# EVALUATING PERFORMANCE OF WRP AND AODV MANETS ROUTING PROTOCOLS UNDER MOBILITY

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**Abstract**
The Mobile *ad hoc* networks (MANET) is a wireless networks which have no central bridge, and where each node acts as a destination as well as a router. The MANETs are dynamic networks because the network topology keeps on changing because of the mobility of the nodes. There are many protocols that have been developed to aid in routing in these types of networks. Each of these protocols is designed with some certain mobility scenarios in mind. To achieve effective routing in a given scenario, the right protocol must be chosen. Choosing the right protocol involves evaluating many interdependent performance metrics that define the effectiveness of a routing protocol, and this often poses a challenge to application designers. This research endeavored to model a simulation platform on which various protocols could be evaluated under various mobility scenarios to determine their suitability. The GloMoSim was used as the simulation platform and two MANET protocols namely wireless routing protocol (WRP) and *ad hoc* on-demand distance vector (AODV) evaluated. Our results demonstrated the usefulness of this modeled platform as it was able to establish that the AODV outperformed WRP in four out of the five of the measured performance metrics. The AODV is thus a better protocol for MANETs compared to WRP. The same simulation platform could be used test other protocols.

**Key words**: MANET, WRP, AODV, Simulation, GloMoSim

## 1.0 Introduction

Mobile *ad hoc* networks (MANETs) (Macker and Corson 1997) are networks composed of a set of communicating nodes able to spontaneously interconnect without any pre-existing infrastructure. These nodes generally have a limited transmission range and, so, each node seeks the assistance of its neighboring nodes in forwarding packets. In addition to that, these devices are generally mobile.

In order to establish routes between nodes which are further than a single hop, specially designed routing protocols are engaged. The unique feature of these protocols is their ability to trace routes in spite of a dynamic topology. These protocols can be categorized into two main types: reactive and proactive. In this research work we have chosen one protocol from each of these two categories for purposes of evaluating and comparing their performances. In the category of proactive protocols we have chosen WRP and in the category of reactive protocols we have chosen AODV. The Reactive routing protocols discover routes only when they are essentially required. This has an advantage of reducing the messaging overhead but has a disadvantage of increasing the end to end delay as it takes time before a route could be established. In contrast, the proactive routing protocols establish and maintain routes at all instants of time. This has an advantage of reducing the end to end delay but it increases the messaging overhead which could lead less to congestion.

Some of the applications of MANETs are as follows (Jeroen *et al.* 2003):

(i) Military vehicles on a battlefield with no existing infrastructure.
(ii) A fleet of ships at sea.
(iii) Emergency workers at an earthquake that destroyed the infrastructure
(iv) A gathering of people with notebook computers in an area lacking 802.11 (Wi-Fi).

Selecting a particular protocol for an application or deployment environment involves evaluating many inter-dependent metrics and can be an overwhelming task for an application designer. However, this decision can have a significant impact on the success of a system in terms of performance. Hence, there is need to analyse and compare the performances of various available protocols to determine their suitability in a given network scenario.

Evaluating performance of MANETs routing protocols is achieved by resorting either to experimentation networks (test-beds) or to the software-based simulators (Furqan and Thomas 2005). In our case we resorted to the use of a software based network simulator. What hindered the use of a test-bed is its implementation cost and its inherent lack of flexibility and repeatability. This becomes particularly impeding as the size of the experimented network grows.

The software based network simulator used in this research work is called GloMoSim (Zeng, Bagrodia and Gerla1998).

This research paper consists of five sections which are organized as follows: Section one has served as an introduction to the MANETs and need to analyze performance of the MANETs routing protocols. Section two surveys the theory behind the two mobile ad hoc network routing protocols under investigation and the performance metrics used. Section three details the simulation set-up. Section four presents the simulation results and discussion. Section five concludes the paper by describing various conclusions and the future research areas.

## 2. 0 Theory

### 2.1 The MANETs Routing Protocols under Investigation

#### 2.1.1 Wireless Routing Protocol (WRP)

WRP is a proactive routing protocol and was proposed by (Murthy and Gracia 1996). The WRP eliminates the possibility of routing loops. Nodes in a network using WRP maintain a set of four tables:

(i) *Link cost table.* This table contains the cost of the link to each immediate neighbor node and information about the status of the link to each immediate neighbor.

