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Enhancing the Efficiency of Wireless Ad Hoc Networks by Improving the Quality of Service Routing

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ABSTRACT

Nowadays, Quality of Service in dynamic, wireless multi-hop Ad Hoc networks is becoming a hot research topic. Various QoS routing protocols are proposed. However, most of the QoS routing protocols provide single route to reach from source to destination. Once links break due to node mobility, establishment of new routes leads to large control overhead and extra end-to-end delay. Thus multipath routing has advantages over single path routing protocol. Also, if the existing path is not QoS guaranteed then the performance in terms of QoS metrics degrades. QoS routing is very important especially in the case of multimedia traffic. Initially the systematic performance study is made on existing routing protocol for Ad Hoc networks such as DSDV, DSR and AODV based on QoS parameters delay, jitter, bandwidth, packet delivery ratio etc. Further, a novel QoS multipath Routing algorithm EMQARP (Enhanced Multipath Quality of Service Aware Routing Protocol) is proposed to support QoS metrics. This algorithm finds the QoS routes only, based on the QoS metrics such as Link life time and the delay, in order to ensure that the routes are link reliable and delay aware and stores only those paths in the routing table. The QoS metrics for the route are computed dynamically. The QoS metrics are measured by varying the Mobility, Speed of movement and Number of Nodes. The simulator NS-2.34 is used.

General Terms

Mobile Ad Hoc Networks

Keywords

QoS, MANET, NS-2.34, AODV, AOMDV, EMQARP, Delay, PDR, Link life time.

1. INTRODUCTION

Mobile Ad Hoc network is a network without physical infrastructure (infrastructure-less), and is established with mobile nodes using wireless connections. No routers or servers are installed, in this network; instead each mobile node acts as a router. Information is transferred in the form of multi-hop between the nodes. This process is facilitated by the self-organization feature built into Ad Hoc networks. This self-organization capability[1] simplifies the management and improves the robustness and flexibility of the network. Ad Hoc network can handle the usage of resources effectively. The Ad Hoc network is widely used in the military, forestry, emergency and rescue services, and in other areas where temporary communication is needed. The advantages of the Ad Hoc network are that it allows arbitrary movement of nodes, and it supports dynamic network topology. The limitations are its access to a power source, less stable routes, and the size of bandwidth available for use.

QoS is very important, especially, in the case of multimedia traffic [2]. Quality-of-Service (QoS) [3] in computer networks refers to the provision of guaranteed service on the networking layer, defined in form of performance contracts between application and service provider. To negotiate such a contract, the application defines QoS requirements that contain sufficient information about the required type and level of service. The QoS parameters such as delay and link life time are first analyzed with single path on demand routing and then the same logic is used to analyze the QoS with multipath on demand routing protocol.

2. RELATED WORK

Initially, a general review of the Single path Ad-Hoc On demand Distance Vector (AODV) and Multipath AODV is carried out, and it is followed by a discussion on existing QoS aware routing protocols. Finally, the EMQARP protocol which includes the multipath routing capability along with the QoS assurance is designed.

2.1 Ad-hoc On-Demand Distance Vector Routing (AODV)

The AODV Routing protocol uses an on-demand approach for finding routes, that is, a route is established only when it is required by a source node for transmitting data packets. It uses features of both DSDV and DSR protocols. It employs destination sequence numbers to identify the most recent path. The major difference between AODV and Dynamic Source Routing (DSR) stems out from the fact that DSR uses source routing in which a data packet carries the complete path to be traversed. However, in AODV, the source node and the intermediate nodes store the next-hop information corresponding to each flow for data packet transmission. In an on-demand routing protocol, the source node floods the RREQ packet in the network when a route is not available for the desired destination. It may obtain multiple routes to different destinations from a single RREQ. The major difference between AODV and other on-demand routing protocols is that it uses a destination sequence number (DestSeqNum) to determine an up-to-date path to the destination. A node updates its path information only if the DestSeqNum of the current packet received is greater or equal than the last DestSeqNum stored at the node with smaller hop count.

