# MANET ROUTING PROTOCOLS WITH QoS SUPPORT-A SURVEY

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***Abstract:*** **With ever increasing usage of mobile devices, Mobile ad-hoc Network (MANET) will eventually become almost indispensable part of wireless communication field. Due to this advancement, there are potential opportunities for using MANET in real time and multimedia applications and Quality of Service (QoS) is vital for implementing such applications. Since MANET is infrastructure less with the nodes moving dynamically, ensuring of QoS parameters like bandwidth, delay, throughput etc are challenging. Designing of optimum Routing protocols with QoS constraints is one of the active research areas in MANET. This paper provides a survey of some of the existing MANET protocols with QoS support.**

**Key Words--MANET, QoS, Protocols and Metrics.**

## I. INTRODUCTION

The important aim of Quality of Service [QoS] is, to achieve better deterministic behavior and due to that the information carried by the network can be better delivered and network resources can be better utilized. According to [1], Mobile Ad hoc Networks are class of networks whose inherent characteristics are,

- Physical characteristics –As MANET is also a class of Wireless network, there are unpredictable link bandwidth and Delay due to the effects of fading and node movement.
- Organization – As mobile nodes are distributed, predetermining of resource estimation is not easy in MANET
- Dynamic Topology – As the nodes are moving the topology is varying hence there is no fixed architecture.

In MANETs as the nodes are mobile, guaranteed QoS is not practical. Hence instead of hard QoS, soft QoS is proposed where in this failure to meet QoS is acceptable, for example cases like when the routes break or the networks become partitioned [1]. But due to dynamic topology of MANET, even providing soft QoS is difficult if the topology change is too frequent and fast. Therefore in order to provide QoS, it is important that the topology change should occur slowly to allow a time window for updated parameters to propagate to entire network [1]. The relationships among the QoS research are discussed in [2] which are given below

- In order to achieve better QoS provisioning in MANETs it is must for QoS routing, QoS MAC and QoS signaling to cooperate together.
- QoS signaling is like control center in QoS support. It coordinates the QoS routing, QoS MAC and others components like scheduling.
- QoS routing searches optimal paths with enough resources and it is not for reserving resources. For the selected path reservation of resources are done by QoS signaling. Hence QoS signaling will work better if it s associated with QoS routing.
- QoS routing and QoS signaling depend on QoS MAC, hence QoS MAC is essential component in MANETs.

QoS can be implemented at different layers of a network and if it is implemented in network layer then it is for finding a route with required quality. As QoS routing protocols function is to select nodes which can meet the application requirements, routing protocols are main part of QoS mechanism. In this paper, in the following sections different QoS routing protocols are discussed with their main features and finally the important points are highlighted in a comparison table.

## II. QoS AWARE ROUTING PROTOCOLS

There are certain design considerations to be satisfied for a protocol to be a QoS aware routing protocol and they are given below,

- Resource Estimation: In MANETs usually the host node shares available resource with its neighbor nodes. As in MANETs the nodes are mobile and the architecture is dynamically varying it is must to estimate the available resources for better QoS provisioning [1].
- Route Discovery: Proactive and Reactive are the two main approaches used in MANET route discovery .In these in proactive approach routes are established with minimum delay where as in reactive approach though it will take time to establish a route , it reduces overhead which is more in proactive approach. For the best QoS support, route discovery must be with reduced overhead and delay.
- Resource Reservation: As the resources are scarce in MANETs, for QoS support it is still challenging to allot the resources among the varying nodes of MANETs.
- Route Maintenance: Route break is a very common phenomena in MANETs since the nodes are moving hence some sort of prediction or redundant routes are required for QoS support [2].
- Route selection: According to this consideration, routes have to be selected by considering not only the available bandwidth but also the length and hop count of the route.

There are different routing protocols that have been developed to support QoS in either one or more of the following way[1]

• Routes with the largest available bandwidth (or minimum delay)

• Providing a call admission feature to deny route requests if insufficient bandwidth is available to support the request

• Providing feedback to the application about available bandwidth resources or route delay estimation

In networking, comparison of different routes is done with the help of numerical value associated with a route and it is called as metric[3]. Metrics are also needed to specify QoS of a network. The QoS metrics can be classified as additive, concave and multiplicative metrics and these classifications are denoted below [3]

Let x (ni, nj) be a metric for link (ni, nj) and p = (n1, n2,. .nm) denotes a path between nodes n1 and nm. Then the named metrics are defined as follows

Additive : $x(p) = x(n1, n2) + x(n2, n3) + \ldots + x(nm-1, nm)$ ----------(1)

