# LOAD BALANCING IN MANET BY LIGHTENING THE CENTRE NODE

MOHD HANIEF KHAN[1], JYOTI ARORA[2]
[1]*M.TECH Student, Desh Bhagat University Mandi Gobindgarh*
[2]*Assistant Professor, Desh Bhagat University Mandi Gobindgarh*

*(E-mail: 9149646820deen@gmail.com)*

***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 bene t is manifested in increasing the life of a battery operated node which can eventually increase the longevity of the entire 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 subnetworks and serve as gateways to some subnetworks 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 subnetwork 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 thesis we have mitigated the unbiased load distribution on centrally located nodes by pushing tra c 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.

***Keywords*****—***MANET; Load Balancing; ADOMDV.*

## I. INTRODUCTION

With the proliferation of Wi-Fi devices and Internet, MANET has gained considerable demand and popularity. MANETs are an infrastructure less networks, meaning no base station, of mobile nodes with a limited radio frequency. The communication among the nodes take place via wireless links of varying capacity on a hop by hop basis. Besides, these mobile nodes come with batteries that carry limited power and often operate in areas where the facility to recharge does not apply. Hence, we must utilize these limited resources very efficiently for better network performances and longevity. Otherwise, unbiased traffic and resource utilization may congest the network and deplete energy very quickly.

The inefficiency in the wireless networks is mostly attributed to load imbalance. Unfortunately, most current routing protocols do not take load distribution into account. In their analysis, Pham and Perreau[3], show that centrally located nodes carry greater load compared to others. This is because central nodes participate in large number of routes. Since few nodes take most burdens of traffic transit they tend to yield undesirable results in the form of high average end to end delay, shortened network life, and lower packet delivery. Thus, we present a novel load balancing mechanism that alleviates the central nodes by pushing the traffic further from the center. A definite location of the center node cannot be established hence we depend on an intuitive definition of centrality based on the route reply messages forwarded by the destination.

The significance of center nodes and their ability in providing connectivity is established in Chapter 3. Based on the conclusions drawn from existing research we are of the opinion that center nodes are the most important nodes of all and have to be effectively

## II. ROUTING

To put in simple terms , routing is a mechanism by which data packets are forwarded onto the next neighbor who either has a path to the solicited destination or is the destination itself. Routing in wireless networks is distinct from routing in wired networks , in the former the routing of packets happen on a hop by hop basis called multi hop routing while in the latter routing is done on a single dedicated path.

A node in a wireless networks is only aware of the next immediate neighbor who promises to deliver the packets to the desired destination and has no information of other criterion or intermediate nodes that form a valid path. Moreover, with the absence of any central authority or base station the nodes itself take up the burden of routing. Hence routing in the context of wireless networks is a complex task and needs efficient routing protocols that utilize the network resources judiciously. There are two known types of routing discussed below.

### *A. Single path routing*

In this type of routing methodology aka shortest path routing , the source node stores information of only one immediate neighbor with the least distance to the destination. The routes are updated dynamically and on demand. When a node needs to transmit a data packet to a destination it only has to see which of its neighbor can deliver to the destination without regard to any other criteria since only one minimum hop path is stored.

### *B. Multi path routing*

The variant of single path routing is the multi path routing where a nodes stores more than one hop neighbor to a desired destination in its routing table. The transmissions occur simultaneously on multiple paths. Multi path routing is more complicated than single path routing in this there arises the problem of interference with the simultaneous transmissions. Hence, multi path routing protocols have to design protocols to introduce no collisions.

### *C. Semi multi path routing*

The nomenclature of this method does not exist in the literature and is a name coined only for the purpose of comprehension. This is a variant of multi path routing protocol where multiple paths to a destination are stored in the routing table of a node but transmission do not occur simultaneously. The alternative paths other than the least distance path serve as contingency paths in the events of link breakdowns or other failures. The purpose of this type of routing is to provide fault tolerance to the networks. Our proposed model of routing is semi multi path routing.

