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Kunjal Patel
Computer Engineering Dept
MAE, Alandi
Pune, India

Prof. S. A. Jain
Computer Engineering Dept
MAE, Alandi
Pune, India

Load balancing with multipath routing in MANETs

Abstract

Mobile ad hoc network is a collection of wireless mobile nodes, such devices as PDAs, mobile phones, laptops etc. that are connected over a wireless medium. There is no pre-existing communication infrastructure (no access points, no base stations) and the nodes can freely move and self-organize into a network topology. Hence, balancing the load in a MANET is important because the nodes in MANET have limited communication resources such as bandwidth, buffer space, and battery power.

Most current routing protocols for mobile Ad-hoc networks consider the shortest path with minimum hop count as optimal route without any consideration of any particular node's traffic and thus degrading the performance by causing serious problems in mobile node like congestion, power depletion and queuing delay. Therefore it is very attractive to investigate Routing protocols which use a Routing Metric to Balance Load in Ad-hoc networks. This paper discusses about LBMPR (Load balancing with multipath routing protocol) for efficient data transmission in MANETs.

Keywords: *Load Balancing, Mobile Ad hoc Networks, Routing*

1. INTRODUCTION

MANET is a temporary wireless network formed by a group of mobile nodes which may not be within the transmission range of each other. The nodes in MANET are self organizing, self-configuring, Self-maintaining and characterized by multi-hop wireless connectivity and frequently changing topology. Mobile nodes in MANET are connected by wireless links and each node act as host end router in the network. It is a collection of mobile nodes, such devices as PDAs, mobile phones, laptops etc. that are connected over a wireless medium The routing protocols in MANET can be categorized in to three different groups: Table Driven/Proactive, On-demand/Reactive and Hybrid routing protocols. In Table Driven routing protocols, each node stores and maintains routing information to every other node in the network. These are done by periodically exchanging routing table throughout the networks. These protocols maintain tables at each node which store updated routing information for every node to every another node within the network. In on-demand routing protocols, routes are created when required by the source node, rather than storing up-to-date routing tables. Hybrid routing protocols combine the basic properties of the two classes of protocols.

In this paper, we propose a multipath routing protocol, LBMPR with fail-safe multiple path [7], in order to minimize the route break recovery overhead. LBMPR provides most of the intermediate nodes on the primary path with multiple paths to destination, along with source node. Primary path is the first path received by source node after initiating the route discovery, which is usually the shortest path. Along with shortest path it provides multiple path to destination from the source node during the route discovery process. All the multiple paths are used for data transmission at a time. Present protocol LBMPR is an extension to the unipath routing protocol AODV. The results are compared with the AOMDV protocol also because, it is important to know if the multipath protocol provides better performance. Except that, comparison between LBMPR and multipath routing protocol LBMR is considered.

This paper is organized as follows. In section 2, we described the related work. Section 3 provides system programmer’s design; finally we include the comparison of the protocols and conclude the paper.

2. RELATED WORK

In this section, we briefly present the research work related to multipath routing in literature recently, some multipath routing protocols have been proposed for ad hoc networks also. Multipath source routing (MSR) [1,2], extends DSR route discovery and route maintenance phases to compute multiple node-disjoint paths. It also proposes a mechanism to distribute load over multiple paths, based on the RTT measurement. SMR finds maximally disjoint multiple paths and uses a per-packet allocation scheme to distribute data packets on to multiple paths. This enables the effective utilization of network resources and avoids nodes from being congested. SMR [10] computes only two paths to each destination. All the above protocols are based on the source routing protocol DSR. Ad hoc on-demand distance vector multipath (AODVM) [3] is also a multipath routing protocol based on AODV [8]. It proposes a routing framework to provide robustness to route breaks. Many disjoint multipath routing techniques have been proposed for ad hoc networks, which have focused on improving the reliability of routing using path disjointness or redundancy. Saha et al. [5] proposed a maximally zone-disjoint multipath routing, which computes a set of zone-disjoint shortest paths for traffic load balancing. The zone-disjointness of paths minimizes the congestion for the traffic sent simultaneously over the multiple paths. Disjoint multipath source routing proposed in [6], statically multiplexes the data traffic over multiple disjoint paths at all nodes on the primary path. It achieves better transport capacity by doing so, when compared to the original source routing algorithm, in which packets go on a single path from source to destination. Tsirigos and Haas [4] proposed a disjoint multipath routing protocol that can be used in the presence of frequent topological changes. It uses multiple paths simultaneously, by splitting the information among the multitude of paths. Li and Cuthbert proposed a stable node disjoint multipath routing, which applies the path accumulation feature of DSR [9] to AODV. But, this path accumulation feature requires the route request packet to carry the full path it has traversed. This requirement increases the size of route request packet, particularly in large networks where paths between nodes are longer. These large-sized route request packets, which are flooded across the entire network for route discovery, increase the routing overhead and thereby limit the network scalability.

