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ANALYSIS AND COMPARATIVE STUDY OF FLOODING AND FORWARDING ROUTING PROTOCOLS IN DELAY TOLERANT NETWORKS

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Abstract: Recent wireless communication observe conditions where there is intermittent path between source and destination, so delay tolerant networks work in that situations. TCP/IP protocols do not work in such networks. Researchers have developed various routing protocols for this network. In this paper routing protocols have been discussed. Comparison of Delivery probability, Overhead ratio of DTNs routing protocols such as Epidemic, Prophet, Spray and wait by varying TTL, buffer and movements models has been presented using ONE simulator.

Keywords: Delay tolerant networks, Epidemic, Prophet, Spray and wait, Delivery probability, Overhead ratio.

1. INTRODUCTION

Conventionally the data networks are supposed to be bidirectional supporting symmetric data rates with little chances of error and delay. However, these suppositions may not hold in some unwanted situations like military war-fares, major explosions, natural disasters etc. These situations causes unreliable path, delay and consume more energy in the network. It remained subject matter of the researchers to find out some solution and they came out with Delay Tolerant Networks (DTN) Technology. In DTN two nodes can exchange data when they come into the contact with each other and for this it uses store-carry-forward techniques. DTN is having characteristic of accommodation even in discontinuous path, high error rates, excessive network resource utilization and long & unwanted delay [1]. Because of these peculiar characteristics of DTN, the routing protocols of conventional networks do not fit in the framework of DTN. Thus the researchers' community started focusing on working out the routing strategies particularly for DTN. The routing strategies of DTN, which primarily uses store-carry-forward technique, can be broadly categorized on two criteria namely (a) number of copies (b) on the basis of network knowledge i.e. about future contact opportunities and message generation distribution [4].

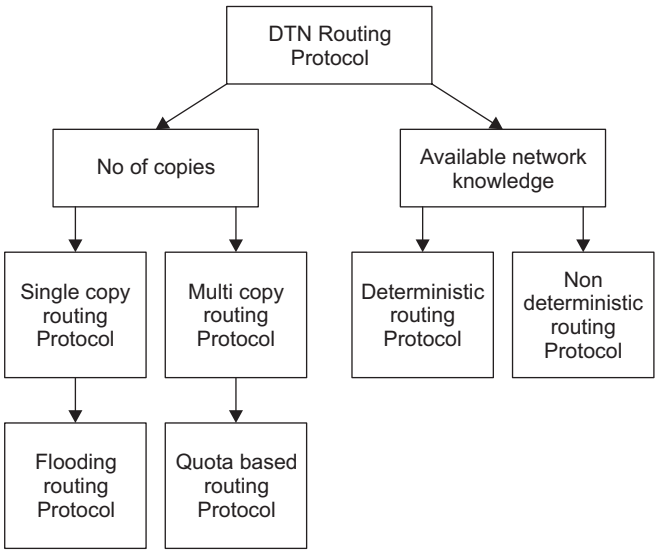


Figure 1: Classification of DTN Routing protocols

Further the various routing protocols of DTN can be classified into sub categories on the basis of: (a) Predicting Good Forwarders (b) Meeting the destinations by schedule, (c) Opportunistically forwarding messages. Routing protocols such as

Prophet[3], Mobispace [7], MV[8], Seek and Focus[10], Context-Aware Routing (CAR)[20], MaxProp [9], RAPID[12] are classified under good forwarder as there routing protocols forward the data packets on the basis of information of history contacts and location of nodes. Based on this information the prediction is made about the best forwarder node for a particular data packet.

Message Ferry (MF) routing protocol falls in Meeting the destinations by schedule category. [5]. Ferries are nodes of Special kind in MF scheme which have capability to change the route to help other nodes to send messages in advance. These nodes have capability of less message overhead and energy consumption.

In the last category i.e. opportunistically forwarding messages the messages are forwarded whenever there is chance/opportunity for doing so. In this scheme the nodes neither try to predict nor uses network knowledge to forward or deliver the data packets. It simply forwards the data packets whenever there is opportunity of doing so. Under this category the routing protocols such as epidemic, PRioritized EPidemic (PREP) falls.

