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Performance Analysis of Ferry Based DTN Routing Protocols for Disconnected Network

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Abstract

DTN are the class of networks that deals with technical issues in heterogeneous network where the nodes do not have continuous connections, but intermittent connections. Routing is one of the major problems which must cope up with the frequent change in connectivity, which affects the overall performance of DTN networks. Over the past few years a number of routing protocols have been proposed for DTN networks. In this paper we have investigated the performance of four different routing protocols namely epidemic, Max Prop, Prophet, and Spray and Wait against varying number of nodes and transmission speed. For the simulation, Opportunistic Network Environment (ONE) Simulator is used. The performance is analyzed on four metrics: Delivery Probability, Overhead Ratio, Buffer Time Average and Average Latency. From the simulated results it is analysed that the Spray and Wait routing protocol gives the best performance in the disconnected global village scenario.

Index Terms—Delay tolerant networks, epidemic, prophet, maxprop, spray and wait, opportunistic network, opportunistic network environment (ONE)

Introduction

Delay Tolerant Network is also referred as the Intermittently Connected Mobile Network. One of the major problems in routing messages is the absence of a complete end-to-end path from the source to the destination. When no path exists to connect a source with a destination, network partition is said to occur. Most of the nodes in a DTN are mobile; the connectivity of the network is maintained by nodes only when they come into the transmission ranges of each other. When instantaneous end-to-end paths are difficult or impossible to establish, routing protocols uses "store and forward" approach, where data is moved in an incremental manner and stored throughout the network in hopes that it will eventually reach its destination. If a node has a message to send but it is not connected to another node, it stores the message in its buffer until an appropriate communication chance arises. A communication chance between two nodes is called a contact in DTN. In these challenging environments, widespread ad hoc routing protocols such as Ad hoc On-demand Distance Vector and Dynamic Source Routing fail to establish routes. This is due to these protocols try to establish a complete route and then, forwards the actual data.

In this study we have analyzed the performance of four different DTN routing protocols Epidemic; Prophet; Maxprop; Spray and Wait) by varying number of nodes and transmission speed. These protocols were analyzed on four different parameter metrics namely Delivery Probability, Over Head Ratio, Average Latency and Buffer Time Average. The detailed simulation setup and metrics is given in section 3.

The remainder of paper is organized as follows: section 2 briefly gives the introduction of the DTN routing protocols such as Epidemic, Prophet, MaxProp, and Spray and Wait. Section 3 gives the details of simulator and the simulation setup. Section 4 provides the results. Section 5 describes the conclusion of the paper.

Routing In DTN

Majority of forwarding and routing techniques ([1] and [2]) uses Store-Carry-Forward mechanism to transfer the message to the destination node. A common method used to maximize the delivery probability of a message is by replicating more copies of the message [3] with the hope that one will succeed in reaching its destination. Routing is classified into three types such as forwarding-based, flooding-based and quota-based. Forwarding based protocol uses single copy of a message to be forwarded which uses less network resources and it does not guarantee the delivery of a message. Because of the unpredictability in network and irregularity in network connections, forwarding based protocols are not well suited for DTN.Replication-based protocols allow for greater message delivery rates, since multiple copies exist in the network with the hope that one may succeed in reaching the destination. However, the trade-off here is that these protocols can waste valuable network resources. Quota based protocols keep the number of replicas of a message independent of the network size by setting up an upper limit on the maximum allowable replicas for a message. Use of quota based protocol will reduce the network congestion as messages are not flooded.

A. Epidemic Routing

Epidemic Routing [4] has been proposed as an approach for routing in sparse and /or highly mobile.Epidemic routing is flooding-based in nature, because whenever a new node is encountered, sending node replicates and transmits messages to the encountered node if it does not already have a copy of the message. When the traffic load is very low, epidemic routing experiences low delay with increased use of resources such as bandwidth, buffer space, and transmission power.

A. *Prophet Protocol*
In Prophet [5], each node computes a delivery probability of the message for all the known destinations. Delivery probability is obtained using history ofpast encounters and transitivity rule in which two nodes rarely meet, but there is another node that frequently meets both of these nodes..Each node in Prophet ranks the messages based on the delivery probabilities of the destination node. These ranks are used to make a decision whether to forward or delete the message. Moreover, a node replicates and forwards the message to its neighbour node, only if the neighbour node has higher delivery probability for reaching the destination of the message than the sending node.

