A COMPARATIVE STUDY AND PERFORMANCE EVALUATION OF REACTIVE QUALITY OF SERVICE ROUTING PROTOCOLS IN MOBILE ADHOC NETWORKS

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ABSTRACT

The recent advancements in wireless technology have lead to the development of a new wireless system called Mobile Adhoc Networks. A Mobile Adhoc Network is a self configuring network of wireless devices connected by wireless links. The traditional protocol such as TCP/IP has limited use in Mobile adhoc networks because of the lack of mobility and resources. This has lead to the development of many routing protocols such as proactive, reactive and hybrid. Reactive routing protocols have been found to be user friendly and efficient when compared to other routing protocols. The main boon of Reactive routing protocols when compared with Proactive and Hybrid routing protocols is the relatively unconditional low storage requirements, higher mobility and the availability of routes when needed. There are a variety of reactive routing protocols such as AODV, DSR, LAR1, LMR, ABR, SSI, TORA, RDMAR, MSR, AOMDV, MRAODV, ARA. However there is no study done over the efficiency of any reactive routing protocols. In this study a comparison and performance evaluation of three reactive routing protocols AODV, DSR and LAR1 are done using **QualNet** Simulator to identify the protocol that is best suited for MANET's.

Keywords: *MANET, Routing Protocols, AODV, DSR, LAR1*

1. INTRODUCTION

Technology has advanced by leaps and bounds in the last few years. This is evident from the recent developments in various fields such as Medicine, Computer science and Information technology. In no other field has these developments been more evident than in field of wireless technology. Though wireless systems have existed since the 1980's it is only in recent times that wireless systems have started to make inroads into all aspects of human life.Mobile Ad Hoc Networks (MANETs) are advanced wireless communication networks. Mobile Ad hoc Network is an autonomous system of mobile nodes connected by wireless links. Each node operates as an end system and a router for all other nodes in the network. A mobile Ad hoc Network is a self configuring network of mobile routers connected by wireless links –the union of which forms an arbitrary topology.An Ad hoc network is often defined as an "infrastructure less" network means that a network without the usual routing infrastructure, link fixed routers and routing backbones

1.2. Properties of Mobile Ad Hoc Network

Wireless ad hoc networks are formed by a group of mobile users or devices spread over a certain geographical area. The user or devices forming network "nodes". The service area of the ad hoc

network is the whole geographical area where nodes are distributed. As mobile ad hoc networks are self organized networks communication in ad hoc networks can generate data for any other node in the networks. The multi hop support makes communication between nodes outside the direct range of each other possible.

1.3. Salient features of MANET

Nodes are free to move arbitrarily; thus network topology which is typically multi-hop may change randomly and rapidly at unpredictable times. Wireless links will continue to have significantly lower capacity than their hard-wired counterparts. Congestion is typically the norm rather than the exception; i.e. aggregate application demand is likely to exceed network capacity frequently.Some or all the nodes in a MANET rely on batteries for their energy. Thus, for these nodes, the most important design criteria may be that of power conservation. Mobile wireless networks are generally more prone to physical security threats than fixed, hard-wired networks.

1.4. Applications of Mobile Ad-Hoc Networks

In Gaming Mobile adhoc networks are used in the development of communication between players at various geographical locations so they can interact and coordinate the gameplay. Business Environment use these networks to delegate assignments to the persons at various places and allow a business meeting with clients located far away. Taxi Dispatch Units use MANET as a replacement to traditional radio dispatch unit which are less effective and more expensive. All taxis are fitted with an adhoc device and they have a central dispatch server which allocates different jobs to all the taxis under its control. Crisis Management Services have develop an early detection and warning system for natural disasters such as earthquakes and typhoons. In the hospital industry it allows the transmission of early data from the sight of the injury to the hospital. Military Applications of Mobile adhoc network allows tracking of enemy position using GPS (Global Positioning System) thereby reducing risk of exposure during combat. It allows intercommunication between mobile forces. Their application is based on the networks self organized nature which allows the mobile military units to communicate efficiently. In adhoc networks eliminates the problem of a vulnerable network base station when nodes are lost in a battlefield of a hostile environment. Mobile networks have increased applicability in areas of military application such as sensor networks, tactical networks and positional systems Mobile adhoc networks have increasing applicability in Law enforcement. Various law enforcement agencies use Mobile adhoc networks to communicate with each other, to track movement of criminals and to spy on criminal activities Video conferencing in some situations where there is no network infrastructure can be done using Ad hoc networking which enables mobile on the spot conferencing. Sensor nodes can be used as an adhoc networks in some situation such as hazardous environment forming a sensor network which are composed of tiny sensor devices equipped with positional indicators to gather information and send them to a third party for analysis.

