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# Experiment of Routing Protocol AODV (AdHoc On-demand Distance Vector)

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***ABSTRACT:*** *In Mobile Ad hoc Network (MANET), routing protocols rely on asymmetric links so the received information for one connection is not useful at all for the other one. In this paper there are two approaches; the first approach is a simulation of MANET with many nodes in one network based FTP traffic. The second approach is a simulation of the combination between WiFi and WiMax wireless technologies in one network based on the IEEE 802.11 and IEEE 802.16 standards respectively. For these two approaches, the simulation considers the situation that the MANET receives traffic from another network via a common gateway. In addition, the mobile nodes are randomly placed in the network that will provide the possibility of multi-hop routes from a node to another. Several scenarios' simulations using WLAN technology were tested to investigate the behavior of the network performance for logical and office applications with fixed and mobile workstations. we considered to operate on a single-hop or multi-hop basis where nodes in the network are able to act as intermediaries (routers) for communications of other nodes. Nodes in networks are forced to operate with power limited batteries for power saving goal addition of the bandwidth constrained is considered.*

***Keywords:*** *MANET, Routing, AODV, WLAN and OPNET Simulator.*

## I. INTRODUCTION

In Mobile Ad hoc Network (MANET) is the establishment and maintenance of the ad hoc network through the use of routing protocols. The Ad hoc On Demand Distance Vector (AODV) routing algorithm is a routing protocol specifically designed for ad hoc mobile networks. AODV is capable of both unicast and multicast routing and it is an on demand algorithm, meaning that it builds routes between nodes only and only if it is desired by source nodes. It maintains these routes as long as they are needed by the sources [1][2].

In other words, the primary objectives of the algorithm are to broadcast discovery packets only when necessary in order to distinguish between local connectivity management and general topology maintenance and to disseminate information about changes in local connectivity to those neighboring mobile nodes that are likely to need information. [3][4]. Many researchers

Working with wireless routing protocols; Charles E. Perkins [5] studied a systematic performance analysis of Dynamic Source Routing (DSR) and AdHoc On-demand Distance Vector (AODV) routing protocols. Ferrari and Malvassori [6] proposed in a protocol called a MAODV (modified ad hoc on demand distance vector) which evaluated the benefits of using power control (PC) among selected routes in order to reduce the bite error rate at the destination node. Authors of [7] and [8] developed a reactive routing algorithm for multi-rate adhoc wireless networks which enhances the AODV protocol and shows in results the higher throughput over traditional adhoc routing protocols.

This paper submitted two study cases as follows; the first one related to using an AODV routing protocols in ad hoc network with Standard MAC 802.11. The second one is related to combining WiFi and WiMax networks then evaluating and analyzing the performance behavior of this network combination. we are build our implemented in OPNET 14.5 simulator. The rest of this paper is organized as follow. Section Two reviews some detailed description of AODV Routing. Section

three describes the Path Discovery in AODV. Section four represents the MANET model architecture in OPNET simulation. Case studied scenarios (simulation experiments) are included in section five. The sixth section shows the researchers simulation results. Finally, the conclusions drawn are given in section seven.

## II. (AODV) PROTOCOL

Ad hoc routing protocol is a network routing protocol developed with some mechanisms to cope with the dynamic nature of MANETs. The efficiency of a routing protocol is determined among other things by its power consumption of a participating node and routing of traffic into the network. How fast the routing protocol adapts to the connection tearing and mending is also considered paramount [9]. AODV is an on-demand routing protocol used in ad hoc networks, like any other on-demand routing protocols and facilitates a smooth adaptation to changes in the link conditions. In case a link fails, notifications are sent only to the affected nodes, this information enables the affected nodes invalidate all the routes through the failed link. It has low memory overhead and builds unicast routes from source to the destination.

There is minimal routing traffic in the network since routes are built on demand. It does not allow nodes to keep routes that are not in use. When two nodes in an ad hoc network are establishing a connection between each other, AODV will enable them to build multi-hop routes between the mobile nodes involved. AODV is a loop free protocol since it uses Destination Sequence Numbers (DSN) to avoid counting to infinity. This is the most important distinguishing feature of this protocol [10]. AODV is a reactive protocol, which plans the path for packets “as and when” it needs to. Updates to the routes are performed when needed and in the process of route discovery. The disadvantage of this general approach is the risk of full flooding which occurs when nodes receive a hit message, and flood the network with Route Request Packets [11].

