J Electr Eng Technol Vol. 8, No. 3: 649-657, 2013
http://dx.doi.org/10.5370/JEET.2013.8.3.649

ISSN(Print) 1975-0102
ISSN(Online) 2093-7423

Connection Frequency Buffer Aware Routing Protocol for Delay Tolerant Network

Qaisar Ayub†, M soperi Mohd Zahid*, Abdul Hanan Abdullah* and Sulma Rashid*

Abstract – DTN flooding based routing protocol replicate the message copy to increase the delivery like hood that overloads the network resources. The probabilistic routing protocols reduce replication cost by forwarding the message to a node that holds high predictability value to meet its destination. However, the network traffic converges to high probable nodes and produce congestion that triggers the drop of previously stored messages. In this paper, we have proposed a routing protocol called as Connection frequency Buffer Aware Routing Protocol (CFBARP) that uses an adaptive method to maintain the information about the available buffer space at the receiver before message transmission. Furthermore, a frequency based method has been employed to determine the connection recurrence among nodes. The proposed strategy has performed well in terms of reducing message drop, message relay while increases the delivery probability.

Keywords: Store-carry-forward, Routing protocols, Delay Tolerant Network, Algorithm

1. Introduction

The Ad-hoc routing protocols assumes the existence of end-to-end path, small link and node failure before the start of communication. This affection is not applicable in environments such as satellite communication, wildlife monitoring, military and sensor network where an end-to-end path is highly unstable and may change or break soon after it has been discovered. More precisely the reactive protocols may not be able to find the complete end-to-end path while proactive protocols will not be able to maintain the routing tables.

Delay Tolerance Network (DTN [6]) provides the communication architecture in situations where con-nectivity among nodes is intermittent and/or disrupted due to dynamic topology change, network partitioning, node mobility and short transmission range. As a result, source and destination cannot sustain the uninterrupted end to end connectivity and connections between nodes are provisional. The DTN protocols use short-term end-to-end connectivity and transmit a message over existing links by adopting a paradigm called as store-carry and forward. Accordingly, each node stores the incoming message in its buffer, carries it while moving and forward when comes within the communication range of other nodes. This hop by hop transmission continues until the message reaches its destination.

The DTN routing protocols can be classified into the single copy [2] and multi copy [3]. In single copy routing protocols, the node generates the unique copy of message and transmits it along a single path. These protocols minimize the consumption of network resources. However suffers unbounded delivery delay and least delivery ratio. The multi copy routing protocols diffuse the redundant copies of each message along dissimilar paths. For example, the Epidemic [4] protocol performs the pair wise exchange of messages on each encounter. Despite the message have several paths to reach destination, the expenditure of high volume of network resources such as buffer space, node energy and bandwidth makes Epidemic protocol insubstantial for real time applications.

The resource disbursement can be controlled by limiting the number of message replicas. This initiates the era of quota based routing protocols [5-7] where each node was given the quota to transmit ‘N’ number of message copies. For instance, in spray&wait [5], a node starts by forwarding ‘N’ message copies across its neighbors. This is referred as spray phase. If destination is not found in the spray phase then each node is allowed to deliver the message directly to its destination. Spray&Focus [6] extends spray&wait algorithm by converting the wait phase into focus. Hence, the spray phase remains same while the focus phases forward the message by computing the utility value.

The quota based protocols restrict the message copies to a fixed limit, however does not take the benefit of important factors such as movement pattern, mobility and contact history of nodes that can improve the forwarding decision [8-11].

In [8] A. Linger et.al. proposed probabilistic routing protocol (PRoPHET) that computes the metric of delivery predictability for each known destination. The node forwards the message only if the predictability value of

† Corresponding author: Depart of computer science, Faculty of com-puterscience and information system, UTM Malaysia (sheikhqaisar @gmail.com).
* Depart of computer science, faculty of computer science and information system UTM Malaysia. ({soperi, hanan}@utm.my, sulmaqaiser@gmail.com).
Received: June 5, 2012; Accepted: December 26, 2012

encountering node is higher than its own. In [11] Rugved jathar et.al. proposed PROCS routing protocol that forwards the message by studying the movement pattern of contacts and their time sequence. NECTAR [12] routing protocol utilize the previous history of connections in terms of neighbor hood index. This index is determined by the frequent contact of nodes with each other.

Despite, an accurate forwarding decision can increase the delivery ratio, it is also important to examine the capability of the encountered nodes to carry the transmitted message. For instance, if a node 'Nj' keeps high predictability value to meet destination of the message 'M' but does not have enough buffer space to accommodate it, then forwarding the message to 'Nj' will results in the drop its previously stored messages.

