Performance Evaluation of Epidemic Routing Protocol for Delay Tolerant Network Based on Node Movement Model

Shaurya Gupta, Ramesh Chandra Poonia, Xiao-Zhi Gao

Abstract: ***Delay Tolerant Networks are major significant developments of Mobile Ad Hoc Networks (MANET). They are varied networks which permit association between different devices running with different operating systems. The network allows sending of numerous copies of a single message, which increases the delivery probability ratio but significantly it decreases the delay of message transmission, though transmission of numerous copies of the similar communication increases the overhead. This paper evaluates the performance DTN routing protocol i.e. Enhanced Epidemic on the basis of Shortest Map Based Movement Model and Random Waypoint Model.***

Index Terms: ***VANET, DTN, Routing Protocol, Bundle Protocol, ONE-Simulator.***

I. INTRODUCTION

A Delay-Tolerant Network (DTN) [1] is explained as "association of regional networks" which ropes extensive holdup, unbalanced associations and asymmetric message data rate by means of "Store & Forward" message switching. In this approach the nodes will be accepting data packets from the origin which are stored in their buffer area and distribute carbon copies of data packets to their adjoining nodes as and when they get nearer to transmission range. The DTN routing protocols are classified into two categories a) Flooding based b) Forwarding based [2]. Epidemic and Prophet routing comes under Flooding based category. Flooding mechanism creates more number of packets in a network which causes congestion in a network along with consumption of network resources. In this mechanism, network resources are to be utilized significantly so as to recognize the messages which are to be delivered and dropped. This research focuses on Epidemic routing protocol, which is based on flooding policy. The given name epidemic is derived from "epidemic spreading" which illustrates fast spreading of disease in general terms, whereas here epidemic indicates flooding of messages to nodes in an epidemic fashion. Here, nodes imitate the communication and broadcast them all to their adjoining nodes which are not having a replica of that particular message. Every node swaps their communication with other node they meet and acknowledge the only messages not possessed by those nodes. This is called message swap method in Epidemic routing strategy. The primary purpose of DTN is to overcome flaws of varied networks like association connectivity issues.

II. RELATED WORK

In heterogeneous networks, priority is always on establishing best associations between origin and end nodes of communication and these networks facilitate communication between the nodes anywhere and anytime [3]. DTN was introduced to prevail over the drawback of varied network like network association issues. Though these networks have high prospect of packet deliverance but there is a lot of wastage of resources which results in degradation of system [4] [5]. Epidemic routing strategy shows improved presentation in provisions of confronts of other sporadically linked networks like 2-hop and multi hop network [6]. In view to lessen the routing overhead resources of the system should be exploited efficiently. Here, the source node is responsible for generating plentiful identical duplicates of the identical communication to a set of nodes. These set of nodes saves the messages in their buffer till the association terminates [7]. As the nodes gather they swap the list of messages with each other so that both nodes have identical list of messages. Though this method leads to faster delivery of messages as it maximizes the message deliverance rate and minimizes the message latency, number of resources used in message deliverance. Epidemic shows improved show in terms of other irregularly connected networks when 2 hop and multi hop networks are considered [8]. Multi hops are the networks in which a node takes two or more hops to get to the destination. To reduce the overhead in epidemic steering, the network resources should be used efficiently via priority rule [9]. The message with the top precedence hop count up will be handed over first [10]. The performance of DTN may be improved using forwarding queue plan which reduces the deliverance time of messages. DTN with sparse nodes are called opportunistic networks where their performance can be measured from time to time as they follow a particular pattern [11].

III. DELAY TOLERANT NETWORK

Delay Tolerant Network is a wireless uneven or discontinuous collection of associations which allows elongated waits in data broadcast. It utilizes bundle procedure which supports late binding of data in varied

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Shaurya Gupta, AIIT, Amity University Rajasthan, Jaipur, India.
Ramesh Chandra Poonia, AIIT, Amity University Rajasthan, Jaipur, India.
Xiao-Zhi Gao, School of Computing, University of Eastern Finland, Finland.

critical circumstances like armed and isolated section communication [20]. DTN assist irregular connections and promises ideal data deliverance, as data is stored in the buffer area of sender or receiver instead of being misplaced [12]. Bundle protocol permits DTN to cover numerous diverse networks and allows DTN protocols to be differentiated from identification and addressing schemes. In these kinds of network, data is replicated to other nodes prior being transmitted. DTN is a move ahead to computer association which arranges the functional concerns in a varied system which are lacking in invariable system association, though they maintain connectivity in between nodes to guarantee successful deliverance of packets from end to end. The nodes which are in charge for transportation of data packets are called relay nodes. Nodes are transmitting simulated packets to other nodes as they get in touch with them, while the duplication of messages causes issues like congestion of network or resource wastage. Therefore, DTN uses flooding and forwarding strategy for transmission of packets in a network. Flooding uses duplication of messages whereas forwarding follows the best selection of path for transmission based on information about network.

