Quality of Service for Ad hoc On-Demand Distance Vector Routing
draft-perkins-manet-aodvqos-00.txt

Abstract

The Ad hoc On-Demand Distance Vector (AODV) routing protocol is intended for use by mobile nodes in an ad hoc network. It offers quick adaptation to dynamic link conditions, low processing and memory overhead, low network utilization, and determines both unicast and multicast routes between sources and destinations. To
provide quality of service, extensions can be added to the messages used during route discovery. These extensions specify the service requirements which must be met by nodes rebroadcasting a Route Request or returning a Route Reply for a destination. This draft describes how service guarantees are met using these extensions.
1. Introduction

Route discovery in AODV is on-demand and follows a route request/route reply query cycle. When a source is in need of a route to a destination, it broadcasts a Route Request (RREQ) control in search of a route. Nodes having a current route to the indicated destination respond by unicasting a Route Reply (RREP) to the source node. To provide quality of service, extensions can be added to these messages during the route discovery process. A node which receives a RREQ with a quality of service extension must be able to meet that service requirement in order to either rebroadcast the RREQ (if it does not have a route to the destination) or unicast a RREP to the source. For more details on the route discovery process, please see the AODV Internet Draft [2].

This document specifies extensions which can be used to ensure maximum delay and minimum bandwidth along a route between a source and destination.

This protocol specification uses conventional meanings [1] for capitalized words such as MUST, SHOULD, etc., to indicate requirement levels for various protocol features.

2. Quality of Service

Using the extensions in this document, AODV enables mobile nodes in an ad hoc network to specify, as part of a RREQ, Quality of Service requirements that a route to a destination must satisfy. In particular, a RREQ MAY include a QoS Object extension (see Section 3.2) which includes bandwidth and delay parameters. In order to enable accumulated measurement for end-to-end delay, AODV also provides an Maximum Permissible Delay extension (see Section 3.4).

If, after establishment of such a route, any node along the path detects that the requested Quality of Service parameters can no longer be maintained, that node MUST originate a ICMP QOS_LOST message back to the node which had originally requested the now unavailable parameters.
3. Extensions

Several extensions are needed in the routing table structure and the RREQ and RREP messages for supporting QoS routing. The extensions defined in this section conform to the format defined for extensions to RREQ and RREP messages as specified in [2]. We first describe the extensions needed for the routing table.

3.1. Routing Table Extensions

The following fields are added to each route table entry corresponding to each destination requesting QoS.

- Maximum Delay
- Minimum Available Bandwidth
- List of Sources Requesting Delay Guarantees
- List of Sources Requesting Bandwidth Guarantees

3.2. QoS Object Format

The QoS information about a microflow is expected to be encoded into a standard format [3], illustrated in figure 1. The standard format allows both complete flexibility for specification of arbitrary values for various QoS requirements, and also allows very compact representation, especially for well-known requirements for common applications such as voice over IP (VoIP). In this section, we present the standard object format. This object format is used as the main part of the QoS Object Extension (see section 3.3).

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reserved</td>
<td>Sent as 0, value unused and undefined on reception</td>
</tr>
<tr>
<td>QoS Profile Type</td>
<td>If nonzero, an index for a list of QoS parameter field definitions and default values for those fields. If zero, the fields are as listed below in this section, and there are no default values.</td>
</tr>
</tbody>
</table>
NNNNN

If QoS Profile Type is zero, this bit is not defined to be part of the QoS Object format. Otherwise, if the QoS Profile Type is nonzero, when the 'N' bit is set, the next 31 bits are part of the "Non-Default Values" bit vector.

Non-Default Values
A bit vector with one bit for each field parameter field defined for the particular QoS Profile Type number.

QoS Parameter Fields
Defined in accordance with the QoS Profile Type. If the profile type is 0, then the fields are as defined below in this section.

For QoS Profile Type zero, the following parameter fields are defined

Capacity Requirement

32-bit number, measured in bits/second
Maximum Permissible Delay

16-bit number, measured in milliseconds

Maximum Permissible Jitter

16-bit number, measured in milliseconds

Traffic Class

According to Differentiated Services Code Points

3.3. QoS Object Extension Format

A node MAY append a QoS Object extension to a RREQ in order to find a path that satisfies the QoS parameters which are present in the QoS Object, which is situated within the QoS Object extension data.

```
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Type     | Length     | QoS Object (variable) ... |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type         TBD

Length       variable

QoS Object   variable length; as defined in section 3.2.

A node originating a RREQ message MAY append a QoS Object Extension after the RREQ data. If a delay parameter is specified, either explicitly or implicitly by a default value for some QoS Profile type, the originating node MUST also append a Maximum Delay Extension for use of the intermediate nodes that need to accumulate the expected value for delay across various candidate paths.

Likewise, if an originating node specifies a maximum value for allowable Jitter as part of the QoS parameter data, either explicitly
or implicitly, it MUST also append a Maximum Jitter Extension after the QoS Object extension.

3.4. Maximum Delay Extension Format

The Maximum Delay Extension Format may only be applied to RREQ messages containing the QoS Object extension. It provides information about the cumulative delay that has been experienced by nodes along the path from the originating node to the node currently processing the RREQ.

