INTERNATIONAL JOURNAL FOR ADVANCE RESEARCH IN ENGINEERING AND TECHNOLOGY
WINGS TO YOUR THOUGHTS…..

Load Balancing in MANETs

Priyanka sachdeva[1], Dr. Kamal Kumar Sharma[2], Er. Sahil Verma [3]

[1]Student, M. Tech in Computer Science Engineering
E-max School of Engineering and Applied Research, Ambala (Haryana)
Priya.etn@gmail.com
[2]Professor, Dept. of ECE
E-Max group of Institutions, Ambala (Haryana)
kamalsharma111@gmail.com
[3]Assistant Professor, Dept. of CSE
E-Max group of Institutions, Ambala (Haryana)
sahilkv4010@yahoo.co.in

***Abstract**: Mobile Ad hoc Network (MANET) consists of mobile nodes which are a part of self-organizing and self-autonomous network. Since there is no centralized infrastructure in such a network, a highly adaptive routing scheme to deal with the frequent topology changes and congestion is required. Load balancing turns out to be an emerging tool to use MANET resources in an efficient manner in order to improve network performance. The load must be uniformly transferred to different alternative routes to provide effective utilization of the network, increase packet delivery ratio and reduce end to end delay. In this thesis, we have proposed load balancing in AODV that reduces the probability of selection of congested route by distributing data packets over multiple routes. The route priorities are assigned based on the hop count and interface queue length. NS-2 is used as simulator and results revealed that proposed algorithm outperforms in terms of dropped packets, packet delivery ratio and average end to end delay.*

***Keywords:** MANET, Load balancing, AODV, Performance, Delay*

1. INTRODUCTION

MANET (mobile ad hoc network) is defined by its own characteristics such as self-organizing nature, self-autonomous, dynamic changing topology and high mobility [1]. Due to lack of centralized infrastructure, various issues arise in the adhoc networks i.e. security, load balancing, routing etc. [2]. The network relies on multi-hop radio relaying in case destination lies outside the radio range of source node. Each node act as router or host interchangeably. An unbalanced distribution of traffic often leads to power depletion of heavily loaded nodes. The network connectivity suffers leading to frequent disconnections due to network partitioning as more number of nodes is powered down. Load balancing is a solution to avoid congestion in the network. The principal metric is load balancing, one idea, inspired by nature, is to simultaneously use all available resources. In addition, end to end delay and packet loss increases for the connections using these heavily loaded nodes. Load balancing can maximize lifetime of mobile nodes, minimize traffic congestions, energy consumption of mobile nodes and end to end packet delays [3/45]. If the load is balanced then it will provide effective use of the network and reduce packet delay and improve packet delivery ratio. The paper is organized as follows. Section II discusses related work. Section 3 overviews MANET routing protocols particularly AODV. Section III gives proposed algorithm. Section IV discusses simulation results and Section V concludes the paper and specifies future research directions.

2. RELATED WORK

This section gives details of the related work in the field of load balancing in wireless networks. The LBAR [4] is an on demand routing protocol implemented specially for delay sensitive application. In this the routing protocol the source node finds the path which is least loaded with traffic. The source node broadcasts a setup message to its neighbors along with cost (from source to current neighbors). The cost function is based on its node activity value. A neighborhood-aware source routing protocol NSR was proposed in [5]. In NSR, a shortcut is found between a node and a two hop neighbor and used when a link breakage occurs.

Lu et al. [6] found that AODV is ineffective under stressful network traffic situations. They therefore proposed a modified version of AODV (called CADV) which favors nodes with short queuing delays in adding into the route to the destination. While this modification may improve the route quality, the issues of long delay and high overhead when a new route needs to be discovered remain unsolved. Furthermore, CADV is not congestion adaptive. It offers no remedy when an existing route becomes heavily congested. This is probably the reason that CADV improves AODV in delivery ratio by only 5 percent in highly loaded networks. Reddy and Raghavan [7] have proposed a scalable multipath on-demand routing protocol (SMORT), which reduces the routing overhead incurred in recovering from route breaks, by using secondary paths. Though it provides fail-safe multiple paths, it does not consider the individual QoS characteristics of the nodes like bandwidth, energy, load etc.

