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Mobility Prediction and Forwarding Routing in Delay Tolerant Networks

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Abstract: The aim of this research is to propose a routing protocol for Delay Tolerant Networks (DTNs). Routing in DTN is a difficult task as nodes have no prior information about the partitioned network and transfer opportunities between nodes are limited. In this paper, we propose Mobility Prediction and Forwarding Routing Protocol (MPFRP), an effective routing protocol for DTNs that makes use of clustering and mobility prediction. Least mobile node is selected as Cluster Head (CH) and the node continues to be a CH as long as the node remains in the transmission range, else a new CH is selected. As CH is least mobile node, forwarding nodes does not change frequently and hence time spent in selecting new forwarding nodes reduced. By comparing the proposed protocol with previous protocols, the enhanced performance in packet delivery ratio, delivery latency and overhead has been proved using NS 2 simulations.

Key words Cluster · Mobility Prediction · Routing · DTN

INTRODUCTION

Delay Tolerant Networks (DTNs) [1, 2] are characterized by lack of connectivity resulting in a lack of instantaneous end to end path. DTNs overcome the problems associated with intermittent connections [3-5], long variable delays, asymmetric data rate and high error rates by using store-carry- and forward routing. DTNs find application in many areas such as deep space network, under water networks, military tactical networks, vehicular ad hoc network and disaster recovery systems.

Traditional routing protocols assume that end to end path exists between communicating nodes. In DTN as there is no assurance about the existence of path in the network between source and destination, it is challenge to construct the best routing protocol. DTNs [6] are opportunistic networks uncertain of the node it would meet in future and routing in DTNs consists of sequence of independent, local forwarding decisions, based on current connectivity information and may predict future connectivity information.

Flooding approach was initially used as packet tries to access all available network routes and ultimately reaches its destination. Epidemic [7-10], is flooding based resource hungry protocol, where nodes continuously replicate and transmit messages to all newly discovered contacts that do not already possess a copy of the message. In order to control the unnecessary resource consumption, protocols forwarded messages [11] only to qualified encountered nodes. Probabilistic Routing Protocol using History of Encounters and Transitivity (PRoPHET) transmits messages during opportunistic encounters based on the history of encounters. An ordered queue based on the destination of each message, ordered by the estimated likelihood of a future transitive path to that destination is maintained and the messages to be transmitted first or dropped first is determined in MaxProp. Bubble Rap is a social based forwarding algorithm that improves forwarding efficiency using real world traces. An upper bound is set on the number of copies per message, thereby benefits from both replication as well as low resource utilization is obtained from Spray and Wait Protocol [12]. Spray and Focus [13] is similar to Spray and Wait in the Spray Phase but in focus phase it performs single copy utility based transmission among the intermediate relay nodes until message arrives at the destination. Seek and Focus is a single copy routing scheme that adopts a combination of both random and utility based routing preventing messages from being struck at a particular local maxima node. The TBR protocol applies the value of message TTL, hop count, replication count and message size as parameters for determining message priority used in managing buffer. ORWAR protocol proposes to reduce

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partial transmission of a message and thereby optimizes resource utilization. BUFE-MAC protocol consists of 5 phases and used to provide enhanced bandwidth utilization and fairness index.

Exponentially Weighted Moving Average (EWMA) scheme is employed for online updating nodal contact probability, which helps in converging to true contact probability. Clusters are formed and gateway nodes are selected based on nodal contact probabilities. Predict and Relay determines the probability distribution of future contact times and choose a proper next hop in order to improve end to end delivery probability.

In this work, Mobility Prediction and Forward Routing Protocol (MPFRP) is proposed which combines the benefit of clustering and mobility prediction. MPFRP consists of 5 phases. In Cluster Selection phase, nodes in a network are divided into clusters and least mobile node is chosen as the Cluster Head. Local information is gathered from every node. Nodes are allowed only to receive, in the Receive Only phase in order to avoid congestion. A time slot is divided into mini time slots and each node is permitted to transmit at one mini time slot in mini time slot scheduling phase. Cluster Head forwards the packet to the neighbor Cluster Heads in Packet Sending Phase. Before the next set of nodes begins transmission, the position of the Cluster Head is predicted. If it lies in the transmission range same Cluster Head is used, else a new Cluster Head is selected.

