

PERFORMANCE EVALUATION OF QOS ON AODV ROUTING PROTOCOL

P.Udaykumar^{1*}, C.P. Agrawal² and O.P.Vyas³

1 - Dept. of M.C.A RCET (Rungta) Bhilai (CG), INDIA 00919893263785

2 - Computer Deptt, MCRPSV, 38 B, Press Complex, Bhopal (MP), INDIA 00919425602011

3 - Computer Center 02, IIIT Deoghat Jhalwa, Allahabad (UP), INDIA 00915322922218

ABSTRACT

Recent growing widespread attention given to mobile communications has led to rapid growth in research and development involving mobile wireless networks. The need for easy deployment and self-configured networks makes mobile ad-hoc networks (MANETs) an attractive choice for various applications. However, due to its dynamic nature and imprecise network state information, there are many challenges which need to be addressed including Quality of Service (QoS) routing. Numerous approaches have been proposed including QAODV. It is proposed to enhance one of the existing routing protocols for MANETs namely AODV (Ad-Hoc On-Demand Distance Vector). Q-AODV adds necessary new fields to cater QoS provisioning requirements. This paper aims to conduct evaluation study on AODV and QAODV approaches. Some new fields are added with AODV to form QAODV to avoid resource wastage as well as maximize utilization of network capacity. In order to identify the pros and cons of both methods, NS-2 Simulator is used to conduct the simulation study. Throughput, End-to-end delay, Packet Delivery Ratio (PDR) and Normalized Overhead are the selected evaluation metrics. Our experiments study the effect of number of mobile nodes, mobility and traffic load.

1. INTRODUCTION

Mobile Ad-Hoc Network (MANET) is defined as an autonomous system of mobile nodes which are free to move about arbitrarily [1]. The mobile nodes may be located anywhere: airplanes, ships, trucks, cars, perhaps even on people or very small devices. Another definition states that ad-hoc wireless networks are described as the category of wireless networks that utilize multi-hop radio relaying and are capable of operating without the support of any fixed infrastructure [2]. The ability to operate without the support of any fixed infrastructure as well as relative ease of deployment make ad-hoc networks an attractive choice for various applications including military, disaster recovery etc.

In ensuring quality of service (QoS) provisioning, a network is expected to guarantee a set of measurable pre-specified service attributes to the users in terms of end-to-end performance, such as

delay and bandwidth [3]. When it comes to QoS routing, the routing protocols have to ensure that the QoS requirements are met. Unfortunately unlike wired networks, it is a challenging task to ensure Quality of Service (QoS) provisioning including routing in ad-hoc networks due to the mobile and dynamic nature of the nodes[7].

Numerous QoS routing protocols have been proposed for this environment by researchers. Most of these protocols provide QoS support for the available bandwidth requirement for a given path. This is because bandwidth is the most critical parameter in most MANET applications due to the scarcity of this resource in the wireless environment. The protocols support QoS to varying degrees, in different ways, and using various networks and communication models.

This paper focuses on one of the proposed protocols namely QoS Ad-Hoc On-Demand Distance

Vector protocol (QAODV). QAODV is extended from AODV and resides in the on-demand (reactive) type. As an on-demand routing protocol, it maintains no routing tables at the nodes, and hence the source node has to discover the route on the fly. Due to its wide implementation, it is selected to be evaluated qualitatively [14].

This paper is organized as follows: Section 2 presents overview of QAODV and its operation. In Section 3, we have summarized related work in this field. Section 4 explains the simulation environment and its important performance parameter and metrics. Section 5 and 6 cover the results, discussion and conclusion in details.

2. OVERVIEW OF Q-AODV

Basically, some Internet Engineering Task Force (IETF) drafts on extending AODV to provide QoS support had been proposed. Route discovery in AODV is on-demand and follows a route request/route reply query cycle [11]. 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.

In order to provide QoS, extensions can be added to these messages during the route discovery process. Several extensions are needed in the routing table structure and the RREQ and RREP messages as reported in [2][12]. The additional fields to each route table entry corresponding to each destination are: maximum delay, minimum available bandwidth as well as list of sources requesting delay and bandwidth guarantees. Special messages which are called QoS LOST messages are forwarded to all sources potentially affected by the change in QoS parameter. These are the sources to which a RREP with QoS extension has been forwarded before [11].

