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Editorial Board

Title

A NODE DISJOINT MULTIPATH ROUTING PROTOCOL IN MOBILE AD HOC NETWORK

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ABSTRACT:

The applications of Mobile Ad hoc Network (MANET) are based on all-IP architecture. In MANET, the applications place stringent requirements on networks for delivering data packets reliably and quickly. Mobile ad hoc networks are characterized by a dynamic topology, limited channel bandwidth and limited power at the nodes. Because of these characteristics, paths connecting source nodes with destinations may be very unstable and go down at any time, making communication over ad hoc networks difficult. Typical applications may require higher reliability connections than that provided by a single link. Also, to fulfill certain quality parameters; presence of multiple node-disjoint paths becomes beneficial. Such paths aid in the optimal traffic distribution and reliability in case of path breakages. Thus, to cater these challenges of routing in Mobile Ad hoc Networks, a Node Disjoint Multipath Routing protocol considering high mobility in MANET has been proposed by the authors. This protocol can discover multiple node-disjoint route paths with low routing overhead, so it can provide load balancing and higher aggregate bandwidth.

Key words: MANET, Multipath Routing, Node disjoint, Proactive protocols, Reactive protocols

1. Introduction:

Mobile Ad hoc Networks (MANET) are wireless networks without any fixed infrastructure, which are usually set up on a temporary basis to serve a particular purpose within a specific period of time. MANET has found applications in military field missions, emergency rescue operations, expeditions in remote areas, common communication needs of organisations, especially in conferencing, personal area networks, etc. Effective routing has become an issue of significant concern in MANET. This is because mobile networks need to be handled by ordinary nodes that have neither specialized equipment nor a fixed position in the network. Therefore any efficient and effective routing for MANET must tackle the challenges posed by the mobility of the nodes, their limited energy resources and heterogeneity.

Providing multiple routes is beneficial in network communications, particularly in MANETs, where routes become obsolete frequently because of mobility and poor wireless link quality [1]. The source and intermediate nodes can use these routes as primary and backup routes. Alternatively, traffic can be distributed among multiple routes to enhance transmission reliability, provide load balancing, and secure data transmission.

So many multipath routing protocols have been designed for MANET that have in one or the other way solved the aforementioned challenges to some extent. Of all the protocols overviewed, it is found that although these protocols can build on demand multiple routing paths, all of them encounter a broadcast storm of routing packets in the process of looking for multiple disjoint routing paths .To overcome these issues we have proposed a new protocol HYMR. The HYMR protocol has got some special characteristics geared at improving the efficiency of routing in MANET.

2. Related Works:

In the recent period, lot of research has been done in the area of multi-path routing. The recent studies broadly focused on the multipath discovering extension of the on- demand routing protocols in order to alleviate problems of single path protocols like AODV[2] and DSR[3], such as, high route discovery latency, frequent route discovery attempts and possible improvement of data transfer throughput. The AOMDV (Ad hoc On-demand Multipath Distance Vector) [4] is a multipath extension to AODV. These provide link disjoint and loop free paths in AODV. Cross-layered multipath AODV (CM-AODV) [5], selects multiple routes on demand based on the signal-to-interference plus noise ratio (SINR) measured at the physical layer. The Multipath Source Routing (MSR) protocol [6], a multipath extension to DSR, uses weighted round robin packet distribution to improve the delay and throughput. Split Multipath Routing (SMR) [7] is another DSR extension, which selects hop count limited and maximally disjoints multiple routes. MP-DSR [8] is a QoS-aware multipath source routing protocol, based on Dynamic Source Routing protocol (DSR). It is a fully distributed QoS protocol, which creates and selects routes based on a newly defined QoS metric, end-to-end reliability. The CacHing And Multipath routing Protocol (CHAMP) [9] is a protocol which uses data caching and shortest multipath routing to reduce packet loss due to frequent route breakdowns. Although these protocols can build on-demand multiple routing paths, all of them will encounter a broadcast storm of routing packets in the process of looking for multiple disjoint routing paths. Moreover The MSR, SMR, MPDSR are based on Source routing, so packets contain complete path in header. This increases the overheads significantly.

3. Proposed Work: Hybrid Multipath Routing Protocol- HYMR:

Motivated by the need to reduce the resource overhead associated with routing algorithms and to cater to frequent link failure due to high mobility of nodes, a novel Node-Disjoint Multipath Routing protocol with low control overhead is proposed to solve these problems.