1.5. Quality of service in MANET

Quality of Service has been defined by the United Nations Consultative Committee for International Telephony and Telegraphy (CCITT) recommendation E.800 as “The collective effect of service Performance which determines a degree of satisfaction of a user of the service”. The Quality of Service is a rapidly growing area in both wired and mobile Ad Hoc Network. Many problems exist especially for MANETs [11]. Quality of service in mobile ad hoc networks depends not only on the available resources but also on the mobility rates of such resources. It means to provide a set of parameters to adapt the applications to the quality of the network while routing them through the network.[12] The Three main constraints related to the quality of service are bandwidth constraints, dynamic topology of MANET and the limited processing and storing capacity of mobile nodes. This has led to the development of several routing protocols which emphasizes on the implementation of effective technologies to improve quality of service thereby significantly increasing the performance. [6].

1.6. Critical Issues In MANET

An ad hoc network is a dynamic type of network with similarities and great differences to its parent fixed communication network. The properties of an ad hoc network will define its shortcomings and

highlight security challenges [17][18][19][20][21][22].An ad hoc networks, is a spontaneous, self created network which cannot rely on a fixed network infrastructure, and by definition does not. A fixed entity structure such as a base station or central administration is crucial for security mechanisms. The trusted third party member who is expected in traditional networks often defines security services; the absence of such a control entity introduces new opportunities for security attacks on the network. The network instead of relying on a central administrator for network and security service, the network relies upon the nodes for these duties in a self-organized manner. Connectivity is a problem in ad hoc networks as networks are created spontaneously and nodes are mobile. Therefore connectivity between the nodes is sporadic. In ad hoc networks nodes may have no prior relationships with other nodes within the network. Prior acquaintance between nodes can be seen as pre-trust relationships between nodes. It cannot be assumed that pair wise secrets exist between nodes. Physical vulnerability is a major problem in Mobile adhoc network. Mobile node capture or compromised nodes are of higher probability in ad hoc networks than in traditional wired networks with stationary hosts. Lack of Resources is a problem with a network which has no central administrator to perform network and security tasks, and rather relies upon nodes to accomplish such services. This creates a heavy burden upon nodes to perform their own tasks as well as network tasks therefore nodes will have limited resources compared to fixed wired nodes. Threats or attacks upon the network come from entities known as adversaries, these may include insider and outsider nodes that maliciously attack or threaten the network or the secrecy of the networks content.

1.7. Objectives of the Study

The main objective of the study is to compare and analyze the performance of reactive routing protocols in mobile ad hoc network. Keeping this main objective in mind the following objectives are stated

- Study focuses on identification of reactive routing protocols which emphasizes on quality of service in mobile ad hoc networks.
- To compare the performance of three reactive routing protocols which focuses on quality of service namely AODV,DSR and LAR1
- To deduct the reactive routing protocol which is most efficient in enhancing quality of service and which may lead to optimal increase in performance.

The remainder of this paper is organized as follows – the next section gives the details about the routing protocols and its classification. In Section 3 describes in detail about reactive routing protocols and its various types and follow it with brief specifics of implementation in section 4. Section 5 consists the conclusion of the research work.

2. ROUTING PROTOCOLS IN MANET

Routing is the Exchange of information (in this case typical term ‘packets’) from one station of the network to the other. The major goals of routing are to find and maintain routes between nodes in a dynamic topology with possibly uni-directional links, using minimum resources. A protocol is a set of standard or rules to exchange data between two devices. Routing protocols are classified into unicast routing protocols, multicast routing protocols and broadcast routing protocols. Unicast forwarding means a one-to-one communication, i.e., one source transmits data packets to a single destination. This is the largest class of routing protocols found in ad hoc networks. Multicast routing protocols come into play when a node needs to send the same message, or stream of data, to multiple destinations. Broadcast is the basic mode of operation over a wireless channel; each message transmitted on a wireless channel is generally received by all neighbors located within one-hop from the sender. The simplest implementation of the broadcast operation to all network nodes is by naïve flooding, but this may cause the broadcast storm problem due to redundant re-broadcast. There are several unicast protocols such as proactive, reactive and hybrid routing protocols.

