Mobile Ad hoc Network: Issue and Challenges Related to QoS and Solutions

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ABSTRACT
Mobile Ad Hoc Network (MANET) applications such as multimedia applications, audio/video conferencing, VOIP and webcasting need uninterrupted, stringent and inflexible Quality of Service (QoS). The provision of QoS guarantees in MANET is more challenging and difficult than wired network because of node mobility, lack of centralized control and a limited power supply. A lot of researches have been accomplished and also ongoing so far to offer QoS guarantees by designing QoS models and protocols. In the past some years, a number of QoS routing protocols for MANET with distinguish features have been designed. In this paper issues and challenges of QoS, overview of QoS routing metrics, and various performance metrics have been discussed.

KEYWORDS MANET, QoS, QoS Protocols, Performance Metrics.

1. INTRODUCTION
A MANET (an advanced version of traditional wireless network), known as mobile mesh network, is a self configurable and self organize network of portable devices which can communicate each other using single hop as well as multi-hop manner over wireless links as shown in Figure 1. Its topology frequently keeps on changing with time, that ‘why, routing path are formed and deleted arbitrarily due to the node’s mobility [1].

![Figure 1: A Mobile Ad-Hoc Network](image1)

MANET is supposed to be a dominating network in the coming time. With the advent of wireless prevalence such as MANET, Sensor Network, VANET etc., there are lot of applications coming and adapting to wireless techniques to communicate and getting dominance over wired network [2]. QoS guarantee is much more challenging task in wireless multi-hop networks than wire line networks because of its mainly multi-hop communication, frequently varying topology, interference, distributed on-the-fly nature and channel access contention. Some of the features of MANET are compared with one of the other wireless ad hoc network (Sensor Network) in table 1.
<table>
<thead>
<tr>
<th>Features</th>
<th>MANET</th>
<th>Ad Hoc Sensor Networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility</td>
<td>Varies (slow to fast)</td>
<td>Limited</td>
</tr>
<tr>
<td>Decentralized control</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Energy deficient</td>
<td>Yes. But this is of secondary importance as battery packs can be replaced</td>
<td>Yes, it is of primary importance</td>
</tr>
<tr>
<td>Bandwidth deficient</td>
<td>Yes</td>
<td>Sometimes</td>
</tr>
<tr>
<td>Data rate</td>
<td>High</td>
<td>Low [1-1000 Kbps]</td>
</tr>
<tr>
<td>Flow of data</td>
<td>Bi-directional</td>
<td>Mostly Uni-directional [sensor to sink]</td>
</tr>
<tr>
<td>Fault tolerance</td>
<td>Needed as mobility increases</td>
<td>Needed only if nodes exhaust available energy or are moved</td>
</tr>
<tr>
<td>Main Goal</td>
<td>To optimize QoS and high bandwidth efficiency</td>
<td>Prolonging the life of the network through aggressive energy management, to prevent connectivity degradation.</td>
</tr>
<tr>
<td>Traffic</td>
<td>Multimedia rich</td>
<td>Statistical and Multimedia</td>
</tr>
<tr>
<td>Basic features of routing protocol</td>
<td>Loop free, energy and bandwidth efficient, secure, provides QoS, fault tolerant and reactive instead of proactive, and distributed in nature</td>
<td>Most of the same features as for MANETs, but with less emphasis on mobility and more emphasis on energy efficiency, scalability, and multipath connectivity.</td>
</tr>
<tr>
<td>Redundancy in data</td>
<td>No</td>
<td>Very few</td>
</tr>
<tr>
<td>QoS</td>
<td>Highly needed</td>
<td>Lesser as compared to MANET</td>
</tr>
</tbody>
</table>

In recent times, with the proliferation of infrastructure-less and inexpensive nature of MANETs, ongoing research on a broader level has been shifted up to provide assurance related to QoS in the. To accommodate applications in MANET, some specific QoS parameters like delay, bandwidth, energy etc. needs to be taken into account which can utilize the limited resources efficiently. None of the traditional approach or routing protocol deals with these characteristics efficiently in MANET in their implementation [3][4].

2. ISSUE DUE TO QOS IN MANET

The goal of QoS provisioning is to get more deterministic network behaviour, so that information carried by the network can be better delivered and network resources can be better utilized [5][6]. There are significant issues related to QoS solutions in MANET which have been discussed below [7][8].

1. Mobility of the node: Since the nodes considered here are mobile nodes, that is they move independently and randomly at any direction and speed, the topology information has to be updated frequently so as to provide routing to reach the final destination which result in again less packet delivery ratio and bound to affect the QoS [9].

2. Unreliable channel: The bit errors are the main problem which arises because of the unreliable wireless channels. These channels cause high bit error rate and this is due to high interference, multipath fading effects and so on. This leads to low packet delivery ratio. Since the medium is wireless in the case of MANETs, it may also lead to leakage of information into the surroundings, a serious threat to QoS in network [10].
3. MANET Scalability

Although, the heterogeneous networks consist of different nodes with different resource but still has better scalability as compared to homogenous networks. Homogenous networks even, are easy to model and analyze but they exhibits outdated and sub optimal decision which leads to poor scalability and affects the QoS as shown in the Figure 2.

![Figure 2: General view of MANET scalability](image)

4. Maintenance of route: The dynamic nature of the network topology and changing behaviour of the route makes the maintenance of network state information very tedious task. The established routing paths may be broken even during the process of data transfer. That ‘why the need for maintenance and developing of paths in MANET with minimum routing overhead and delay causes the QoS.

