

# A Survey on Routing Protocols and QoS in Mobile Ad Hoc Networks (MANETs)

L. Raghavendar Raju<sup>1\*</sup> and C. R. K. Reddy<sup>2</sup>

<sup>1</sup>Department of CSE, Matrusri Engineering College, Hyderabad - 500059, Telangana, India; lraghavenderraju@gmail.com

<sup>2</sup>Department of CSE, CBIT, Hyderabad - 500075, Telangana, India; crkreddy@cbit.ac.in

## Abstract

**Objective:** MANET is a collection of wireless mobile devices, mobility and scalable network. These key details are behind the fame of MANETs. A good survey is done on QoS and routing protocols. This study presents merits and demerits of some of the QoS routing protocols. Also, a thorough investigation has been carried out on the current problems and feature trials that are in the field of MANETs. **Findings:** Every routing protocol must provide Quality of Service (QoS): With intent to improve bandwidth, delay, jitter, and energy consumption. The purpose of any ad-hoc network routing protocol is to meet these challenges. Therefore, it becomes an essential parameter for MANETs to develop a proficient routing and QoS procedures. Some QoS routing-protocols are proposed newly by various characteristics. A similar survey is done on QoS and routing protocols. It has been observed that Maximizing accuracy, Minimizing overhead, Maintaining route, Reserving resources, reducing power utilization, reliability are unsolved issues. **Applications:** The designing of these routing protocols is an interesting task because of mobility, the dynamic behavior of the Mobile Ad-hoc Networks. This study is helpful for designing new routing protocols with improved QoS in MANETs.

**Keywords:** MANETs, QoS, Routing, Scalability, Security

## 1. Introduction

Since MANETs allow global service access, anywhere, anytime without any fixed infrastructure, this may be useful in military operations, disaster controlling, MANETs ad-hoc fashion networking developments lead to the development of vast multimedia applications such as video-on-demand and video conference.

Multicasting applications<sup>1</sup> requires the support of group communication protocols. Hence the concept of multicast routing has been more proficient as it shapes a multicast distribution structure. This permits the multi-cast supplier to send one copy of information only, and the in between nodes will reproduce the information if required. Only the nodes that belong to aimed group will obtain data.

In recent times many efforts are made to improve the QoS in multicast protocols for MANETs. It is a major test

to maintain reliability, scalability in multicast mobile networks. It is a challenge to supervise group memberships.

The major problem in multicasting is scalability. The scalability issue is considered as burning research area because of high demand for scalable multicasting protocols.

This study is structured as follows: Chapter 2 discusses various types of routing protocol, Chapter 3 Comparative study of various primitive and enhanced routing protocols, Chapter 4 describes Scalability in MANETs, and Chapter 5 describes Discussions and Conclusions.

## 2. Types of Routing Protocols

The MANET routing protocols are categorized based on how routing data is developed, sustained by mobile devices. Routing decisions depend on neighbourhood associations of mobile networks. Routing protocols can

\*Author for correspondence

be categorized into two types: Topology-based protocols and Position-based protocols<sup>2</sup> as shown in Figure 1.

### 2.1 Topology-Based Routing Protocols

Uses links information available in the existing network to forward packets. They are further categorized into

- Proactive protocols.
- Reactive protocols.
- Hybrid protocols<sup>3</sup>.

A brief description of these protocols follows.

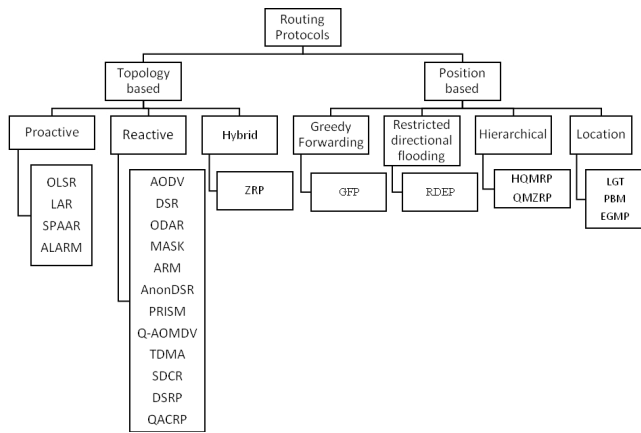


Figure 1. Classification of routing protocols in MANETs.

#### 2.1.1 Proactive Protocols

Mobile devices are necessary to keep the network topology information as routing tables through an exchange of routing data at regular intervals. These protocols maintain route information to all destinations so that extra time is not required to find the route. This category of the protocol is not appropriate for MANET’s environment because they utilize node resources, irrespective of traffic present in the network. Also, they are not planned to trace topology changes<sup>4</sup>. Destination Sequenced Distance Vector Routing (DSDV)<sup>5</sup> and Optimal Link State Routing Protocol (OLSR)<sup>6</sup>, and Anonymous Location-Aided Routing in Suspicious MANETs (ALARM)<sup>7</sup> belong to this category.