Proactive Protocols keep track of routes for all destinations in the ad hoc network are called Proactive protocols or Table-driven Protocols, as the routes can be assumed to exist in the form of tables. The main advantage is that Communications with arbitrary destinations experience minimal initial delay from the point of

view of the application. The Disadvantages of proactive protocols is that Additional control traffic is needed to continually update stale route entries. some of the Proactive Routing Protocols are:

1. AWDS (Adhoc wireless Distribution Service)
2. CGSR (Clusterhead Gateway Switch Routing Protocol)
3. DFR (Direction Forward Rouitng)
4. DBF (Distributed Bellman-Ford Routing Protocol)
5. HSR (Hierarchical State Routing Protocol)
6. IARP (Intrazone Routing Protocol)

Reactive Protocols acquire routing information only when it is actually needed. The Advantage is that due to the high uncertainty in the position of the nodes, however, the reactive protocols are much suited and perform better for ad-hoc networks. The Disadvantages of reactive protocols include High latency time in route finding and excessive flooding leading to network clogging. Some of the Reactive Routing Protocols are:

1. Admission Control Enabled On Demand Routing (ACOR)
2. Associativity Based Routing (ABR)
3. AODV (Adhoc on-demand Distance Vector)
4. DSR (Dynamic Source Routing)
5. CHAMP (CacHing And MultiPath Routing)
6. LAR1 (Location Aided Routing – Scheme 1)

Hybrid routing are protocols in which the routing is initially established with some proactively prospected routes and then serves the demand from additionally activated nodes through reactive flooding **Disadvantages** of hybrid protocols is that success depends on amount of nodes activated and Reaction to traffic demand depends on gradient of traffic volume. Some of the Hybrid Routing Protocols are:

1. HRPLS (Hybrid Routing Protocol for Large Scale Mobile Adhoc Networks with Mobile Backbone)
2. HSLS (HAZY Sighted Link State Routing Protocol)
3. HWMP (Hybrid Wireless Mesh Protocol)
4. OORP (Orderone Routing Protocol)
5.ZRP (Zone Routing Protocol)

