A New Queuing Policy for Delay Tolerant Networks

G.Fathima
Adhiyamaan College of Engg
Hosur. Tamil Nadu, India

Dr. R.S.D. Wahidabanu
Govt. College of Engg
Salem, Tamil Nadu, India

ABSTRACT
Recently there has been much research activity in the area of Delay Tolerant Networks (DTNs). Routing is one of the key components in the DTN architecture. DTNs operate with the principle of store, carry and forward. According to this principle, a node may store a message in its buffer and carry it along, until it can forward it further. The message transmission occurs only when nodes come into the communication range of each other. Mobility of the nodes shortens the contact duration. It may not be possible for a node to transmit all messages it has during the available period of contact. Therefore decision has to be made on the order of messages to be transmitted. Similarly, in order to cope up with long disconnections, messages are buffered for a long period of time. Once the buffer capacity is reached, nodes must decide on the message to be dropped. Thus a new queuing policy has been proposed in this paper which takes care of both. The proposed policy considers the class of service and the expiration time for making such decisions. The Delay Tolerant Networks with random behavior is considered in this paper. Therefore epidemic routing which is the better choice for such network has been used for evaluation. The simulation results show that the new policy outperforms existing policy in terms of delivery ratio and delivery latency with preferential delivery.

General Terms
Algorithms, Performance.

Keywords
Delay Tolerant Networks, Epidemic routing, Queuing policy, Delivery ratio, Delivery latency.

1. INTRODUCTION
Mobile Ad hoc Networks (MANETs) are infrastructure-less networks and nodes in the network are mobile in nature. In MANETs, nodes can directly communicate with each other if they enter into each other's communication range. Thus in an ad hoc network, packet traverses from one node to another until it reaches the destination. As the nodes are mobile, the topology changes frequently. To accommodate the dynamic topology of mobile ad hoc networks, many routing protocols have been proposed such as OLSR, DSR, LAR etc,. and they are compared in [7]. All these protocols assume that the network is connected at any point of time and there is a contemporaneous end-to-end path between the source and destination pair. But there are certain challenging environments like i) inter-planet satellite communication network where satellites and ground nodes may only communicate with each other several times a day, ii) energy constrained network where sensors are scheduled to wake/sleep periodically which result in intermittent connectivity, iii) a military ad hoc network where nodes may move randomly and are subject to being destroyed.

The protocols of ad hoc networks do not work in such challenging environment. According to these protocols, packets whose destination cannot be found are usually dropped. If packet dropping is too severe, TCP eventually ends the session. Therefore new routing protocols and algorithms need to be developed to address the issues of intermittent connectivity and network partitioning. Delay Tolerant Networking (DTN) is emerging as a solution for supporting asynchronous data transfer in such intermittently connected networks. The details of Delay Tolerant Network architecture are available in [8].

The DTN solutions are based on store, carry and forward principle. In such networks, a next hop may not be immediately available for the current node to forward the data. The node needs to store the data until it gets an opportunity to forward the data. So the node must be capable of buffering the data for considerable duration of time. There are different types of DTNs based on their characteristics. There are situations, where the applications using DTN technology require preferential delivery of certain messages. The proposed policy provides preferential delivery depending on their priorities satisfying application-specific requirements.

Among the various DTN routing protocols like Epidemic [4], SWIM [12], Spray and Wait [2] and Prophet [1], Epidemic routing has been chosen for evaluation in this paper for its following characteristics: Epidemic Routing represents the extreme end of the flooding family. So it tries to send multiple copies of each message over all paths in the network. As all nodes receive every message, makes this strategy extremely robust to node and network failures. Additionally, since it tries every path, it delivers each message with high probability in minimum amount of time. Moreover, the network considered here has random behavior and no knowledge about the network is known a priori. Epidemic is the better choice of routing in such kind of networks. The design goal is to provide preferential message delivery with high probability and minimum delivery.

2. EPIDEMIC ROUTING
Vahdat and Becker [4] invented a routing protocol that makes use of an epidemic algorithm [3]. Epidemic Routing works as follows: When a message is sent, it is placed in the local buffer and tagged with a unique ID. When two nodes connect, they send each other the list of all message IDs they have in their buffer, called the summary vector. Using the summary vector, the nodes exchange the messages they do not have. When this operation completes, the nodes have the same messages in their buffers.

