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Adaptive Routing In Dynamic Ad-Hoc Network

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ABSTRACT

The dynamics of an ad hoc network are a challenge to protocol design because mobility of nodes leads to unstable routing, and consequently flows encounter fluctuations in resource availability on various paths during the lifetime of a session. This has become serious, especially for those protocols based on single-path reservation, as frequent reservation and restoration of reservation-based flows increase the instability of connections. Advances in wireless research are focusing more and more on the adaptation capability of routing protocols. These protocols are interrelated to each other among various performance measures such as those related to topological changes (link breakages, node mobility, etc.) and quality of service (QoS) parameters (load, delay, etc). 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 structure 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. Previous research has proposed a variety of routing schemes for each specific network scenario. For instance, distributed routing tables are built for efficient multi-hop, single copy routing in static and dense networks. Mobility assisted multi-copy routings are proposed in sparse networks where contemporary paths might not exist. With the advantages of the existing schemes in mind, we introduce a new routing scheme, Adaptive ROuting in Dynamic ad hoc networks (AROSD), which is a seamless integration of several existing schemes.

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

I. 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. Furthermore in military operations or after environment disaster it is important to establish communication fast in addition it is highly probable the existing infrastructure has been destroyed. After the ad hoc network has been established the nodes that connect the network might move, say for example that one military squad is under heavy attack and has to escape. In ad hoc networks nodes should be able to move freely and the information should be routed through new paths after old ones have been broken, the network should also be able to handled clustering. The advent of ad hoc network has given birth to new kinds of routing algorithms and new security threats.

I.I Ad-Hoc Networks

An ad-hoc (or "spontaneous") network is a local area network or other small network, especially one with wireless or temporary plug-in connections, in which some of the network devices are part of the network only for the duration of a communications session or, in the case of mobile or portable devices, while in some close proximity to the rest of the network and thus usually temporary and does not require a router or a wireless base station.

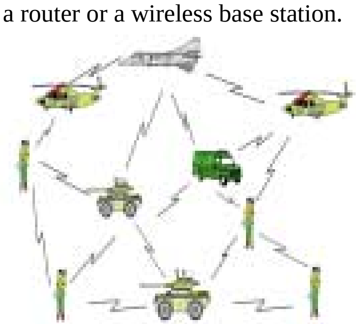

Fig. 1 An example of Ad-Hoc Network

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. Moreover, if different scenarios are exhibited by different parts of a network, the routing protocols used must be able to communicate and cooperate with each other, which is another difficult task. Thus, a routing protocol that is adaptive in an effort to maintain good performance and that also operates seamlessly in different network scenarios is desired. In this preliminary work, we investigate an adaptive routing algorithm in dynamic ad hoc network.

II. LITERATURE SURVEY

A MANET[1] protocol should function effectively over a wide range of networking contexts--from small, collaborative, ad-hoc groups to larger mobile, multihop networks. Characteristics and evaluation metrics of MANET somewhat differentiate MANETs from traditional, hardwired, multihop networks. The wireless networking environment is one of scarcity rather than abundance, wherein bandwidth is relatively limited, and energy may be as well. Previous work on MANETs has been carried out on various assumptions regarding node density and mobility models. Conventional ad hoc network routing schemes such as DSR [3], AODV [7], and DSDV [2] are proposed in dense networks where contemporary source-destination paths exist. In delay tolerant networks [5], especially the extremely sparse networks where the average node degree is smaller than 1, messages can still be delivered if paths exist in the evolving graph of the network. Existing routing schemes such as Epidemic [8], Prophet [9], Spray and Wait [6], Spray and Focus [6], MaxProp, and RAPID, use a store carry forward scheme.

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 [2]. 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 features from previous works. Our main contribution in this work is demonstrating the feasibility of an adaptive routing approach in dynamic ad hoc networks. To this end, we:

- Present a routing protocol, AROSD, which is the first routing scheme that is adaptive to network density as well as to node mobility patterns.
- Show that AROSD behaves appropriately and maintains desired properties in dense as well as in sparse network scenarios.
- Implement AROSD and show its efficacy in different network scenarios.

III. ADAPTIVE ROUTING IN DYNAMIC AD-HOC NETWORKS

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 contemporary path.

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.

III.I *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.

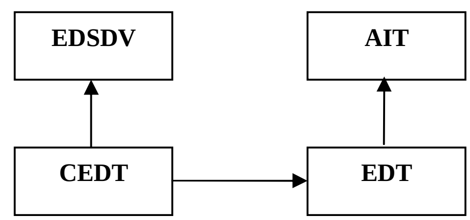

Fig. 2 Update dependency of the table

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

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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:

$$\mathrm{Pr}(i) = \frac{T_L - T_C}{E(d)} \times F(i) \times \frac{1}{T_L} \times \frac{1}{H} \quad \text{.........} \ (1)$$

where T_L is the original TTL of *i*, T_C 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. $T_L - Tc$ is the remaining TTL of *i*, and $T_L - Tc\ /L(d)$ 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. $1/\ T_L$ 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.

III.II *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, last-con-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.

III. *Properties of AROSD*

AROSD has properties identical to the routing schemes of different scenarios, as we will see in the following. In a connected network, AROSD uses multihop delivery, where a message will only be forwarded to the node that is closest to the destination in terms of hop-count. Since, in a connected network, the source and the destination are in the same cloud, the message will be forwarded in a multi-hop manner according to the EDSDV table. In each forwarding of message, the ticket of the message is completely transferred to the receiver, and thus the sender will not send the same message a second time. Consequently, a single copy of the message will be forwarded to the destination along the shortest path. Here we list some of the properties of AROSD

- In a sparse mobile network with random mobility, AROSD resembles spray and wait and performs binary spray. In random mobility, nodes have similar EDTs to any destination.
- In local mobility, AROSD shows the trend to become more similar to a multi-hop delivery and less like multi-copy, mobility-assisted delivery.
- In a DTN consisting of long term clouds, AROSD broadcasts messages in the cloud if the capacity is quite

enough. This maximizes the probability of the message being picked up by the mobile nodes from the other clouds.

