International Journal of Computer Networks and Applications (IJCNA)
DOI: 10.22247/ijcna/2017/48967 Volume 4, Issue 2, March – April (2017)

RESEARCH ARTICLE

Improvement over AODV Considering QoS Support in Mobile Ad-hoc Networks

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Published online: 21 March 2017

Abstract – MANETs are very advantageous and fruitful when there is no infrastructure or has been destroyed due to some reasons like earthquake, floods and so on. Data communication in MANETs are very challenging issue due to threats like limited battery power, limited bandwidth, mobility, routing and QoS and so on. Due to these challenges and scarcity of resources in MANETs, it's very difficult to achieve high quality of service. QAODV, AODV, OLSR, DSDV and ZRP and so on, are some of very popular routing protocols for MANETs. Minimum no. of hops is the route selection criteria used by most of the routing protocols. This makes it necessary to consider QoS parameters to the routing protocols. Above mentioned protocols are not pure QoS routing protocol and insufficient to achieve high Qos because they do not consider parameters which will affect the QoS, Instead they only consider hop count as a route selection criteria. We present a new QoS based routing algorithm AODV-QSRP (AODV based QoS Routing Protocol) for Mobile Adhoc Netwok. AODV-QSRP is based on existing AODV and is reactive (On-Demand) in nature. AODV-QSRP attempts to provide high QoS for the real time applications while considering the various important QoS parameters like Bandwidth, Delay, Link Quality and Battery power for route selection. We have simulated and compared the performance of AODV-QSRP with QAODV, AODV, OLSR, DSDV and ZRP. To implement and simulating the result Network Simulator-2 (NS-2.32) on Fedora platform is used, which is an event driven and real-time simulator.

Index Terms – MANET, QoS, AODV, OLSR, DSDV, ZRP.

1. INTRODUCTION

As in the advancement of technology leads into several new features for communication, MANETS is one of them .MANETs operates on IEEE 802.11(b) specification. IEEE 802.11 standard suggests that any device equipped with wireless links can communicate directly in absence of any infrastructure. MANETs are independent and autonomous system of mobile devices i.e. laptops, PDA, Smart phones and so on. These devices are equipped with wireless links and can connect directly to each other to form a network. Figure 1 shows the example network for MANETs. These nodes are self-configurable and rapidly deployable, so we can form a network to communicate whenever there is no infrastructure or infrastructure has been fully or partially destroyed. Earth quack, military operations, floods, video conferencing are some area where we can take the advantages of MANETs. There is no central coordinator or access point; each device acts as a router and host. Nodes in MANETs generally operate with the limited battery backups. Though MANETS are very advantageous but have some critical issues to be deal with carefully. Nodes are mobile so one can't predict the topology exactly at any time and routing is at its best when the exact topological information's are available. So dynamic topology makes routing a very typical task in MANETs. Scarcity of resources is again a big issue. As the nodes are very light weight devices with limited resources like battery power, storage, processing power makes MANETS to provide high QoS to real-timeor time dependent applications is a challenging task. QoS is biggest challenging issue in MANETs, to be deal with carefully. Routing is a method than can be used to provide high QoS to a specific application [1, 2, 3].

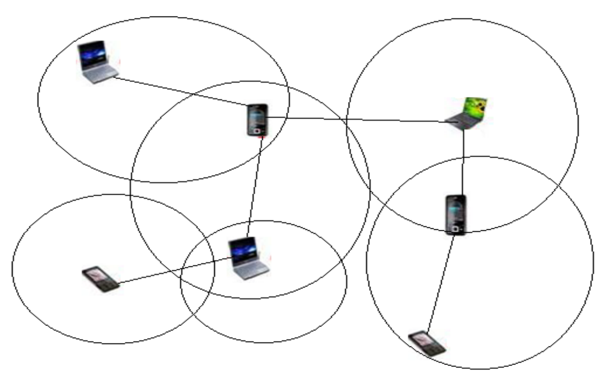

Figure 1 Mobile Ad Hoc Network

2. QOS CHALLENGES IN MANETS

MANETs was originally proposed for military operations. However evolutions of multimedia technology like IPTV,

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VOIP and so on. QoS in MANETs is very important and curtail are since last few years. Because of high QoS is needed for the real time applications. As according to these applications required QoS parameters, quality of service for an application can be defined as a set of measurable QoS constraints like delay, bandwidth, packet loss, and jitter, required bandwidth and so on which an underlying network needs to provide as and when needed while forwarding packets from a source to its destination.

Quality of Service (QoS) is network responsibility to provide better and high quality services to some selected traffic. Where quality covers loss of data, delay or latency, delay variance, efficient use of network resources and service means application communicating with each other's (i.e. Audio, video, E-mail).Central objectives of quality of service are provide priority to these application along with taking care of various QoS parameters like dedicated bandwidth to a particular application, reliability, less delay and delay variance.

A QoS model provides a model for routing in which some special treatment can be provided to different applications in MANETs. Signaling, QoS routing, and MAC layer must be considered while designing a new routing protocol to achieve high QoS [4]. Figure 2 shows the models available for IP based networks.

In wired networks for multimedia traffic, QoS parameters are easy to handle and improved because of the availability of resources like processing power of routers and bandwidth. But in case of MANETs QoS needs some new constraints because of fast mobility, dynamic topology and limited resources like bandwidth, processing power of a node than wire-based network. So it's very tough ask to deal with QoS in MANETs. Error prone natures of the wireless links (attenuation, multipath fading, noise and so on) are another important issue. Control overhead limits the bandwidth as the bandwidths available in MANETs are very less than the wired one. Security is another challenging issue due to broadcasting behaviour of MANETs. Limited battery power is another issue because any node can sink at any time.

3. AVAILABLE QoS MODELS

In MANETs Signaling, routing, and MAC layer must be incorporated together to provide high QoS in MANETs [4].

There are three kinds of services models for wired networks. Two QoS models are the IntServ or guaranteed services [4] and the DiffServ models and another one is best effort delivery services [5]. Both of the QoS models need to predict the availability of resources on a link such as available bandwidth on the link, packet loss ratio, delay/jitter, and topological configuration. Intserv is a flow-based QoS model designed for IP protocol. Where a flow means virtual circuit from the sender to the destination to inform all routers to reserve the resource requirement for communication. The strategy of IntServ is that each router equipped with IntServ, and every application that requires QoS can reserve resources. Every Intserv Routers maintain information of reserved resources.RSVP is used to reserve the resources [6]. DiffServ is a method to classifying the network data and providing QoS to IP based networks. It is inspired by scalable and best effort service without RSVP protocol. But Diffserv does not give the guaranteed services for per-hop on the network. This problem makes it difficult to use for MANETs. DiffServ uses the 6-bit as Differentiated service to classify packets.

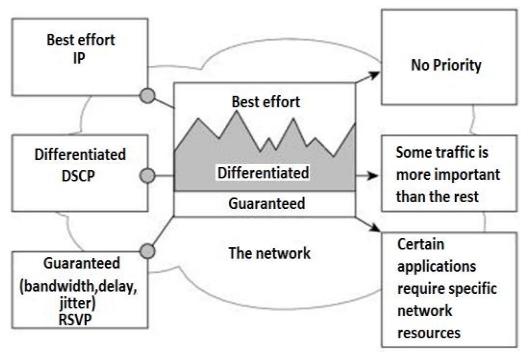

Figure 2 QoS Models

To ensure the QoS is very tough and challenging in mobile ad hoc network as compared to wired networks, due to frequently changing and unpredictable topology due to mobility and power depletion. To reserve resources like bandwidth and give guarantee the specified delay/jitter for time-dependent application is a challenging task in MANETs. All of the existing QoS models require information such as availability of bandwidth, packet loss on the link, delay/jitter, and information about topology. For example, in a scheme involving resource reservation, if the sender moves to other location, a new route to the destination must be established within a fraction of a second if real time application is running. IP based protocols like RSVP is not suitable for wireless environment because of the nature and challenges in MANETs. Therefore, providing QoS in MANETs is more challenging as compared to wireless networks .To many researches has already been done on QoS routing, but results are not very fruitful for MANETs and still quality of service for MANETs is still a big problem for researcher. [7].