A RREQ carries the source identifier (SrcID), the destination identifier (DestID), the source sequence number (SrcSeqNum), the destination sequence number (DestSeqNum), the broadcast identifier (BcastID), and the time to live (TTL) field. DestSeqNum indicates the freshness of the route that is accepted by the source. When an intermediate node receives a RREQ, it either forwards it or prepares a RREP message, if it has a valid route to the destination. The validity of a route at the intermediate node is determined by comparing the sequence number at the intermediate node with the destination sequence number in the RREQ packet. If a RREQ is received multiple times, which is indicated by the BcastID-SrcID pair, the duplicate copies are discarded. All intermediate nodes having valid routes to the destination, or the destination node itself, are allowed to send RREP packets to the source. Every intermediate node, while forwarding a RREQ, enters the previous node address and it's BcastID. A timer is used to delete this entry in case a RREP is not received before the timer expires. This helps in storing an active path at the intermediate node as AODV does not employ source routing of data packets. When a node receives a RREP packet, information about the previous node from which the packet was received is also stored in order to forward the data packet to this next node as the next hop toward the destination.

The main advantage of this protocol is having routes established on demand and that destination sequence numbers are applied for find the latest route to the destination. The connection setup delay is lower. One disadvantage of this protocol is that intermediate nodes can lead to inconsistent routes if the source sequence number is very old and the intermediate nodes have a higher but not the latest destination sequence number, thereby having stale entries. Also, multiple RREP packets in response to a single RREQ packet can lead to heavy control overhead. Another disadvantage of AODV is unnecessary bandwidth consumption due to periodic beaconing.

2.2 Ad-hoc On-demand Multipath Distance Vector Routing (AOMDV)

AOMDV shares several characteristics with AODV. It is based on the distance vector concept and uses Hop-by-hop routing approach. Moreover, AOMDV Also finds routes on demand using a route discovery Procedure. The main difference lies in the number Of routes found in each route discovery. The routing entries for each destination contain a list of the next-hops along with the corresponding hop counts. All the next hops have the same sequence number. This helps in keeping track of a route. For each destination, a node maintains the advertised hop count, which is defined as the maximum hop count for all the paths, which is used for sending route advertisements of the destination. Each duplicate route advertisement received by a node defines an alternate path to the destination. Loop freedom is assured for a node by accepting alternate paths to destination if it has a less hop count than the advertised hop count for that destination.

Because the maximum hop count is used, the advertised Hop count therefore does not change for the same sequence number [5]. When a route advertisement is received for a destination with a greater sequence number, the next-hop list and the advertised hop count are reinitialized.

AOMDV can be used to find node-disjoint or link-disjoint routes. To find node-disjoint routes, each node does not immediately reject duplicate RREQs. Each RREQs arriving via a different neighbor of the source defines a node-disjoint path. This is because nodes cannot be broadcast duplicate RREQs, so any two RREQs arriving at an intermediate node via a different neighbor of the source could not have traversed the same node. In an attempt to get multiple link-disjoint routes, the destination replies to duplicate RREQs, the destination only replies to RREQs arriving via unique neighbors. After the first hop, the RREPs follow the reverse paths, which are node-disjoint and thus link-disjoint. The trajectories of each RREP may intersect at an intermediate node, but each takes a different reverse path to the source to ensure link disjointness.

The advantage of using AOMDV is that it allows intermediate nodes to reply to RREQs, while still selecting disjoint paths. The disadvantage of the AOMDV is, it causes more message overheads during route discovery due to increased flooding and since it is a multipath routing protocol, the destination replies to the multiple RREQs those results are in longer overhead.

2.3 Existing QoS-aware Protocols

Numerous QoS routing protocols have been proposed for wireless ad hoc networks. Many of them are based on the popular on-demand routing protocols, DSR and AODV. Following papers highlights main points about the work that took place in that area.

