Backbone Nodes Based Stable Routing for Mobile Ad Hoc Networks

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ABSTRACT

The recent trend in ad hoc network routing is the reactive on-demand philosophy where routes are established only when required. Most of the protocols in this category, however, use single route and do not utilize multiple alternate paths. This paper proposes a scheme to improve existing on-demand routing protocols by introducing the concept of stable backbone based node scheme in network topologies scenario. The scheme establishes the multi paths without transmitting any extra control message. It offers quick adaptation to distributed processing, dynamic linking, less memory overhead and loop freedom at all times. The Scheme has been incorporated with the AODV and DSR protocols. The extensive simulation has been done for the performance evaluation; it clearly shows that the scheme performs very well with increasing packet delivery for different network scenarios.

Keywords: Ad hoc networks, Routing protocols, Backbone nodes, AODV, DSR.

1. INTRODUCTION

A mobile ad hoc network (MANET)[1] is a collection of autonomous nodes, which communicate using wireless links without any fixed network infrastructure and centralized administrative support. The main application of mobile ad hoc network is in emergency rescue operations and battle fields.

This paper addresses the problem of routing in mobile ad hoc network. Since mobile nodes in mobile ad hoc network can move randomly the topology may change arbitrarily and frequently at unpredictable times. Transmission and reception parameters may also impact the topology. So it is very difficult to find and maintain an optimal route. The routing algorithm must react quickly to topological changes. Due to dynamic nature of MANETs, the problem of broken path becomes prominent. Most of the existing protocols maintain single routing path and rediscover the new path whenever a link fails. A scheme has been proposed here which takes the advantage of stable backbone nodes to provide the alternate path in case of a link failure. This scheme can be incorporated in any existing on demand routing protocol to improve the performance. The efforts in this paper has been made to incorporate the scheme on AODV and DSR.

Rest of the paper is organized as follows. The Section 2 deals with study on existing protocols. In section 3 the proposed scheme is discussed. Section 4 provides simulation details and results. Section 5 concludes the paper.

2. PREVIOUS STUDY

The primary goal of routing protocol is to establish a correct and efficient route between a pair of nodes so that messages may be delivered in a timely manner. Routing protocols in Mobile ad hoc networks can be classified in to two broad categories as

1 Proactive or Table driven
2. Reactive or On demand

The proactive or table driven protocols attempt to find a route continuously and maintain routing information from each node to every other node within the network, so that whenever data is needed to be transmitted between two nodes, the route is already there. The nodes are required to maintain consistent up-to-date routing information in one or more tables. DSDV[2], WRP[3], CGSR[4] etc are the protocols of this category.

In Reactive approach routes are created only when desired by the source node. When a node requires a route to other node, it initiates a route discovery process with in the network. All permutations are examined and best possible route is established. The route is maintained by some route maintenance procedure until either the destination becomes inaccessible or until the route is no longer desired. AODV[5], DSR[6], LMR[7], TORA[8], and ABR[9] etc are reactive protocols.

There is another category of routing protocols known as hybrid routing which is a compromised approach between proactive and reactive approaches. Zone Routing Protocol (ZRP) [10] is one of the most important protocols under this category. This protocol limits the scope of table driven procedure to a small area called zone. Outside the zone area reactive approach is followed. Surveys of routing protocols for ad hoc networks have been discussed in [1,11]

3. PROPOSED STUDY:

The proposed scheme takes care of on demand routing along with a new concept of backbone nodes. These backbone nodes help in reconstruction phase in the fast selection of new routes. Selection of backbone nodes is made upon availability of nodes. Each route table has an entry for number of backbone nodes attached to it. Whenever need for a new route arises in case of route break, check for backbone nodes are made, and a new route is established. Same process is repeated in route repair phase. Route tables are updated at each hello interval as in AODV with added entries for backbone nodes. Backbone nodes are nodes at the one hop distance from its neighbor. Backbone nodes are those nodes which are not participating in route process currently or nodes which enter the range of transmission during routing process. As nodes are in random motion for a scenario, so there is every possibility that some nodes are idle and are in the vicinity of the routing nodes. Whenever a break in the route phase occurs due to movement of participant node, node damage or for other reasons; theses idle nodes which have been termed as backbone nodes take care of the process and start routing. The whole process becomes fast and more packet delivery is assured. The changes in the existing protocol are required at route reply and route recovery phases. In these phases the route table is updated with entries of backbone nodes. Each route table has an entry for number of backbone nodes surrounding it and their hop distance form the node. For simplicity of the protocol the distance has been assumed to be one hop.