#### 2.1.2 Reactive Routing Protocols

They are more suitable for the mobile environment than proactive protocols. Reactive Routing Protocols start a route discovery process when a packet is to be transmitted<sup>8</sup>. After a route is established, then the route should be

continued until the destination becomes unreachable. It reduces the overhead of preserving routing table for routes that are not presently in use. In this category of protocols, route calculation method is classified into two types: Route Discovery and Route Maintenance. The Route discovery method will start when a packet is transmitted from source to destination. The Route Maintenance method discard miscarried routes and restarts route discovery in the case of topology changes. A detailed list of Reactive Routing Protocols is listed in Table 2.

#### 2.1.3 Hybrid Routing Protocols

They are developed by merging the best characteristics of Reactive and Proactive methods. These protocols decrease the delay in reactive routing and limit the overhead of proactive routing protocols<sup>9</sup>. Zone Routing Protocol (ZRP)<sup>3</sup>, comes under this category.

### 2.2 Position-Based Routing Protocols

Based on the position of mobile nodes we have

- Greedy Forwarding Protocol.
- Restricted directional flooding Protocol.
- Hierarchical routing protocols.
- Location based routing Protocols<sup>10</sup>.

A brief description of these protocols is given here.

#### 2.2.1 Greedy Forwarding Routing Protocols

In these protocols<sup>10</sup>, updated local topology is compulsory. To maintain an updated local topology, all the nodes must broadcast a small packet called beacon by specifying their position, so that other nodes will maintain a one-hop neighbour table. A source node sends the packet to her neighbouring node, which has the greatest improvement towards (or nearer to) the destination than itself. Likewise, each in-between node selects her closer neighbour hop node till the packet reaches the destination. If the node didn’t have a near neighbour, additional rules must be defined in the greedy strategy to discover another path. Greedy forwarding is scalable because route discovery and maintenance is not required. In dense networks, these routing protocols work well. But, in sparse network their performance degrades because on the way to the destination node, near forwarding node may not find a closer near a node, so the data packets are abandoned. Furthermore, proactive beaconing of one-hop neighbours is maintained

at each node in a neighbourhood table. This generates congestion in the network, and a lot of nodes energy is consumed. And also, greedy forwarding performs complex computations at the nodes which increase delay at internal nodes. GFRP<sup>10</sup> comes under this category.

### 2.2.2 Restricted Directional Flooding Routing Protocols

In these protocols, the flooding area is restricted upon on distance, angle, and distance covered by the next internal node. Using distance, route discovery is done by the nodes which are nearer to the destination only. Nodes which are far away from sender node will not partake in packet forwarding. In specific, sender node transmits the packet to all single-hop neighbour nodes along the destination. Near nodes that receive the packet equates its distance from the destination with the distance of the previous hop to the destination. If the node which gets the packet is closer to the destination, it resends the route request packet; the packet is dropped otherwise. Restricted Directional Flooding Routing Protocols (RDFP)<sup>10</sup> comes under this category.

### 2.2.3 Hierarchical Routing Protocols

Hierarchical position routing protocols, uses two stages of hierarchy for providing routing scalability. Packets are routed based on 'proactive distance vector' if the desti-

nation node is closer to the sender, but long distance routing<sup>10</sup> uses a greedy routing protocol. HQMRP<sup>11</sup>, GMZRP<sup>12</sup> will come under this category.

### 2.2.4 Location-Based Routing Protocols

These protocols are used to remove network flooding and offer more scalable and robust packet transmission. To offer scalability for both network size and group size location-aware approach is used by these protocols. Examples of these protocols are LGT<sup>13</sup>, PBM<sup>14</sup>, and EGMP<sup>15</sup>. Strengths and limitations of the routing protocols are given in Table 1.

There are various protocols developed based on Topology and Position based protocols. A brief explanation about various routing protocols is given in the following chapter.

## 3. Comparative Study of Various Existing Routing Protocols in MANETs

### 3.1 Review of Primitive Routing Protocols based on Topology

Few routing protocols available in MANETs are which are used to provide privacy and security to routing

**Table 1.** MANETs routing protocols categorization based on topology

Type of Protocols	Method of Approach	Strengths	Limitations
Topology-based routing protocols	Proactive	1. Every node in the network maintains routing information to every other node in the network even before it is needed	1. Not suitable for larger networks, as they need to maintain node entries for each node in the routing table of every node
		2. Routing information is constantly updated which minimize the end-to-end delay of sending data packets	2. More overhead in the routing table leading to wasting the limited wireless bandwidth
	Reactive	1. Routes are only constructed when they are needed 2. Scale to medium size networks with moderate mobility 3. Minimize control overhead and power consumption since routes are only established when required	3. Not suitable for highly mobile networks
			1. Source node has to wait for the route to be discovered before starting communication
	Hybrid	1. Combines the advantages of both proactive and reactive approaches; reduce the overhead of proactive and Reduce the delay of reactive.	1. In large routing zone it inherits the disadvantages of proactive protocols, and inherits those of reactive ones for small routing zones