4. QoS FRAMEWORK

QoS framework defines a model in which some special services can be provided in MANETs. This framework includes QoS resources reservation, QoS routing and QoS MAC. As the diagram shows that while providing QoS we must think about this framework because the data link layer and network layer directly communicates to each other and Routing takes place on top of these layers. While designing a routing protocol special attention must be given to this QoS architecture. It controls and acts as behavior of routing. Routing is to find a

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connection based on some predefined parameters and to manage at MAC layer while scheduling needs to manage the resource availability for specific transmission. Figure 3 shows the framework for QOS at MAC layer.

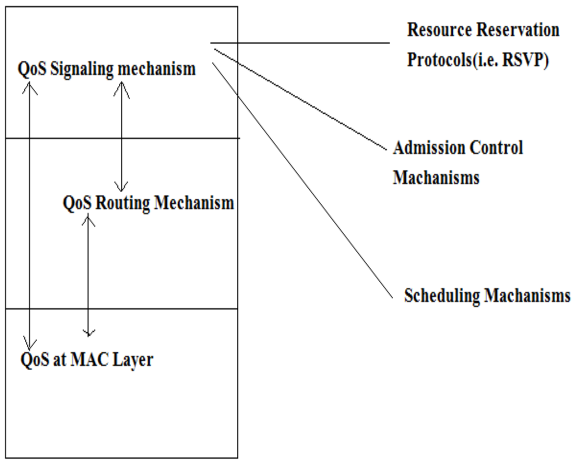

Figure 3 Quality of Service Framework

5. QUALITY OF SERVICE (QOS) PARAMETERS

Overall running applications on the networks can be divided in to two categories: Time dependent and ordinary like Non- time dependent applications. Real-time applications are time dependent applications and require strong and high QoS. On the other hand applications like traditional mail, file transfer are the non-real time applications and do not require high QoS values. QoS means the capacity of a network to provide specific treatment to some of the special applications i.e. time dependent or real-time applications. Goal of QoS is to provide priority to the applications including dedicated bandwidth, reliability controlled jitter and latency. QoS for a network is the value of various parameters that decides the quality of a service or application running on the network. When we talk about QoS parameters, End to End delay, jitter, Bandwidth and throughput are the primary concern,. In most research these parameters are the primary concern for the researcher to improve the quality of service. As the MANETS consists of mobile nodes they have limited resources like processing power, transmission capabilities and battery are the most critical issue that must be handled carefully, while designing a new routing protocol.

Before designing or modifying a routing protocol we must consider some network performance evaluation parameters which will affect overall performance of the network. Following are the some of the most important one.

5.1. Latency

Time taken by a packet to travel from its source to destination is the End-to-End delay or in simple terms delay. For real time applications delay is very critical factor because as the delay increase, the quality of communication decreases.

End-to End Delay=Packet Arrival time- Packet Start time (1)

5.2. Packet delay variance (Jitter)

Packet delay variance is the average variation in the arrival times between consecutive packets. It is due of congestion in the network or different packet arrives from different paths.

$$\text{End-to End delay} = \sum_{i=1}^{n} \frac{\text{Delay}_i - \text{Delay}_{i-1}}{n-1} \quad (2)$$

5.3. Throughput

Throughput is the avg. amount of data in bits/sec. is transferred in a specific amount of time from source to the destination.

Throughput=Total packets sent/Data Duration (3)

5.4. Packet Delivery Ratio

PDR is the total packets successfully delivered to the destination against the total sent packets.

PDR= (Total packets Received / Total Packets sent)*100 (4)

5.5. Packet Loss Ratio

It tells the ratio of packet lost against the number of packet sent. Packet loss ratio is reciprocal to PDR and throughput.

PLR= (Total packet send- Total packet received)/send *100 (5)

5.6. Control Overhead:

These packets are used to manage and maintain topological information in the network. But some of the protocol uses these messages and create extra overhead in the network. Control overhead limits the available bandwidth for communication and leads the network into congestion. To efficient use of available bandwidth the control overhead must be kept minimized.

5.7. Bandwidth:

Total amount of data that can be sent on the network at a time. Amount of data transfer can’t be equal to the available bandwidth because of control traffic. As the control traffic increase, it will limit the available bandwidth for communication.

5.8. Average Energy Consumed and Battery power:

Due to several operations like sending and receiving data by nodes will consume the battery of a mobile node and this energy is limited for mobile nodes.

Avg_Energy_Consumption=totalenergy/nodes (6)

6. QoS AND RELATED WORK IN MANETS

To provide high QoS guarantee is challenging in MANETs as compared to weird networks, due to dynamic topology high

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mobility and limited battery power. To reserve resources and guarantee the specified latency, jitter for time dependent application is a very tough and challenging task in MANETs. Routing is an important way to achieve QoS guaranteeing in network. QoS routing must find a path intended from source towards a destination that be able to satisfy the QoS requirements of an application [8] [9]. In wired networks IntServ and DiffServ are two models used for QoS. DiffServ is a connection based service and all the traffic is classified into several classes according to the priority. IntServ is findividual link flow basis approach means, it is not well suited for networks like MANETs because of limited resources in MANETs. Any how these approaches are not as beneficial because of the hurdles in MANETs [10].

When we talk about QoS routing, the designed routing protocols have to ensure that is it able to meet the required QoS. Unlike wired networks; it is difficult to ensure QoS provisioning in MANETs [11]. Almost all routing protocols for MANETs like AODV, ZRP, OLSR, DSR are designed without considering QoS . The number of hopes is only criteria to select a route. It is clear that such routing protocols are insufficient for real-time and multimedia applications. So they are not QoS routing protocol. AODV is one of the most popular used protocol due to the advantages of it i.e. small computation, self-repair, reactive routing protocol. However AODV focuses on Number of hops to select a route and does not deal with other QoS parameters. So it isn't a QoS routing protocol [12]. Perkins et al. changed the original QoS AODV by adding more field extensions and new formats. De Renesse et al. proposed a QoS-AODV enhancement while modifying it by adding minimum available bandwidth into AODV [11, 12]. Nur Idawati et al. added minimum available bandwidth, maximum delay as QoS parameter. Performance of above versions of AODV is better but they increase routing and calculation overhead [13].

Chen and Heinzelman proposed a QoS protocol that was based on admission control scheme and a feedback scheme to meet the QoS. [14]

Zheng Sihai et al. proposed QMMRP protocol based on. Entropy of nodes is treated as an important parameter to find a stable path [15].

C.Wu et al.proposed Q-AOMDV, In this work they have used bandwidth, no of hops and delay in mobile ad hoc networks (MANET).

7. ROUTING IN MANETS

On the basis of their operations and routing technique a number of routing protocols in MANETs like AODV, DSDV, OLSR, TORA, ZRP so on, are suggested. There are three types of routing protocol: Proactive, Reactive and Hybrid.

7.1. Proactive or Table Driven

Proactive routing protocols always keep up to date the overall topological information and maintain all routing information in routing table. Routing tables are periodically updated when the network topology changes so routes are available as and when source node need. This approach is similar to the OSPF in wired network. DSDV is one of the most popular proactive routing protocol, it removes the problem of count-to-infinity by using sequence number.

7.2. Reactive or on-Demand

Reactive routing protocol also known as On-demand because route discovery is done as and when the route is needed. These protocols try to find a route when a node wants to send data by flooding Route Request packets. High latency time in route finding is main issue. ADOV, DSR are the popular reactive routing protocols. These protocols reduce the control overhead and cost into delay taken to find the route to the destination. These protocols are most suitable in MANETs because of low overhead cost while finding the route.

7.3. Hybrid Routing Protocol

Hybrid routing protocols is the approach taken by combining both the reactive and proactive routing approach. It takes benefit of both proactive and on-demand routing protocols. In this approach corresponding protocol divides the network into several zones. The routing in first attempt is done using proactive and request toward and from outside the zone through reactive routing. ZRP is one of popular protocol in this category.

