Simulation & Performance Evaluation of AODV Protocol with QoS (Quality of Service)

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ABSTRACT: Ad hoc mobile networking is a current active research area. They can be used in agriculture for monitoring and control of environmental parameters in the form of wireless sensor networks. The aim of this paper is performance evaluation of protocol of these Ad hoc networks i.e. QoS-enabled AODV protocol. The performance evaluation is done by means of its comparison with normal AODV protocol. QoS stands for Quality of Service. The research proposed some enhancements to the AODV protocol to provide QoS by adding extensions to Route Discovery messages, related to bandwidth estimation. This paper focuses on three of the parameters namely Traffic Rate, Speed of nodes & Pause Time of mobile nodes. For evaluation purpose the performance metrics used are Average end-to-end Delay, Packet Delivery Ratio (PDR), Normalized Overhead Load (NOL) and Throughput. Performance of the AODV protocol for QoS as well as Non-QoS is evaluated with respect to these parameters.

Keywords: Ad hoc networks, AODV, bandwidth estimation, quality of service

I. INTRODUCTION

In an Ad hoc mobile network, every node in the network carries its own router with it, and all nodes cooperate in carrying traffic. The whole philosophy of the Ad hoc networking model is a radical departure from the highly structured and frequently hierarchical models employed for both local area and wide area networking, currently in use. The range of possible situations in which Ad hoc networking can be exploited is huge. What mature and robust Ad hoc networking offers is virtually universal connectivity, limited only by the link performance and routing delays of the participating nodes, and their connectivity to the established fixed network. As shown in Figure 1 Ad hoc networks are well within the bounds of today's technology, provided that suitable Ad hoc routing protocols exist and are implemented.

Static networks mostly use either Distance Vector (DV) or Link State (LS) routing algorithms, neither of which are spectacularly well suited to highly dynamic topologies. In a highly dynamic wireless network, such protocols run into a number of difficulties:

- topologies may be highly redundant, with some nodes being in the situation of being able to connect to a very large number of neighbors, while others see very few neighbors.
- bandwidth is scarce and cannot be wasted.
- battery power on portable equipment is a finite resource that cannot be wasted.
- high rates of topology change require high update rates.

Figure 1. Ad-hoc Networking (From Computer Desktop Encyclopedia ©2007)
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A. Routing Models

Routing models can also be divided in following ways:
1) Proactive Routing
2) Reactive Routing
3) Hybrid Routing

This paper focuses on three of the parameters namely traffic rate, speed & pause time of mobile nodes. For evaluation purpose the performance metrics used are average end-to-end delay, packet delivery ratio (PDR), normalized overhead load (NOL) and throughput. Evaluate the AODV protocol for QoS as well as Non-QoS is done with three of the parameters & four performance metrics by means of graphical representation of their interrelations.

B. AODV Protocol Overview

AODV routing protocol is an on-demand reactive routing protocol that uses routing tables with one entry per destination. When a source node needs to find a route to a destination, it starts a route discovery process, based on flooding, to locate the destination node, as shown in Figure 2.

Upon receiving a route request (RREQ) packet, intermediate nodes update their routing tables for a reverse route to the source. Similarly, the forward route to the destination is updated upon reception of a route reply (RREP) packet originated either by the destination itself or any other intermediate node that has a current route to the destination. The AODV protocol uses sequence numbers to determine timelines of each packet and to prevent the creation of loops. Expiry timers are used to keep the route entries updated. Link failures are propagated by a route error (RERR) message from a broken link to the source node of the corresponding route. When the next hop link breaks, RERR packets are sent by the starting node of the link to a set of n the destination.

C. AODV and QoS-AODV

The Ad hoc On Demand Distance Vector (AODV) protocol is proposed by Perkins. The research focuses on enhancement in performance of normal AODV protocol by improving the QoS. The various QoS parameters can be stated as bandwidth, cost, end-to-end delay, delay variation (jitter), throughput, probability of packet loss, battery charge, processing power etc. Various Performance metrics are to be studied for Performance evaluation of QoS-enabled AODV protocol. Research is going on towards Performance Improvement by emphasizing any of these parameters. This research considers the Bandwidth parameters so as to improve QoS.

