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Performance Analysis and Comparative Study of QoS Routing Protocols in MANET

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Abstract: ***MANETs is a special kind of wireless networks. It is a collections of mobile node without having of established infrastructure [1]. A MANET is an autonomous system of mobile nodes. The system may operate in isolation, or may have gateways to and interface with a fixed network. MANET includes easy installation and upgrade, low cost, maintenance and more flexibility. Quality-of-service (QoS) is the performance level of service offered by the network to the user, the major goal of QoS provisioning is to achieve a more deterministic network behavior, so that information carried by the network can be better delivered and network resource can be better utilized. This Article presents a thorough overview of QoS routing metrics, resources and factors affecting of QoS routing protocols. QoS routing protocols are classified accordingly to the QoS metrics used type of QoS guarantee assured.***

Keywords: QoS, MANETs, Ad hoc Networks, QoS aware routing, EI, Routing Protocols

1. Introduction

Mobile Ad Hoc Networks (MANETs) is a class of wireless networks that have been researched extensively over the recent years [1] MANETs allow ubiquitous service access, anywhere, anytime without any fixed infrastructure they can be widely used in military battlefields, crisis management services, classrooms and conference halls etc. MANETs fashion networking developments leads to development of enormous multimedia applications such as video-on-demand, video conferencing etc. Routing in mobile ad hoc networks and some fixed wireless networks use multiple-hop routing. However, most of the existing Ad Hoc routing protocols do not consider the QoS problem. Most of the multimedia applications have stringent QoS requirements that must be satisfied. However, there still remains a significant challenge to provide QoS solutions and maintain end-to-end QoS with user mobility. Most of the conventional routing protocols are designed either to minimize the data traffic in the network or to minimize the average hops for delivering a packet. [2, 16]

QoS routing protocols requires not only finding route from source to destination but a route that satisfies the end-to-end QoS requirements often given in terms of bandwidth (or) delay. A network or a service provider can offer different kinds of services to the users. Here a service can be characterized by a set of measurable pre specified service requirements such as minimum bandwidth, maximum delay, maximum delay variance (jitter), and maximum packet loss rate. After accepting a service request from the user the network has to ensure that the service requirements of the user's flow are met, as per the agreement, thought the duration of the flow (a packet from the source to the destination). After receiving a service request form the user, the first task is to find a suitable loop free path from source to the destination that will have the necessary resources available to meet the QoS requirements of desired service. This process is known as QoS routing. After finding a suitable path, a resource reservation protocol is employed to reserve necessary resources along that path [7, 13,14].

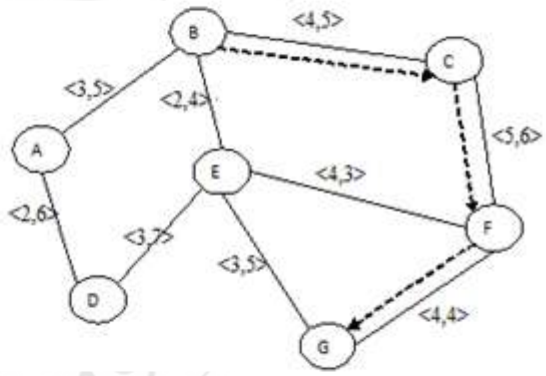

Figure 1: QoS routing in Ad hoc Wireless Networks

The Attributes of each link are shown in a tuple <Bandwidth, Delay>. Suppose a packet flow B to node G requires a bandwidth guarantee of 4 Mbps. Here six paths are available between node B to G as shown in Table 1 QoS routing selects paths 3 because out of the paths , paths 3 alone meets the bandwidth constraint of 4 Mbps for the flow. The end-to-end bandwidth of a path is equal to the bandwidth of the bottleneck link. The end-to-end delay of a path is equal to the sum of delays of all the links of a path. Clearly path 3 is not optimal in terms of hop count and /or end-to-end delay parameters, while path 1 is optimal in terms of both hop count and end-to-end delay parameters.

