Analysis of QoS Attributes for AODV Routing Protocol in MANETS

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Abstract

Quality of Service () for MANETS is an industry-wide set of standards and mechanisms for ensuring high-quality performance for critical applications. The goal is to provide preferential delivery service for the applications that need QoS by ensuring sufficient bandwidth, controlling latency and jitter, and reducing data loss. In this paper, various attributes of QoS like bandwidth, end-to-end delay, jitter, Resource reservation for Ad hoc On-demand Distance Vector (AODV) routing protocol are addressed.

Keywords*: *MANET, QoS, AODV, bandwidth and jitter

1. Introduction

A "Mobile Ad hoc Network" (MANET) is an autonomous system of mobile routers (and associated hosts) connected by wireless links forming an arbitrary graph. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. The device must forward traffic unrelated for its own use, and therefore act as a router. Such networks operate in a stand-alone fashion, or may be connected to the Internet.

The routing protocols meant for wired networks can't be used for Mobile Ad hoc Networks because of the mobility of networks. The Ad hoc routing protocols can be classified into two types i.e., table-driven and on-demand. Table-driven protocols are proactive in nature and require more network bandwidth where as On-demand routing protocols exchange routing information only when required. Ad-hoc On-demand Distance Vector (AODV) routing protocol is an on-demand routing protocol that concentrates on finding the shortest path between two nodes without considering the reliability of a node. Ad hoc On-demand Distance Vector Routing is more advantageous than other protocols because of its simplicity, low computational complexity and low processing overhead. The major drawback of conventional AODV is the absence of the Quality of Service (QoS) provision.

The need for QoS in routing for MANETS is

- some applications like VoIP have special service requirements (like delay, jitter, minimum bandwidth, intelligent buffer handling and queuing)
- high mobility of users and network nodes
- for use in emergency and military operations
- scarcity of resources like bandwidth and battery capacity

Various attributes of QoS like bandwidth, end-to-end delay, jitter and resource reservations for Ad hoc On-demand Distance Vector (AODV) routing protocol are addressed in this paper.

2. QoS

Quality of Service which means degree of user satisfaction is characterized by a number of important parameters like bandwidth, throughput, availability, delay, jitter and packet loss. It is especially important to provide QoS because of the resource limitations and dynamic nature of MANET networks.

A QoS enabled network ensures that its applications and users have their parameters fulfilled, besides also ensuring an efficient resource usage. Also the most important traffic still has its parameters fulfilled during network overload.

3. AODV

AODV is packet routing protocol designed for Ad hoc networks. It is an on demand algorithm, loop-free, self starting, scales to large numbers and supports unicast and multicast transmission. To ensure route validity, AODV uses sequence numbers. The basic message set includes a route request message, route reply message, route error message, and a hello message. AODV uses Route request /Route reply to discover a route.

AODV Characteristics:
- It will find routes only as needed
- It uses Sequence numbers to track accuracy of information
- AODV keeps track of next hop for a route instead of the entire route
- It uses periodic HELLO messages to track Neighbors

AODV Operation – Message Types:

RREQ Messages: A RREQ message is broadcasted by a node when it wants to discover a route to a destination. As the RREQ message propagates through the network, intermediate nodes use it to update their routing tables. The RREQ contains the most recent sequence number for the destination. A valid destination route must have a sequence number at least as great as that contained in the RREQ message.

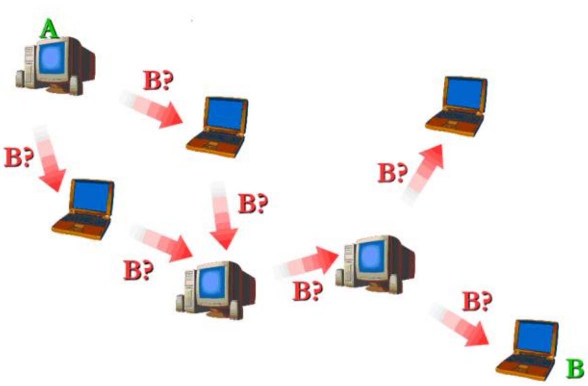

Figure 1. RREQ Message

In the above Figure, the node in the middle receives two copies of the RREQ. In this case, the middle node must choose the correct version of the message for forwarding and also for updating its own routing tables. The hop count field is the key that allows them to decide which message to keep and which message to throw away. In this case the hop count from the source (A) is the same, so it doesn't matter how its own routing back to A is updated.

RREP Messages: When a RREQ reaches a destination node, the destination route is made available by unicasting a RREP back to the source route. A node generates a RREP if it itself is the destination or it has an active route to the destination. Ex: an intermediate node may also respond with an RREP if it has a "fresh enough" route to the destination.