### *D. Load Balancing*

As the name indicates we are required to balance load in a network but what does load and balance mean in the context of wireless networks? Load refers to the tra c or the data packets a node has to forward onto the appropriate links for deliver at the destination. Balancing on the other hand means to distribute load over nodes in a network in an unbiased manner. This means that no node in the network must be burdened to transmit more packets than other nodes unless situation demands. The load imbalance in a network is attributed to the routing protocols and the way in which they pick up valid source-destination paths. Thus, a good routing protocol not only has good throughput and minimum latency but also strives in proper distribution of load.
When load is not balanced it introduces unnecessary delay in packet delivery, increases packet drop ratio , aspects the overall throughput , prunes a node's lifetime , partitions the network and becomes a reason for congestion. Thus, it is important that a routing protocol lay emphasis on balancing load along with other considerations.

## III. LITERATURE REVIEW

The literature has a vast mention of routing protocols for both single path routing and multi path routing. Each routing protocol has a different objective to achieve and researchers have come up with unique solutions to improve upon the existing ones or bring about something entirely new. While no definitive argument can be made about the effectiveness or popularity of a particular routing protocol we rely on a comparative study presented in the research community. In any case, we appreciate and acknowledge all work studied and researched under the canvas of routing and load balancing in wireless networks.

### *A. Mechanisms in multi path routing*

The articles below are some of the associated load balancing mechanisms in the multi path routing protocols where more than one path information is available for a destination at the source.
MALB is a multipath routing protocol by Shouyi YIN and Xiaokang LIN [6] that employs altering model that combines both per packet and per ow filtering to shift traffic among multiple paths thereby facilitating the data packets not to be received out of order. The mechanism of load balancing to distributing traffic across many paths is a decision taken based on the measurement of path statistics like traffic load and packet delay. The path statistics are gathered by sending probe packets periodically. The operation of the protocol is broadly divided into two stages :

1. balance phase and

2. imbalance phase

In the balance phase the congestion measures ( a function of path statistics) on multiple paths are equalized but when the congestion measures become unequal the paths are said to exhibit an imbalance phase which then moves to balance phase for equalization.
The modification proposed on DSR [7] by Lianfang Zhang et al [8] is yet another protocol running on the same lines of MALB. It is essentially a multi path source routing protocol that forwards packets on multiple arbitrary paths without consideration to the path calculation in intermediate hops. The load balancing methodology in this protocol is again based on probing packets periodically but here to calculate the RTT(round trip time) using the Karn's algorithm [9] that aids in the estimation of delay in a path. Such delay calculation gives the picture of congested or heavy traffic paths and helps us in dispatching fewer packets on paths that report greater delay than the anticipated and greater packets on paths with accepted delay.
Wu and Harms [10] coined a metric correlation factor , , defined as the number of links connecting two node disjoint paths. The value equals zero when there are no links between the paths and we conclude that the paths are completely unrelated. When the value is non-zero the paths are said to be related. The analogy they draw is : larger the value greater the average end to end delay on both the paths. However, they do not base the path selection criteria solely on correlation factor but also on relatively shorter alternative paths and node disjointness. This approach not only tries to improve better load distribution on paths but also decreases the average latency.
Another yet subtly different metric interference correlation factor defined by Evan et al, [11] counts not the connecting links between paths but only those connecting links that fall within the interference range of the paths. The interference range is assumed to be twice the transmission range. Their load

balancing criteria is purely based on this parameter which has shown considerable improvements in terms of throughput from 0.25 up to 0.8 when multiple paths are introduced. Based on the interference correlation factor the authors have tried to achieve a global schedule of packet transit on paths that causes no collision thereby improving overall throughput on that path.

### *B. Mechanisms in single path routing*

In the shortest path routing or popularly known as single path routing there is absolutely only one path information to a destination at any given instant of time. Lets look into some of the load balancing solutions introduced into the research community in this regard.

L. Wang et al , introduced a new routing protocol called Multi path Source Routing (MSR) [12] where the load balancing mechanism was achieved through the metric weight. The weight featured in every path information and is a per-destination based load distribution weight between all the routes that have the same destination.