7.4. DSDV

It is a proactive routing protocol. It overcomes with the looping problem in case of broken links. Bellman-Ford routing protocol works successfully works in wired network, but in MANETs due to topological changes it creates the problem of count to infinity and can't work efficiently. To overcome this problem DSDV adapts a new attribute, sequence number in the routing table. Using this attribute in routing table DSDV can differentiate between stale route and new route, and overcome the problem of count to infinity. Each node using DSDV maintains routing table, which contains all available destination, metric and next hope to reach them along with the sequence number generated by destination. Each node advertises the routing table periodically and updates its routing table with newly received information.

7.5. AODV

Perkins et al. introduced AODV routing protocol, which shows optimization of route by flooding RREQ packets. AODV is a reactive protocol. AODV provides unicast and multicast both kind of communication. AODV eliminates the periodic broadcast of Hello packets. AODV implements only a single route. Route discovery and maintenance are the two operations

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performed by AODV Using RREQ, RREP, RERR and Hello Packets. Route discovery is done by broadcasting RREQ packets to all destinations. When a node receives the RREQ packet then it checks weather it is destination, if it is so then it generates Route reply to the destination. If it knows the route to destination than it uses RREP packet to inform the destination about the route. If neither it's a destination nor it's having route towards route it simply broadcast the route request message further. In case of any error it uses RERR message to inform the source about the Error.

7.6. QAODV

QAODV is variation of AODV protocol. In QAODV the message field add extra information like data rate, delay etc. to improve the performance of AODV. To select route this protocol considers only those routes which have minimum hop count and total path delay less than or equal to the predefined in the route request. For calculating path delay, it estimates current delay at each node. The algorithm two best route during route discovery and informs all the intermediate nodes about that.

7.7. ZRP

Zone based routing protocol is a hybrid routing protocol. It takes the benefit of both the proactive and reactive routing protocols. The main idea behind the ZRP is to get rid of routing overhead and long route request delay of reactive and proactive routing protocols. Whole network is divided into small routing zones on the basis of no of hops from. Inside a particular zone it works as proactive and outside the zone it works as reactive. Within the zone routes are available as and when needed same as proactive routing concept. If the destination is not in its zone means than reactive approach same as AODV is used to find the route. Routing zone for each node is separate from each other. Routing zone is defined in terms of hopes. A zone for a node is the number of nodes that lies within the N hops away from this node i.e. N=2, means the nodes coming within the radius of 2 are in the zone of this node. Number of nodes in a zone depends on the transmission power of nodes [15].

8. THE PROPOSED QOS BASED ROUTING METHODOLOGY AND ALGORITHM

Applications can specify required QoS constraints, and the routing protocol will search for a route that satisfies them during its route discovery process. In order to provide QoS, We can revise the conventional AODV (reactive) routing protocol. Adding the QoS information to each node in its routing table i.e. available bandwidth, delay, link quality and remaining battery power. Extensions can be added to the RREQ message during the route discovery process. .When a path discovery process is initiated, calculating the corresponding QoS values and finally on the basis of QoS value (minimum) we can find the path based on the best QoS value.

8.1. Route Optimization

Finding a route in MANETs is an optimization problem, while taking several Qos parameters together. Each and every parameter must be optimized means either maximize or minimize. For example available bandwidth may vary on each and every link throughout the routing path but we have to consider the minimum one. If there are too many paths and need to select one than on a path minimum available bandwidth must be considered and so on for the other paths and finally chose maximum available bandwidth from different paths. Similarly the same strategy is used to select a path on the basis of delay, battery power and link quality.

Let G (V, E) a graph, where V is a set of vertex (Mobile nodes) and E is set of edges (all communication link) $E = \{(i, j)/ i, j \in V, i \neq j\}$. We consider Delay, Bandwidth, Link quality and remaining battery power as our main criteria for route selection. As we have discussed in the beginning of this paper to achieve high QoS these parameters must be considered. Where bandwidth, link quality and battery power must be maximum from available minimum bandwidth throughout the path and delay must be minimum. For route selection we can take bandwidth, link quality and battery power as a single objective by taking all together and assigning them a weight say P_i, as they must be maximized. Delay is taken separately as it must be minimum. So we define out new QoS metric as follows.

QoS routing metric= $MaxMin_{(i,j)\in E}(P_1 B_{ij} + P_2 Lq_{ij} + P_3\ BP_{ij})$ (7)

$Min_{(i,j)\in E}\ D_{ij} Cij$ (8)

Where- P is weight, Cij Decision variable (C_{ij}=1, if (i,j) is on the routing path) , Lq link quality of the link (i,j), Bij

Bandwidth available on (i,j), Dij End to End delay on link (i,j), BPij is available battery power on the link (i,j).

$Bp>=B_{min}$ (greater or equal to 0.5e6)
$Dp<=D_s$ (less than or equal to 0.3)
$Lqp>=L_{qs}$ (greater or equal to 1e-6)
$BPP>=BP_s$ (minimum 0.2 Joules)

B_{min}, D_s, L_{qs} and BP_s are the constraints defined over the objective function. These constraints must be satisfied during the route selection procedure to optimize the route.

9. FLOW CHART FOR PROPOSED ALGORITHM AND PSEUDO CODE

Flow Chart 1 and Flow Chart 2 are given below tries to show working of our routing algorithm. Flow Chart 1 show the generation of RREQ packet and the second one shows processing of RREQ message at intermediate node or by destination, depending on the condition according to the algorithm. In Table 1 and Table 2 we have shown the pseudo code for our proposed algorithm.

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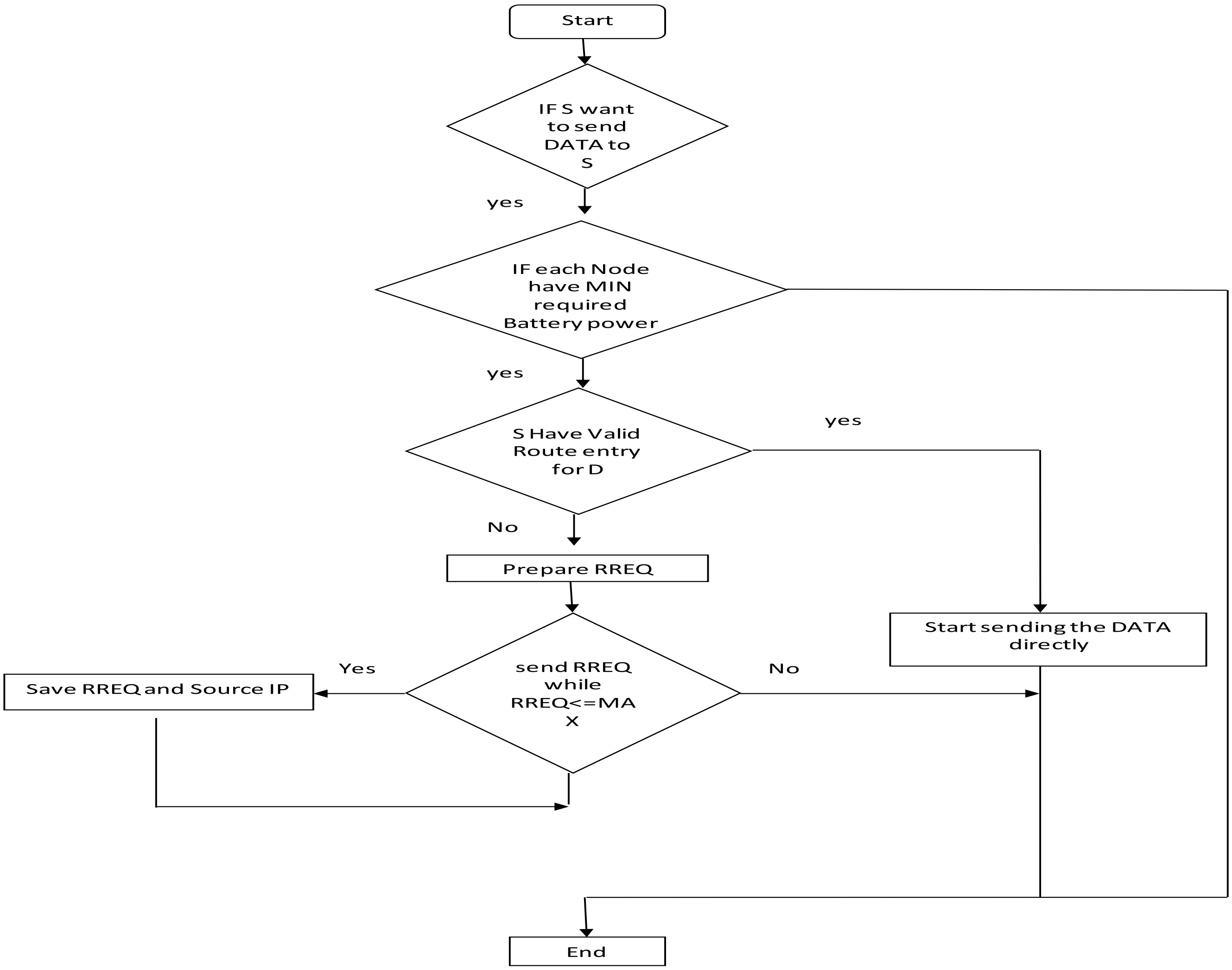

