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Performance Evaluation of Delay Tolerant Networks Routing Protocols under varying Time to Live

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Abstract: To analysis the performance of routing protocols Delay Tolerant Networks (DTNs) play important role to considerate the design of DTNs. With the help of performance analysis we can find out the optimized routing protocol for the application or the system under control. During routing these protocols use their own knowledge to make routing decision and number of copies forwarding in the network scenario. In this paper we analysis the impact of Time to Live (TTL) to different DTNs routing protocols like Epidemic, Spray and Wait (SaW), Probabilistic Routing Protocol using History of Encounters and Transitivity (Prophet). The first two routing protocols do not require any knowledge about the network. The latter one protocol uses some extra information to make decisions on forwarding. As the results illustrated in graphs show that the delivery ratio steadily increased with the increasing TTL in the case of SaW routing protocol. . Simulation results also show that 20%-25% L copies of the total number of nodes in the network gives better delivery ratio and less overhead with minimum average delay in SaW.

Keywords: Delay tolerant networks, epidemic, prophet, spray and wait, opportunistic network environment (ONE).

I. INTRODUCTION

A Delay Tolerant Networks (DTNs) is a sparse dynamic wireless network where mobile nodes work on ad hoc mode and forward data opportunistically upon contacts [1], [2]. Since the DTN is sparse and nodes in the network are dynamic, the irregular connectivity makes it difficult to assurance an end-to-end path between any nodes pair to transfer data and long round trip delays make it impossible to provide timely acknowledgements and retransmissions [16]. The communication of nodes can only be made possible when they are in the communication range of each other. When a node has a copy of message, it will store the message in the buffer throughout the network in hops until forwarding the message to a node in the communication range which is more appropriate for the message delivery. In these challenging environments the traditional ad-hoc routing protocols such as Ad hoc On Demand Distance Vector (AODV) [3] or Dynamic Source Routing (DSR) [4] do not work well in DTN because they require fully connected path between source and destination for communication to be possible. DTNs allow people to communicate without network infrastructure; they are widely used in battlefield, wildlife tracking, and vehicular communication etc. where setting up network infrastructure is almost impossible and costly [5]. In recent years, with the propagation of social network applications and mobile devices, people tend to share texts, photos and videos with others via mobile devices in DTNs.

In this paper we have analyzed the effect of TTL on different DTN routing protocols (Epidemic, Spray and Wait (SaW), Probabilistic Routing Protocol using History of Encounters and Transitivity (Prophet)). These protocols were analyzed on three different metrics namely Delivery Probability, Average Latency and Overhead Ratio. The performance metrics is given in section III. The remainder of paper is organized as follows: section II briefly gives the introduction of the DTN routing protocols. Section IV gives the details of simulator and section V gives the simulation setup used to carry out the work. Section VI discusses the results. Section VII concludes the paper and lists the directions for future work.

II. ROUTING PROTOCOLS IN DTN

The DTN routing protocols taxonomy is based on whether or not a protocol creates replicas of messages. The routing protocols that never replicate a message are considered as forwarding-based routing whereas the protocols that do replicate messages are considered as replication-based routing [6]. There are both advantages and disadvantages of each type of the routing protocols. Forwarding-based schemes cost generally much less network resources as only a single copy of a message exists in the storage in the network at any given time [7]. The protocols which generate just single copy [8] (e.g., First Contact [9], Direct Transmission/Delivery [8]), Furthermore, when the destination has received the message, no other node can have a copy of it. It can eliminate the need for the destination to provide feedback to the network for indicating the outstanding copies can be deleted. Unfortunately, forwarding-based approaches cannot ensure sufficient message delivery rates in many DTNs [10]. Replication-based schemes, on the other hand, are able to have greater message delivery rates [1], because multiple copies exist in the network while only one copy will reach the destination. However, the tradeoff is that these protocols will consume large valuable network resources. Furthermore, many flooding-based protocols are inherently not scalable. Some protocols, such as SaW [10], attempt to compromise by limiting the number of possible replicas of a transmitted message.

A. Replication-based Routing

Epidemic routing [11] isflood ing based in nature, as nodes continuously replicate and transmit messages to newly discovered contacts that do not already possess a copy of the message. In the simplest case, epidemic routing is flooding. However, more sophisticated techniques can be used to limit the number of message transfers. Epidemic routing has its roots in ensuring distributed databases remain synchronized. And other techniques such as rumor mongering can be directly applied to routing.

Burgess et al. [10] presented SaW; an n-copy routing protocol with two phases of SaW routing protocol: the spray phase and wait phase. In the spray phase when new message is created at the source node, n copies of that message are initially spread by the source and possibly received by other nodes. In wait phase, every node containing a copy of message and simply holds that particular message until the destination is encountered directly. There are two versions of SaW: normal mode, a node gives one copy of the message to each node encountered that does not have same copy. In Spray and Wait Binary mode (SaWBinary), half of the n copies to the first node encountered and that node transmits half of the copies to the one it encounters first this process is continue until one copy is left with the node.