CHAMP routing protocol by Valera , Rao and Seah [13] , uses cooperative packet caching and shortest multi path routing to reduce packet loss due to frequent route breakdowns. Their load balancing mechanism is to use a ve packet data cache, where CHAMP exhibits excellent improvement in packet delivery, outperforming AODV [14] and DSR [7] by at most 30% in stressful scenarios. Furthermore, end-to-end delay is significantly reduced while routing overhead is lower at high mobility rates.

Roy et al, [15] demonstrated through simulations that route coupling cannot be mitigated with only node disjoint paths but either zone disjoint or partial zone disjoint paths are used for data communication. The zone disjoint paths are those paths that do not interfere with transmission on other paths. These paths are very di cult to nd and hence the use of directional antennas have proven to improve a lot better than omni-directional antennas.

The degree of nodal activity defined as the number of active paths through a node given by Zhu et al, [16] in their new routing protocol LBAR, dictates the amount of load a node should undertake for a better load balance in the network. The path with least degree of nodal activity is selected for traffic transit.

Lee and Riley [17] propose a solution where overloaded nodes have the freedom to forbid further establishing of routes through them until their overloaded status get dis-solved. This serves as a mechanism to avoid an unbiased load distribution on nodes. The merit of the protocol lies in the fact that the decision of overloading in bestowed on an individual node without the intervention of any central authority.

## IV. RESULTS AND DISCUSSIONS

In the following sections we will discuss the approach in validating our model, the tools necessary for simulating the network environment, the visual manifestation of the validity of the model, the improvements seen and the compromises made.

The following states the utilities used in completing the implementation:

NS version 2.34 : implementing the protocol functionality

NSG version 2.1 : jar le for generating TCL scripts to mimic a desired topology

NAM version 1.15: network animator to visualize the network in real time

GAWK version 4.0.1: scripting tool for analyzing the trace le

Libre version 3: to plot bar and line graphs

The details of the above packages is beyond the scope of this thesis and the reader is redirected to the internet for complete information and working knowledge.

In what follows we display the visual intepretation 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.

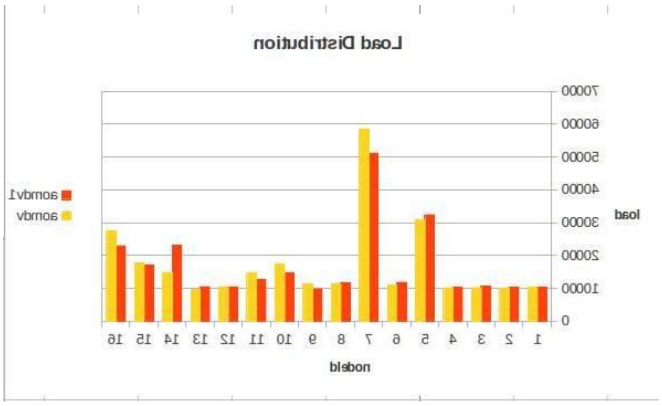

Figure 1: load on each node in a network of 16 nodes

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.

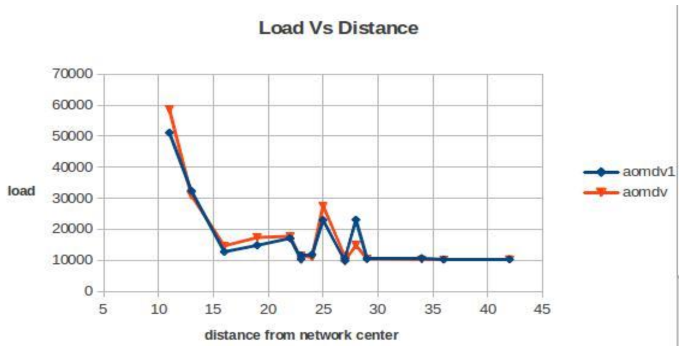


Figure 2: load Vs distance from network center (16 nodes)