2.1. Classification of Routing Protocols in Mobile Adhoc Network

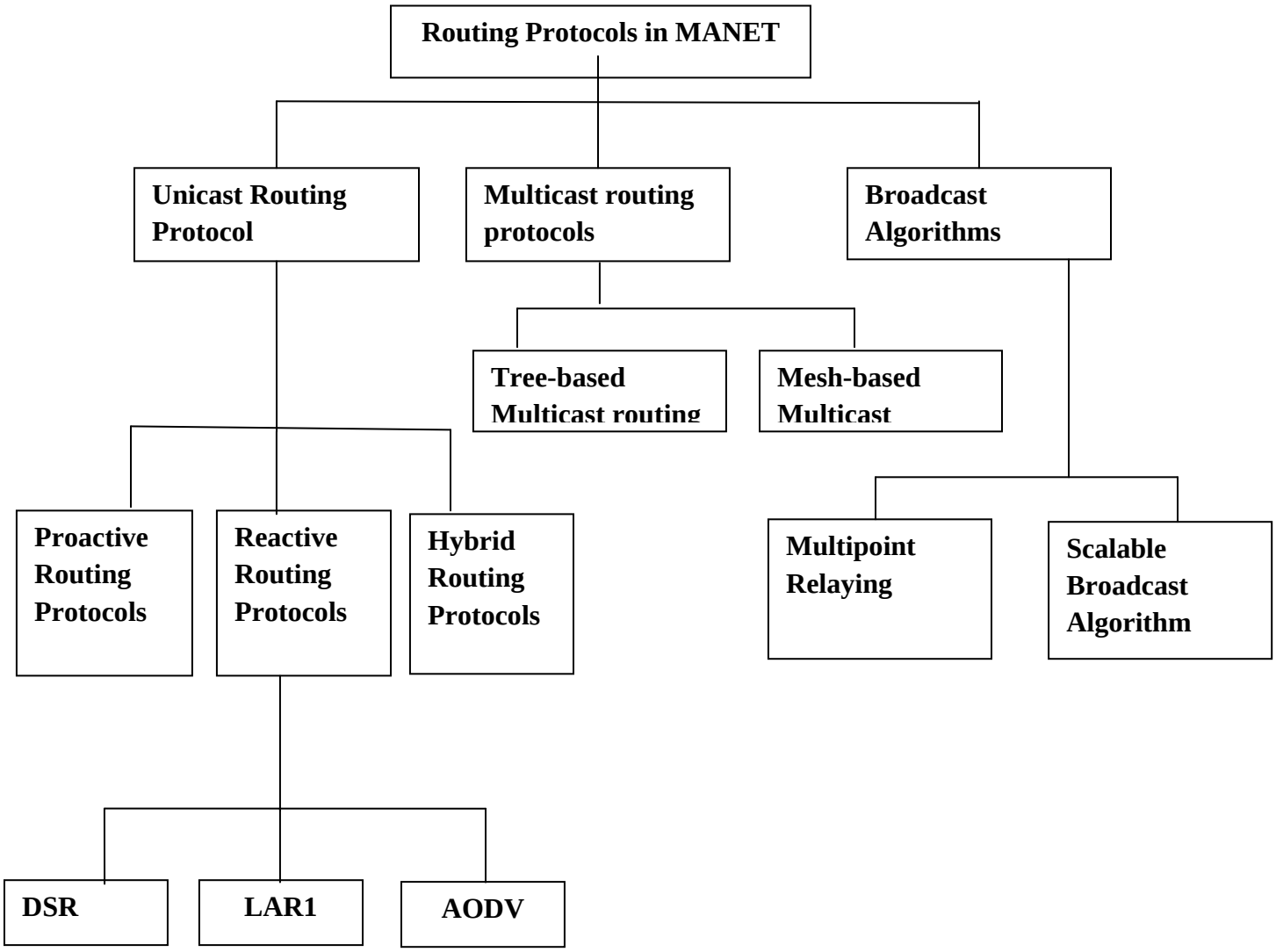


Fig.1 Classification of Routing Protocols in MANET

3. REACTIVE ROUTING PROTOCOLS IN MANET

Reactive Routing Protocols otherwise known as on demand routing protocols take a lazy approach to routing which differs from proactive routing protocols by identifying and maintaining routes only when needed which results in reduced overhead. Routes are identified and maintained for nodes that require sending data to a known destination, this is typically done by invoking route discovery mechanisms to find path to the destination. [9]

3.1. AODV (Ad hoc On-Demand Distance Vector Routing)

AODV is a reactive routing protocol which is basically a combination of DSR and DSDV algorithms. It uses the advantageous feature of both these algorithm. Dynamic, self-starting and multi-hop routing is allowed between participating mobile nodes. The basic on demand routing mechanism of route discovery and route maintenance of DSR and the use of hop by hop routing sequencing number and periodic update packets of DSDV are both available in AODV. It

employs destination sequence numbers to identify the most recent path. In AODV, the source node and the intermediate nodes store the next-hop information corresponding to each flow for data packet transmission [5][8][13][14].

Advantages

The main advantage includes its adaptability to highly dynamic networks and reduced overhead. The other advantages include lower setup delay for connections and detection of latest route to the destination

Disadvantage

It requires periodic updates. The distinguishing feature is the use of a destination sequence number for each route entry. If the source sequence number is very old it leads to inconsistent routes. Unnecessary bandwidth consumption occurs in response to periodic beaconing

3.2. DSR (Dynamic Source Routing)

DSR is an on demand routing protocol in which a sender determines the exact sequence of nodes through which a packet is propagated. The packet header contains a list of intermediate nodes for routing. Route cache is maintained by each node which caches the source route that it has learned. The major components of DSR are "Route Discovery" and "Route Maintenance" which work together for determining and maintaining routes to arbitrary destinations [3]. It is designed to restrict the bandwidth consumed by control packets in ad hoc wireless networks by eliminating the periodic table-update messages required in the table-driven approach. A route is established by flooding Route Request packets in the network. [14].

Advantages

A route is established only when it is required. It allows the sender to select and control routes there by reducing load. The other advantage includes loop-free routing in networks containing uni-directional links.

Disadvantage

The source route has to be included with each packet causing significant overheads. The other disadvantage includes aggressive use of caching and lack of any mechanism to detect freshness of routes which causes delay and throughput reduction. The route maintenance mechanism does not locally repair a broken link. The connection setup delay is higher than in table-driven protocols.

3.3. LAR1 (Location Aided Routing)

Location Aided Routing [4] decreases overhead of route discovery by using the location information for mobile host. It limits the search to a smaller request zone causing significant reduction of the number of routing messages [7].