The rest of the paper is organized as follows. In section 2, the proposed Mobility Prediction and Forward Routing Protocol (MPFRP) is presented in detail. In section 3, the MPFRP protocol is evaluated using simulation and the results are discussed. Finally, conclusion is presented in section 4 with some discussion on future work.

Proposed Algorithm: The proposed Mobility Prediction and Forward Routing Protocol (MPFRP) consist of the following five phases:

- Cluster Head Selection
- Receive Only
- Mini Slot Scheduling
- Packet sending
- Mobility Prediction

Cluster Head Selection: Clustering is a process that divides the network into interconnected substructures, called clusters. In a clustering scheme, all the mobile nodes in a MANET are grouped into different geographically distributed groups. In clustering procedure, a representative of each sub domain (cluster) is ‘elected’ as a cluster head (CH) and a node which serves as intermediate for inter-cluster communication. Remaining members are called ordinary nodes. The boundaries of a cluster are defined by the transmission area of its CH. Cluster head (CH) election is the process to select a particular node within the cluster as a head node. The responsibility of the CH is to manage the nodes of its own cluster and to communicate with other Clusters to reduce traffic. It can communicate by sending and receiving the data, compressing the data and transmitting the data to the other Cluster Heads Nodes in a transmission range of 250 m are considered a Cluster. At regular time interval [14], each node transmits local information (node ID, location, time of location and bandwidth request). Nodes store this information in a routing table. It computes the distance covered by each node using consecutive local information. Each node selects the node that has travelled least and sends token (called ‘DIST’) to that node. Node receiving this token ‘DIST’ is chosen as Cluster Head CH. Clustering in MANET thus improves the efficiency and reduces the chances of interference thereby increasing the network throughput.

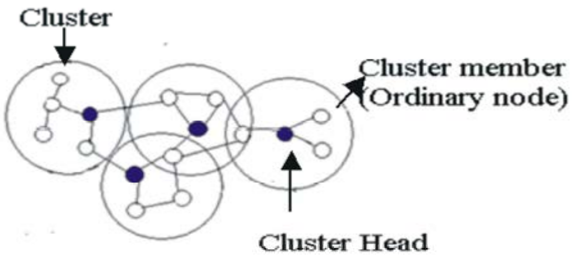

Fig. 1: Cluster Head Selection

Receive Only: All nodes in this phase are not allowed to transmit packets but they receive packets in order to avoid collision. Nodes enter into this phase after sending token ‘DIST’ and remain in this state until first set of transmitting nodes have completed their transmission.

Mini Time Slot Scheduling: Cluster Head divides the total time slot by the number of transmitting nodes, giving Mini Time Slot which alleviates data collision and increase bandwidth utilizations [15]. CH allocates mini time slots to the nodes wanting to transmit depending on the bandwidth requirement of each node. The node that requires the highest bandwidth [16] is given the highest priority.

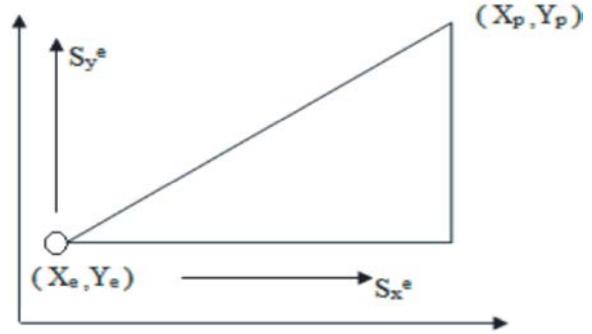

Fig. 2: Mobility Prediction Rule

Packet Sending: Cluster Head forwards the messages to all the neighboring Cluster Heads as available in the queue. The next local information is transmitted and the next set of transmitting nodes is ready.

