Performance Evaluation of Flooding based Delay Tolerant Routing Protocols

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ABSTRACT
Delay tolerant Network is of great interest during these days. Like adhoc network, there is no route setup and maintenance phase and hence routing is an issue of greatest interest for opportunistic network called Delay Tolerant Network. The majority of routing schemes that have been proposed earlier are broadly classified as flooding and forwarding strategies. In this paper, we try to evaluate the performance of the most prominent routing protocols design for Delay Tolerant Networks viz. Direct Contact, Epidemic, First Contact. These strategies called delay tolerant routing protocols are configured for map based model on city traffic environment by considering local route map on which we are daily travelling for our college work. After study and simulations of these protocols, it is proved that by considering unlimited storage place and bandwidth, the Epidemic routing protocol gives best performance among all flooding based routing strategies under evaluation.

General Terms
Routing Protocol

Keywords
Contact, Routing, Delay Tolerant Network, Flooding, Forwarding, MaNeT.

1. INTRODUCTION
MaNet is the originator of most promising network called Delay Tolerant Network where end to end connectivity is never ensured. This is not in case of MaNeT. MaNet is sparse and intermittently connected mobile adhoc network where reliable communication is not sure for message transmission. DTN uses "Store and Forward" approach of routing. Each node in DTN stores incoming message in the buffer and then delivered it to the other desirable node towards destination during phase called "contact". Intermediate node copies incoming message and work as a relay node in order to increase the probability of message delivery. DTN is called opportunity network as the intermediate node always searches best opportunity to relay a message from source to destination. The probability of message transmission is more in DTN as compared to MANET. MANET uses two phase approach to deliver data. First phase is used for route setup from source to destination and second phase is used to transmit message and maintain route information till data transmission is over. This is not possible in case of DTN where nodes are sparsely deployed in the region and the two or more nodes can exchange message when they come across transmission range of each other during "Contact" phase. The store and forward approach helps to increase message delivery probability in DTN irrespective of time taken to delivered message over normal MaNet [1, 2]. The nodes carry on message transmission as they exist in the transmission range of each other. As soon as they move out of transmission range of each other, communication link breaks. In conventional MaNet, a routing protocol has to establish end-to-end route to complete message transmission. This is not in case of DTN. In DTN, end-to-end path is very rare and unstable in nature and opportunity to establish complete route is negligible. DTN support those applications, whose time requirement is hours or even days or longer. Hence, it is necessary to deliver high priority message during contact phase [3, 4]. This problem of prioritize the message is discussed in literature by many researchers.

Rest of paper is organized as follows: Section 2 gives details of simulation setup and parameters with their values. Section 3 exposes major routing protocol based on flooding strategies viz. Direct Delivery, First Contact and Epidemic along with their simulations. At the end conclusion is given in section IV.

2. SIMULATIONS

2.1 Simulation Setup
For simulation purpose, Opportunistic Network Simulator (ONE) is used running on Java 2 platform. Route map between Wardha (District in Maharashtra State, India) to Sevagram (village in Wardha District) is considered by configuring working day model for different groups as shown in Figure 1.

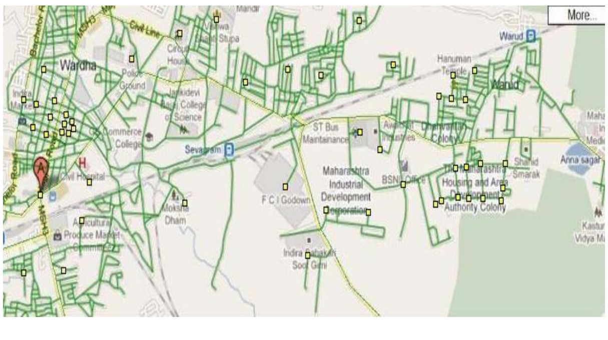

Figure 1: Route map, Wardha to Sevagram.