The message drops reduce the delivery ratio because the node 'Nj' was carrying the dropped messages due to its better probability to meet their destinations. As there exists multi copies of each message, the node 'Nj' due to its optimal predictability can reputedly receive the dropped messages from the other parts of the network and originate the high number of transmissions.

In this paper, we have proposed a routing protocol called as the Connection frequency buffer aware routing protocol (CFBARP) for delay tolerant network. protocol forwards a message by computing the frequency of connection. In addition, before transmitting the message the sender node keeps the track of available buffer space of the receiver. The experiment proves that the proposed CFBaRP is better as compared to PRoPHET and Epidemic protocol in terms of increasing delivery ratio and minimizing message drop and number of transmissions.

The remainder of paper is organized as follows. Sections 2 discuss motivation; section 3 discovers the proposed protocol. Section 4 is about the simulation results and performance metrics with the conclusion in Section 5.

2. Motivation

In General, a network is poised three types of nodes, Static, Partially static and Active. The static node(s) does not change their location and sustain the constant positional coordinates similar to throw boxes [14] and base stations. The partial stationary nodes move across the network for the specific time intervals for example people go for office, take afternoon lunch and evening come back to home at around the same time.

The active node belongs to the class of mobile terminals that travels very fast and rapidly changes their positional coordinates. Active nodes remains in the moving stage, thus subject to the high number of encounters. Hence, the probabilistic protocols can exploit such nodes to carry the network traffic across the disconnected part of the network. However, under the limited network resources such as buffer space, such nodes may not be able to hold the message for longer duration of time.

In the next part we will discuss the problems in the existing probabilistic routing protocol.

2.1 Additional computational resources

In PRoPHET routing protocol, each node encounter performs the predictability, aging and transitivity computations. The aging and transitivity are suitable for sparse nodes. However, when the node encounter is frequent then aging and transitive computation does not have significant effect on the forwarding decision. The reason is that, nodes show minimum aging and transitive values at frequent encounters.

2.2 Increased number of transmissions

As in PRoPHET routing protocols, the process of maintaining the delivery predictability depends on the history of node encounters. Hereby, the active node due to its higher encountering rate will hold the predictability about all on the way terminals. As a result, these nodes become extremely convenient to receive the traffic flow from multiple relays. This convergence of traffic is beatable with infinite buffer space. Nevertheless, the DTN is the resource constrained environment with limited buffer. Therefore, when message size is larger compared to available buffer space then node triggers the drop event on the previously stored message. Since PRoPHET is a multi copy routing protocol, therefore the same node can receive the dropped message from the other parts of the network.

2.3 Rampant message drop effect the deliver ratio

Since a node under PRoPHET routing strategy receive and carry the messages due to its better predictability value to meet their destinations. However, when a node forward the message to a highly probable node suffering congestion then such forwarding decision will results in the drop of its previously stored messages. These drops reduce the delivery ratio because the dropped message has lost their opportunity to be delivered. We cannot remove the drop event, however minimizing its impact can improve the network throughput.

Table 1. Symbol and Meanings

Symbol	Meaning
B_A	Available buffer
M	Message
M_{size}	Message size
B_U	Used buffer
C_{buffer}	Current buffer
EOQ	End of queue

3. Connection Frequency Buffer Aware Routing Protocol

3.1 Terminology

When two nodes come in contact they exchange the count of their buffered messages termed as the volume index. The node with high volume index will become the transmitter and titled as Initiator. When nodes have the same volume index then either node has the equal probability to become as Initiator.

The receiving node will be termed as active. A node is said to be active if it is not busy in communicating with its neighbors. At any time instance there can be one initiator and one active

The Initiator node iterates its buffered message one at a time and forwards it by validating algorithm.

Fig. 1 represents 'A' as Initiator while 'X' as the active node. .For subsequent encounters of 'A' with 'Z' or 'N' the decision of the initiator will be based on the volume index.

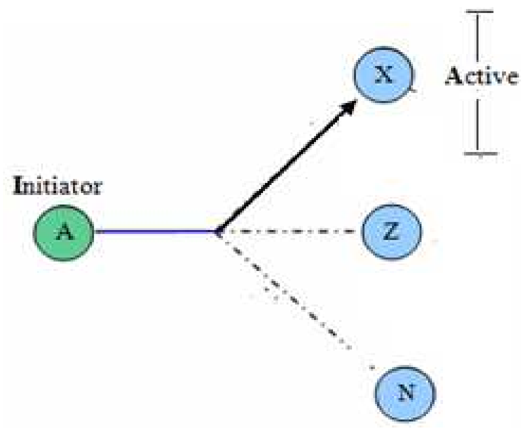

Fig. 1. The initiator 'A' is communicating with active node 'X' while 'Z' and 'N' are the next encountering nodes.