This protocol has couple of novel aspects compared to the other on-demand multipath protocols: it reduces routing overhead significantly and achieves multiple node disjoint routing paths. The protocol has load balance mechanism. By using the load balance mechanism, it is possible to reduce the traffic congestion which is an important contributing factor to an improved network performance.

This protocol is designed in a way that it combines the advantages of proactive and reactive routing both. While maintaining network topology information it works like a proactive protocol and while maintaining the routing table it works like reactive protocols. It means, the routing table is generated based on the information of network topology only if a particular node takes part in data transmission.

Protocol generates multiple node disjoint routes and uses all the paths simultaneously to distribute the traffic. By producing less traffic and having low overheads, it utilizes the limited resources of MANET optimally.

The HYMR protocol has four major phases i.e. topology exchange, route creation, route maintenance and data transmission.

3.1 Topology Exchange

A node **N** broadcasts Hello packet periodically. Every other node that is in the range of node **N** immediately responds to it and as a result node N comes to know about its neighbours. Node **N** then prepares a topology packet that it broadcasts to the network. In this way, all other nodes receive topology status that is local to node N.

Every node receives such topology packet from each other and as a result they are aware of the network topology at that instant of time. After receiving this information, a node prepares a graph table of the network to keep topology information. This operation is performed whenever a node discovers that any of its neighbours is not present / moves out of range (link is broken) and the time-period is over since last broadcasting of topology packet. This is the proactive behaviour of the protocol.

3.2 Route creation

Initially routin table is empty. When a node receives a request for data transmission it searches the routing table which was created during last transmission through it based on the topology information available and starts the transmission through the multiple paths available simultaneously. Otherwise it creates new route entries based on the topology information available in graph table. The basis of creating such route is to find node disjoint multiple paths from the graph table.

3.3 Route maintenance

It is a basic characteristic of the MANET that links are frequently breaks due to mobility of nodes. Thus it is necessary to re establish the routes.

For example, if a node **Z** moves from its current location, it will not reply to HELLO packet of the previous neighbour node **N** and will come in the range of some other nodes.

Similarly if this link break occurs during data transmission a link error packet will be generated. As a result, node **N** will now update its topology packet and broadcasts it.

In the same manner, other nodes who are now new neighbours of node **Z** will also update their topology packet and broadcasts it. In this manner, link break information will soon pass on to all nodes of the network and the topology is updated.

After receiving new topology packets, a node redraws the graph and finds new multiple node disjoint paths and updates its routing table and send the data through newly found route for existing transmission (if current session is on).

Based on the information available through link error packets or topology packets, the node updates the graph and the entries of all the paths containing the broken link are deleted from the routing tables. This way the routing table contains the most updated information. Since the protocol utilise multiple path to send data whenever a path is broken during running transmission it start looking for new path to add from the graph table

3.4 Data transmission

Whenever a request for data transmission is received, node searches the routing table entries for the availability of paths. If it finds path(s), node starts sending the data along all the path simultaneously and in this manner load balancing is achieved. Otherwise it starts for a fresh route creation process.

4. Algorithm :

```
Perform for every node whenever a packet is received:

INPUT: Packet* p;

String packet_type = getType(p);

if packet_type = LINK_ERROR, then

        updateGraph();

        clearRoutingTable();

elseif packet_type = TOPOLOGY, then

        updateGraph();

else    // means it's a data packet

        int dest = getDestination(p);

        int route_flag = searchRoutingTable(dest);

        if route_flag = FALSE, then         // means route not available in
        routing table

                routeCreation(dest);

        Array route = getRoute(dest);

        transmitData(route, p);
```

5. Evaluation of HYMR Protocol:

In order to evaluate the performance of HYMR in different mobility conditions, it is simulated using Network Simulator NS version 2.34. It is then compared with Ad hoc on demand Distance Vector Routing (AODV) Protocol. The simulation is carried out for different node velocities 0, 1, 5, 10 and 20 meter/second. The simulation parameters set are as follows:

No. of nodes	50
No. of sources	20
Area	1000 x 1000 meter
Mobility Model	Random Waypoint
Bandwidth	2 Mbps
Pause Time	5 sec.
Buffer Size	100
Transmission Range	250 meters
Sensing Range	250 meters
Packet Size	512 bytes
Traffic Source	CBR
MAC Protocol	IEEE 802.11

5.1 Performance Metrics:

The following metrics [9] are used in varying scenarios to evaluate the two different protocols:

- Packet delivery ratio: The ratio of the data packets delivered to the destinations to those generated by the CBR sources.
- Average delay of data packets: This includes all possible delays from the moment the packet is generated by source to the moment it is received by the destination node.
- Normalized routing load: The number of routing control packets transmitted per data packet delivered at the destination. Normalized routing load gives a measure of the efficiency of the protocol.
- Throughput: network throughput is the average rate of successful message delivery over a communication channel.