3. PROGRAMMERS DESIGN

Proposed system is divided into modules and these modules are integrated together for the execution of the system. The proposed system includes following modules,

[1] Route discovery process

A node initiates route discovery process, when it wants to communicate to a destination.

a. Route Request Phase

The source node inserts address of the destination into a route request packet and broadcasts it. An intermediate node receiving the route-request, replies by sending a route-reply packet if it has a route to the destination. Otherwise, it simply rebroadcasts. In below figure, node S is sending a RREQ to neighbour node F, A and J. These nodes will rebroadcast the request. All the intermediate nodes accept multiple copies of route-request, but, only the first copy of the route request is re-broadcasted. Nodes store all route-request copies in a request-rcvd table. Each entry in the request-rcvd table contains address of the previous node that relayed the route-request to it, called last hop, and the number of hops the route-request has traversed from the source node. Nodes use this information to relay route-reply packets back to source node. If none of the intermediate nodes possess a fresh route to the destination, the destination itself replies to the route-request, if it receives a copy of the route-request.

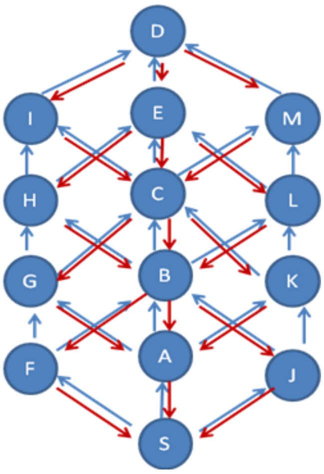

Fig. 1 Multiple path between nodes S and D

b. Route Reply Phase

Route replies follow the reverse paths stored in the request-rcvd table to reach the source node. The route-reply packet used by LBMPR contains three extra fields, apart from some of the fields of AODV's reply packet.

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[2] Data transmission

Once the fail safe path has been discovered data is transmitted through the all the failsafe multiple path at a time to achieve better load balancing. Even if any of the link breaks, or nodes get failure there will be always failsafe path. For example, in above figure there is a link S-A-B-C. Suppose the link between A-B is broken for any reason, traffic will go through S-A-G-C OR S-A-K-C. Suppose any of the node gets fail traffic can be send through failsafe path.

[3] Route maintenance

Route maintenance phase maintains the routes, for the time duration of session, established during the route discovery phase. The lifetime of routing entries is used to provide this. The $lifetime_i$ of $route_i$ represents the time until when the route from the node to $nexthop_i$ is valid. Each times nodes on the primary path refresh the lifetime of their routing table entries, whenever a data packet for the corresponding destination is forwarded. The lifetime of routes at the nodes on the secondary path is initiated to a sufficiently large value. This value of the lifetime can be decided based on the frequency of path breaks because of node mobility and probability of node failures. This parameter is called as SEC_ROUTE_LIFETIME. If a requirement for the secondary route arrives before this time, the secondary route is used for data transmission, and then its lifetime is updated as long as data transmission happens through it. Otherwise, secondary routes are deleted from routing tables once their initial lifetime expires.

The $lifetime_i$ of $route_i$ is updated to CURRENTTIME + ACTIVE-ROUTE-TIMEOUT, whenever a data packet is successfully forwarded through $nexthop_i$. This means that the route is valid and needed till the next ACTIVE-ROUTE-TIMEOUT seconds. CURRENT-TIME is the absolute clock time of the node performing this update. If a route to the destination expires, i.e., if route's existing-lifetime is less than CURRENT-TIME, the route is invalidated and cannot be used for sending data packets anymore. Later, when a data packet arrives for this destination, the node checks if a valid secondary path to the destination is available in the route-list of the routing entry. If a valid secondary route exists, the primary path is replaced with this path and packets are forwarded through it. If a valid secondary does not exist, a route error packet is sent to all source nodes through the nodes in the precur-list of the destination's route entry.

3.1. Data independence and Data Flow architecture

The route table is used to store routing information towards every destination.

Request received table: The table is used to store route request information. Tupple contains <address of the previous node, number of hops>.

Address of the previous node field represents the node that relayed the route-request to it (called lasthop). Number of hops field represents the route-request has traversed from the source node.

Route Table: The route table has an update list of all the possible routes to the desired destinations. Each element in the table is a six-tuple of the form,

<destination_addr, route–list, dest_seq_nb, precur–list> destination_addr represent the unique addresses of the destination node; route–list Multiple routes to destination are stored in route-list of the routing entry; precur–list The list of lasthops, through which replies are sent, are stored in the precur-list of the routing entry;

4. RESULTS AND DISCUSSION

4.1 Performance metrics

Following metrics were computed to evaluate scalability and performance of LBMPR:

1. Normalised routing overhead

It is the number of routing packets transmitted per data packet sent to the destination

2. Packet delivery ratio

Packet delivery ratio is defined as the ratio of data packets received by the destinations to those generated by the sources.

