Performance Evaluation of Social Routing Protocols Based on the Effect of Delivery Ratio and Average Hop Count in Delay-tolerant Networks (DTN)

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Abstract—**Delay-Tolerant Networks (DTNs) are part of Opportunistic networks. In the case of opportunistic networks, the joined node of a network can have zero or partial knowledge about other nodes in a network. For this reason, the evident information towards the nodes in the existing network is most difficult to collect for forwarding the message. The application of Opportunistic networks is where have a high tolerance for long delays, high error rate, etc. DTNs are also sparse dynamic Ad-hoc networks were source to destination path does not present all-time for successfully message transmission. As DTN has no end-to-end path for message transmission source to destination node so, the routing design is so sophisticated. The social-based routing protocol is developed to improve the routing mechanism by focusing on social behavior and the interaction with the nodes of a network. Consequently, the performance analysis of existing several DTN routing protocols represents a significant role in designing or developing a new routing protocol for a specific scenario. This article investigates the execution of ordinary routing protocols of DTNs such as Epidemic, Binary Spray and Wait (BSNW), including two social-based routing protocols such as Scorp and dLife using Opportunistic Network Environment (ONE) simulator. The performance of these routing protocols is measured based on delivery ratio and average hop count with inevitable simulation settings. From the simulation result, it is condensed that for higher delivery ratio, BSNW is best, and for average hop count, dLife is the best routing protocol.**

Index Terms—**Delay Tolerant Networks (DTN), Binary Spray and Wait (BSNW), Social-aware Content-based Opportunistic Routing Protocol (Scorp), dLife, Opportunistic Network Environment (ONE).**

I. INTRODUCTION

Most of the communication [1-3] of a network occurs with each other by using TCP/IP based protocol. The Delay Tolerant Network (DTN) is one of the most attractive inventions in the field of Mobile Ad Hoc Network (MANET). The main characteristic of MANET network is to have a continuous path between the sender and destination node concurrently. If there is no continuous path between source and target node, then the message will be dropped in the network that means the destination node cannot receive the message. Therefore, the multi-hop path can be connected simultaneously in a pervasive network. The DTN network aims to exchange data or messages with presumed that there is no physical connection to end-to-end [4]. DTN uses a mechanism to transfer the messages from the source node to the destination node is called the store-carry-and-forward mechanism. By using this mechanism, the source nodes send the message to an intermediate node that can preserve the message in the buffer, until finding the proper node to deliver the message to the destination node or intermediate node [5].

To design an efficient routing protocol for the opportunistic network is one of the challenges at DTN due to lack of knowledge about the topology of the network [6]. For this purpose, different routing protocols are proposed over the previous years.

However, they will consume too many resources, and they will not be appropriated for the majority of scenarios. In that way, more complex protocols are started to discover. Social-Based approaches are currently a research area that is growing at a fast-pace due to the initial results that started to appear from different authors. The available Social-Based protocols survey various social properties which called as social metrics, and usually, they combine at least two of them to decide where to forward the messages. It is essential to say that it is possible to have two protocols based on the same properties but with different results in terms of performance. The explanation is simple, and they can differ in terms of how they calculate those metrics, like how to determine the communities. In other words, different algorithms can be applied to reach the same global concept [7]. In [8], the authors introduced a Social based forwarding algorithm, BUBBLE Rap that is created based on community and centrality. They also compare BUBBLE Rap with Prophet routing protocol considering delivery ratio and delivery cost. Hence, their paper was demonstrated as a first step in combining rich multi-level information of social structures. In [9], the authors proposed a new Social-Based routing algorithm for Delay and Disruptive Tolerant Networks that is known as Social Routing and compared the performance with Epidemic and Spray and Wait routing protocol and shown that the mentioned algorithm performs better than other routing protocols.

II. DIFFERENT ROUTING PROTOCOLS FOR ANALYSIS

A summarized description of viewed traditional DTN and Social based DTN routing protocols: Epidemic, Binary Spray and Wait (BSNW), Scorp, and dLife are discussed in this section.

A. Epidemic

In DTN, Epidemic is the first routing protocol. This protocol is also known as a flooding based protocol. This protocol does not know other nodes in a network. It replicates the message following a flooding based manner that means it forwards message copy all of the nodes that nodes are encountered with the source node. By forwarding in this manner, at least one copy of the message reached in the destination node. It forwards the message that the node does not receive the same message copy from another node in this networking procedure. For the process of replication, this protocol needs more message copy for successfully message transmission, and as a result, this protocol has meager message delivery ratio than other routing protocols [10].

B. Binary Spray and Wait (BSNW)

The authors [11] initiated the Spray and Wait routing protocol to solve the difficulty of blind flooding nature. The main distinction between Epidemic and Spray and Wait routing protocol is that it originates only a limited number of message copy.

The SNW protocol has two phases. The first phase is Spray phase, in this phase the protocol originates only a limited number of message copy and spread between neighboring nodes. In the second phase, that means wait for phase, in this phase, all of the nodes that nodes have message copy wait for direct delivery the message to the destination node.