Sridhar and Chan propose the Channel-aware Packet Scheduling for MANETs (CaSMA), they depend on two major criteria in their work which are the congestion state and the end-to-end path duration, congestion area should be avoided and packets flow during short-lived paths should b given high priority [8].

Souihli et al. [9] have proposed a load-balancing mechanism that pushes the traffic farther from the center of the network, using a routing metric that takes into account a node’s degree of

INTERNATIONAL JOURNAL FOR ADVANCE RESEARCH IN ENGINEERING AND TECHNOLOGY
WINGS TO YOUR THOUGHTS.....

centrality, for both proactive and reactive routing protocols. Their approach improves the load distribution and significantly enhances the network performances in terms of average delay and reliability. However this approach use only single path routing, which may cause extra overhead under high node mobility due to frequent route breaks.

Raj bhupinder et al. used the ant based algorithm [10] for load balancing by calculating threshold value of each routing table through average number of requests accepted by each node. According to this threshold value, they can control the number of ants that has been send. If the threshold value is less, it means the average number of requests to that particular node is low. Then they simply broadcast the ants for updating their pheromone table. If the average number of requests is high, then a data packet will be send according to the pheromone table of that particular node. Their work presents a new dynamic and adaptive routing algorithm for MANETs inspired by the ant colony paradigm.

Pradeep et al [11] propose some enhancements to the AODV protocol to provide QoS and load balancing features by adding two extensions to the messages used during route discovery. The first extension (Delay field) specifies the service requirements, which must be met by nodes rebroadcast a Route Request or returning a Route Reply for a destination. The second extension (Cost field) provides mobile nodes with sufficient information about different routes to achieve load balancing through the network.

Kumar et al. [12] proposed E^2AODV protocol which balances the load with energy efficiency considering both congestion and the nodes energy usage. RREQs packets are broadcasted by source node like in normal AODV. An intermediate node receiving the RREQ will compare its current queue length with its threshold before rebroadcasting it further in the network. If the queue length at node is greater than the threshold, the RREQ packets will be dropped thus bypassing the node from path establishment. Otherwise, the node will deal with RREQ normally and further the node's energy is compared with threshold energy. If the node's energy is less than the threshold energy than the packets are transmitted or less the packets are dropped. In above scheme, the threshold value plays an important role in selecting nodes whether or not to forward RREQ and the threshold value changes dynamically with the current load status of network. Every time an intermediate node receives a RREQ packet threshold value is re-calculated according to the nodes' queue length around the backward path.

Ali et al. proposed NCLBR [13] for MANET in which each node avoids the congestion in greedy fashion. This algorithm uses the alternative route towards the destination to divert traffic away from itself onto other routes existing in the network and to avoid establishment of new routes through congested nodes. Each node monitors the current status of its interface queue size. When a node notices that the congestion threshold (say 50) has been reached, it automatically starts ignoring new RREQ packets so as to not allow any new routes passing through it.

Geng et al. [14] proposed a LCM protocol which used a new route metric called Expected Transmission Time with Coding and Load Balancing (ETTCL). ETTCL-based protocol includes multiple node-disjoint paths, multicast routing discovery by constructing the node-disjoint multicast tree on the basis of ETTCL and route maintenance through network coding to encode the data flows that reduces routing overhead of LCM protocol.

3. ADHOC ON-DEMAND DISTANCE-VECTOR ROUTING (AODV)

Ad hoc On Demand Distance Vector Routing Protocol (AODV) is a type of reactive routing protocol [15, 16]. The routing table is maintained and it contains the information of the destination nodes as shown in Figure 1. Whenever the node wants to transmit the data to another node which is not its immediate neighbour, source node begin the process of finding the route by sending RREQ message to neighbouring nodes and the latter one after receiving the RREQ renew the information regarding source node and in routing table create a backward link to source node. Further it checks if it has already received the same RREQ, then the RREQ is discarded. If the RREQ is received by the intermediate node which does not have information about path to the destination then it is re broadcasted to the neighbour nodes. After the destination node or with intermediate node which knows about the path to destination node, RREP is propelled back. RREP travel the same track as that of RREQ and reaches source node.

Destination ID	Sequence Number	Hop count	Lifetime of a route	Next hop

Figure1: Routing Table Entry in AODV

As shown in figure 2, source node A broadcasts RREQ to its neighbor E and B which further broadcasts it to F and C and they further to G and D. When RREQ reaches destination D, RREP is unicasted back to source. Meanwhile duplicate RREQ received by D from G and by C from F is discarded. Source node saves routing path to D as A-B-C-D in its routing tables for sending data packets.