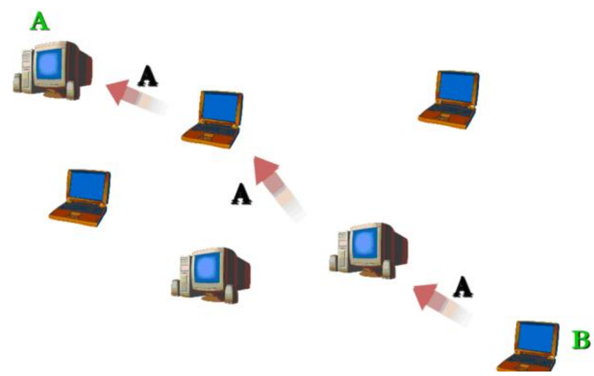

Figure 2. RREP Message

In the above figure, as the RREP propagates back to the source node, intermediate nodes update their routing tables.

RERR Messages: This message is broadcast for broken links generated directly by a node or passed on when received from another node.

Hello Messages: It is used for broadcasting connectivity information. Ex: If a neighbour node does not receive any packets (Hello messages or otherwise) for more than (ALLOWED_HELLO_LOSS * HELLO_INTERVAL) 'm' seconds, the node will assume that the link to this neighbour is currently lost. A node should use Hello messages only if it is part of an active route.

AODV Routing: There are two phases i.e Route Discovery and Route Maintenance. Each node maintains a routing table with knowledge about the network. AODV deals with route table management. Route information maintained even for short lived routes – reverse pointers as shown in the below figure.

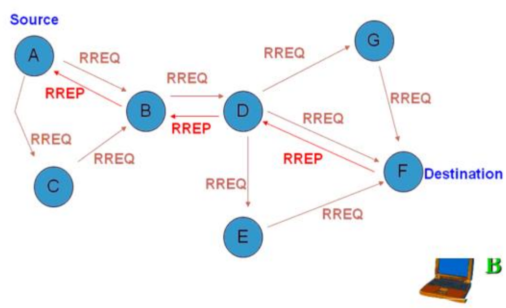

Figure 3. Message Routing

Each route table entry includes the following fields:

- Destination IP Address
- Destination Sequence Number
- Valid Destination Sequence Number flag
- Other state and routing flags
- Network Interface
- Hop Count
- Next Hop
- List of Precursors
- Lifetime

Route Discovery: RREQ messages are broadcasted. Intermediate nodes update their routing table. RREQ is forwarded if it is not the destination. A back-pointer to the originator is maintained. The Destination generates RREQ message. RREQ is sent back to source using the reverse pointer set up by the intermediate nodes. RREQ reaches the destination and communication starts.

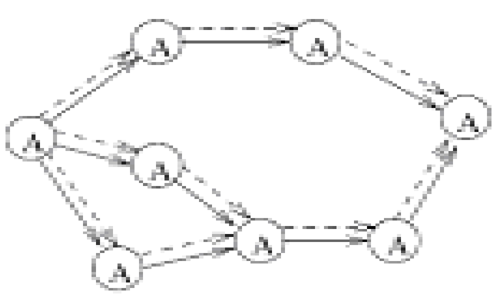

Figure 4. Propagation of RREQ

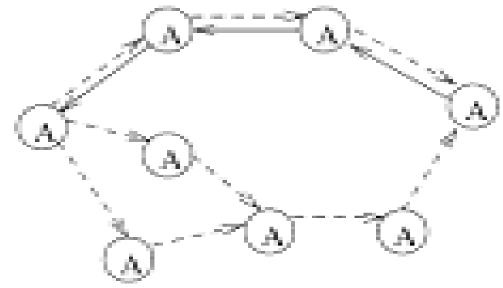

Figure 5. Propagation of RREP to the source

Route Maintenance: Hello messages are broadcasted by active nodes periodically. If there are no hello message(s) from a neighbour in DELETE_PERIOD, link failure is identified and a local route repair to that next hop is initiated. After a timeout, error is propagated both to originator and destination. Entries based on the node are invalidated.

