Alternate Route for Improving Quality of Service in Mobile Ad hoc Networks

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Summary

ARQoS is an on-demand routing protocol for mobile ad hoc network, where the routing table of ARQoS maintains an alternate route to the specified node by considering the bandwidth requirement of the source node. The route is discovered by calculating the corresponding QoS provision parameter to find the primary route and the alternate route from the source node to destination by applying the mechanism of carrier sense in IEEE 802.11b. In ARQoS the route is rediscovered when both the primary route and the alternate route fails.

In this paper, the Ad hoc On-demand Distance Vector (AODV) routing protocol is improved to support primary route and alternate route for better QoS and a framework is described based on using QoS parameter in route discovery process that can significantly reduce end-to-end delay and increase packet delivery ratio under conditions of high load and moderate to high mobility.

Keywords
Ad Hoc, ARQoS, AODV, packet delivery, bandwidth, alternate route

1. Introduction

MANET (Mobile ad-hoc networks) consists of mobile nodes capable of moving freely, they operate independently, or may have attachment at some point(s) or gateways to the fixed network [1]. MANETs are ad hoc network and are relatively easy for deployment for various emergency communications like post disaster rescue operations, military applications and instant communications such as meetings and conferences etc.

Mobile ad-hoc networks can turn the dream of getting connected “anywhere and at any time” into reality. MANETs are expected to be based on all-IP architecture and be capable of carrying multitude real-time multimedia applications such as voice, video as well as data [2]. MANET applications required to meet certain level of performance in terms of delay and bandwidth applications are expected to ensure quality transmission and reception [3]. To achieve these better QoS routing support has to be provided. The important purpose of QoS routing is to set up a loop-free path satisfying a given set of QoS constraints like bandwidth [4]. If network QoS is not in place, real time traffic like IP voice or videoconferencing calls will be unreliable, inconsistent, and often unsatisfactory [5, 6].

The prerequisite for QoS in MANET is challenging because of its unique characteristics: the mobility of nodes which causes the network topology to be changed dynamically and the shared wireless medium [5]. The routing protocols used in MANET are classified into two categories: Proactive and Reactive. In this work, QoS provision in reactive protocol and is based on AODV protocol where it is a purely on demand.

Different routing protocols have been designed and studied for their performance in the literature Some conventional and well studied routing protocols for MANETs include Ad hoc On-demand Distance Vector (AODV) routing [7], Dynamic Source Routing (DSR) [8], Optimized Link State Routing (OLSR) [9] and one of the most recently proposed protocols; Dynamic MANET On-demand (DYMO) routing [10]. None of the proposed protocols provide acceptable QoS for real-time traffic. A large amount of work has been done to develop new QoS routing protocols for MANETs [11], [12], [13], as well as extending existing protocols with QoS features [14], [15], [16], [17]. To the best of our knowledge, these protocols are all experimental and none of them are considered for standardization.

The proposed model ARQoS is based on AODV routing protocol and refinement is made to AODV to increase the QoS in ARQoS each source node maintains an alternative route to the specified destination node by considering the QoS parameters (bandwidth). In the proposed scheme when the primary route fails considering the QoS parameters at the best utilization the source node will use the backup route to send packets. In ARQoS the advantage is that due to mobility of the nodes an alternate route is always available for packet routing even when the primary route fails not by sacrificing the QoS for packet transmission. Further in

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ARQoS the route is rediscovered when both the primary and the alternative route fails.

The rest of the paper is organized as follows. Section II briefly describes the routing operations of AODV. Section III describes our proposed method ARQoS and presents the details of the packet structures with the conventional AODV. Finally conclusions and future work is drawn in Section IV.

2. The AODV Routing Protocol

AODV is a reactive routing protocol for MANETs that uses hop count as metric for route selection. It uses three main message types for route discovery and maintenance: Route Request (RREQ), Route Reply (RREP) and Route Errors (RERR) messages. When a source node needs to send data, it initiates a route discovery process by broadcasting a route RREQ) message to its neighbors until it reaches the destination. or an intermediate note with a valid route to the destination or any intermediate nodes having a fresh route to the destination generates a route reply (RREP) in response to the RREQ [4]. Each node stores only information of the next hop in a route to a destination. Whenever a link breakage occurs, any node detecting this immediately notifies all nodes that used the link that the link no longer exists. This is done by sending a RERR message to all these nodes.