**A). Path Discovery in AODV**

The Path Discovery process is initiated whenever a source node needs to communicate with another node for which it has no routing information in its table. The source node initiates path discovery by broadcasting a route request (RREQ) packet to its neighbors. The RREQ contains the following fields as shown in Fig.(1).

- Source address
- Source sequence number
- Broadcast ID
- Destination address
- Destination sequence number
- Hop count

```
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |R|A|    Reserved     |Prefix Sz|   Hop Count   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Destination IP Address                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Destination Sequence Number                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Originator IP Address                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Lifetime                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1. an example of RREQ message format [11].

The pair source address and broadcast ID uniquely identifies a RREQ. Broadcast ID is incremented whenever the source issues a new RREQ. Each neighbor either satisfies the RREQ by sending a route reply (RREP) back to the source or rebroadcasts the RREQ to its own neighbors after increasing the hop count. Notice that a node may receive multiple copies of the same route broadcast packet from various neighbors. When an intermediate node receives a RREQ, which it has already received with the same broadcast ID and source address, it drops the redundant RREQ and does not rebroadcast it.

**B). Reverse Path Setup.**

There are two sequence numbers included in a RREQ: the source sequence number, and the last destination sequence number known to the source. The source sequence number is used to maintain freshness information about the reverse route to the source, and the destination sequence number specifies how fresh a route to the destination before it can be accepted by the source [4][12].

Let's suppose the procedure shown in Fig. (2).When the source node S determines that it needs a route to the destination node D and it does not have the root available, then immediately node S starts broadcasting RREQ (Route Request) message to its neighboring nodes in quest of route to the destination. The nodes 1 and 4 being as neighbors to the node S receive the RREQ message. So nodes 1 and4 create a reverse link to the source from which they have received RREQ. Since the nodes 1 and 4 are not aware of the link to the node D, they simply rebroadcast this RREQ to their neighboring nodes 2 and 5. As the RREQ travels from a source to various destinations, it automatically sets up the reverse path from all nodes back to the source. This reverse route will be needed if the node receives a RREP back to the node that has originated the RREQ. Before broadcasting the RREQ, the originating node buffers the RREQ ID and the originator IP address. In this way, when the node receives the packet again from its neighbors, it will not reprocess and re-forward the packet [1].