2.2 Simulation Parameters

Following are the different simulation parameters used for simulation of all the flooding based routing protocols. These parameters are kept constant for all the protocols under consideration.

i. Simulation Time = 10000 ms
ii. Number of host groups = 8
iii. officeWaitTimeParetoCoeff (parameter controlling pause time inside office) = 0.5
iv. workDayLength (parameter defining working day length) = 28000 s
v. timeDiffSTD (parameter controlling differences in schedules nodes have) = 20
vi. Transmit Speed = 250 kbps
vii. Transmit Range = 10 Meter
viii. Buffer Size = 5 Messages
ix. Message TTL = 300 Minutes

3. PERFORMANCE EVALUATION OF FLOODING BASED ROUTING STRATEGIES

Following are the flooding based routing strategies found in the literature.

3.1 Direct Delivery Routing

The simplest way of relaying message from source to destination in DTN is to transmit messages immediately as soon as nodes called source and destination come in contact with each other directly. This can be possible if these nodes are located in the circle of one hop radius. The simplicity lies in the technique of direct delivery because node called source can deliver it's own message. This strategy waits until the node called source comes in contact with the node called destination before forwarding any message. This is the degenerate case of the flooding family, where the set of nodes called relay nodes contains only the destination. This technique always selects the direct path between the source and the destination. Direct delivery routing strategy does not require any information about the network. Due to its simplicity, it does not consume many resources, and it uses exactly one message transmission. However, it only works if the source node comes in contact with the destination node. The message statistics, we get after simulations is tabulated in Table 1.

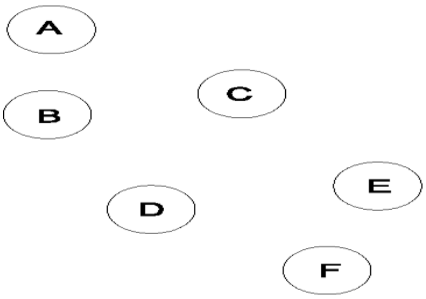

Figure 2: Routing Using Direct Delivery

Using above message statistics given in Table 1, we plot the graph of message delay (in ms) vs. message sequence number as shown in Figure 3.

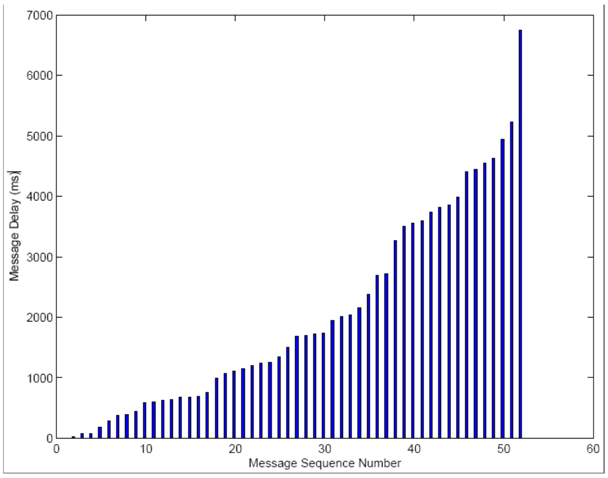

Figure 3: Message Delay in Direct Delivery Routing

Table 1: Message Statistics, DD Routing

Sr. No.	Name of Parameter	Values
1	Messages Created	340
2	Messages Started	74
3	Messages Relayed	52
4	Messages Aborted	22
5	Messages Dropped	19
6	Messages Removed	00
7	Messages Delivered	52
8	Message Delivery Probability	0.1529
9	Overhead Ratio	0.0000
10	Latency Average	2021.1385
11	Hopcount Average	1.000
12	Buffertime Average	5817.8211

Also, the graph as shown in Figure 4 showing cumulative probability values are plotted for all the 52 messages which are relayed using Direct Delivery routing strategy.