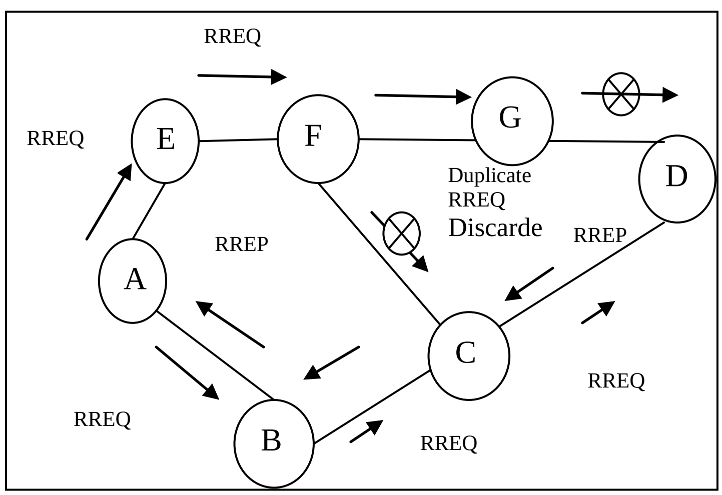

Figure 2: AODV Route Discovery

INTERNATIONAL JOURNAL FOR ADVANCE RESEARCH IN ENGINEERING AND TECHNOLOGY
WINGS TO YOUR THOUGHTS.....

4. PROPOSED ALGORITHM

MANET routing protocols discover shortest path for forwarding data packets but it may suffer from traffic congestion. In order to reduce the probability of selection of congested route, data packets are distributed over multiple routes. Our proposed algorithm modifies normal AODV is to maintain several routes to a destination in routing tables of all intermediate and source nodes and priorities are assigned based on the hop count and interface queue length. An intermediate node receiving RREQ checks its routing table to find an unexpired route to destination and if route is not found, it rebroadcasts RREQ adding packets to interface queue. RREQ's packets are broadcasted based on load values of each node. The queue used for accessing the queue length of a node is "Queue/DropTail/PriQueue" which drops packets from its tail and gives priority to routing packets.

The maximum number of routes to a destination node maintained is given by threshold M. If M routes are returned by destination or intermediate nodes to source node then priorities are assigned to routes based on hop count and load value. The shortest and least loaded route will have highest priority and higher number indicates higher priority. The load to be transmitted L then each path will carry (p_i*100/P) % of load, where p_i is priority assigned to path 'i' and P is total priority of routes. In Figure 3 below, source node S wants to send data packets to the destination node D, it will initiate a route discovery process. Let threshold value M = 3, so routes returned are (S, F, G, D) with hop count 3, (S, H, I, G, D) with hop count 4 and (S, A, B, C, E, D) with hop count 5 (S, H, I, J, K, L, D). The source node S will sort these routes based on the interface queue length and hop count, and assigns a priority to each route.

The path with highest aggregated value one will have a route priority equal to one, and the next route's priority will be two and so on. The load will also be distributed among these three paths to reduce congestion. The path (S, F, G, D) with lowest aggregated value has priority 3 and will carry 50% of load, second route with priority 2 (S, A, B, C, E, D) will carry 33.3% and third route (S, H, I, J, K, L, D) with priority 1 will carry 16.7% of total load.

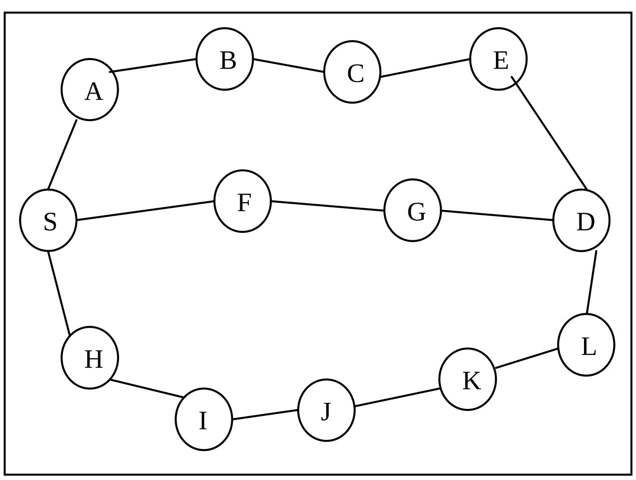

Figure 3: Load balancing in proposed algorithm

Algorithm:

