# Energy Aware Congestion Control Mechanism toward Improving Performance in MANET

Suveg Moudgil
Ph. D Research Scholar,
CSE Deptt,
MMEC, MMU, Mullana

Sanjeev Rana, PhD
Prof, CSE Deptt,
MMEC, MMU, Mullana

## ABSTRACT
A Mobile ad-hoc Network (MANETs) is an infrastructure less network consist of mobile nodes which communicate with each other. MANETs have dynamic topology, limited bandwidth and limited power of mobile nodes. Routing is the challenging task in MANETs due to its characteristics. As wireless network grows in size, complexity and demand, effective load balancing becomes the crucial part of MANET routing protocols. For the sustained network functionality, load balancing mechanism need to compute energy aware paths with lesser load. In this paper, we have devised an alternative approach to select the primary path using any multipath algorithm on the basis of energy, load and delay parameters. Proposed approach is integrated in AOMDV protocol for simulation. Comparison is done between I-AOMDV and original AOMDV. Simulation results shows that I-AOMDV improves the overall performance of the network.

## Keywords
AOMDV, Congestion Control, Load Balancing, Routing Protocols

## 1. INTRODUCTION
MANETs are infrastructure less communication networks in which mobile nodes communicates with each other. MANETs are characterized by dynamic topology, limited bandwidth, limited battery power & computation resources of nodes & error prone transmission medium [1]. They uses multi-hop routing. Each Intermediate node acts as a router. All these factors make the routing in MANETs a challenging task.

Most of routing protocols in MANET use shortest path or minimum hop routing. Major drawback of existing MANET shortest path routing protocols is that they consider the path with minimum no. of hops as optimal path to any given destination. The fewer innermost nodes becomes the backbone for most of the traffic, leading to congestion. This leads to higher end to end delays, lower packet delivery and higher routing overhead. The heavily loaded nodes have high power consumption which reduces battery power. It increases no. of dead nodes in the network which further creates network partitions. Congestion control is challenging task in mobile ad hoc network. Main objective of any congestion control mechanism is to balance the traffic to increase throughput of the network.

Load balancing is essential to avoid traffic congestion problem (2). With Load balancing, traffic congestion and load imbalance can be minimized resulting in better network throughput, minimize end to end delays, mobile node life time can be maximized. Thus, increasing the overall network life time. Load balancing can be defined as a methodology to distribute or divide the traffic load evenly across two or more network nodes in order to mediate the communication and to achieve redundancy. Load balancing can result in optimal resource utilization, increased throughput and lesser overhead. The existing routing protocols do not have a mechanism to convey load information to the neighbors and can not evenly distribute the load in the network. A network is less reliable if the load among network nodes in not well balanced [3].

Multipath routing allows the establishment of multiple paths between a single source – destination pair [4]. Multipath can provide the advantages for load balancing, fault-tolerance and aggregate bandwidth. Intelligent path selection can be used to enhance the performance of multipath routing. From a fault tolerant perspective, more reliable path should be selected to reduce the chance of route failures. Path selection plays an important role for QoS routing. It is necessary to develop mechanism to support QoS in terms of multiple metrics. For instance, when searching for multiple paths that have the required bandwidth requirements while also meeting certain reliability requirements would result in better performance.

In this paper, energy aware congestion control mechanism toward improving performance in Manet is proposed. In the paper, new weight based scheme is proposed which uses three parameters residual energy, queue load and end to end delay to select the robust path in terms of high residual energy, lesser load and lower end to end delay. The rest of the paper is organized as follows. Section 2 discuss the overview of AOMDV routing protocol. Section 3 discuss the related work. In section 4 proposed system model details are given. Section 4 proposed I-AOMDV protocol is presented. In Section 5 simulation results are presented and discussed. Section 6 concludes the paper.

