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# Design of Load Balanced Ad-hoc on Demand Multi Path Distance Vector Routing for MANETs

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**Abstract – Load balancing is an essential requirement of any multi-hop wireless network. A wireless routing protocol is accessed on its ability to distribute traffic over the network nodes and a good routing protocol achieves this without introducing un- acceptable delay. The most obvious benefit is manifested in increasing the life of a battery operated node which can eventually increase the longevity of the en- tire network. In the endeavor of finding the shortest distance between any two nodes to transmit data fast the center nodes become the famous picks. The centrally located nodes connect many sub networks and serve as gateways t o some sub networks that become partitioned from the rest of the network in its absence. Thus, the lifetime of the center nodes become a bottleneck for connectivity of a sub network prior to its partition from the rest of the network. An unbiased load can cause congestion in the network which impacts the overall throughput, packet delivery ratio and the average end to end delay. In this paper we have mitigated the unbiased load distribution on centrally located nodes by pushing traffic further to the peripheral nodes without compromising the average end to end delay for a greater network longevity and performances. We proposed a novel routing metric, load and a minimization criterion to decide a path that involves nodes with less load burden on them. The simulations of the proposed mechanism run on NS-2.34 for 16 and 50 nodes have revealed an average 2.26% reduction of load on the center node in comparison with AOMDV.**

**Index Terms – AOMDV, Load balancing, Load distribution, Multi-path routing, WLAR.**

## 1. INTRODUCTION

A *mobile ad hoc network* (MANET) is an infrastructure less network consisting of a set of mobile nodes that are able to communicate with each other in a multi-hop manner without the support of any base station or access point. A node in a MANET is not only a node but also a router that is responsible of relaying packets for other nodes. A MANET has the merit that it is quickly deployable. Applications of MANETs include communications in battlefields, disaster rescue operations, and outdoor activities. Among the limitations that blame the routing protocols currently used in mobile ad hoc networks face the problem of load balancing distribution in the network. While some nodes may be involved in routing, others are heavily congested and most of the routing network traffic. Because of this inhomogeneous load distribution, the nodes loaded quickly consume their limited material resources and show a high congestion. These effects can significantly degrade the performance of ad hoc network. In our efforts to balance load in a network of mobile nodes, we have improvised AOMDV to incorporate load balancing mechanism for efficient use of network resources resulting in prolonged node and network lifetime.

## 2. RELATED WORK

The term “Load balancing” distributes traffic to a nodes set, in order to smooth the network load. That is to say, divide the total load to the various nodes of the network by sending data as nodes in a position to respond. Load balancing aims to increase capacity and fault tolerance of networks. It is necessary to ensure a good load balancing on all ad hoc network paths. Load balancing to single path routing has been adopted in Ad hoc networks [1], [2], [3].

The load-balancing technique in ad hoc networks can be generally divided into two types. The first type is “Traffic-size” based [4][5], in which the load is balanced by attempting to distribute the traffic evenly among the network nodes. The second type is the “Delay” based [6], in which the load is balanced by attempting to avoid nodes with high delay. In this paper, the proposed scheme is applicable to most on-demand routing protocols, either single-path routing or multipath routing. It belongs to the “Traffic-size” based type, and will distribute the traffic load evenly among the nodes in ad hoc network [12].

Distributing processing and communications activity evenly across a computer network so that no single device is overwhelmed. Load balancing is especially important for networks where it's difficult to predict the number of requests that will be issued to a server. Busy Web sites typically employ two or more Web servers in a load balancing scheme. If one server starts to get swamped, requests are forwarded to another server with more capacity. Load balancing can also refer to the communications channels themselves [7].

In [8], load balancing is Load balancing is a technique to forward the traffic from a source to destination across multiple paths. With equal load balancing, the traffic is balanced across multiple equal-cost paths. This can be done on a per-packet basis (packet are sent N equal-costs paths using a round robin algorithm).

Another solution is proposed protocol *WLAR* (Weighted Load Aware Routing) [9] protocol is proposed. This protocol selects the route based on the information from the neighbor nodes which are on the route to the destination. In WLAR, a new term traffic load is defined as the product of average queue size of the interface at the node and the number of sharing nodes which are declared to influence the transmission of their neighbors. (WLAR) protocol adopts basic AODV procedure and packet format. In WLAR, each node has to measure its average number of packets queued in its interface, and then check whether it is a sharing node to its neighbor or not [13].

## 3. LOAD BALANCED AOMDV

In our efforts to balance load in a network of mobile nodes, we have improvised AOMDV to incorporate load balancing mechanism for efficient use of network resources resulting in prolonged node and network lifetime. For this, we have based our proposal on the existing routing protocol AOMDV and introduced the mechanism of load balancing naming our modified AOMDV a Load balanced AOMDV(AOMDV-LB). AOMDV is a popular multi-hop multi-path routing protocol that is largely prevalent and in use for real time applications in MANET.