3.2 DTN node configuration

We have considered the pedestrians, cars, bus, and trains as DTN nodes. These nodes can communicate each other when comes in contact. A contact is said to be happened when nodes are in the communication rage of each other. The nodes do not have the prior information about the future availability of contacts. The node behavior is hybrid meaning that it can generate its own traffic; forward carried message and receive the transmissions from other contacts.

Each node will maintain Frequency Vector (FV) , Recent Encounter Vector and Buffer for Incoming messages. The Recent Encounter V**ector (REV) consists** of node id (Nid) and Encounter Time (ET). The frequency vector consists of node id (Nid), Frequency Value (Fv). Each node has been equipped with finite buffer to store the incoming messages.

3.3 Frequency computation

In a complete random movement, the nodes do not exhibit a symmetrical movement pattern. However, in most of the real time scenarios, we can observe a specific movement pattern of mobile nodes. For example, a city train moves on a pre-defined path and reputedly encounters with on the way buildings, shopping malls and crosses various junctions. In this way, the frequency at which it connects with these objects becomes higher. We can take the advantage of these encounters by forwarding the message to a node that has higher encounter frequency to meet its destination.

The proposed connection frequency buffer aware (CFBARP) routing protocol utilizes the encounter frequency to determine the connection recurrence among nodes.

The **Rule:1** of the algorithm states that

> "When the node 'A' and 'B' comes in contact, they first update their frequencies based on the previous frequency value of frequency vector (FV) and Encounter Time (ET) of Recent Encounter Vector (REV) ".

Each network node maintains the frequency information about the nodes in a vector named as Frequency vector (FV). The nodes initialize or decrease the frequency values by using equation 1.

$$F(A,B)_{new} = ABS\,[FV(A,B)_{previous} - (ABS(LOG(1-FV(A,B)_{previous})\hat{}\ ET(A,B))*\ \infty)] \qquad (1)$$

Hence, FV (A B,) $_{previous}$ is earlier frequency, ET (A, B) is the time passed since nodes last saw each other. For the first-time encounter, ET (A, B) is initialized to the current time, $F(A,B)_{previous}$ is set to zero and parameter ∞ initializes the frequency. For the subsequent encounters, the parameter ∞ reduces the frequencies based on the Encounter Time (ET) and $FV(A,B)_{previous.}$

3.4 Rule 2: Relay the message by adaptive computing of available buffer

Since, a transmitted message consumes the energy of sender, bandwidth of network and buffer space of the receiver. Hereby, the network throughput severely suffers when the receiving node drops its previously stored messages due to the lack of available buffer space. Thus, we need a strategy that forwards the message by utilizing the frequency of node encounters and also consider the available buffer space of the receiver.

The **Rule:2** states that

> "The Initiator 'A' will forward 'M' to 'B' only if 'B' has high frequency to meet with the destination of 'M' and current available buffer (BA) at 'B' is greater than the Message size".

This part of algorithm works in the adaptive way to manage the transmissions as well as the buffer of the current connected node. The Initiator 'A' computes the available buffer of active node 'B' by using equation 2 and stores this value in its variable called as current buffer C_{buffer} (B).

$$C_{buffer}(B) = \text{Total Buffer (B) - Used Buffer (B)} \quad (2).$$

The initiator 'A' forwards the message only if C_{buffer}(B) is greater than message size. After transmission, the initiator will subtract the M_{size} from the C_{buffer} (B) of 'B' by using equation 3.

$$C_{buffer} = C_{buffer}(B) - M_{size} \quad (3).$$

Hereby, the C_{buffer} (B) provides the storage capability of the active node. The initiator will not forward the subsequent messages if C_{buffer} (B) is less than the Message size. This will prevent the transmission of messages on the congested nodes and reduce the number of message drops.