5.2 **Simulation Results**

In order to evaluate performances of the HYMR, it is compared with AODV in different network mobility conditions; node's velocity is varied from 0 to 20 mtr/second in steps of 5.

5.2.1 **Packet Delivery Ratio (PDR)**

Packet delivery ratio is defined as ratio of the data packets delivered to the destination nodes generated by the CBR sources. Since PDR shows the rate of packet loss, which in turn affects the maximum throughput of the network, it is very important metric. The simulation result for packet delivery ratio of the two protocols is shown in Figure 1. The Figure depicts the variation of the packet delivery ratio as a function of velocity of nodes. In general as the velocity of the nodes increases, the probability of link failure also leading to increase number of packet drops. The result shows that HYMR has much higher packet delivery ratio than AODV. More than 95% data packets of HYMR can be delivered to specified destinations which can be deemed an excellent performance, considering the high mobility characteristics of MANETs.

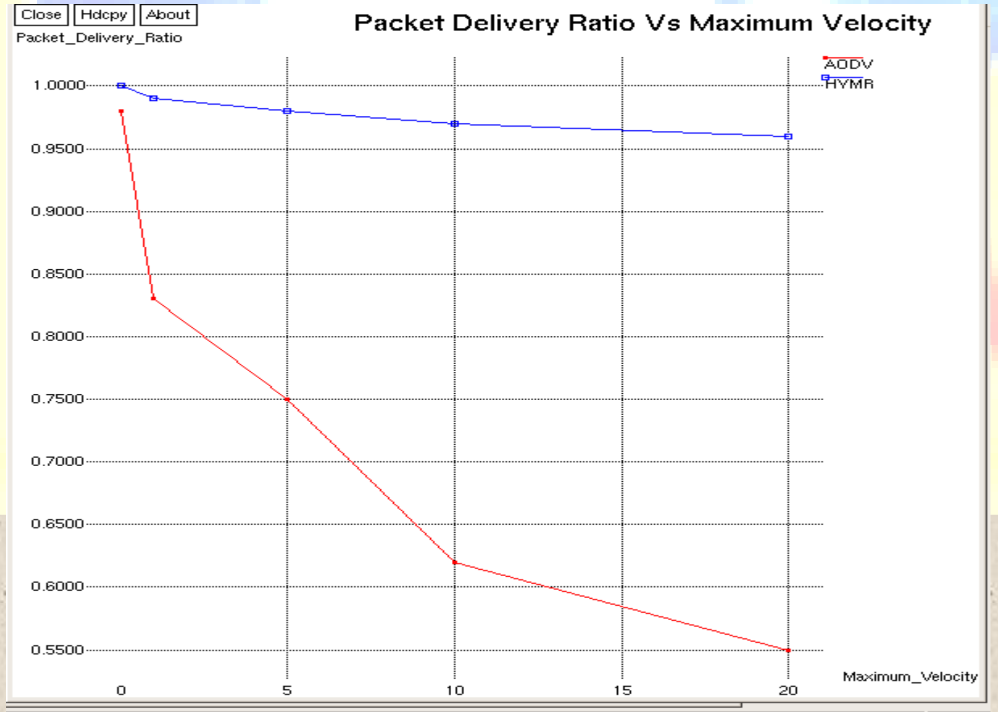

Figure:1 (Packet Delivery Ratio)

5.2.2 **Average end-to-end delay of data packets**

The average end-to-end delay includes all possible delays occurs during communication; from the moment the packet is generated to the moment it is received by the destination node. Generally, there are three factors affecting end-to-end delay of a packet: (1) Route discovery time, which causes packets to wait before a route path is found; (2) Buffering waiting time, which causes packets to wait in the queue before they can be transmitted; (3) The length of routing path. The more number of hops a data packet has to travel, the more time it takes to reach its destination node.