3. RELATED WORK

Based on our findings, there are several approaches and proposals to cater QoS provisioning

in the existing AODV. Perkins et al. themselves revised the QoS-AODV internet drafts by adding more field extensions and new formats [8] [13]. IETF is not the only party involved in enhancing AODV to provide QoS support. QoS-AODV proposals by Gerasimov and Simon only refer to original AODV internet draft [5] [6].

Unlike Perkins et al. who identified the format and extensions to provide QoS support in AODV, Gerasimov and Simon proposed an approach which operates within a TDMA (Time Division Multiple Access) network[4][6]. On the other hand, de Renesse et al. enhanced AODV by basing their work on QoS-AODV internet draft [7]. The main idea of enabling AODV routing decision based on QoS objects is to add extensions to the route messages during route discovery.

This work is based on Mac 802.11b bandwidth measurement and reservation [6]. In our paper, AODV is extended by using NS-2 to provide QoS guarantee. The main idea is to enable AODV routing decision based on QoS objects by adding extensions to the route discovery messages.

4. PERFORMANCE METRICS

Four performance metrics [6] will be used to judge the performance of the AODV and the QAODV routing protocols. The explanation for each performance metric will be given in this part.

4.1 Average end to end delay

The end-to-end delay calculates the delay of the packet which is successfully transmitted from the source to the destination [6]. This end-to-end delay includes all possible delays caused by buffering during route discovery latency, queuing in the interface queue, retransmission delays at the MAC, propagation and transfer times. [7] It is the duration of the time a packet travels from the application layer of the source to the destination. End-to-end delay is one of the most important metrics when analyzing the performance in QoS aware routing protocols [2]. The average end-to-end delay is averaged out of all the end to end delay of successfully transmitted packets.

4.2 Packet Delivery Ratio (PDR)

It is the ratio of the successfully received packets to those sent by CBR sources as shown in the formula of the following part [15]. The higher the PDR, the lower the packet loss rate, the more efficient the routing protocol from the data delivery point of view. In real time communications, the routing protocol with higher PDR may not be considered better than the one with lower PDR, since packets which arrive late could be useless although they reach the destination successfully. Real time traffic is delay sensitive [10].

$$PDR = \frac{\text{Number of received pkts}}{\text{Total number of sent pkts}}$$

4.3 Normalized Overhead Load (NOL)

It is the ratio between the total number of generated packets and the total number of successfully sent packets [15]. The overhead packets in the routing layer include packets both for route discovery and route maintenance e.g. Hello messages, RREQs, RREPs and RERRs [5]. Each hop-wise transmission of a routing packet is counted as one transmission.

$$NOL = \frac{\text{Total Number of generated packets}}{\text{Number of sent packets}}$$

5. RESULTS AND DISCUSSIONS

The reason for studying the usage of HELLO messages in Q-AODV is due to the need for keeping information about available bandwidth of one-hop neighbors in order to evaluate the amount of free resources on a link. Apart from assuming that the bandwidth has been readily acquired, we also simulate Q-AODV approach which makes use of HELLO messages.

5.1 Effect of Number of Nodes

Number of nodes determines the connectivity of a network. With more nodes in the same area, meaning there are more neighbors to send requests to, thus longer routes can be established.

5.2 Throughput Vs. Delay

In this set of simulations, a group of data rates ranging from 50 kbps to 1800 kbps is applied [10]. The mobility scenario is with a pause time of 10 seconds and the maximum node speed is 1 m/s. Four parameters defined above are calculated. The results are shown in the following figure.