To enhance the achievement of spray and wait Spyropoulos et al. (2005) proposed the Binary Spray and Wait (BSNW) routing technique. In BSNW, the source node generates N message copies and forwards half of N copies between encountered nodes. This system is continued with other interior nodes until at least one message copy is left. When this process happens, the node waits for straight delivery of message copy to the destination [11].

C. Social-aware Content-based Opportunistic Routing Protocol (Scorp)

Scorp is a Social-Based routing protocol that imagines the users' social interaction and their interests to deliver the message in dense scenarios. It uses social proximity and content knowledge to improve data delivery proficiency. There is two motive to utilize social proximity, including content knowledge:

- First, nodes with identical daily habits have a superior probability of having identical (content) interest.
- Second, Social Proximity metrics relegate for rapidly data transmission by taking the opportunity of more frequent and long contacts between neighbor nodes. [12].

D. dLife

Dlife is a Social-based routing protocol which looks on the user's behavior based on their daily periods. It takes into account two complementary of utility functions: time-evolving Contact Duration (TECD) and TECD Importance (TECDi). Using TECD function, source node or intermediate node forwards the message another relay node that has a potential relationship with destination node than the current carrier node. By TECD each node enumerates the average contact duration with other nodes. The TECD Importance (TECDi) function captures the evolution of the importance of the user based on its node degree and the social power of neighbors over time [13].

III. SIMULATION STRATEGY

In this paper, we viewed the performance of Epidemic, Binary Spray and Wait (BSNW), Scorp, and dLife routing protocols. All these routing protocols are simulated using the Opportunistic Network Environment (ONE) simulator of version 1.4.1. This section explains the ONE simulator, simulation environment setup.

A. The ONE simulator

For the intention of simulation, we used Opportunistic Network Simulator (ONE) that is a Java-based platform. It is a discrete agent-based event simulation engine that is developed for DTN routing protocol evaluation and generating new routing protocol [14]. The main function of one simulator is to inter-node connection respect to a different interface, handling of message, movement model of the node, and interaction with the application. Result analysis and collection are done by visualization, reports in one package. The one simulator interaction and their element are shown in Fig. 1. Which has four modules, namely, movement models, routing, event generator and visualization, and results. Full information of one simulator is available in [15] and the ONE simulator project page where the source code is also available [16].
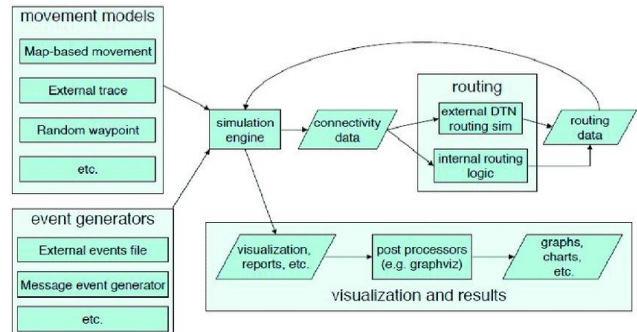

Fig. 1: Overview of ONE simulator

B. Simulation Environment Setup

For analysis the performance of routing protocols, the simulation setup is summarized in Table-I and Table-II.

IV. SIMULATION RESULT AND ANALYSIS

This section discusses the simulation results by running the simulations based on the following performance metrics: delivery ratio, transmission cost and average hop count by varying the buffer size and node density in each group.

TABLE I: PARAMETERS FOR SIMULATION SET UP

Parameters	Values
Simulator	Opportunistic Network Simulator (ONE)
Simulation time	28800 Sec (8 hour)
Update interval	0.2 Sec
Interface	Bluetooth interface
Interface type	Simple Broadcast Interface
Transmit speed	280 Kb
Transmit range	12m
Familiar Threshold	700
Buffer size (MB)	4,8,12,16,20
Message Size	700 KB
Total Message generation	2
Message TTL	240 min (4 hour)
Number of nodes each group	30,50,70,90,110
Routing protocol	Epidemic,B-SNW,Scorp, dLife
Movement model	Shortest path map-based movement
Simulation area size	9000x8700 m

TABLE II: PARAMETERS FOR ROUTING PROTOCOLS

Routing Algorithm	Parameters	Value
Epidemic	N/A	N/A
Binary Spray and Wait	No. of Copies (L)	8
Scorp	Group Router	Decision Engine Router
dLife	Group Router	Decision Engine Router
	Decision Engine Router Familiar Threshold	700

A. Performance analysis on Delivery Ratio

The delivery ratio can be defined as the number of the message delivered to the destination node over the message created at the source node.