Internet Engineering Task Force (IETF) drafts have proposed several extensions in the routing table structure and the RREQ and RREP message formats for supporting QoS routing. RREP and RREQ will carry the QoS information. The fields need to be added to each route table entry is based on the different requirement to attain QoS.

3. Proposed ARQoS

In ARQoS the original AODV is extended where each source node maintains an alternative route based on QoS parameter (bandwidth) to the specified destination node. When the primary route fails, the source node will use the alternate route to send packets not by sacrificing QoS. In the proposed ARQoS source not only improves the packet routing process, packet delivery fraction and also reduce the average end to end delay and the route discovery frequency.

3.1 Route Request Packet Structure

Few additions are made to the routing table entries and routing tables of AODV to satisfying primary route and alternate route differentiation along with QoS parameters for packet delivery. We add a flag in the aodv_rt_entry class to distinguish between primary routes and alternative routes, and we also add two functions in the aodv_rtable class which are used to add and find an alternative route in routing tables. As in AODV if either the destination or any intermediate nodes having a fresh route to the destination generates a route reply RREP in response to the RREQ. When a source node needs to send a packet to a destination node while there is not a valid route in the routing table, it broadcasts a route request packet RREQ to find a route to the destination node. A RREQ packet contains <ARQoS RSV, ARQoS_min and AQoS_max, ARQoS RREQ header> where ARQoS RREQ header has the source identifier, destination identifier, source sequence number, broadcast identifier, time to live field, and a hop count. When each node receives the RREQ, it creates or updates a reverse route to the source node in the routing table based on the residual bandwidth and requested bandwidth and stores these values in the routing table of node. If the node does not have a valid route to the destination node in the routing table, it re-broadcasts the RREQ. If each node has a valid route to the destination node in the routing table when it receives the RREQ, it sends the RREP to the source node along with the reverse route. During the route discovery process, when each node receives the RREQ that it has been already processed, it discards the RREQ, which guarantees loop freedom.

Option Type	Flags	raodv_rt_entry		Hop Count
SRC IP address	Dest IP address			
Src Seq Num	Dest Seq Num			
RREQ ID				
ARQoS RSV		ARqoS Max	ARQos Min	

Table 1: Alternate Route Request Packet Structure

In Fig. 1 Node 1 broadcast the RREQ to find the best possible route to the destination by considering the Residual bandwidth and the Requested bandwidth with the different set of nodes in the transmission range.

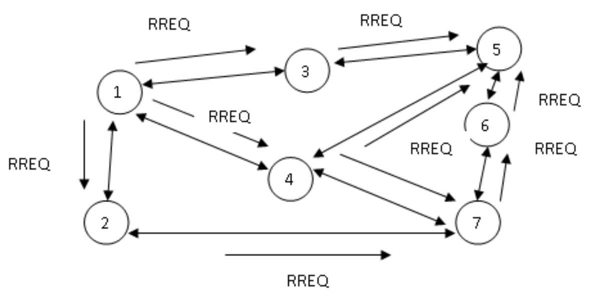

Fig.1: Route Request for finding route from source to destination.

When a node needs a new route to a destination, it initiates a route discovery process. The steps in Route Discovery process are listed below:

- The source node first calculates the needed bandwidth and examine the links between itself and neighbor nodes. If there is enough available bandwidth, the source node generates a RREQ packet, and sets up a routing table for this data packet and broadcast the RREQ packet.
- An intermediate node receiving a RREQ examines the links between itself and neighbor nodes, if the required bandwidth is available the RREQ packet is rebroadcast and a reverse path to the source node is set up if there are enough available bandwidth till the destination receives the RREQ packet.
- When there are more than one nodes meet the need of bandwidth, the source node will choose the best path basing on the delay and the other alternate path is kept in the routing table of the source node with the raodv_rt_entry field set as enabled to know that there exits and alternate path.
- Further an alternative route from the source to the destination is recorded in the routing table entries of the routing tables of ARQoS routing protocol, if the source node fails to transmit the packet from the earlier chosen route then the alternate/backup route will be very much useful.
- When the destination receives a RREQ it generates a RREP. The RREP is routed back to the source node via the reverse path established previously. As the RREP travels towards the source, a forward path to the destination is established. Then the source node sends a packet to reserve the bandwidth, ensuring that the resources are not used by other applications.