## 2. AOMDV ROUTING PROTOCOL
AOMDV is a multipath extension of AODV (ad hoc on-demand distance vector) protocol. AOMDV finds multiple paths between any source-destination pair. It guarantees loop freedom and disjoint ness of alternate paths [5]. AOMDV works in two phases. In route discovery phase, the source node sends RREQ message to its adjacent nodes. The adjacent nodes acts as relay nodes. The destination node receive RREQ message in the end. Destination node reply back RREP message to source node through different paths from which RREQ have been received. Source node receives multiple RREQ messages from multiple paths. Source node selects the best path on the basis of lower hop count and set the path as primary path. Remaining paths are used as secondary path and are used if primary path fails. In Route maintenance phase when route breaks due to congestion or less power. RERR message will be generated from node to source node. Source node selects another secondary path for data transmission and make it a primary path. When there is no path available from

source to destination then route discovery process is again started.

# 3. RELATED WORK

## 3.1 Load Balanced Routing

Load balancing approaches in the literature can be divided into two main categories. These are single path approaches & multipath routing approaches. In single path approaches [6], [7],[8] a single path is established between a source destination pair. DLAR, Dynamic Load Aware Routing [6] selects the primary route on the basis of no. of Packets buffered in the interface. Load Aware Routing (LARA) [7] define a new metric called traffic density, to represent the degree of contention at the MAC level. The traffic density of a node is calculated by the sum of traffic queue qi of node i and traffic queue of all its neighbors. Load Balanced Ad hoc routing [8] is focused to find the path with least load, so that data can be routed with least delay. It defines a new metric known as Degree of Nodal Activity. Activity is the number of active paths through a node. Cost function is calculated by minimum traffic load and interference. Weighted Load Aware Routing [9], a new metric traffic load computed by the product of average queue size of the interface at the node and no. of sharing nodes which are declared to influence the transmission of their neighbors. Total traffic load in a node is computed by its own traffic load plus the product of its own traffic load and number of sharing nodes. Path load is defined as a sum of total traffic loads of nodes which include the source node and all intermediate nodes.

In Multipath routing approaches, many paths are established between a source-destination pair of nodes & traffic between these nodes is divided on the different paths. Load balancing in multipath routing includes determining the amount of traffic on each path minimizing a certain cost function. For example CLAR [10] uses traffic load through and around neighboring nodes as a parameter to make the routing decision. Workload Based Adaptive Load Balancing (WBALB) [11], uses interface queue occupancy and workload to control RREQ messages adaptively. MALB (Multipath adaptive load balancing) [12] distributes the traffic among the multiple paths dynamically based on measurement of path statistics. It is a common framework and can be embedded with any multipath source routing protocol. LB-AOMDV [13], uses queue length and hop count to select the route from source and destination that avoids congestion and provides load balancing. When queue length crosses certain threshold value, then load balancing via alternate paths is carried out.

## 3.2 Energy Aware Routing

No. of research proposals are proposed which takes energy as a key parameter in order to preserve energy in MANET [14],[15],[16],[17]. While taking the routing decision, it is beneficial to consider information about node's battery levels. Power aware routing [14] uses the residual energy of the node. In [15], authors proposed MMRE-AOMDV, which finds the minimal nodal residual energy of each route in the process of selecting path and sort multi-route by descending node residual energy. Another protocol is Conditional Max-Min Battery Capacity Routing (CMMBCR) [16], uses the concept of threshold to maximize the life time of each node and to use battery fairly. Localized Energy Aware Routing (LEAR) [17], a node decides whether to forward RREQ or not depending on its residual power. A node will forward RREQ only when its residual energy is above the defined threshold, otherwise it will drop the RREQ packet. The destination node will receive a RREQ only when all intermediate nodes along the route have good battery power.

## 3.3 Delay Aware Routing

Several delay aware routing protocols are proposed [18], [19], [20], [21] in the literature which takes the delay as a metric for path selection between source and destination. In [18] authors proposed QoS-AODV protocol with some extensions that help in selecting the best path from source to destination in terms of delay and bandwidth. In [19], authors have proposed delay aware AODV multipath (DAAM) which recorded the delay of each route during the discovery for routes between source and destination. Ad hoc QoS on demand routing (AQOR) [20] uses restricted flooding to discover the best path in terms of minimum end to end delay and bandwidth guarantee. Source selects the route with least delay. In [21], EDDSR is proposed which use energy and delay extensions to the DSR protocol. In [22], SMR (Split Multipath Routing is proposed) which calculates two paths in route discovery. One is based on delay as the main metric and other is the maximum disjoint path.