This paper/work is related to the performance evaluation of various routing protocols of DTN namely epidemic, Prophet, spray and wait under varying TTL, buffer size and movement model. The section II discusses the previous related work of other researchers in the field of DTN and its routing protocols. Section-III gives the simulation set up and performance evaluation of considered routing protocols under the selected network scenario. Section-IV elaborates the results and present the detailed comparison of the considered routing protocols under the varying parameters detailed above.

2. REVIEW ON ROUTING PROTOCOLS IN DTN

Basic DTN routing protocols depends on node movement only and no other source of information regarding communication set up. Basic DTN routing protocols are "custody transfer" and "epidemic routing".

Epidemic routing[2] protocols for DTN was introduced by Amin Vahdat[2]. This protocol falls in flooding routing protocol category. In this protocol when nodes get chance to send they keep on sending messages until the messages are reached to their destination. Therefore, message delivery probability of epidemic is high but consumption of resources is very high ie the limitation of this protocol. PROPHET [3] is the probabilistic routing algorithm in which the packet is sent by predicting the behavior and history of the node to send the message. So in this protocol resource consumption is less as compared to Epidemic as message is not broadcasted to all nodes.

A new routing scheme called Spray and Wait[11] that "sprays" number of copies and wait till the time any one node finally reaches the destination was proposed. Author shows that this protocol perform better than all other existing protocols in case of delivery of the message and delay. John Burgess proposed MaxProp[9] efficient routing protocol for DTN which chooses the efficient one from the schedule of packets transmitted and the packets to be dropped on priority basis. RAPID[12] a resource allocation protocol for DTN routing was introduced. It formulates the optimization of delivery delay matrices and translation of these parameters for packets utilities. Spray And Focus[18] routing technique in DTN was introduced to reduce the message overhead of flooding schemes like spray and wait. This protocol can work where mobility is slow and correlated in space and time. A DTN protocol SMART[17] uses travelling companions of the destinations to increase the delivery opportunities. Therefore, its delivery ratio is high and delivery latency is low as compared to other flooding type protocols. In 2007, PRioritized EPidemic (PREP)[16] was introduced as the extended version of epidemic for routing in flooding type of networks. It prioritizes packets based on sending costs and expiry time. PREP maintains a pitch of repetition density that decreases with increasing distance from the destination. A researcher further modified the epidemic routing protocol by including immunity based information

scattered in the reverse direction once messages get delivered to their destination and got improvement both in delivery ratio and delay in comparison to existing protocols[15]. Based on literature Comparative analysis of above discussed routing protocols has been done in Table 1.

Table 1
Comparative Analysis of Routing Protocols

	No of Data Packet Copies				*Immunity Based Node Features*	*Chances of Data Delivery*	*Resource Utilization*
	Single	*Limited*	*Controlled*	*Unlimited*			
Flooding Protocols							
Epidemic[2]				Unlimited	No	High	Excessive
Rapid[12]				Unlimited	No	High	Medium
Spray and wait[11]		Limited			No	Medium	Medium
Prioritized Epidemic [16]			Controlled		yes	Medium	Limited
Fuzzy Spray[23]		Limited			No	Medium	Limited
Spray and focus[18]			Controlled		No	Medium	Medium
Forwarding Protocol							
Prophet[3]				Unlimited	No	Medium	Medium
Maxprop[9]				Unlimited	No	Medium	Limited
Fresh (FResher Encounter SearcH)[22]			Controlled		No	Medium	Medium
MV[8]	Single				No	Medium	Limited

3. SIMULATION AND RESULTS

In simulation comparative study of various routing protocols of DTN has been done by varying TTL, buffer size. By changing movement models performance of routing protocols has been also analyzed. By getting the best movement model all the simulation based on TTL and buffer size has been done. We have used ONE (Opportunistic Network Environment) simulator. In our simulation we have assigned simple broadcast type Bluetooth interface. To make our simulation scenario comparable to real time application, to better judge the performance of Epidemic, prophet and SNW routing protocol.