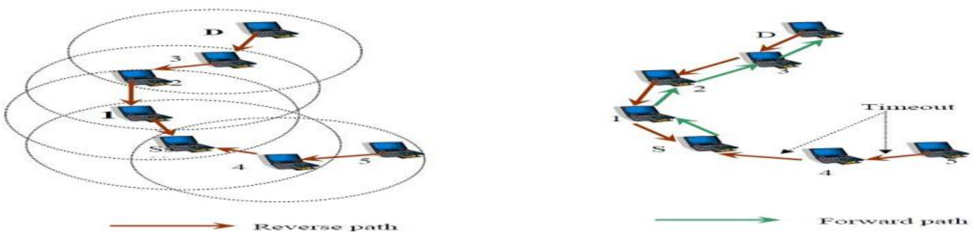


Figure (2): Forward Path Setting and Reverse Path.

**C). Forward Path Setup.**

Eventually, a RREQ will arrive at a node that possesses a current route to the destination or the destination itself. The receiving node first checks that the RREQ was received over a bi-directional link. If an intermediate node has a route entry for the desired destination, it determines whether the route is current by comparing the destination sequence number in its own route entry to the destination sequence number in the RREQ. If the RREQ's sequence number for the destination is greater than that recorded by the intermediate node, the intermediate node must not use its recorded route to respond to the RREQ. Instead, the intermediate node rebroadcasts the RREQ. The intermediate node can reply only when it has a route with a sequence number that is greater than or equal to that available in the RREQ. If it does have a current route to the destination and if the RREQ has not been processed previously, the node then unicasts a route reply packet (RREP) back to its neighbor from which it has received the RREQ.

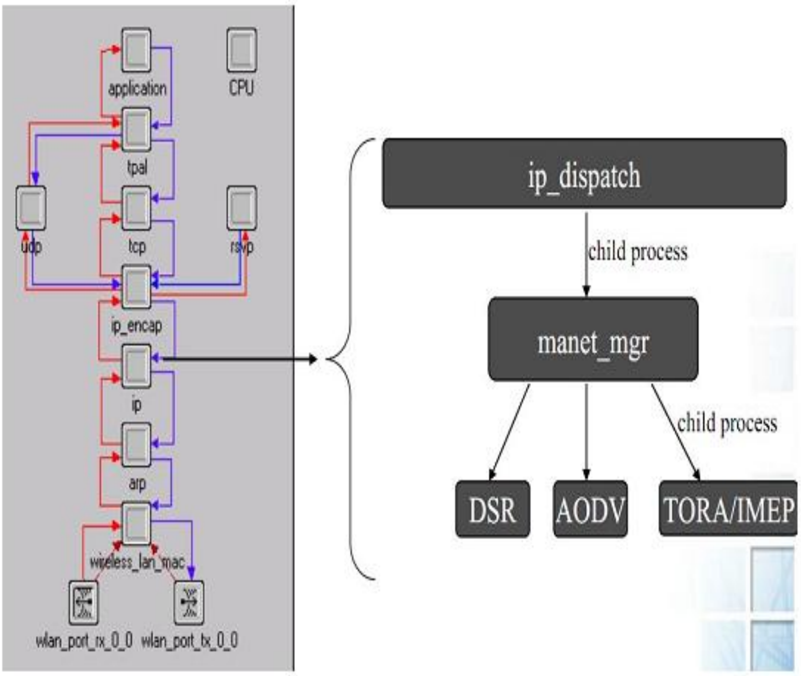


**Figure (3):** node model in OPNET simulator.

**D). Manet Model Architecture in Opnet.**

OPNET is widely being accepted as the frontrunner in simulation based tools in most universities and industry. This simulator helps to have a better understanding of how a wireless network is designed and implemented towards a real life scenario. It allows researchers to design and study communication networks, devices, protocols, and applications with great flexibility. OPNET provides a graphical editor interface to build models for various network entities from physical layer modulator to application processes. All the components are modeled in an object-oriented approach which gives intuitive easy mapping to real systems. Models of AODV and other ad hoc routing protocols are available in OPNET version 14.5. This section explains a model architecture, node models of MANET and all source, header and external files that are used by AODV process. Fig (3) Shows the node model in OPNET simulator [13].Traditionally, there are two profiles used to configure any network models [14];

- Profile Configuration -Profiles describe the activity patterns of a user or group of users in terms of the applications used over a period of time. Several different profiles run on a given LAN or workstation. These profiles can represent different user groups, for example, you can have an Engineering profile, a Sales profile and an Administration profile.
- Application Configuration- A profile is constructed using different application definitions. For each application definition, you can specify usage parameters such as start time, duration and repeatability. You may have two identical applications with different usage parameters; you can use different names to identify these as two distinct application definitions.