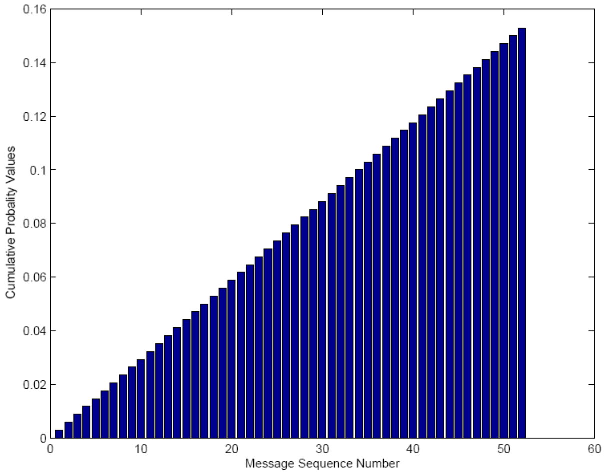

Figure 4: Cumulative Delay in Direct Delivery Routing

We plot the graph of message delivery vs. message created for the map based model described earlier as shown in Figure 5 . Total number of messages created during the simulation is 340 out of which only 52 messages were relayed i.e. delivered to final destination.

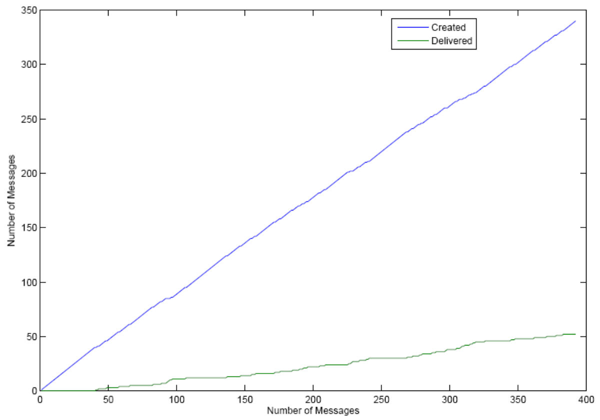

Figure 5: Message Created vs. Delivered in Direct Delivery Routing

3.2 First Contact Routing

In this strategy, source node along with the nodes called relay nodes which at the first instance come in contact with source node work in cooperative manner to increase message delivery probability to successfully deliver the message to the destination. This approach increases the message delivery probability. Also it increases the bandwidth and storage consumption. This strategy has same fundamental advantages and limitations as direct transmission. This approach was studied as routing strategy for sensor network [9] and for sensors with proactive mobility [10, 11]. In this strategy, the node called source node copies the message to be relayed to the first N number of nodes which comes in contact with it. Nodes, called source and the relays hold the message and deliver it to the destination as it comes in the transmission range of first N nodes. The Simulation setup is used as described earlier. The message statistics, we got after simulations is tabulated in Table 2.

Table 2: Message Statistic, First Contact Routing

Sr. No.	Name of Parameter	Values
1	Messages Created	340
2	Messages Started	3344
3	Messages Relayed	2936
4	Messages Aborted	406
5	Messages Dropped	75
6	Messages Removed	2936
7	Messages Delivered	41
8	Message Delivery Probability	0.1206
9	Overhead Ratio	70.6098
10	Latency Average	2189.6756
11	Hopcount Average	9.6585
12	Buffertime Average	327.6891

Using above message statistic given in Table 2, we plot the graph of message delay (ms) vs. message sequence number as shown in Figure 6.

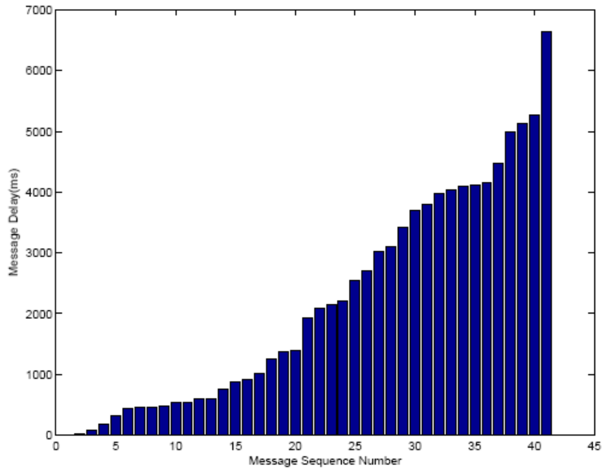

Figure 6: Message Delay in First Contact Routing.

Also, the graph as shown in Figure 7 showing cumulative probability values are plotted for all the 41 messages which are relayed using First Contact routing strategy.