(a) Shahram Jamali, Bita Safarzadeh, Hamed Alimohammadi, "A stable QoS aware reliable on-demand distance vector routing protocols for mobile Ad Hoc networks", Scientific Research and Essays Volume 6, Academic Journals , July 2011[6]. This paper highlights the following significant points:

- Recently, many routing protocols were proposed for MANETs that use global positioning system (GPS).
- The coordinates of each node can be known using GPS. Further, the transmission routing protocols can complete the process of route discovery by mathematically calculating the routing.
- Due to the mobility of mobile nodes in MANETs, the shortest path is not necessarily the best path. If we do not consider the stability of routing paths, then wireless links may be easily broken.
- There have been many efforts made to design a reliable routing protocol to enhance a network's stability.
- In order to select a reliable route proposed protocol uses 3 parameters: route life time, mobility and number of hops.

(b) S. Chakrabarti and A. Mishra, "Quality of Service Challenges for Wireless Mobile Ad Hoc Networks," International Journal of Wireless Communication and Mobile Computing, Volume 4, pp. 129–53, March 2004 [7] .Their conclusions highlighted several significant points :

- Many of the underlying algorithmic problems, such as multi-constraint routing, have been shown to be NP-complete.
- QoS and, indeed, best-effort routing can only be successfully achieved if the network is combinatorially stable. This means that the nodes are not moving faster than routing updates can propagate.
- Different techniques are required for QoS provisioning when the network size becomes very large, since QoS state updates would take a relatively long time to propagate to distant nodes.
- There is a trade-off between QoS provisioning and minimization of power utilization.

(c) J. Stine and G. de Veciana, "A Paradigm for Quality of Service in Wireless Ad Hoc Networks using Synchronous Signalling and Node States," IEEE Journal of Selected Areas in Communications, Volume 22, Sept. 2004, pp. 1301–21 [8]. This paper highlights several significant points:

- A major advantage of discovering QoS state proactively surfaces in situations where different applications specify their requirements with different metrics. As long as it is decided which QoS states to keep up-to-date, a route may be computed from the routing table based on any QoS metric, without the need for a separate discovery process for each metric.
- A purely reactive routing solution avoids the potential wastage of channel capacity and energy by discovering QoS routes.

(d) Taejoon Park, *Student Member, IEEE,* and Kang G. Shin, *Fellow, IEEE,* "Optimal Trade-offs for Location-Based Routing in Large-Scale Ad Hoc Networks", 2005,IEEE TRANSACTIONS ON NETWORKING, VOL. 13, NO. 2, APRIL [9].

This paper states that while simple multi-constraint QoS routing proposals are numerous, there are few that attempt to optimize multi-constraint routing. One example was based on genetic algorithms. However, such methods have limited applicability due to the overhead and energy cost of collecting enough state information. Accurate studies are required to establish, with various networking environments and topologies, whether or not it is feasible to collect and maintain sufficient state information to apply methods such as GAs. For the cases where it is, more research is required on different types of heuristic algorithms for calculating near optimal paths with multiple QoS constraints. Comparative studies on the performance and impact of the heuristics are additional future work.

(e) Ronald Beaubrun and BadjiMolo, "Using DSR for Routing multimedia traffic in MANETs", January 2010 [10]:

This paper discusses an extension of the on-demand DSR protocol. It consists of a scheme to distribute traffic among multiple routes in a network. Its performance in terms of delay degrades (reaches to 2.2 Seconds) as the traffic increases i.e. 40 and above.