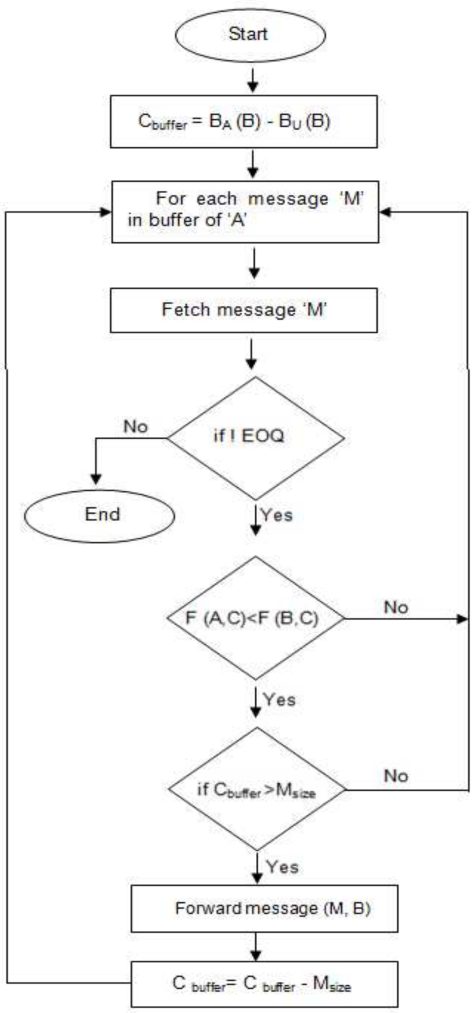

Fig. 2. Flow chart Connection Frequency Buffer Aware Routing Protocol

3.5 Example

Fig. 3, describes a sample scenario where the node A and B by carrying the messages has formulated the intermittent connectivity. We have considered 'A' as initiator and B as the active node. The buffer size at each node is fixed as 1000KB.

For each message, the initiator 'A' will compare the frequency value of 'B' to meet 'M1' destination then its own. As, the frequency of 'B' to meet destination of 'M82' is greater than 'A' i.e. F(B,C) > F(A,C). Hence, despite forwarding, 'A' will compute the available buffer at 'B' by using equation 2 and store it in its local variable C_{buffer}(B) .

C_{buffer}(B)= (1000KB)- (535KB) = 465KB

Since, the C_{buffer}(B) > $M82_{size}$ therefore 'A' forward the message to 'B' and subtract its size from C_{buffer}(B) by using equation 3.

$$C_{buffer}(B) = 465KB - 320KB = 145KB$$

As, the frequency of 'B' to meet destination of message 'M51' is high compared to A. However, according to rule 2 the Msize > C_{buffer}(B) therefore, no transmission will occur.

In this way, the message will not be replicated on the congested nodes and will prevent the message drop.

Message	Size	Destination
M82	321KB	C
M51	214KB	C
B_A = 465KB		

FV_B

Node	Frequency
C	0.63
O	0.31
X	0.30
N	0.40

FV_A

Node	Frequency
C	0.23
X	0.31
B	0.30
A	0.40

Message	Size	Destination
M1	320KB	C
M51	512KB	C
B_A = 465KB		

Fig. 3. Message exchange using connection frequency buffer aware routing protocol

4. Simulation and Results

This section provides the performance comparison of existence and the proposed Connection Frequency Buffer Aware Routing Protocol with performance metrics mentioned in section 3.6. The extensive simulations were performed by varying different parameters such as the number of nodes, buffer size, and message size under ONE simulator. ONE is a discrete event simulator written in JAVA and have been massively used by various researchers to measure the statistics of disrupted store-carry-forward applications.

4.1 Simulation settings

The simulation parameters have been divided into two categories Fixed (F) and Variable (V). The fixed parameters remain constant throughout the experiment while variable parameters are different for each scenario under evaluation.

Table 2 shows the fixed simulation parameters that consist of three major population groups, i.e. pedestrian (P) , cars (C) and Trains (T). The pedestrians are moving with the shortest path map based movement (SPMBM) model at the speed of 0.5km/h to 1.5 km/h with transmission range of 10meters. One group of cars is moving via map route movement (MRM) at speed of 10km/h-50km/h. One group of trains are moving with map route movement (MRM) at speed of 7km/h-10km/h with storage capacity of 50M. The message creation interval is 25s-35s. The bandwidth is equally distributed at 2 MBPS.

Table 2. Fixed simulation parameters

Groups	Value	Movement Model	Speed
Pedestrians	2	SPMBM	0.5km/h – 1.5 km/h
Cars	1		10 km/h - 50km/h
Train	3	MRM	
Transmission Range		10meters	
Message Creation Interval		25s – 35s	
Simulation Area		4500 m * 3400m	

4.2 Performance metrics

Number of transmissions

The number of transmissions is the enumeration of messages forwarded by the nodes. As, the transmitted messages consume the energy of sender, buffer space of receiver and bandwidth of network. Therefore, the objective of routing protocol is to minimize the number of transmissions.

Message Dropped

The message drop metric is the count of messages dropped by the nodes. The message drop reduces the delivery ratio because a dropped message lost its opportunity to be delivered. Therefore, the objective of routing protocol is to minimize drop magnitude.

Delivery predictability

The delivery probability measures the successful transmission of messages to their destinations. This metric measure the overall network throughput as more messaged deliver to destination shows the optimal use of network resources. Thus, the objective of routing protocol is to increase the delivery ratio.

4.3 Scenario 1 by increasing buffer size

In the section we have configured the simulation scenario by changing the buffer size with parameters specified in Table 3.