(ii) *Distance table.* The distance table of a node contains a list of all the possible destination nodes and their distances beyond the immediate neighbors.

(iii) *Routing table.* The routing table contains a list of paths to a destination via different neighbors. If a valid path exists between a source and a destination node, its distance is recorded in the routing table along with information about the next-hop node to reach the destination node.

(iv) *Message Retransmission List (MRL).* The MRL of a node contains information about Acknowledgement (ACK) messages from its neighbors. If a neighbor does not reply with an ACK to a hello message within a certain time, then this information is kept in its MRL and an update is sent only to the non-responding neighbors.

The WRP works by requiring each node to send an update message periodically. This update message could be new routing information or a simple ‘hello’ if the routing information has not changed from the previous update. After sending an update message to its all neighbors, a node expects to receive an ACK from all of them. If an ACK message does not come back from a particular neighbor, the node will record the non-responding neighbor in MRL and will send another update to the neighbor node later. The nodes receiving the update messages look at the new information in the update message and then update their own routing table and link cost table by finding the best path to a destination. This best-path information is then relayed to all the other nodes so that they can update their routing tables.

WRP avoids routing loops by checking the status of all the direct links of a node with its direct neighbors each time a node updates any of its routing information.

#### 2.1.2 *ad hoc* On-demand Distance Vector Routing (AODV)

The ad hoc on-demand distance vector routing (AODV) as described by (Perkins, Belding and Das 2003) is an improvement of the destination-sequenced distance-vector (DSDV) algorithm. It is a reactive protocol and constructs routes on demand and aims to reduce routing load. It uses a table driven routing framework and destination sequence numbers for routing packets to destination mobile nodes and has location independent algorithm. It sends messages only when required and it has bi-directional route from the source and destination. When it has packets to send from source to destinations mobile node then it floods the network with route request (RREQ) packets. When a node receives an AODV control packet from a neighbor, or creates or updates a route for a particular destination or subnet, it checks its route table for an entry for the destination. All mobile nodes that receive the RREQ checks its routing table to find out that if it is the destination node or if it has fresh route to the destination then it unicast route reply (RREP) which is routed back on a temporary reverse route generated by RREQ from source node, or else it re-broadcast RREQ.

Five performance metrics were used to analyse and compare the two protocols.

### 2.2 Performance Metrics

To analyse and compare the performances of protocols, standard performance metrics are used as described by (Jayakumar and Gopinath 2008) . In our case we have used five metrics namely; packet delivery ratio, mean end-end delay; messaging overhead; energy consumption and throughput. The five metrics used in our experiments are defined as follows:

#### 2.2.1 Packet Delivery Rate

Packet delivery rate (PDR) is the number of received packets divided by the number of sent packets, computed at the application layer. It reflects the routing protocol reliability which is a very important issue. It is expressed as a percentage. The higher the value of the PDR, the better the performance of the protocol. High values of this metric reflect a good reliability, i.e low packet loss.

#### 2.2.2 Consumed Energy

Because energy resources of devices used in MANETs are limited, energy consumption is an important issue related to routing protocols. A routing protocol is better if it causes less energy consumption compared with others in the same conditions. The consumed energy is measured in milliwatt hour (mwHr).

#### 2.2.3 Messaging Overhead

Messaging overhead is the number of control packets generated by the routing protocol during the simulation. The generation of high number of control packets would decrease the protocol performance as more network resources are taken up by these control packets leaving fewer resources for the actual data packets delivery. Although control packets are essential to ensure protocol functionality, their number should be as low as possible. The messaging overhead is expressed in terms of the number of control packets generated.

#### 2.2.4 Mean End-End Delay

The mean end-end delay is the average time it takes for a data packet to move from the source node to the destination node. This metric is very important to study the quality of service, especially in real-time applications. The lower the value of mean end-end delay the better the protocol in-terms of its performance. The mean end-end delay is expressed in second(s).

#### 2.2.5 Throughput

Throughput refers to how much data can be transferred from one location to another in a given amount of time. It is used to measure the performance of network connections. A high throughput value is desirable as it ensures maximum delivery of data packets. The throughput is expressed as bits per second (bps).