5. Limited power supply: The mobile nodes are generally inhibited by limited power supply compared to the nodes in the wired networks. Offering QoS to the network absorb more power because of overhead from node which may drain the node’s power quickly.

6. Lack of centralized control: The node in MANET can join or leave dynamically and the network is set up unexpectedly. So, there is not an any provision of centralized control on the nodes which leads to increased algorithm’s overhead and complexity, as QoS state information must be disseminated efficiently.

7. Channel contention: Nodes in a MANET must communicate with each other on a common channel so as to provide the network topology. However, this introduces the problems of interference and channel contention which is an issue for QoS. This requires a distributed channel selection mechanism as well as the dissemination of channel information.

8. Security: Security can be considered as an important QoS attribute in MANET. Without offering a satisfactory security provision, unauthorized accesses and usages may infringe the QoS negotiations. The nature of transmission of packets in the network may lead to more security exposures. Hence, we need to design more security-aware routing algorithms for this kind of network.

3. EVALUATION METRICS FOR QOS ROUTING PROTOCOLS

In MANET each application has its own different requirements and the services. The related QoS parameters in the network differ from application to application. For instance, in the multimedia applications, packet loss, delay, bandwidth and jitter (delay variation) are the main QoS parameters, whereas in the military type applications strict and reliable security requirements are demanded [11][12].

The value of a metric over the entire path can be one of the following compositions:

- **Additive metrics** - This can be represented mathematically as follows

\[
m(p) = \sum_{i=1}^{L} m(lk_i)
\]
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 \( i=1,\ldots LK \). Delay, delay variation (jitter) are examples of this type of composition. Various factors that find out delay in wireless networks are reviewed.

- **Concave metrics**: This can be represented mathematically as follows:
  \[
  m(p) = \min (m(lki))
  \]

  Where bandwidth is an best example of this type of composition. This bandwidth is here, the residual bandwidth that is available for new transfer of packets in the network. It is the minimum of the residual bandwidth of all links on the path in the network or we can say, the bottleneck bandwidth.

- **Multiplicative metrics**: This can be represented mathematically as follows:

  \[
  m(p) = \prod_{i=1}^{L K} m(lki)
  \]

  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

  \[
  m(p) = \max (m(lki))
  \]

  Here, 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. These metrics include residual bandwidth, delay, and jitter. Therefore, the flow of QoS requirements have to be mapped onto path metrics in MANET. Hence the metrics illustrate the types of QoS guarantees, a network can support [12].

4. **PERFORMANCE METRICS USED FOR MENET**

The set of constraints in the network which tend to regulate for a specific link to satisfy the requirements for a specific application is known as QoS metrics. The following are sample of the metrics commonly used by applications to specify QoS requirement [3].

a. **Throughput**

In MANETs throughput is measure as a rate of successful packets delivery over a wireless channel. This data can be forwarded over logical link, or pass through a certain network node. The throughput is generally measured in bits per second (bps or bit/s), or sometimes in data packets per second, or data packets per time slot.

\[
\text{Throughput} = \frac{\text{Total packet received}}{\text{amount of forwarded packet}} \text{ over certain time interval}
\]

b. **Dropped Packets**

These are the number of packets that sent from the source node and fail to reach the destination node.

\[
\text{Dropped packets} = \text{sent packets from source} - \text{received packets at destination}
\]

c. **Mean inter arrival time**

Mean inter-arrival time is the summation of inter-arrival times by the number of received packets and can be computed by the following equation

\[
\text{av} = \frac{\sum ai}{n}
\]

where \( av \) is mean inter arrival time, \( ai \) is arrival time of the packet and \( n \) is the number of received packets.

d. **Average end to end delay**

End to End delay represents the time required to move a packet from source node to destination node. The average end to end delay can be calculated by summing the times taken by all received packets divided by its total numbers.

\[
\text{Average E-2-E} = \frac{\sum (\text{received time-sent time})}{\sum (\text{number of packets})}
\]
It is the accumulation of queuing delay, transmission delay and end system processing delay in mobile node; propagation delay in the links. Lesser End to End delay (E2E) implies better performance in network.

e. Jitter

In MANET, Packet jitter is measured as an average of the variation in latency from the network mean latency. However, the standard based term is "packet delay variation" (PDV) which is an important quality of service (QoS) factor in assessment of network performance. A network with constant latency has no jitter.

\[
Jitter \ (J) = D_{i+1} - D_i
\]

where \(D_{i+1}\) is the delay of \(i+1\) packet and \(D_i\) is the delay of \(i\)th packet.

f. Packet delivery fraction (PDF)

It can be expressed as the ratio of the delivered packets at destination to the packets sent from the source node [Imran Khan et. al. 2006].

\[
PDF = 100\% \left( \frac{\text{Number of received packets}}{\text{Number of sent packets}} \right)
\]

g. Normalized Routing Load metric

The routing load metric evaluates the efficiency of the routing protocol. Note, however, that these metrics are not completely independent. For example, lower packet delivery fraction means that the delay metric is evaluated with fewer samples. In the conventional wisdom, the longer the path lengths, the higher the probability of a packet drops. Thus, with a lower delivery fraction, samples are usually biased in favour of smaller path lengths and thus have less delay.

5. CONCLUSION

In this paper, we have discussed several issues and challenges involved in providing QoS. an basic overview of QoS metrics and design considerations is also provided. We have summarized QoS routing metrics and performance measurements for MANET.

REFERENCES