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

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ABSTRACT:
An area of active research right now is ad hoc mobile networking. They can be utilized in agriculture as wireless sensor networks to monitor and regulate environmental parameters. The purpose of this paper is to assess how well the QoS-enabled AODV protocol, the protocol used in these Ad hoc networks, performs. Its performance is assessed by comparing it to the standard AODV protocol. Quality of Service, or QoS, is an acronym. Through the addition of extensions to Route Discovery messages that are related to bandwidth estimation, the research has suggested some improvements to the AODV protocol to provide QoS. Three parameters—Traffic Rate, Node Speed, and Mobile Node Pause Time—have been the focus of this paper. Average end-to-end delay, packet delivery ratio (PDR), normalized overhead load (NOL), and throughput are the performance metrics used for evaluation. Regarding these parameters, the AODV protocol's performance for both QoS and Non-QoS is assessed.
Keywords: Ad hoc networks, AODV, bandwidth estimation, quality of service.

I. INTRODUCTION

Every node in an ad hoc mobile network carries its own router, and all nodes work together to carry traffic. The Ad hoc networking model's entire philosophy is a radical departure from the currently used highly structured and most often hierarchical models used for both local area as well as wide area networking. There are countless scenarios wherein ad hoc networking may be used. Only the participating nodes' link performance, routing delays, and connectivity to the existing fixed network place restrictions on the virtually universal connectivity that mature and reliable ad hoc networking offers. Ad hoc networks are perfectly feasible with the technology available today, as demonstrated in Figure 1, provided that appropriate Ad hoc routing protocols are available and used.

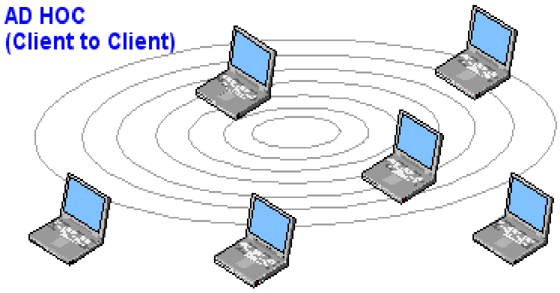


Figure 1. Ad-hoc Networking (From Computer Desktop Encyclopedia ©2007)

Both the Distance Vector (DV) and Link State (LS) routing algorithms are commonly used in static networks, but neither is particularly well suited to fast changing topologies. Such protocols encounter a number of issues in a wireless network that is very dynamic:

- Topologies could be highly redundant, with a few nodes able to connect to a huge number of neighbours while only seeing a small number of them.bandwidth is scarce and cannot be wasted.
- Portable equipment's battery power is a limited resource that should not wasted.
- High update rates are needed when topology changes frequently.

A. Routing Models

Routing models are of two types:

1) Proactive Routing

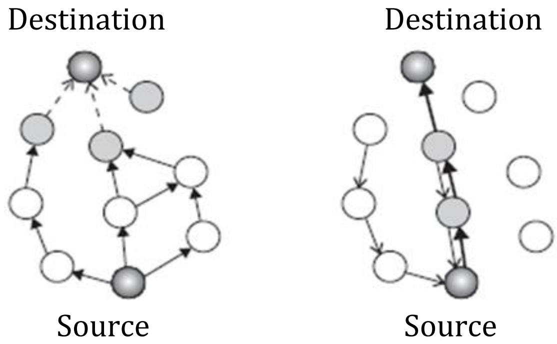
2) Reactive Routing

3) Hybrid Routing

Three parameters, namely traffic rate, speed, and pause time of mobile nodes, have been the focus of this paper. Average end-to-end delay, packet delivery rate, normalised overhead load, and throughput are the performance metrics used for evaluation. By using a graphical representation of their interrelations, three parameters and four performance metrics are used to evaluate the AODV protocol for both QoS and Non-QoS.

B. AODV Protocol Overview

On-demand reactive routing protocols like the AODV use routing tables with one entry for each destination. As seen in Figure 2, when a sender node needs to locate a route to the destination, it initiates a route discovery procedure based on flooding to find the destination node.