Table 3. Simulation parameters by changing buffer size

Parameter	Type: Variable	Type: Fixed	Group	Setting	Increment
Buffer	√		P	2M	0.1M
	√		C	2M	
		√	T	50M	Null
Message Size		√	500k-1MB		Random size
No of nodes		√	P	80	Nil
		√	C	40	
		√	T	6	

Fig. 4, provides the comparison of existing PRoPHET, Epidemic and proposed connection frequency buffer aware routing protocol (CFBARP) by varying the storage capacity of nodes. The Epidemic protocol has performed high number of transmissions because each encounter among node results in exchange of messages.

The PRoPHET protocol has fewer transmissions then Epidemic. The reason is that the PRoPHET protocol forwards the message copy only to the high probable nodes.

The proposed CFBARP on average has reduced 92% transmission compared to Epidemic and 90% for PRoPHET routing protocol.

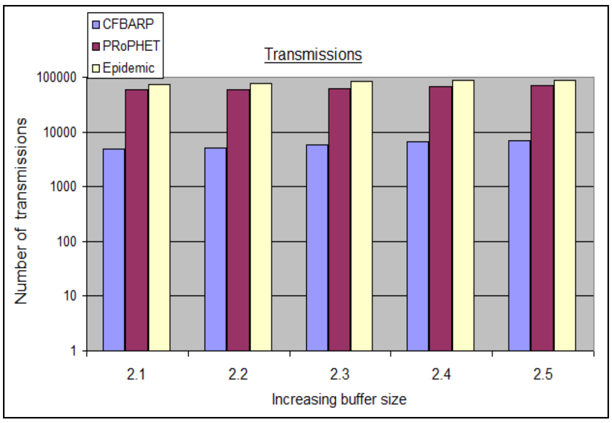

Fig. 4. Number of transmissions by increasing buffer size of nodes

Fig. 5 evaluates the performance of existing and proposed routing strategies in the context of delivery probability. In conjunction to bandwidth, battery power and mobility, the successful delivery of the message also depends on storage capacity.

We can see that under small buffer sizes such as [2.1M], [2.3M] Epidemic protocol has performed poorly. The reason is that the blind flooding produce congestion and messages were dropped before reaching their destinations. However, with the increase in storage capacity like [2.4M], [2.5M] message stayed in the buffer for long durations and results in the high delivery ratio.

The PRoPHET protocol with small buffer capacity like [2.1M], [2.2M] performs better and delivered more messages then the Epidemic protocol.

The proposed CFBARP delivers 47% more messages then Epidemic and 31% to PRoPHET routing protocol.

Fig. 6 provides the comparison of message drop for existing Epidemic , PRoPHET and proposed CFBARP. In Epidemic routing protocol the nodes rapidly get congested and drop more messages.

The PRoPHET protocol due to its controlled replication has dropped fewer messages then Epidemic protocol. However, its drop magnitude is high compared to CFBARP. The reason is that in PRoPHET Protocol, a high probable node receives the traffic flow from multiple sources and cannot accommodate traffic due to the lack of buffer space. This triggers the drop of its previously stored messages. However, the same high probable node rampantly receives the dropped messages from the other parts of network thus cause cyclic drop and re transmissions.

The proposed CFBARP has **r**educed 90% message drop compared to Epidemic and 87% for PRoPHET routing protocol.

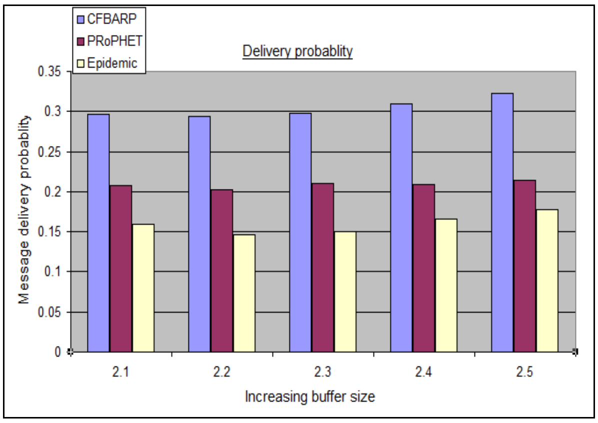

Fig. 5. Message delivery by increasing buffer size of nodes

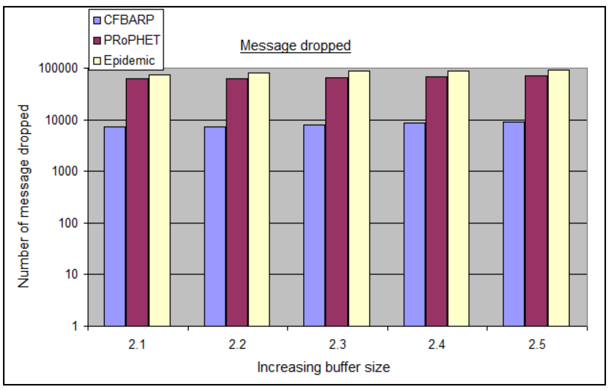

Fig. 5. Message drop by increasing buffer size of nodes

4.4 Scenario 2: Increasing message size ranges

In the section, we have configured the simulation scenario by changing the message size ranges. A message size range is a random integer value generated from sample space (x,y). The detailed parameters have been specified in Table 4.