- The sum of the tickets of all the copies of a message is 1. This is generally true, except in situations where a sender, without receiving an acknowledgement, has no idea of whether a message has been forwarded to a receiver and thus can deduce from the local copy the ticket given to the sent copy.

IV. PERFORMANCE EVALUATION

We have carried out simulation in Matlab environment using standard functions of Matlab. The following metrics are used in my simulation: (1) Convergence speed, (2) Delivery ratio, and (3) Delivery latency (delay). Two mobility models are used in our simulation: (1) the Random Waypoint (RWP) model, which is a representative of the random mobility, and (2) the Circular Trajectory (CT) model which is a representative of the local mobility. In the Circular Trajectory model, each node has a fixed circular trajectory that it travels at a constant speed.

IV.I *Network Density*

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.

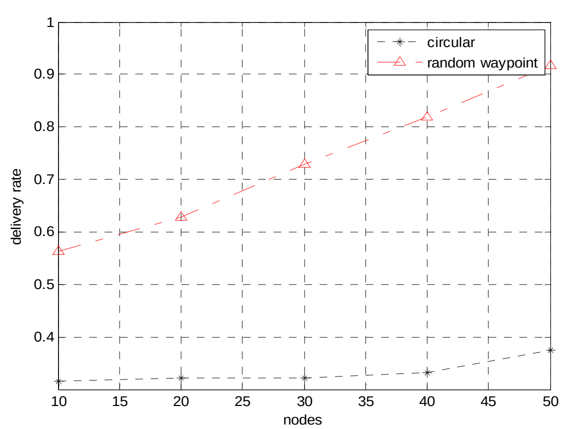

Fig. 3 Delivery rate v/s nodes

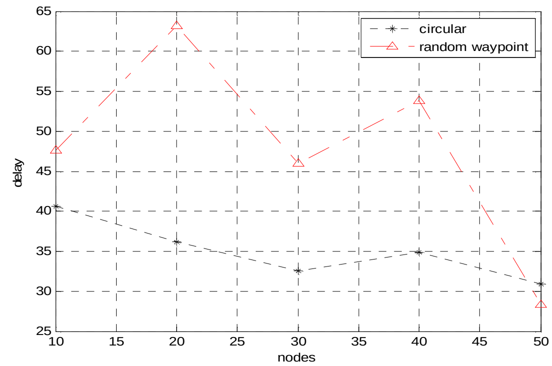

Fig. 4 Delay v/s nodes

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.

IV.II *Message Generating Rate*

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

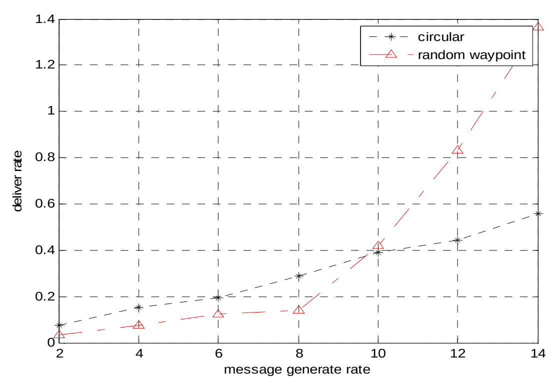

Fig. 5 Message generating rate v/s delivery rate

IV.III *Convergence Speed and TTL*

Figure 6 and Figure 7 shows the convergence speed of AROSD in the RWP model and the CT model respectively. AROSD's EDT tables converge faster in the RWP model where each node meets a greater number of other nodes. We can also observe in these figures that the delivery rate might increase or decrease as the TTL of the messages changes. In our simulation, the ACKs use the same TTL as the data messages. 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.

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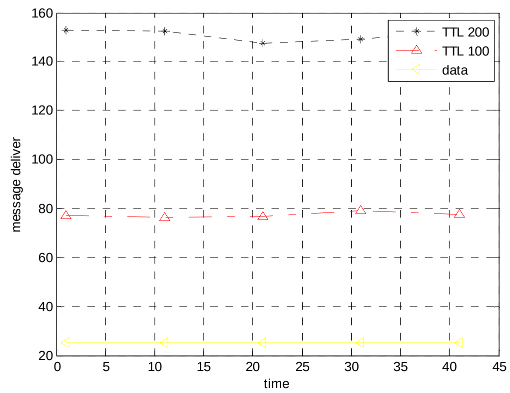

Fig. 6 Circular Trajectory

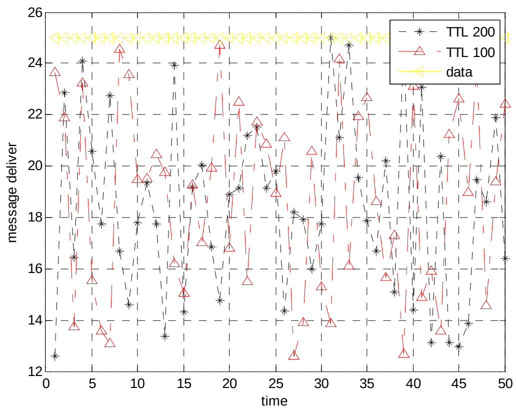

Fig. 7 Random Waypoint

V. 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.

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