As it has been described in Figure 1, the Route selection from S (source) to D (destination) is made via 1-2-3-4 using shortest path routing. In case any of the participating nodes damages or move out of the range, the backbone nodes can be 6, 8 and 9. These nodes are nearer to the routing path nodes and can join the process any time.

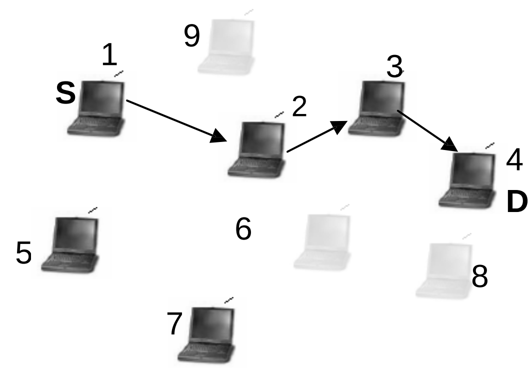

Figure 1: Stable route using Backbone Nodes.

AODV: For AODV the protocol description has been explained as: the protocol is divided into three phases. Route Request (REQ), Route Repair (REP) and Error Phase (ERR).

3.1 Route Construction (REQ) Phase

This scheme can be incorporated with reactive routing protocols that build routes on demand via a query and reply procedure. The scheme does not require any modification to the AODV's RREQ (route request) propagation process. In the scheme with Backbone nodes, when a source needs to initiate a data session to a destination but does not have any route information, it searches a route by flooding a ROUTE REQUEST (REQ) packet. Each REQ packet has a unique identifier so that nodes can detect and drop duplicate packets. An Intermediate node with an active route, upon receiving a no duplicate REQ, records the previous hop and the source node information in its route table. It then broadcasts the packet or sends back a ROUTE REPLY (REP) packet to the source if it has an active route to the destination. The destination node sends a REP via the selected route when it receives the first REQ or subsequent REQs that traversed a better active route. Nodes monitor the link status of next hops in active routes. When a link break in an active route is detected, an ERR message is used to notify that the loss of link has occurred to its one hop neighbor. Here ERR message indicates those destinations which are no longer reachable by way of the broken link. Taking advantage of the broadcast nature of wireless communications, a node promiscuously overhears packets that are transmitted by their neighboring nodes.

When a node that is not part of the route overhears a REP packet not directed to itself transmit by a neighbor (on the primary route), it records that neighbor as the next hop to the destination in its alternate route table. From these packets, a node obtains alternate path information and makes entries of these backbone nodes (BN) in its route table. If route breaks occurs it just starts route construction phase from that node. The protocol updates list of BNs periodically in the route table.

3.2 Route Error & Maintenance (REP) Phase

Data packets are delivered through the primary route unless there is a route disconnection. When a node detects a link break (for example, receives a link layer feedback signal from the MAC protocol, node1 does not receive passive acknowledgments, node2 does not receive hello packets for a certain period of time, etc.), it performs a one hop data broadcast to its immediate neighbors. The node specifies in the data header that the link is disconnected and thus the packet is candidate for alternate routing. Upon receiving this packet, previous one hop neighbor starts route maintenance phase and constructs an alternate route through backbone nodes by checking their stability. Nodes those have an entry for the destination in their alternate route table; transmit the packet to their next hop node. Data packets therefore can be delivered through one or more alternate routes and are not dropped when route breaks occur. To prevent packets from tracing a loop, these mesh nodes forward the data packet only if the packet is not received from their next hop to the destination and is not a duplicate. When a node of the primary route receives the data packet from alternate routes, it operates normally and forwards the packet to its next hop when the packet is not a duplicate. All this route maintenance occurs under *local repair* scheme.