Position-based routing protocols	Greedy	1. Scalable since it does not need routing discovery and maintenance	1. Degrades in sparse networks; the forwarding node may not find a node closer to the destination
		2. Works well in dense networks	2. Proactive beaconing creates a lot of congestion in the network and consumes nodes' energy
	Restricted directional	1. The flooding region is limited based on distance, angle and distance covered by the next intermediate node	1. Route request packet is managed by several nodes (higher routing overhead than greedy, but less than that of topology-based protocols)
	Hierarchical	1. Control overhead is reduced compared to proactive protocols	1. Inherits disadvantages of proactive protocols for large routing zone, and those of greedy ones for small routing zones
		2. Eliminates disadvantages of beacon packets used in greedy ones	
Location	1. Combine location service with membership management. 2. Minimize the bandwidth cost 3. Scalable 4. Robust against node mobility, dynamic network topology.	1. Each group member has to know the location of all other group members. 2. The network performance is poor in sparse network. 3. Increases the overhead.	

information. Some reactive, proactive and location based protocols have been discussed. Table 2 represents comparative information of various Topologies based routing protocols. Cryptographic methods like, scalability and privacy are used to compare these protocols. Also, advantages and disadvantages of these protocols are mentioned. Clearly, all protocols have few disadvantages. They are overcome in other protocols. Now, the primary concern is, to provide privacy to each node by maintaining the efficiency and scalability of these protocols. But using of long IP addresses are vulnerable to the spoofing attack. Therefore location aided routing may be efficient in avoiding spoofing attack.

### 3.2 Review of Enhanced Topology based Routing Protocols

In network to exchange information among the nodes, routing is the major problem. Several routing protocols (Reactive Protocols) have been proposed for wireless networks, like DSR<sup>16</sup>, AODV protocol<sup>17</sup>. These protocols do not consider Quality of Service of the routes they generate. To provide quality-of-service (QoS) routing, it is not only sufficient to find a route from source to one or more destinations but also route must satisfy one or more QoS constraints such as bandwidth and delay. After establish-

ing a route, QoS constraints are guaranteed by resource reservations in participating nodes. Nodes in Ad hoc networks shares wireless bandwidth among them and the network will changes when nodes move randomly, because of this providing QoS constraints in Ad hoc networks is difficult. Frequently reactive routing protocols use less bandwidth and have limited overhead than proactive protocols. But these protocols will have a long delay to establish a route to the destination before authentic communication. The merits and demerits of QoS routing protocols are available in Table 3. Lastly, a comparative study is done on various routing protocols to explore them for further research.

However, sufficient survey is done on QoS routing protocols in MANETs it appears that they are less suitable to analyze different parameters like bandwidth reservation, stability, multipath, load balancing and cross-layer among various QoS routing protocols. Table 3 gives comparison of improved QoS protocols based on the basic routing protocols given in Table 2

## 4. Scalability in MANETS

In a routing protocol, scalability is defined as the ability to support additional parameters of the network (like the

**Table 2.** Various routing protocols comparison based on topology

Sr No	Protocol	Category	Advantage	Disadvantage	Encryption method used	Privacy	Scalable
1.	OLSR <sup>6</sup>	Proactive Protocol	Reduces flooding overhead.	No security and privacy. Exposes network topology	None	None	NO
2.	LAR <sup>21</sup>		Reduce routing overhead.	No security and privacy.	None	None	YES
3.	SPAAR <sup>22</sup>		Provides security	Require on-line location servers.	Third party certificates	None	YES
4.	ALARM <sup>2</sup>	Proactive Protocol	Rapid route finding.	Exposes topology information	Group signature.	Node and communication privacy	YES
5.	AODV <sup>1</sup>	Reactive Protocols	Detect link failures / congestion	No security and privacy.	None	None	YES
6.	DSR <sup>23</sup>		Faster route recovery	No security and privacy.	None	None	NO
7.	ODAR <sup>24</sup>		Provides anonymity. Use of bloom filters	Requires online public key dist server	Public private key encryption.	node, link and path anonymities	NO
8.	MASK <sup>18</sup>		It can also withstand a variety of attacks, e.g., message coding, flow recognition, and timing analysis	Contains the final destination in clear, in each RREQ message.	Pairing Based cryptography	Node un-locatability and node intractability	YES
9.	ARM <sup>19</sup>	Provides node identity security	Assume that each authorized source-destination pair pre-shares a unique symmetric key	Secret Key & Pseudonym	Destination privacy	YES	
10.	AnonDSR <sup>20</sup>	Protection for user security and anonymity.	Assume that each source-destination pair shares some secret information.	Dst-ID & Secret & Public Key	None	YES	
11.	PRISM <sup>21</sup>	Uses on demand routing schemes.	May incur message overhead due to encryption and decryption process.	Group signature.	Resistant against tracking of node movements	YES	
12.	ZRP	Hybrid Protocol	It has reduced amount of overhead during communication and also reduces delays. Route was discovered faster due to association of DSR.	Proactive overhead is limited by ZRP to the zone size only and reactive over head is also limited by ZRP	None	None	NO