### 2.3 Mobility Models

To evaluate the performance of a protocol for an ad-hoc network, it is necessary to test the protocol under realistic conditions, especially including the movement of the mobile nodes. This is achieved by the use of a mobility model. Several mobility models exist for use in MANETs (Davies 2000). In this work we have chosen to use the random waypoint mobility model because we found it to be more realistic in-terms of modeling the movement of the nodes.

In random waypoint mobility model, each node remains stationary for the duration of its 'pause time'. At the end of a pause time, a node starts moving in a randomly selected direction in the network terrain at a fixed speed. Once a node reaches its new location, it remains stationary during its next pause time. At the end of the new pause time, a node again starts moving in another randomly selected direction in the network. This movement process is continued during a simulation experiment. Therefore a shorter pause time denotes high mobility and vice versa.

## 3.0 Simulation

### 3.1 Simulation Environment

To evaluate the performances of the two routing protocols, a parallel discrete event-driven simulator, global mobile simulator (GloMoSim), was used. Our simulation experiments were executed on a Compaq Presario CQ60 notebook Personal Computer (PC) with a Pentium IV processor@ 2.16 MHz with 2GB random access memory (RAM).

#### 3.1.1 Global Mobile Simulator (GloMoSim)

GloMoSim as described by (Zeng, Bagrodia and Gerla1998) is developed at UCLA (California, USA). It is widely used as wireless network simulator. GloMoSim is written in Parsec and hence benefits from the latter's ability to run on shared-memory symmetric processor (SMP) computers. New protocols and modules for GloMoSim must be written in Parsec too. GloMoSim conforms to the OSI standard.

### 3.2 Simulation Experiments

To compare the performance of the two routing protocols described in the previous sections, simulation experiments were performed.

#### 3.2.1 Experimental Modeling

In setting up our experimental model for purposes of simulation, we used the Nodes' mobility as the control parameter. Three different levels of nodes' mobility were used as described as below:

(i) High mobility- pause time 30s;
(ii) Medium mobility- pause time 120s and
(iii) Low mobility- pause time 240s.

For each of the two protocols under investigation, the five performance metrics were then measured for each of these three levels of nodes' mobility and results tabulated in Table 1 and Table 2.

The movement of the nodes was modeled using the Random Waypoint mobility model.

Traffic load generated by each source node was modeled by a constant bit rate data stream, whose transmission rate is defined by packet transmission interval for fixed-size packets. In our case one packet was sent every 1s. The network terrain size was fixed for 2000m x 2000m. The radio signal transmission range was fixed at 175m (radius of 175m). The transmission data rate of each link was fixed at 2Mbps and the simulation time was 15 Minutes for all the experiments. In every experiment, there were 30 randomly selected pairs of a sender and a receiver nodes.Data packet size was fixed at 512 bytes. The above parameters were used for both of our simulation experiments.

## 4.0 Results and Discussion

The data obtained from the simulations is as contained in Table 1 and Table 2.

*Table 1: WRP simulation data*

| ***Nodes mobility*** | ***Energy (mwHr)*** | ***Control Packets*** | ***Throughput*** | ***Delay (s)*** | ***Packet Delivery Ratio(PDR)%*** |
|---|---|---|---|---|---|
| High | 225.16 | 912 | 1530 | 0.01 | 34.61 |
| Medium | 225.15 | 831 | 2519 | 0.008 | 46.14 |
| Low | 225.14 | 797 | 2532 | 0.007 | 50.0 |

*Table 2: AODV simulation data*

| **Nodes mobility** | **Energy (mwHr)** | **Control Packets** | **Throughput** | **Delay (s)** | **Packet Delivery Ratio(PDR)%** |
|---|---|---|---|---|---|
| High | 225.023 | 120 | 1771. | 0.0356 | 54.20 |
| Medium | 225.015 | 80 | 2383 | 0.0339 | 68.21 |
| Low | 225.01 | 50 | 2664 | 0.032 | 78.05 |

The analysis of the results is done using graphs shown in Figures 1 to Figure 5. Each Figure denotes a particular performance metric evaluated against the three different levels of nodes' mobility.