When a message arrives at an intermediate node, it floods the message to all its neighbors. Then it relies upon carriers coming into contact with another connected portion of the network through node mobility. At this point, the message spreads to an additional set of nodes. Through such transitive transmission, messages have a high probability of eventually reaching their destination. The Epidemic algorithm does the message replication which imposes a high bandwidth and storage overhead on wireless nodes. Survey on various routing protocols for DTNs is given in [13]. Even though there has been a large amount of effort towards the design of efficient routing protocols for DTNs, there has not been much focus on scheduling/queuing policies.

2.1 Impact of Node Mobility

In context of DTN, message transmissions occur only when nodes encounter each other. The node mobility limits the duration of contact between nodes. The contact duration of the nodes in turn limits the amount of messages that can be transmitted. In Epidemic routing, the contact duration is assumed to be long enough to transmit all messages a node has. But this is not always true because of limited bandwidth. It implies that it may not be possible for a node to transmit all messages it has during the short available period of contact. Therefore it becomes necessary for the node to choose the messages to be transmitted during the period of contact.

2.2 Impact of Buffer Size

To limit the total resource consumption is to bind the amount of buffer space available. The impact of buffer size on the DTN protocols is evaluated in [6]. The Epidemic routing works with the assumption of availability of infinite buffer. But this is not the case in reality. So the buffer size available at each node is considered to be limited in this paper. In DTNs, to cope up with long disconnections, messages are buffered for a long period of time. This implies that at certain point of time buffer capacity will be reached. Therefore decision has to be made by the nodes to choose the message to be dropped in favor of new ones. The following section defines the new queuing policy to handle the above problems.

3. PROPOSED QUEUING POLICY

It observed from the literature studies that the messages are transmitted in the order in which they were stored in the buffer. i.e., in First Come First Served (FCFS) basis by default when the contact opportunity arises. Apart from FCFS, there are other policies proposed in literature [9] which requires information like history of past encounters, hop count, utility function and delivery likelihood. Though a number of scheduling policies are possible, FCFS is the easiest to implement. As long as the contact duration is long enough to transmit all the messages a node has, FCFS is a very reasonable policy. However if the contact duration is limited, FCFS is sub-optimal as it does not provide any mechanism for preferentially delivering or storing of high priority messages. In this case, there requires a queuing strategy to handle high priority messages. The proposed policy prioritizes the messages based on service class and expiration time and transmits them according to their priority. This policy is more advantageous in emergency applications as it does preferential delivery.

In the proposed approach, the available buffer is divided into many queues to hold the incoming bundles. Separate queue is maintained for each class of service as shown in Fig 1. As soon as the bundle arrives, it is placed in the appropriate queue. The bundles are scheduled according to the class of service ordered with expiration time. The class of service can be specified by the application.

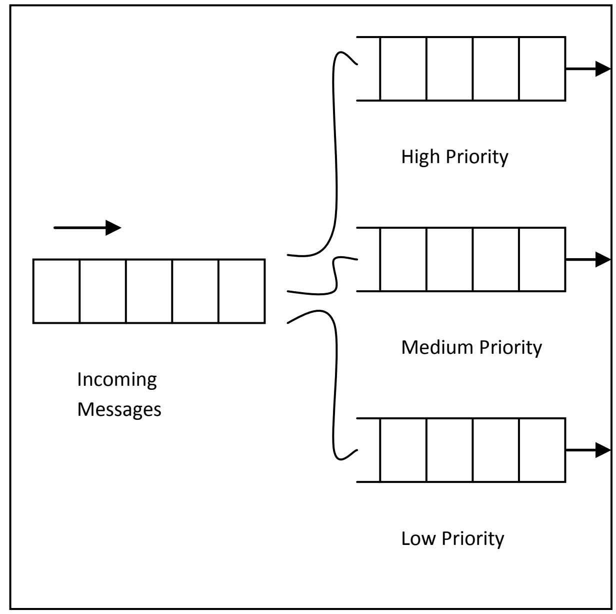

Figure 1. Maintaining High, Medium and Low Priority Queues

It should be noted that irrespective of the forwarding policy adopted, the message whose destination encountered, are the first to be transmitted and the same may be deleted from the buffer. Nodes do not delete the messages after forwarding them as long as there is sufficient space available in the buffer.