Mobility Prediction: Before the same Cluster Head is used for forwarding, mobility prediction rule is applied. Mobility prediction [17, 18], of a node is the estimation of their future locations. Position of the Cluster Head at time instant $T_{e,}$ speed of the node along X and Y (S_x^e, S_y^e) axes $_{is}$ known from the routing table. The neighbors can predict the position of cluster head using

$X_p = x_e + (T_p\text{-}Te)* S_x^e$
$Y_p = Y_e + (T_p\text{-}T_e)* S_y^e$

The Cluster Head is present in the transmission range same Cluster Head is used, else a new Cluster Head is selected.

Variables

NID	Node ID
LOC	Location
TLOC	Time of location
BWR	Bandwidth Request
DIST	Distance
CH	Cluster Head
RO	Receive Only Phase
TR	Transmit Receive Phase
MTS	Mini Time Slot
Xp, Yp	Predicted node coordinates
Xe, Ye	Node coordinates of the earlier time instant included in the earlier baecon
Tp	Time at which prediction occurs
Te	Time of the earlier baecon
$S_x^{e,}$ S_y^e	Speed of the node in x and y direction

```
for each node in cluster
    {
        local information (NID,LOC, TLOC,BWR) gathered
        DIST = $LOC_{n-1} – LOC_n$
        CH = min (DIST(n))
        Send token ‘DIST’ to CH
    }

for each CH
    {
        if
    one set of nodes transmitting, nodes in RO phase
        else
                TR phase
    }

function compute_MTS
    MTS = Total time slot / no. of transmitting nodes

for each MTS
    {
        nodes are assigned for transmission by CH
        node1(highest BWR),………….node n(least BWR)
    }

for each packet received by CH
    {
        forwards to neighbor CH
    }

while next set of transmitting nodes waiting to transmit

    {
    function compute_predicted location
    $X_p = x_e + (T_p\text{-}Te)* S_x^e$
    $Y_p = Y_e + (T_p\text{-}T_e)* S_y^e$
    }
if
    $(X_p, Y_p) < 250$ m; same CH forwards packets
else
    new CH is selected
```

Results

Mobility Prediction Forwarding Routing Protocol (MPFRP) and the protocol in comparison, Epidemic, Spray and Wait and Spray and Focus protocol was evaluated using NS-2 simulator. Table 3.1 summarizes the simulation parameters

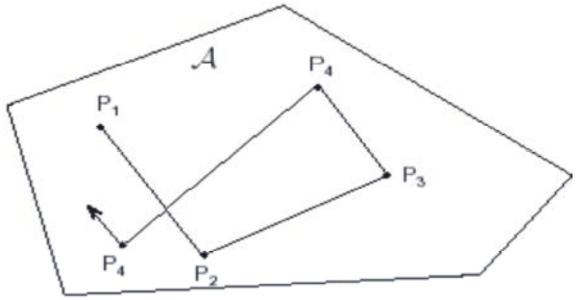

Fig. 3: Simple RWP Path

Table 3.1:

No. of nodes	50, 100, 150 and 200 nodes
Area Size	6000 m x 6000 m
MAC	802.11
Simulation Time	5000 s
Traffic Source	CBR
Packet Size	500 bytes
Transmission range	250 m
Mobility Model	Random Way Point Model
Routing Protocol	MPFRP
Rate	50 kbps
Speed	5, 10, 15 and 20 m/s

MP based one random waypoint model (RWP) that is synthetic and not limited to special geometry so that easy to describe the analytical values and estimate link expiration time in order to improve routing performances

We have evaluated the MPFRP protocols in terms of the following metrics

- Bandwidth is defined as a data transfer rate, the amount of data that can be carried from one point to another in a given period of time (usually a second).
- Delivery ratio, defined as the ratio of number of messages successfully delivered to destination to the total number of messages generated.
- Delivery latency, defined as the average delay needed to deliver a message to the destination
- Overhead ratio, defined as the ratio of total number of relayed messages to the total number of messages delivered.
- Buffer is defined as the Packets are stored temporarily during the transmission of information to create a reserve for use during packet transmission delay s or during retransmission request

The bandwidth, delivery ratio and delivery latency demonstrate how successful the routing protocol is in message delivery. The overhead ratio shows the usage of network resources and the buffer size (amount of queuing) determines how the routing protocol is able to tolerate in an interface without dropping packets and causing performance degradation.