II. IMPLEMENTATION

The implementation section discusses how AODV protocol was implemented and analyzed for the comparison. This includes the platform i.e. Fedora and the tools such as ns2 (Network Simulator version, NAM (Network Animator) and Gnuplot. Then the core implementation is discussed.
A. Need of Fedora

All simulation, implementation and analysis work was done on Linux. The flavor of Linux used for this purpose was Fedora. The reason for choosing this specific operating system for research work is that, it is one of the most stable and robust platforms around. Secondly Linux systems provide more security than others and security is a very essential element in network environments. Since the platform provides the basis for doing everything, therefore it becomes essential to discuss some core features of this platform.

B. Network Simulator ns2

After setting up the platform, software named ns-2 was set up on it which was used for all the analysis and simulation work apart from other tools used. ns-2 is the de facto standard for network simulation. Its behavior is highly trusted within the networking community. It is developed at ISI, California, and is supported by the DARPA and NSF.

C. Core Implementation

1) Basic Protocol Simulation: This section discusses how the AODV protocol was simulated and implemented. First the platform i.e. Fedora 8 was set up in a virtual environment. Then ns-2 was set up on the platform on which the above said protocols were implemented. ns-2 requires a script file to be run on it. These script files are written in a language called TCL (Tool Command Language). We have made use of shell scripting & Gnuplot for plotting of graphs.

2) QoS-Enabled Protocol Simulation: In this research a quality of service (QoS) architecture for supporting real-time data transmission in mobile Ad hoc networks (MANETs) is explored. The QoS architecture includes a QoS transport layer, QoS routing, queue management and a priority MAC protocol. Through simulations, it is found that the QoS architecture reduces packet loss and greatly improves the resource utilization in MANET's.

3) QoS architecture: Figure 3 shows proposed QoS architecture, which includes all networking layers from the application layer to the MAC layer. The bold lines indicate the flow of data packets and the narrow lines indicate the flow of control packets.

B. Bandwidth Estimation

In a distributed Ad hoc network, a host’s available bandwidth is not only decided by the raw channel bandwidth, but also by its neighbor’s bandwidth usage and interference caused by other sources, each of which reduces a host’s available bandwidth for transmitting data. Therefore, applications cannot properly optimize their coding rate without knowledge of the status of the entire network. Thus, bandwidth estimation is a fundamental function that is needed to provide QoS in MANETs. Bandwidth estimation can be performed in several different network layers, as shown in Figure 3.

In this research, I tried to improve QoS with major focus on Bandwidth parameter. Fig. 4 & 5 shows RREQ message format before and after QoS enabling, in AODV protocol. For enhancing performance of the basic protocol one more field named “Bandwidth Required” is added in the given RREQ format. This RREQ packet is used to store the information of bandwidth required field & then used to compare it with the current requirement. And, the packet is forwarded to the next intermediate node only when it does have sufficient amount of bandwidth otherwise it is dropped & then it is re-transmitted when favorable condition present.
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![QoS Architecture Diagram](image)

**Figure 3: QoS Architecture**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>RESERVED</th>
<th>HOP COUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadcast ID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination IP Address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination Sequence Number</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source IP Address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source Sequence Number</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Request Time</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 4. RREQ Message Format before QoS-Enabling**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>RESERVED</th>
<th>HOP COUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth Required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadcast ID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination IP Address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Destination Sequence Number</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source IP Address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source Sequence Number</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Request Time</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 5. RREQ Message Format after QoS-Enabling**
III. METHODOLOGY

A. Performance Analysis

The performance analysis has been done on Fedora 8 as the operating system. ns 2.34 was installed on the platform for simulating the protocols along with necessary software such as GnuPlot, which is software for plotting graphs from the trace files. ns (version 2) is an object oriented, discrete event driven network simulator written in C++ and Otcl.