Mathematically, it can be defined as:

PDR= S1÷ S2

Where, S1 is the sum of data packets received by the each destination and S2 is

Where, S1 is the sum of data packets received by the each destination and S2 is the sum of data packets generated by the each source

3. End to end delay

It is the average time taken by a data packet to arrive in the destination.

4.2 Simulation model for performance evaluation

LBMPR is implemented using the NS-2 simulation. NS-2 is a scalable simulation environment. In order to evaluate the performance of LBMPR with other protocols, we have also implemented the LBMR protocol in NS-2. LBMR protocol provides load balancing. As

LBMPR is a non-disjoint multipath routing protocol, comparing its performance with a disjoint multipath routing protocol brings out the real strength of LBMPR. LBMPR's performance is also compared with the multipath routing protocol AOMDV.

4.3. Simulation experiments

LBMPR, LBMR, and AOMDV are studied by increasing number of nodes in the network from 10 and 50. Also, performance (in terms of normalized routing overhead, packet delivery ratio and end to end delay) of these three protocols is evaluated with varying mobility, number of nodes and queue length.

4.3.1. Experiment

Normalized routing overhead packet delivery ratio and end to end delay are computed by increasing the number of nodes in the network from 10 to 0 nodes. Mobility of nodes is kept at a minimum speed of 0 m/s, a maximum speed of 50 m/s, and a pause time of 100 s. Ifq length is taken as, 100, 50, 20 and 10.

4.3.2. Observations

Fig. 2(a) & (b) shows the normalized routing overhead comparison of LBMPR, LBMR and AOMDV for different scenario.

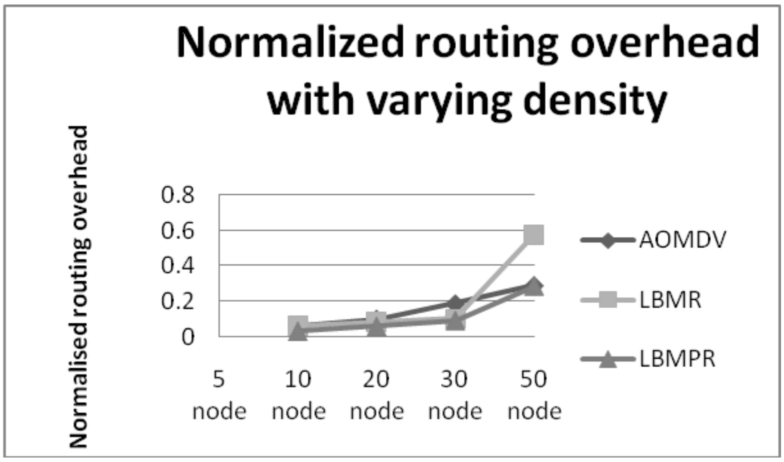

Fig. 2 (a) Ifq length = 100 and Connection = 10 and mobility = 50 m/s

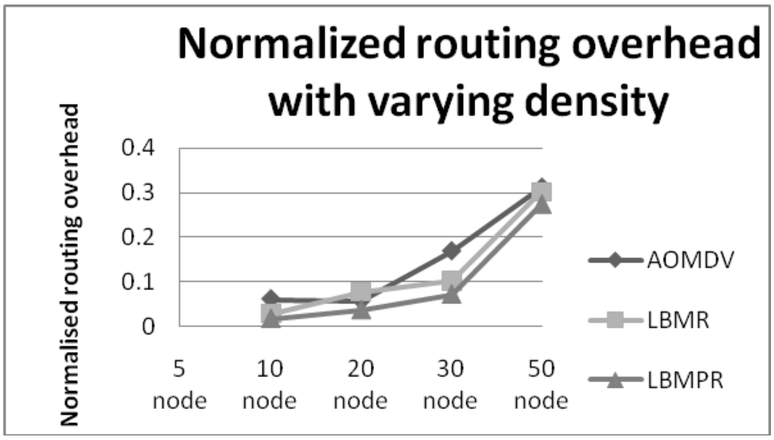

Fig. 2 (b) Ifq length = 50 and Connection = 5 and mobility = 25 m/s

Fig. 3(a) & (b) shows the packet delivery ratio comparison of LBMPR, LBMR and AOMDV for different scenario.