(f) Chandra Mouli Venkata Srinivas Akana Sandeep Kumar, Dr C Divakar ,"QoS for Real time transmission on MANETs", International Journal of Advanced Networking and Applications volume: 02, Issue: 03, Pages: 679-685 (2010)[11]:

This paper states that for a QoS AODV routing protocol, problems would rise when the node density of the network is high. The reason is that the QoS AODV routing protocol uses the control message to exchange information between neighbors. When the node density is too high, the sending of control will cost much available data rate. As a result, the network will be ruined and traffic will be delayed more since control messages have higher priority than data packets. To conclude, it is predicted that the QOS AODV will not work well in high density ad hoc networks.

From the summary of all the papers the following issues are still needed to be solved:

- Scalability
- Stability of the route
- Better performance metric along the path
- Reduction of unsuccessful packet deliveries

3. SOLUTION APPROACH AND METHODOLOGY

The link reliability and delay are very important parameters in the case of multimedia data transmission in MANET. In the original Ad Hoc On demand Distance Vector Routing unnecessary packets are getting broadcasted, causing congestion in the network. Also due to high mobility, the routes stored are not link reliable, so stability of the path is very less. On demand Multipath link reliable and delay-aware routing protocol is designed by including QoS constraints (link reliability and delay) [6][9]. As and when the route to transmit the information is computed, those QoS metrics are also computed automatically and accordingly the routes are updated in the Routing table and hence the route selected will be link reliable and delay-aware route. Other routes which are not QoS-aware are discarded from the Routing table.

3.1 Calculation of Average Timestamp

In the new QoS Routing Protocol, the loss of unnecessary packet is avoided. Each of the packets broadcasted by the source node across the network has a timestamp associated with it. As the nodes are updated in the e routing table, we calculate the average timestamp value using the following equation :

$$T_{avg} = \frac{\sum_{i=0}^{i=n} Ti}{C} \quad (3.1)$$

Where T_{avg} is the Average Timestamp, n stands for maximum simulation time, Ti is the Timestamp of each Packet and C is the Total count of each entry made to the Routing table. This average is a runtime average which is directly proportional to the number of nodes N. As the number of nodes increase, the number of nodes getting added to the Routing Table also increases:

$$T_{avg} \propto N \qquad (3.2)$$

The positions of the node added to the Routing Table are known. Henceforth, if there is a particular node which is very far away such that its timestamp is higher than that of the average value, re-broadcasting of the RREQ from that node is not allowed. In this way, we save the loss of packets and force the Route Discovery Process to search for another route with limited time.

3.2 Calculation of Percentage Life Time Ratio (PLTR)

Due to dynamic change in topology of the Ad Hoc network, it is required to compute the route reliability dynamically.

Assuming two mobile nodes A and B are within the radio transmission range of each other, let:

(X_A, Y_A): coordinate of mobile node A;

(X_B, Y_B): coordinate of mobile node B;

V_A: mobility speed of mobile node A;

V_B: mobility speed of mobile node B; Type equation here.

Θ_A: direction of motion of mobile node A $(0<\Theta A<2\pi)$;

Θ_B: direction of motion of mobile node B $(0<\Theta B<2\pi)$.

Using the aforementioned parameters, we can define the link life time equation as follows:

$$\text{LLT} = \frac{-(ab+cd)+\sqrt{(a^2+c^2)r^2-(ad-cb)^2}}{(a^2+c^2)} \qquad (3.3)$$

Where,

$a = V_A \cos \Theta_A - V_B \cos \Theta_B$, $c = V_A \sin \Theta_A - V_B \sin \Theta_B$

$b = X_A - X_B$, $d = Y_A - Y_B$

The link life time is calculated at each hop during the route request packet is traversing the path. Each node calculates the life time of the link between itself and previous hop. If node A is the previous hop of the packet for node B, it appends its position and movement information to the route request packet. When node B receives this packet, it calculates the life time of the link. The Route Life Time (RLT) [11] is the minimum link life time along a routing path. Therefore, the RLT is equal to the minimum of LLTs for a route.

