ISSN 2277-3061

CHBR: Contact History Based Routing in Time Varying Approach

Pravesh S Patel, Hemal Shah, Yogeshwar Kosta
U. V. Patel College of Engineering, Ganpat University,Mehsana Gujarat, India
pravesh.patel@ganpatuniversity.ac.in
U. V. Patel College of Engineering, Ganpat University,MehsanaGujarat, India
Hemal.shah@ganpatuniversity.ac.in
Marwadi Education Foundation, Rajkot, Gujarat, India
ypkosta@gmail.com

ABSTRACT

In Delay tolerant network having intermittent connectivity so there is no guarantee of finding a complete communication path that connecting the source and destination. There no any end to end connectivity for delay-tolerant network selection of routing protocol is important to deliver the message in an efficient way and increases chance to deliver a message to the destination. Some existing routing protocols improve the delivery ratio but it also increases the overhead. Our paper proposed Contact History Based Routing (CHBR) that use Neighborhood Index and Time varying properties such as temporal distance, Temporal Diameter and centrality for benchmarking the existing routing protocol. First, temporal metrics are evaluated for synthetic and real trace data. Then CHBR protocol is compared with the Epidemic and PROPHET for delivery ratio, overhead and the number of messages dropped. This has been carried using Opportunistic Network Environment simulator under real and synthetic datasets.

Indexing terms/Keywords

DTN, Routing, CHBR, Neighborhood Index, PROPHET, Mobility model, Time Varying Graph, Time window size, RWP

Council for Innovative Research

Peer Review Research Publishing System

Journal: INTERNATIONAL JOURNAL OF COMPUTERS & TECHNOLOGY

Vol 13, No. 2

editor@cirworld.com

www.cirworld.com, www.ijctonline.com

ISSN 2277-3061

Introduction

Provide examples of relevant academic disciplines for this journal: E.g., History; Education; Sociology; Psychology; Cultural Studies;

Delay tolerant networks[1] or networks with intermittent connectivity networks are wireless networks often where, a communication path between a source node and destination node does not exist, either directly or through established routes by intermediate nodes. This situation occurs if the network is sparse and partitioned due to high mobility, or when the network extends over long distances; in these cases, the traditional routing protocols have been developed for ad hoc networks proved to be insufficient because they require the existence of end to end path in order to route the packets. Hence, researchers have proposed different techniques for exchanging the message in such environment based on store carry and forward mechanism.

Broad routing techniques in DTN environment can be classified as forwarding and replication. Forwarding technique only keeps the single copy of message in network. e.g. direct transmission, first contact [2]. This protocol utilizes the available resources optimally but suffers from lower delivery ratio. In replication, copies of each message spread across the network. E.g. epidemic routing[3]. This protocol give better delivery ratio[3] but, wastes resources such as bandwidth, buffer of network. Since, contacts are almost opportunistic, past history stored at each node may be use for future contact prediction. PROPHET[4] protocol uses the predictability values. These values are calculated using history of encounters and based on that forwarding decision is taken. With Prophet we get better delivery ratio compare to other routing but it increases overhead ratio. The work presented in this paper describes author's contribution as:

1. Temporal and Static representation of network
2. Proposed protocol based on contact history in time varying Approach
3. Performance analysis and comparison using ONE simulator

The rest of the paper is organized as section II introduces about routing protocols and mobility models, temporal graph simulator used respectively. Section III gives the information about the CHBR routing protocol and characteristics of it. Section IV discusses about the performance analysis our propose CHBR routing protocol with existing multi-copy routing scheme.

Related Work

Routing in delay-tolerant networking concerns itself with the ability to transport, or route, data from a source to a destination, which is a fundamental ability all communication networks must have. Delay- and disruption-tolerant networks (DTNs) are characterized by their lack of connectivity, resulting in a lack of instantaneous end-to-end paths. In these challenging environments, popular ad hoc routing protocols such as AODV[5] and DSR [6] fail to establish routes. This is due to these protocols trying to first establish a complete route and then, after the route has been established, forward the actual data. However, when instantaneous end-to-end paths are difficult or impossible to establish, routing protocols must take to a "store and forward" approach, where data is incrementally moved and stored throughout the network in hopes that it will eventually reach its destination[7][2]. A common technique used to maximize the probability of a message is successfully transferred is to replicate many copies of the message in hopes that one will succeed in reaching its destination[8].