Figure 2 depicts the variation of the average end-to-end delay as a function of velocity of nodes. It can be observed that with the increase of velocity of nodes the general trend of all curves is an increase in delay. The reason for this is mainly that high mobility of nodes causes an increased probability of link failure that leads to increase in the number of route discovery processes. This makes data packets to wait for more time in its queue until a new routing path is discovered. Result shows that the delay of HYMR remains approximately equal at all mobile velocities, while delay in AODV increases sharply as the velocity increases.

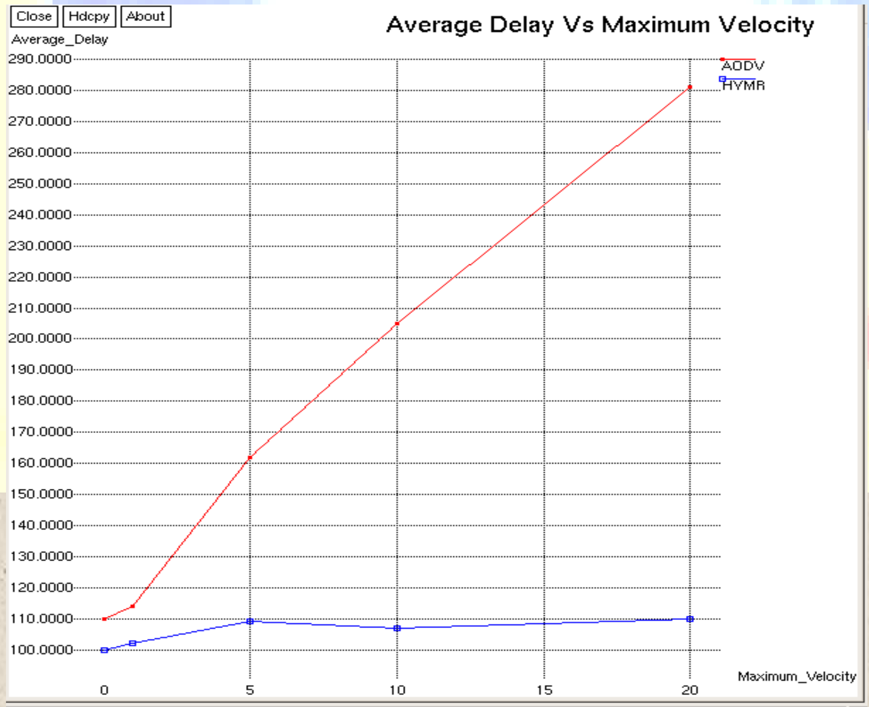

Figure: 2 (Average end-to-end delay of data packets)

5.2.3 **Normalized routing load**

Normalized routing load can be measured by the number of routing control packets transmitted per data packet delivered at the destination. To compare the performance of different protocols, the normalized routing load is an important metric since it can give a measure of the efficiency of protocols. Protocols that transmit a large number of routing packets have increase probability of packet collisions and waiting time of data packets in transmission buffer queues. Figure 3 shows the normalized routing load characteristics of the 50-node networks. It can be observed from the graph that the normalized routing load performance in HYMR is much better than that of AODV. The normalized routing load increases slowly with the increase of velocity. In AODV it increases more quickly than that in HYMR.

There are following reasons for this result:

(1) AODV encounter more link failures with the increase in mobility therefore it has to trigger route discovery processes more frequently which cause more routing control packets to be generated in the whole network. On the contrary, since the HYMR can find multiple node-disjoint route paths during route discovery, the protocol decreases the number of route rediscovery process.

(2) The HYMR has higher packet delivery ratio than AODV in high mobility of nodes.