Multiplicative: $x(p) = x(n1, n2) \times x(n2, n3) \times \ldots \times x(nm-1, nm)$----------(2)

Concave : $x(p) = \min (x(n1, n2), x(n2, n3), \ldots, x(nm-1, nm))$----------(3)

To find a QoS feasible path for a concave metric, the available resource on each link should be at least equal to the required value of the metric. The two most commonly used metrics in QoS networks are bandwidth and delay. In these bandwidth is handled as concave metric and delay as additive metric. Besides these there are other interesting additive metrics available for QoS specifications like delay jitter, energy and number of hops. According to [4] finding optimal path with multiple constraints may be an NP-complete problem if it involves two or more additive metrics.

But finding an optimal route that satisfies multiple constraints simultaneously is inherently hard and challenging [3,5]. Hence most of the algorithms proposed in the literature are intended for finding paths that satisfying multiple constraints rather than finding optimal routes. In the following chapter some of the existing protocols are analyzed and their performances are compared.

## III. CLASSIFICATIONS AND SURVEY OF ROUTING PROTOCOLS

In this section some of the existing MANET routing protocols with QoS are surveyed. The main features and functionality of these protocols are studied and finally a comparison table is framed to highlight all the discussed points.

Routing protocols in MANETs are classified as follows,

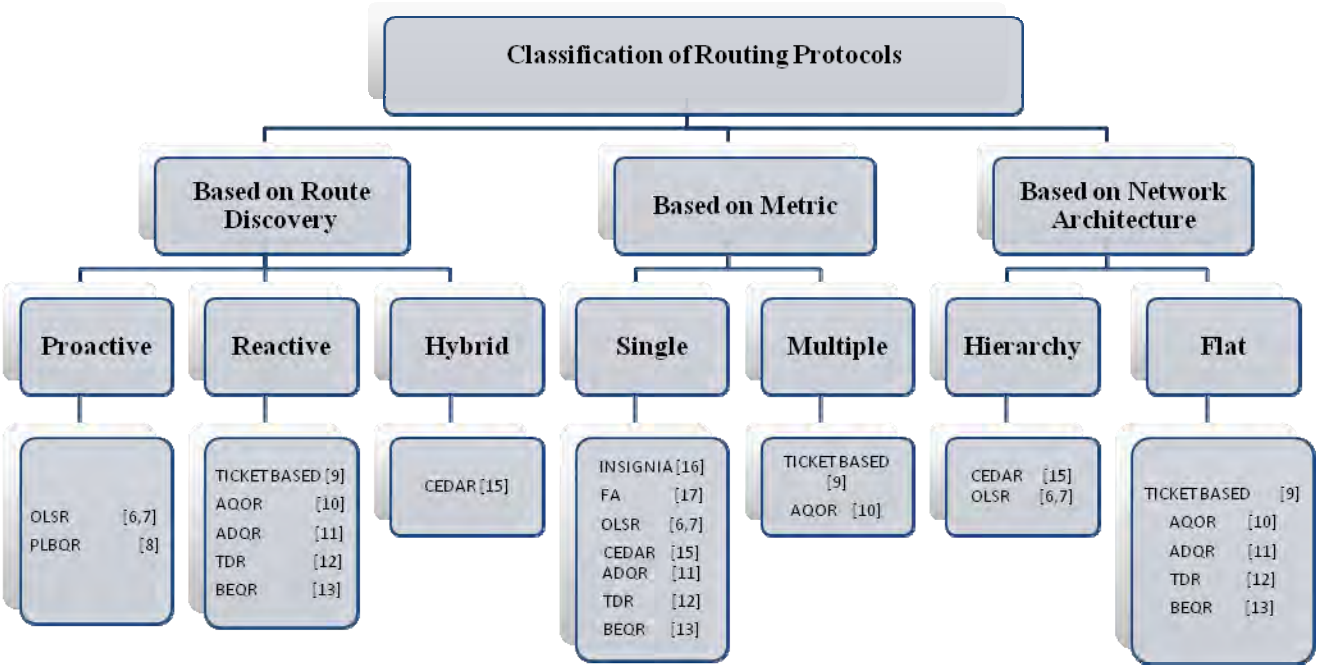


Fig.1. Classifications of Routing Protocols

**OLSR [6, 7]**: Optimization of Link State Routing Protocol is introduced by IETF MANET working group. [6]It is based on Multi Point Relays (MPRs) and MPR set is selected such that it covers all the nodes that are two hop distance. But this MPR selection may miss some good quality links and due to this QoS provisioning is difficult in OLSR. Ge et al [6] have proposed QoS for OLSR by selecting MPR set with larger bandwidth route.Resource estimation is done by measuring percentage of busy time by using the carrier-sense capability in the IEEE 802.11 MAC protocol Resource reservation and Route maintenance are not considered[1].