# 4. PROPOSED MECHANISM

In proposed MANET model, MANET is represented as an undirected graph G (N, L) where N is set of nodes and L is the set of links connecting the nodes. All the hosts communicate on the same shared wireless channel and are globally synchronized. Each node has a unique identifier with at least one transmitter and one receiver. Effective transmission distance between every node is equal. Two nodes are assumed to be neighbors with a link between them if they are in transmission range of each other. All nodes are initialized with same energy & they consume fix transmission power to send control and data packets. Nodes are randomly distributed. For every node i, there is associated residual energy $E_{re}$ queue length $Q_{pt}$ and delay $D_p$. Energy model, traffic model and delay model are used to model energy, traffic and delay. Details of these models are mentioned below. For Energy Model following terms are defined.

$E_{in(i)}$ is initial energy which is fixed for every node i.

$E_{co(i)}$ is consumed energy of node i.

$E_{re(i)}$ is the residual energy of node i. It is calculated by following equation.

$E_{re(i)} = (E_{in(i)} - E_{co(i)}) / E_{in(i)}$

Every time a node sends or receives a packet, energy is deducted from the initial energy of the node. Energy consumed is the total of energy consumed by the node in sending or receiving a packet. Node residual energy is the ratio computed by residual energy divided by node initial energy.

Energy of each disjoint path $P_k$ is represented by $E_{P(k)}$.

$E_{p(k)}$ = (Min ($E_{re(i)}$) among all nodes in path $P_k$)

Thus, $E_{p(k)}$ represent the residual energy of the path.

For Traffic Model following terms are defined.

$Q_{m(i)}$ is maximum queue size of a node i

$Q_{pt(i)}$ represent the no. of packets in the queue of node i.

$L_{p(k)}$ is traffic load of each disjoint path $P_k$ and is calculated by

$L_{p(k)}$ = (Average of $Q_{pt(i)}$ among all nodes in path $P_k$) / $Q_{m(i)}$

Delay indicates the time taken by the packet to reach from the source to destination. Packet delay consist of processing delay, queuing delay, transmission delay and propagation delay. The end to end delay is the sum of the node delay at each node in addition to link delay at each link on the path. The destination node finds the overall delay and update it in route reply message.

$D_{(i)}$ is the delay from previous node.

$D_{p(k)}$ is the sum of the delays of all nodes in path $P_{k.}$

Our proposed scheme takes in to account above three parameters. We define a term Weight W, which is calculated by the following equation

$$W_{Pt(k)} = a1.\ E_{Pt(k)} - a2.\ L_{pt(k)} - a3.\ D_{p(k)} \qquad (1)$$

Where a1, a2 and a3 are three variables that decides the dominance of above parameters in W. Sum of a1, a2 and a3 is 1.

## 4. 1 MANET Scenario

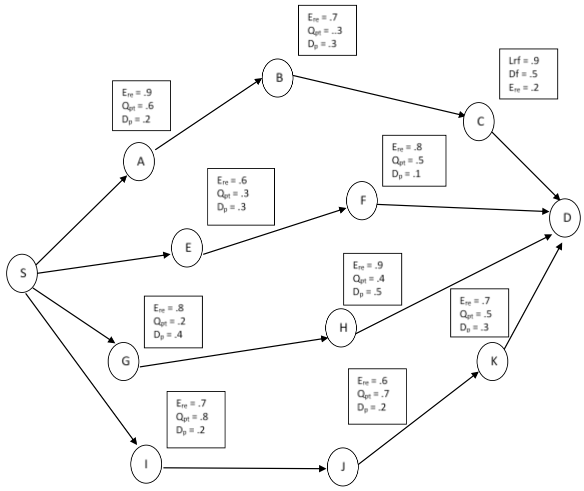


**Figure 1: A MANET Scenario with 12 Nodes**

S is the source node and D is the destination node.

AOMDV finds four paths.