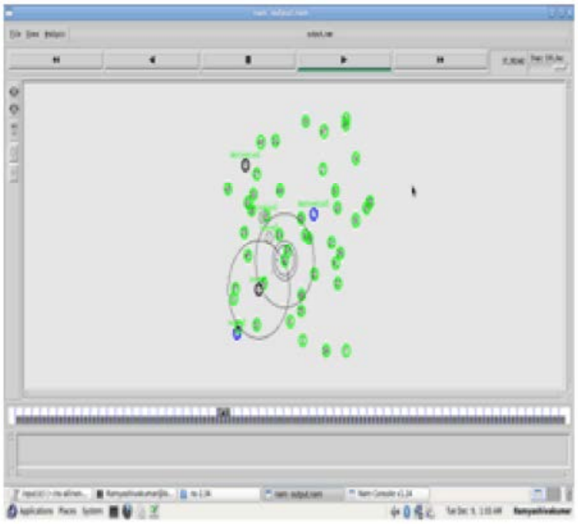

Fig. 4: Mobility of 50 nodes

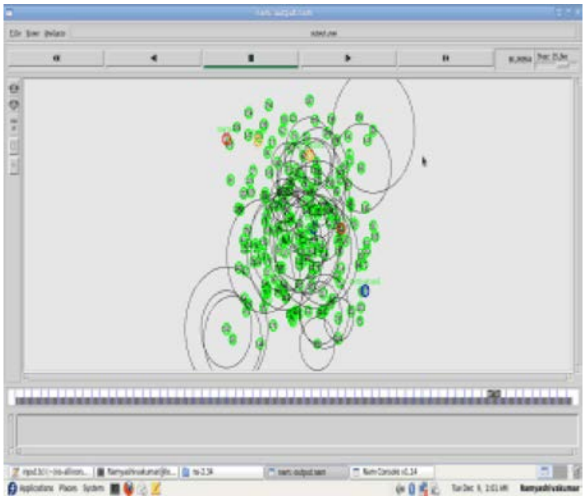

Fig. 5: Mobility of 200 nodes

The mobility of 50 nodes was simulated with the Network simulator as shown in Fig 4. The nodes were simulated to travel with an average speed in the range between the low speed of 1ms and the high speed of 300ms. Red colour node represent the source 1 and destination 1where orange and blue colour node represent source 2, destination 2and source 3,destination 3.Nodes broadcast their information to their neighbour node that are represented with black circles. Similarly, Fig 5 shows the mobility of 200 nodes was simulated with the Network simulator. The nodes were simulated to travel with an average speed in the range between the low speed of 1ms and the high speed of 300ms. Red colour node represent