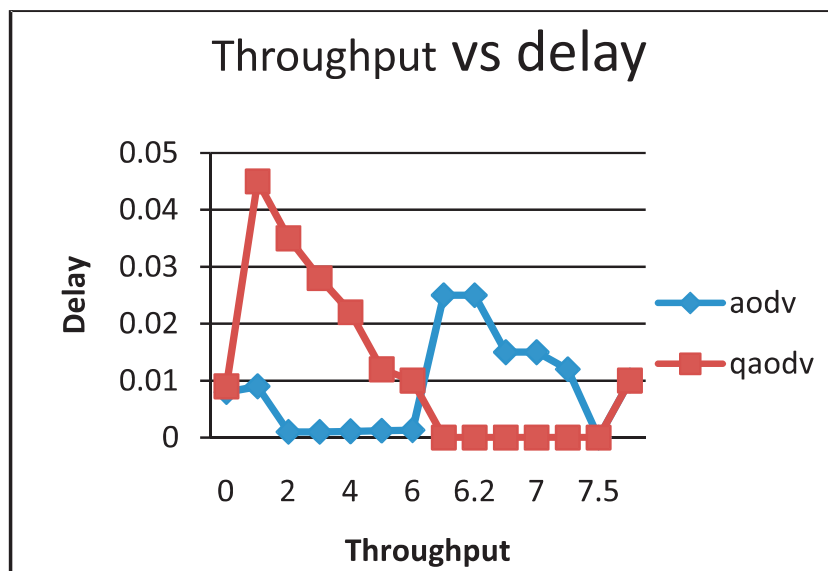


Figure 1 : Throughput vs. Delay for 5 nodes

In figure 1, it can be seen clearly that the QAODV routing protocol outperforms the AODV routing protocol a lot except under some low data rate (data rate below 400 bps). In AODV, the maximum average end to end delay reaches 115 ms. It shows that networks with the QAODV routing protocol can provide lower end to end delay for traffic flows than the AODV since the QAODV always choose to find a route with satisfying data rate. In addition, during the transmission, the QoS of the traffic is monitored in the QAODV routing protocol. Once the QoS is not satisfied as it promised, the traffic will be stopped.

5.3 PDR

When the maximum throughput of nodes cannot satisfy the on-going traffic, queues at nodes begin to be full; the packets in the end of queues of nodes will be dropped both at source nodes and at intermediate nodes. The PDR with the QAODV routing protocol is always lower than the one with the AODV routing protocol.

Mostly, it is because that the source node takes more time to find a suitable route in QAODV and during this period of time, the source which keeps on sending packets from the application layer of the node, it cause drops of packets at the end of the queue when the queue is full. Also, the traffic session can be paused anytime when the local available data rate of nodes in the path is not satisfied during the transmission in the QAODV routing protocol.

To sum up, the reason that the PDR with the QAODV routing protocol is lower than the one with the AODV routing protocol is that the QAODV routing protocol has more restrictions to the route for transmission. Actually, the packets which are not delivered and dropped at the source node because of the delay for searching for a more suitable route in the QAODV routing protocol should be dropped.