1. S – A – B – D
2. S – E – F – D
3. S – G – H – D
4. S – I – J – K – D

Taking the value of constants a1 = .6, a2 = .2 and a3 =.2.

Based on the equation (1) W1, W2, W3 and W4 is calculated and they have the order

W3 > W4 > W2 > W1

So path S – G – H – D is selected and used as primary path for data transmission and other paths become the secondary paths.

## 4.2 I-AOMDV Steps

Step 1: Initialize the network with mobile nodes.

Step 2: Initialize energy levels and queue length of all nodes.

Step 3: Source node wishes to communicate with destination node, it broadcast RREQ packet with three additional parameters for energy, traffic and network load.

Step 4: Intermediate node above the minimum energy threshold value participate in route discovery process and forward the RREQ packet by updating the values in the fields.

Step 5: Source node stores the multiple paths & values in the routing table and calculate weight W.

Step 6: Best path is used according to weight W for data transmission.

Step 7: In case primary path fails, next path according to weight W can be chosen for data transmission.

Step 9: In case all routes fails, new route discovery is started by the source node.

## 5. SIMULATION AND PERFORMANCE EVALUATION

We analyze the I-AOMDV with original AOMDV protocol using NS2 Simulator [23]. For Simulation, we have taken 50 mobile nodes which are spread randomly over the area of 1500 x 1500. A sources and destinations are selected randomly. Two ray model is used. Each node is assumed to have a transmission range of 250 meters and channel capacity of 2 Mbps. IEEE 802.11b radio model is used as MAC protocol. Traffic Generator tool cbrgen is used to generate CBR Traffic. Packet size is 512 bytes. Mobility pattern of mobile nodes are generated using Random way point model. Simulation runs for 250 Seconds. Max Speed of mobile node is 20 meters per sec. we use a pause time of 2 sec. For Simulation we have consider the following parameter values.

**Table 1: Simulation parameters**

| Parameter | Values |
|---|---|
| Simulator | NS 2.34 |
| Simulation Time | 250 sec |
| Scenario Dimension | 1200x1000 |
| No. of Nodes | 50 |
| Routing Protocols | AOMDV, Proposed AOMDV |
| Mobility Model | Random Way Point |
| Radio type | 802.11b |
| Path Loss Model | Two Ray |
| Packet Size | 512 Bytes |
| Queue Length | 50 |
| Interface Type | Queue/Drop Tail |

## 5.1 Performance Metrics

We have chosen Packet delivery ratio and End to end delay to compare the proposed algorithm with original AOMDV algorithm. Packet Delivery Ratio is the ratio of the total number of data packets received by destinations over the total number of data packets transmitted by sources. End-to-End Delay is the average delays for all received data packets from the source to the destination. This includes all possible delays caused by buffering during route discovery, interface queuing delay, retransmission delays at MAC layer, propagation and transfer times. To study the effect of increasing network load these parameters are examined by varying the no. of connections and data rate.