New metric called load will tells us the approximate load a node is subjected to in a network, its value will indicate the measure of current load. This Load will then feature in every RREP packets to enable the source in choosing a path that promises better load balance based on two criteria quoted below:

- Minimum value of load among all possible candidate nodes as next hop and
- Relatively smaller hop count than the optimal path

The number of routes a node can support, in essence be an intermediate hop to a valid source-destination path can be judged by the number of RREP messages that route back to sources. Intuitionally, we can argue that if a RREP is routed back then there is a high chance that the corresponding node will participate as an intermediate hop for data transfer. So, the conclusion is, greater the RREPs routed back through a node, greater the load and greater the possibility for it to be the center node of the network. Or, if locational implication is not to be enforced, then we can still comment on the unbiased load distribution on that node which should be alleviated [11].

Every node maintains a counter labeled load which will count all the unique RREPs routing back through it. Now, whenever a node routes back a RREP, it will sum the load field in the RREP with its own load counter and then routes back the RREP to the upper node. Hence, every node in a valid source-destination path will add its counter to the counter in the RREP packet until this RREP finally reaches the source. The source and the intermediate nodes then choose from among the valid RREPs they receive the best load balancing path with the help of the criterions stated above. Therefore, we have two alias for load yet they are distinct in the context of node and RREP, the former being an indication of a node's load and the latter a measure of a path's load.

### 3.1. The criteria

The first criterion helps us in finding a path which has very fewer loads or in other words does not have much traffic in transit. The additive value of load that features in RREP is the measure of the load across all the nodes below that node. The mobility of the nodes cause to change this value often but due to regular purging of routes the routing table ensures to keep a fresh value of load rather than stale ones.

The second criterion is to make sure that in pursuit of load balance we may not end up choosing larger routes resulting in greater latency. Hence, we choose those routes that are relatively optimal. The relatively optimal can be achieved by allowing only those next hops that differ by only an admissible number of hops from the optimal. The admissible number of hops is dependent upon the network diameter and is another area of research but in our approach the max hop difference was fixed to 4, an experimental value beyond which no good results were yielded.

## 4. THE ALGORITHMS

The following shows the way in which our proposed algorithm picks up a path which will guarantee fewer loads. And by fewer loads we mean a node farther away from center. Thus alleviating the center nodes from the load imbalance and helping in longevity of connected sub-networks.

**Algorithm 1** pathFind algorithm

**if** $path = rt \rightarrow rtfind(dst)$ /= 0 **then while** $path$ /= 0

**do**

// fetch that record with min load among next-hop records

**if** $path \rightarrow load \leq rtminload$ **then**

// rtminload will have the min load among all next-hops for that destination forward (path,pkt);

break;

**end if**

$path = path \rightarrow next$

**end while end if**

The algorithm below is building the RREP packet. Notice that **it** now includes the load field in the packet. This load is the summation of the load that path undergoes and the nodes load as the node will now become an intermediate node. The details pertaining to load only are emphasized other considerations are omitted for clarity.

**Algorithm 2** send reply algorithm

**if** $path = rt \rightarrow rtfind(dst)$ $/== 0$ **then**
**while** $path$ $/= 0$ **do**
// fetch that record witn min load among next-hop records
**if** $path \rightarrow load \leq rtminload$ **then**
// rtminload will have the min load among all next-hops for that destination
$rpdst = path \rightarrow nexthop$
$rphopcount = path \rightarrow hopcount$
$rpload = path \rightarrow load + load$
$rpexpire = path \rightarrow expire + CURRENTTIME$
break;
**end if**
$path = path \rightarrow next$
**end while**forward(rpdst,p);
**end if**

4.1. Simulation Parameters

| S.No | parameters | values |
|---|---|---|
| 1 | Chann | Channel/WirelessChannel |
| 2 | Anten | Antenna/OmniAntenna |
| 3 | Propogation Model | Shado |
| 4 | Interface Queue Length | 50 |
| 5 | M | 802.11 |
| 6 | Routing Protocol | AOMDV,$AOMDV - LB$ |
| 7 | No of Nodes | 16,50 |
| 8 | Densi | 4096 nodes per kmsq |
| 9 | Simulation time | 1000s |
| 10 | Mobil | Static |
| 11 | Traf | Node-UDP |
| 12 | CBR rate | $\leq$5.4 mbps |
| 13 | Transmission range | 250m |

Table 1: Simulation Parameters

5. RESULTS

In what follows we display the visual interpretation of the results achieved during and after simulation of the proposed scheme. The bar graphs show how both the existing and the modified protocols distribute load on nodes of a network. The xy plot helps us in concluding the adverse effect of the protocols on the center node.