4. Analysis of QoS Attributes for AODV Protocol

a) Bandwidth: It is used as a synonym for data transfer rate which is the amount of data that can be carried from one point to another in a given time period. It is usually expressed in bits per second (bps) or bytes per second (Bps). Bandwidth is a challenging issue in MANETS i.e., to perform routing operation between a transmitter and a receiver and being able to convey data packets continuously using less bandwidth. The conventional AODV protocol was motivated by the limited bandwidth that is available in the media that are used for wireless communications. Efficient utilization of bandwidth is achieved as the protocol does not require periodic global advertisements and all the intermediate nodes in an active path update their routing tables based o maximum utilization of the bandwidth. The routing tables will be used very frequently if the intermediate nodes receive any RREQ message from another source for same destination. Also, the RREPs that are received by the nodes are compared with the RREP that was propagated earlier using the destination sequence numbers and are discarded if they are not better than the already propagated RREPs. Efficiency of a protocol depends on better bandwidth [1] [2] management. Bandwidth is dependent on other attributes like load control [3] and packet loss [4]. As the volume of the control packet [3] increases, performance degrades and more bandwidth is used by control packets than data. The variant M-AODV [5] discovers in a first step, all possible paths between sources and destinations and maintains them during all data transfer phase. In case of a failure of the actual route, the data transfer will use one of the previously established routes (secondary routes). The failure state is declared only if all paths, found in discovery phase, cannot be used M-AODV also suggests improving mechanisms that generate data packet loss and efficient utilization of bandwidth. AODV performs better than DSDV in terms of bandwidth [7] as AODV do not contain routing tables so it has less overhead and consume less bandwidth while DSDV consumes more bandwidth.

b) End-to-End Delay: It reflects the time taken between data packet transmission and reception. These delays are caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times. The time difference between every packet sent and received was recorded first, and then dividing the total time difference over the total number of packets received gives the average end-to-end delay for the received packets. This metric also describes the packet delivery time: the lower the end-to-end delay the better the protocol performance.

Most existing MANET routing protocols such as AODV, DSR and OLSR are designed to search for the shortest path with minimum hop counts. However, the shortest routes do not always provide the best performance, especially when there are congested nodes along these routes. The analytical model [8] proposed for average end-to-end delay that takes into account the packet arrival process, backoff and collision avoidance mechanisms of random access MAC between a pair of source and destination suggests for improvement in end to end delay in AODV. AODV shows the shortest end-to-end delay when compared to other routing protocols like CBRP, PAODV, DSDV and DSR. The use of fuzzy scheduler [6] for AODV routing protocol helps in improving the end-to-end delay. The fuzzy scheduler proposed here, calculates the priority index of each packet. The fuzzy scheduler uses two input variables and one output variable. The two input variables to be fuzzified are the data rate and channel capacity of the nodes to which the packet is associated with. The inputs are fuzzified, implicated, aggregated and defuzzified to get the crisp value of the output.

c) Jitter: Jitter is the variation of delay. That it is the variation in the delay of received packets. At the sending side, packets are sent in a continuous stream with the packets spaced evenly apart. Due to network congestion, improper queuing, or configuration errors, this steady stream can become cumbersome, or the delay between each packet can vary instead of remaining constant. AODV routing protocol has less jitter when compared to proactive routing protocols.

d) Throughput: It is the average rate of successful message delivery over a communication channel. AODV performs better and has better throughput [9] than both DSR and DSDV protocols. The throughput of AODV decreases with node velocity. The presence of backup paths (multiple paths) in M-AODV [5] version improves a better throughput especially for a high and medium mobility and network size less than 80 nodes;

e) Packet Delivery Ratio: It is the ratio of the number of packets received by the destination to the number of data packets generated by the source.. The Packet delivery ratio determines protocol efficiency in delivering packets from source to destination. The higher the value, better are the results. AODV uses an on demand approach for finding routes. AODV and most of the on demand ad hoc routing protocols use single route reply along the reverse path. Due to rapid changes of topology the route reply may not arrive to the source node resulting in sending several route request messages and degrading the performance of the routing protocol. The extended AODV called Reverse Ad Hoc On Demand Vector (R-AODV) protocol [10] uses a reverse route discovery mechanism and performs well when link breakage is frequent. Multiple route reply messages in MANET results in a stable packet delivery ratio. Thus, with the increase in node velocity R-AODV gives more PDR outperforming AODV.

f) Resource reservation: This is an important issue when designing a solution. Providing QoS guarantees in an Ad hoc network requires very important component admission control to ensure that the total resource requirements of admitted flows can be handled by the network. If there are not enough resources for all real time flows, some real time flows must be rejected to maintain the guarantees made to other real time flows. The proposed algorithm AODV with QoS [11] suggests an approach to estimate available resources on a node. This algorithm is based on the estimation of the busy ratio of the shared canal. Several constraints related to the Ad hoc transmission mode such as Interference phenomena are considered in this estimation. It is observed that AODV with QoS provides support in ad hoc wireless networks with good performance and low overhead.

5. Conclusion

In this paper, various QoS attributes like bandwidth, end-to-end delay, jitter, throughput, packet delivery ratio and resource reservation for Ad hoc On-demand

Distance Vector (AODV) routing protocol are discussed. AODV routing protocol is best suited for general mobile ad-hoc networks as it consumes less bandwidth and lower overhead when compared with DSDV routing protocol. It has better throughput and it decreases with node velocity.

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