When a particular queue is full, the bundle is placed in the subsequent queue. When the entire buffer is full, a dropping policy is invoked. The default policy followed is Drop tail which drops new arrivals when buffer is full. Apart from Drop tail, there are other policies available which can be studied from [9]. They are Drop Random (DR), Drop Last (DL), Drop Youngest (DY), and Drop Old (DO). These policies do not consider the priority of the messages. But the proposed policy considers the priority and drops the bundles with least class of service which has low priority. Therefore the queue with least class of service is chosen. Then among the bundles available in that queue, the bundle with least remaining time is the one selected for dropping. As each bundle is discriminated using class of service field in the bundle header, there is no need to maintain flow-specific information and therefore the solution is more scalable. The proposed queuing policy is used with epidemic routing and evaluated for its effectiveness. Simulation results show that the proposed scheme has better performance than the other schemes.

4. SYSTEM EVALUATION

In DTN, bundle protocol is used for transfer of messages. A bundle is a protocol data unit of the DTN bundle protocol [5]. Each bundle comprises a sequence of two or more "blocks" of protocol data, which serve various purposes. Bundle Processing Control Flags Bit is used to differentiate the class of service. The bits in positions 7 through 13 of control flag are used to indicate the bundle's class of service. The bits in positions 8 and 7 constitute a two-bit priority field indicating the bundles priority, with higher values signifying high priority: 00 = bulk, 01 = normal, 10 = expedited, 11 is reserved for future use. This priority of the bundles is used to store them in the appropriate queue. Creation timestamp and lifetime fields are available in the primary bundle block which gives the expiration time. This information is used to decide the bundles that are to be transmitted and dropped when necessary.

To evaluate the new scheme, Network Simulator ns-2 [11] has been used. The implementation includes (i) the Epidemic routing with FCFS as scheduling and Drop Old as dropping scheme (ii) the Epidemic routing with the proposed scheme of scheduling and dropping. The simulation is based on Random Waypoint model. It is the model in which nodes move independently to a randomly chosen destination with a randomly selected velocity. The total number of nodes considered is 50. and the simulation area is 1500 X 300 m2. Each node has a transmission range of 250 m.

The performances of epidemic routing with both the schemes are compared based on the following two metrics: the average delivery ratio and average delivery latency. The average delivery ratio is defined as ratio of total number of messages delivered to the destination and the total number of messages sent by the sender. The average delivery delay is measured as the average of the time taken by the messages to reach from source to destination.