B. *MaxProp Protocol*
Max Prop [6] is flooding-based in nature, in that if a new node is encountered, all themes ages not held by the encountered node will attempt to be replicated and transferred. The intelligence of Max Prop comes in determining which messages should be forwarded first and which messages should be dropped first. In essence, Max Prop upholds an ordered-queue depending upon the destination of each message, ordered by the estimated possibility of a future transitive path to that destination.

C. *Spray and Wait Protocol*
Spray and Wait (SNW) [7]routing protocol is Quota based routing protocol which limits the number of replicas of the message. SNW breaks routing into two phases: Spray phase and Wait phase. In the Spray phase, the source node replicates and forwards L copies of message to the first L encountered nodes and enters into wait phase, which waits for delivery confirmation. In the wait phase, all nodes that received a copy of the message wait to meet the destination node directly to deliver data to it. Once the message is delivered to the destination node, confirmation is sent back to the source using the same principle.

Simulation Setup
The above mentioned protocols performance were analysed through simulation using the Opportunistic Network Environment (ONE) Simulator (Keranen et al. 2009) which adds more realism to the simulations. At its core, ONE is an agent-based discrete event simulation engine. To make it suitable and efficient enough for simultaneous movement and routing simulation it uses time slicing approach, so the simulation time is advanced in fixed time steps. The simulations can contain any number of different types of agents, i.e., wireless nodes. The nodes are grouped in node groups and a one group shares a set of common parameters such as message buffer size, radio range and mobility model. Since different groups have different configurations e.g., creating a simulation with pedestrians, cars and public transportation is possible. All movement models, report modules, routing algorithms and event generators are dynamically loaded into the simulator with different types of plug-in is made easy for users and developers. Creating a new class and defining its name in the configuration file is usually enough. Result collection and analysis are done through visualization, reports and post-processing tools. The elements and their

interactions are shown in Figure 1.Here, a global village scenario is considered which consist of three villages in which ferry nodes are used to establish communication between villages. To advocate the performance of the Epidemic, Prophet, Max Prop, and Spray and Wait routing protocol, the simulation is executed for 150 seconds for each routing protocols separately for a global village scenario. By varying number of nodes and transmission speed of nodes, performance of each routing protocol is analyzed in terms of delivery probability, max prop, prophet, and spray and wait. A detailed description of the ONE simulator is available in [8] and the ONE simulator project page [9] where the source code is also available.

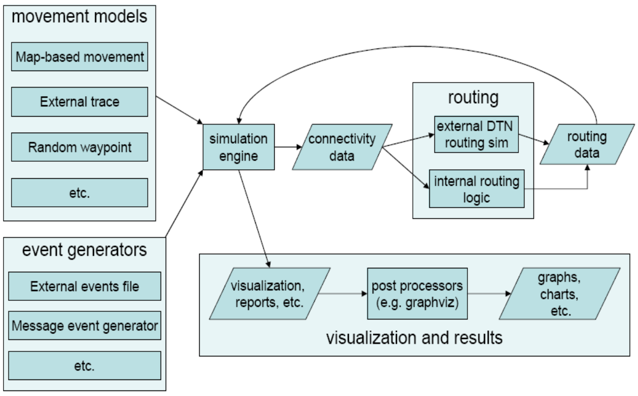

Figure 1: Overview of ONE simulator

A. Simulation Parameters

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

Table 1: Simulation Parameters

Parameter	Value
Simulation Time	150 s
Simulation Area	5400 X 5500 m
Routing Protocol	Epidemic; Max Prop; Prophet; Spray and Wait
Movement model	Random waypoint
Buffer size	50 – 250M
Number of nodes	30, 60, 90, 120, 150
Transmission range	50 – 100 m
Transmit speed	0.1 – 10 m/s
Message size	500 KB – 1MB
Message creation rate	One message per 25 – 35 sec