Fig. 7 portrays the comparison of existing and proposed routing protocols in context of message transmissions. We can observe the high number of transmissions at the range of [500K-1MB]. The reason is that the small size messages require less bandwidth and transmission time, thus, fertilize the network more rapidly. However, with the increase in the message size range, for instance, [600K-1MB], [700K, 1MB], [800K, 1MB] and [900K, 1MB] all routing protocols begin to perform fewer transmissions. The reason is that the small numbers of the large size message were generated. The proposed CFBARP on average has reduced

Table 4. Simulation parameters by changing message sizes

Parameter	Type		Group	Setting	Increment
	Variable	Fixed			
Buffer		√	P	2M	Null
		√	C	2M	
		√	T	50M	
Message Size		√	500KB-1MB		100KB
No. of nodes		√	P	80	Null
		√	C	40	
		√	T	6	

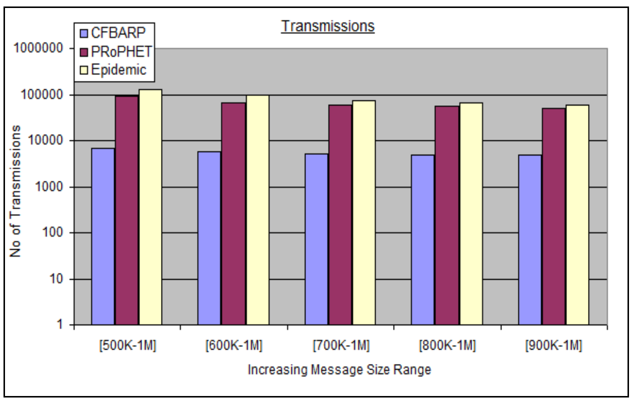

Fig. 7. Number of transmissions by increasing message sizes ranges

93% transmission compared to Epidemic and 91% for PRoPHET routing protocol.

Fig. 8 shows the comparisons of message drop for existing and proposed routing protocol by changing the message size ranges. High message drops have been observed at the message ranges such as [500K-1M] and [600K-1M]. The reason is that the small size messages infect the network nodes more rapidly, produce congestion that results in the drop of previously stored messages. The proposed CFBARP has reduced 93% message drop for Epidemic and 91% for PRoPHET routing protocol.

Fig. 9 shows the performance of existing and proposed CFBARP in terms of delivery probability. We can observe that all routing protocols have delivered more messages within the range of [100K-600K]. The reason is that the small size messages find their destinations more rapidly. However, with the increase in the message size range such as [600K-1M],[700K-1M] fewer transmissions reached to the destination. In addition, this ratio gets lower at [800K-1M] and [900K-1M]. The reason is that at this stage, the small numbers of large-size messages were generated for the small number of destinations. The proposed CFBARP delivers 48% more messages then Epidemic and 21% to PRoPHET routing protocol.

The proposed CFBARP Has reduced 90% message drop compared to Epidemic and 92% for PRoPHET routing protocol.

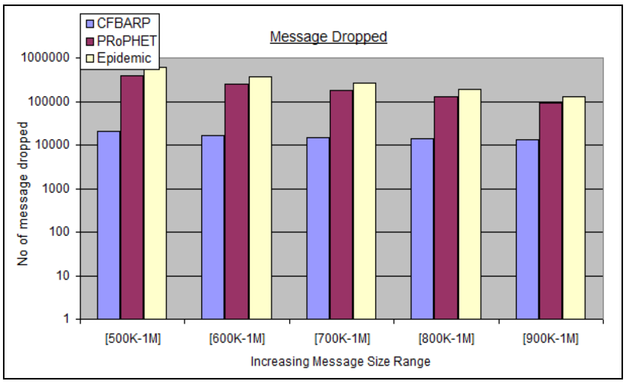

Fig. 8. Message drop by increasing message size range

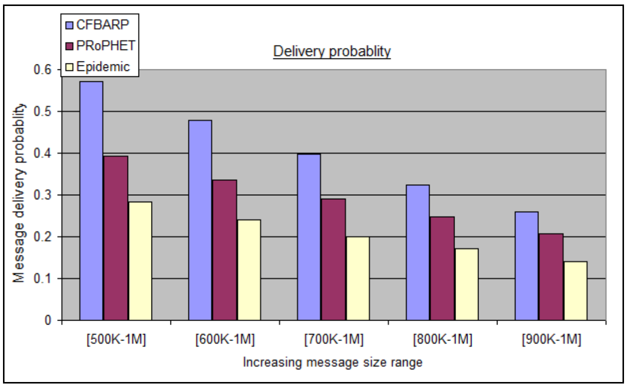

Fig. 6. Message delivery by increasing message size range

4.5 Scenario 3: Increasing number of nodes

In this simulation scenario, we have changed the simulation parameters by changing the number of nodes with an increment of 15 nodes in pedestrian (P) and car (C). The detailed parameters have been specified in Table 4.