B. Basic Protocol Simulation

This section discusses how the AODV protocol was simulated and implemented. First the platform i.e. Fedora 8 was set up in a virtual environment. Then ns 2.34 was set up on the platform on which the above said protocols were implemented. ns2 requires a script file to be run on it. These script files are written in a language called TCL (Tool Command Language). We have make use of shell scripting & Gnuplot for plotting of graphs.

C. Performance Metrics used for Analysis

The following metrics were used for the comparison of the protocols:

1) Throughput: This is the effective share of bandwidth that the application is getting from the network.
2) Bandwidth: This signifies the portion of the available capacity of an end-to-end network path that is accessible to the application or data flow. Consequently, the number of bits that are injected into the network by the various flows of an application have to be adjusted accordingly.
3) Average Packet Delay: It is average packet delivery time from a source to a destination. First for each source-destination pair, an average delay for packet delivery is computed. Then the whole average delay is computed from each pair average delay.
4) Packet Delivery Ratio: It is a ratio of number of data packets delivered to the destination and the number of data packets sent by the source or number of data packets delivered over number of data packets generated. Number of data packets delivered is the total number of received data packets by destinations.
5) Network Overhead Load: It is the ratio of total amount of overhead caused due to control routing packets and the amount of wireless bandwidth wasted to transmit the packets that are dropped in other links.

IV. RESULTS & ANALYSIS

A. Traffic Environment

The tests were performed on CBR traffic with 50 nodes. Packet size was set to 500 and the time interval between transferring the packets was set to 0.005 ms. Bit rate was set to 1 Mbps with a Drop Tail of 10 ms. As it is not easy to create traffic simulations for such large number of nodes manually, therefore the simulations were generated with the help of CMU traffic generator and the scenario was generated with the help of setdest, which are the tools preinstalled with the ns2. The field configuration was set to 500 by 500 m.; accordingly, with the help of three of the parameters & four performance metrics, 12 graphs are generated and are used for evaluation of AODV protocol for QoS as well as Non-QoS.

It is clear from Fig. 6 that for data rates above 600 kbps, the average delay suffered by packets is very less for QAODV in comparison with AODV. For low data rates delay suffered is approximately similar for both AODV and QAODV. The reason behind better performance of AODV is that it blocks the packet at source itself as soon as QoS criteria of path is lost which results in less contention in common intermediate sub-paths of different flows.

As shown in Fig. 7, each Pause time, the average packet delay suffered by QAODV is approximately 40-60 ms less than that suffered by AODV. For both AODV and QAODV, minimum delay is achieved when pause time of the nodes is 6 seconds. For each value of speed, the average packet delay suffered by QAODV is very less than that suffered by AODV, as can be seen in Fig. 8. For both AODV and QAODV, minimum delay is achieved when moving speed of the nodes is 4 m/s.
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Figure 9 shows NOL versus CBR. The overhead of using QAODV is higher than the overhead of AODV at each data rate. The overhead values of both AODV and QAODV decrease with the increase in traffic data rate. It is difficult to explain the reason behind huge increase in the overhead value of QAODV when traffic data rate is 1200kbps.

Figure 10 shows NOL versus Pause Time. The overhead of using QAODV is higher than the overhead of AODV at each pause time value. The overhead values of AODV are approximately same at different pause time values. It is difficult to explain the reason behind huge increase in the overhead value of QAODV when pause time is set to 12 seconds.

Figure 11 shows NOL versus Speed of Nodes. The overhead of using QAODV is higher than the overhead of AODV at each moving speed value. The overhead values of AODV are approximately same at different speed values.
Figure 12 shows Packet Delivery Ratio versus CBR. At every data rate value, the PDR obtained by AODV is higher than that obtained by QAODV. The PDR value for AODV remains approximately same with increase in traffic data rate whereas the PDR value of QAODV decreases with the increase in traffic data rate. When the QoS (bandwidth) demand is high it is difficult to find QoS satisfying path for the flows. Therefore QAODV blocks the packets at source itself which results in decrease in the PDR value with increase in the data rate. Figure 13 shows Packet Delivery Ratio versus Pause Time. Here the data rate is set to 2000kbs and PDR value of QAODV is less than that of AODV at every pause time value. Figure 14 shows Packet Delivery Ratio versus Speed of Nodes. Here the data rate is set to 2000kbs and PDR value of QAODV is less than that of AODV at every speed value.