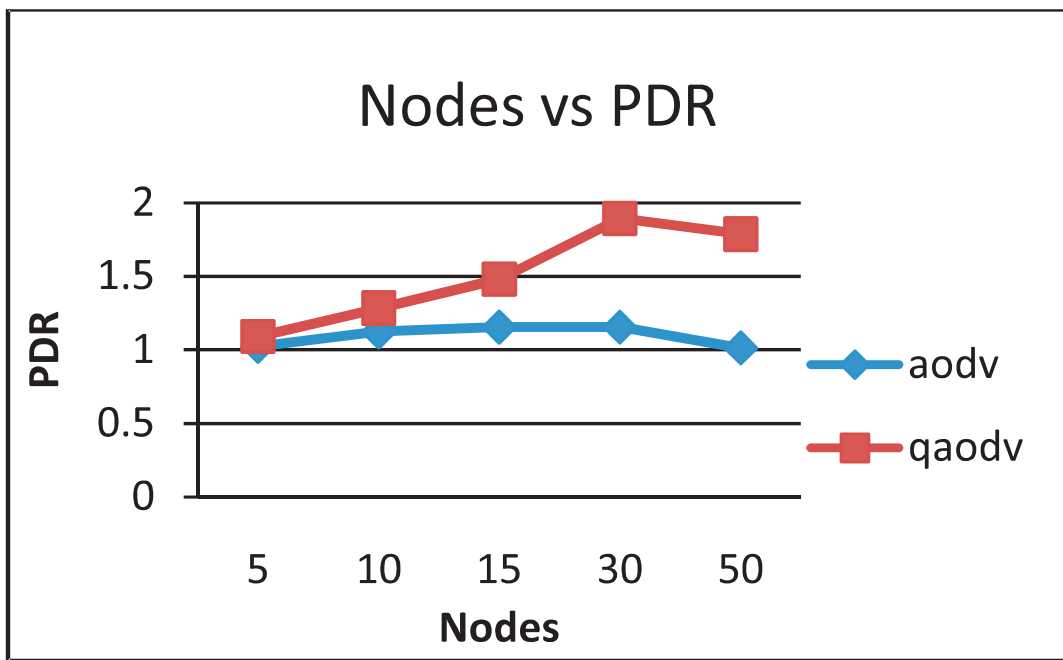


Figure 2 : Nodes vs. PDR

5.4 NOL

In Figure 3, with the increase of data rate, NOL decreases in QAODV. In QAODV, Hello messages are sent periodically, that is, the number of Hello messages sent independent of the load on the network. In addition, with the increase of data rate, the total number of packets sent increases. As a result, when the data rate is low, NOL is relatively high in QAODV.

In AODV, the NOL in AODV is always low since the AODV routing packets are only sent during the routing searching and maintenance periods without exchanging Hello messages. It results in the low NOL with the AODV routing protocol.

From this figure 3, we could conclude that the use of the QAODV routing protocol in networks with low traffic will cost relatively more data rate than the use of the AODV routing protocol to send routing packets. A network with high traffic load has lower NOL.

6. CONCLUSIONS & FUTURE WORK

With the above simulations, it can be seen that the QAODV routing protocol improves the performance of the ad-hoc network in terms of end to end delay when there are large traffic in the network (that is when the data rate of the traffic flows is high). In addition, the QAODV routing protocol shows the reliability at different moving speeds.

Although the PDR is decreased when using the QAODV routing protocol, but considering the special characteristic of real time traffic, it is reasonable to drop those packets. The reason is that, in real time transmissions, only packets that arrive at the destination in time are useful, and packets that arrive late are useless. With the QAODV routing protocol, source nodes insist on trying to find a route which has enough data rate to send the traffic to ensure that the packets arrive at the destination on time.

To sum up, it is reasonable to drop packets when the source does not have a suitable route to