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Table 1: Available paths from node B to node G

No	Path	Hop count	End-to end Bandwidth(Mbps)	End-to-end Delay (ms)
1	B→ E→G	2	2	9
2	B→ E→F→G	3	2	11
3	B→C→F→ G	3	4	15
4	B→C→F→E→ G	4	3	19
5	B→A→D→E→G	4	2	23
6	B→A→D→E→F→G	5	2	25

2. Characteristics of QoS

The major challenges in providing QoS will lead to increase in computational and communicational cost. In other words, it requires more time to set up a connection and maintains more state information per connection. The improvement in network utilization counterbalances the increase in state information and the associated complexity and various issues are needed to be faced while providing QoS for MANETS. The major problems that are faced are as follows: [1] [2]

- Dynamically varying network topology
- Imprecise state information
- Lack of centralized control
- Error- prone shared radio channel
- Hidden terminal problem
- Limited power supply
- Mobility of the node
- Insecure medium

3. Evaluation Metrics for QoS Routing Protocols

As different applications and requirements, the services required by them and the associated QoS parameters differ from application to application. For example, in case of multimedia applications, bandwidth, delay and delay-jitter are the key QoS parameters, whereas military applications have stringent security requirements. The following is a sample of the metrics commonly used by applications to specify QoS requirement to the routing protocol.

- Minimum Throughput (bps) – the desired application data throughput. [7]
- Maximum Delay (s) – maximum tolerable end-to-end delay for data packets. [13]
- Maximum Delay jitter – difference between the upper bound on end-to-end delay and the absolute minimum delay. [14]
- Maximum Packet loss ratio - the acceptable percentage of total packets sent, which are not received by the final destination node. [6] The value of a metric over the entire path can be one of the following compositions [15]:

Additive metrics: This can be represented mathematically as follows:

$$m(p) = \sum_{i=1}^{LK} m(lk_i)$$

Where m (p) is the total of metric m of path (p), lki is a link in the path (p), LK is the number of links in path (p), and i= 1,…LK Delay, delay variation (jitter), and cost are examples of this type of composition. Various factors that determine the delay in communication networks are reviewed in [10][14].

Concave metrics: This can be represented mathematically as follows:

$$m(p) = \min(m(lk_i))$$

Bandwidth is an example of this type of composition. The bandwidth we are interested in here is the residual bandwidth that is available for new traffic. It can be defined as the minimum of the residual bandwidth of all links on the path or the bottleneck bandwidth.

Multiplicative metrics: This can be represented mathematically as follows:

$$m(p) = \prod_{i=1}^{LK} m(lk_i)$$

Loss probability is an indirect example of this type of composition.

Convex metrics: This can be represented as the maximum of all metric along the path

m(p)=max (m(lki))

Vulnerability (in context of security) and throughput use the convex rule. Whatever the metrics used in determining the path, these metrics must represent the basic network properties of interest. Such metrics include residual bandwidth, delay, and jitter. Since the flow QoS requirements have to be mapped onto path metrics, the metrics define the types of QoS guarantees the network can support.

4. Classification of QoS

The QoS solutions can be classified in two ways [2] [3] [5] [12] [17]

1) Based on the QoS approach employed.
2) Based on the layer.
3) Other QoS Solutions

4.1 Based on the QoS Approach Employed

The QoS approach can be classified into three categories as Based on the interaction between the routing protocol and the QoS provisioning mechanism, Based on the interaction

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between the network and MAC layer, Based on the routing update mechanism.

1) Based on the interaction between the routing Protocol and the QoS Provisioning mechanism.

The QoS approach can be classified into two categories are Coupled Qos Approach and Decoupled Qos Approach as follows [20][21] :

(a) Coupled QoS Approach. The coupled approach and the QoS provisioning mechanism closely interact with each other for delivering QoS guarantees. If the routing protocol changes, it may fail to ensure QoS guarantees.