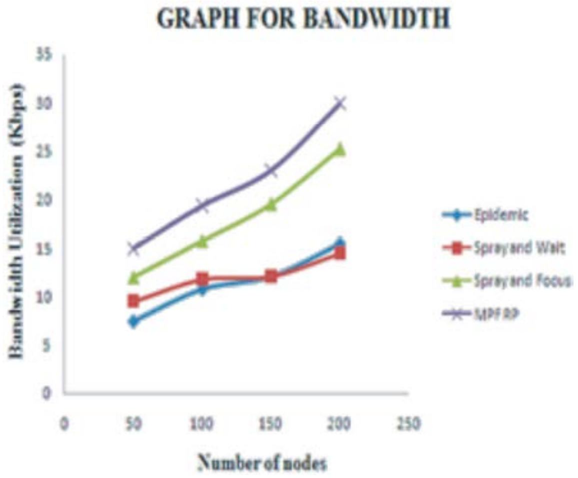

Fig. 6: Number of nodes vs Bandwidth Utilization

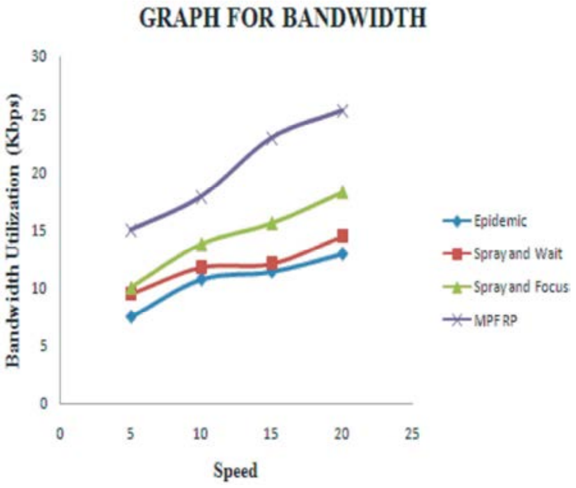

Fig. 7: Speed Vs Bandwidth Utilization

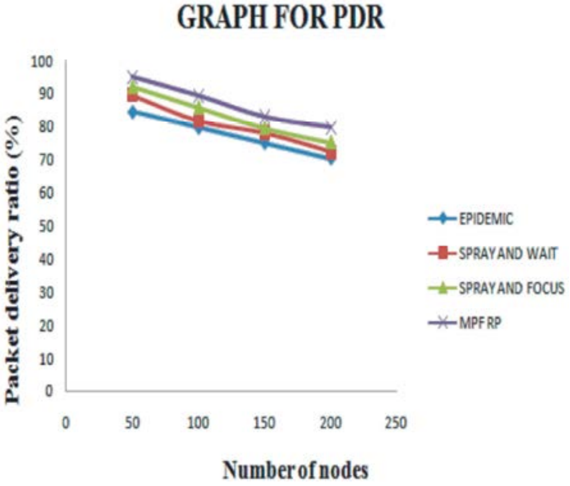

Fig. 8: Performance of all routing protocol under varying number of nodes as function of Packet delivery ratio

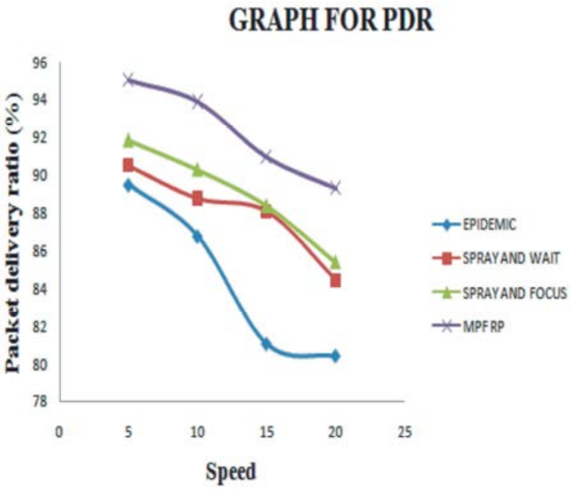

Fig. 9: Performance of all routing protocol under varying speed as function of Packet delivery ratio

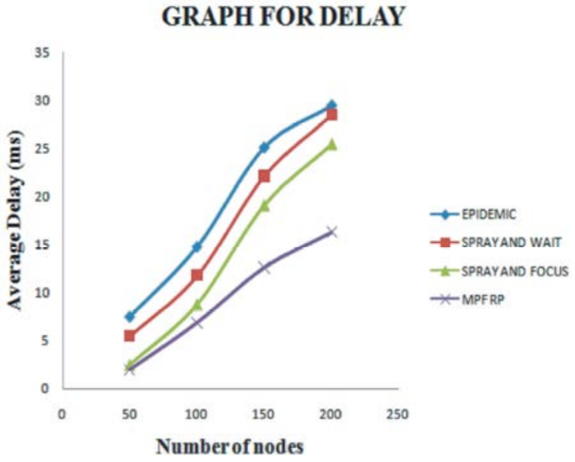

Fig. 10: Number of nodes vs Average Delay

the source 1 and destination 1where orange and blue colour node represent source 2, destination 2 and source 3, destination 3. Nodes broadcast their information to their neighbour node that are represented with black circles.