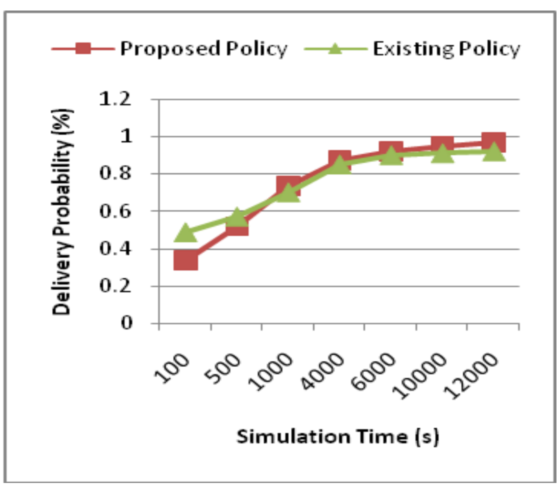

Figure 2. Delivery Probability

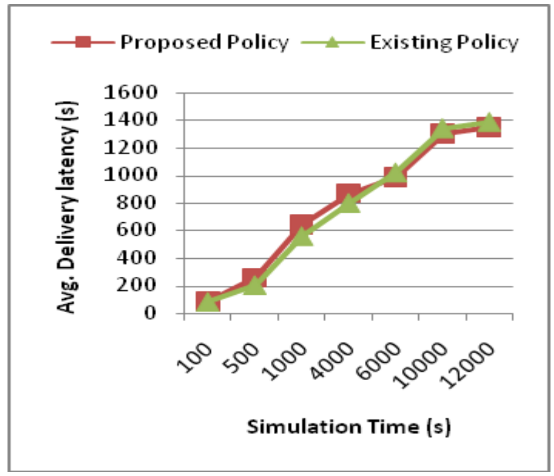

Figure 3. Average Delivery Latency

The results in Fig 2 and Fig 3 show the delivery probability and average delivery latency respectively for growing simulation time. It is observed that incorporating the new policy with epidemic routing results in increased delivery probability and reduced delivery latency for high priority messages. The same policy can also be applied to other routing protocols of DTN. This investigation is deferred for future work.

5. CONCLUSION

A large number of routing protocols have been recently proposed possessing relative strengths and weaknesses under different circumstances [6], [8]. One among them is the Epidemic routing which is based on the flooding strategy. Since it is observed that Epidemic routing attains high percentage of delivery rate with reduced latency, it is chosen in this paper. Mobility of nodes in ad hoc networks can cause performance degradation. The amount of messages that can be transmitted depends on the duration of the contact. Therefore the new policy proposed in this paper that considers the service class and expiration time of messages to schedule and drop when necessary. The proposed policy shows better performance compared to default approach used in Epidemic routing in terms of message delivery ratio and delivery latency with preferential delivery. The effectiveness of conjunction of bundle dropping mechanism with fair queuing can be investigated. The fair queuing with dynamically assigned weights, can be utilized for controlling the quality of service which is carried over as future work.

6. REFERENCES

[1] A. Lindgren *et al.*, 2004. "Probabilistic Routing in Intermittently Connected Networks," Springer LNCS, Vol. 3126, pp. 239-254.

[2] A. Spyropoulos *et al.*, 2005. "Spray and Wait: An Efficient Routing Scheme For Intermittently Connected Mobile Networks," *ACM SIGCOMM Wksp. Delay Tolerant Networking (WDTN-05).*

[3] Alan Demers, Dan Greene, Carl Hauser, Wes Irish, John Larson, Scott Shenker, Howard. Sturgis, Dan Swinehart, and Doug Terry, 1987. "Epidemic algorithms for replicated database maintenance." In Proceedings of the 6th ACM Symposium on Principles of Distributed Computing, pp. 1–12

[4] Amin Vahdat and David Becker, 2000. "Epidemic routing for partially connected ad hoc networks," Technical report CS-200006, Duke University. http://issg.cs.duke.edu/epidemic/

[5] Bundle Protocol specification, 2007. IETF RFC 5050

[6] Evan P.C. Jones, Paul A.S.Ward, 2007. "Practical Routing in Delay Tolerant Networks," IEEE Transactions on Mobile Computing, Vol. 6, No. 8, pp. 943-959.

[7] Josh Broch, David A. Maltz, David B. Johnson, Yih-Chun Hu, and Jorjeta Jetcheva, 1998. "A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocols". In *Proceedings of the Fourth Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom).*

[8] Kevin Fall, 2007. "A delay-Tolerant Network Architecture for challenged Internet," IETF, RFC 4838.

[9] Davids, A. H. Fagg, and B. N. Levine, 2001. "Wearable Computers as Packet Transport Mechanisms in Highly-Partitioned Ad- Hoc Networks," *Proc. Int'l. Symp Wearable Comp.*, Zurich, pg. 141-148.

[10] Sushant Jain, Kevin Fall, Rabin Patra, 2004. "Routing in Delay Tolerant Network," ACM-*SIGCOMM'04*.

[11] The Network Simulator – ns-2, 2004. http://www.isi.edu/nsnam/ns/

[12] T.Small and Z. J. Haas, 2003. "The shared Wireless Infostation Model — A New Ad Hoc Networking Paradigm (or Where there is a Whale, there is a Way)," *Mobihoc 2003.*

[13] Zhensheng Zhang, San Diego Research Center, 2006. "Routing In Intermittently Connected Mobile Ad Hoc Networks And Delay Tolerant Networks: Overview and Challenges," IEEE Communications Surveys 1st Quarter 2006, Vol. 8, No. 1. pp. 24-37