DTN focus is mainly on being as efficient as possible with few available paths[4]. Hence routing protocols have been classified according to practical scenarios. These protocols can be classified according to methodology used to find destinations and whether replicas of messages are transmitted or not. Consequently routing protocols can be broadly characterized by

1. Knowledge based (Forwarding) protocols
2. Flooding based (Replica) protocols
3. Coding based protocols

The Direct Delivery Routing: is protocol that delivery message direct to destination, so until the destination is not in range of source, the source will carry the message. According to behavior of direct delivery routing the delivery ratio is to small compare to above discussed epidemic and prophet protocols

The epidemic routing protocol[9]: Messages propagate through the network like an outbreak of disease. This approach ensures that the message reaches its destination as much as possible, but it also wastes a lot of resources by unnecessary transfers of messages.

ISSN 2277-3061

The PROPHET [Probabilistic ROuting Protocol using History of Encounters and Transitivity] Routing[4] : is protocol is one of the routing algorithm that have been proposed to use their resource properly. Prophet introduced a metric called Delivery Predictability, P(a,b) in [0, 1]. This metric is calculated by each node a of the DTN network and for each known destination b and will be used to decide which messages to be exchanged whenever two nodes meet.

The calculations of the delivery predictabilities have three parts. The first thing to do is to update the metric whenever a node is encountered, so that nodes that are often encounteredhave high delivery predictability. This calculation is shown in Eq. (i), where Pint in [0, 1] is an initialization constant.

$$P(a,b) = P(a,b)old + (1 - P(a,b)old) \times Pint \qquad (i)$$

If a pair of nodes does not encounter each other in a while, they are less likely to be good forwarders of messages to each other, thus the delivery predictability values must age, being reduced in the process. The aging equation is shown in Eq. (ii), where α is the aging constant, and k is the number of time units that have elapsed since the last time the metric was aged. The time unit used can differ, and should be defined based on the application and the expected delays in the targeted network.

$$P(a,b) = P(a,b)old \times \alpha k \qquad (ii)$$

The delivery predictability also has a transitive property, that is based on the observation that if node A frequently encounters node B, and node B frequently encounters node C, then node C probably is a good node to forward messages destined for node A to. Eq. (iii) shows how this transitivity affects the delivery predictability, where β Є [0,1] is a scaling constant that decides how large impact the transitivity should have on the delivery predictability.

$$P(a,c) = P(a,b)old + (1 - P(a,c)old) \times P(a,b) \times P(b,c) \times \beta \quad (iii)$$

NECTAR protocol:

NECTAR[10] protocol is based on the contacts history in order to create a Neighborhood Index and then determine the most appropriated route for DTNsIt uses the occurrence of an opportunistic contact to calculate a Neighborhood Index and spread messages in a controlled manner. During the contact period, nodes fist start the transmission of messages whose destination is the node that established the contact, then exchange information about the neighborhood (Neighborhood Index), and eventually forward other messagesThe NECTAR protocol can operate as the Epidemic Protocol. MinEpidemicLevel and MaxEpidemicLevel parameters were defined to allow this mode of operation and determine how many times a message can flood the network.

If the expression (TTL) < MinEpidemicLevel is true, then the message will be transmitted to all neighbors. If MinEpidemicLevel parameter is set to one, only the source node will flood the network. If MinEpidemicLevel parameter is set to two, the source node will flood the network, as well as the source's direct neighbors.To avoid buffer overflow problem and network congestion, when the expression MinEpidemicLevel < (TTL) < MaxEpidemicLevel is true, neighbors only accept this kind of message if the buffer occupation is below a certain threshold.