Experiments Are Performed by Varying the Number of Nodes and Speed: Fig 6 and Fig 7 compares the performance of Epidemic, Spray and Wait, Spray and Focus and MPFRP protocols concerning bandwidth utilization (throughput). The proposed MPFRP significantly improves bandwidth utilization compared with other DTN protocol by 3Kbps than spray and focus, 3Kbps than spray and wait and 8Kbps than Epidemic when nodes are varied and 4Kbps than spray and focus, 5Kbps than spray and wait and more than other protocol when speed is varied.

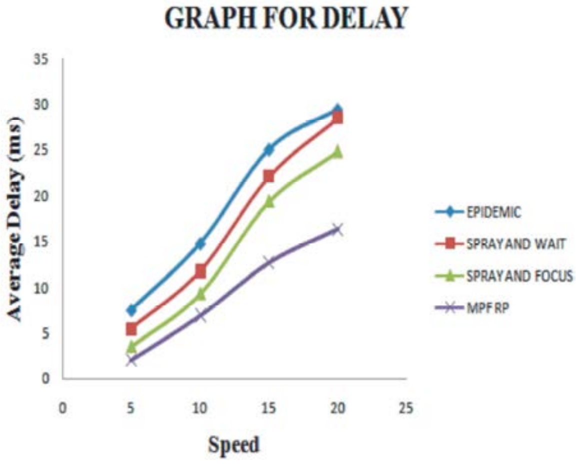

Fig. 11: Speed Vs Average Delay

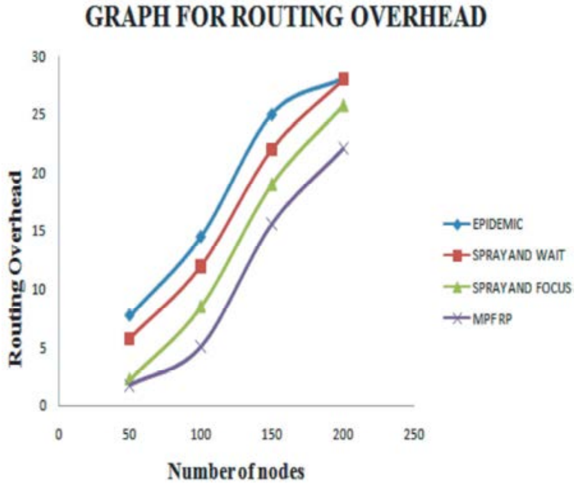

Fig. 12: Comparison of Epidemic, Spray and Wait, Spray and Focus, MPFRP under varying Number of nodes as a function of Routing overhead

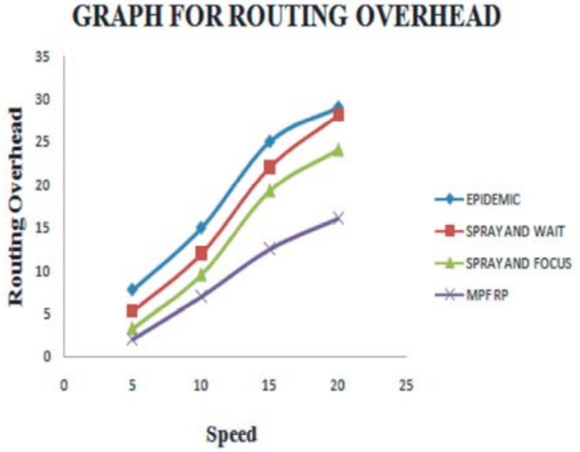

Fig. 13: Comparison of Epidemic, Spray and Wait, Spray and Focus, MPFRP under varying Speed as a function of Routing overhead

