

# Analysing impact of range and storage constraints on various routing protocols in Delay Tolerant Networks

To choose the best routing protocol in the context of delivery probability,  
overhead ratio & average latency

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**Abstract**—Delay Tolerant Network (DTN) is special type of wireless mobile ad hoc network characterized by intermittent connectivity, long or variable delay, asymmetric data and high error rates. In this paper we compare some of well-known routing protocols namely MaxProp, Epidemic, SprayAndWait, Prophet and FirstContact. In this paper we have analysed protocols on the basis Transmission Range and Buffer Size of nodes. We examined the behaviour of protocols in two different scenarios firstly with constant transmission range & varying buffer size, second with constant buffer size & varying transmission Range. Simulation results shows that delivery ratio with constant transmission range is almost equal for all routing protocols and delivery ratio with constant buffer size is maximum in MaxProp protocol. Overhead ratio with constant transmission range is almost equal for all routing protocols and overhead ratio with constant buffer size is more in case of epidemic routing protocol. Latency average with constant transmission range is more in MaxProp routing protocol in case of less buffer size and equal in case of more buffer size. Latency average with constant buffer size is maximum in Maxprop protocol.

**Keywords**-MaxProb; SprayAndWait; FirstContact; Epidemic; Overhead; Latency.

## I. INTRODUCTION

Delay Tolerant Network (DTN) is evolved from Mobile ad hoc Network. It is intermittent<sup>1</sup> and sparsely connected because of limited transmission range and mobility. DTN is characterized by intermittent connectivity, long or variable delay, asymmetric data rate and high error rates. DTN uses “Store and Forward” strategy for routing of messages where message is successively moved and stored in the buffer throughout the network in hops that it will finally reach its destination. In these challenging environments the traditional ad-hoc routing protocols such as Ad hoc On-Demand Distance Vector<sup>8</sup> (AODV) or Dynamic Source Routing<sup>7</sup> (DSR) do not work well in DTN because they require fully connected path between source and destination for communication to be possible.

The rest of paper is organized as follows. Section 2, reviews routing in DTN and presents routing protocols in DTN. Section

3 describes simulation setup and performance metrics. Section 4 comprises of the simulation results to analyze the routing protocols.

## II. ROUTING PROTOCOLS IN DTN

The routing protocols in Delay Tolerant Networks (DTN) are classified into two categories based on the property used to find the destination:

- Flooding families, and
- Forwarding families

To find the estimation, two different approaches of replication & knowledge are used. The replication is used in the flooding strategy & there are many algorithms to manage multiple copies of message & to make those copies, while the knowledge is used in forwarding strategy.

### A. Flooding families:

In flooding families, each node has a number of copies of each message & transmits them to a set of nodes (sometime called relays). All the relays maintain the copies and store them in their buffer space until they connect with the next nodes. Using the message replication can increase the probability of message delivery. The basic protocols in this family do not want any information about network. However if some knowledge about network is referred to as an additional routing metric, the flooding strategy can be significantly improved.

- **Epidemic Routing**

In Epidemic routing<sup>2</sup>, every node continuously replicates messages to newly arrived nodes that do not already have the message copy but stops if predefined hop count's maximum value is reached. Epidemic routing protocol provides guaranteed transmission of message irrespective of delivery delay.

The protocol simply replicates messages to all encountered nodes but stops if predefined hop count's maximum value is reached. Overhead gets high due to more utilization of buffer space but delivery probability gives good value.

- **Spray and Wait**  
Spray and Wait<sup>3</sup> combines the speed of epidemic routing with the simplicity and speed of direct transmission. It initially spreads message copies in a manner similar to epidemic routing. When enough copies have been spread to guarantee that at least one of them will find the destination quickly (with high probability), it stops and lets each node carrying a copy perform direct transmission.

It consists of two phases spray phase and wait phase. In the spray phase the source node initially spray L number of message copies to L distinct relay nodes. After receiving the message copy all L relay nodes go into the wait phase and wait till the direct transmission to the destination.

- **MaxProp**  
In MaxProp<sup>4</sup> protocol maximum probability of message to be delivered is calculated and packets in buffer are prioritized. Lower the hop count value, higher is the probability set and if hop count value exceeds the threshold value then priority of packet is determined by calculating the probability of nodes meeting. MaxProp has poor performance when nodes have small buffer sizes because of the adaptive threshold calculation while its performance is better with large buffer size.

#### B. Forwarding families

In the forwarding families, the network topology information is used to select the best path and the message is then forwarded from node to node along with the path. These routing protocols require some knowledge about network.