1. Initialize the network with mobile nodes. All nodes use AODV as default routing protocol.
2. A source node wishes to communicate to destination node broadcasts RREQ packets.
3. Any intermediate node or destination itself having unexpired route to destination can send RREP back to source node.
4. Each intermediate node 'i' receiving RREP calculates load L at time 't' as follows:
   $$L_i(t) = a * IFq_{len_i}(t) + (1-a) * T_{busy}(t)$$
   Where a is weighted factor chosen between [0, 1]. IFqlen is interface queue length and Tbusy is channel busy time
5. Receive_Reply() of AODV is modified to allow source nodes to store multiple paths in its routing tableonly if new path does not differ too much in length than already existing and it does not exceeds maximum alternate path count.
6. The source node calculates loadof nodes along the multiple alternate paths.
   $$L(path) = \sum_{node=1}^{hop\ count+1} L_{node}$$
7. The aggregated value 'AV' of each path is calculated as:
   $$AV_{path} = \beta * L_{Path} + (1-\beta) * Hopcount_{path}$$
8. Paths are prioritized on the basis of AV. Lower the value of AV, higher is the priority. Priority p of path is 'm' with lowest AV value where m is the number of paths found and p is 1 for path with highest AV value.
9. The alternate paths are prioritized on the basis of Lnodand hop count
10. The load to be transmitted L then eachpath will carry (pi*100/P) % of load, where pi is priority assigned to path 'i' and P is total priority of routes.
    P = p1 + p2 + p3+ …….pM

5. SIMULATION RESULTS

NS-2 [17] is used to simulate proposed algorithm. This section presents the topology and different parameters used in the simulation process as shown in table 1. The simulation results obtained with unrealistic mobility models such as random models may fail to capture movement of mobile nodes in the real world scenario. Mobile nodes in random models move independent of each other but in real life applications there is a specific leader whom nodes follow or move in groups such as group of friends going for a trip to Shimla so spatial models are used. We have used nomadic mobility model [18]. Nomadic mobility model is used by every MN to move around the reference point. If the reference point changes, then the reference point decides the area where all the MNs in the group move. This simulation process considered a wireless network of 25 nodes which are placed within a 500m x 500m area. CBR (constant bit rate) traffic is generated among the nodes. The simulation runs for 300 seconds.

INTERNATIONAL JOURNAL FOR ADVANCE RESEARCH IN ENGINEERING AND TECHNOLOGY
WINGS TO YOUR THOUGHTS…..

The simulation was done for varying pause time and data rate. Data packet size is 512 bytes and control packet size is 48 bytes.

Table 1: Different Parameters and their values

Parameters	Values
MAC Type	802.11
Number of nodes	25
Maximum no of connections	50
Pause Time (sec)	5
Speed of nodes (m/s)	1, 2, 5, 10
Maximum no of connections	40
Packet Size (Kb)	512
Queue Length	50
Interface Type	Queue/Drop Tail
Data Rate	0.1, 0.05, 0.02, 0.01
Number of nodes in a group	5

The following metrics are considered in order to compare the performance of our proposed algorithm with AODV.

- **Dropped Packets:** It is the difference of packets received from packets sent in the network.
- **Packet delivery ratio:** Packet delivery ratio is the ratio of total packets sent by the source node to the successfully received packets by the destination node [19].

$$PDR(\%) = \frac{Number of packets received}{Number of packets sent} X\ 100$$

- **Average end-to-end delay:** Average End-to-End delay is the average time of the data packet to be successfully transmitted across a MANET from source to destination [19].

$$\text{Average-end-to-end delay} = \frac{\sum_{1}^{n}(Packets\ received - packets\ send)}{\sum_{1}^{n} packets\ received}$$

In first set of simulations, data rate is varied from 0.1 to 0.01 and speed is kept constant i.e. 5 m/s to study the effect of increasing network traffic on different parameters. Figure 5-7 clearly depicts that our proposed algorithm works well for increasing traffic rate. The number of dropped packets decreases by63% with our proposed algorithm with data rate 0.1. As data rate changes from 0.05 to 0.01, number of dropped packets reduces from 38 to 6. Packet delivery ratio ranges between 91.99 to 93.94 with load balanced AODV as compared to 76.63 to 81.82 in AODV without load balancing. The average end to end delay reduces from 55.11 ms to 30.22 ms for 0.1 data rate, 111.23 ms to 109.85 ms for 0.05 data rate, 464.24 ms to 387.83 with 0.02 data rate, 1470.79 ms to 1412.41 ms with 0.01 data rate as shown in Figure 7.