The formula to compute PLTR is as shown below:

$$\text{PLTR}=\frac{Route\ LifeTime}{TTL}*100 \qquad (3.4)$$

Where TTL carries a time to live (TTL) value that states for how many hops this message should be forwarded. This value is set to a predefined value at the first transmission and increased at retransmissions. Retransmissions occur if no replies are received. The LTR multiplied by 100 gives the Percentage Life Time Ratio (PLTR) for a route. If the PLTR is bigger than 50% then the intermediate node allows the rebroadcasting of RREQ messages.

3.3 Algorithm for Route discovery process in EMQARP:

Suppose **n** is the number of mobile nodes and **N** is the set of mobile nodes, **N= {N_1, N2, Nn}**. Assume that the node N_i seeks to find a path to node N_j and N_t receives the RREQ packet, where N_i, N_j, **Nt ϵ N** and 1**<i, j, t<n and i ≠ j.**

Step 1. At the source node N_i:

a) Calculate the time taken for the packet to reach the destination using the formula:

   Time taken = receive time – send time

b) Check whether the concerned node has an entry in the Routing Table.

c) If no entry found in the Routing table then create the RREQ packet with field values set as :

   Source = **N_i,** Destination **= N_j,** TTL =1

   LLT =PRLT=0, Velocity = direction = Coordinate position =0

d) Send the RREQ packet to the neighbouring node N_t and compute the parameters LLT and TTL.

Step 2. If (the neighboring Node N_t is the destination node N_j) then

Begin

a) Receive all the paths arriving to it for wait period T.

b) Select the paths which are node disjoint among the list of paths.

c) Compute the parameters PRLT and Average delay at the destination node using the following equations: avgTimeTakenByPackets=totalTimeTakenByPackets/C

Percentage Life Time Ratio=Route Life Time/TTL * 100

e) Store the Average delay and PRLT in the Routing table for these paths.

f) Generate the RREP packet for unicasting to the source node for all the node disjoint paths selected and the paths with PRLT>50.

g) Store the paths in the Routing table of Source node.

End

Step 3. If (the neighboring Node N_t has a route to the destination node) then

Begin

a) Copy the parameters of RREQ to the RREP packet along with computed parameter PRLT

b) Send the RREP packet to the Source node

End

Step 4. If (the neighboring Node N_t is neither destination nor having route to node $N_{j)}$

Begin

a) Compute the delay, PRLT

b) If (the delay>=average delay) || (the PRLT<=50)

c) Do not broadcast RREQ from there.

Else

If (the delay <=average delay)

Begin

Update the parameters of RREQ packet

Rebroadcast the RREQ

End

Else

End

4. SIMULATION MODEL AND PARAMETERS

4.1 Movement Model

The mobile nodes move according to the random waypoint model. Each mobile node begins the simulation by remaining stationary for pause time seconds. It then selects a random destination in the defined topology area and moves to that destination at a random speed. The random speed is distributed uniformly between zero (zero not included) and some maximum speed. Upon reaching the destination, the mobile node pauses again for pause time seconds, selects another destination, and proceeds.

4.2 Communication Model

In the scenario used in this study, up to 150 nodes are generated and the traffic connection pattern is generated by cbrgen.tcl. The Table 1 shows the simulation parameters:

Table 1: Simulation parameters

Simulation time	200 seconds
Number of nodes	10,20,30,40,60,80,100,120,140, 150
Map size	1000 X 1000
Speed	5m/sec,15 m/sec, 25m/sec
Mobility Model	Random Way Point
Traffic type	CBR
Packet size	512 bytes
Pause time	0, 10, 20, 40, 60, 80, 100

The NS-2.34 is used for simulation. It has support for simulating multi hop wireless networks. We simulated numerous test conditions using CBR traffic. The simulation is run using various scenarios (such as varying the pause time and speed) and traffic patterns (such as varying the number of nodes). To overcome the effect of randomness in the output we have taken the averages of the results to get their realistic values. Simulations are carried out by varying the pause time, speed and node density simultaneously. The simulation results reveal some important characteristic differences between the existing AODV and the EMQARP. The following metrics are used to compare the performances of two routing protocols:

(i) **Packet Delivery Ratio (PDR)**: The fraction of packets sent by the application that are received by the receivers.