- TBP - Ticket-Based QoS Routing Protocol.
- PLBQR – Predicate Location-Based QoS Routing Protocol.
- TDR- Trigger-Based Distributed QoS Routing Protocol.
- QoSAODV-QoS Enabled Adhoc On-Demand Distance Vector Routing Protocol.
- BR- Bandwidth Routing Protocol.
- OQR- On-Demand QoS Routing Protocols.
- OLMQR-On-Demand Link-State Multipath QoS Routing Protocol.
- AQR-Asynchronous Slot Allocation Strategies.
- CEDAR- Core Extraction Distributed Ad hoc Routing Protocol.
- INORA [19].

(b) Decoupled QoS Approach. The decoupled approach, the QoS provisioning mechanism does not depend on any specific routing protocol to ensure QoS guarantees.

- INSIGNIA [18]
- SWAN-Stateless Wireless Adhoc Networks.
- PRTMAC- Proactive Real Time MAC.

2) Based on the interaction between the Routing Protocol and the MAC Protocol.

This QoS approaches can be classified into two categories are Independent QoS Approaches and Dependent QoS Approaches as follows.

(a) Independent QoS Approaches. In the independent QoS Approaches, the network layer is not dependent on the MAC layer for QoS Provisioning.

- TBP- Ticket-Based QoS Routing Protocol.
- PLBQR- Predicate Location-Based QoS Routing Protocol.
- QoSAODV- QoS Enabled Adhoc On-Demand Distance Vector Routing Protocol.
- INORA [19].
- INSIGNIA [18].
- SWAN- Stateless Wireless Adhoc Networks.

(b) Dependent QoS Approaches. The dependent QoS approach requires the MAC layer to assist the routing for QoS provisioning.

- TDR-Trigger-Based distributed Routing Protocol.
- BR- Bandwidth Routing Protocol.
- OQR- On-Demand QoS Routing Protocols.
- OLMQR- On-Demand Link-State Multipath QoS Routing Protocol.
- AQR- Asynchronous Slot Allocation Strategies.
- CEDAR- Core Extraction Distributed Adhoc Routing Protocol.
- PRTMAC- Proactive Real Time MAC.

3) Based on the routing information update mechanism employed.

The routing information update mechanisms employed QoS approaches can be classified into three categories namely as Table-Driven QoS Approach, On-Demand QoS Approach and Hybrid QoS Approach.

(a) Table-Driven QoS Approach. In the Table-Driven approach each node in the network maintains a routing table which aids in forwarding packets.

- PLBQR- Predicate Location-Based QoS Routing Protocol [11].

(b) On-Demand QoS Approach. In the On-Demand approaches, no such tables are maintained at the nodes, and hence the source node has to discover the route on the fly.

- TBP- Ticket-Based QoS Routing Protocol.
- TDR- Trigger-Based Distributed Routing Protocol.
- QoS AODV- QoS Enabled Adhoc On-Demand Distance Vector Routing Protocol.
- OQR- On-Demand QoS Routing Protocols.
- OLMQR- On-Demand Link-State Multipath QoS Routing Protocol.
- AQR- Asynchronous Slot Allocation Strategies.
- PRTMAC- Proactive Real Time MAC.
- INORA [19].

(c) Hybrid QoS Approach. The hybrid approaches incorporates features of both the table-driven and the on-demand approaches.

- BR- Bandwidth Routing Protocol.
- CEDAR- Core Extraction Distributed Adhoc Routing Protocol.

4.2 Based on the Layer

In the layer wise of existing QoS solutions can be classified into three categories are MAC Layer solutions, Network layer solutions and QoS Frame works (cross layer solutions) as follows.

MAC layer solutions: The MAC protocol determines which node should transmit net on the broadcast channel when several nodes are competing for transmission on that, channel. The existing MAC protocol for Adhoc wireless networks use channel sensing and random back-off schemes, making them suitable for best-effort data traffic, real time traffic (voice and video) requires bandwidth guarantees. Some of the existing MAC protocols are belong to this categories are given below [8],

- Cluster TDMA-Time Division multiple access.
- 802.11e- IEEE802.11 task group e (TGe)
- DBASE-distributed bandwidth allocation sharing extension.
- MACA/PR-multiple access collision avoidance with piggy-backed reservation.
- RTMAC-real time MAC.