**Table 3.** QoS routing protocols comparison based on QoS constraints and features

Protocol	Base Protocol	Mobility Support	MAC Layer Functionality	QoS Metrics	BW /Delay Estimation	End to End Delay	Control Overhead:	Multipath	BW reservation	Stability
Q-AOMDV <sup>24</sup>	AOMDV	High as compared to AOMDV	IEEE 802.11 MAC	BW, Hop count, end to end delay	BW and delay estimation	Lower than AOMDV	Higher than AOMDV at low speed and lower Than AOMDV at higher speeds.	Yes	No	No
TDMA <sup>25</sup>	AODV	Less mobility support	TDMA	Delay and BW	BW and delay estimation	Lower than AODV & higher than QoS-AODV	Increases with the increase in no. of nodes	No	Yes	No
SDCR <sup>26</sup>	DSR	High mobility support	IEEE 802.11 MAC	Delay and link stability	Delay estimation done	Lower than DSR & DQR. It increases with the increase in speed of nodes.		No	No	Yes
DSRP <sup>27</sup>	-	Higher mobility support than DSRP w/o SAP, Zhu and Corson's, Liao's protocol.	TDMA	Bandwidth	-	Average delay time of DSRP is higher than DSRP w/o SAP, Zhu and Corson's, Liao's protocol. Also it grows with increase in traffic.	Control overhead of DSRP is less than Liao's but more than DSRP w/o SAP, Zhu and Corson's protocol. Also it grows up with increase in traffic	No	Yes	No
QACRP <sup>28</sup>	AODV	Higher mobility support than QoS routing protocol and CACP protocol	IEEE 802.11 DCF	Bandwidth	Bandwidth estimation done	Lower end to end delay than QoS aware routing protocol and CACP protocol		No	No	No

size of the network, network concentration, mobility rate of nodes and rate of data generation) by maintaining its performance<sup>18</sup>. So, it is a challenging task to design a scalable and reliable routing protocol for mobile Ad-hoc networks because of frequent change in network topology.

The performance of routing protocol degrades in topology-based if the density of the network increases and this leads to scalability problem<sup>19</sup> in the network. So, to achieve routing scalability, reducing routing control becomes a major issue. Routing protocols broadcast routing information to every node in the network in proactive protocols. So, each node maintains other nodes information; this leads to lack of scalability<sup>20</sup>.

## 5. Discussions

Multicasting is the best communication system which proficiently supports lot many applications that are categorized in near association. Based on applications requirements, network properties and assumptions we have to model a multicast routing protocol. The subsequent points summarize our observation from the survey:

For dense and dynamic networks, proactive routing protocols are not suitable because huge volumes of data transmission take place if the network topology is altered. Route acquisition latency cost is increased in reactive protocols if network size is large.

It is a challenging task to scale topology-based routing protocols because of the below-mentioned reasons. 1) group membership change 2) construction of the multicast structure.

In MANETs, due to limited bandwidth, dynamic network topology and multi-hops, guaranteeing QoS is not a simple thing in them. This makes MANETs are complex when compared with traditional networks.

To improve protocol performance, following issues are to be considered. They are mobility, leader selection, node controlling, reducing packet loss and failures among networks.

Even though there is a vast number of routing protocols available, acceptable solutions for MANET are not apparent. However, they contain some unsolved issues and challenges like (reliability, security, and power consumption). Further, this needs more analysis and research.

## 6. Conclusions

For any QoS architecture, QoS routing became an essential component. After surveying it has been observed that there are some unsolved issues that are yet to be achieved

in this area. Some of them are Maximizing accuracy, minimizing overhead, maintaining route, Reserving resources, reducing power utilization, reliability and improve security. Solving the above-said issues will require designing of new QoS protocols.

In this study, it was observed that most of the available protocols do not consider scalability issue when holding the multicast sessions, specifically in QoS protocols. These protocols are facing control overhead problem when the network is dense. There is no precise solution for the above-said problem, and numerous issues remain as open problems which require a lot of research in this area. However, this study highlights the efficiency of routing protocols with scalability issues which are useful for many multimedia applications.

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