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A review of Opportunistic Routing for Wireless Ad-hoc Networks

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Abstract

A distributed adaptive opportunistic routing scheme for multi-hop wireless ad-hoc networks is proposed. The proposed scheme utilizes a reinforcement learning framework to opportunistically route the packetsin unreliable network model. This scheme is shown to be optimal with respect to an expected average per packet reward criterion. The proposed routing scheme jointly addresses the issues of learning and routing in an opportunistic context, where the network structure is characterized by the transmission success probabilities. In particular, this learning framework leads to a stochastic routing scheme which optimally "explores" and "exploits" the opportunities in the network.

Keywords

Ad-hoc Network, Adaptive Routing, Nodes, Unstable Routing.

1. Introduction

The rapid growth of Internet has made communication an integrated and highly important factor of computing. In today's society with the development of mobile devices it has become important to stay online all the time. In order to stay online all the time it must be possible to set up a network fast and cost effective when moving between different infrastructures, ad hoc networks deals with this kinds of issues .In ad hoc networks, two nodes can exchange data when they are located within one another's communication range. A node can deliver data to another node directly or via intermediate nodes without relying on base stations. Traditional ad hoc routing uses a single-copy, Multi hop delivery scheme under the assumption of the existence of contemporary source-destination paths and unlimited network.

1.1 Ad-hoc Network: A wireless ad hoc network is a decentralized type of wireless network. [1]

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The network is ad hoc because it does not rely on a pre-existing infrastructure, such as routers in wired networks or access points in managed (infrastructure) wireless networks. Instead, each node participates in routing by forwarding data for other nodes, and so the determination of which nodes forward data is made dynamically based on the network connectivity. In addition to the classic routing, ad hoc networks can use flooding for forwarding the data. Different existing routing protocols would work well for the different scenarios exhibited by a dynamic ad hoc network. However, it is inconvenient to require the users to switch between multiple routing protocols.

Figure 1: Ad-hoc Network

2. Related Work and Contribution

This paper focus on routing protocols in mobile ad hoc networks that do not rely on particular hardware support or prior knowledge, such as a GPS that provides a node with its position, a powerful global channel to disseminate the status information of the nodes, or a bounded network area. Previous work on MANETs has been based on various assumptions regarding node density and mobility models. Conventional ad hoc network routing schemes such as DS, AODV, and DSDV are proposed in dense networks where contemporary source-destination paths exist. Previous proposed adaptive routing protocol includes CAR, where routing methods are selected depending on whether the recipient presents in the same connected component (cloud) in the network. If it does, the message is delivered by DSDV. Otherwise, the message is sent to the node in the cloud which has the highest delivery probability. This protocol, however, uses pure single-copy forwarding and works well only for local mobility. Routing information is exchanged by peers in the control channel of AROSD. Our approach is built on several important insights from previous works. Chen and Nahrstedt [4] and Spyropoulos et al. [6] use replicas to decrease average delay and increase delivery rates. Leguay [9], Burgess et al. [3], Bhagwat et al. [2], and Leguay et al. [9] suggest using historical connectivity information and predictions of future connectivity information in order to improve routing performance. Burgess al. [3] shows that flooding acknowledgements effectively reduce delays and increase delivery rates by freeing up resources used by delivered packages. Mirco et al. [11] uses proactive routing to send messages to destinations within the same cloud, and to predict forwarding nodes for destinations in other clouds. Our main contribution in this work is demonstrating the feasibility of an adaptive routing approach in dynamic ad hoc networks. To this end, we:

- Show the different nodes can exchange data when they are located within one another's communication range.
- Show the data transmission from different routes.
- Calculate the shortest path using AROSD algorithm.

3. Adaptive Routing in Dynamic Ad-hoc Network

Dynamic ad hoc networks are mobile ad hoc networks (MANETs) where network characteristics, such as network density and node mobility, change significantly over time and space. Sometimes, dynamic ad hoc networks resemble a dense ad hoc network. At other times, they resemble a delay tolerant network. Many real networks follow the paradigm of dynamic ad hoc networks. Military networks, wildlife tracking sensor networks, and vehicle networks are some of these examples. In dynamic ad hoc networks, conventional routing schemes fail when the network characteristics do not fall into their applicable scenarios.

Adaptive Routing in Dynamic ad hoc networks (AROD), which is a seamless integration of several existing schemes. Simulation results show that AROD is highly scalable and is adaptive to different network scenarios.