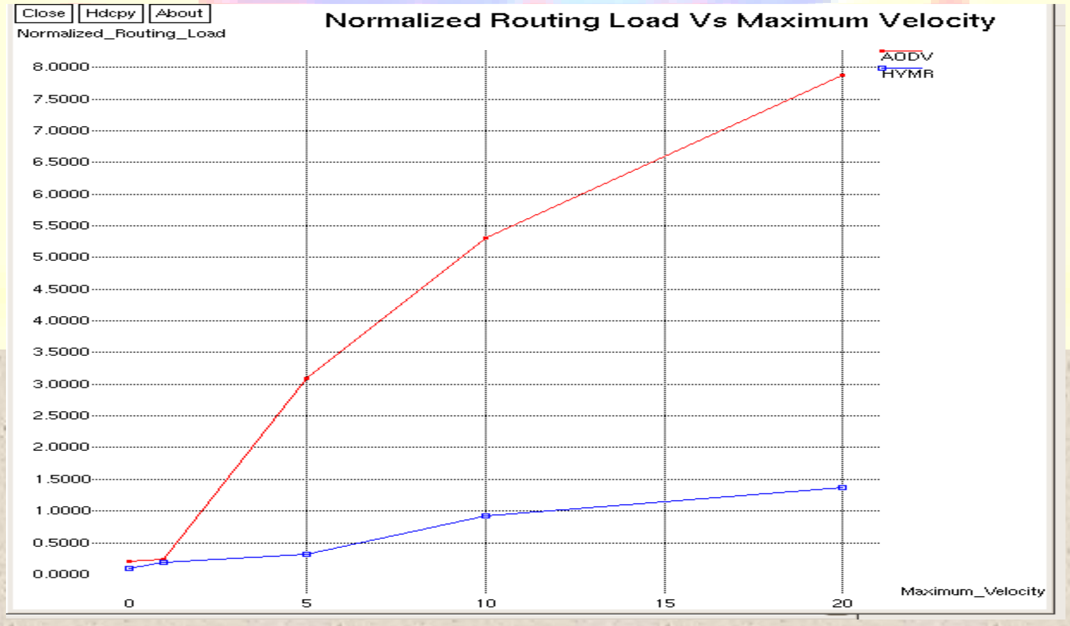

Figure: 3 (Normalized routing load)

5.2.4 **Throughput:**

Total data transmitted in the network and total data received in the network is calculated as throughput. It is found that HYMR outperforms the AODV. The reason for the same is that HYMR uses multiple paths to send the data. The moment a node receive link error, immediately it searches for new route establishment without affecting the ongoing data transmission from other paths. In AODV after a route break, a fresh route discovery is initiated thus the data packet transmitted in ongoing transmission is to be repeated that leads to reduced throughput**.** Figure 4 depicts the throughput of HYMR and AODV.

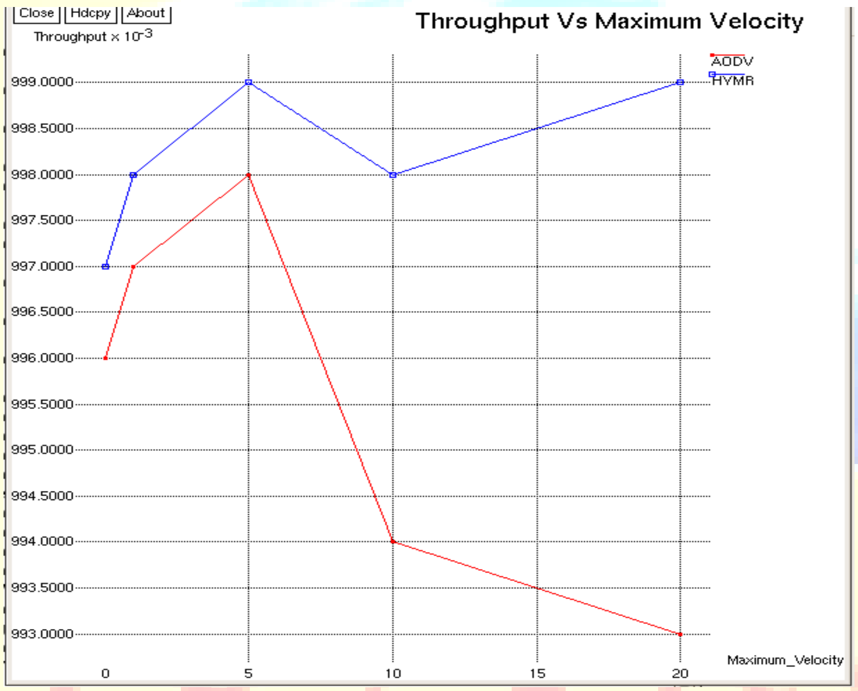

Figure: 4 (Throughput)

6. Conclusion and future work:

In order to find a solution for effective routing with low overheads in MANETs, we have designed a novel multipath node disjoint multipath routing protocol HYMR. Performance results for unipath routing protocol AODV with HYMR is compared in varying mobility scenario. Simulation results show that performance of HYMR is much better than that AODV in terms of

Packet delivery ratio, Average delay of data packets, Normalized routing load, and Throughput. In our next research we will analyse HYMR protocol in other network condition like varying number of nodes and varying number of source destination pairs to check the effect of HYMR's Performance in more crowded network.

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