Flow Chart 1 Generation of RREQ Packet

Table 1 Generating Route Requests and Processing at Source node [29].

Precondition: Every node on the path-broadcast the RREQ packet if minimum required battery power is available.
If (Node S wants to send data to D)
{
If Have a valid destination entry in route table)
{
Start sending the data;
}
Else If (No valid entry in routing table of node S for destination D)
{
1. Source node specifies QoS constraints in RREQ and prepares RREQ packet.
i. e. specify maximum delay, bandwidth, link quality.
2. Save (RREQ_ID and IP address source); // To Avoid rebroadcast.
3. Generate and send RREQ While (RREQ Retries < = MAX)
}
}

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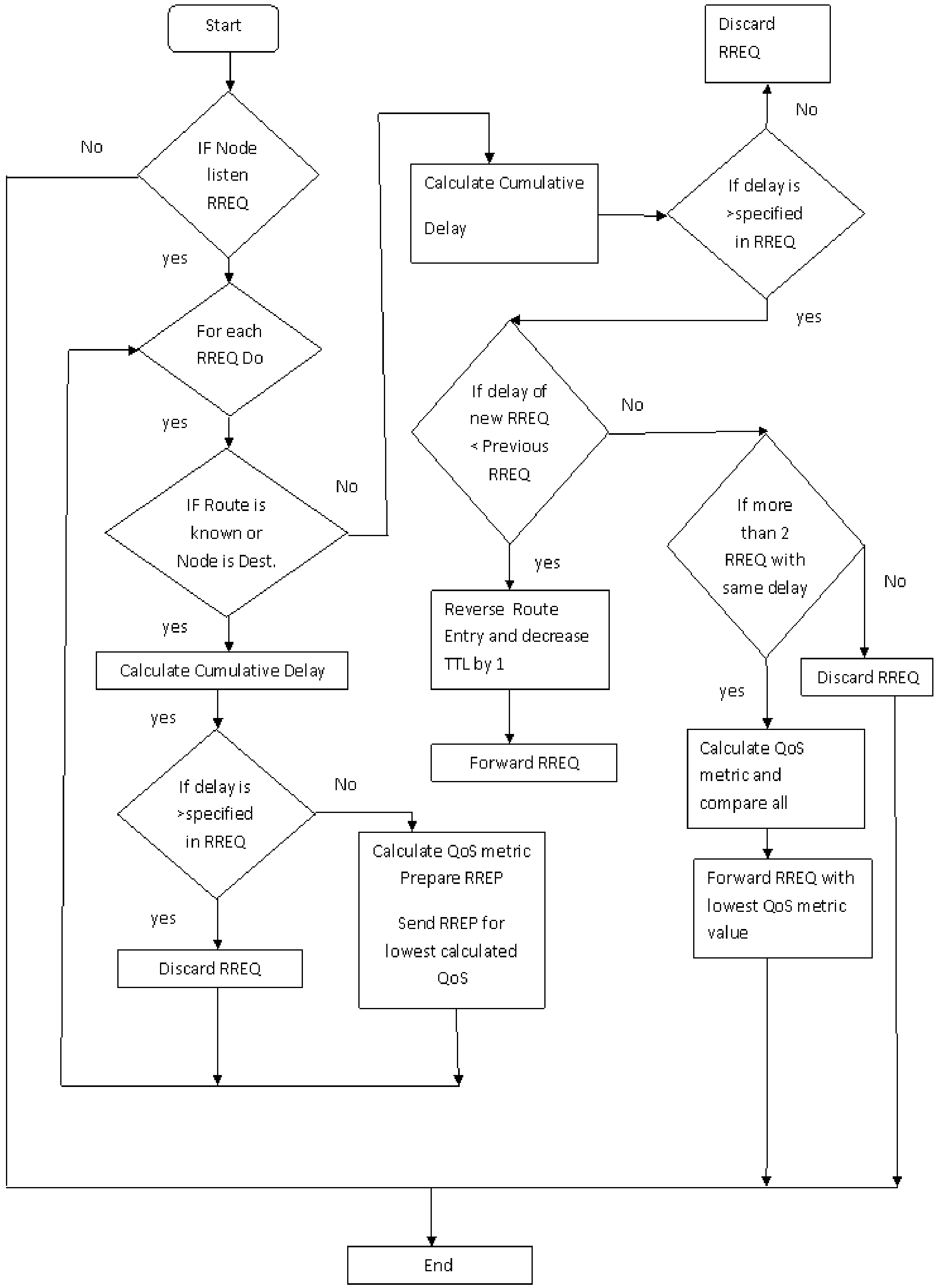

Flow Chart 2 Processing of RREQ at Intermediate Node

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Table 2 Processing and Forwarding RREQ packet at intermediate Node and Generation of route Reply [29].

Precondition: Forward RREQ if minimum required battery power is available.
If (Node listen a RREQ)
{
For each Received RREQ:
if (Node is Destination for this RREQ or Route is known)
{
Calculate the Cumulative delay.
if (delay is greater than specified in RREQ)
simply discard RREQ;
else{
Calculate the QOS Metric;
QoS metric =$MaxMin_{(i,j)\in E}\ (P_1B_{ij}+P_2Lq_{ij}+P_3BP_{ij})$
Set QoS metric in RREP packet and prepare RREP packet;
Send RREP for lowest QoS Metric;
}
}
}
Else{
Calculate the Cumulative delay .if Cumulative delay is greater than specified in RREQ simply discard RREQ;
If (Fresh RREQ OR RREQ with lowest delay value as compare to previous one)
{
Entry for Reverse Route // (Route from node to originator node)

1. Update the routing table entries for originator IP address;
2. Increase the hop count by one in RREQ packet;
3. Each intermediate node after receiving RREQ packet will calculate the cumulative delay and update the RREQ packet.
4. Each intermediate node will check available bandwidth on each link, if it is less as compare with RREQ than update Min B (bandwidth) in RREQ else not.
5. Each intermediate node will check available Lq, if it is less as compared with RREQ than update Min LQ in RREQ.
6. Decrease the TTL field by one;

Forward RREQ;
}
Else if (More than one RREQ with delay is same than select)
{
Calculate & compare QoS metric: $MaxMin_{(i,j)\in E}(P_1B_{ij}+P_2Lq_{ij}+P_3BP_{ij})$
Forward RREQ with lowest QoS metric;
}
Else
{
Discard;
}
}
}