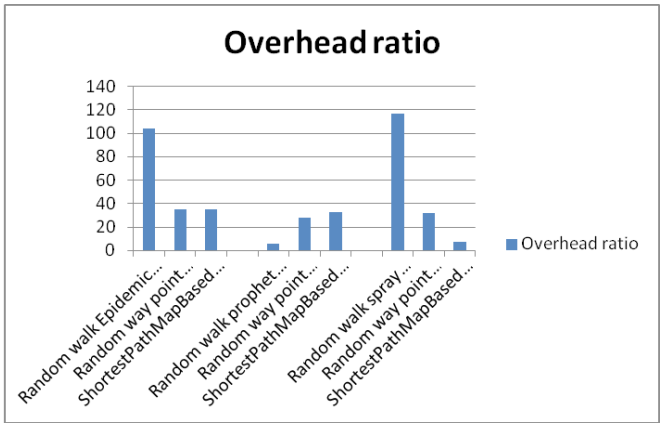
Table 2
Scenario Set Up

Name	*Simulate connection*	*Update Interval*	*End Time*
Default_scenario	True	0.1s	43200s
Interface Specific Setting			
Name	*Type*	*Transmit Speed*	*Transmit Range*
bt Interface	Simple Broadcast Interface	250k	30m
Node Group Specific Settings			
Movement Models	*Router*	*Buffer size (M)*	*Wait Time*	*No. of Interfaces*	*Interface1*	*Speed*	*Msg TTL (Mins)*	*No of Hosts*
Random walk, Random Way point, Shortest Path Map Based Movement	Epidemic; Spray and Wait; Prophet	2, 4, 6, 8, 10, 12, 14, 16, 18, 20	0.120s	1	bt Interface	0.5, 1.5m/s	60, 120, 180, 240, 300	40
Message Creation Parameters								
Event.n rof	*Event 1.class*	*Events 1.interval*	*Event 1.size*	*Events 1.hosts*	*Event 1.prefix*			
1	Message Event Generator	15, 30 s	250k, 2M	0, 39	M			
Movement Model Settings								
Movement Model .rng Seed	*Movement Model world Size*			*Movement Model warmup*				
1	4500,3400 m			1000 s				
Style	Bold and Italic: Category Heading		Bold: Attribute	Italic: Attribute		Attribute which is varied		

1. **TTL:** Lifetime of a packet or data in a network.
2. **Buffer size:** Allocated buffer size to each node.
3. **Movement models:**
   (i) **Shortest Path Map Based Movement:** Find shortest path to reach to destination.
   (ii) **Map Route Movement:** follows predefined routes on map.
   (iii) **Map Based Movement:** Moves nodes to directions that following a map.
   (iv) **Random Walk:** It relays on random speed in random directions.
   (v) **Random Way Point:** Add pause time when assume new destinations.

A. Simulation of Various Routing Protocols with Different Movement Models

Delivery probability and overhead ratio of Epidemic, Prophet and Spray and wait has been compared. From the simulation result it has been analyzed that under random walk movement model overhead ratio of epidemic, spray and wait protocols is highest and delivery probability is lowest. As we know resource consumption is more in epidemic that is why overhead is more. Epidemic is using flooding method to deliver the messages so delivery probability is more. Under shortest path map based delivery probability of epidemic prophet and spray and wait is highest and overhead is lowest. Therefore overall performance of shortest path map based is best. So all other simulations are done by using shortest path map based.