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Network layer solutions: The bandwidth reservation and real-time traffic support capability of MAC protocol can ensure reservation at the link level only hence the network layer support for ensuring end-to-end resource negotiation, reservation and reconfiguration is very essential. This category can be further classified into three types [10].

- Table-Driven
- On-demand
- Hybrid. In this classification were already discussed in the before categories.

QoS frame works (cross layer solutions): A frame work for QoS is a completed system that attempts to provide required/promised services to each user or application. All components within this system cooperate in providing the required services. The existing cross layer solutions are given below.

- INSIGNIA [18].
- INORA [19].
- SWAN- Stateless Wireless Adhoc Networks.
- PRTMAC- Proactive Real Time MAC.

4.3 Other QoS Solutions

COAAF (a context aware fuzzy based QoS approach)
Fuzzy logic approaches [22] had been applied in multiple resource assignment and control related problems, hence it can play major role in identifying and controlling the QoS on demand based on differentiable services over a Mobile node MANETs. COAAF employs fuzzy logic systems to determine the vehicle's speed over an effective time period for any type of service in use between multiple MANET nodes to engage or co-operate in communication The basic functions of the components in the module are described as follows. fQ can be gathered and determined based on fuzzification process, which consists of four modules being,

1) Fuzzifier,
2) Fuzzy rule base,
3) Inference engine,
4) Defuzzifier. The need for system reliability and varying aspects of QoS of the actual obtained measure of QoS in relation to QoS on demand for a service is highly an abstract value.

EI based QoS Routing in MANET: Emergent Intelligence (EI)[23] is an intelligence process to solve the problems with the help of group of agents and nodes. This scheme dynamically monitors behavior and abnormalities of entities in the group and provides the information to the respective agents during interaction to take decisions and which will be used later for sharing with other agents.

5. Summary of QoS Aware Routing Protocols

To facilitate a comparison among the various QoS-aware routing protocols, the salient features of the QoS routing protocols is described in a Table 2. The table lists the design constraints listed, such as Route discovery, Resource reservation, Route maintenance, QoS metrics constrained, Network architecture and routing overhead and discussing how each protocol addresses[4][9].

Table 2: QoS Aware Routing Protocols

Routing Protocol	Network Architecture	Route Discovery	Type of QoS guarantee	Resource Reservation	QoS Metrics	Routing Overhead
CEDAR	Hierarchical	Proactive / Reactive	Soft	Yes	Bandwidth	Core Setup
MRP	Hierarchical	Reactive	Soft	Yes	Bandwidth	Full Flooding of RREQ
GAMAN	Hierarchical	Reactive	Soft	Yes	Bounded delay, packet loss rate	Node traversal delay
PLBQR	Location prediction	Proactive/ Reactive	Soft	No	Delay and Bandwidth	Route recomputation in anticipation of link breakage
QMRPD	Hierarchical	Reactive	Pseudo-hard	Yes	Bandwidth, delay, delay-jitter and cost	Less message processing overhead
QOLSR	Hierarchical	Proactive	Soft	Yes	Throughput and delay	Minimum flooding of RREQ
AQOR	Flat	Reactive	Soft	Yes	Bandwidth and delay	Full flooding of RREQ
TBR	Flat	Reactive	Soft	Yes	Bandwidth and delay	Minimum flooding of RREQ
QAODV	Flat	Reactive	Soft	No	Bandwidth and delay	Node traversal delay

6. Conclusion

In this paper , the major challenges involved in the design of a QoS routing protocol and the different classification , evaluation of metrics and Comparison of QoS Aware routing protocols for Ad hoc Wireless Network were described. The major goal in providing Qos in Ad hoc wireless network must dynamic varying network topology, lack of precise state information, lack of a channel controller, error-prone shared radio channel, limited power supply, hidden terminal problem and insecure medium.

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