## III. SOME OF CASIES

### A) AODV Algorithm in Ad Hoc Network with Standard MAC 802.11

In this case the researchers used the following modeling standards given below for three proposed scenarios. A standard scenario contains (2-4) MANET Workstations and the Ad-Hoc Routing DSR or AODV depending on the scenarios . -The Workstation is connected wirelessly to the MANT Gateway at 2 –11MB.

-The Wireless Network BSS Identifier is 0. The scenario will take place in an office of size 100m x 100m.-Time of simulation is about 20 minutes.

*Scenario 1*: In this scenario, an office of 300m scale is chosen with Wireless LAN server and two nodes (source and destination) without any routing protocol. This scenario is shown in Fig.(4).

*Scenario 2*: For an ad-hoc network, AODV algorithm is used as shown in Fig.(5).By using node (0), the destination node can be connected to the network by AODV algorithm. The simulation duration is chosen as 20 minutes.

*Scenario 3*: As Fig.(6), two fixed node are added between source node and trajectory mobile node to see the effect of the trajectory and the number of nodes on distance vector and number of hopes. Figs.(7-9) show the simulation results of these three scenarios respectively. Figs (10-14) shows how the different number of nodes (different hopes) in the AODV simulation can have an effect on the network delay and throughput. The figures below show that increasing number of nodes (no. of hops) will decrease the network throughput.

Furthermore, it can be noted that the network delay with using AODV routing is less than any other network that uses any other routing algorithms.


Figure (4): scenario 1_network implementation


Figure (5): scenario 2_network implementation.

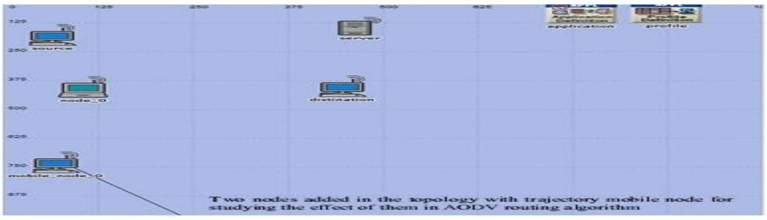


Figure (6): scenario 3_network implementation.

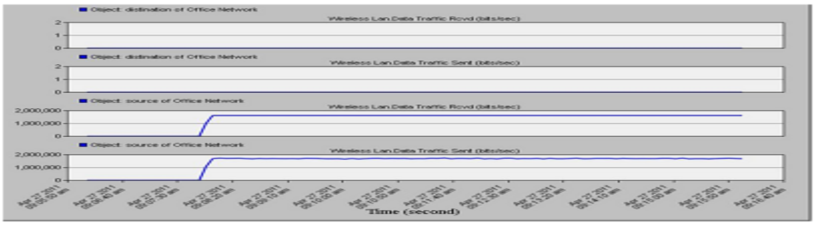


Figure (7): scenario 1_the results.

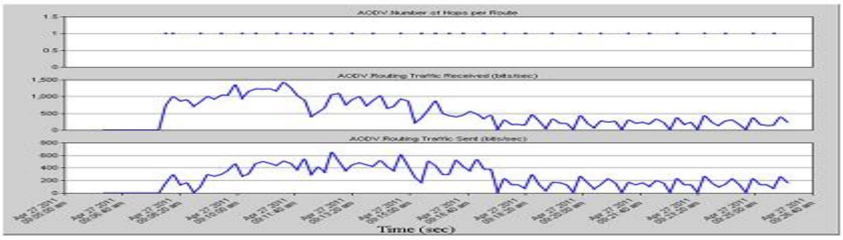


Figure (8-A): scenario 2_destination node results

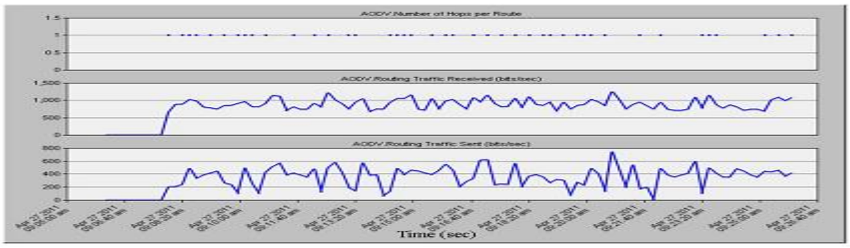


Figure (8-B): scenario 2_source node results.

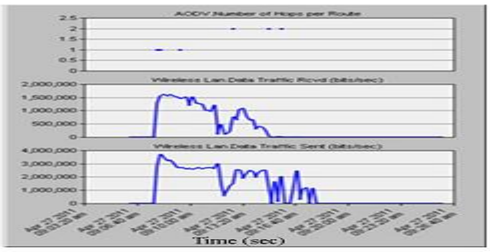


Figure (9): scenario 3_the results.

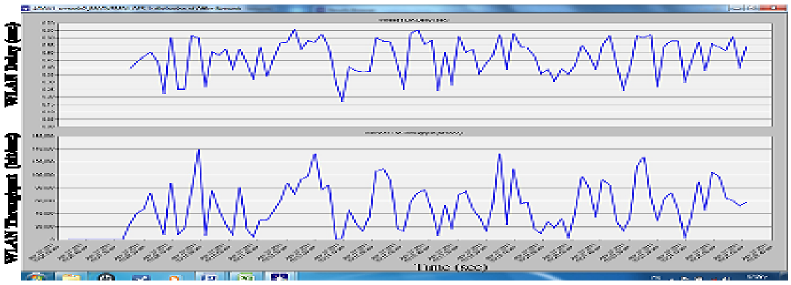


Figure (10): throughput and delay of AODV after adding two nodes.

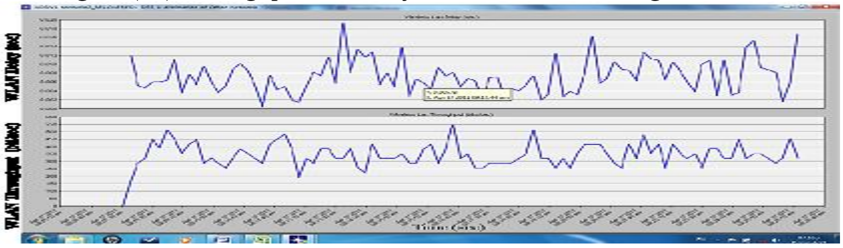


Figure (11): Throughput and Delay of AODV after adding three nodes.

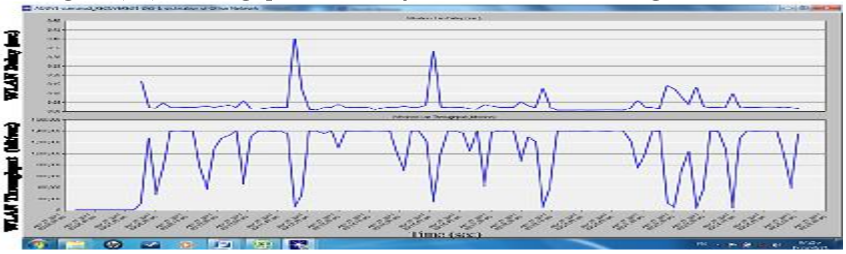


Figure (12): Throughput and Delay of AODV after adding five nodes.

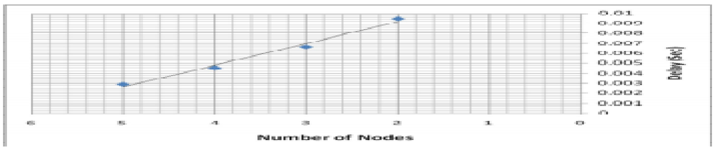


Figure (13): delay vs. no. of nodes.

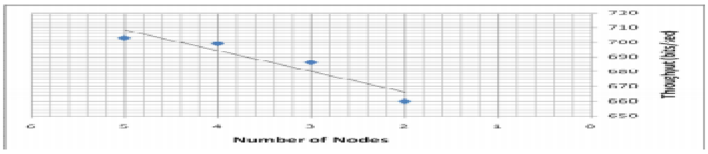


Figure (14): throughput vs. no. of nodes.

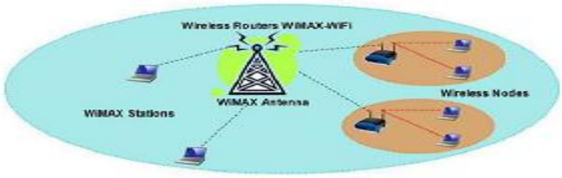


Figure (15): Wi-Fi and WiMax network convergence [15]

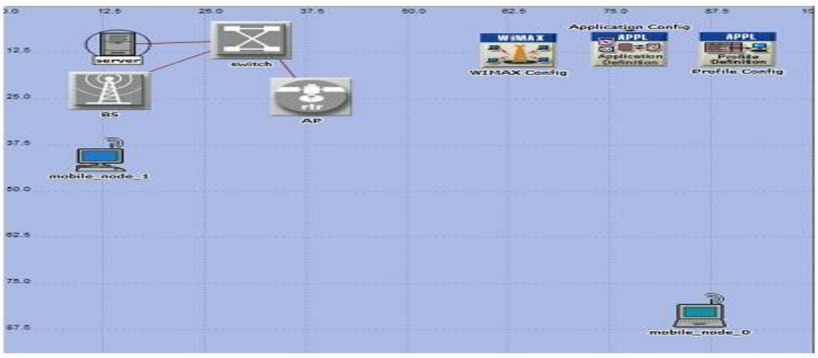