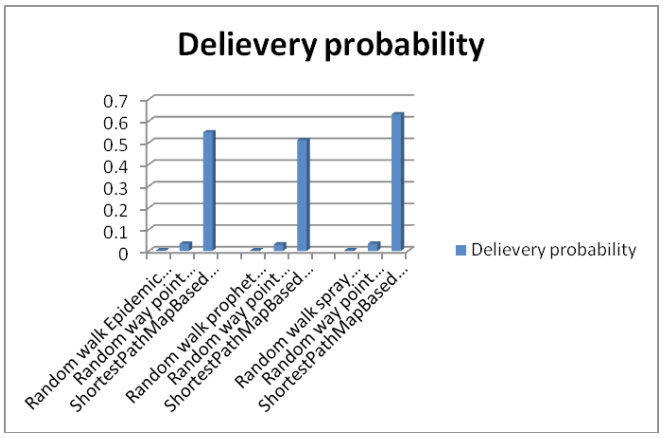


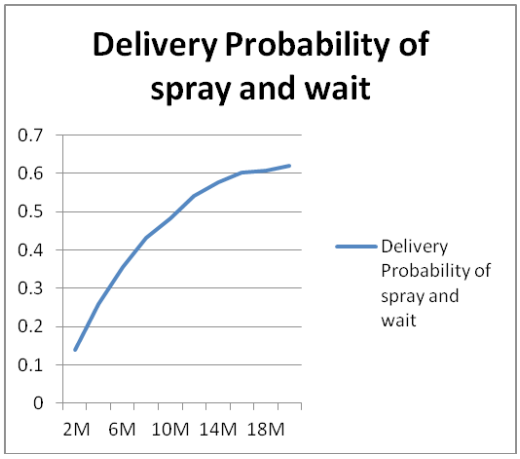
Figure 2: Comparison of routing protocols under movement models based on delivery probability and overhead ratio

B. Simulation of Various Routing Protocols with Different Buffer Size

Delivery probability of epidemic, prophet and spray and wait is analyzed by buffer size 2M, 4M, 6M, 8M, 10M, 12M, 14M, 16M, 18M, 20M. It has been observed that as the buffer size increases, Capacity of a node to keep messages is increases so delivery probability increases. But as the buffer size increases more and more like 30M 40M 50M then delivery probability becomes constant for all routing protocol.

C. Simulation of Various Routing Protocols with Different TTL

Delivery probability of epidemic, prophet and spray and wait is analyzed by TTL 60, 120, 180, 240, 300 minutes. It has been observed that as the TTL increases means life of messages in a network increases then delivery probability increases.



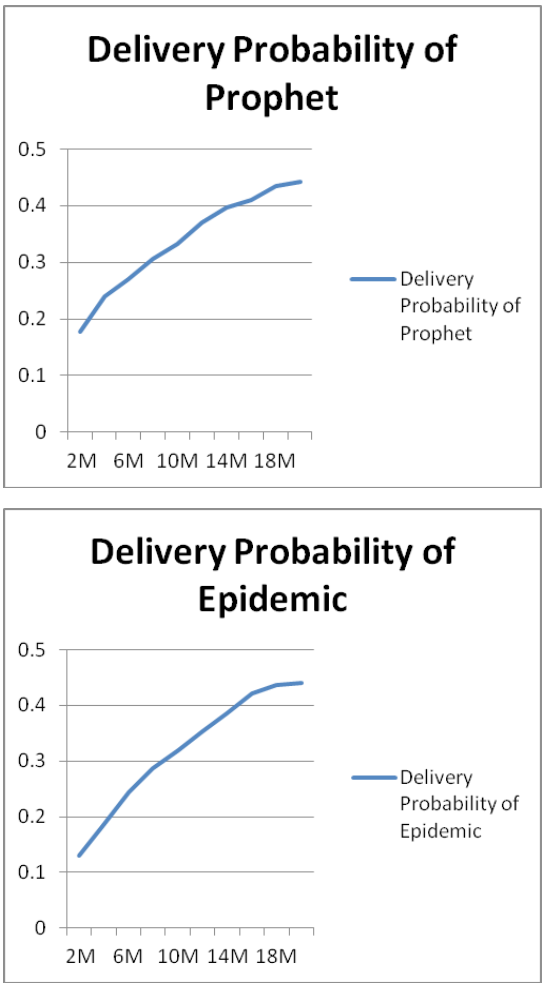
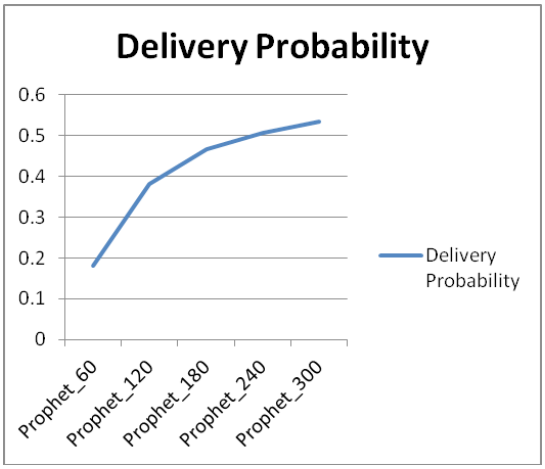