DTN Characteristics

This section elaborates different features of DTN which focuses the direction-finding and forwarding protocols accomplishment e.g. path choice, network architecture.

- **Connections are not stable**: Nodes do not have end to end stable connection i.e. connection gets disrupted at times. It can be due to dynamic nature of nodes i.e. the topology changes frequently [9].
- **Short Data Rate**: Nodes have relatively short transmission rates therefore the end to end delay can be very large.
- **Extended Queuing Delay**: As the transmission time of nodes in network is more due to traffic traversing in network, therefore the nodes in network may get delayed because of delay of nodes before them [11].
- **Limited Resources**: Network nodes have limited energy due to mobility or they do not have a grid resource in nearby area. Nodes use their energy in movement and path detection.

Epidemic Routing

Epidemic routing protocol falls under the category of flooding based scheme [22]-[24]. In this flooding mechanism accidental pair wise swap of communication amongst mobile nodes make sure deliverance of messages, increases the messages deliverance rate and reduces message latency as well as total number of resources consumed in deliverance of messages [13]. It focuses on forwarding of messages based on least possibility of network topology and connectivity. Every node has a buffer which is used for storage of messages received from other hosts or nodes in a network [23]. To achieve the proficient administration of communication, the messages are listed in a hash table. Every node has a collection of bits which is called the summary vector which depicts the number of entries which are stored in a hash table. Whenever two nodes are in communication, the node with the lowest id initiates an anti entropy gathering with the node with the highest id through which communication is forwarded. Every node has a record of nodes with which connection has taken place in recent times so as to shun unnecessary sessions [14]. As this process is completed, it produces a huge quantity of redundancy in a network which requires good bandwidth and buffer capacity and at the same time the network should be strong enough to handle network congestion failure as the network overhead is extremely high in this case. Though, epidemic routing promises broadcasting of data in a network immaterial of delivery delay.

IV. ROUTING PROTOCOL SIMULATION

In this simulation Epidemic routing protocol is tested using ONE simulator [15], [16] using Shortest Map Based Movement Model and Random Waypoint Model. The performance comparison of Epidemic routing protocol between the two node movement models is done for delivery probability ratio and transmission range. ONE not only focuses on simulating direction-finding protocols but also on mobility modeling [21]. ONE tool is extensible i.e. more class libraries can be added in it whereas it also includes a combination of reporting and analyzing modules [17]. Open JUMP [18] is a free Java based open source GIS program which is utilized for controlling and importing the maps for simulation purpose. Node progress is put into practice by means of movement models. These are moreover synthetic models or accessible movement traces.

The steps involved in initiating the simulation are as follows:

a. Firstly, the setup of ONE is downloaded from its source http://www.dtnrg.org.
b. As the commands for simulations can be executed in batch mode, where the simulations can't be visualized.
c. Therefore, installation of eclipse is important where the simulations along with their code can be visualized.
d. As eclipse is started, a new java project is to be started and uncheck the default location, then after clicking next menu is opened where order and export is selected then finish button is clicked.
e. The next step involves of building path by clicking on project name followed by adding external archives like DTN consoleconnection.jar and ECLA.jar. One of the external library i.e. junit-4.12.jar is also added to the project.
f. Thereafter, the project is run as java application, by default one scenario is executed.
g. Here, epidemic routing is executed and the results are captured, using two node movement models i.e. Shortest Map Based Movement Model and Random Waypoint Model.

The simulation parameters are described below in Table I.

Parameters	Values
Simulation Scenario	Helsinki Downtown(4500x3400m2)
Simulation Time	2 Hours

Number of Nodes	100
Node Movement	Shortest Map Based Movement and Random Waypoint Model
Moving speed	0.5~13 m/s
Transmission range	10m
Message size	250kb
Transmission speed	2Mbps

Table I. Simulation Parameters

Apart from simulation parameters there are performance metrics on which the performance of a network is evaluated. The following metrics were used for performance comparison:

• **Network Overhead:** It is defined as the quantity of messages copied in a network compared to the number of messages which are actually delivered to the destination.