In the second set of simulations, speed of the node is varied as 1 m/s, 2 m/s, 5 m/s and 10 m/s and data rate is 0.1. It is observed from figure 8 that average number of dropped packets is 197 with normal AODV and 38 with load balancing in AODV. PDF rises from 81 to 99 with 1m/s speed, 81.67 to 99.26 with 2 m/s, 76.63 to 99.26 with 5 m/s, 79.79 to 96.71 with 10 m/s as shown in figure 9.

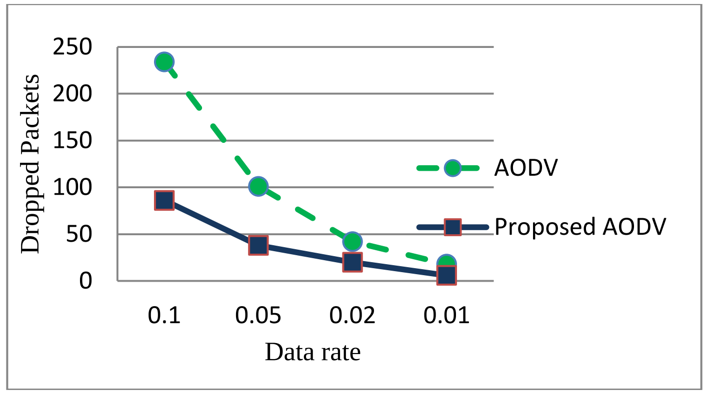

Figure 5: Variation in number of dropped packets with data rate

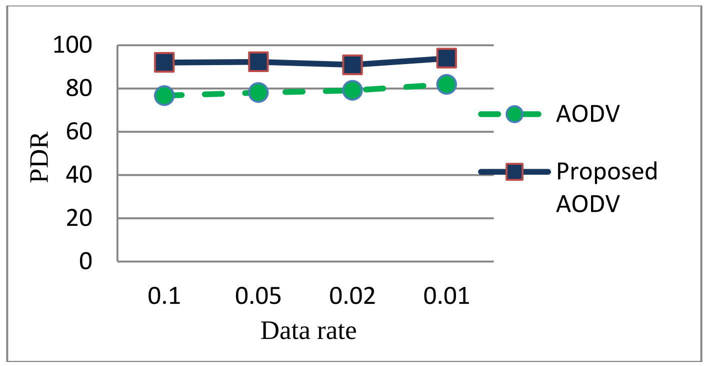

Figure 6: Variation in PDF with data rate

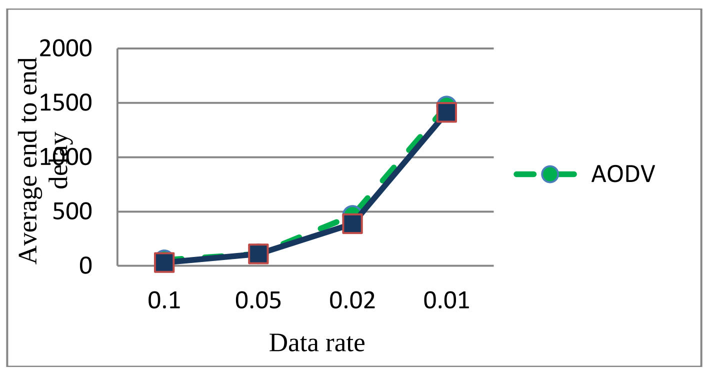

Figure 7: Variation in average end to end delay with data rate

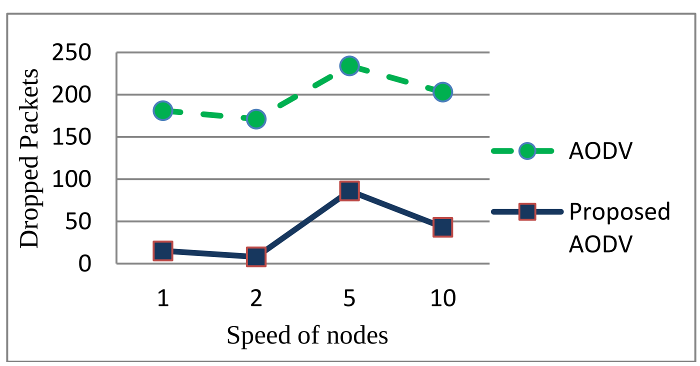

Figure 8: Variation in no of dropped packets with speed of nodes

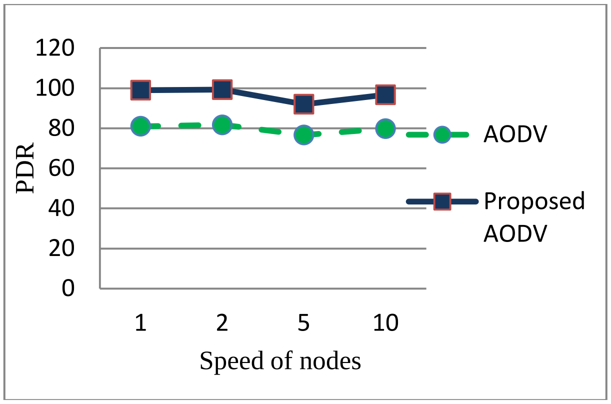

Figure 9: Variation in PDR with speed of nodes

The average end to end delay of proposed algorithm as shown in Figure 10 is less than normal AODV by 19.7% on an average. As speed increases from 1m/s to 10m/s, average end to end delay decreases from 61.67 ms to 49.52 ms and 43.18 ms to 40.22 ms respectively. Our proposed algorithm suits well for highly mobile environment as delay is less than AODV without load balancing. As speed increases from 1m/s to 5m/s, there is slight decrease in delay of AODV as mobile nodes move towards destination and afterwards it increases as congestion in the network overpowers movement towards destination.

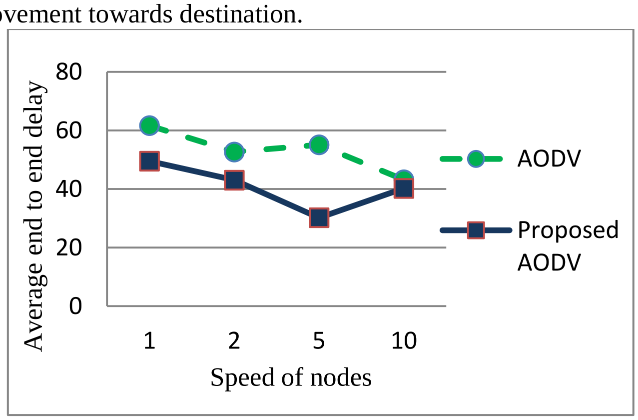

Figure 10: Variation in average end to end delay with speed of node

6. CONCLUSION AND FUTURE SCOPE

Excessive load in the network is responsible for link breakage and performance degradation. A congested node in the network dies more quickly than other nodes. An optimized load balancing technique distribute the traffic load evenly among all the nodes those can take part in transmission. Transferring of load from congested nodes to less busy nodes and involvement of other nodes in transmission that can take part in route can improve the overall network life. In this paper, load balanced AODV routing protocol has been proposed for distributing traffic load evenly among nodes in ad hoc. The idea is to distribute load based on the route priority calculated on the basis of load and hop count and to reduce congestion in high load networks. We performed a simulation study and compared the load-balanced AODV with basic AODV protocol. The results of simulation shows that the proposed load balanced protocol can improve packet delivery ratio by 21% on an average, reduce average end to end delay by 23.34% approximately, reduce dropped packets by 80% and improves overall network life with varying network speed. Similar performance is observed by varying traffic load. Hence, the proposed protocol can be used to achieve QoS requirements for longer transmission in highly mobile and loaded mobile adhoc networks. In future, we wish to apply proposed technique to other reactive and proactive protocols. Further investigation is needed to determine the performance of proposed algorithm using additional path parameters like energy of nodes, current delays, etc. We have assumed a homogeneous traffic so we would like to modify proposed algorithm so it addresses both real-time and best effort traffic.