```
+------------------+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     |           Delay               |
+------------------+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type         TBD
Length       2
Delay        This field indicates the current estimate of cumulative delay from the originating node up to the intermediate node retransmitting the RREQ on behalf of the originating node.

The Maximum Delay Extension can be appended to a RREQ by a node requesting a QoS route in order to measure the existing delay from the originating node, in order to determine whether the path can still meet the required Maximum Delay specification within the QoS Object data.

Before forwarding the RREQ, an intermediate node MUST compare its NODE_TRAVERSAL_TIME to the (remaining) Delay indicated in the Maximum Delay Extension. If the Delay is less, the node MUST discard the RREQ and not process it any further. Otherwise, the node subtracts NODE_TRAVERSAL_TIME from the Delay value in the extension and continues processing the RREQ as specified in [2].
A node forwarding a RREP also records the Source IP address in RREP message in the list of source nodes requesting delay guarantees in the corresponding destination’s route table entry. These source nodes are to be notified with an ICMP QOS_LOST message in case there is a change in NODE_TRAVERSAL_TIME at this node.

3.5. Maximum Jitter Extension Format

The Maximum Jitter Extension Format may only be applied to RREQ messages containing the QoS Object extension. It provides information about the cumulative jitter that has been experienced by nodes along the path from the originating node to the node currently processing the RREQ.

```
| Type | Length | Jitter |
+------|--------|--------|
```

Type          TBD
Length        2
Jitter        This field indicates the current estimate of cumulative jitter from the originating node up to the intermediate node retransmitting the RREQ on behalf of the originating node.

The Maximum Jitter Extension can be appended to a RREQ by a node requesting a QoS route in order to measure the existing jitter from the originating node, in order to determine whether the path can still meet the required Maximum Jitter specification within the QoS Object data.

Before forwarding the RREQ, an intermediate node MUST compare its approximate jitter to the (remaining) Jitter indicated in the Maximum Jitter Extension. If the Jitter is less, the node MUST discard the RREQ and not process it any further. Otherwise, the node subtracts
its estimated jitter value from the (remaining) Jitter value in the extension and continues processing the RREQ as specified in [2].

A node forwarding a RREP also records the Source IP address in RREP message in the list of source nodes requesting jitter guarantees in the corresponding destination’s route table entry. These source nodes are to be notified with an ICMP QOS_LOST message in case there is a substantial change in the jitter experienced at this node.

4. ICMP QOS_LOST Message

An ICMP QOS_LOST message is generated when an intermediate node experiences a significant change in its ability to live up to the QoS guarantees it has made as part of generating a RREP during the QoS Route Discovery process. The format of this message is as follows.

```
+----------------+----------------+----------------+----------------+----------------+
|     Type      |           Dest.  |
+----------------+----------------+----------------+----------------+----------------+
|                |                   |
+----------------+----------------+----------------+----------------+----------------+
|                | IP address      |
+----------------+----------------+----------------+----------------+----------------+
|                |
```  

Type 8

Destination IP address

IP address of the destination node using the link for which there has been a change in a QoS parameter.

This message is extended using the QoS Object Extension (see section 3.2). Typically, QoS Profile Type zero is used, with field reporting the actual measured parameter which fails to meet some previously requested QoS. For instance, the Minimum Bandwidth field is used when there is a drop in link capacity and the change in bandwidth is indicated in the Capacity Requirement field. The Maximum Permissible Delay parameter is present when there is a substantial increase in the forwarding delay at a particular node; likewise for the Maximum Permissible Jitter parameter.
The QOS_LOST message is forwarded to all sources potentially affected by the change in the QoS parameter. These are those sources to which a RREP with a QoS extension has been forwarded before. Recall that these sources are recorded in a list as a part of the route table entry.

5. Security Considerations

This draft specifies mechanisms for handling quality of service. It does not introduce any special security considerations which were not already present in the AODV routing protocol [2].
References


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