Figure (16): scenario 1_The WiMAX model implementation.

Figure (17): scenario 2_ WLAN-WiMAX packet flow and node movement.

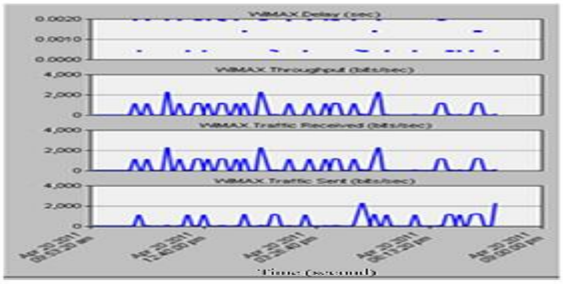


Figure (18): scenario 2_the simulation results.

**B) WiFi and WiMax Evaluation and Network Performance.**

WiMAX which is based on the IEEE802.16 standard provides a wireless broadband technology. Both the technical execution and the business cases show the differences between WiMAX and traditional Wi-Fi technology. As they are both wireless technology, most people consider WiMAX as the robust of WiFi. A simple comparison shows the advantage of WiMAX in larger network coverage area and faster transfer speed over Wi-Fi. Because of technologies reason and standardization issues, WiMAX does not present its better performance in market position In addition, the relatively high price also decreases the speed of WiMAX to occupy the market [15]. The main differences in protocol and services are shown in Table (1) below.

| | **3G** | **WiFi 802.11** | **WiMax 802.16** | **Mobile-Fi 802.20** |
|---|---|---|---|---|
| **Max Speed** | 2Mbps | 54Mbps | 100Mbps | 16Mbps |
| **Coverage** | Several miles | 300 feet | 50 miles | Several miles |
| **Airwave** | Licensed | Unlicensed | Either | Licensed |
| **Advantages** | Range, mobility | Speed, Price | Speed, range | Speed, mobility |
| **Disadvantages** | Slow, Expensive | Short range | Interference issues | High Price |

Table (1) comparison among different wireless technologies

The physical layer for WiMAX at the start stage is IEEE 802.16 which limits the physical layer to be operated in 10 GHz to 66 GHz. During going through the standard of IEEE 802.16a and IEEE 802.16e, WiMAX obtain benefits from the network coverage, self-installation, power consumption, frequency reuse and bandwidth efficiency. The standard IEEE802.16d is used on WMAN fixed and IEEE 802.16e is used on WMAN Portable. The throughput for Fixed WiMAX is up to 75 Mbps with the 20MHz bandwidth while the portable WiMAX is up to 30Mbps with 10MHz bandwidth. Also, the network coverage of fixed WiMAX and the portable WiMAX is 4-6 miles and 1-3 miles respectively. The conflict between WiMAX and Wi-Fi is the resistance for WiMAX to develop. In order to extend the reach of WiMAX technology, redundant efforts have been done to cooperate with the traditional Wi-Fi. This seems the only way to satisfy both the Wi-Fi supporters and those who focus on the higher speed and larger range. While the Wi-Fi is playing a smaller role in the wireless industry, the opportunity for wireless technologies to grow up and offer high speed appears. Fig.(15) gives an outline of how Wi-Fi and WiMAX is integrated to work together to approach a better performance in either distance or transfer speed [16][17].