Fig. 10 manipulates the results for proposed and existing protocols in context of message transmissions. We can observe that message transmission rate gets higher by increasing the node density. The reason is that, the encounter rate gets higher that produce high volume of

Table 5. Simulation parameters by changing number of nodes

Parameter	Type		Group	Setting	Increment
	Variable	Fixed			
Buffer		√	P	2M	Null
		√	C	2M	
		√	T	50M	
Message Size		√	500KB-1MB		Null
No. of nodes		√	P	40	15
		√	C	20	15
		√	T	6	Null

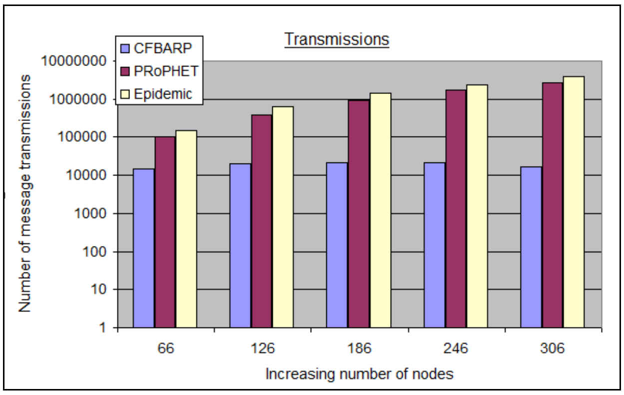

Fig. 10. Number of message transmission by increasing number of nodes

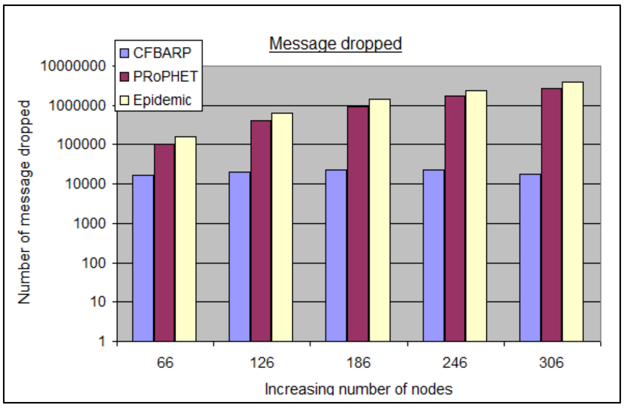

Fig. 7 Number of message drop by increasing no of nodes

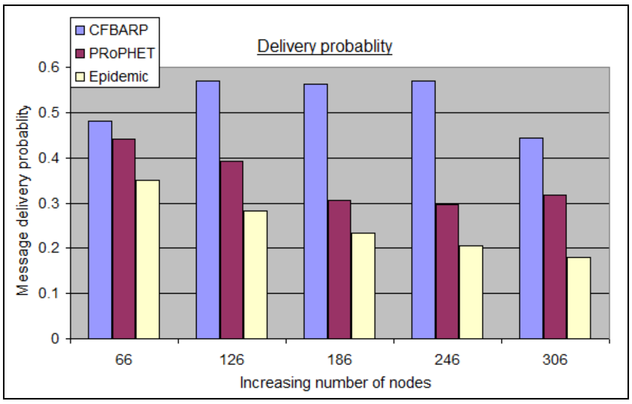

Fig. 12. Message delivery probability by increasing number of nodes

message exchange. The proposed CFBARP on average has reduced 98% transmission compared to Epidemic and 97% for PRoPHET routing protocol.

Fig. 11 represents the results of message drop for existing and proposed CFBARP by increasing number of nodes. The proposed CFBARP has reduced 96% message drop for Epidemic and 94% for PRoPHET routing protocol.

Fig. 12 presents the metric of delivery probability for existing and proposed routing protocols. The proposed CFBARP delivers 51% more messages then Epidemic and 32% for PRoPHET routing protocol.