• **Delivery Probability Ratio**: It is defined as the proportion of total quantity of message transported to the total quantity of originated message.

In our attempt, we have considered an urban circumstance. The actual records map is generated of Helsinki city in Finland which was imported from Open Street Map [19].In the experimentation simulation time of two hours is taken in account during which nodes travel on mapped paths with speed which ranges from 0.5~13 m/s . Every node has 1MB storage space. All the nodes are connected by Wi-Fi bond with a propagation data rate of 2mbps. Shortest Map based movement model and Random Waypoint model have been used in the simulation. Here, nodes travel randomly but all the time follows a passageway which is described by map data.

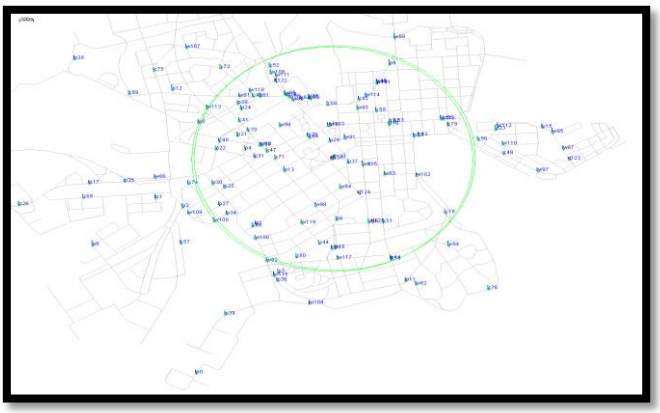

Fig.1 Nodes arrangement in Epidemic Routing in playfield graphics

The playfield graphics is the default output field to show simulation in transmission. The map can be any city map which can be imported from Open Jump. The circle depicts the radio range of nodes in communication. The nodes follow pre determined paths according to node movement model.

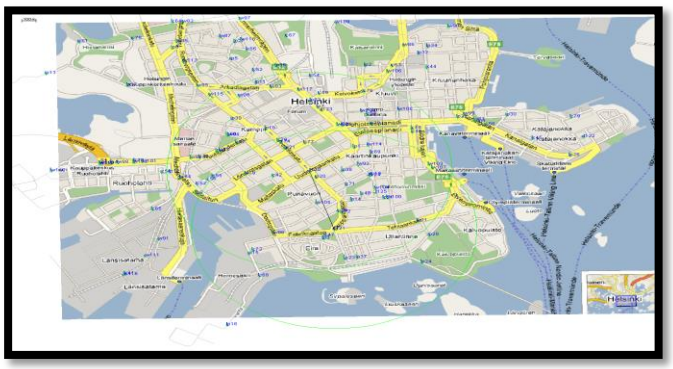

Fig.2 Nodes arrangement in Epidemic Routing in underlay image

Here, epidemic steering is considered. The maps taken in consideration are situation cases of epidemic steering in playfield graphics form and underlying image form correspondingly. There are options in ONE simulator to display images in graphics form or underlying image form, whereas the images can be imported from Open Street Map also [19].

V. RESULTS AND DISCUSSION

When the simulation is conceded out in observance of parameters, then the subsequent results are obtained. The simulation may be considered for various movement models and for diverse routing protocols [12]. Simulation outcome is recorded for epidemic routing protocol and observing and recording the behavior of parameters like overhead ratio and delivery probability against transmission range for Shortest Map Based Movement Model and Random Waypoint Model.

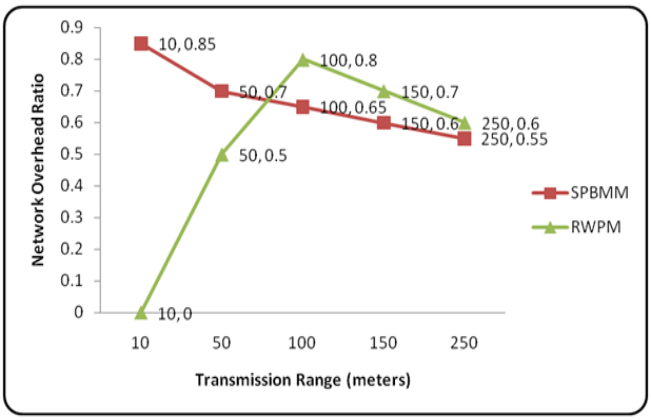

Fig.3 Network Overhead Ratio of SPBMM and RWPM

Fig. 3 clearly depicts that the network overhead ratio in case of Shortest Path Based Map Model decreases with transmission range. Here, it can be clearly seen that as the transmission range of nodes in a network is increased the network overhead ratio keeps on decreasing and it remains stable at a point. Whereas, in case of Random WayPoint Model network overhead ratio increases with increase in transmission range and after a certain point of contact, network overhead ratio starts decreasing and it becomes

stable at a point. Therefore, Shortest Path Based Map Model shows slightly better performance than Random WayPoint Model.