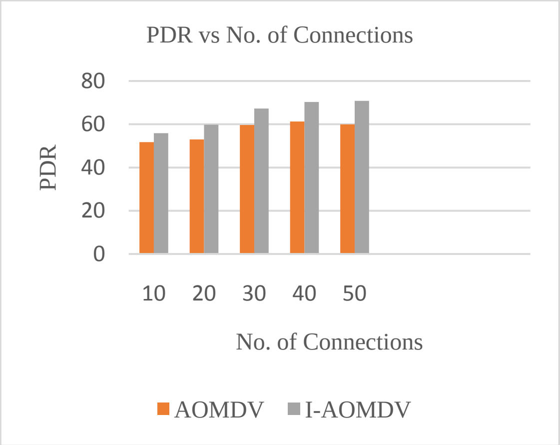


**Figure 2: PDR versus No. of Connections of AOMDV and I-AOMDV**

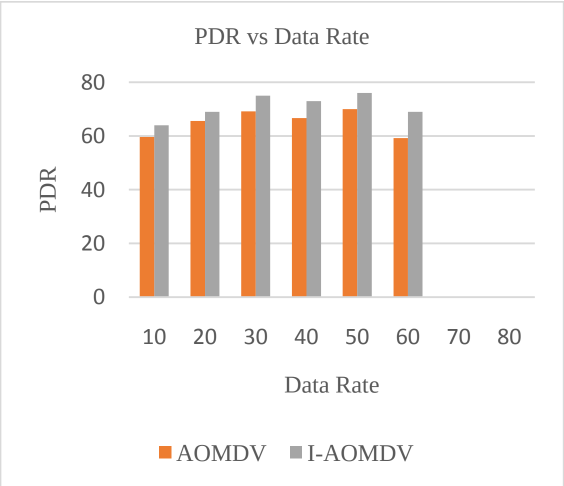


**Figure 3: PDR versus Data rate of AOMDV and I-AOMDV**

Packet Delivery ratio is better in our approach as compared original AOMDV as compared in fig 1. When we have varied the no. of connection from 10,20,30,40 and 50 taking the data rate fix as 10 packets per second. As Proposed AOMDV consider the path selection on the basis of load and residual energy of nodes which is not there in original AOMDV. Next we have varied the data rate 10, ,30,50,70 and 90 packets per second and no. of connections are fixed and is 30. Packet delivery ratio is again better in this case, as the path selected is based on residual energy so it can live more and can handle higher data rates.

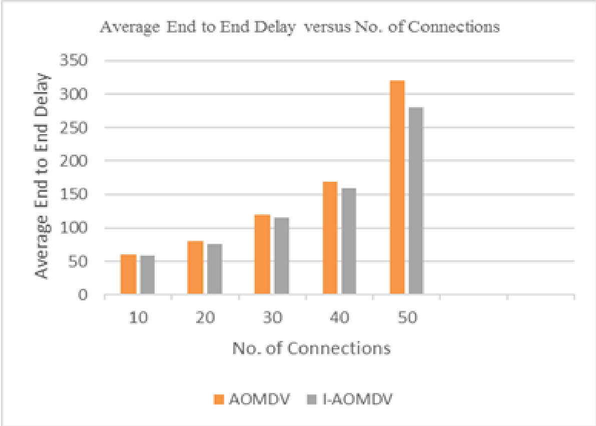


**Figure 4: End to end delay versus No. of Connections of AOMDV and I-AOMDV**

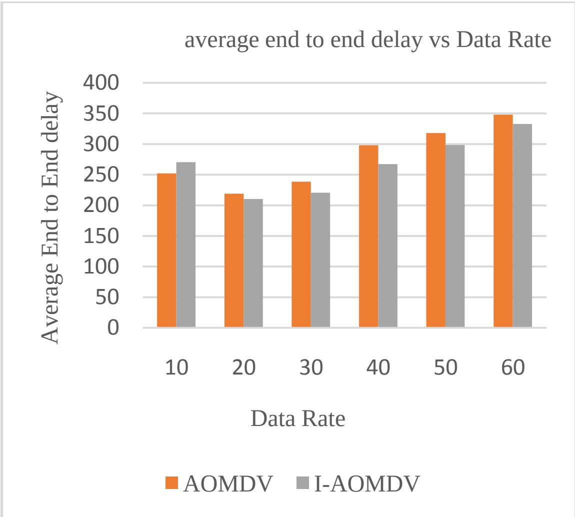


**Figure 5: End to end delay versus Data rate of AOMDV and I-AOMDV**

Next Performance Metrics is end to end delay. There is an improvement in end to end delay as compared to original AOMDV in both the cases as shown in the Figure 4 and Figure 5. Proposed AOMDV selects the less congested path thus avoiding the queuing delay and path are selected on residual energy so the path live longer. Thus increasing the overall lifetime of network.

## 6. CONCLUSION

In this paper, we have studied the problem of load balancing and energy efficiency. We have presented an alternative approach to select primary path in a multipath algorithm based on load, residual energy and delay. For calculating load, we have taken queue length as a parameter and residual energy is calculated by total energy minus consumed energy at any time. We have run the simulation using ns2 simulator. We have integrated the proposed mechanism with AOMDV protocol resulting I-AOMDV & performed simulation. After comparing the result we have found that I-AOMDV protocol improves overall performance of network as compared to original AOMDV.