5. Conclusion

In this paper, we have proposed a routing pro called as the connection frequency buffer aware routing (CFBARP) for Delay Tolerant Network. The proposed method has jointly considered the connection frequency and availability of buffer space to determine the suitability of a node to deliver the message. If current connection holds the high frequency value to meet the message destination but does not have enough buffer space to carry it, then no transmission will occur. The simulation results have proven that the proposed strategy reduces the message drop, number of transmissions and increases the delivery ratio.

Acknowledgements

This work was supported by Scholarship provided by UTM and Ministry of Higher Education Commission of Malaysia.

References

[1] Kevin Fall, Stephen Farrell.DTN: an architectural retrospective, *IEEE Journal on Selected Areas in Communications*, Vol. 5, No. 56, pp. 828-836, 2008.

[2] Thrasyvoulos Spyropoulos, Konstantinos Psounis, Cauligi S. Raghavendra, Single- Copy Routing in Intermittently Connected Mobile Networks. *SECON'04.* pp. 235-244, 2004.

[3] Thrasyvoulos Spyropoulos, Konstantinos Psounis, Cauligi 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, 2008.

[4] Vahdat, A., & Becker, D., Epidemic routing for partially connected ad hoc networks. *Duke University, Tech. Rep*, 2008.

[5] Thrasyvoulos Spyropoulos, Konstantinos Psounis, Cauligi S. Raghavendra, Spray and wait: an efficient routing scheme for intermittently connected mobile networks. *WDTN '05*, 2005.

[6] Thrasyvoulos Spyropoulos, Konstantinos Psounis, Cauligi S. Raghavendra, Spray and Focus: Efficient Mobility-Assisted Routing for Heterogeneous and Correlated Mobility. *PERCOMW '07,* pp. 79-85, 2007.

[7] Guizhu Wang, Bingting Wang, Yongzhi Gao, Dynamic Spray and Wait Routing algorithm with Quality of Node in Delay Tolerant Network. *CMC'10*, pp. 452-456, 2010.

[8] A.Lindgren, A. Doria, and O. Schelen, Probabilistic routing in intermittently connected networks, *SIGMOBILE Mobile Computing and Communication Review,* 2003.

[9] Sunil Srinivasa and Sudha Krishnamurthi, CREAST: An opportunistic forwarding protocol based on conditional residual time. *SECON'09*. pp. 1-9, 2009.

[10] Wei Gao, Guohong Cao, On exploiting transient contact patterns for data forwarding in Delay Tolerant Networks. *ICNP'10,* pp.193-202, 2010.

[11] Jathar Rugved,Arobinda Gupta, Probabilistic Routing using Contact Sequencing in Delay Tolerant Networks,*COMSNETS'10,* pp. 1-10, 2010.

[12] Etienne C. R. de Oliveira and C´ elio V. N. de Albuquerque, NECTAR: A DTN Routing Protocol Based on Neighborhood Contact History, *SAC '09*. pp. 8-12, 2008.

[13] Keränen, A., J. Ott, and T. Kärkkäinen. The ONE simulator for DTN protocol evaluation,*ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering)*, 2009.

[14] N. Banerjee, M. D. Corner, and B. N. Levine. An

[15] Energy-Efficient Architecture for DTN Throwboxes. *In Proc. IEEE Infocom,* Amherst May 2007.

[16] Shouyi Yin,Xiaokang Lin. Traffic self-similarity in mobile ad hoc networks. *Second IFIP International Conference on Wireless and Optical Communications Networks,* June 2005.

Qaisar Ayub He has obtained his MCS Computer Science degree in 2005 from Comsat Institute of Information Technology Pakistan. And BCS (Hons.) computer science from Allama Iqbal Open University Pakistan in 2003. He has 8 years of teaching experience in conducting professional trainings (Oracle, Java,) and software development. As a part of this paper he is working on Routing and forwarding research issues in Delay tolerant Networks.

Mohd Zahid, M. Soperi He received Ph.D degree in Computer Science from University of Wisconsin, Milwaukee in 2009, M.S. degree in Computer Integrated Manufacturing from Rochester Institute of Technology, New York and B.S. degree in 1988 from New Mexico State University, Las Cruces in Computer Science and Mathematics. He is currently a faculty member in Computer Science, University Technology Malaysia. His research interests include Internet Routing Protocols and Delay/Disruption Tolerant Networks.

Sulma Rashid She has received her MS Degree in computer science in 2007 from IQRA University Islamabad Pakistan and MCS degree in 2001 from UAAR Pakistan. She has 10 years of teaching experience at university level. As a part of this paper she is working on Optimizing buffer scheduling research issues in DTN routing protocols.

Abdul Hanan Abdullah He received the B.Sc. and M.Sc from University of San Francisco, California, and the Ph.D degree from Aston University, Birmingham, UK, in 1995. His research interest is in Information Security. He is also a head of Pervasive Computing Research Group PCRG) UTM and member of ACM.