Issues with NECTAR:

With NECTAR the node having a higher Neighborhood index for destination is select for next rely node but, if there is no contact in future then ?NECTAR protocol is designed based on static graphs for Neighborhood index calculation thus; it reveals inaccurate information about node’s neighbor. Hence , there is scope to extend the work of extracting Neighborhood index and propose a new routing protocol using Time Varying graph NECTAR is flooding based routing algorithm so each node require high buffer size, so there is scope for integration of good message drop policy

DTN as Time Varying Graph

Time varying graph (Temporal graph) can be represented in a sequence of time windows. Where for each of window we consider a snapshot of the network state at that particular time interval[11][12].It behaves like a Tool for understanding the dynamic properties of network over periods of time. Classical studies on social networks have focused on a static Representation of nodes and edges. After all static means, all edges are assumed to occur at the same time in temporal graph. However, in reality, such edges come and go across time.

Fig. (a)[13] shows the temporal graph of edge sequence. It consists six nodes that represented by A, B, C, D, E and F. If we want to calculate the temporal distance then we have to follow the algorithm steps. Fig.(b) represents static representation of Fig.(a)

ISSN 2277-3061

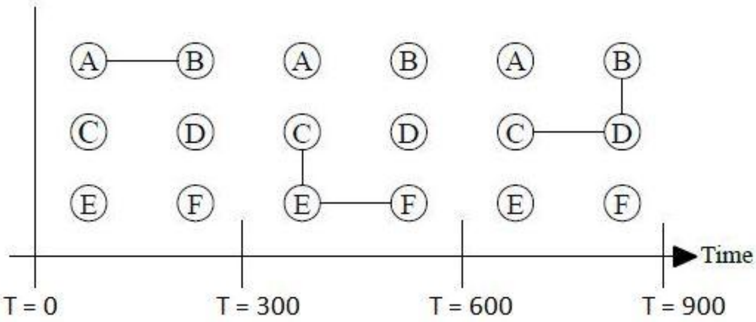


Fig.(a)Temporal Graph showing the sequence of edge connections

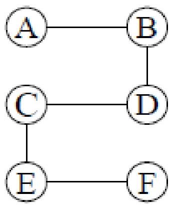


Fig. (b) Static graph constructed from Fig. (a)

Temporal Metrics[14][15]:

Temporal distance, temporal centrality and temporal diameter is important metrics that used to get dynamic properties of network

CHBR routing

Proposed protocol uses the occurrence of an opportunistic contact to calculate a Neighborhood Index and spread messages in a controlled manner. During the contact period, nodes first start the transmission of messages whose destination is the node that established the contact, then exchange information about the neighborhood (Neighborhood Index), and eventually forward other messages. The proposed routing protocol also uses the temporal distance and temporal diameter for efficient information diffusion.

The spread of the Neighborhood Index[10] allows a more accurate knowledge of network topology, which, inherently, aids the routing task. Although, to avoid unnecessary consumption of network resources, each node maintains a cache of neighbors it has contacted recently. Hence, nodes i and j can establish a new contact only after Tslot time slots (units of time) elapsed from the last contact between them, and if the Neighborhood Index table or message storage area (buffer) has changed

Neighborhood Index calculation

The Neighborhood Index is based on recent contact's history, in such a way that nodes that are frequent neighbors present a high Neighborhood Index.

. **Table 1: Neighborhood Index Parameters**

Parameter	Description
Contact(i,j)	Define the amount of time slots that i and j remained in contact
Hops(i,j)	Express the number of hops required for i to reach j
TS	Current time Stamp
ts_update(i,j)	Time stamp of the last route update from i to j
σ	Define the aging constant
ω	Weight applied to the known Neighborhood Index
N(i,j)	Neighborhood Index from i to destination j

CHBR Algorithm based on Neighborhood index

Input: Timewindow size, Weight function, aging constant
Output: Delivery ratio, Overhead Ratio, Message Drop Ratio
Definition: Overhead Ratio: (Relayed Message – Delivered Message) / Delivered Message
Algorithm Step:

1. Read the values of simulation time, time window size, aging constant and weight function.
2. If contact occurs ybetween i and j then
   a) If contact counter is zero then set Neighborhood Index

      N(i ,j) is 1.

   b) Otherwise

      Increment Neighborhood Index *N(i , j)* by 1.
3. Increment contact counter of node i and node j
4. For each message of node i do with each destination d
   a) If j is a not a destination (d)

      If *N(j , d)* >N(i ,d) then

      Compute distance matrix = *Hops (j, d) + 1* and

      Aging constant (σ) = Amount of Time slot j and d are not in radio range

$$N(i,d) = \frac{Contact(j,d)}{(Hops(j,d)+1) \times (TS - ts\_update + 1)^{\sigma}}$$

      Otherwise

$$N(i,d) = \frac{N(i,d) \times \omega) + N(i,d)}{\omega + 1}$$

   b) Otherwise, do not update Neighborhood index *N(i ,d)*
5. Repeat step 4 for node i = j and j = i

Computation of Time Window size

There are six nodes (1,2,3,4,5,6) in network, if we wish to calculate Time window then find the total contact duration of each pair and also count the number of connections in each pair.

Table 2: Computation of Time Window size[13]

Node ID	1	2	3	4	5	6	Total contact time / Total no of occurrences
1	0/0	480/2	720/3	480/2	960/4	480/2	3120/13
2	500/2	0/0	750/3	250/1	1000/4	500/2	3000/12
3	735/3	490/2	0/0	490/2	735/3	245/1	2695/11
4	235/1	940/4	1175/5	0/0	705/3	470/2	3525/15
5	1300/5	260/1	780/3	520/2	0/0	1040/4	3900/15
6	510/2	510/2	255/1	1530/6	1275/5	0/0	4080/16
$\frac{\sum T_{ij}(T_{min}, T_{max})}{\sum N_{ij}}$							20320/82
Time Window Size							247.80

Experimental Setup

We used ONE simulator [18] to evaluate our proposed protocol CHBR and generate message state reports of for specific scenario of simulation Performance evolution of CHBR is compared with existing epidemic and Prophet routing.

Objective for simulation: to measure delivery ratio and overhead ratio of our proposed protocols and existing routing protocol. Delivery Ratio is define as ratio of total numbers of created message by the number of successfully delivered messages and Overhead Ratio is define by Equ (i)

$$Overhead\ Ratio = \frac{Relayed\ Messages - Delivered\ Messages}{Delivered\ Messages} \quad .....(i)$$

Dataset Information

Dataset being downloaded from Community Resource for Archiving Wireless Data at Dartmouth[19] (CRAWDAD) is a wireless network data resource for the research community site. Synthetic data is generated on ONE simulator and make compatible with existing real dataset.

Table 3: Dataset

1.	***Name***	RollerNet-INFOCOM09
	Location	During roller tour in Paris
	Date	August 20, 2006
	Duration	3096 seconds
	Participants	63 people participated to the rollerblading Tour
	Address IDs	ID 27-51 (25 iMotes)Staff members ID 1-26 (26 iMotes)Skating associations ID 52-62 (11 iMotes)A set of friends
2.	***Name***	Synthetic Data Set (Generate using ONE Simulator)
	Duration	3096 Seconds
	Participants	63 Nodes
	Mobility Model	Random Way Point (RWP)
	Interface range	100 meters
	Address IDs	0 – 62

First the temporal metrics is evaluated using Networkx tool for rollernet and synthetic (RWP) dataset . The evaluated temporal metrics of dataset is given in table 4

Table 4 : Evaluated Temporal Metrics

Dataset Details	***Rollernet***	***Synthetic_63***
Tmin	0	0
Tmax	3096	3096
Total Nodes	63	63
Total Number of Contacts	2711107	576
Time Window Size	15	71

Total timestamps	207	44
Static distance	1.22	3.64
temporal distance	0.649	0.317
Diameter	2	6
Degree centrality	(51, 0.1)	(14, 0.29)
Betweenness centrality	(51,0.004)	(14, 0.65)
Clossness centrality	(51, 0.1)	(15,0.43)