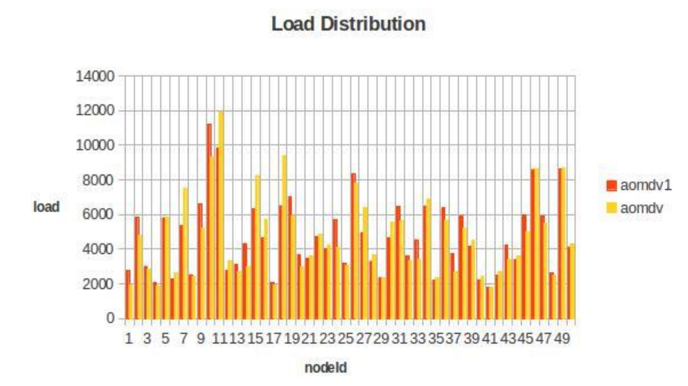


Figure 3: load on each node in a network of 50 nodes

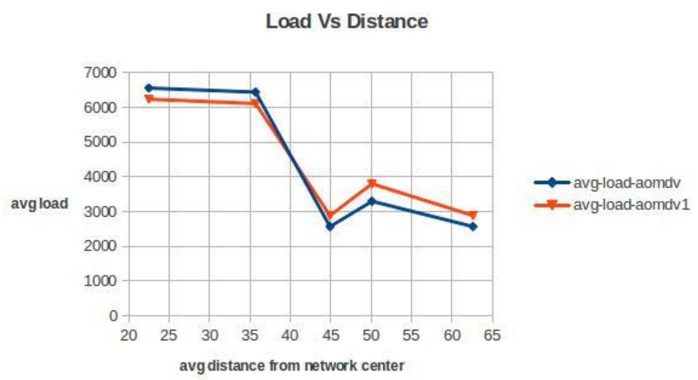


Figure 4: avg-load Vs avg-distance from network center (50 nodes)

## VI. CONCLUSION

All through the thesis we have tried to bring clarity to the reader in understanding and appreciating the research work undertaken. We have developed a background of MANET and its growing popularity, the evidence of load imbalance in the network and the partiality or favoritism in picking up centrally located nodes for data transfer. The way in which this unbiased load on center node became the reason for many subnetwork partitions and early death of nodes. Hence, it became the problem of interest requiring mitigation. We have explored the existing models and solutions in this regard and have come to believe the complexity of multipath routing has given rise to a new definition of multipath routing (inherently single path routing with multiple next hops for contingencies). We have proposed a modified AOMDV routing protocol called Load Balanced AOMDV, the complete mechanism employed in balancing load. The changes that were obligatory for its implementations. We have presented our experimental results and outlined a brief comparative analysis of both AOMDV and AOMDVLB. The average 2.26% load reduction on center nodes have been evident from the graphs plotted.

## REFERENCES

[1] Azzedine Boukerche, Begumhan Turgut, Nevin Aydin, Mohammad Z Ahmad, Ladislau B•ol•oni, and Damla Turgut. Routing protocols in ad hoc networks: A survey. Computer Networks, 55(13):3032{3080, 2011.

[2] Mahesh K Marina and Samir R Das. Ad hoc on-demand multipath distance vector routing. ACM SIGMOBILE Mobile Computing and Communications Review, 6(3): 92{93, 2002.

[3] P.P. Pham and S. Perreau. Performance analysis of reactive shortest path and mul-tipath routing mechanism with load balance. In INFOCOM 2003. Twenty-Second Annual Joint Conference of the IEEE Computer and Communications. IEEE So-cieties, volume 1, pages 251{259 vol.1, 2003. doi: 10.1109/INFCOM.2003.1208677.

[4] Oussama Souihli, Mounir Frikha, and Mahmoud Ben Hamouda. Load-balancing in manet shortest-path routing protocols. Ad Hoc Netw., 7(2):431{442, March 2009. ISSN 1570-8705. doi: 10.1016/j.adhoc.2008.04.007. URL http://dx.doi.org/10. 1016/j.adhoc.2008.04.007.

[5] Y. Ganjali and A. Keshavarzian. Load balancing in ad hoc networks: single-path routing vs. multi-path routing. In INFOCOM 2004. Twenty-third AnnualJoint Conference of the IEEE Computer and Communications Societies, volume 2, pages 1120{1125 vol.2, 2004. doi: 10.1109/INFCOM.2004.1356998.