PDR = Number of successfully delivered packets / Total number of transmitted packets.

(ii) **Delay:** End-to-end delay indicates how long it took for a packet to travel from the application layer of the source to the application layer of the destination

4.3 Modeling the network and simulation parameters

The NS-2.34 is used to analyze the performance of AODV and new protocol EQARP. In the simulations following three network scenarios are taken: (1) a low density network with N = 25 nodes; (2) a medium sized network with 25<N<=80 nodes; and (3) a high density network with 80<N<=150 nodes. The mobile nodes are placed randomly within a 1000 m x 1000 m area. Radio propagation range for each node is 250m and channel capacity is 11 Mbps. Each node moves in this area according to the random waypoint mobility model, with a speed of 5m/sec, 15m/sec and 25m/sec. Also considering 10sec as low mobility, 40sec as medium mobility and 80sec as high mobility. The Table 1 shows the values used in the simulations. Each simulation run lasted for 200 seconds. The 2 metrics End-to-End packet and PDR were used for performance study of AODV and EMQARP.

5. SIMULATION RESULTS

The base protocol used to compare the performance of EMQARP is the AODV [11]. The metrics used in comparing these two protocols are PDR and End-to-End delay.

5.1 Combined effect of Node density and Speed

Following are the various cases for the combined effect of node density and the speed:

(i) For the low density and low speed the protocols AODV and EQARP performs same in terms of PDR and End-to-End delay.

(ii) For low density and high speed still the AODV gives high PDR, but the delay of AODV is average. For average density and any speed the PDR of AODV and EQARP are similar. But the delay of EQARP is better compared to AODV.

(iii) For high density with low speed the performance of EQARP is better compared to AODV in terms of PDR and delay.

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(iv) For high density with high speed the performance of EQARP is better compared to AODV in terms of PDR and End-to-End delay.

The Figure 1 shows the PDR for the combined effect of Node density and speed.

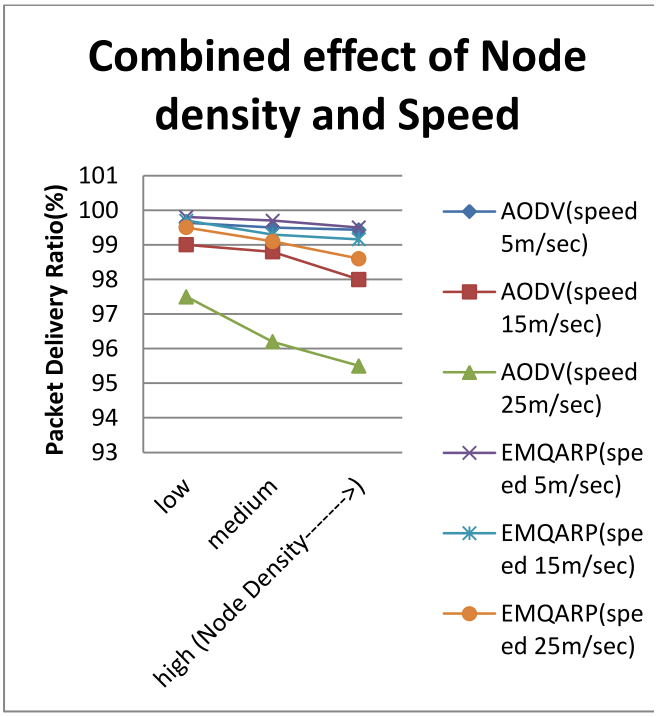

Figure 1. PDR for the combined effect of Node density and Speed

The Figure 2 shows the delay for the combined effect of Node density and speed.