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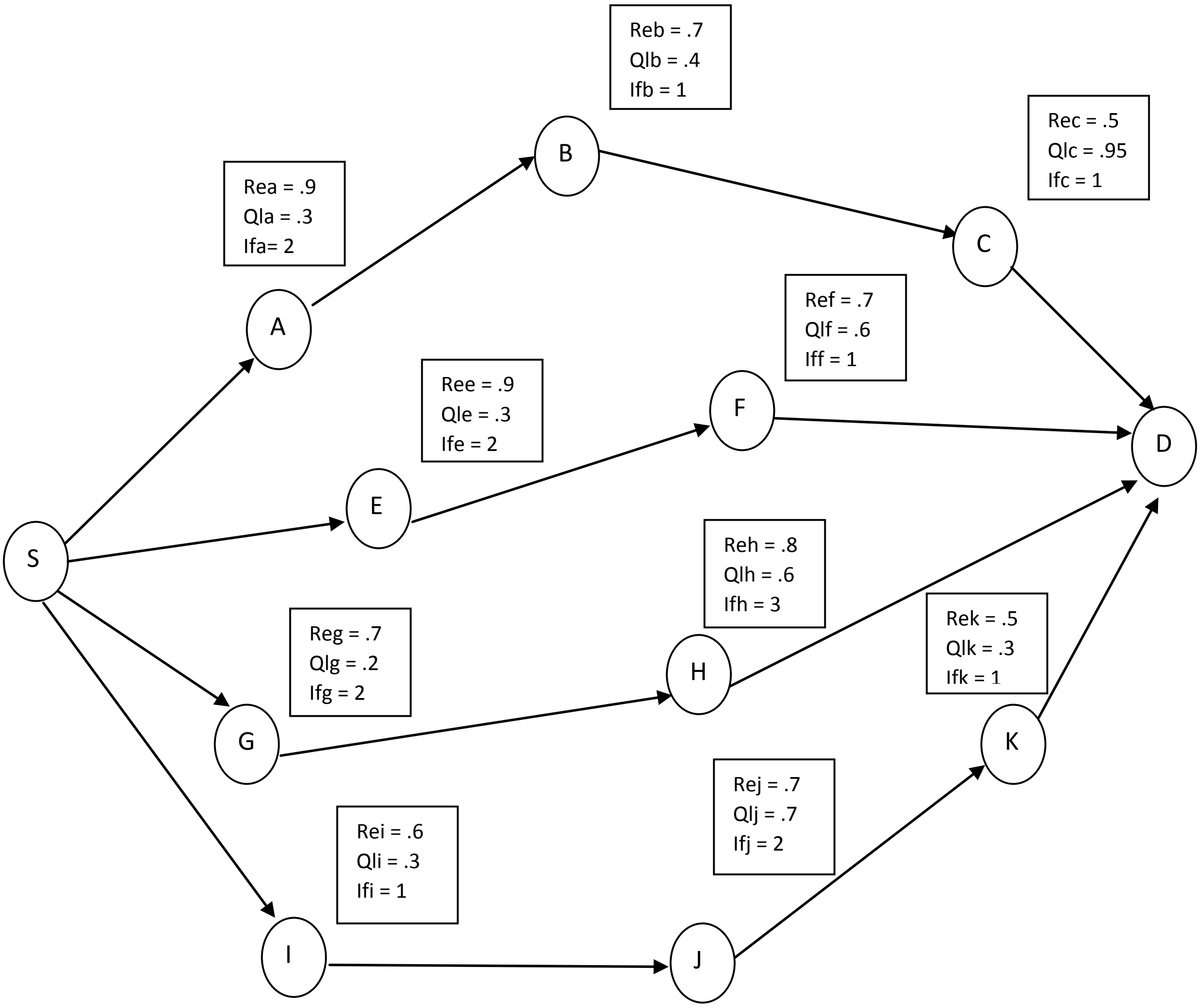
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Qla = .3
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