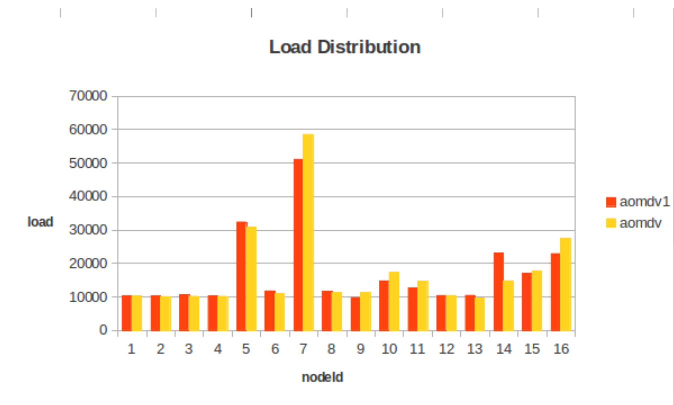


Figure 1: load on each node in a network of 16 nodes

In figure 1 we see the load distribution of AOMDV colored yellow and in red of AOMDV-LB. The visual interpretation tells us that AOMDV-LB maintains a proper distribution than AOMDV owing to its sharp peeks at some nodes in which places AOMDV-LB has a relatively less load. The difference in load at nodes prove that AOMDV-LB is balancing load better than AOMDV.

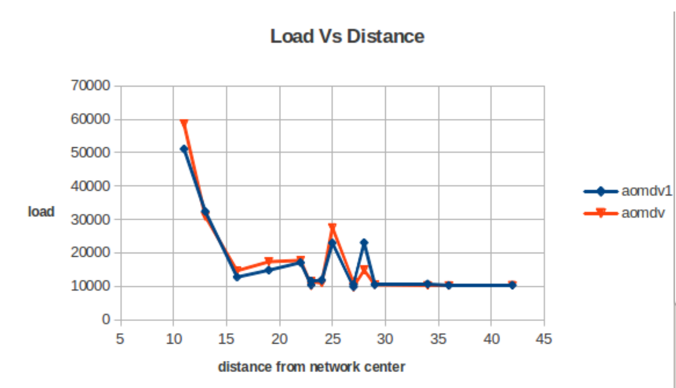


Figure 2: load Vs distance from network center (16 nodes)

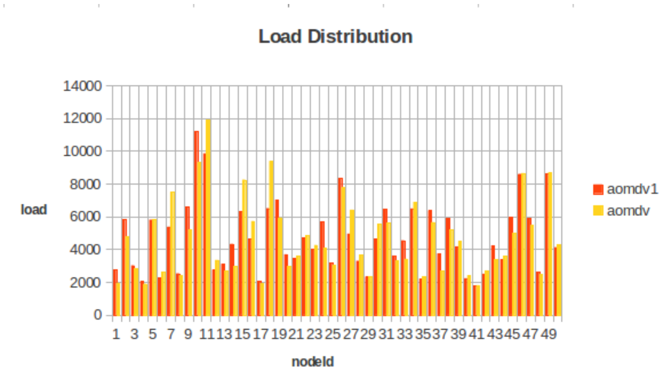


Figure 3: load on each node in a network of 50 nodes

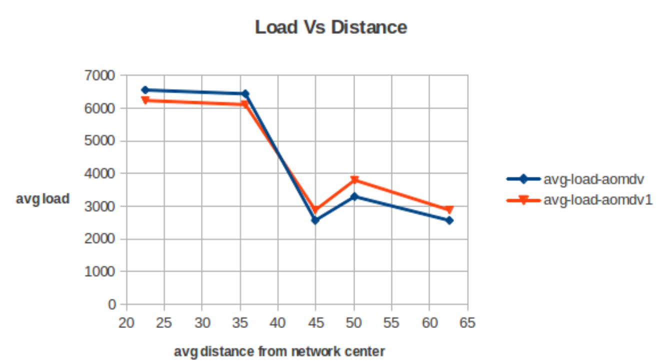


Figure 4: avg-load Vs avg-distance from network center (50 nodes)

### 5.1. The Pros and Cons

**It** this section we shall carry out a comparative study on the performances of both the protocols under the simulation parameters outlined in Table 1. The table data are self-explanatory and require only the knowledge about the metrics defined.

| S.No | Metric | Aomdv | *Aomdv − lb* |
|---|---|---|---|
| 1 | Total CBR sent | 161954 | 161954 |
| 2 | Total CBR received | 154093 | 152268 |
| 3 | recv/sent ratio | 95.146 | 94.0193 |
| 4 | Total forwards | 20000 | 19960 |
| 5 | avg-end-to-end-delay | 0.0726s | 0.0490s |
| 6 | routing overhead | 0.0725 | 0.0740 |
| 7 | avg throughput | 315kbps | 311kbps |
| 8 | pkt loss | 13675 | 16068 |
| 9 | pkt loss in Bytes | 6585208 | 7788012 |
| 10 | pkt loss ratio | 4.85 | 5.98 |
| 11 | No of collisions | 689527 | 677127 |

Table 2: Performance Comparison for 16 nodes

## 6. CONCLUSION

In this paper we have developed a brief understanding of our routing protocol which was predominantly similar to the popular AOMDV algorithm but subtly different. One can appreciate the mechanism in which the protocol is trying to choose those nodes which are not heavily loaded and yet do not introduce unnecessary delay in the packet delivery time.

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