Simulation Settings of CHBR Routing for all dataset is given in table 5

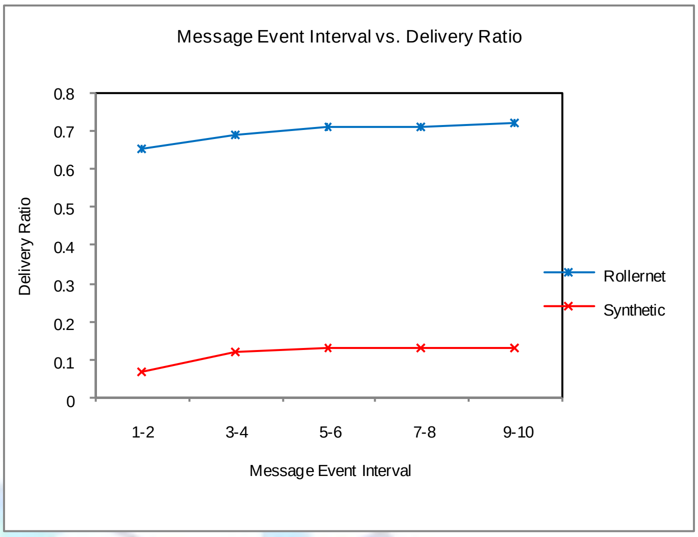
Table 5 : Simulation Settings of all dataset

Dataset	***Rollernet/Synthetic***
Scenario.simulateConnections	False
Scenario.updateInterval	1
Scenario.endTime	3096
Scenario.nrofHostGroups	1
Group.nodeLocation	10,10
Group.movementModel	StationaryMovement
Group.router	CHBR Router
Group.nrofHosts	63
Events.nrof	2
Events1.class	MessageEventGenerator
Events1.interval	1-2, 3-4, 5-6,7-8,9-10
Events1.hosts	0,62
Events2.class	ExternalEventsQueue
Events2.filePath	rollernet.dat / Synthetic.dat
UpdateInterval(window size)	15 / 71

Performance evolution with rollernet and synthetic dataset

Delivery Ratio

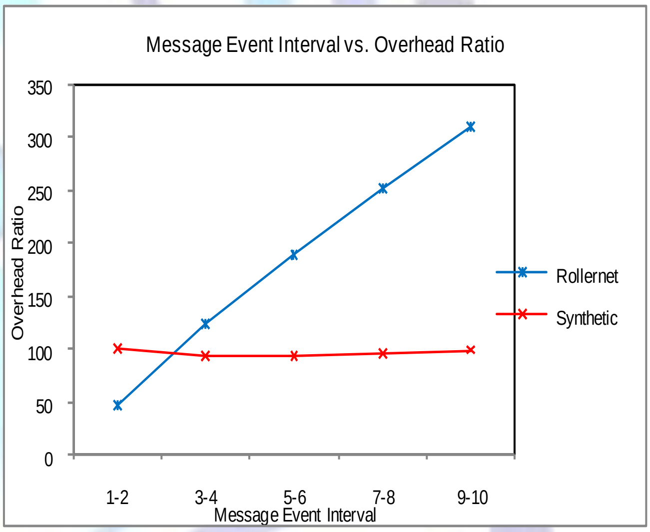
Message Event Interval	*No of Messages*	*Rollernet*	*Synthetic*
1-2	3096	0.65	0.07
3-4	1032	0.69	0.12
5-6	619	0.71	0.13
7-8	442	0.71	0.13
9-10	344	0.72	0.13



In Synthetic dataset, number of connection edge is less due to randomize behavior of mobility model (RWP), also the contact period is very short, thus it impacts the delivery ratio compared to rollernet dataset with CHBR Routing.