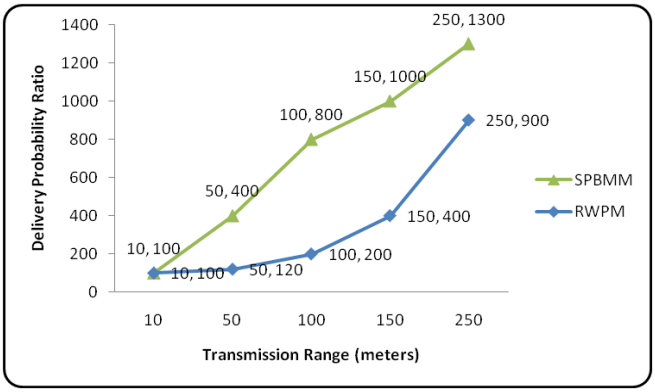

Fig.4 Delivery Probability of SPBMM and RWPM

Fig. 4 clearly shows the delivery probability ratio increases with increase in transmission range. Here, in case of Shortest Path Based Map Model and Random Waypoint Model we can clearly see that delivery probability ratio of nodes in a network increases as the transmission range increases. In case of Shortest Path Based Map Model, the raise of delivery probability ratio is far more than that of Random Waypoint Model. Therefore, Shortest Path Based Map Model shows a far better performance than Random WayPoint Model in terms of delivery probability ratio.

VI. CONCLUSION AND FUTURE WORK

From the simulations, it can be concluded that as and when the transmission range raises the delivery probability is exaggerated more in case of Shortest Path Based Map Model than Random WayPoint Model, whereas in case of network overhead ratio Shortest Path Based Map Model shows slightly better performance than Random WayPoint Model. Simulations can be carried out keeping a parameter fixed and testing the behavior of other parameters under certain network movement model scenario. The network scenarios can be Map Based Movement Model or Working Day Movement Model. The results of parameters like delivery probability ratio and network overhead ratio would be different in case of different network movement model scenario. Future work may be done in optimizing these protocols using cross approach so as to attain optimized consequences in