3.1 Dynamic Routing

Two nodes transfer data messages to each other when they are within one another's communication range. During a transfer, the sender replicates messages while retaining a copy. Messages may not be fragmented. Here we assume unlimited storage capacity and that a node never deletes messages until it receives an acknowledgement or timeout. Each message is given a Time-To-Live (TTL) which specifies a timeout of the message after which a message is no longer meaningful and can thusly be dropped. Two nodes are in the same cloud if there is a contemporary multi-hop Similar to DTN [5], we give each message a logical floating point ticket which is initialized 1.0. Whenever a message is delivered, both the sender and the receivers hold a complete copy of the message while the new tickets associated with their copies in the sender and the receivers add up to the ticket of the original message in the sender.

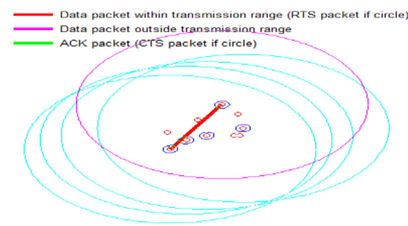

Figure 2: Data transmission & acknoldgment

3.2 Data Transmission from different Routes

One way of using the multipath is to have the traffic flow through the multiple paths simultaneously. Concurrent multiple paths routing in MANETs have been developed to improve the throughput and reliability and to achieve load balancing. Some type of source coding schemes such as Forward Error Correction (FEC) and Reed Solomon (RS) coding are usually incorporated as the redundancy in the data to improve the reliability. A set of concurrent multiple paths that are available for the transmission of data packets from a source node to a destination node [5]. All these paths are also mutually disjoint in the sense that they have no common nodes. The security level of these paths is obtained by assigning the node compromization probability for each node forming the communicating network.

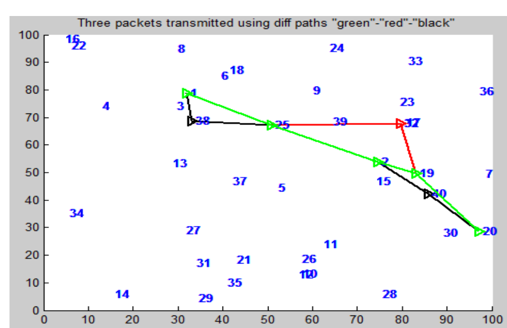

Figure 3: Data Transmission from different routes.

4. AROSD Design

AROSD's adaptation to the correct forwarding strategy is designed by the formulation of message priority which is maintained by four tables: the EDSDV table, the Average Inter- meeting Time (AIT) table, the Estimated Delivery Time (EDT) table, and the Collective estimated Delivery Time (CEDT) table. Each of these tables is of size *O* (*N*) (a moderate transmission and memory requirement), where *N* is the network size. The EDSDV table maintains the hop-count to the other nodes in the same cloud, while the hop-counts of the nodes not in the same cloud are ∞. Later, we will explain the Economic DSDV (EDSDV), which requires each node to send incremental updates of sequence numbers only when topology is changed. It is an improvement of DSDV where nodes frequently flood messages from which the nodes discover shortest paths. In DTNs where communication opportunities need to be discovered in a timely manner, EDSDV can substantially reduce the control overhead.

The AIT table records the average direct intermeeting times (or waiting times) of the current node and all the other nodes in the networks. The AIT is the averages of the periods of time between a disconnection and the consecutive establishments of a new connection between two nodes. New intermeeting times are weighted more. The AIT record between two nodes is ∞, if they meeting frequency is less.

The EDT table maintains the minimal multihop transitivity inter-meeting time between the current node and the other nodes. For instance, if node *A* and node *B* have an AIT of 400 seconds, and *B* and *C* have an AIT of 150 seconds, then the EDT between node *A* and node *C* is at most 550 seconds. In the local mobility models two nodes should be close if they met recently. Also, node *X* is local to another node *Y* if *X* or some recent contact of *X* has a small average intermeeting time with *Y*. Note that an AIT record being ∞ does not necessarily imply that that corresponding EDT is ∞.

The CEDT tables of the nodes in the same cloud are same as that of EDT. Each CEDT record for a particular destination in the CEDT table equals the minimal record in the EDT tables of the nodes in the cloud. When a node moves into a cloud, its destination node is also in same cloud then data messages delivered by a multi-hop forwarding. Other messages that contribute to the minimum CEDT records are then forwarded to the nodes.