[6] Shouyi Yin and Xiaokang Lin. Malb: Manet adaptive load balancing. In Vehicular Technology Conference, 2004. VTC2004-Fall. 2004 IEEE 60th, volume 4, pages 2843{2847 Vol. 4, 2004. doi: 10.1109/VETECF.2004.1400578.

[7] David B Johnson and David A Maltz. Dynamic source routing in ad hoc wireless networks. Kluwer International Series in Engineering and Computer Science, pages 153{179, 1996.

[8] Lianfang Zhang, Zenghua Zhao, Yantai Shu, Lei Wang, and O. W W Yang. Load balancing of multipath source routing in ad hoc networks. In Communications, 2002. ICC 2002. IEEE International Conference on, volume 5, pages 3197{3201 vol.5, 2002. doi: 10.1109/ICC.2002.997425.

[9] Phil Karn and Craig Partridge. Improving round-trip time estimates in reliable transport protocols. ACM SIGCOMM Computer Communication Review, 17(5): 2{7, 1987.

[10] Kui Wu and Janelle Harms. Performance study of a multipath routing method for wireless mobile ad hoc networks. In Modeling, Analysis and Simulation of Computer and Telecommunication Systems, 2001. Proceedings. Ninth International Symposium on, pages 99{107. IEEE, 2001.

[11] E.P.C. Jones, M. Karsten, and P.A.S. Ward. Multipath load balancing in multi-hop wireless networks. In Wireless And Mobile Computing, Networking And Communi-cations, 2005. (WiMob'2005), IEEE International Conference on, volume 2, pages 158{166 Vol. 2, 2005. doi: 10.1109/WIMOB.2005.1512865.

[12] Lei Wang, Lianfang Zhang, Yantai Shu, and Miao Dong. Multipath source routing in wireless ad hoc networks. In Electrical and Computer Engineering, 2000 Canadian Conference on, volume 1, pages 479{483 vol.1, 2000. doi: 10.1109/CCECE.2000. 849755.

[13] A. Valera, W.K.-G. Seah, and S. V. Rao. Cooperative packet caching and shortest multipath routing in mobile ad hoc networks. In INFOCOM 2003. Twenty-Second Annual Joint

Conference of the IEEE Computer and Communications. IEEE So-cieties, volume 1, pages 260{269 vol.1, 2003. doi: 10.1109/INFCOM.2003.1208678.

[14] Charles Perkins, Elizabeth Belding-Royer, and Samir Das. S. das," ad hoc on-demand distance vector (aodv) routing. Technical report, RFC 3561, July, 2003.

[15] Siuli Roy, Somprakash Bandyopadhyay, Tetsuro Ueda, and Kazuo Hasuike. Mul-tipath routing in ad hoc wireless networks with omni directional and directional antenna: A comparative study. In Distributed Computing, pages 184{191. Springer, 2002.

[16] Audrey Zhou and Hossam Hassanein. Load-balanced wireless ad hoc routing. In Electrical and Computer Engineering, 2001. Canadian Conference on, volume 2, pages 1157{1161. IEEE, 2001.

[17] Y.J. Lee and G.F. Riley. A workload-based adaptive load-balancing technique for mobile ad hoc networks. In Wireless Communications and Networking Conference, 2005 IEEE, volume 4, pages 2002{2007 Vol. 4, 2005. doi: 10.1109/WCNC.2005. 1424826.

[18] Deepinder Singh Wadhwa and Er Tripatjot Singh Panag. Performance compari-son of single and multipath routing protocols in adhoc networks. Department of Electronics and Communication Engg., BGIET, Sangrur International. Journal of Computer Technology, 2011.

[19] Ming-Hong Jiang and Rong-Hong Jan. An e cient multiple paths routing protocol for ad-hoc networks. In Information Networking, 2001. Proceedings. 15th Interna-tional Conference on, pages 544{549, 2001. doi: 10.1109/ICOIN.2001.905507.