Advantages and Disadvantages

A node forwards a route request only if it belongs to the "request zone"

4. EXPERIMENTAL SETUP

The study has been done to compare the efficiency of three different reactive routing protocols in Mobile Adhoc Networks. The tool used is QualNet4.5, the QoS parameters are First Packet Sent at (s), Last Packet Sent at (s), Total Packets Sent, Total Packets Received, Total Bytes Sent, Total Bytes Received, Throughput, Average End to End Delay and Average Jitter. The simulation using 25, 50, 75 and 100 nodes. The performance of all three routing protocols is carried out and results are compiled.

4.1. Results

Table.1 Metrics Values using 25 Nodes

Protocols	FPS(s)/ FPR(s)	LPS(s)/ LPR(s)	TBS/ TBR	TPS/ TPR	Throughput	Avg.ETED	Avg.Jitter
AODV	1/ 2.4	100	40%	41%	1720	0.18	0.13
DSR	1/ 2.5	100	100%	100%	4200	0.0098	0.00263
LAR1	1/ 1.09	100	100%	100%	4200	0.0229	0.00085

Table.2 Metrics Values using 50 Nodes

Protocols	FPS(s)/ FPR(s)	LPS(s)/ LPR(s)	TBS/ TBR	TPS/ TPR	Throughput	Avg.ETED	Avg.Jitter
AODV	1	1.8	100%	100%	4200	0.0299	0.0084
DSR	1	1.3	100%	100%	4200	0.0358	0.0061
LAR1	1	3.19	100%	100%	4200	0.057	0.0023

Table.3 Metrics Values using 75 Nodes

Protocols	FPS(s)/ FPR(s)	LPS(s)/ LPR(s)	TBS/ TBR	TPS/ TPR	Throughput	Avg.ETED	Avg.Jitter
AODV	60	159	90%	96%	3900	0.038	0.031
DSR	60	160	98%	99%	4200	0.0302	0.0158
LAR1	1.0	100	100%	100%	4200	0.023	0.00124

Table.4 Metrics Values using 100 Nodes

Protocols	FPS(s)/ FPR(s)	LPS(s)/ LPR(s)	TBS/ TBR	TPS/ TPR	Throughput	Avg.ETED	Avg.Jitter
AODV	60	159	81.7%	84%	3500	0.062	0.038
DSR	1	100	98%	99%	4200	0.0343	0.0092
LAR1	1	100	98%	99%	4200	0.046	0.0018

FPS-First Packet Sent; FPR-First Packet Received; LPS-Last Packet Sent; LPR-Last Packet Received; TBR-Total Bytes Sent; TBR-Total Bytes Received; TPS-Total Packet Sent; TPR-Total Packets Received; ETED-End to End Delay; Avg- Average.

