Time

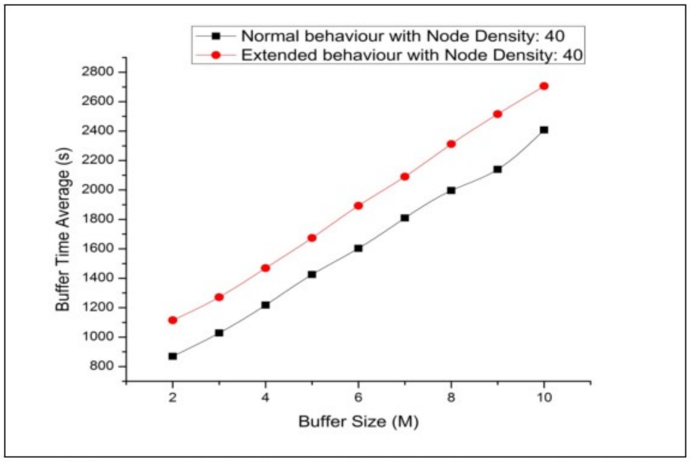

Figure 6: Average Buffer Time of Epidemic Routing Protocol under Normal and proposed Extension with node density of 40 nodes per group

From figure 6 it can be seen that there is improvement of about 28% i.e. packets stays for about 1115 secs compared to 869 secs for normal epidemic routing at 2 M buffer size at 40 nodes per group node density. Similarly, if we see at 10 M buffer size at node density of 30 nodes per group, the average buffer time is improved by 28%.

6. CONCLUSION

In this chapter we have evaluated, analyzed and compared the performance of Epidemic routing protocol with the base configuration and with the proposed extension applied. This comparison is done for having the understanding of the working of this routing protocol and also to investigate the effectiveness of the proposed extension of the epidemic routing protocol. The results given in this work clearly show that the extension applied to the Epidemic routing protocol has significant impact on the performance of the routing protocol and hence it is to be applied in the working environment.

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