The update dependency of the CEDT, EDT, DSDV is shown in Figure 3.1. For instance, an arrow from table *A* to table *B* means that *A*'s update is triggered by *B*'s update. The AIT table triggers the update of the EDT table, whereas the update of a node's CEDT table is triggered by the updates of its neighbors' DSDV tables, EDT tables, or CEDT tables. When nodes meet, they exchange the acknowledgements of the delivered messages and the message vectors of the messages that the nodes are storing before forwarding any data message. The messages whose destinations are in the cloud are given priorities that are significantly larger than those of the other messages. The priorities of the destination-in-cloud messages are inversely proportional to the hop-count between its destination and the current node. The priority of a destination-out of cloud message is calculated based on the delivery probability (basically according to the CEDT record) and some fairness considerations. The priority of a message *i* destined for node *d* is defined as Pr:

$$pr(i) = \frac{T_{L-} T_C}{E(d)} * F(i) * \frac{1}{T_L} * \frac{1}{H}$$

where *TL* is the original TTL of *i*, *TC* is the creation time of *i*, *E*(*d*) is an optimal expected delivery latency to *d* (which comes directly from the CEDT table), *F*(*i*) is the ticket held by the replicas of *i*, and *H* is the hop count from the current node to the node contributing to the best CEDT record *E*(*d*) for *i*'s destination. $TL - Tc$ is the remaining TTL of *i*, and $TL - Tc \ /L(d)$ is the delivery probability of *i* based on the estimated delivery time. All messages have the same chance of being selected in the whole network since the *F*(*i*)s of all replicas of *i* add up to 1. 1/ *TL* gives all messages an equal chance of being selected during their lifetime. Finally, $1/H$ estimates the cost of forwarding the current message to the node contributing to *E*(*d*). The AROSD algorithm is shown in Algorithm. Without loss of generality, we describe the action a node takes when it comes in contact with other nodes

Algorithm: AROSD

1: AIT, EDSDV, EDT, and CEDT tables are updated.
2: update ACKs and message vectors.
3: deliver destination-in-cloud messages.
4: while the node wants message to send do
5: the priority of each message is being calculated.
6: transfer a message with a probability proportional to its priority.

7: end while
8:broadcast hello messages when all eligible messages are transmitted.

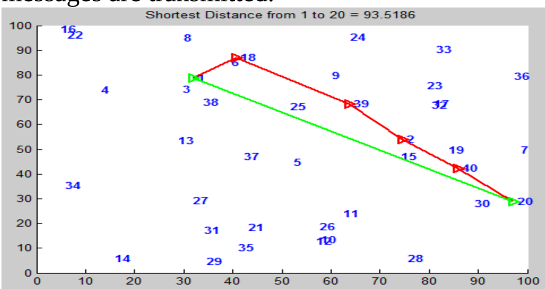

Figure 4: Shortest Path

5. Implementation Details

Each node in the network sends "hello" messages to other nodes to detect its presence. Once a node detects "hello" messages from another node (neighbor), it adds contact record to store information about the neighbor, including the received table updates from the neighbor. If message failure occurs or node doesn't receive any message for particular time period then it is assumes as contact link is broken.

To implement the above functions efficiently, here we have made some modification in 802.11 MAC layer, such that the routing layer receives notifications directly from the MAC layer to indicate the connections/disconnections with neighbors. They also include the acknowledgment that the message transfer is completed, and whether a MAC layer ACK for a unicast is received. Having this notification from the MAC layer, we can implement a blocked transmission function with an ACK-received indicator that is returned in the routing layer, such that a reliable unicast is realized by rescheduling retransmissions when the failure of a previous transmission is indicated. The EDSDV table contains the following rows: dst-ID, next- ID, hop, and dst.-time. Unlike DSDV, a dst.- time is functioned as the sequence number. EDSDV requires each node to store the most recent DSDV tables advertised by its neighbors, which requires a D × N memory space where D is the number of neighbors. It is obvious that EDSDV transmits fewer messages than DSDV in all circumstances.

The AIT table contains five rows: dst-ID, lastcon-time, last-discon-time, con-times, and AIT. Each time a node's connection with another node is broken, the corresponding last-discon-time is updated to the current time and con-times is increased by one.

6. Performance Evaluation

We have carried out simulation in Matlab environment using standard functions of Matlab. The following metrics are used in my simulation:

- Delivery rate vs Nodes.
- Message generating rate vs Delivery rate.
- Random Waypoint.

Network analysis is a method of studying networks in terms of graph theory thus the network density determined in this study, is based on the number of nodes found in a particular area and the connectivity of the nodes. Therefore even though the number of nodes found in a small area may not be packed, given a high transmission range then it can be determined that the node in the area is dense. Otherwise given either a very large or low connectivity the node density could be determined as sparse.

This result shows that AROSD performs better in denser networks due to the adaptation of the multi-hop delivery, which saves bandwidth compared to the multi-copy delivery. Also, AROSD performs better in RWP, which shows that increased mobility improves delivery rate.