Prophet (Probabilistic Routing Protocol using History of Encounters and Transitivity); an unlimited-copy routing protocol or flooding-based in nature [12]. It estimates probabilistic metric called delivery predictability. This routing protocol based on the probability of node’s contact with another node. The message is delivered to another node if the other node has a better probability of delivering it to the destination.

Table 1. Summarize the DTN routing protocols and there characteristics.

TABLE 1. DTN Routing Protocols

Routing Protocol	***Abbreviations***	****-copy***	***Estimation-based***
Direct Delivery [8]	DD	Single-copy	No
First Contact [9]	FC	Single-copy	No
Epidemic [11]	Epidemic	Unlimited-copy	No
PRoPHET [12]	Prophet	Unlimited-copy	Yes
MaxProp [5]	Maxprop	Unlimited-copy	Yes
Spray and Wait [10]	SaW Normal / SaW Binary	n-copy	No

III. PERFORMANCE METRICS

This section characterizes the measurements that are regarded in this study to look at and assess the performance of different DTN routing protocols. The DTNs routing protocol need to tolerate delays resulting from the tested environment and the main requirement of such protocols is that the messages are reliably delivered. Hence, performance metrics for evaluating the performance of DTN protocols are delivery probability and delivery latency [13, 14]. Overhead in transmission of the messages results in additional energy consumption. As the mobile nodes in DTNs are energy constrained, the overhead is considered as another important metric. In this study, the performances of various DTN protocols are evaluated based on the metrics like delivery ratio, average delivery latency and overhead ratio under different scenarios. Besides these metrics, the buffer utilization is observed and the impact of buffer size on performance is also examined. These metrics are defined as follows:

a) ***Delivery probability:*** It is defined as the ratio of the number of messages actually delivered to the destination and the number of messages sent by the sender.

Delivery Probability = no of message delivered to destination/ no of message sent by sender

b) ***Average latency:*** It is defined as the average of time taken by all messages to reach from source to destination.

Average latency = Average (Time taken by all messages to reach from source to destination)

c) ***Overhead ratio:*** This metrics is used to estimate the extra number of packets needed by the routing protocol for actual delivery of the data packets.

Overhead ratio = no of relayed message-no of delivered message/no of delivered message

IV. THE SIMULATOR

The majority of researcher use simulator which easily allow for a large number of reproducible environment-conditions. Simulation plays an important role in analyzing the behavior of DTN routing protocols. There are various simulators available like NS-2 (Network Simulator, 2000), DTNSim (Delay Tolerant Network Simulator), OMNet++, OPNET and The ONE. The ONE is preferred among the simulators because the NS-2 simulator lacks full DTN support. It only supports Epidemic routing whereas DTNSim lacks in movement models. OPNET and OMNet++ are tailored to specific research needs and hence have fairly limited support for available DTN routing protocols. The ONE simulator is a discrete event based simulator. It is a java-based tool which provides DTN protocol simulation capabilities in a single framework. A detailed description of The ONE simulator is available in [15] and ONE simulator project page [Available: http://www.netlab.tkk.fiutkimus/dtn/theone,2009) where source code is also available. The overview of ONE simulator with its elements and their interaction are shown in Fig 1.

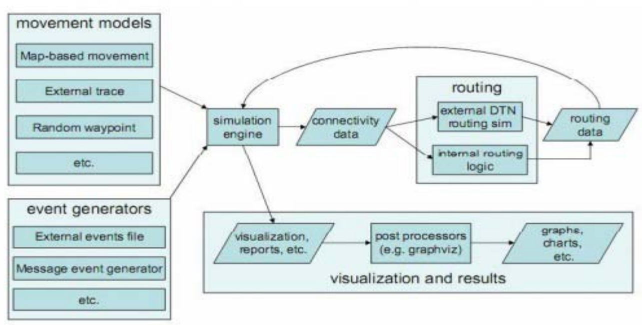

Figure 1. Overview of the One Simulator Environment

V. SIMULATION SETTING

Simulation scenarios are created by defining simulated nodes and their characteristics. The simulation parameters are set as mentioned in Table 2. The simulation is modeled as a network of mobile nodes positioned randomly within an area (4500 x 3400 m^2).

TABLE II. Simulation parameter setting

Parameter	***Values***
Total Simulation Time	14 hrs
Transmission range	10 m
Transmission Speed	250kbps
Routing Protocol	Epidemic, Prophet, SaW
Number of hosts (N)	150
Speed (m/s)	Min =0.5 m/s Max=1.5 m/s
Packet Inter arrival time	150-250 sec
Buffer Size	5 MB
msgTTL	60, 120, 180, 240, 300, 360
Number of copies (n) in SaW	6
Movement Model	Shortest Path Map Based Movement (SPMBM)

VI. Result and Analysis

The effect of varying TTL on different routing protocols like Epidemic, SaW, and Prophet Protocols are evaluated. The results of performance metrics are presented in the form of graph.