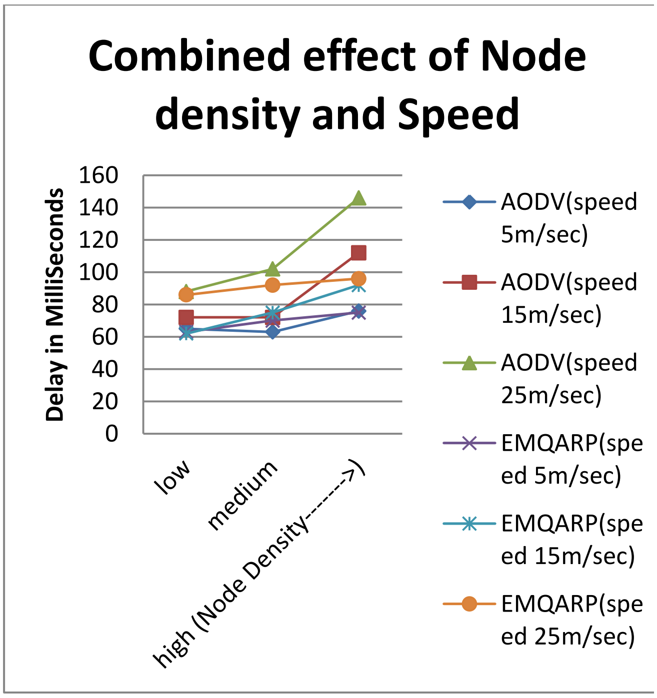

Figure 2. Delay for the combined effect of Node density and Speed

5.2 Combined effect of Node density and Pause Time

(i) For the low and average densities with low and average pause times the performance in terms of PDR and End-to-End delay, the protocols AODV and EMQARP performs same.

(ii) For low density and average densities with high pause time still the AODV gives high PDR, but the delay of AODV is average.

(iii) For average density with any pause time, the performance in terms of PDR and delay of AODV degrades compared to EMQARP.

5.3 Result Analysis Table

The analysis of AODV and EMQARP results has been shown in the table. We define a standard for simulation results. We consider 25 nodes and low density, 80 nodes as average density and 150 nodes as high density. We consider 5 m/sec as low speed, 15m/sec as average speed and 25 m/sec as high speed. We also consider 10sec as low pause time, 40sec as medium pause time and 80sec as high pause time. The Table 2, 3 and 4 shows the overall result analysis for the combined effect of 3 network parameters for Low Node density, Medium density and High density respectively in terms of various ranges of Speed and Pause Time.

Table 2. Result Analysis Table for a Low density MANET

Node Density	PDR (%)		End to End Delay(milliseconds)	
Low Density	**AODV**	**EMQARP**	**AODV**	**EMQARP**
Low Speed				
Low Mobility	99.4	99.8	65	70
Average Mobility	99.5	99.7	66	64
High Mobility	99.2	99.5	89	72
Average speed				
Low Mobility	99.5	99.7	63	63
Average Mobility	99.4	99.6	76	75
High Mobility	99.3	99.5	84	66
High speed				
Low Mobility	99.5	99.6	76	75
Average Mobility	99.2	99.6	92	83
High Mobility	99.1	99.6	100	86

Table 3. Result Analysis Table for an Average density MANET

Node Density	**PDR (%)**		**End to End Delay(milliseconds)**	
Average Density	**AODV**	**EMQARP**	**AODV**	**EMQARP**
Low Speed				
Low Mobility	99.4	99.7	65	73
Average Mobility	99.2	99.6	81	75
High Mobility	99.1	99.5	108	100
Average Speed				
Low Mobility	99.5	99.8	72	62
Average Mobility	98.9	99.6	92	82
High Mobility	98.7	99.4	118	106
High Speed				
Low Mobility	99.4	99.5	113	92
Average Mobility	99.2	99.8	121	96
High Mobility	99	99.5	133	97