B. Performance Metrics

The metrics used for the performance analysis are as follows:

a) Delivery Ratio: It is the fraction of number of messages delivered from the number of messages generated. It is defined as

$$\frac{Number\ of\ messages\ delivered}{Number\ of\ messages\ generated}$$

b) *Over Head Ratio*: It is the average number of replicas per messages needed by the routing protocol to deliver the message to the destination. It is defined as

$$\frac{Number\ of\ messages\ relayed\ - Number\ of\ messages\ Delivered}{Number\ of\ messages\ generated}$$

c) *Average Latency*: It is the measure of average timebetween the creation and delivery of the messages to the destination. It is defined as

Delivery time – Creation time

d) *Buffer Time Average*:It is the average time spends by all the messages in the buffer of a node.

Results and Discussion

The simulated environment is focused on the performance comparison of various routing protocols with respect to parameter metrics. The results presented here are obtained by running the simulations as per the parameters defined in Table 1.

1) Varying Number Of Nodes

A. Delivery Probability

From Fig 2, it is evident that the delivery probability of Spray and Wait routing protocol in the global village scenario is high as compared to the delivery probability of Epidemic, Max prop and Prophet routing protocol. The delivery probability of spray and wait routing protocol is 20% higher than other routing protocols which increases gradually with increase in number of nodes (from 30 to 150 nodes).

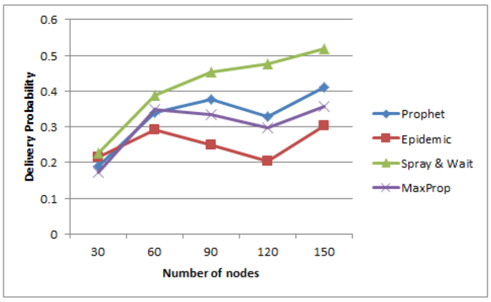

Figure 2: Delivery probability Vs. Number of nodes

B. Overhead Ratio

Overhead ratio of Spray and Wait routing protocol decreases(Fig 3.), whereas the overhead ratio of Prophet, Max Prop and Epidemic routing protocol increases as the number of nodes increases. In the complete scenario, the overhead ratio of Spray and

Wait routing protocol is approximately 75% less than the Prophet, Max Prop and Epidemic routing protocols.

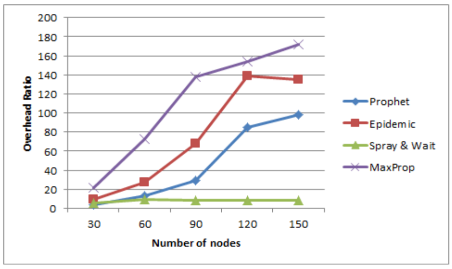

Figure 3: Overhead ratio Vs. Number of nodes

C. Average Latency

From the Fig 4., it is evident that the average latency of Spray and Wait routing protocol is lower than the Prophet and Max Prop whereas higher than Epidemic. Epidemic routing has lower latency when compared to other routing protocols since it floods the messages to all the encountered nodes and delivers it to the destination with lower end-to-end delay.

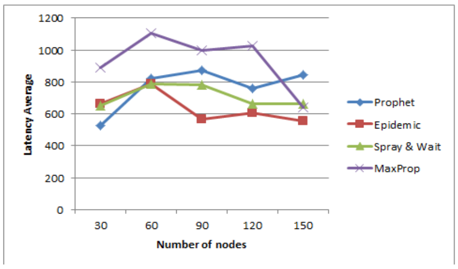

Figure 4: Average latency Vs. Number of nodes

D. Buffer Time Average

From the Fig. 5 buffer time average of spray and wait routing protocol is 40% higher than other routing protocols since the drop rate is lower, amount of time spent by a packet in the buffer is longer.