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10. SIMULATION EVALUATION AND RESULT DISCUSSION

10.1. Effect of Mobility

Mobility is one of the most critical issues in MANETs that must be deal carefully. As the mobility increase the probability of route break also increases. It also increases control overhead. Due to route break the packets may get loss and also increase the delay. Table 3 shows the simulation parameters for different mobility. In our scenario we have taken values 0,5,10 meters per second mobility. As we can observe by Figures 4,5,6,7 and 8, AODV-QSRP performs better as compare to other protocols and its PDR and throughput is approximately (near about) 100 percent. Though QAODV performs better than AODV, OLSR, DSDV and ZRP, but it does not reach up to 100 percent performance as PDR. Performance of QAODV is also poor compare to AODV-QSRP. As we have set our QoS requirements at application level, AODV-QSRP performs accordingly. Maximum Avg. delay for AODV-QSRP is under the required delay by application (0.3) that is 0.2 in for our protocol. Avg. delays of DSDV and OLSR protocols is less than AODV,LPPMM and ZRP because these are proactive protocols and have routes available at any time. Avg. Jitter for DSDV, OLSR and ZRP gets increase as the mobility increases. Avg. Jitter for AODV-QSRP (<0.2) is very less as compared to the base protocol that is AODV and other protocols. Though avg. Jitter for QAODV is less than other protocols greater to AODV-QSRP. The base protocol AODV consider minimum hop count as route selection criteria. It does not consider any other QOS parameter(s). Same as AODV, QODV adds one more QoS parameter that is Cumulative delay from source to destination. In comparison to both AODV and QAODV, AODV-QSRP consider almost all the critical QOS parameter like available battery power, link quality, delay and bandwidth to optimize route. And selects best route which is more robust and long lasting. That is the reason why AODV-QSRP performs better than any other protocol.

Table 3 Simulation Setup Parameters for Mobility

Simulation Parameters	Values
Tool	NS-2
Network Type	MANET(IEE802.11(b))
Simulation Area (in meters)	1000*1000
Simulation time (In sec.)	500s
Data duration (in sec.)	100
No. Of Nodes	60
Node placement strategy	Random distribution
Mobility Pattern	Random Waypoint
Mobility speed (meter/sec.)	0,5,10
Type of source	CBR
No. Of source	3
Packet size(Bytes)	1100
Interval between packets	0.1 sec.
Routing Protocols	QAODV, AODV, DSDV, OLSR, AODV-QSRP, ZRP

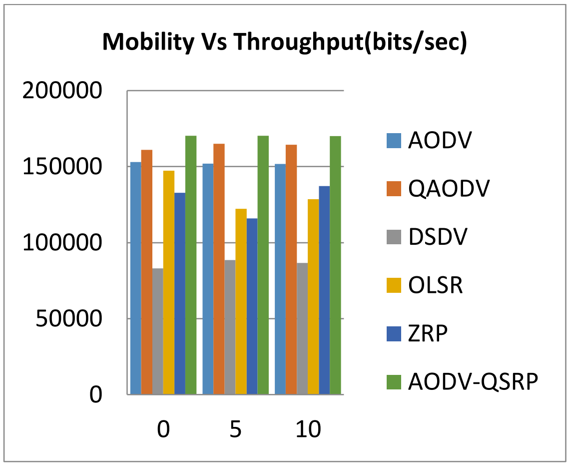

Figure 4 Mobility Vs Throughput (bits/sec)

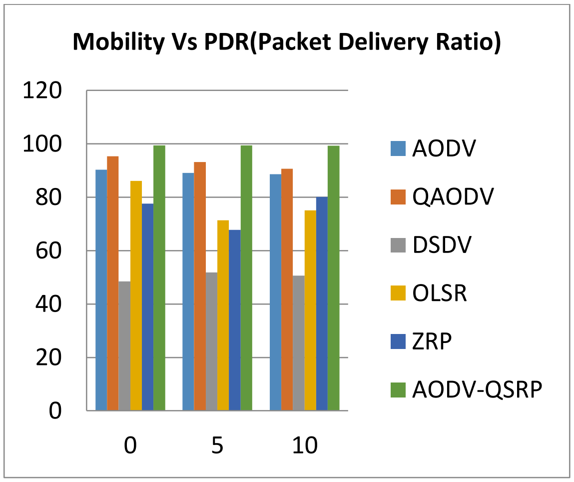

Figure 5 Mobility Vs PDR (Packet Delivery Ratio)

International Journal of Computer Networks and Applications (IJCNA)
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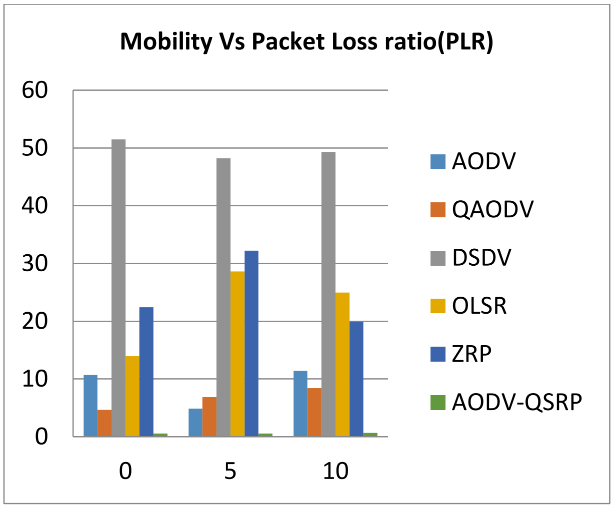

Figure 6 Mobility Vs Packet Loss ratio (PLR)

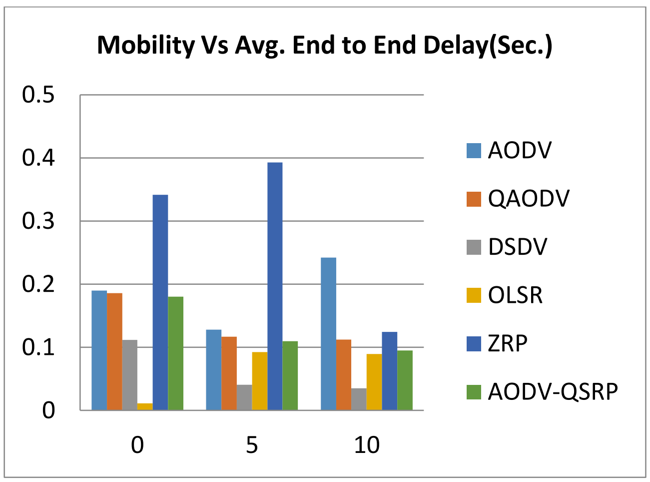

Figure 7 Mobility Vs Avg. End to End Delay **(**Sec.)

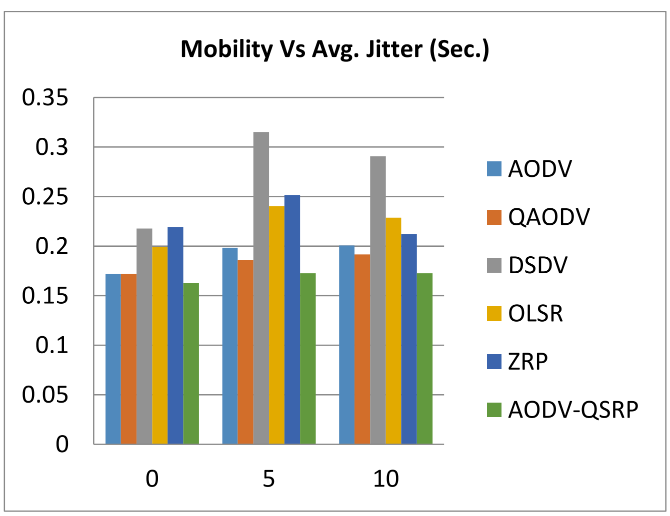

Figure 8 Mobility Vs Avg. Jitter (Sec.)