From Fig. 2, it is evident that the delivery ratio of Epidemic and Binary Spray and Wait routing protocol are gradually increase by increasing buffer size. Furthermore, seen that the delivery ratio is almost constant for Scorp and dLife routing protocol. From the plot, we have seen that the delivery ratio of BSNW is better than other routing protocols. In BSNW, the message is limited. So, when we increase the buffer size, the message can be stored in the new node and hence nodes can easily forward the message to the destination node and increase the delivery ratio. Fig 3 shows the delivery ratio of BSNW is better than other routing protocols, and Epidemic gives the lowest performance by increasing the node density in each group. For both cases, BSNW gives excellent performance.
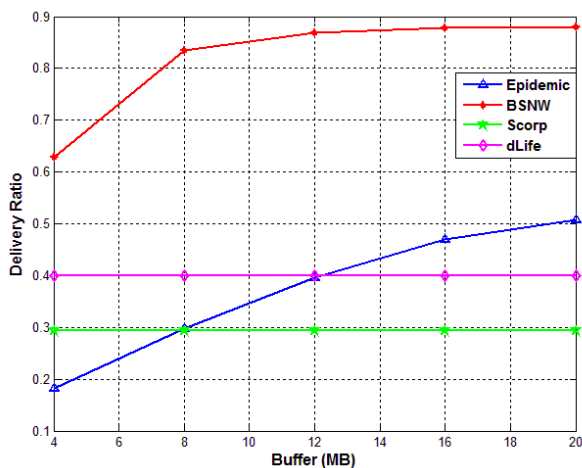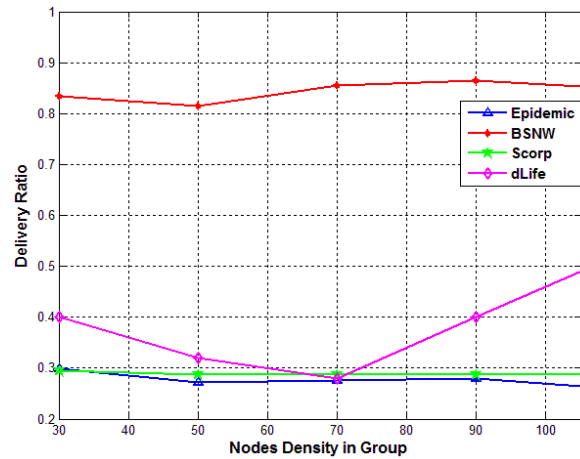

Fig. 2. Delivery Ratio by varying Buffer Size

Fig. 3. Delivery Ratio by varying Node density in group

B. Performance analysis on Average Hop Count

Average Hop Count can be defined as how many interior nodes are needed averagely for source to destination message transmission.

If a message copy can reach the destination node easily by taking less number of the relay node, after that this protocol is better as it required less relay node and consumes lower power.

The evaluation result of average hop count by varying buffer size and node density in each group is shown in Fig 6 and Fig. 7. From both figures, it is shown that the dLife forward the message to the destination using less number of intermediate nodes. As dLife forwards the message to the nest intermediate, that node has a higher relationship with the destination node and a higher chance to deliver the message to the destination node. Finally, it is clear that dLife gives the best performance and Epidemic produces the worst performance for the metric of average hop count.
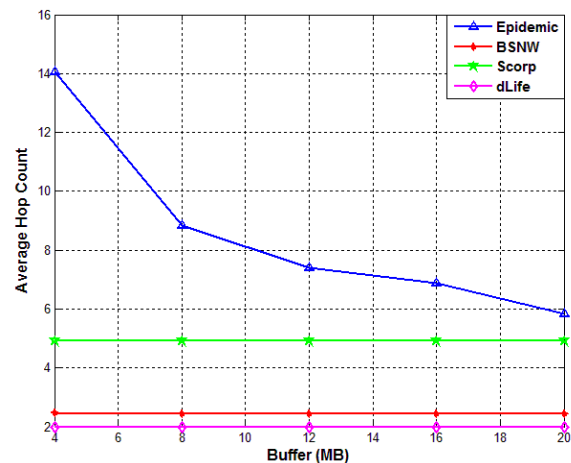

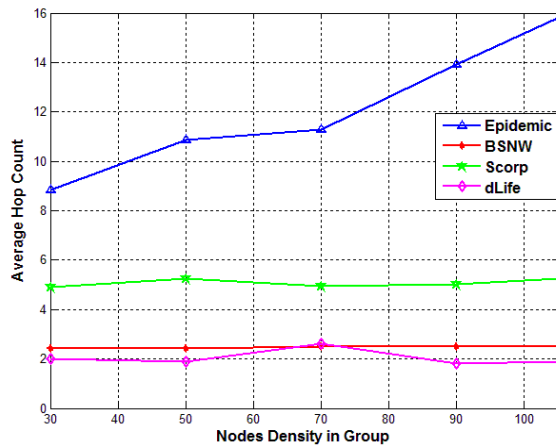Fig. 4. Average Hop Count by varying Buffer size

Fig. 5. Average Hop Count by varying Node density in group

V. CONCLUSION

In this paper, the performance of Epidemic, B-SNW, Scorp, dLife are evaluated by varying the buffer size as well as node density in each group using ONE simulator. Simulation result elucidated the BSNW performs better in the case of delivery ratio, dLife performs excellently in the case of average hop count, and Epidemic gives the worst result for all metrics. In the future, try to develop a new routing protocol combing the routing metrics of DTN and Social Based protocols.

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