Overhead Ratio:

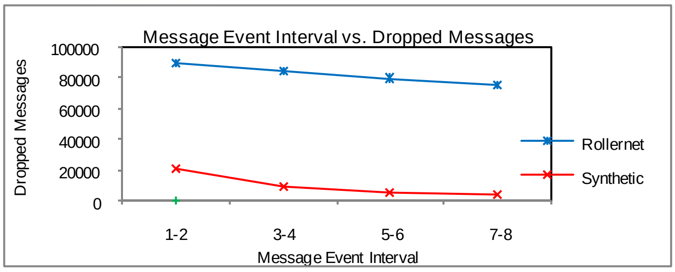
Message Event Interval	*No of Messages*	*Rollernet*	*Synthetic*
1-2	3096	45.39	100.81
3-4	1032	124.2	93.65
5-6	619	189.85	93.02
7-8	442	252.68	96.42
9-10	344	311.35	99.35



In rollernet traces are for short duration and Neighborhood index is higher compared to RWP. Thus, CHBR drops more messages for rollernet. This leads to higher overhead compared to RWP.

Dropped Messages:

Message Event Interval	*No of Messages*	*Rollernet*	*Synthetic*
1-2	3096	89975	20383
3-4	1032	85051	8958
5-6	619	80476	4879
7-8	442	76204	3242
9-10	344	73799	2289

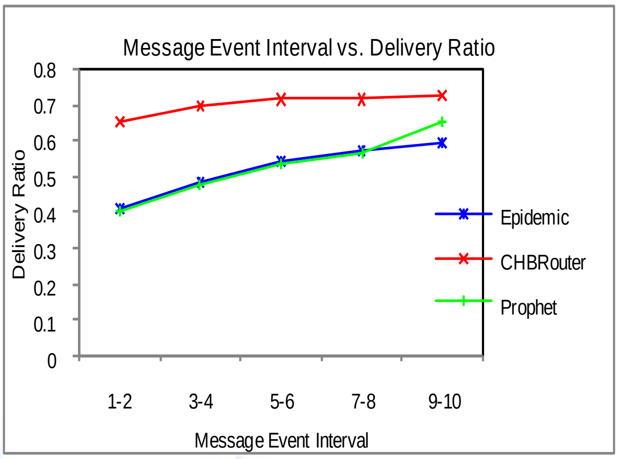


In Synthetic dataset, the number of connection edges is less due to randomize behavior of mobility model (RWP), also the contact period is very short. This leads to a lower node degree and in turn number of messages dropped for RWP compared to rollernet.

Performance evolution of CHBR with other routing

Delivery Ratio:

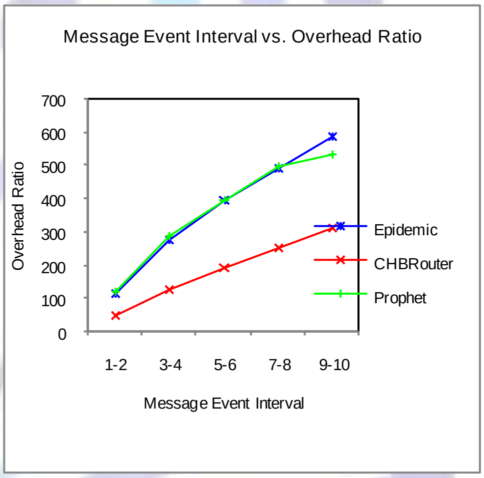
Message Event Interval	*No of Messages*	*Epidemic*	*CHBRouter*	*Prophet*
1-2	3096	0.41	0.65	0.40
3-4	1032	0.48	0.69	0.47
5-6	619	0.54	0.71	0.53
7-8	442	0.57	0.71	0.56
9-10	344	0.59	0.72	0.65



CHBR outperforms Epidemic and PROPHET due to the fact that the epidemic is a pure replication based technique. Thus, it drops the messages at relay nodes. PROPHET forwards the message copies based on probability and transitivity. It checks for contact probability values of all nodes in range and selects the node with high value. Thus, leads to poor delivery ratio compared to CHBR.