A. Delivery Probability

From Figure 2 the following points are evaluated:

- In the current scenario the delivery probability of SaW routing protocol is high as compared to the delivery probability of Epidemic and Prophet routing protocol.
- The delivery probability of Epidemic and Prophet routing protocol is very high with increase of message TTL form 60 to 120 minutes, after that the value these protocol is abruptly decreases with increasing of the message TTL from 120 to 360.
- The delivery probability of SaW routing protocol increases (from 25.43 to 79 approximately) with the increase in message TTL. (From 60 to 360 minutes)

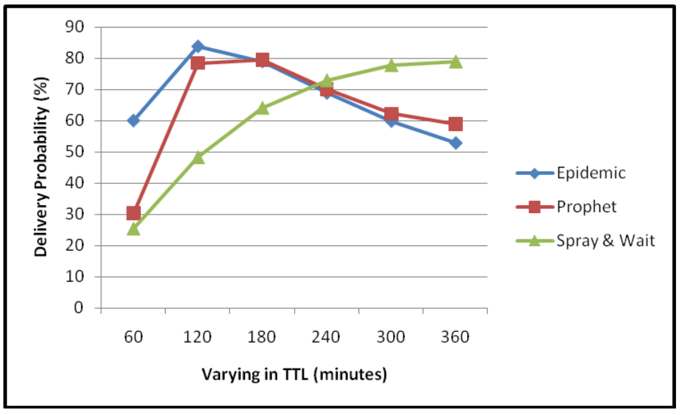

Figure 2. Delivery probability v/s varying in TTL.

B. Overhead Ratio

From figure 3 the following points are concluded:

- Overhead ratio of SaW routing protocol decreases slightly from 25 packets to approximately 11 packets, whereas the overhead ratio of Epidemic and Prophet routing protocol increases as the message TTL is increased.
- Overhead ratio of Epidemic and Prophet routing protocol is higher than SaW routing protocol when the message TTL is increase from 60 to 360 minutes. But as the message TTL increases the overhead ratio of SaW routing protocol decreases.
- In complete scenario the overhead ratio of SaW routing protocol is approximately 60%-70% less than the Epidemic and Prophet routing protocols.

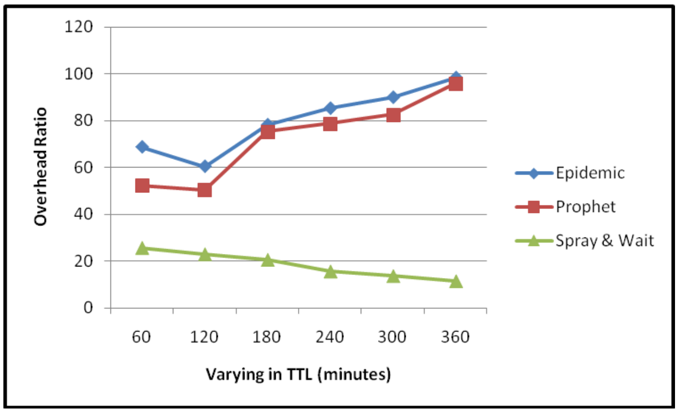

Figure 3. Overhead ratio v/s varying in TTL.

C. Average Latency

The following pints are illustrated form figure 4:

- It is evident that the average latency experienced by the packets in all the three considered routing protocol is same and increases with the increase in the message TTL. This is because as the lifetime of the packet increases the packet has to wait more and more in the buffer before it is either delivered to the destination node or it is being discarded due to lifetime expiry.
- So the overall latency increases with the increase in the lifetime of the message (i.e. message TTL).

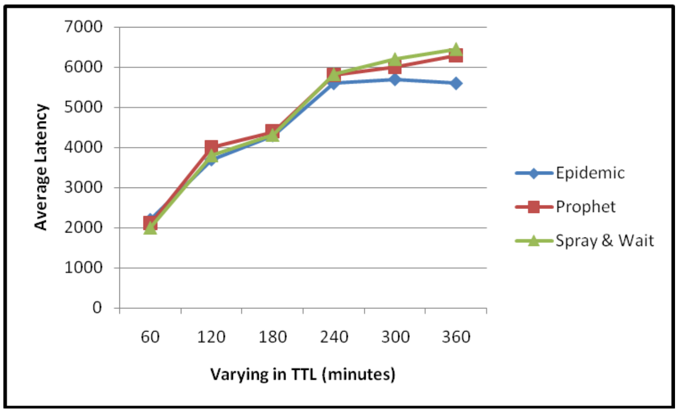

Figure. 4. Average latency v/s varying in TTL.

VII. Conclusion

In this paper we have compare the performance of three DTN routing protocols (Epidemic; Prophet; and SaW) by varying the TTL. The performance evaluation evidently shows that the SaW routing protocol gives best results for delivery probability and overhead ratio under the considered scenario whereas the Average Latency being experienced by the messages is almost comparable in all the three considered routing protocols. So among the considered routing protocols the SaW routing protocol gives the best performance in the given set of conditions and considered scenario. In future we would like to further explore the performance of other routing protocols.

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