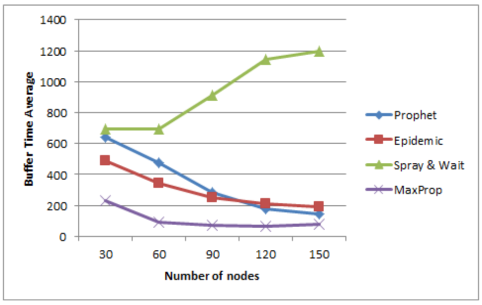

Figure 5: Buffer time average Vs. Number of nodes

2) Varying Transmission Speed

A. Delivery Probability

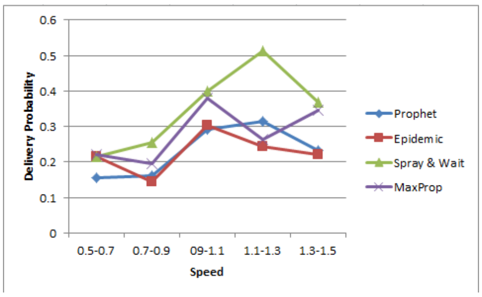

Figure 6: Delivery probability Vs. Transmission speed

From Fig 6, it is evident that the delivery probability of Spray and Wait routing protocol in the global village scenario is high as compared to the delivery probability of Epidemic, Max Prop and Prophet routing protocol. As the transmit speed increases, delivery probability of Spray and Wait increases and it is 10% higher than other routing protocols.

B. Overhead Ratio

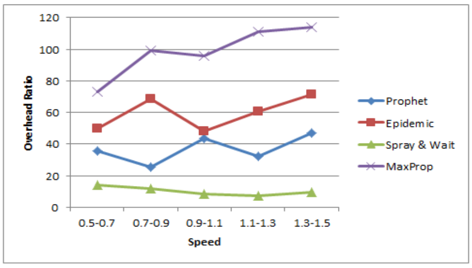

Figure 7: Overhead ratio Vs. Transmission speed

Overhead ratio of Spray and Wait routing protocol decreases gradually as the transmission speed increases (Fig 7.), whereas the overhead ratio of Prophet, Max Prop and Epidemic routing protocols increases as the transmission speed is increased. Overhead ratio of Spray and Wait routing protocol is 20% less than Prophet, 10% less than Epidemic and 40% less than Max Prop. Since Spray and Wait limits the number of replicas of the message, overhead ratio is lower compared to other routing protocols.

C. Average Latency

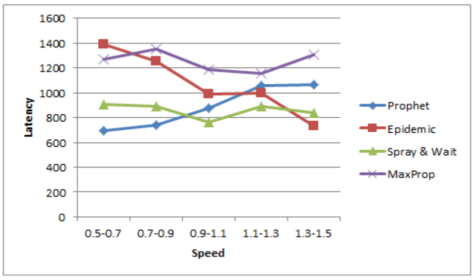

Figure 8: Average latency Vs. Transmission speed

Average latency of Spray and wait is lower whereas Prophet and MaxProp increases as the transmit speed varies. Latency of Epidemic routing protocol decreases as the transmission speed increases as shown in fig 8, since it replicates and forwards the messages to all the encountered nodes. But Spray and Wait provides the constant variation as the transmit speed increases.

D. Buffer Time Average

Fig 9 shows that buffer time average of spray and wait routing protocol is 40% higher than other routing protocols since the drop rate is lower, amount of time spent by a packet in the buffer is longer as the transmission speed increases.

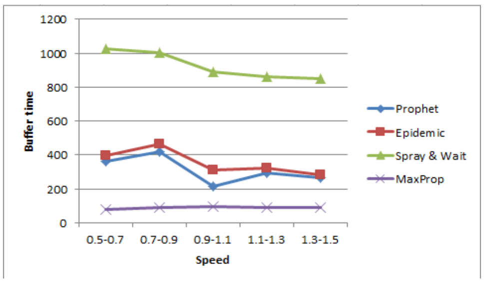

Figure 9: Buffer time average Vs. Transmission speed

Conclusion

In this paper, the performance of four DTN routing protocols (Epidemic; Prophet; Max Prop and Spray and Wait) is compared by varying number of nodes and transmission speed for a global village scenario. The result shows that the Spray and Wait routing protocol gives best results for the parameters such as delivery probability, overhead ratio and Buffer Time Average under the global village scenario. The Average Latency experienced by Spray and Wait is average due to limited number of replicas present in the network since it waits for some duration before forwarding the other replicas of messages to the network until the conformation of delivery of the message to the destination is obtained. In future, comparison of various routing protocols can be performed for different scenario.

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