(a) RREQ Broadcast (b) RREP Propagation and Subsequent Route

Figure 2. Route Discovery Cycle

The intermediate nodes keep updating their routing tables for a backward route to the source after receiving a route request (RREQ) packet. Similarly, upon receiving a route reply (RREP) packet from the destination or any other intermediate node with a valid route to the destination, with a forward route to the destination is updated. Sequence numbers are used by the AODV protocol to establish the timelines of every packet and avoid loops. The route entries are updated using expiry timers. Route error (RERR) messages sent from a broken link to the source node of the corresponding route are used to spread link failures. The starting node of the link sends RERR packets to a group of neighbouring nodes that communicate with the destination over the broken link when the next hop link fails.

C. AODV and QoS-AODV

The goal of this research has been to increase the QoS while also improving the performance of the standard AODV protocol. Broadband, cost, end-to-end delay, delay alteration (jitter), throughput, packet loss probability, battery charge, processing power, etc. are just a few examples of different QoS parameters. For the purpose of evaluating the QoS-enabled AODV protocol's performance, various performance metrics must be studied. By focusing on any of these parameters, research is being done to improve performance. In order to enhance QoS, this study takes into account the bandwidth parameters.

II. IMPLEMENTATION

The AODV protocol's implementation and analysis for the comparison are covered in the implementation section. This applies to the system, Fedora, as well as the applications ns2 (Network Simulator version), NAM (Network Animator), and Gnuplot. The primary implementation is then covered.

A. Need of Fedora

Linux was used for all simulation, implementation, and analysis work. Fedora was the version of Linux that was utilised for this. This particular operating system was chosen for research work because it is one of the most reliable and stable platforms available. Second, Linux systems offer greater security than other operating systems, and security is a crucial component in network environments. It is necessary to discuss some of the platform's key features because it serves as the foundation for everything.

B. Network Simulator ns-2

After the platform was set up, ns-2, a piece of software that was used in addition to other tools for all analysis and simulation work, was installed on it. The accepted protocol for network simulation is ns-2. The networking community highly respects its behaviour. It is being developed at ISI in California with funding from DARPA and NSF.

C. Core Implementation

1) Basic Protocol Simulation: The simulation and implementation of the AODV protocol are covered in this section. The platform, Fedora 8, was first set up in a virtual setting. The platform on which the aforementioned protocols were implemented was then configured for ns-2. A script file must be run on ns-2 for it to function. These script files were created using the TCL programming language (Tool Command Language). For the purpose of plotting graphs, we used Gnuplot and shell scripting.

2) QoS-Enabled Protocol Simulation: This study investigates a quality of service (QoS) architecture for real-time transmission of data in mobile ad hoc networks (MANETs). The QoS architecture consists of a priority MAC protocol, a QoS transport layer, QoS routing, and queue management. Simulations reveal that the QoS architecture significantly increases resource utilisation in MANETs and lowers packet loss.

3) QoS architecture: The proposed QoS architecture is shown in Figure 3 and includes every networking layer, from application layer to MAC layer. The control packet flow is shown by the narrow lines, while the data packet flow is shown by the bold lines.

B. Bandwidth Estimation

In a spread Ad hoc network, a host's available bandwidth is determined not only by the crude channel bandwidth but also by the bandwidth usage of its neighbours and interference from external sources, each of which limits a host's bandwidth that can be used for data transmission. Therefore, without being aware of the state of the entire network, applications cannot effectively optimize their coding rate. As a result, bandwidth estimation is a fundamental operation required for QoS in MANETs. As shown in Figure 3, bandwidth estimation can be carried out at various network layers.

In this study, I attempted to enhance QoS with a primary emphasis on the bandwidth parameter. Figures 4 and 5 depict the RREQ message format in the AODV protocol before and after QoS is enabled. In the provided RREQ format, a new field called "Bandwidth Required" is added to improve the performance of the fundamental protocol. The bandwidth required field information is stored in this RREQ packet, which is then used to compare it to the current requirement. The packet is only forwarded to the following intermediate node when it has enough bandwidth; otherwise, it is dropped, and when the circumstances are right, it is retransmitted.