REFERENCES

[1] Ilyas, M. (Ed.). (2014). The handbook of ad hoc wireless networks. CRC press.

[2] C.K. Toh, A.-N.Le, and Y.-Z. Cho, "Load Balanced Routing Protocols for Ad Hoc Mobile Wireless Networks," Wireless CommunicationsMagazine, vol. 47, no. 8, pp. 78-84, 2009.

[3] M. Ali, Oman, B.G.Stewart, A. Shahrabi , Vallayaraj, "Congestion Adaptive Multipath Routing For Load Balancing In Mobile Ad Hoc Network" Innovations in Information Technology (IIT), 2012 International Conference on 18-20 March 2012, pp. 305-309.

[4] H. Hassanein and A. Zhou, "Routing with Load Balancing in Wireless Ad hoc Networks," Proc. 4th ACM MSWiM '01, Rome, pp. 89–96, Italy, 2001.

[5] M. Spohn and J.J. Garcia-Luna-Aceves, "Neighborhood Aware Source Routing," Proc. ACM MobiHoc, 2001.

[6] Y. Lu, W. Wang, Y. Zhong, and B. Bhargava, "Study of Distance Vector Routing Protocols for Mobile Ad Hoc Networks," Proc. IEEE Int'l Conf. Pervasive Computing and Comm. (PerCom), pp. 187- 194, Mar. 2003.

[7] L. Reddeppa Reddy and S.V. Raghavan, "SMORT: Scalable multipath on-demand routing for mobile ad hoc networks", in proceedings of Journal on Ad Hoc Networks, vol. 5, no. 2, pp: 162- 188, March 2007.

[8] K. N. Sridhar and M. Chan, "Channel-aware packet scheduling for MANETs, World of Wireless, Mobile and Multimedia Networks," 2008. WoWMoM 2008. 2008 International Symposium; June 2008, pp. 1 - 9.

[9] O. Souihli, M. Frikha, M. B Hamouda, "Load-balancing in MANET shortest-path routing protocols", in proceedings of Journal on Ad Hoc Networks, vol. 7, no. 2, pp: 431- 442, 2009.

[10] Raj bhupinder Kaur et. al. "Load Balancing of Ant Based Algorithm in MANET", IJCST, Vol. 1, Issue 2, ISSN: 0976 - 8491, 2010.

[11] B. S. Pradeep, S. Saumya, A New Method for Load Balancing and QOS in On demand Protocols–In the MANET's Perspective, Int. J. of Advanced Networking and Applications, Volume: 01, Issue: 04, Pages: 275-281 (2010)

INTERNATIONAL JOURNAL FOR ADVANCE RESEARCH IN ENGINEERING AND TECHNOLOGY
WINGS TO YOUR THOUGHTS…..

[12] Kumar, R. V., &Banu, R. W. (2012). E^{2}AODV Protocol for Load Balancing in Ad-Hoc Networks. Journal of Computer Science, 8(7), 1198-1204.
[13] Ali, Amjad, and Wang Huiqiang. "Node centric load balancing routing protocol for mobile ad hoc networks." International MultiConference of Engineers and Computer Scientists. 2012.
[14] R. Geng, Z. Ning and N. Ye, "A load-balancing and coding-aware multicast protocol for mobile ad hoc networks", International Journal of Communication Systems, 2015, doi: 10.1002/dac.2928.
[15] I. D. Chakeres and E. M. Belding-Royer, "AODV routing protocol implementation design", In Distributed Computing Systems Workshops, 2004 Proceedings. 24th International Conference on pp. 698-703, 2004
[16] T. Bhatia and A . K . Verma, "Simulation and Comparative Analysis of Single Path and Multipath Routing Protocol for MANET," Anveshanam- The Journal of Computer Science & Applications, vol. 2, no 1, pp. 30-35, 2013.
[17] T. Issariyakul and E. Hossain, "Introduction to Network Simulator NS2," Springer, US, 2009.
[18] W. Navidi and T. Camp, "Stationary distributions for the random waypoint mobility model", IEEE Transactions on Mobile Computing, vol. 3, no. 1, pp. 99–108, Jan-Feb 2004.
[19] T. Bhatia and A.K Verma, "QoS Comparison of MANET Routing Protocols", International Journal of Computer Network and Information Security, 9, pp. 64-73, 2015.