Figure 15 shows Throughput versus CBR. At low data rates throughput achieved by QAODV is approximately similar to that achieved by AODV. When the QoS (bandwidth) demand is high, it is difficult to find QoS satisfying path for the flows. Therefore QAODV blocks the packets at source itself with results in decrease in the throughput at the data rates higher than 1200 kbps.

Figure 16 shows Throughput versus Pause Time. Here the data rate is set to 2000kbs and QAODV’s throughput is less than AODV’s throughput. For both AODV and QAODV, Throughput achieved is highest when pause time is 4 seconds.
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Figure 17 shows Throughput versus Speed of Nodes. Here the data rate is set to 2000kbs and QAODV’s throughput is less than AODV’s throughput. For both AODV and QAODV, Throughput achieved is highest when speed is 4 m/s. There is sudden decrease in throughput for both AODV and QAODV when speed is 8 m/s. Throughput achieved by AODV and QAODV does not vary much for the speed values greater than 12m/s.

V. CONCLUSION

In this research, I presented the QoS (Quality of Service) enabled AODV protocol. Firstly, I have simulated the basic protocol using ns². Then using Gnuplot, the twelve graphs are generated with three varying scenarios for simulation used are 1) Speed of Nodes, 2) Traffic Rate, 3) Pause Time or Mobility & the performance metrics used are 1) PDR, 2) NOL, 3) Average packet delay, 4) Throughput. Then, the QoS of basic protocol is improved & again graphs are generated. Finally, the comparison of the Non-QoS and QoS-enabled protocol is carried out. The result shows the improvement in routing of data from source to destination.

By observing the graphs generated, following points can be concluded:

1) Average Packet Delay is reduced in QAODV as compared to basic AODV protocol.
2) As we are making use of Hello Messages to read the bandwidth, the Network Overhead Load is increased to some extend in QAODV as compared to AODV.
3) Average throughput and Packet Delivery Ratio of QAODV are moderately same as AODV Protocol.

Reduced Average Packet Delay in case of QAODV indicate that this approach is suitable for modern and futuristic networks. Whenever streaming of multimedia based data such as video, audio and text is performed, traffic will be more and network becomes congested. It is observed that network congestion is the dominant reason for packet loss, longer delay and delay jitter in streaming video. The primary goal of a protocol is to increase the overall utility of the network by granting priority to higher-value or more performance-sensitive flows. QAODV protocol is found to cope up with this situation better as compared to AODV protocols although there is marginal increase in Network Overhead Load with Average throughput and Packet Delivery Ratio of QAODV are almost same.
Achievement of reduced Packet Delay of this new QAODV is very significant. This is because, wireless networks of future will need such approach, which will reduce delay in transmission. This reduced delay will transpire to very important parameter for networks handling real time traffic like video calling.

According to a survey by Cisco, mobile data in 2010 was triple the volume of the entire global Internet traffic in 2000. The growth rate in the previous year was 159%, which is 10% higher than anticipated in 2009. This rapid growth in mobile data is forecast to continue for the next five years with an average annual growth of 92%. There are several reasons why mobile traffic has grown so quickly. Firstly, mobile video, which requires high bit rates, is considered to lead to the increase of mobile traffic. It is reported that mobile video reached as high as 49.8% of total mobile traffic in 2010 and will account for two thirds of mobile traffic by 2015. Moreover, Internet gaming, which consumes, on average, 63 PB per month in 2009, also results in a growth in mobile traffic and it is expected to achieve an annual growth of 37% in the coming five years. Last but not the least, Voice over IP (VoIP) which includes phone-based VoIP services direct from or transported by a third party to a service provider, and software-based internet VoIP such as Skype, leads to the expansion of mobile traffic. Many of those applications described above are real-time applications which demand certain guarantees for performance metrics like Average Packet Delay for acceptable operation. Hence achievement of reduced Average Packet Delay of this new QAODV is very crucial for Ad hoc networks.

References

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