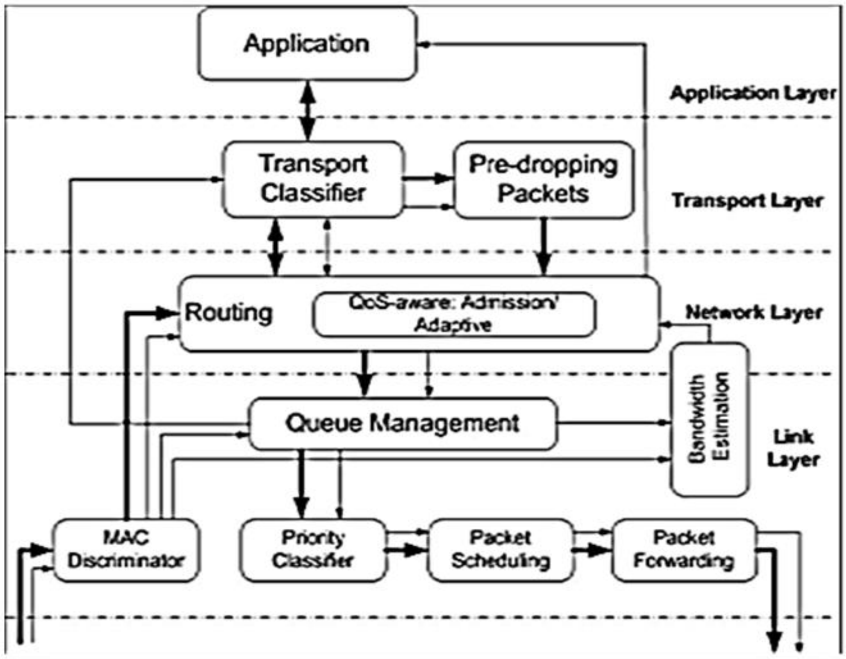


Figure 3. QoS Architecture

.TYPE	RESERVED	HOP COUNT
Broadcast ID		
Destination IP Address		
Destination Sequence Number		
Source IP Address		
Source Sequence Number		
Request Time		

Figure 4. RREQ Message Format pre QoS-Enabling

TYPE	RESERVED	HOP COUNT
Bandwidth Required		
Broadcast ID		
Destination IP Address		
Destination Sequence Number		
Source IP Address		
Source Sequence Number		
Request Time		

Figure 5. RREQ Message Format post QoS-Enabling

III. METHODOLOGY

A. Performance Analysis

ns 2.34 was installed on the console for simulating the protocols, together with necessary software like GnuPlot, which is tool for plotting the graph from the trace files. Fedora 8 was used as the operating system for the performance analysis. The object-oriented, discrete event-driven network simulator ns (version 2) was created in C++ and Otcl.

B. Basic Protocol Simulation

The simulation and implementation of the AODV protocol are covered in this section. The platform, Fedora 8, was first set up in a virtual setting. The platform on which the aforementioned protocols were implemented was then configured with ns 2.34. A script file must be run on ns-2 for it to function. These script files were created using the TCL programming language (Tool Command Language). For the purpose of plotting graphs, we have used Gnuplot and shell scripting.

C. Performance Metrics used for Analysis

The protocols were compared using the following metrics:

1) Throughput: This is the actual amount of network bandwidth that application is using.

2) Bandwidth: This is the actual amount of network bandwidth that application is using.

3) Average Packet Delay: The delivery time between a source and a destination of a packet is average. First, an average packet delivery delay is calculated for each source-destination pair. After that, the average delay for all pairs is calculated.

4) Packet Delivery Ratio: It is the proportion of data packets that were sent from the source to the destination or the number of delivered packets over the number of generated packets. The total number of data packets received across all destinations is the number of data packets actually delivered.

5) Network Overhead Load: The portion of wireless bandwidth used to transmit packets that are dropped in many other links is compared to the overall overhead brought on by control routing packets.

IV. RESULTS & ANALYSIS

A. Traffic Environment

The tests were run using 50-node CBR traffic. As it is difficult to manually create traffic simulations for such a large number of nodes, the simulations were generated with the aid of CMU traffic generated, and the scenario was generated with the aid of setdest, which are the tools preinstalled with the ns2. Packet size was set to 500 and the time interval between transferring the packets had just been set to 0.005 ms. The field configuration had just been set to 500 by 500 meters, and as a result, 12 graphs were produced and used to evaluate the AODV protocol for both QoS and Non-QoS using three parameters and four performance metrics.