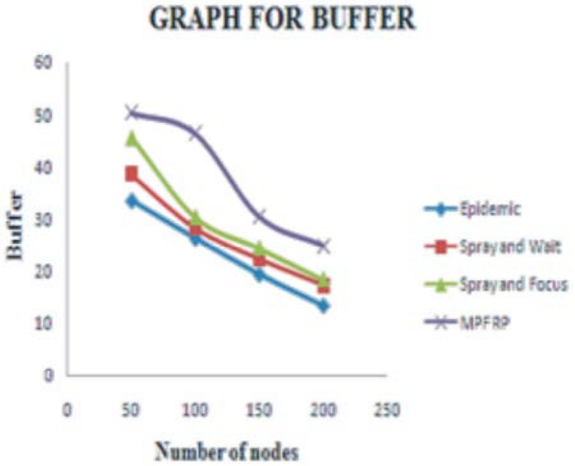

Fig. 14: Depict buffer as a function of number of nodes

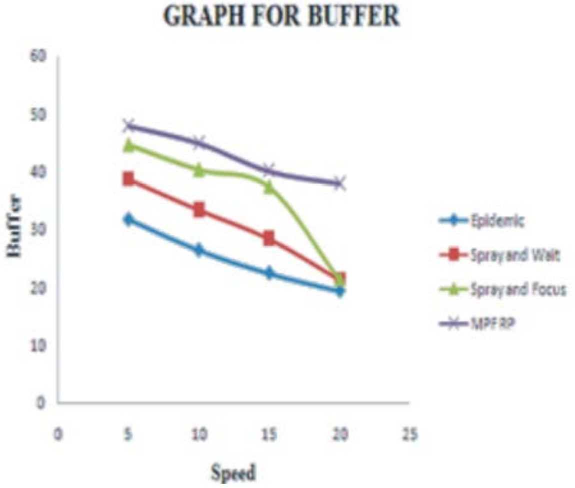

Fig. 15: Depict buffer as a function of speed

It is evident from Fig 8 and Fig 9 that packet delivery ratio of MPFRP is better than other DTN protocols. MPFRP has obtained 4% higher packet delivery ratio than Spray and Focus 6% than spray and wait and more than other protocol when number of nodes are varied and 3% more than other DTN protocol when speed is varied, since messages are sent through nodes that have high delivery probability to meet destinationn speed are varied MPFRP attains 10% lesser delay than spray and focus and 15% lesser delay than spray and wait, epidemic when nodes are varied MPFRP gives 12 % lesser delay than other DTN protocol when speed is varied, t as shown in Fig 10 and Fig 11. The messages reach their destination quickly as the forwarding nodes do not change often, hence reducing the time required to select new forwarding nodesFig 8. Performance of all routing protocol under varying number of nodes as function of Packet delivery ratio.

The overhead ratio results are shown in Fig 12 and Fig 13. MPFRP achieved 5% less overhead when varying nodes and 14% less when speed is varied, than other protocols as it judiciously confirms cluster head by associating mobility prediction value, before making the routing decision, so that message transmission which may fail are not supported thus reducing the overhead..

It is conspicuous from Fig 14 and Fig 15that buffer utilization of MPFRP is better than other DTN protocol, MPFRP has obtained 15% higher buffer utilization than epidemic 10% than spray and wait 2% than spray and focus protocols when number of nodes are varied 5% than Spray and focus protocol 10% than Spray and Wait protocol and more than epidemic when speed is varied,

CONCLUSION

In this paper, we presented a routing protocol called MPFRP that combines the benefits of clustering and mobility prediction, which estimates the presence of clustering head within the transmission range before sending packets for forwarding. The best carrier for a message is determined by the prediction result using a novel contact model based on the probability distribution of future inter-contact and contact durations, where the network status, including wireless link condition and nodal buffer availability, are jointly considered This eliminates transmission that would fail because of forwarding packets to cluster head nodes that has moved out of transmission range. Simulation results have shown that the proposed protocol had provided improved delivery ratio with lower latency and minimum overhead. Performance study shows that the propose MPFRP outperforms the existing Epidemic, Spray and Wait, Spray and Focus in terms of bandwidth utilization, transmission delay, packet delivery ratio.In future work, the performance metrics shall be evaluated in network scenarios, where the nodes have limited buffer, bandwidth and energy resources.