3..3 Local Repair

When a link break in an active route occurs, the node upstream of that break may choose to repair the link locally if the destination was no farther and there exists Backbone Nodes that are active. The Time to live (TTL) of the REQ should initially be set to the following value:

TTL = max (MIN_Repair_TTL+ BN, 0.5* #hops)

Where MIN_Repair_TTL is the known hop count to the destination. #hops is the number of hops to the sender (originator) of the currently undeliverable packet. BN attached is number of backbone nodes. This factor is transmitted as weight factor to all nodes to select best available path. Addition of backbone nodes help in selecting stable routes.

DSR:

The key feature of DSR is the use of *source routing*. That is, the sender knows the complete hop-by-hop route to the destination. These routes are stored in a *route cache*. The data packets carry the source route in the packet header. When a node in the ad hoc network attempts to send a data packet to a destination for which it does not already know the route, it uses a *route discovery* process to dynamically determine such a route. Route discovery works by flooding the network with route request (RREQ) packets. Each node receiving a RREQ, rebroadcasts it, unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the RREQ with a route reply (RREP) packet that is routed back to the original source. RREQ and RREP packets are also source routed. The RREQ builds up the path traversed so far. The RREP routes itself back to the source by traversing this path backwards. The route carried back by the RREP packet is cached at the source for future use. If any link on a source route is broken, the source node is notified using a route error (RERR) packet. The source removes any route using this link from its cache. A new route discovery process must be initiated by the source, if this route is still needed. DSR makes very aggressive use of source routing and route caching. No special mechanism to detect routing loops is needed. Also, any forwarding node caches the source route in a packet it forwards for possible future use. Some additional optimizations have been proposed here for DSR as (i) *Selection*: In DSR route request have been modified by changing cache settings. A value is set at some minimum level and route reply is checked, If route reply does not occur in that time then backbone nodes are used. Backbone nodes have been entered at random level for DSR for better results. An intermediate node can use an alternate route from its own cache, when a data packet meets a failed link on its source route. (ii) *route repair*: A source node receiving a RERR packet piggybacks the RERR in the following RREQ. This helps clean up the caches of other nodes in the network that may have the failed link in one of the cached source routes. (iii) Duplicate routes: When a node overhears a packet not addressed to itself, it checks whether the packet could be routed via itself to gain a shorter route. If so, the node sends a RREP to the source of the route with this new, better route. Aside from this, promiscuous listening helps a node to learn different routes without directly participating in the routing process.

4. Simulation and Results

Simulation study has been carried out to study the performance study of proposed scheme with existing different protocols. Simulation Environment used is NS-2[12] (network simulator).The version NS 2.28 has been used to carry out the process. Simulation results have been compared with AODV and DSR and their modified versions. The metrics used in the simulation study to perform evaluations have been discussed below.

Packet Delivery Ratio: The fraction of successfully received packets, which survive while finding their destination. This performance measure also determines the completeness and correctness of the routing protocol.

End-to-End Delay: Average end-to-end delay is the delay experienced by the successfully delivered packets in reaching their destinations. This is a good metric for comparing protocols. This denotes how efficient the underlying routing algorithm is, because delay primarily depends on optimality of path chosen.

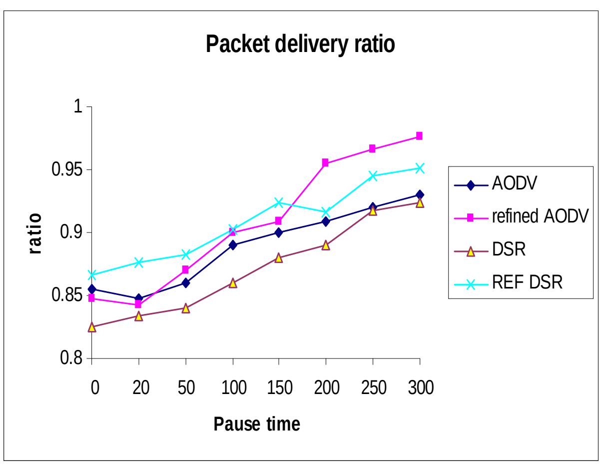

Figure 2 : Packet delivery at pause times

In simulation study 50 nodes have been taken in a random scenario with 1000 × 750 areas. The area selected is rectangular instead of square as in earlier simulations. This relates it better to real life scenarios. The study has been conducted at different pause times.