Figure 6 shows that for high data rates above 600 kbps, the average packet delay suffered by QAODV is significantly less than that experienced by AODV. The amount of delay experienced at low data rates is roughly equivalent to AODV and QAODV. The reason AODV performs better is that it blocks packets at the source as soon as QoS criteria in the path are violated, reducing congestion in the shared intermediate sub-paths used by various flows.

According to Fig. 7, each Pause time, QAODV experiences an average packet delay that is between 40 and 60 ms less than that of AODV. When the nodes pause for 6 seconds, the minimum delay is obtained for both AODV and QAODV. As can be seen in Fig. 8, the average packet delay suffered by QAODV for each speed value is significantly less than that suffered by AODV. When the nodes are moving at a speed of 4 m/s or less, the minimum delay is achieved for both AODV and QAODV.

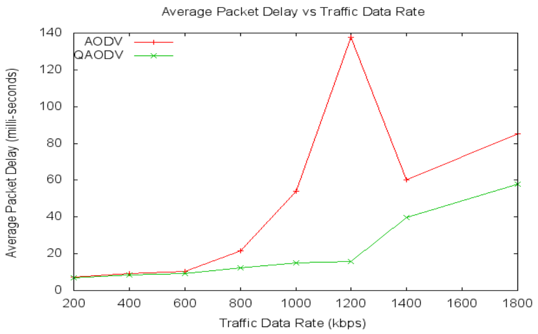


Fig. 6. Average Packet Delay versus CBR

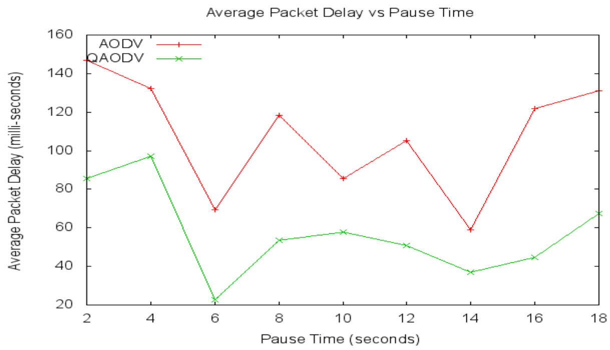


Fig. 7. Average Packet Delay versus Pause Time

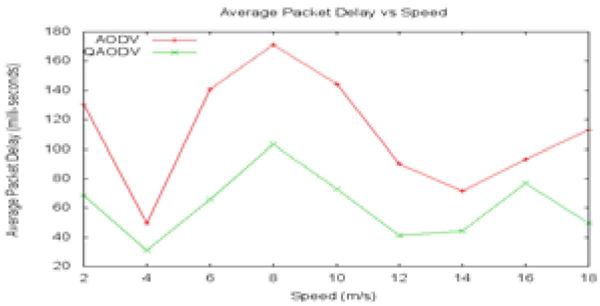


Fig. 8. Average Packet Delay versus Speed of Nodes

Figure 9 compares NOL and CBR. At each data rate, using QAODV has a higher overhead than using AODV. With an increase in traffic data rate, both AODV and QAODV's overhead values decrease. When the traffic data rate is 1200kbps, there is a significant increase in the overhead value of QAODV, which is difficult to explain.

NOL is plotted against Pause Time in Figure 10. When using QAODV, the overhead is greater than when using AODV for each pause time value. At various pause time values, the overhead values of AODV are essentially the same. When the pause time is set to 12 seconds, the overhead value of QODV significantly increases for unknown reasons.

NOL versus Speed of Nodes is depicted in Figure 11. At each moving speed value, using QAODV has a higher overhead than using AODV. At various speed values, the overhead scores of AODV are essentially the same.