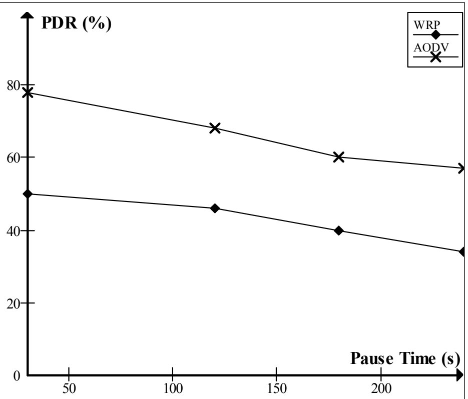


*Figure 1: Packet Delivery Ratio (PDR) versus nodes' mobility*

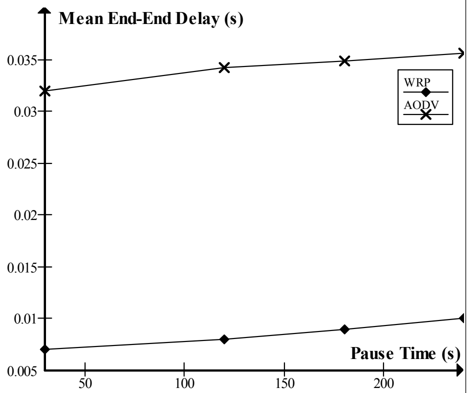


*Figure 2: Mean End-to-End Delay versus nodes' mobility*

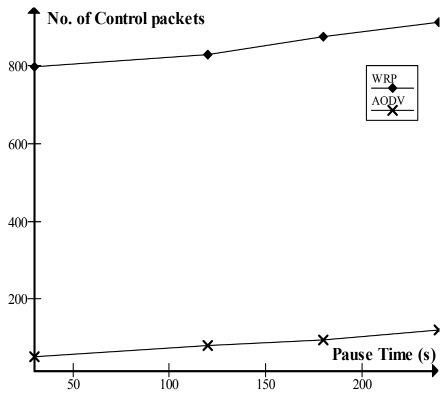


*Figure 3: Messaging Overhead versus nodes' mobility*

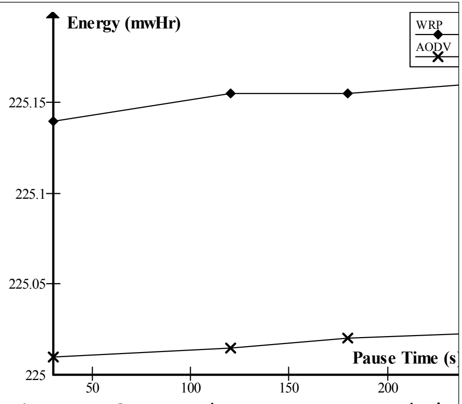


*Figure 4: Consumed Energy versus nodes' mobility*

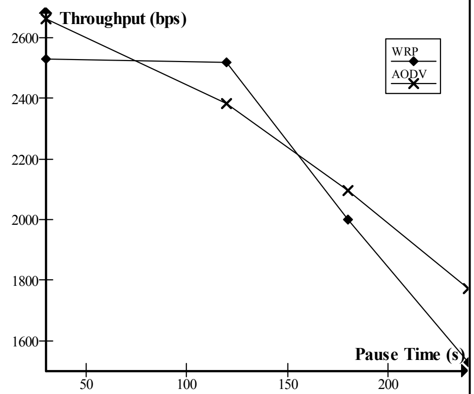


*Figure 5: Throughput versus nodes' mobility*

### 4.1 Packet Delivery Ratio

In Figure 1, we see that the AODV has a higher packet delivery ratio **(**PDR) compared to WRP in all mobility speeds which implies a better performance. The reason for this is that AODV being a reactive protocol responds more quickly to link failures by each node sending an error packet to all its active neighbors as soon as it detects a link failure thus avoiding excessive packet losses. On the other hand WRP being a proactive protocol sends packets before routing tables converge to a stable state, which leads nodes to take failed routes supposed to be valid and thus suffer from increased packet losses. For both protocols, PDR decreases when the mobility increases.