**PLBQR [8]**: Predictive Location Based QoS Routing protocol is based on prediction of the location of nodes in ad hoc wireless networks. The location prediction is used to predict the geographic location of the node at a particular instant "$t_f$" in the future when the packet reaches that node. The propagation delay prediction is used to estimate the value of "$t_f$". No resources are reserved along the path from source to destination but QoS aware admission control is performed. The QoS routing protocol takes the help of an updated protocol and location and delay protocol.

**Ticket Based QoS Routing [9]**: In this the basic idea is, it uses tickets to probe the feasible path which could be either delay constrained or bandwidth constrained. Here there are two types of tickets used, one is called yellow ticket which is for finding a route with delay/bandwidth constrained and the other one is green ticket it is for determining low cost routes. The source node has to estimate number of tickets to establish QoS aware route. If the constraints are strict then more the number of tickets issued by the host better the chances of finding feasible a path [1]. Resource estimation of each node is incorporated with resource availability of neighbor nodes and this is the main drawback of this protocol as each node must keep complete information of each of its neighbor which requires more memory. Once the primary route has been established then the destination node acknowledges the source node hence in this protocol resource reservation is established.

**AQOR[10]**: In this Ad Hoc QoS On demand Routing, the best route is one which satisfies the constraints of smallest end to end delay with guaranteed bandwidth. Here in route discovery, the route request packet contains both of these constraints and if a node satisfies both then it will rebroadcast the request to next hop and make entry with expiration time. If the reply is not received by the node in stipulated time then entry will be deleted. If still routes need to be explored, then only intermediate nodes will forward the reply. Once the route has been

discovered resource (bandwidth) reservation takes place on the established route. Since this protocol is not maintaining redundant routes, if path break occurs then source will initiate another route discovery.

**ADQR [11]**:In this Adaptive QoS Routing algorithm, it is intended for establishing disjoint routes between source and destination with longer life time. Here routes break and route reconstructions are based on signal strength. For example if the source node sends route request packets, the intermediate nodes append their own address and forwards to its neighbor. If the packet reaches the destination node then it will be checked by the destination node as to whether this route contains links with enough signal strength and whether it is disjoint from other available routes. Once the route has been established then QoS_ Reserve packet is transmitted on the selected route or routes and for this QoS Ack will be sent back to the source to guarantee that reservation is made correctly [1]. Resource (bandwidth) estimation is assumed available from the lower layers. Route maintenance is composed of two phases called pre-routing and rerouting and these are based on signal strength. If the signal strength below the threshold value then pre-routing occurs and rerouting occurs if it goes much lower.

**TDR [12]:** Trigger-based Distributed-QoS Routing is another location based protocol. In this every host node is required to maintain two data bases.One is about local neighbor and the other one is activity based. The mobility and location information are supposed to be transferred by the hosts and upon receiving this, neighbor nodes must record the power level as well as the location and mobility information in their local neighbor database. The routing information of every session is supposed to be recorded in activity-based database and it is refreshed by in-session data packets.

In the process of route discovery the stable route is selected by forming links with neighbors whose power level of the received packet is greater than the threshold value. Route maintenance of TDR is like ADQR protocol [1].

**BEQR [13]**: This protocol is based on AODV [14] for route discovery and it aims for providing soft QoS for better service with bandwidth constraint. Feedback scheme and admission scheme are the two schemes used in this protocol in which the admission scheme is for searching routes that satisfy bandwidth constraint, where as the feedback scheme is for updating the constraint if a node does not have enough residual bandwidth. Estimation of residual bandwidth is done in different ways like ratio of free and busy times or by listening to the channel, or by appending periodic AODV[14] hello messages with the node's current bandwidth and that of its one-hop neighbors. In this resource (bandwidth) reservation is not considered. This protocol is QoS aware and not for hard QoS guarantees.