Fig.2 Comparative Chart for the Metric – Total Bytes Sent at Seconds

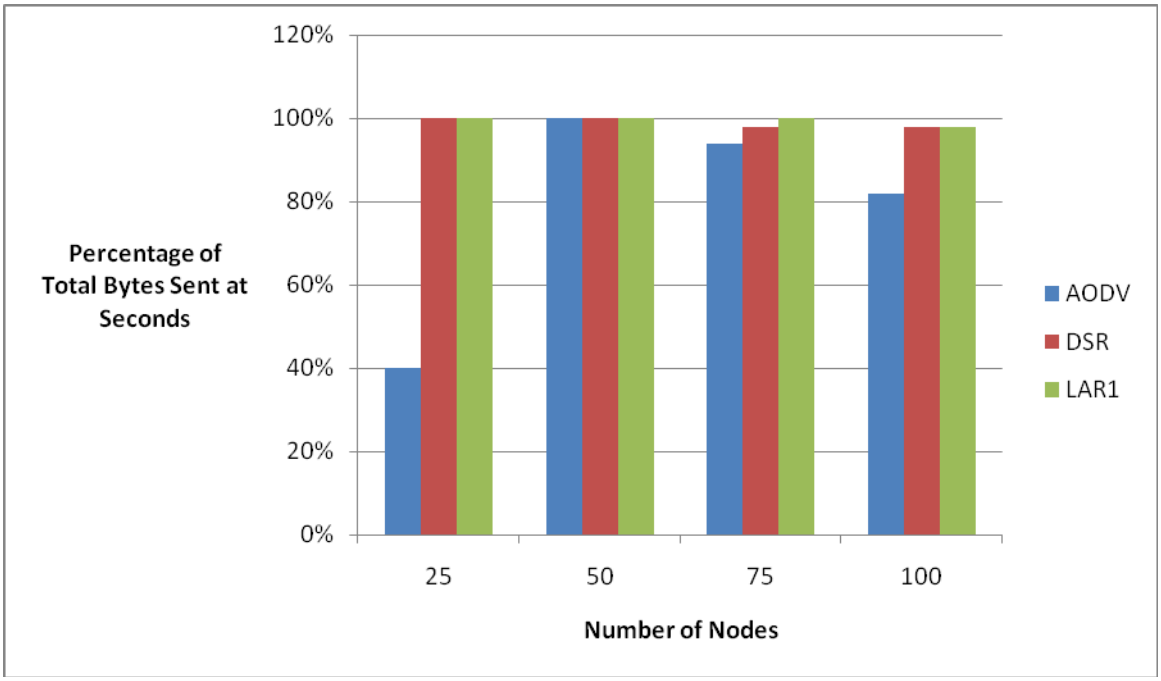


Fig.3 comparative chart for the Metric – Total Packets Received

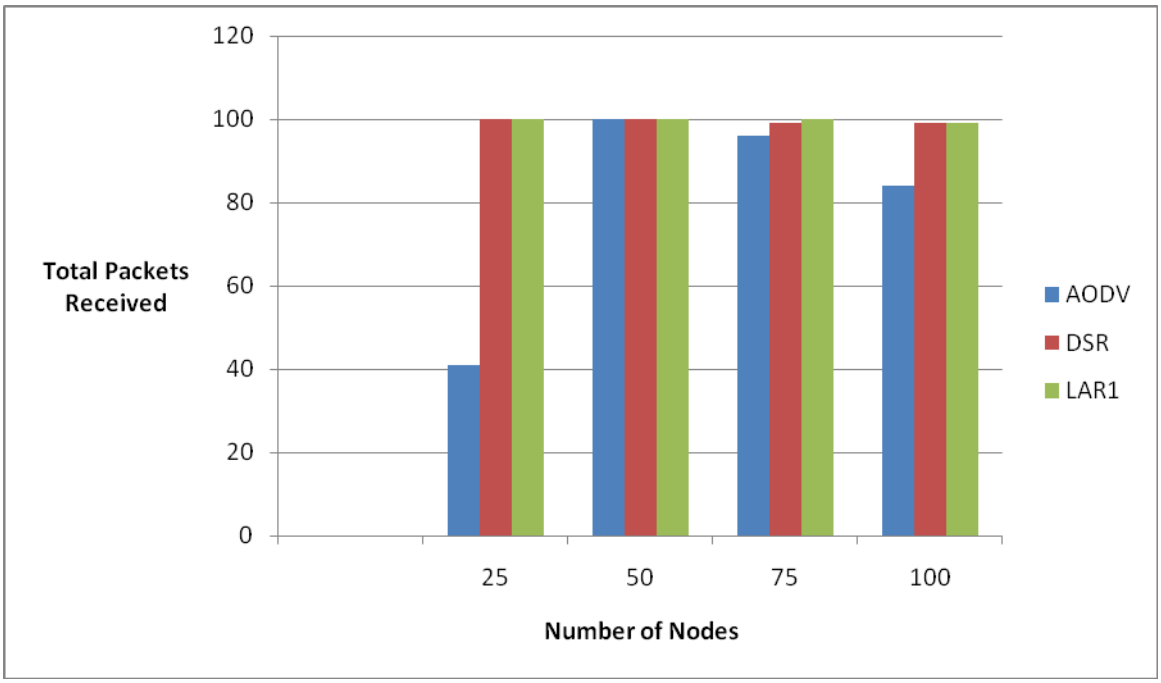


Fig. 4 Comparative chart for the Metric – Throughput

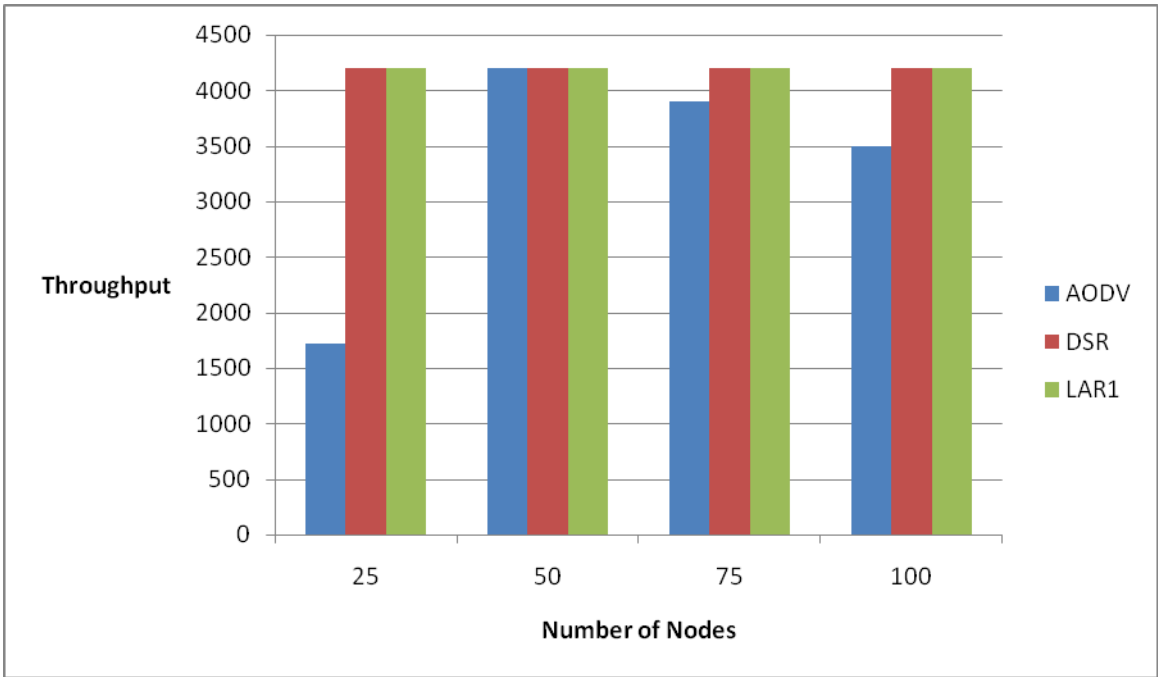


Fig.5 Comparative Chart for the metric – Average End to End Delay

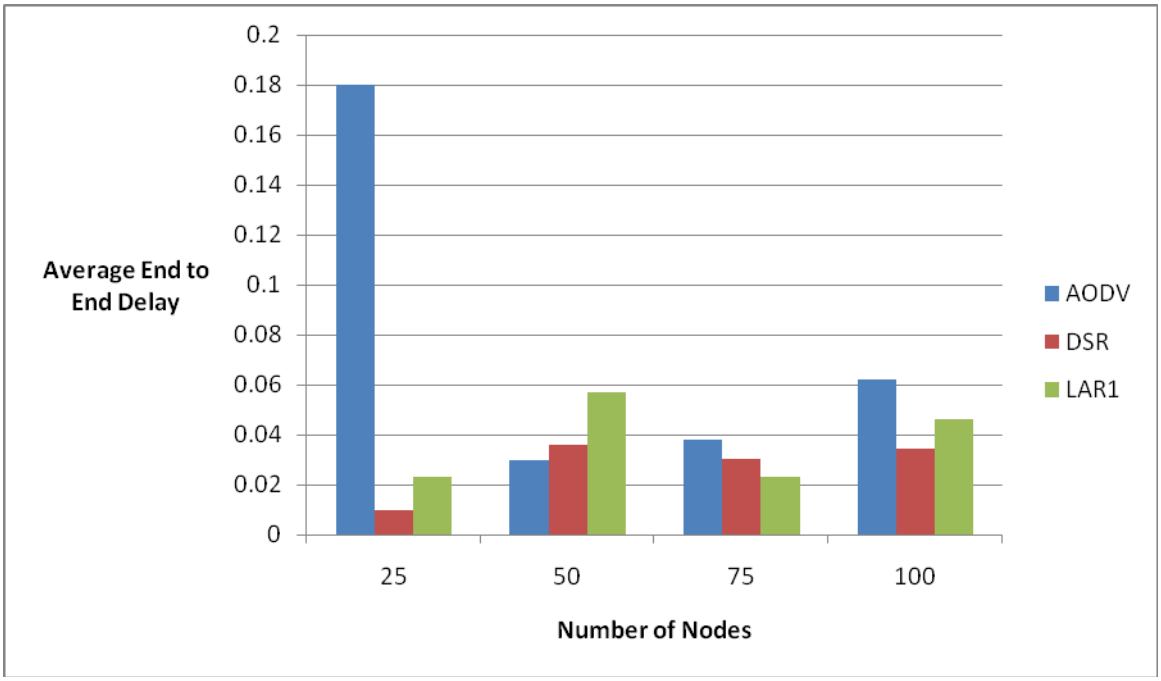
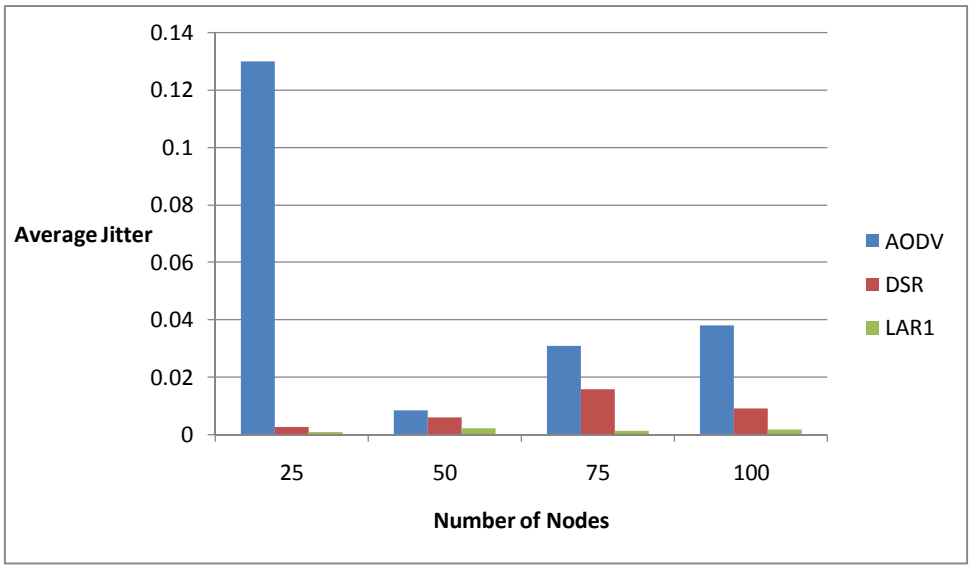


Fig.6 Comparative Chart for the Metric – Average Jitter



4.2. Numerical comparison for the metrics

The QoS metrics can be classified into three groups and they are Additive Metrics, Multiplicative Metrics and Concave Metrics [16]. The study takes into account End to End Delay and Jitter in order to have numerical comparison as they both belong to Additive Metrics.

The formula to calculate the metrics End to End Delay and Jitter is