10.2. Effect of Pause Time

Pause time is the time for which node may be still means it is not moving. If we increase the pause time value the topology is also stable .In this case it decreases the probability of route break and thus the QoS parameter values for all the protocol must be 100%. Means delay & jitter must be very negligible, also PDR and throughput must be very high. But in our scenario of simulation the results are not accordingly .Table 4 shows the simulation parameter setup for different pause time. In our scenario we have taken values 0, 5, 10, 15, 20 seconds as the pause time value. As we can observe by Figures 9, 10, 11, 12, and 13 AODV-QSRP performs better than QAODV and other protocols and its PDR and throughput is approximately 100 percent. As the pause time increases the throughput also increases and the delay and jitter also decreases. Though QAODV performs better than AODV, OLSR, DSDV and ZRP, but it does not reach up to 100 percent performance as PDR. Performance of QAODV and AODV is also poor than AODV-QSRP as we can see by the charts .As we have set our QoS requirements at application level, AODV-QSRP performs accordingly. Maximum Avg. delay for AODV-QSRP is under the required delay by application (0.3) that is 0.2 in for our protocol. Avg. delays of DSDV and OLSR protocols is less than QAODV, AODV, AODV-QSRP and ZRP because these are proactive protocols and have routes available at any time. Avg. Jitter for DSDV, OLSR and ZRP gets increase as the mobility increases. Avg. Jitter for AODV-QSRP (<0.2) is very less as compared to the base protocol that is QAODV and AODV and other protocols. Though avg. Jitter for QAODV is less than other protocols but it is greater to AODV-QSRP. The base protocol AODV consider minimum hop count as route selection criteria. It does not consider any other QOS parameter(s). Same as AODV, QODV adds one more QoS parameter that is Cumulative delay from source to destination. In comparison to both AODV and QAODV, AODV-QSRP consider almost all the critical QOS parameter like available battery power, link quality, delay and bandwidth to optimize route. And selects best route which is more robust and long lasting. That is the reason why AODV-QSRP performs better than any other protocol.

Table 4 Simulation Setup Parameters for Pause Time

Simulation Parameters	Values
Tool	NS-2
Network Type	MANET(IEE802.11(b))
Simulation Area (in meters)	1000*1000
Simulation time (In sec.)	500s

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Data duration (in sec.)	100
No. Of Nodes	60
Node placement strategy	Random distribution
Mobility Pattern	Random Waypoint
Pause time	0,5,10,15,20
Type of source	CBR
No. Of source	3
Packet size(Bytes)	1100
Interval between packets	0.1 sec.
Routing Protocols	QAODV, AODV, DSDV, OLSR, AODV-QSRP, ZRP

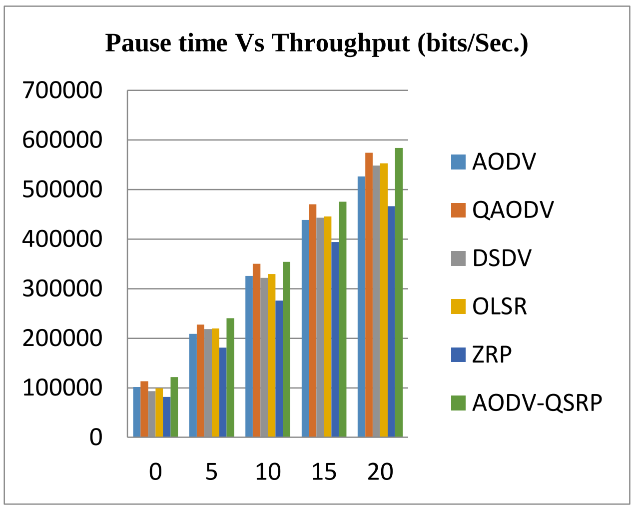

Figure 9 Pause time Vs Throughput (bits/Sec.)

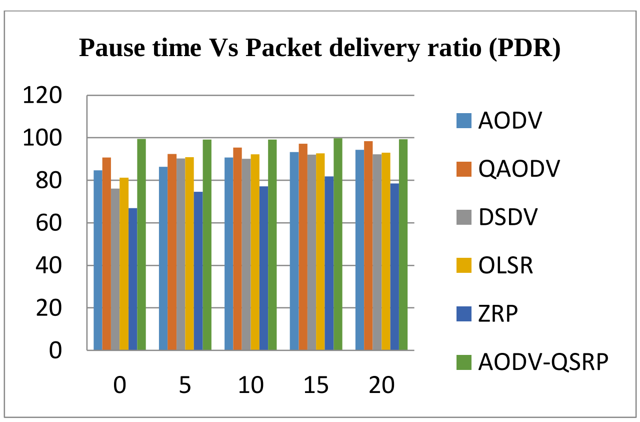

Figure 10 Pause time Vs Packet Delivery Ratio (PDR)

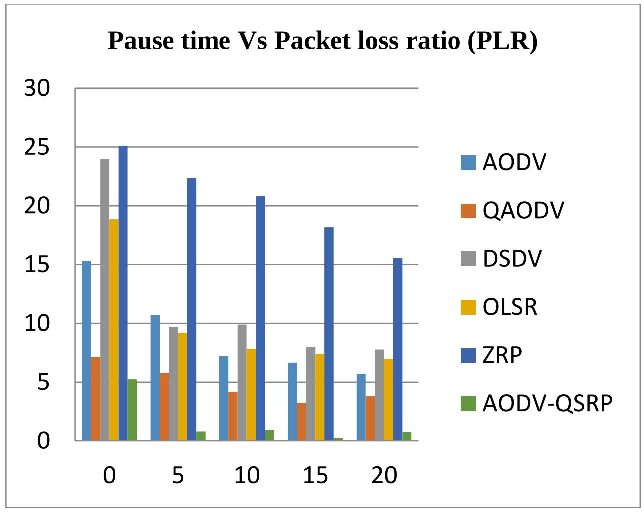

Figure 11 Pause time Vs Packet loss ratio (PLR)

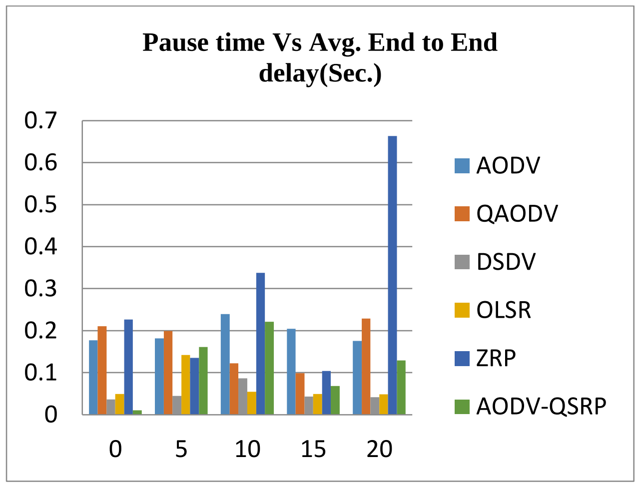

Figure 12 Pause time Vs Avg. End to End delay (Sec.)

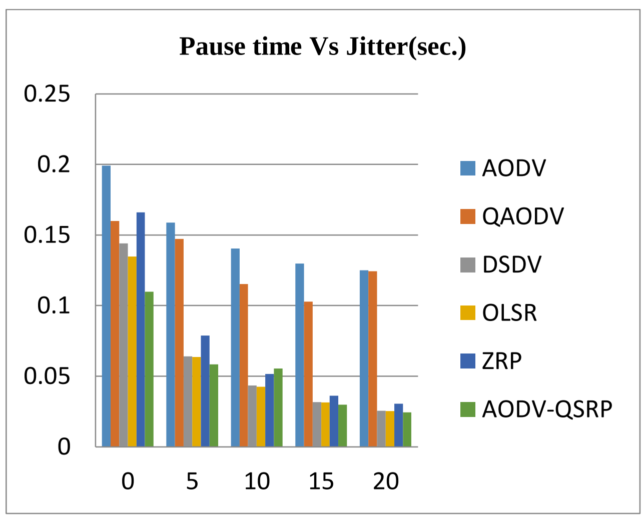

Figure 13 Pause time Vs Jitter (sec.)