### 4.2 Mean End-to-End Delay

Looking at Figure 2, we remark that WRP has low mean end-end delay compared to the AODV protocol which implies a better performance. This is because WRP being a proactive protocol constructs and maintains routing tables permanently, which eliminates the route discovery time as opposed to AODV which constructs routes on demand. In both protocols, the delay is not significantly affected by mobility

### 4.3 Messaging Overhead

We can see in Figure 3 that WRP generates the most overhead of the two protocols by a factor of 80. This is because WRP being a proactive protocol generates periodic messages whereas AODV do not generate overhead unless there is a need for a route or when a route is failed.

The messaging overhead in both protocols increases slightly with increase in mobility. This is because mobility rise implies route failure rise, which causes the generation of more route discovery packets. So as far as this performance metric is concerned the AODV performs better than the WRP.

### 4.4 Energy Consumption

We remark that consumed energy plots (Figure 4), shows that WRP consumes more energy than AODV. The reactive protocols consumed less energy than the proactive ones, because the latter, generated more control packets that led to consumption of more battery power. Therefore the AODV performed better than the WRP as far as this metric is concerned.

### 4.5 Throughput

It can be seen from Figure 5 that the throughput of both protocols is heavily adversely affected by mobility. This is because mobility increases the chances of link failures, which in turn decreases the throughput as more packets end up not reaching their destinations. But of the two, the AODV has a higher throughput and hence a better performance.

## 5.0 Conclusion

In this paper, we have conducted a GloMoSim based simulation study, to investigate the mobility effects on the performance of two MANETs' routing protocols; A reactive (AODV), and a proactive (WRP). This study is performed by measuring different performance metrics at different mobility levels.

From the study it was seen that the AODV outperformed the WRP in four out of the five measured performance metrics namely Packet Deliver Ratio, Messaging Overhead, Energy consumption and Throughput. Its only in Mean End-End Delay that the WRP outperformed the AODV. We could therefore conclude that the AODV is a better MANET routing than the WRP especially under the considered three levels of nodes’ mobility. Hence the AODV protocol could be used in network scenarios where nodes’ mobility is relatively highly and where the packet end to end delay is not a critical parameter. On the other hand, the WRP protocol could be used in network scenarios of relatively low mobility but where end to end delay is a critical parameter especially in real time applications.

We also realize from this study that the mobility, which characterizes MANETs, has negative effects on routing protocols. This is because of the broken links caused by the nodes’ mobility. This in turn causes more energy consumption, more Mean End-End Delay, more packet loss, and more congestion (due to the increasing overhead).

The results obtained also showed that our modeled platform that used the GloMoSim is a good tool for use in determining the right protocol for a given network scenario.

As work for future research area, it would be interesting if someone was able to carry out this study but now using a test-bed in order to compare results.

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**References**

Perkins C., Belding-Royer E. and Das S. Ad hoc on-demand distance vector (aodv) routing,. in *Internet Engineering Task Force (IETF) draft*,July 2003.

Haq F. and Kunz T. (2005). Simulation vs. Emulation:Evaluating Mobile Ad Hoc Network Routing Protocols. Systems and Computer Engineering Carleton University Ottawa, Canada.

Jayakumar G. and Gopinath G., (2008) "Performance Comparison of MANET protocols based on Manhattan Grid Mobility Model": Journal of Mobile Communications,**2,** (1) pp 18-26.

Macker J. and Corson S., "Mobile Ad Hoc Networks (MANET)," IETF WG Charter., http://www.ietf.org/html.charters/manet-charter.html, 1997.

Hoebeke J., Moerman I., Dhoedt B. and Demeester P.(2003). An Overview of Mobile Ad Hoc Networks: Applications and Challenges. Department of Information Technology (INTEC), Ghent University, Belgium.

Murthy S., Gracia-Luna-Aceves J. J. (1996). An efficient routing protocol for wireless networks. *ACM Mobile Networks and Applications Journal*, Special Issue on Routing in Mobile Communications Networks. pp 183–197.

Davies V. (2000). Evaluating mobility models within an ad hoc network, Master's thesis, Colorado School of Mines, pp. 24-37.

Zeng X., R. Bagrodia and Gerla M., Glomosim (1998). A library for parallel simulation of large-scale wireless networks, in: Workshop on Parallel and Distributed Simulation, pp. 154–161.