- **Prophet**  
In PROPHET if a node has visited a location several time then there is a possibility that this pattern will repeated in the future. In PROPHET every node uses probabilistic metric called delivery predictability to transfer messages to a reliable node. It is seen that the delivery rate of PROPHET and Spray-And-Wait are close to a single-hop direct delivery method.
- **First Contact Routing**  
In this strategy, source node along with relay nodes which at the first instance come in contact with source node work in a manner to increase message delivery probability to the destination. Also it increases the bandwidth and storage consumption.

### III. SIMULATION SETUP

The above mentioned protocols performance were analysed through simulation using the Opportunistic Network

Environment (ONE)<sup>5</sup> Simulator. The main functionality of the ONE consists of modelling of node movement, inter-node contacts using routing and message handling.

#### A. Simulation Parameters

The Table 1 summarizes the simulation configuration used for the current analysis.

#### B. Performance Metrics

The following are the performance metrics used for the analysis:

- **Overhead Ratio:** This metric is used to estimate the extra number of packets needed by the routing protocol for actual delivery of the data packets.
- **Delivery Probability<sup>6</sup>:** It is the fraction of generated messages that are correctly delivered to the final destination within a given time period
- **Average Latency:** It is the measure of average time between messages is generated and when it is received by the destination.

TABLE I: SIMULATION PARAMETERS

Total Simulation Time	69.44 Hours
Node Buffer Size	10M, 50M, 100M
No of Nodes	15
Interface transmit Speed	250k
Interface Transmit Range	10m, 25m, 50m
Message Creation Rate	One message per 25-35 sec
Message Size	500 KB to 1 MB

### IV. RESULTS AND DISCUSSION.

In the simulated environment, we have focused on comparing the performance with regard to the metrics defined above. The results presented here are obtained by running the simulations as per the parameters defined in Table 1.

#### A. Delivery Probability

- Constant Range

From figure 1, it is evident that all the five routing protocols gives the same results when the Buffer Size is varied, while keeping the Range as constant.

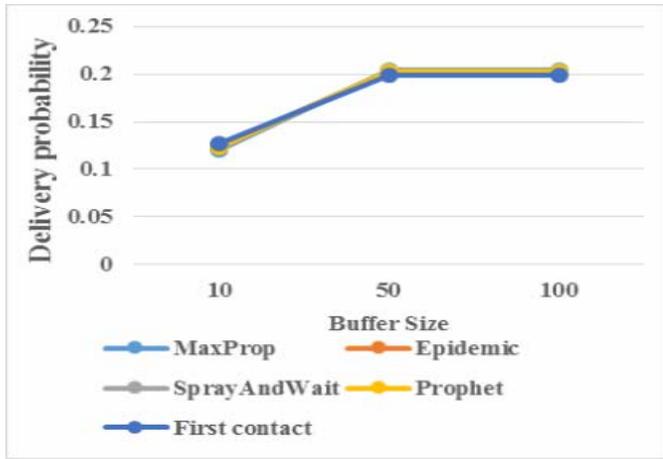


Figure1: Delivery probability of protocols with constant Range and varying buffer size.

- Constant buffer size

While keeping the buffer size constant and varying the range, the delivery probability of a MaxProp router is maximum among the rest of the routing protocols. The delivery probability of MaxProp Router is 0.5775 at 100 m range as compared to 0.3662, 0.4783, 0.4290, 0.3755 of Epidemic, SprayAndWait and Prophet router's respectively in Figure 2.

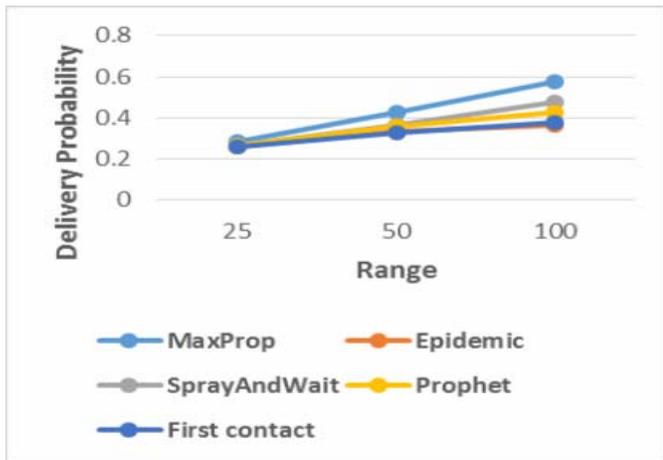


Figure2: Delivery probability of protocols with constant buffer size and varying range.

### B. Overhead Ratio

- Constant Range

From Figure 3, it can be seen that all the protocols show nearly the same results with varying buffer size. At 10 M buffer space the FirstContact routing protocol has the minimum overhead ratio of 1.1881 as compared to 1.4031 of MaxProp. As the buffer size increases, the results are approximately the same for all the protocols.