Table 4. Result Analysis Table for a High density MANET

Node Density	PDR (%)		End to End Delay(milliseconds)	
High Density	**AODV**	**EMQARP**	**AODV**	**EMQARP**
Low Mobility	97.5	99.7	93	86
Average Mobility	96.2	99.5	138	110
High Mobility	97	99.6	150	79
Average Speed				
Low Mobility	99.3	99.5	106	96
Average Mobility	99.4	99.7	123	120
High Mobility	99.7	99.4	167	121
High Speed				
Low Mobility	96.2	99.4	146	96
Average Mobility	98	99.5	102	95
High Mobility	99	99.5	144	93

6. CONCLUSIONS AND FUTUREWORK

The performance of the two MANET Routing Protocols by combining the network parameters node density, speed and pause time is investigated in this work using NS-2.34. The performances of these two routing protocols show some differences in low, medium and high node densities. From the experimental analysis it is concluded that the AODV protocol can be used with MANET having low density with low mobility and high density with low mobility. The QoS metrics PDR and delay are almost same for both AODV and EMQARP for this situation. For the MANET with medium and large density with high mobility, the performance of AODV in terms of PDR and delay degrades. But the performance of EMQARP is improved for the MANET with high density, high mobility and high speed situations. In future the QoS can be further improved by calculating the energy dynamically.

7. REFERENCES

[1] Falko Dressler, "Self-Organization in Ad Hoc Networks: Overview and Classification", Autonomic Networking Group, Dept. of Computer Science 7,University of Erlangen, Martensstr 3, 91058 Erlangen, Germany, 2006.

[2] A text book titled "Adhoc Wireless Networks Architecture and Protocols", by C Siva Ram Murthy and B S Manoj, Pearson Education, 2005.

[3] S. Chakrabarti and A. Mishra, "Quality of Service Challenges for Wireless Mobile Ad Hoc Networks," International Journal of Wireless Communication .and Mobile Computing., vol. 4, pp. 129–53, Mar 2004.

[4] Perkins, C.; Belding-Royer, E., Das S, Ad hoc On-Demand Distance Vector (AODV) Routing. IETF. RFC 3561. https://tools.ietf.org/html/rfc3561. July 2003

[5] H.D.Trung, W.Benjapolakul, P.M.Duc, "Performance evaluation and comparison of different ad hoc routing protocols", Department of Electrical Engineering, Chulalongkorn University, Bangkok, hailand, May 2007.

[6] Shahram Jamali, Bita Safarzadeh, Hamed Alimohammadi, "A stable QoS aware reliable on-demand distance vector routing protocols for mobile Ad Hoc networks", Scientific Research and Essays Volume 6, Academic Journals , July 2011.

[7] S. Chakrabarti and A. Mishra, "Quality of Service Challenges for Wireless Mobile Ad Hoc Networks,"

International Journal of Wireless Communication and Mobile Computing, Volume 4, pp. 129–53, March 2004.

[8] J. Stine and G. de Veciana, “A Paradigm for Quality of Service in Wireless Ad Hoc Networks using Synchronous Signaling and Node States,” IEEE JSAC, vol. 22, Sept. 2004, pp. 1301–21.

[9] Taejoon Park, *Student Member, IEEE,* and Kang G. Shin, *Fellow, IEEE*, “Optimal Tradeoffs for Location-Based Routing in Large-Scale Ad Hoc Networks”, IEEE TRANSACTIONS ON NETWORKING, VOL. 13, NO. 2, 2005, APRIL.

[10] Ronald Beaubrun and BadjiMolo, “Using DSR for Routing multimedia traffic in MANETs”, January 2010.

[11] Chandra Mouli Venkata Srinivas Akana, Sandeep Kumar, Dr. C Divakar, “QoS for Real time transmission on MANETs”, International Journal of Advanced Networking and Applications volume: 02, Issue: 03, Pages: 679-685, 2010.