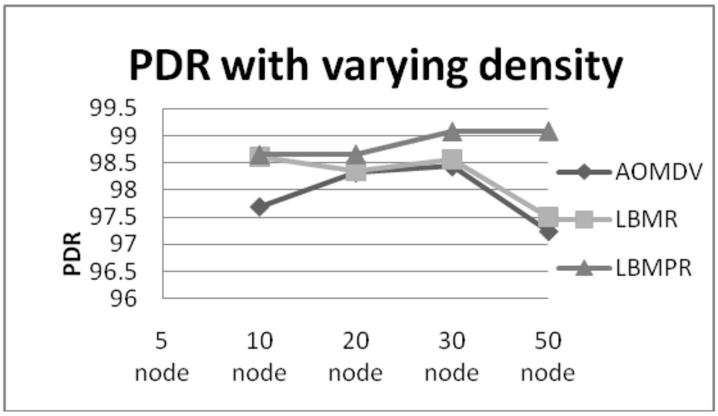

Fig. 3 (a) Ifq length = 100 and Connection = 10 and mobility = 50 m/s

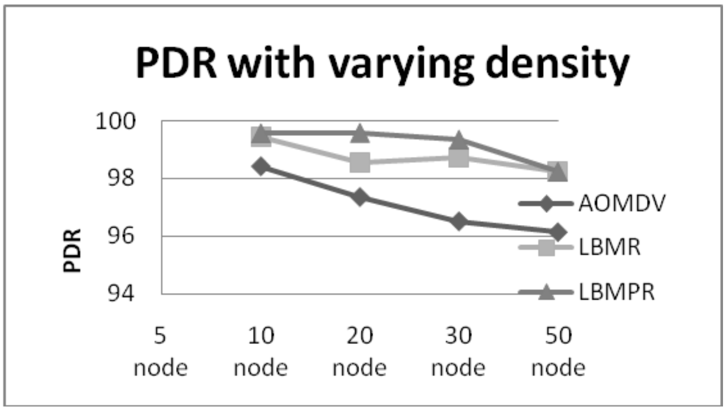

Fig. 3 (b) Ifq length = 50 and Connection = 5 and mobility = 25 m/s

Fig. 4(a) & (b) shows the end to end comparison of LBMPR, LBMR and AOMDV for different scenario.

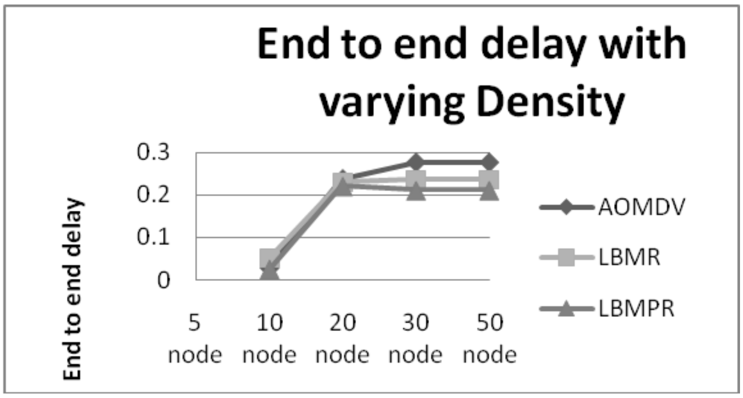

Fig. 4 (a) Ifq length = 100 and Connection = 10 and mobility = 50 m/s

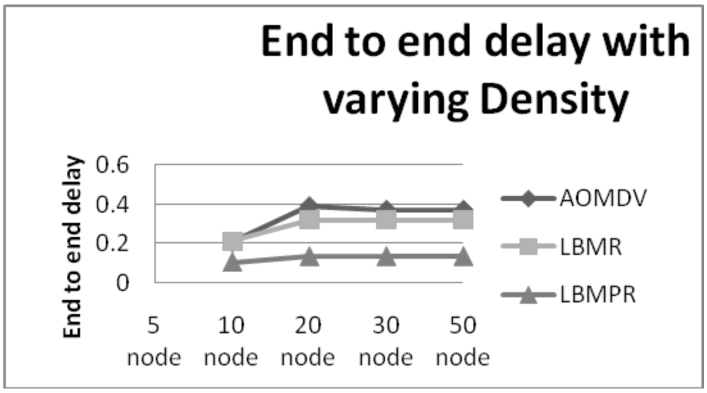

Fig. 4 (b) Ifq length = 50 and Connection = 5 and mobility = 25 m/s

5. CONCLUSION

Related graphs of the relative comparison of algorithmic efficiency parameters concluding the result of the research, that proposed protocol LBMPR performs better in reference to normalized routing overhead, packet delivery ratio and end to end delay. In reference with the above results graphs, it is proved that, normalised routing overhead is decreased; end to end delay is deceased too. Packet delivery ration ratio is increased in comparison with multipath routing protocol AOMDV and load balancing protocol LBMR.

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