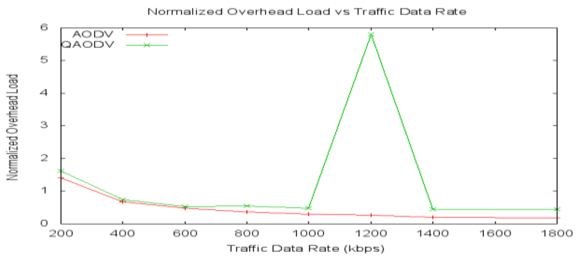


Fig. 9. NOL versus CBR

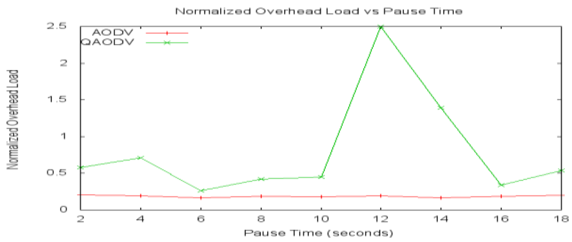


Fig. 10. NOL versus Pause Time

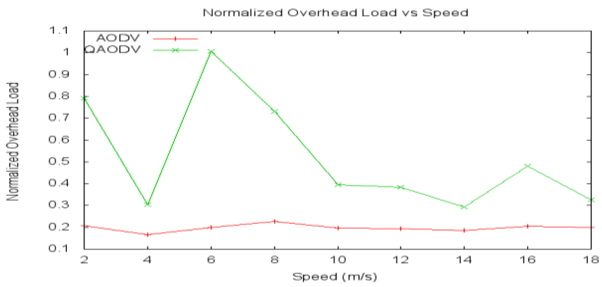


Fig. 11. NOL versus Speed of Nodes

Packet Delivery Ratio versus CBR is displayed in Figure 12. The PDR obtained by AODV is greater than that obtained by QAODV at every data rate value. With an increase in the traffic data rate, the PDR value for AODV roughly stays the same, whereas the PDR value for QAODV decreases. Finding a QoS-satisfying path for the flows is difficult when the QoS (bandwidth) demand is high. As a result, QAODV blocks the packets at the source, which causes the PDR value to decline as the data rate increases. Packet Delivery Ratio versus Pause Time is displayed in Figure 13. Here, the data rate is set to 2000 kbps, and at each pause, the PDR value of QAODV is lower than that of AODV. Packet Delivery Ratio versus Speed of Nodes is shown in Figure 14. Here, the data rate is 2000 kbps, and QAODV's PDR value is lower than AODV's at every speed value.

Fig. 12. Packet Delivery Ratio versus CBR

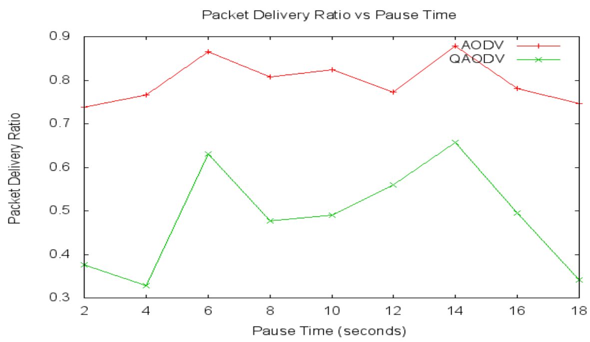


Fig. 13. Packet Delivery Ratio versus Pause Time

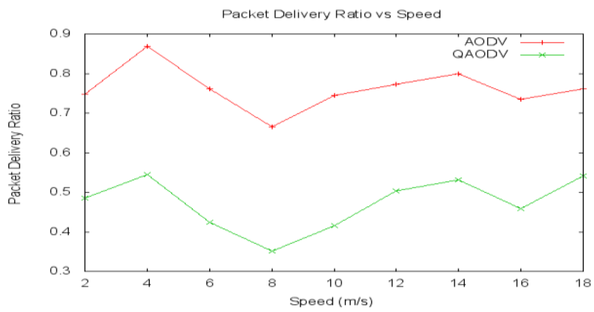


Fig. 14. Packet Delivery Ratio versus Speed of Nodes

Throughput versus CBR is shown in Figure 15. Throughput achieved by QAODV at low data rates is roughly comparable to that of AODV. Finding a QoS-satisfying path for the flows is difficult when the QoS (bandwidth) demand is high. As a result, QAODV blocks a packets at the source, which reduces throughput at data rates greater than 1200 kbps.

Throughput is plotted versus Pause Time in Figure 16. In this case, the data rate is 2000 kbps, and QAODV has a lower throughput than AODV. The throughput is greatest for both AODV and QAODV when the pause duration is 4 seconds.

Figure 17 plots throughput against node speed. In this case, the data rate is 2000 kbps, and QAODV has a lower throughput than AODV. The highest throughput is attained for AODV and QAODV when the speed is 4 m/s. When speed is 8 m/s, there is an abrupt decrease in throughput for both AODV and QAODV. For speed values greater than 12 m/s, there are not many differences in the throughput that AODV and QAODV can achieve.