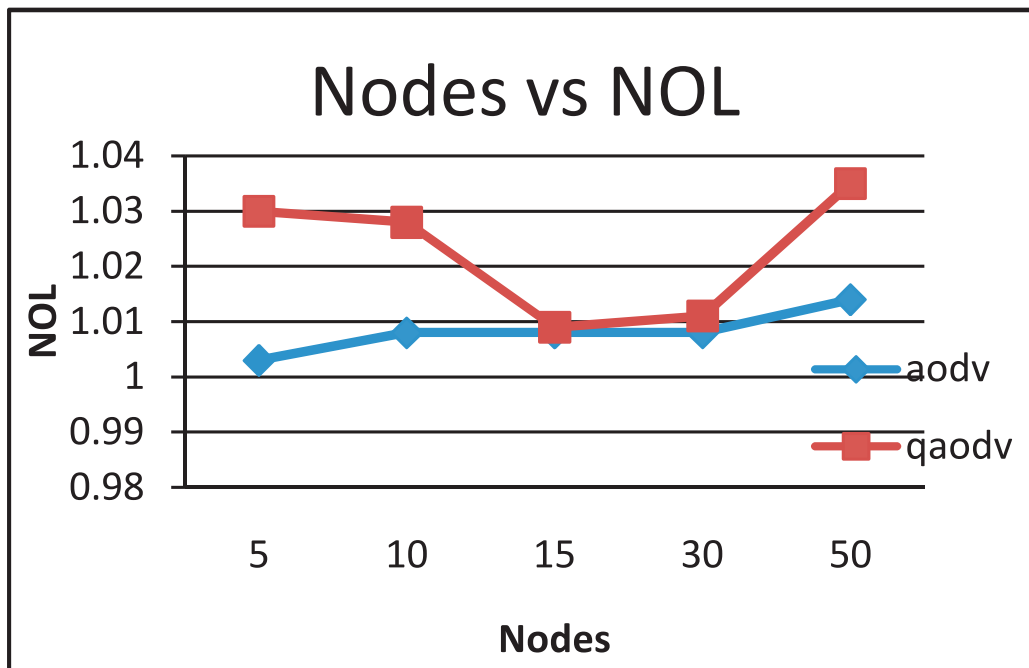


Figure 3 : Nodes vs. NOL

the destination. It also helps to decrease the traffic in the network. The good performance with the QAODV routing protocol is achieved at the expense of sending more routing packets. This can be seen from the value of NOL. To conclude, with real time traffic, the QAODV is suitable when the traffic of the network is high. It could help to ensure the transmission as well as constrain the useless transmissions in the network.

In terms of metrics in the QoS aware routing protocols, only data rate metric is considered in the simulations. End to end delay for the nodes more than 50 could be an additional task for the simulations during the route discovery and maintenance in the routing protocol. This can be done with new and fast simulation tools.

7. REFERENCES

1. C.S.R. Murthy and B.S. Manoj "Ad Hoc Wireless Networks: Architectures and Protocols", Prentice Hall, (2004).
2. Jawhar, and J. Wu "Quality of Service Routing in Mobile Ad Hoc Networks", in M Cardei, I Cardei & DZ Du (eds), Resource Management and Wireless Networking, Kluwer Academic Publishers.
3. P. Stüdi "Quality of Service for Mobile Ad Hoc Networks", Diploma Thesis, (2003).
4. I.Gerasimov, and R. Simon "Bandwidth-Reservation Mechanism for On-demand Ad Hoc Path Finding", IEEE/SCS 35th Annual Simulation Symposium, pp. 27-33 (2002).
5. I.Gerasimov, and R. Simon "Communication Support for Tightly-coupled Distributed Mobile Applications, International Journal of Simulation", Vol. 3, no. 2, pp. 23-40 (2002).
6. Gerasimov, and R. Simon "Performance Analysis for Ad Hoc QoS Routing Protocols", IEEE MASCOTS Mobility and Wireless Access Workshop (MobiWAC), pp. 87 -94 (2002).
7. R. de Renesse, M. Ghassemian, V. Friderikos and A. H. Aghvami "Qos Enabled Routing in Mobile Ad Hoc Networks", Fifth IEEE International Conference on 3G Mobile Communication Technologies, pp. 678-682 (2004).
8. C.E. Perkins, E.M. Royer and S.R. Das "Quality of Service for Ad hoc On-Demand Distance Vector Routing", IETF Internet Draft: draft-perkins-manet-aodvqos-02.txt. (2003).
9. S. Corson, and J. Macker "Mobile Ad hoc Networking (MANET): Routing Protocol Performance Issues and Evaluation Considerations", RFC 2501 (1999).
10. Ns Notes and Documentation, <http://www.isi.edu/nsnam/ns>.
11. C.E. Perkins, E.M. Royer and S.R. Das "Ad hoc On-Demand Distance Vector (AODV) Routing", IETF Internet Draft: draft-ietf-manet-aodv-05.txt. (2000a).
12. C.E Perkins, E.M. Royer and S.R. Das "Quality of Service for Ad hoc On-Demand Distance Vector Routing", IETF Internet Draft: draft-ietf-manet-aodvqos-00.txt. (2000b).
13. C.E Perkins and E.M. Royer "Quality of Service for Ad hoc On-Demand Distance Vector Routing", IETF Internet Draft: draft-perkins-aodvqos-00.txt. (2001).
14. Nur Enzai & Zeldi Suryady, "Analyzing the effect of HELLO messages is QOS-AODV", Proceeding of International Conference on Electrical Engineering & Informatics, Indonesia, June 17-19, 2008.
15. Chang Lin & Yuan Chang "QoS for Mobile Ad-hoc Network", proceedings of 11th IEEE conference on networks (ICON 2007), September 2007.