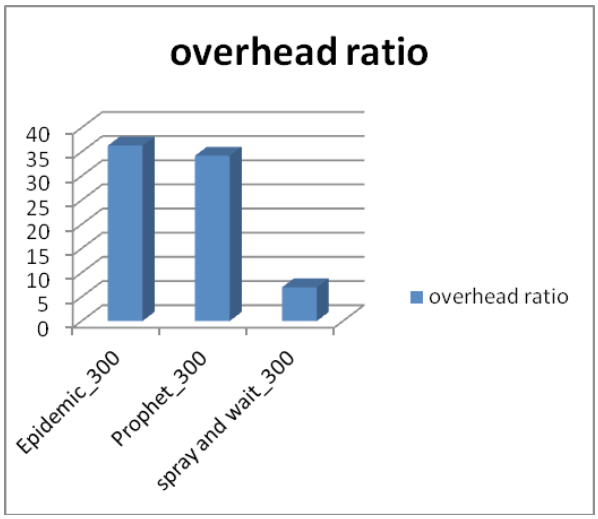
Figure 3: Comparison of routing protocols based on buffer size

Figure 4: Comparison of routing protocols based on TTL

D. Delivery Probability and Overhead Ratio of Epidemic, Prophet and Spray and Wait

Epidemic is flooding type protocol in which message is sent to all possible nodes so resource consumption is more in epidemic that is why overhead is more. But delivery probability is high. In Prophet Message is sent to only those nodes which have high probability to send messages rather than to all.





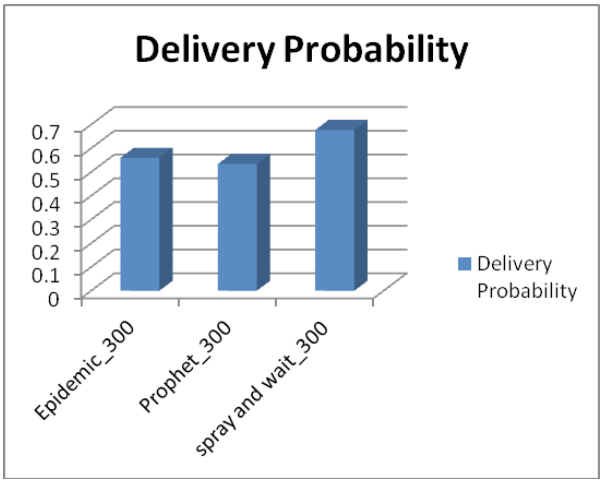


Figure 5: Comparisn of routing protocols based on delivery probability and overhead ratio.

4. CONCLUSION AND FUTURE WORK

In this study, we have examined and analyzed the performance of DTN routing protocols epidemic, Prophet, spray and wait under the varying network parameters. We started our study with varying movement model and found that under the similar network conditions, shortest path map based movement model gives the acceptable performance. Hence if it is not the network demand then under other network condition shortest map based movement model should be used. Further then we analyzed the performance of considered routing protocols under varying buffer size and varying TTL with shortest path map based movement model. We found that at 20 M buffer size and 300 minutes TTL, Various routing protocols gave the highest performance under the considered network conditions. Further in future, we will use these values as a benchmark values for implementing the attacks on these routing protocols under same network conditions to analyze the effect of attacks on the performance of considered DTN routing protocols or on the other protocols.

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