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10.3. Effect of Packet Size

If we increase the packet size then the network will be more congested as we know the bandwidth is constraint and limited in MANETS. In this case it decreases the probability of packet drop and thus the QoS parameter values for all the protocol must be 100%. Means delay & jitter must be very negligible, also PDR and throughput must be very high. But in our scenario of simulation the results are not accordingly. Table 5 shows the parameter setup for the effect of packet size. In our scenario we have taken values 128, 256, 512, 1024, 2048 bytes as the packet size value. As we can observe by Figures 14, 15 16, 17, and 18 AODV-QSRP performs better than all other protocols and its PDR and throughput is approximately 100 percent. Avg. Jitter and delay for AODV-QSRP is negligible as compare to rest of the protocols, as we can see in the graphs. Also AODV-QSRP performs better than the base protocol QAODV. The base protocol AODV consider minimum hop count as route selection criteria. It does not consider any other QOS parameter(s). Same as AODV, QODV adds one more QoS parameter that is Cumulative delay from source to destination. In comparison to both AODV and QAODV, AODV-QSRP consider almost all the critical QOS parameter like available battery power, link quality, delay and bandwidth to optimize route. And selects best route which is more robust and long lasting. That is the reason why AODV-QSRP performs better than any other protocol.

Table 5 Simulation Setup Parameters for Packet Size

Simulation Parameters	Values
Tool	NS-2
Network Type	MANET(IEE802.11(b))
Simulation Area (in meters)	1000*1000
Simulation time (In sec.)	500s
Data duration (in sec.)	100
No. Of Nodes	60
Node placement strategy	Random distribution
Mobility Pattern	Random Waypoint
Packet Size	128,256,512,1024,2048
Type of source	CBR
No. Of source	3
Packet size(Bytes)	1100
Interval between packets	0.1 sec.
Routing Protocols	AODV, DSDV, OLSR, AODV-QSRP, ZRP

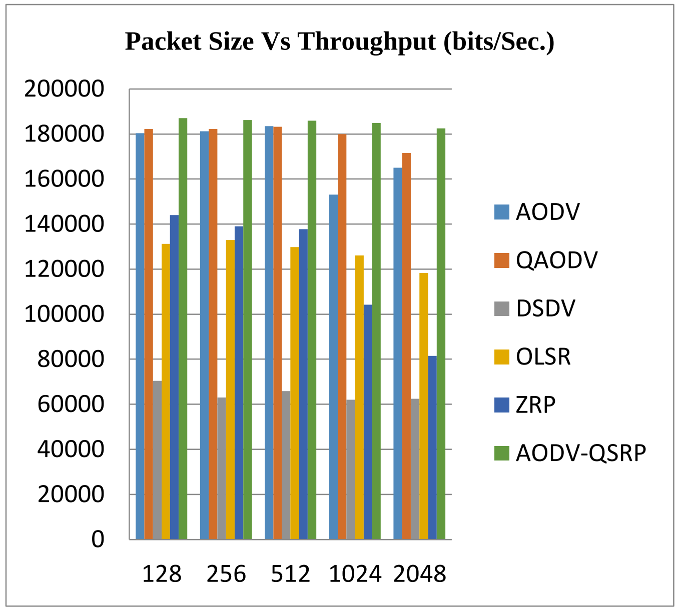

Figure 14 Packet Size Vs Throughput (bits/Sec.)

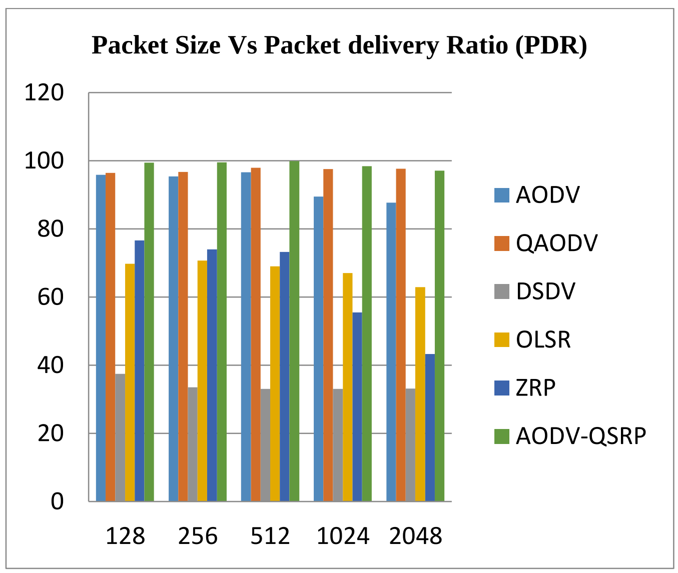

Figure 15 Packet Size Vs Packet delivery Ratio (PDR)

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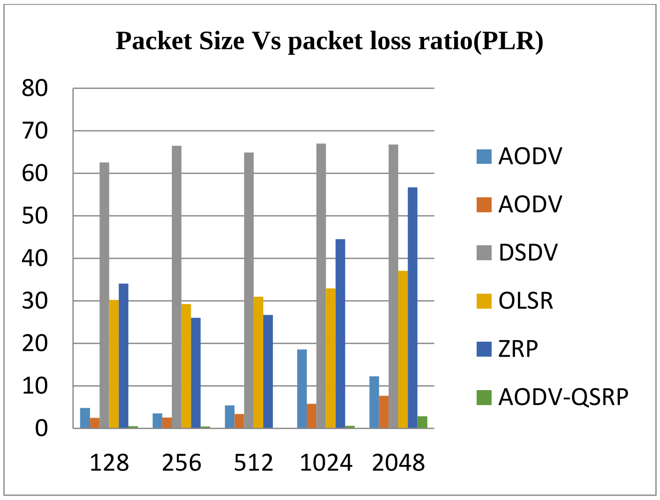

Figure 16 Packet Size Vs Packet Loss Ratio (PLR)

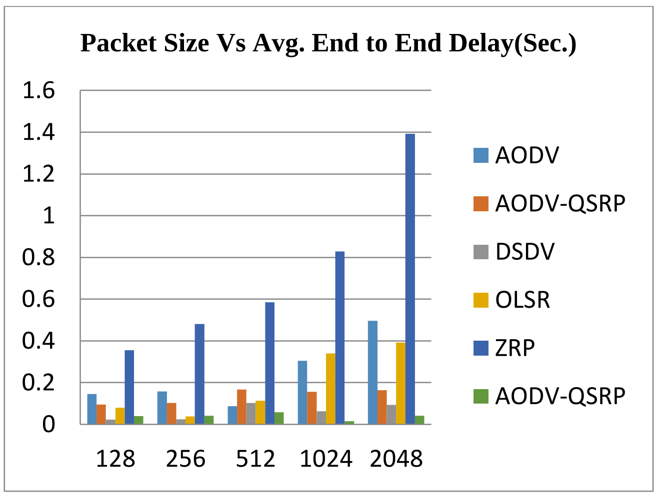

Figure 17 Packet Size Vs Avg. End to End Delay (Sec.)

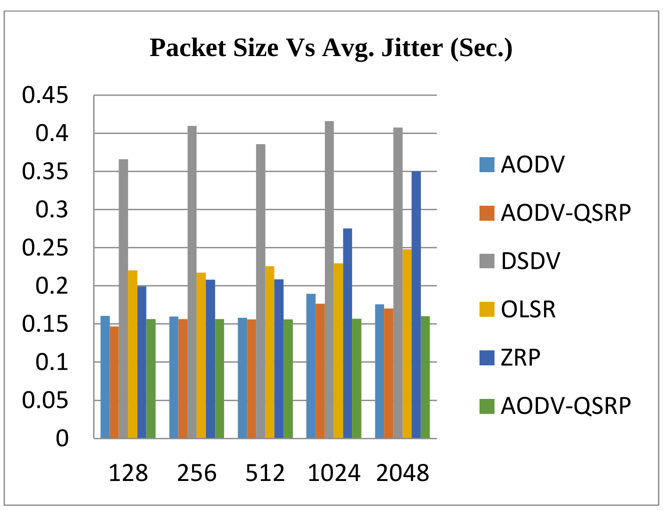

Figure 18 Packet Size Vs Avg. Jitter (Sec.)