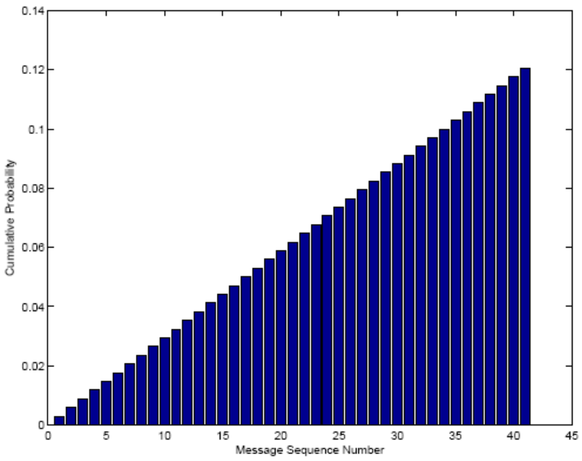

Figure 7: Cumulative Delay in First Contact Routing

We plot the graph of message delivery vs. message created for the map based model described earlier as shown in Figure 8. Total number of messages created during the simulation is 340 out of which only 41 messages were relayed i.e. delivered to final destination.

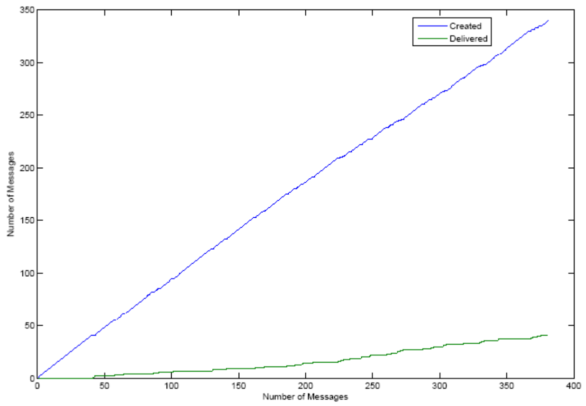

Figure 8: Message Created vs. Delivered in First Contact Routing

3.3 Epidemic Routing

Epidemic routing is an early sparse network routing protocol proposed for DTN [12]. It assumes that each node has unlimited storage space and bandwidth [13]. Epidemic routing strategy guarantees that it can provide a sufficient number of random exchanges of messages in order to deliver messages to ultimate destination. This means that the node called destination is guaranteed to receive the messages anyhow. Therefore every node can store all the messages transmitted during contact phase. This use the concept of database replication. Also, a relay node can exchange the entire message during contact phase. Each node maintains list of messages in the database called summary vector. This vector is exchanged first and then only those messages are exchanged that are absent in the other's summary vector. This epidemic strategy is practically possible In case of very sparse network and small size message. Epidemic routing is very simple and so it is proposed to work when no better method is available. Main problem with epidemic strategy is that the message continues to propagate even the message is successfully delivered to the destination. Many researcher works on epidemic routing strategy to consume fewer resources. As soon as, the message is sent by the source node, it is inserted in the local buffer which can be ordered by their message ID which is unique in nature. When two nodes comes in transmission range of each other, they exchange their message vector called summary vector containing list of message IDs they have in their own buffer. Then they will decide to place new messages which are not in the respective summary vector of nodes contacting each other. The limitations of this technique are that it has to perform large number of redundant work, since all nodes in the network will receive each and every message. This will adversely affect the buffer utilization. But it increases the probability of message transfer during network failure also. In addition to this it will minimize the amount of time required to deliver the message successfully.

We simulate the Epidemic routing strategy in Delay Tolerant Network using ONE Simulator. The Simulation setup is kept constant as described earlier. The parameters under consideration viz. message delivery ratio, message dropped ratio and cumulative probability [14, 15]. The message statistics, we got after simulations is tabulated in Table 3.

Table 3: Message Statistics, Epidemic

Sr. No.	Name of Parameter	Values
1	Messages Created	340
2	Messages Started	17270
3	Messages Relayed	16284
4	Messages Aborted	982
5	Messages Dropped	13915
6	Messages Removed	0
7	Messages Delivered	105
8	Message Delivery Probability	0.3088
9	Overhead Ratio	154.0857
10	Latency Average	2278.0762
11	Hopcount Average	3.1619
12	Buffertime Average	826.7152

Using above message statistic given in Table 3, we plot the graph of message delay (ms) vs. message sequence number as shown in Figure 9.