**CEDAR [15, 1]** :Core Extraction Distributed Ad hoc Routing protocol was proposed by R.Sivakumar et.al[15].In this protocol core nodes have been selected by a distributed algorithm and these core nodes are responsible for route computation, route maintenance and also for QoS provisioning. The link state information is propagated to the nodes by using increase/decrease wave approach based on whether the network state is dynamic /stable respectively. Route computation is on-demand based and it consists of three components they are

(a)Destination location discovery and establishing the core path to destination

(b)Using core path as a directional guide line and establishing a short and stable QoS path between source to destination and

(c) If any topology changes or link failure occurs then dynamically re-establishing the route

CEDAR assumes resources (bandwidth) are reserved. [1]Depends upon the location of link failure occurs whether it is near to source or near to destination, the route maintenance in CEDAR is carried as source initiated route maintenance or dynamic route maintenance(initiated by intermediate core nodes).

**INSIGNIA [16]:** This protocol is proposed for adaptive services in ad-hoc networks. Adaptive services supports for services which requires minimum QoS guarantee (like minimum bandwidth) and when sufficient amount of resources are available then it can be extended to enhanced QoS service. INSIGNIA in-band signaling is the key component which supports fast reservation, restoration and adaption schemes to deliver the adaptive services [4].

In this protocol routing module is responsible for finding a route between source and destination and also it is used to forward the packets to next intermediate node. In case of topology changes then also it is to establish a new route. To carry the control information, each data packet contains an optional QoS field and the signaling information is encoded in to this optional QoS field. Resource (Bandwidth) reservation is done by admission control module and this reservation must be refreshed periodically by a soft state mechanism. If an application requires minimum bandwidth then bandwidth indicator flag is set to MIN else if the application requires certain maximum bandwidth but can operate with a certain minimum bandwidth below which they are useless then bandwidth indicator flag is set to MAX.

In case of any path break occurs then the ongoing routing is rerouted (route maintenance) by either by (a) immediate restoration which happens immediately, (b) degraded restoration which occurs when rerouted flow is degraded for a period "T" before it recovers to its original reservation and (c) permanent restoration, which occurs when the rerouted flow never recovers to its original reservation

**FA [17]-**Forward Algorithm is the class of on-demand algorithm with bandwidth as QoS constraint parameter. Modified version of AODV [14] is used for route discovery, where each routing packet is appended with additional information. For to measure the bandwidth of the path, this algorithm is calculates local maxima for adjacent links and forwards this calculated value during route discovery [3]. FA is not limited to only AODV [14] but also it can use other on demand protocols like TORA [18] and DSR [19] for route discovery. By using parts of old routes the route maintenance is effectively managed in this protocol.

## III.SUMMARY OF ROUTING PROTOCOLS

All the discussed MANET protocols in this paper are summarized in the following table

| Routing Protocol | QoS Metric | Route Discovery | Network architecture | Resource reservation | Route break prediction | Redundant route | Remarks |
|---|---|---|---|---|---|---|---|
| OLSR[6,7] | Bandwidth | Proactive | Hierarchical | No | No | No | Route reservation and maintenance are not considered |
| PLBQR[8] | Delay& Bandwidth | Proactive | Location Prediction | No | No | Yes | Inaccuracy in delay prediction affects the performance |
| TICKET BASED[9] | Delay& Bandwidth | Reactive | Flat | Yes | No | Yes | No clear heuristic for computing tickets |
| AQOR[10] | Delay& Bandwidth | Reactive | Flat | Yes | No | No | There is upper time bound after then only broken routes will be detected |
| ADQR[11] | Bandwidth | Reactive | Flat | Yes | Yes | Yes | Assumptions on bandwidth availability from lower layers. |
| TDR[12] | Bandwidth | Reactive | Location based | Yes | Yes | No | Fading increases control overhead. |
| BEQR[13] | Bandwidth | Reactive | Flat | No | No | No | Bandwidth (resource) is not reserved. |
| CEDAR [15] | Bandwidth | Hybrid | Hierarchical | Yes | No | No | Core may fail due to Software or Hardware |
| INSIGNIA[16] | Bandwidth | Reactive | Flat | Yes | No | No | Not Suitable for real time applications that require stringent QoS |
| FA[17] | Bandwidth | Reactive | Flat | Yes | No | No | Applications are restricted to small networks with low mobility |

Table.1. Comparison of MANET Routing Protocols

## CONCLUSION

Providing QoS Support in ad hoc wireless networks is one of the active research area and MANETs have certain unique characteristics that pose several difficulties in QoS provisioning .In this paper some of the existing MANET protocols with QoS support are discussed and their inherent qualities are listed in the form of table. Besides this review paper there are other survey papers covering the same topic like Lei Chen[1],Philip Becker[3] and ultimately the main aim of this review paper and other survey papers are to enable researchers to either improving the existing protocols or invent new protocols.

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