Overhead Ratio:

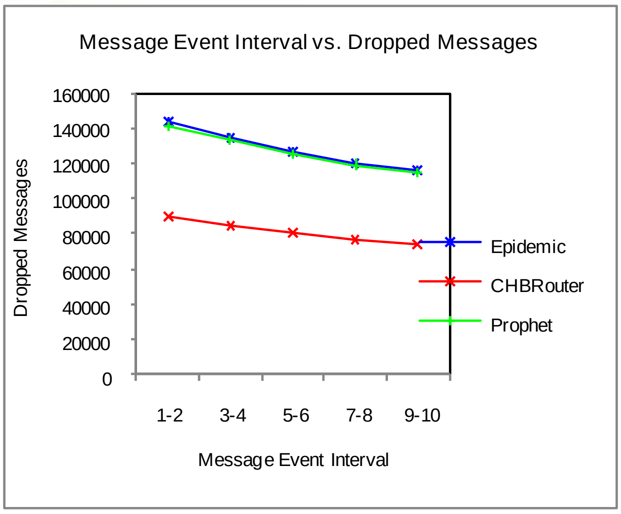
Message Event Interval	*No of Messages*	*Epidemic*	*CHBRouter*	*Prophet*
1-2	3096	114.26	45.39	114.75
3-4	1032	276.34	124.2	281.74
5-6	619	392.9	189.85	396.37
7-8	442	489.88	252.68	496.29
9-10	344	586.13	311.35	532.76



CHBR has lowest overhead due to selection of relay node based the higher neighborhood index. Thus, it spreads less number of copies into network compared Epidemic and PROPHET. This results into lower overhead ratio.

Dropped Messages:

Message Event Interval	*No of Messages*	*Epidemic*	*CHBRouter*	*Prophet*
1-2	3096	144387	89975	141127
3-4	1032	135036	85051	133342
5-6	619	126915	80476	125768
7-8	442	119773	76204	120025
9-10	344	115864	73799	115686



Epidemic is a pure replication based technique. It floods the network with message copies. Thus, it drops the messages at relay nodes. PROPHET forwards the message copies based on probability and transitivity. Though numbers of copies are flooded by PROPHET is more compared to CHBR, resulting in higher message drops.

Conclusion

CHBR uses a neighborhood index technique for forwarding the message copies. It does base on time intervals. This resulted into accurate information regarding per node neighbor's compared to similar probability based protocols. It has been further extended for suitable integration of drop policy-MOFO. It keeps track of forward count of messages per relay node. MOFO selects candidate for drop messages with highest forward count. Thus, it helps in reducing the overhead and improving the delivery ratio

AKNOWLEGDEMENT

We express our sincere gratitude to the management of Ganpat University – Mehsana for providing us research opportunities and their wholehearted support for such activities. Finally, our acknowledgement cannot end without thanking to the authors whose research papers helped us in making this research.

REFERENCES

[1] F. Warthman, Delay Tolerant Networks (DTN), *prius.ist.osaka-u.ac.jp*, no. March, 2003.

[2] T. Spyropoulos, K. Psounis, and C. S. Raghavendra, Efficient Routing in Intermittently Connected Mobile Networks: The Multiple-Copy Case, *IEEE/ACM Transactions on Networking*, vol. 16, no. 1, pp. 77–90, Feb. 2008.

[3] E. P. C. C. Jones, L. Li, P. A. S. S. Ward, and J. K. Schmidtke, Practical Routing in Delay-Tolerant Networks, in *Proceeding of the 2005 ACM SIGCOMM workshop on Delay-tolerant networking - WDTN '05*, 2005, vol. 6, no. 8, pp. 943–959.

[4] A. Lindgren, A. Doria, and O. Schelén, Probabilistic routing in intermittently connected networks, *ACM SIGMOBILE Mobile Computing and Communications Review*, vol. 7, no. 3, Jul. 2003.

[5] C. E. Perkins and E. M. Royer, Ad-hoc on-demand distance vector routing, in *Mobile Computing Systems and Applications, 1999. Proceedings. WMCSA '99. Second IEEE Workshop on*, 1999, pp. 90–100.