10.4. Effect of No. of Nodes

Increasing the nodes means the corresponding network will get denser and the probability of data delivery gets increase. It leads into cost of congestion in the network as the number of communication gets increase. Table 6 shows the simulation parameter setup for the effect of increasing the nodes. In our scenario we have taken 50, 60,70,80,90,100 as the node values. As we can observe by Figures 19, 20, 21, and 22 AODV-QSRP performs better than other protocols and its PDR and throughput is approximately 100 percent. Though QAODV performs better than AODV, OLSR, DSDV and ZRP, but it does not reach up to 100 percent PDR. It Performs poor as compare to AODV-QSRP.As we have set our QoS requirements at application level, AODV-QSRP performs accordingly. Maximum Avg. delay for AODV-QSRP is under the required delay by application (0.3) that is 0.2 in our result. Avg. delays of DSDV and OLSR protocols is less than QAODV, AODV-QSRP and ZRP because these are proactive protocols and have routes available at any time. Delay for ZRP gets increase as the size of network grows because its hybrid in nature. Avg. Jitter for DSDV, OLSR and ZRP gets increase as the size of network increases. Avg. Jitter for AODV-QSRP (<0.2) is very less as compared to other protocols. Though avg. Jitter for QAODV is less than other protocols but greater to AODV-QSRP. So overall performance of AODV-QSRP is better than the other protocol and meets the specified QoS requirements. As our protocol is based on AODV and it performs better than AODV as can be seen by comparison graphs. The base protocol AODV consider minimum hop count as route selection criteria. It does not consider any other QOS parameter(s). Same as AODV, QODV adds one more QoS parameter that is Cumulative delay from source to destination. In comparison to both AODV and QAODV, AODV-QSRP consider almost all the critical QOS parameter like available battery power, link quality, delay and bandwidth to optimize the route and selects best route which is more robust and long lasting. That is the reason why AODV-QSRP performs better than any other protocol.

Table 6: Simulation Setup Parameters for Nodes

Simulation Parameters	Values
Tool	NS-2
Network Type	MANET(IEE802.11(b))
Simulation Area (in meters)	1000*1000
Simulation time (In sec.)	500s
Data duration (in sec.)	100
No. Of Nodes	50,60,70,80,90,100

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Node placement strategy	Random distribution
Mobility Pattern	Random Waypoint
Type of source	CBR
No. Of source	3
Packet size(Bytes)	1100
Interval between packets	0.1 sec.
Routing Protocols	AODV,QAODV, DSDV, OLSR, AODV-QSRP, ZRP

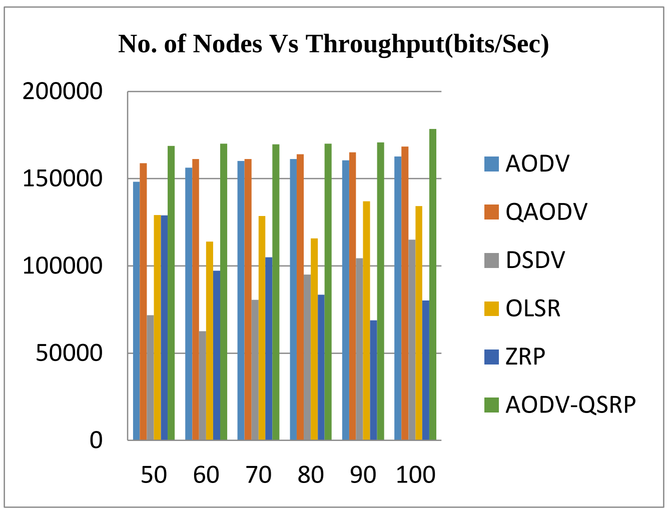

Figure 19 No. of Nodes Vs Throughput (bits/Sec)

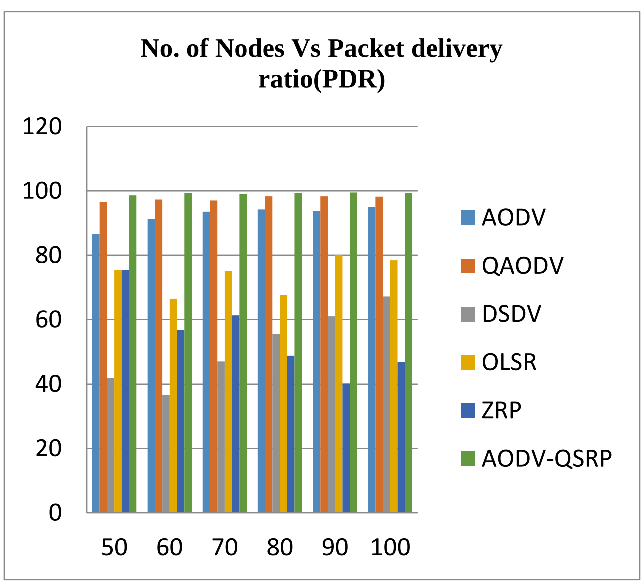

Figure 20 No. of Nodes Vs Packet Delivery Ratio (PDR)

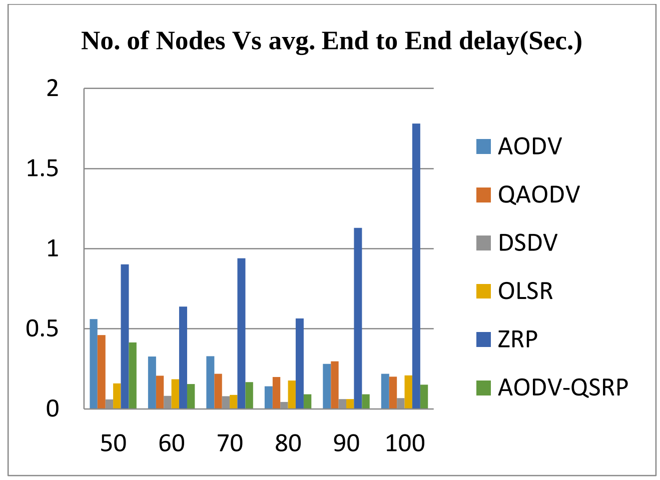

Figure 21 No. of Nodes Vs avg. End to End Delay (Sec.)

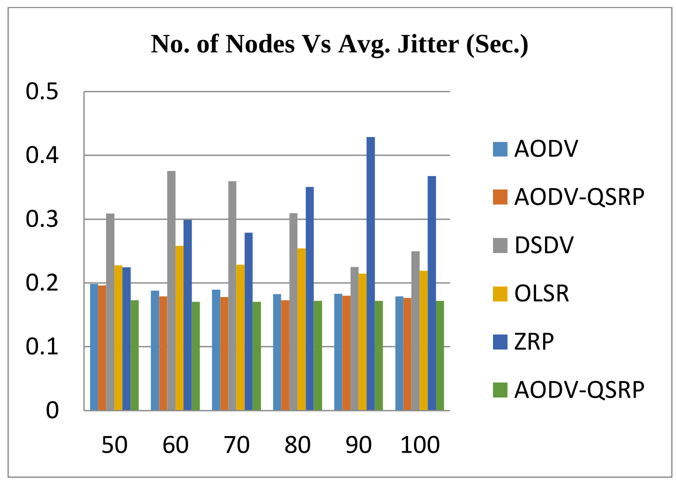

Figure 22 No. of Nodes Vs Avg. Jitter (Sec.)

11. CONCLUSION AND FUTURE WORK

To achieve high QoS in MANETs for real time communication is a very important and issue because of various issues faced in MANETs. Therefore in this paper, we proposed an efficient QoS based routing algorithm to improve the performance and to support real-time applications in MANETs. Our Protocol recognise the problem of QoS in MANETs. To achieve the batter performance for real-time applications we have used several QoS parameters in our protocol, Which has not been taken in the QoS protocols like QAODV etc, AODV-QSRP also energy aware routing protocol because it consider remaining battery power. To support high QoS we also considered delay, bandwidth and link quality as route selection criteria. As according to simulation study overall performance of AODV-QSRP is better than AODV and QODV and other protocol and meets the specified QoS requirements as we need. As our protocol is based on AODV and it performs better than QAODV, AODV as can be seen by comparison graphs. Due to

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several calculations overhead the avg. energy consumption is more than AODV, OLSR and DSDV. In future study we will try to minimize the overhead and reduce the battery consumed by this protocol.

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