Additive: d (p) = d (n1, n2) + d (n2, n3) +…. +d (n_{m-1}, n_m)

Table.5. Mathematical Concepts applied for the metrics End to End Delay and Jitter.

Protocols	25 Nodes	50 Nodes	75 Nodes	100 Nodes
AODV	1734.1328	1758.2553	1503.3897	1953.4837
DSR	3197.3502	1607.6807	1542.5276	2019.1406
LAR1	**1348.08**	**1348.94**	**1262.395**	**1345.182**

5. CONCLUSION

In the recent time there has been a lot of interest in the field of wireless networks. The fast moving world demands seamless communication facilities, so former types of connectivity like wired networks, radio waves are fast becoming obsolete. One of the recent developments in the world of wireless technology is the use of mobile ad hoc networks which was initially developed for military applications but now has expanded to include many commercial applications. The rapid use of MANET has resulted in the identification of several problems. Earlier MANET protocols did not focus on the quality of service but the recent applications like multimedia has impressed the importance of quality of service in MANET and this has become the area of potential interest. The study has been done by comparing three reactive routing protocols AODV, DSR and LAR1. The parameters studied include average jitter, average end to end delay, throughput and total number of packets sent and received. The result were analyzed using simulation method and QUALNET Simulator was used for the analysis

The three routing protocols, all result in improvements of the various parameters such as total number of packets sent and received, total bytes sent and received, average jitter, average throughput and average end-to-end delay but these improvements are greater in LAR1 than in the AODV and DSR, therefore it can be concluded that LAR1 is the best among the three routing protocols.

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