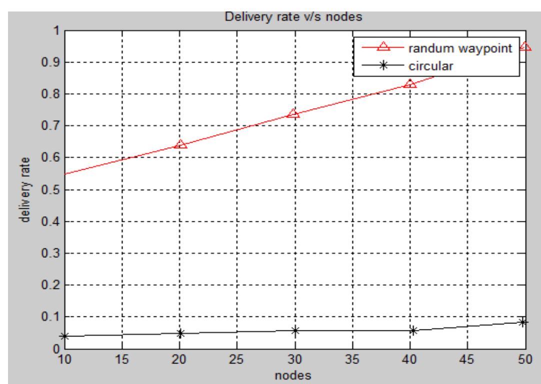

Figure 5: Delivery rate vs Nodes

Throughput is the average number of messages successfully delivered per unit time i.e. average number of bits delivered per second. Node stability helps in increasing the message generating rate. Here we have plotted the graph of message delivery rate Vs delivery rate which help us to figure out the throughput of AROSD

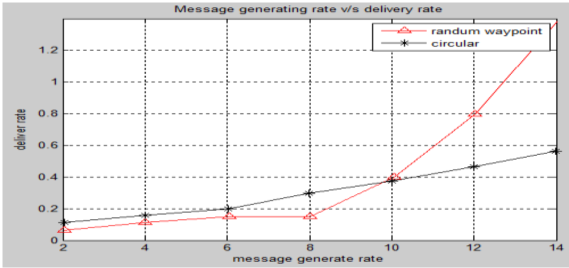

Figure 6: Message generating rate vs Delivery rate

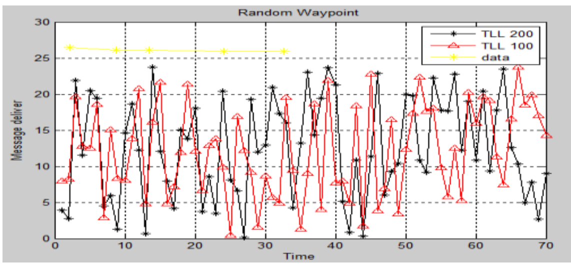

Figure 7: Random Waypoint

7. Conclusion

In dynamic ad hoc networks, conventional routing schemes fail when the network characteristics do not fall into their applicable scenarios. Previous research has proposed a variety of routing schemes for each specific network scenario. After studying the development in the field of mobile Ad-Hoc network there are so many protocols have been proposed for particular type of network. AROSD performs better in denser networks due to the adaptation of the multi-hop delivery, which saves bandwidth compared to the multi-copy delivery. Also, AROSD performs better in RWP, which shows that increased mobility improves delivery rate. In limited transmission opportunities, when fewer messages are generated, the number of transmissions shared by each message increases, and thus the delivery rate increases and the delay decreases. These figures show that AROSD adaptively utilizes the bandwidth. The longer the TTL, the longer a message stays in the buffer, giving it more chances to be delivered. On the other hand, with more ACKs, less bandwidth is available for the data messages since ACKs are delivered first.

References

[1] Ivan Stojmenovic " Handbook of Wireless Networks and Mobile Computing" Copyright © 2002 John Wiley & Sons, Inc. ISBNs: 0-471-41902-8 (Paper); 0-471-22456-1 (Electronic).

[2] C. Perkins and P. Bhagwat. " Highly dynamic destination-sequenced distance-vector routing (DSDV) for mobile computers." In Proc. of Conference on Communications Architectures, Protocols and Applications in conjunction with SIGCOMM 94, pages 234–244, 1994.

[3] J. Burgess, B. Gallagher, D. Jensen, and B. N. Levine. MaxProp: Routing for Vehicle-Based Disruption-Tolerant Networking. In Proc. of IEEE INFOCOM 2006, 2006.

[4] S. Chen and K. Nahrstedt. A distributed quality-of-service routing in ad-hoc networks. IEEE Journal on Selected Areas in Communications, 17(8):547–560, August 1999.

[5] S. Jain, K. Fall, and R. Patra. " Routing in a delay tolerant network". In Proc. of ACM SIGCOMM, August 2004.

[6] T. Spyropoulos, K. Psounis, and C. Raghavendra. Efficient routing in intermittently connected mobile networks: The multi-copy case. In ACM/IEEE journal of Transactions on Networking, 2007.

[7] Charles E. Perkins, Elizabeth M. Royer, Samir R. Das, "Ad Hoc On-demand Distance Vector Routing", October 99 IETF Draft, 33 pages.

[8] A. Vahdat and D. Becker. Epidemic routing for partially connected ad hoc networks. Technical Report CS-200006, Duke University, April 2000.

[9] J. Leguay, T. Friedman, and V. Conan. Evaluating mobility pattern space routing for DTNs. In Proc. of IEEE INFOCOM, 2006.

[10] [M. Mirco, H. Stephen, and M. Cecilia. Adaptive Routing for Intermittently Connected Mobile Ad Hoc Networks. In Proceedings of the IEEE 6th International Symposium on a World of Wireless, Mobile, and Multimedia Networks (WoWMoM 2005). IEEE press, June 2005.

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