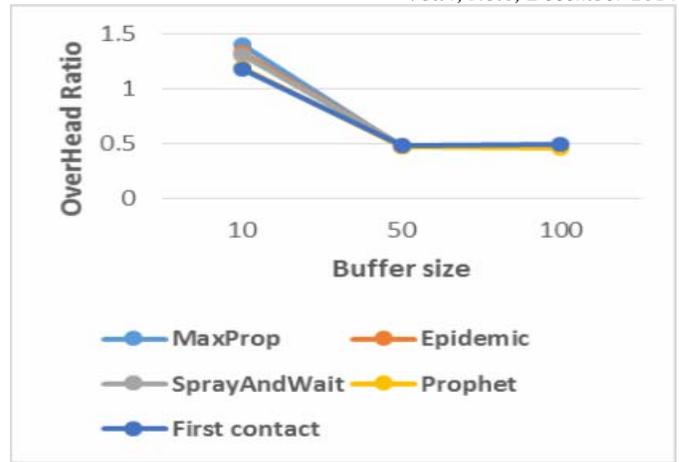


Figure3: Overhead ratio of protocols with constant range and varying buffer size.

- Constant Buffer Size

As in Figure 4, the transmit range of the routers increases, Epidemic routing protocol suffers more overhead whereas MaxProp and SprayAndWait has the least overhead ratio.

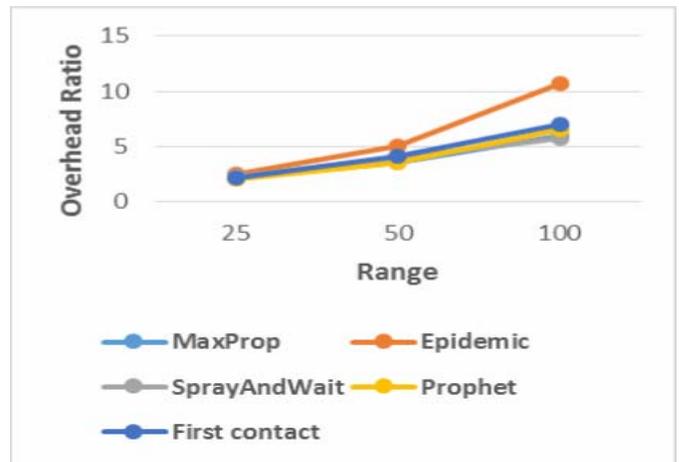


Figure4: Overhead ratio of protocols with constant buffer size and varying range.

### C. Average Latency

- Constant Range

From figure 5, the average latency of all the routing protocols is approximately the same for buffer size greater than 50. At a buffer size of 10 M, MaxProp protocol has the highest average latency than rest of the other protocols.

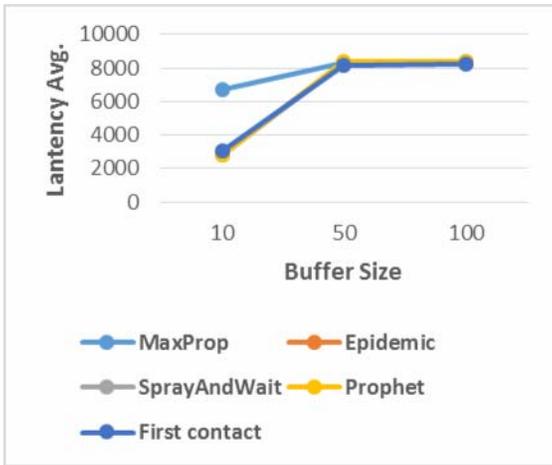


Figure5: Average Latency of protocols with constant range and varying buffer size.

- Constant buffer size

From the figure 6, it can be seen that as the range of a router increases the associated average latency decreases in all the routing protocols. Of all the cases, MaxProp has the highest average latency whereas SprayAndWait has the lowest.

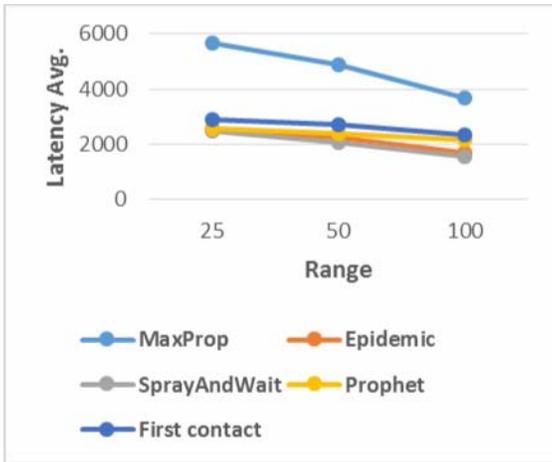


Figure6: Overhead ratio of protocols with constant buffer size and varying range.

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