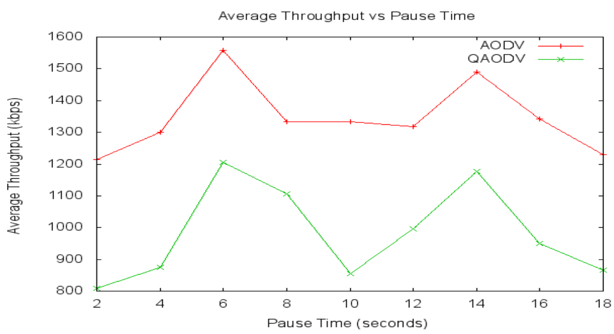


Fig. 15. Throughput versus CBR

Fig. 16. Throughput versus Pause Time

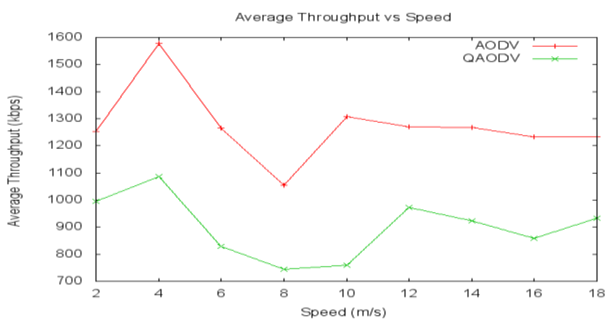


Fig. 17. Throughput versus Speed of Nodes

V. CONCLUSION

In this study, I introduced the AODV protocol with QoS (Quality of Service) support. First, I've used ns-2 to simulate the fundamental protocol. The twelve graphs are then created using Gnuplot with three different simulation scenarios: 1) Speed of Nodes, 2) Traffic Rate, 3) Pause Time or Mobility, and performance metrics: 1) PDR, 2) NOL, 3) Average packet delay, 4) Throughput. The basic protocol's QoS is then enhanced, and graphs are once more generated. Finally, a comparison between the QoS-enabled and non-QoS protocol is done. The outcome demonstrates the improvement in data routing from source to destination.By observing the graphs generated, following points can be concluded:

1) QAODV has a lower average packet delay than the original 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) QAODV's throughput average and packet delivery ratio are largely the same as those of the AODV Protocol.

Reduced Average Packet Delay for QAODV suggests that this strategy is appropriate for contemporary and future networks. The network will experience increased traffic whenever multimedia-based data, such as text, audio, and video, is streamed. In streaming video, packet loss, longer delays, and delay jitter are all commonly caused by network congestion. A protocol's main objective is to make the network more useful overall by giving higher-value or more performance-sensitive flows priority. Although there is a slight increase in network overhead load, the QAODV protocol is found to handle this situation better than AODV protocols even though its average packet throughput and packet delivery ratio are nearly identical.

Lowered Packet Delay of this QAODV is a major accomplishment. This is because wireless networks in the future will require an approach like this to cut down on transmission delays. For networks handling real-time traffic, such as video calling, this decreased delay will prove to be a crucial factor.

A Cisco study found that the amount of mobile data in 2010 was three times greater than the total amount of Internet traffic worldwide in 2000. The previous year's growth rate was 159%, which is 10% higher than what was anticipated for 2009. The next five years are expected to see continued rapid growth in mobile data, with an average annual growth rate of 92%. The rapid increase in mobile traffic can be attributed to a number of factors. First, it is thought that mobile video, which necessitates high bit rates, will increase mobile traffic. According to reports, mobile video accounted for up to 49.8% of all mobile traffic in 2010 and will make up two thirds by 2015. Additionally, Internet gaming, which consumed 63 PB per month on average in 2009, contributes to an increase in mobile traffic and is predicted to grow by 37% annually over the next five years. Last but not least, Voice over IP (VoIP), which includes phone-based VoIP services that are delivered directly to a service provider or by a third party, and software-based internet VoIP services like Skype, causes an increase in mobile traffic. Numerous of the aforementioned applications are real-time ones that require specific assurances for performance metrics such as average packet delay in order to function properly. Therefore, it is essential for ad hoc networks that this new QAODV achieves a lower average packet delay.

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