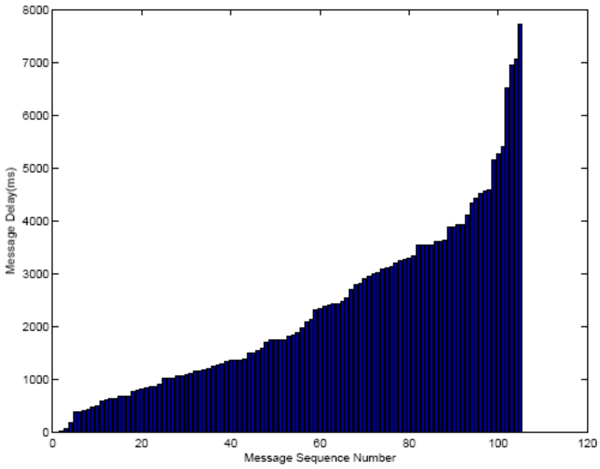

Figure 9: Message Delay in Epidemic Routing

Also, the graph as shown in Figure 10, showing cumulative probability values are plotted for all the 105 messages which are relayed using Epidemic routing strategy.

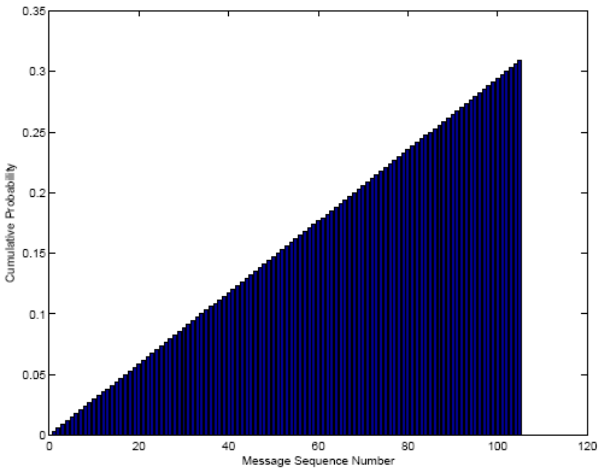

Figure 10: Cumulative Probability in Epidemic Routing

We plot the graph of message delivery vs. message created for the map based model described earlier as shown in Figure 11. Total number of messages created during the simulation is 340 out of which only 105 messages were relayed i.e. delivered to final destination.

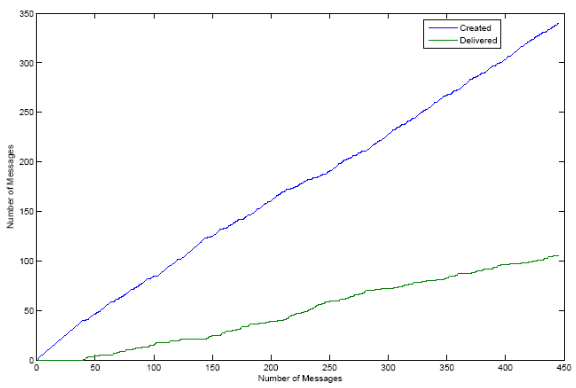

Figure 11: Message Created Vs. Delivered in Epidemic Routing

4. CONCLUSIONS

In this paper, we try to evaluate the performance of Delay Tolerant Routing Protocol based on flooding category viz. Direct Delivery, First Contact and Epidemic. Different parameters were examined for evaluation of these protocols. The flooding based protocol creates more traffic due to the inhabitant nature of flooding based protocols. If we observe the message delivery statistic for all the above three routing strategies under consideration, the message delivery ratio is more in epidemic as compared to other two protocols. Total 105 messages were delivered in Epidemic Routing and 52 messages were delivered in Direct Contact routing wereas 41 messages were delivered in First contact routing out of total 340 messages in all three routing protocols under consideration. Thus, the conclusion is that by considering unlimited storage space to store incoming messages and bandwidth, the performance of Epidemic routing protocol gives outstanding and significant results over other two routing protocols under consideration.

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