## IV. RESULTS AND DISCUSSION

**A). WiMax Connection Model.**

The basic components of WiMAX connection station is the wireless work station and WiMAX base station. The most common connections of WiMAX are PMP which means point to multi-point. The PMP topology, where a group of subscriber terminals are connected to a base station separately, is the best choice for most of the users who do not need entire bandwidth and extremely high speed. The basic WiMAX model is shown in Fig.(16) (scenario (1)). In this model, the components that have been used are; WiMAX config., WiMAX base station and WiMAX workstations. This model that has been built to test file transfer process contains the following:

- Application configuration.
- Profile configuration.

- Application server
- WiMAX_WLAN router

Model building steps are as follows; Creating the Topology, Configuring Node Mobility, Adding Traffic to the WiMAX Network Model and Configuring WiMAX Parameters). While load traffic are added to the WiMAX network model, the standard application models such as FTP, Email, and custom application is implemented in the WiMAX subscriber workstation and WiMAX application server.

**B). WLAN-WiMAX Network Model.**

Fig.(17) Shows the configuration for WLAN-WiMAX network model for scenario(2) and after the model was built, the file transfer performance of a WLAN-WiMAX was analyzed. The simulation result for this model can be seen in Fig. (18).

## V. CONCLUSION

Our two approaches were discussed as two cases. For the first case study, AODV Algorithm in Ad-Hoc Network was used. It works by constructing routes between nodes on demand by source nodes, and they are kept until they are not needed so as to minimize the route discovery time. However the study shows that AODV is a faster protocol at finding the route due to using one route instead of multiple.

Following conclusions are made based on the analysis of simulation results:

-Using sequence numbers on route updated to find the latest route to destination that increase the speed and make the network fast and of high capacity.

With the increase of number of hops, throughput degrades due to higher delay.

The results show that AODV is the strongest candidate when experiencing an increase in nodes and bandwidth.

The performance of AODV is observed to improve with the increase in the number of sources. The hop-by-hop initiation in AODV helps to reduce the end-to-end delay. For the second case study (Wi-Fi and WiMAX), the network performance is evaluated and analyzed,. The following conclusions for this approach are: -By using these models together, the limitation of this network is the WLAN transfer performance. By improving the overall performance of the network, a WiMAX work station could be used instead the WLAN router with WLAN work stations.

The best way to enjoy the advantage of the WiMAX system is to combine the WiMAX and Wi-Fi systems together. The Simulation results show that throughput and lifetime become better by using WLAN-WiMAX model.

-Each access point has its own BSS. The connection change in this scenario considered a layer 2 handoff.

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