Pause time of 0 means maximum mobility and 300 is minimum mobility. Speed has been kept constant at 15 meter per second.

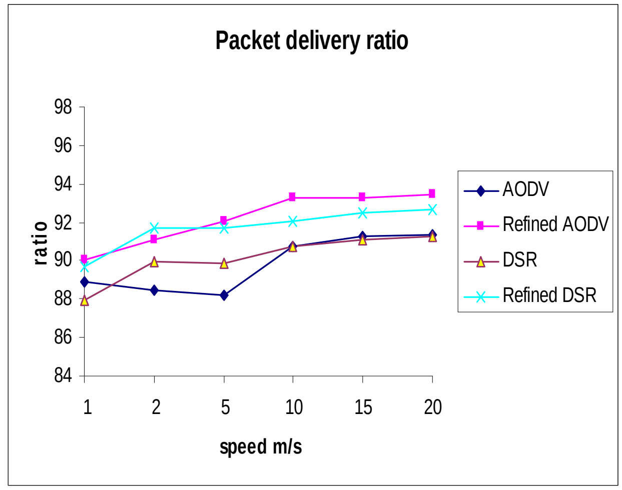

Figure 3 : Packet delivery at different speeds

An approximate increase of 16-20 % have been seen in packet delivery of AODV and DSR modified versions. AODV gets stable even at higher pause time as shown in figure 2. This trend is more evident with use of stable backbone nodes. The scenario has been changed in figure 3 for 50 nodes moving at different speeds. Speed has been varied from 1 meter per second to 20 meters per second.

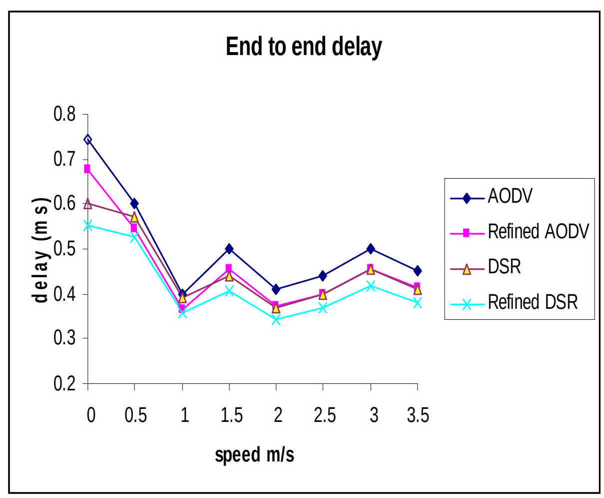

Figure 4: End to end delay at different speeds

The trend clearly indicate more packet delivery for refined versions of protocols. Refined ADOV has better delivery at faster speeds. It gets stabilized at fast speeds. The initial fall can be attributed to time required for more calculations involved in better selection of stable route.

One more parameter has been used as End to end delay. It is expected that initially delay is more for refined versions. This is because all initial calculations take more time. It takes more time in initial selection of Route and when it stabilizes then the delay decreases as shown in figure 4. DSR is better in all cases as it uses cache

5. CONCLUSION

A new scheme has been presented that utilizes a mesh structure and alternate paths. The scheme can be incorporated into any ad hoc on-demand unicast routing protocol to improve reliable packet delivery in the face of node movements and route breaks. Alternate routes are utilized only when data packets cannot be delivered through the primary route. As a case study, the proposed scheme has been applied to AODV and DSR and it was observed that the performance improved. Simulation results indicated that the technique provides robustness to mobility and enhances protocol performance. Average increase in packet delivery occurs for both protocols. The Backbone based node Routing gives a better approach for on demand routing protocols for route selection and maintenance. It caused a bit more end to end delay. The process of checking the protocol scheme is on for more sparse mediums and real life scenarios and also for other metrics like Path optimality, Link layer overhead. Additionally, the plan is to further evaluate the proposed scheme by using factor of power and quality of service.

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