3.2 Route Reply Procedure in ARQoS

Route request packets are used to obtain rout(s) to the destination and to specify the QoS level required along with the flag to differentiate between the primary route and the alternate route. The RREP packet structure varies depending on the routing protocol. To enable QoS support in the RREP packet two extra fields are needed as illustrated in Table 2. These fields are called Raodv-rrep-flag and QoS flag to differentiate between the primary route and the alternate route.

<table>
<tr><td>Reserved</td><td>Type</td><td>Raodv-rrep-flag</td><td>Hop Count</td></tr>
<tr><td>Dest Seq Num</td><td colspan="3">Dest IP address</td></tr>
<tr><td>Src IP address</td><td colspan="3">Lifetime</td></tr>
<tr><td colspan="4">QoS</td></tr>
</table>

Table 2: Alternate Route Request Reply Packet Structure

Route reply process is performed when a route request packet arrives at the destination. When the destination node receives the RREQ, The destination node creates or updates the reverse route RREP based on the QoS parameters and also the alternate route from the source to destination on the residual bandwidth with the requested bandwidth. The reason for allowing only the destination to initiate the route reply is twofold. First, the route reply process provide to the source a route to the destination and second it allocates the QoS value (i.e. bandwidth) required by the application. QoS allocation is performed by the route reply process due to the fact that once the route request packet arrives at the destination it carries the information about what is the maximum QoS value supported along the entire route (i.e., the contents of QoS RSV field in the RREQ packet). Based on this, only the destination is allowed to initiate the route reply process and then it propagates a route reply packet RREP with incremented destination sequence number and sends the RREP packet via the reverse route to the source node. When each node receives the RREP, it creates or updates a forward route to the destination node before it forwards the RREP to the source node along with the alternate route. When the source node receives the RREP packet, it creates or updates the forward route along with the alternate route, and then starts communications with the destination node finding the better route based on the QoS parameters.

The principal goal of this process is to provide the source with a route(s) to the destination that meets the QoS value required (The source node then selects the best route in terms of the QoS metric chosen).

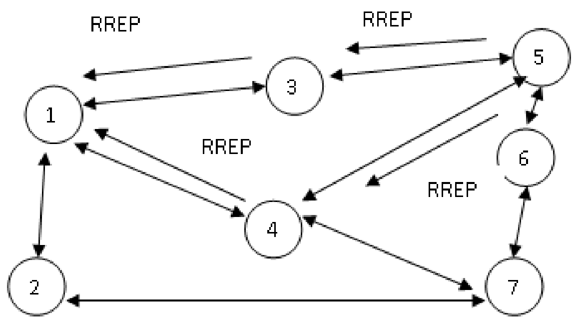

Fig. 2: Route Reply from destination to source satisfying bandwidth requirement.

As depicted in Fig 2, Assume, when node 3 receives the RREQ, it propagates a RREP packet towards node 5. When node 4 receives the RREQ packet forwarded by node 1, it forwards the RREQ packet to node 5. Assuming that the routing table of node 3 and 4 doesn't have a valid route to node 5, then node 3 and 4 forwards the RREQ packet to node 5. Node 5 sends a RREP packet which has an incremented destination sequence number to node 1. When the RREP propagated by node 3 is forwarded to node 1, the route 1-3-5 will be written to the routing table of node 1. Then node 1 starts to send packets to node 5. When the RREP propagated by node 5 reaches node 1, the route 1-3-5 should not be discarded as well as here both the routes have to be compared for the QoS parameters and select the best possible available route from the source 1 to destination 5 before discarding any packet the QoS parameters have to be checked for finding out the best possible route to route the packet.

3.3 ARQoS Route Maintenance

ARQoS Maintenance is the process in charge of maintaining acceptable levels of QoS in the network for the duration of the data flow. Once a QoS route is established, it must be kept until the end of the data flow. In the presence of link partitions, QoS route maintenance must select the alternate route already enabled in the RREP packet to avoid interruption in the data transmission (to make the error invisible to the user).

Congestion control is important to perform an efficient utilization of resources (e.g. bandwidth) the bandwidth available in the network decreases as the number of QoS reservations increase. Hence, admission control (AC) mechanism is needed to assure that the channel is still meeting the requirements that the applications require.

4. Conclusion

In this paper we provided a frame work for improving the possible enhancements to AODV routing protocol to improve the Quality of Service. Future work will be to evaluate the performance of this proposed ARQoS routing protocol with other protocols by using Formal methods and by extending the implementation of ARQoS with different QoS parameters.

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