[6] D. B. Johnson and D. A. Maltz, Dynamic source routing in ad hoc wireless networks in *Mobile Computing*, 1996, pp. 153–181.

[7] J. Burgess, B. Gallagher, D. Jensen, and B. N. Levine, MaxProp: Routing for Vehicle-Based Disruption-Tolerant Networks, in *Proceedings IEEE INFOCOM 2006. 25TH IEEE International Conference on Computer Communications*, 2006, pp. 1–11.

[8] A. Vahdat and D. Becker, Epidemic Routing for Partially Connected Ad Hoc Networks. 2000.

[9] Amin Vahdat and David Becker, Epidemic Routing for Partially Connected Ad Hoc Networks, *Tech. Rep. CS-200006*, 2000.

[10] E. C. R. de Oliveira and C. V. N. de Albuquerque, NECTAR: a DTN routing protocol based on neighborhood contact history in *Proceedings of the 2009 ACM symposium on Applied Computing*, 2009, pp. 40–46.

[11] J. Tang, M. Musolesi, C. Mascolo, V. Latora, and V. Nicosia, Analysing information flows and key mediators through temporal centrality metrics, in *Proceedings of the 3rd Workshop on Social Network Systems*, 2010, pp. 3:1–3:6.

[12] J. Tang, M. Musolesi, C. Mascolo, and V. Latora, Characterising temporal distance and reachability in mobile and online social networks, *SIGCOMM Comput. Commun. Rev.*, vol. 40, no. 1, pp. 118–124, Jan. 2010.

[13] V. Patel and H. Shah, Characterization & Evaluation of Temporal Metrics and Information Diffusion in Delay Tolerant Network, Ganpat University, 2012.

[14] J. Tang, M. Musolesi, C. Mascolo, and V. Latora, Characterising temporal distance and reachability in mobile and online social networks, *ACM SIGCOMM Computer Communication Review*, vol. 40, no. 1, Jan. 2010.

[15] A. Casteigts, P. Flocchini, W. Quattrociocchi, and N. Santoro, Time-Varying Graphs and Dynamic Networks, *CoRR*, Nov. 2010.

[16] J. Tang, M. Musolesi, C. Mascolo, and V. Latora, Temporal distance metrics for social network analysis, in *Proceedings of the 2nd ACM workshop on Online social networks*, 2009, pp. 31–36.

ISSN 2277-3061

[17] M. E. J. Newman, A measure of betweenness centrality based on random walks, *Social Networks*, vol. 27, no. 1, pp. 39–54, 2005.

[18] A. Keränen, T. Kärkkäinen, and J. Ott, Simulating Mobility and DTNs with the ONE (Invited Paper), *Journal of Communications*, vol. 5, no. 2, pp. 92–105, Feb. 2010.

[19] CRAWDAD: A community resource for archiving Wirelessdata at dartmouth. .

Author' biography with Photo

Pravesh Patel has done B.E Computer engineering in year 2006 and M. Tech Computer Engineering in year 2013 from Ganpat University. Currently he has working as assistant professor at U.V. Patel College of Engineering, Ganpat University, having 6 years of teaching experience.

Hemal Shah is Ph.D. Scholar of Ganpat University, Gujarat India. He has done B.E. in year 1999 and M.E. Computer Engineering in year 2007 from DDIT Nadiad. Currently he has working as assistant professor at U.V. Patel College of Engineering, Ganpat University, having 12 years of teaching experience. He has carried out his PG- dissertation at Space application centre, Ahmadabad on TCP Performance Enhancing Proxies [PEP] for satellite links.

Yogeshwar Kosta is Professor and Director at Marwadi Education Foundation, Rajkot, Gujarat India. He has around 20 years of experience in Academic Teaching, Consultancy, Research and development in the field of Satellite Communications, RF and Microwave and Wireless Communications. He has worked as scientist at Space application centre, Ahmadabad around 8 years and Design and development of Ku-Band (Receiver) payload for the