REFERENCES

[1] Delay Tolerant Networking Research Group. Available: “http://www.dtnrg.org”.
[2] Shen, Jian, Sangman Moh, and Ilyong Chung, "Routing protocols in delay tolerant networks: A comparative survey." The 23rd International Technical Conference on Circuits/Systems, Computers and Communications (ITC-CSCC 2008). 2008.
[3] Assouma, Abdoul Djalil, Ronald Beaubrun and Samuel Pierre. "Mobility Management in heterogeneous wireless networks.” IEEE journal on selected areas in communications 24.3 (2006): 638-648.
[4] Spyropoulos, Thrasyvoulos, Konstantinos Psounis, and Cauligi S. Raghavendra. "Efficient routing in intermittently connected mobile networks: The multiple-copy case." IEEE/ACM Transactions on Networking (ToN) 16.1 (2008): 77-90.
[5] Guan, Xin, Min Chen, and Tomoaki Ohtsuki. "Epidemic theory based H+ 1 hop forwarding for intermittently connected mobile ad hoc networks." EURASIP Journal on Wireless Communications and Networking 2012.1 (2012): 76.
[6] Maheswari, B. Uma, and T. S. B. Sudarshan. "Error resilient multipath video delivery on wireless overlay networks." Telecommunication, Computing, Electronics and Control (TELKOMNIKA), Vol. 14, No. 3, 2016.
[7] Boudguig, Mohammad, and Abdelmounaïm Abdali. "New predictability concept for routing in DTN”, International Conference on Multimedia Computing and Systems, IEEE, 2012.
[8] Xin Guan, and Tomoaki Ohtsuki, “Epidemic theory based H + 1 hop forwarding for intermittently connected mobile Ad Hoc networks”, EURASIP Journal on Wireless Communications and Networking, June 2012.
[9] Guan, Xin, Min Chen, and Tomoaki Ohtsuki. "Epidemic theory based H+ 1 hop forwarding for intermittently connected mobile ad hoc networks." EURASIP Journal on Wireless Communications and Networking 2012.1 (2012): 76.
[10] Sindhuja, M., et al. "Delay Tolerance in Wireless Networks through Optimal Path Routing Algorithm." Procedia Computer Science 48 (2015): 401-407.
[11] Neena, V. V., and V. Mary Anita Rajam., "Performance analysis of epidemic routing protocol for opportunistic networks in different mobility patterns.”, International Conference on Computer Communication and Informatics, IEEE, 2013.
[12] Gupta, Shaurya, and Ramesh C. Poonia., "Performance Evaluation of Direction-Finding Protocols in Vehicular Delay Tolerant Network." (2018).
[13] Lu, Xiaofeng, and Pan Hui. "An energy-efficient n-epidemic routing protocol for delay tolerant networks." 2010 IEEE Fifth International Conference on Networking, Architecture, and Storage, IEEE, 2010.
[14] De Rango, Floriano and Salvatore Amelio., "Performance evaluation of scalable and energy efficient dynamic n-epidemic routing in delay tolerant networks.", International Symposium on Performance Evaluation of Computer and Telecommunication Systems (SPECTS). IEEE, 2013.
[15] Keränen, Ari, Jörg Ott, and Teemu Kärkkäinen., "The ONE simulator for DTN protocol evaluation. “Proceedings of the 2nd international conference on simulation tools and techniques. ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering), 2009.
[16] The ONE. Available: “https://akeranen.github.io/the-one/”
[17] Keränen, Ari. "Opportunistic network environment simulator." Special Assignment report, Helsinki University of Technology, Department of Communications and Networking (2008).
[18] Open JUMP - The free, Java based and open source Geographic Information System for the World. Available: “http://www.openjump.org” .
[19] Open Street Map, Available: “http://www.openstreetmap.org”.
[20] Almeida, Rodrigo, et al. "Forwarding Strategies for Future Mobile Smart City Networks." 2018 IEEE 87th Vehicular Technology Conference (VTC Spring), IEEE, 2018.
[21] Kimura, Tomotaka, and Masahiro Muraguchi. "Buffer management policy based on message rarity for store-carry-forward routing." 2017 23rd Asia-Pacific Conference on Communications (APCC), IEEE, 2017.
[22] Spyropoulos, Thrasyvoulos, Konstantinos Psounis, and Cauligi S. Raghavendra. "Efficient routing in intermittently connected mobile networks: The multiple-copy case." IEEE/ACM Transactions on Networking (ToN) 16.1 (2008): 77-90.

[23] Dhaka, V. S., Ramesh C. Poonia, and Linesh Raja. "The Realistic Mobility Evaluation of Vehicular Ad-Hoc Network for Indian Automotive Networks." International Journal of Ad hoc, Sensor & Ubiquitous Computing 5.2 (2014): 1.
[24] Shastri, A., R. Dadhich, and Ramesh C. Poonia. "Performance analysis of on-demand Routing protocols for vehicular ad-hoc Networks." International Journal of Wireless & Mobile Networks (IJWMN) 3.4 (2011): 103-111.

AUTHORS PROFILE

Shaurya Gupta is working in the capacity of Assistant Professor from past 3.5 years with Amity University, Rajasthan. He is pursuing PhD from Amity University, Rajasthan. He has done M.Tech (CS) in the year 2014 from Jagannath University Jaipur and has over 9.5 years of experience in Teaching, Administration, Liaison & Coordination, Student Management and Research & Analysis. He has published three papers in reputed research journals and attended four national and International conferences. His areas of interest are Delay Tolerant Network, Wireless Sensor Network, Ad Hoc Network.

Dr. Ramesh Chandra Poonia has rich experience of 15 + years as an academician. At present he is an Associate Professor of Computer science at Amity Institute of Information Technology, Amity University Rajasthan, India. He has received his PhD in Computer science from Banasthali University Rajasthan , India. His Research interest include IOT for sustainable agriculture, ITS and WSN Protocol, Simulation and modeling.

Dr. Xiao.-Zhi Gao is working in the capacity of Professor in University of Eastern Finland from April 2018 till present. Prior to that he has worked as a Docent with Aalto University, Finland for about 15 years. His research interest includes Soft Computing, Machine Learning, Data Mining and Networks.