REFERENCES

1. Fall, K., 2003. A delay-tolerant network architecture for challenged internets. In SIGCOMM'03: Proceedings of the ACM conference on computer communications, pp: 27-34.
2. Sushant Jain, Kevin Fall and Rabin Patra, 2004. Routing in a Delay Tolerant Network, SIGCOMM'04, Aug. 30-Sept. 3, 2004, Portland, Oregon, USA. Copyright.
3. Yaozhou, Abbas Jamalipour, 2010. A Cooperative Cache-BasedContent Delivery Framework for Intermittently Connecteds mobile adhoc network, IEEE Transactions on Wireless Communications, 9(1).
4. Spyropoulos, T., K. Psounis and C. Raghavendra, 2008. Efficient routing in intermittently connected mobile networks: The multiple-copy case, IEEE/ACM Trans. Netw., 16(1): 77-90.
5. Spyropoulos, T., K. Psounis and C. Raghavendra, 2008. Efficient routing in intermittently connected mobile networks: The single-copy case, IEEE/ACM Trans. Netw., 16(1): 63-76.
6. Burgess, J., B. Gallagher, D. Jensen and B.N. Levine, 2006. Max-prop: Routing for vehicle-based disruption tolerant networks, in Proc25th IEEE Int. Conf. on Computer Communications, (April 2006), pp 1-11.
7. Matsuda, T. and T. Takine, 2008. (p, q)-epidemic routing for sparsely populated mobile ad hoc networks, IEEE J. Sel. Areas Commun., 26(5): 783-793.
8. Apoorva Jindal, Konstantinos Psounis, 2006. Performance Analysis of Epidemic Routing under Contention, Copyright 2006 ACM 1-59593-306-9/06/0007
9. Vahdat, A. and D. Becker, 2000. Epidemic routing for partially-connected ad hoc networks, Duke University Technical Report Cs-2000-06, Tech. Rep.,
10. Yunfeng Lin, Baochun Li and Ben Liang, 2008. Stochastic Analysis of Network Coding in Epidermic Routing, IEEE Journal on Selected Areas in Communications, 26(5).
11. Pan Hui, Jon Crowcroft and Eiko Yoneki, 2011. BUBBLE Rap: Social-Based Forwarding in Delay-Tolerant Networks, IEEE Transactions on Mobile Computing.
12. Thrasyvoulos Spyropoulos, Konstantinos Psounis Cauligi S. Raghavendra, XXXX. "Spray" and Wait: An Efficient Routing Scheme for Intermittently Connected Mobile Networks
13. Thrasyvoulos Spyropoulos Planete. Konstantinos Psounis and Cauligi S. Raghavendra, XXXX. Electrical, "Spray and Focus: Efficient Mobility-Assisted Routing for Heterogeneous and Correlated Mobility.
14. Giruka, V.C. and M. Singhal, 2005. Hello protocols for ad-hocnetworks: Overhead and accuracy tradeoffs. In Proceedings of ACM/IEEE WOWM.
15. Mahendran, V., Rajkishan Gunasekaran and C. Siva Ram Murthy, 2014. Performance Modeling of Delay-TolerantNetwork Routing via Queueing Petri Nets. IEEE Transactions on Mobile Computing, 13(8).

16. Eric Hsiao-Kuang Wu and Gen-Huey Chen, 2008. Bandwidth-Satisfied Multicast Trees in MANETs, IEEE Transactions on Mobile Computing, 7(6).
17. Pin-Han Ho and Basem Shihada, XXXX. Contention Aware Mobility Prediction Routing for Intermittently Connected Mobile Networks, Dept. of Electrical and Computer Engineering, University of Waterloo, Canada, Computer Electrical Math Sciences & Engineering.
18. Quanjun Chen, Salil S. Kanhere, Mahbub Hassan, 2013. Adaptive Position Update for Geographic Routing in Mobile Ad Hoc Networks, IEEE Transactions on Mobile Computing, 12(3).
00. Importance of on-demand modified power aware dynamic source routing protocol in mobile ad-hoc networks. Microwaves, Antennas & Propagation, IET (Volume: 8, Issue: 7), May 14 2014