Australian Journal of Basic and Applied Sciences, 4(9): 4509-4521, 2010
ISSN 1991-8178

Cross Domain Contour of AODV over OSPFv3 in Heterogeneous Ubiquitous Networks Using Internet Gateway

[1]Shams ul Arfeen, [2]Sayed Hyder Abbas Musavi, [3]Madad Ali Shah, [4]Nusrah Kanwal

[1]Assistant Professor, Faculty of Engineering, Science & Technology, Hamdard University, Karachi
[2]Assistant Professor/Research Scholar, Faculty of Engineering, Science and Technology, Hamdard University Karachi,
[3]Sukkur Institute of Business Administration, Sukkur,
[4]Teaching Assistant, Faculty of Engineering, Science & Technology, Hamdard University.

Abstract: This paper presents the results of packet-level simulation of AODV routing protocol over OSPFv3 protocol under cross domain contour of interconnecting Mobile Ad-hoc Networks with legacy networks using Internet Gateways. The simulation shows results for fixed radius of nodes with varying pause times at different mobility levels for measured QoS parameters of packet loss, routing traffic received/sent and total replies received from destinations using random waypoint propagation model. The results prove medium level satisfaction over decreased packet losses, increased packets' transmission and their acknowledgement with both lower and higher mobility levels for varying pause times.

Key words: Ubiquitous Computing, Heterogeneous Networks, MANET, AODV, OSPFv3, Internet Gateway.

INTRODUCTION

The interconnection of Mobile Ad Hoc Networks (MANET) to legacy networks such as Internet is a challenging research issue of paramount importance due to incompatible routing protocols implemented in multicast environment having varying Gateways with inherent forwarding per-group behavior in heterogeneous networks. The core issue is to identify proper Internet Gateway and associated protocols to support necessary services. In these types of networks the fixed infrastructure lies at one end and the mobile one at the other. Maintaining such schemes the issues of throughput versus node mobility, jitter and latency remains to be paid due attention by the researchers and still the work has not been categorized as satisfactory one. With ubiquitous computing environment in mind, numerous works can be quoted to validate this interconnection with QoS attributes duly proved and verified. In the following section an attempt has been made to briefly describe the past work over this issue:

2. Background:

(Changui Shin *et al*., 2006) have argued about the selection of type of Internet Gateway versus hop counts and have proposed a specific character of node mobility for increasing the throughput of the networks. Considering in another way, when the networks come across cross border domains, the traffic in above mentioned type of networks is not local. Accordingly, (Morgan *et al*., 2008) proposed a new framework at the gateway between the ad-hoc and DiffServ access domains with the objective to get a high level of performance and independence with an insubstantial implementation on only mobile nodes by implementing aggregate resource reservation (ARSVP) for collective resource reservations, combined with a simple sponsorship mechanism. (Daniloy *et al*., 2008) highlighted open source implementation of multiple protocols with suitable policies at the gateways to control forwarding issue and improve throughput attribute of the networks. Earlier (Rakeshkkumar *et al*., 2006) discussed issue of periodic advertisement both at the node as well as at gateway sides and have proved the improvements in the packet delivery fraction with reduced overhead messages through Adaptive Gateway Discovery using AODV routing protocols. (Habib Ammari, 2004) had also showed simulation results of experiments heterogeneous networks' integration using both Mobile IP and dynamic destination-sequenced distance vector (DSDV) to create a hybrid environment, in order to provide MANET nodes with Internet connectivity and access to the Internet resources. (Denko M.K *et al*., 2005) had suggested

Corresponding Author: Shams ul Arfeen, Assistant Professor, Faculty of Engineering, Science & Technology, Hamdard University, Karachi
Email: shams.arfeen@hamdard.edu.pk

integration of MANET nodes with Internet using multiple mobile gateways by using AODV routing protocol and Mobile IP protocol. In (Malinen *et al*., 2002), the authors initially studied the issue of internetworking between wireless ad hoc networks and the IPv6 Internet with reference to the QoS parameters such as end-to-end delay, delivery ratio and routing overhead. The results pointed out no adverse impact on suggested design. The issue of implementing Optimized Link State Routing (OLSR) protocol for MANET in military environment has also been proposed by (Cedric Adjih *et al*., 2008) but the problem of cross domain integration has not been highlighted and thus remains to be addressed seriously unless validated solution is approved.

3. Aim of Research:

The aim of this research is internetworking of Mobile Ad-hoc Network (MANET) with legacy networks such as a Local Area Network (LAN) running any type of applications including but not limited to Internet Services to evaluate the performance of network by adopting novel idea of selection of protocols at either sides. LAN and MANET adopt different modes, such as infrastructure and ad-hoc. To support internetworking between LAN and MANET, a gateway, which operates on OSPFv3 is proposed as an interface whereas for MANET, AODV routing protocol is employed, which is categorized as a reactive routing protocol.

4. MANET Routing Protocols:

The following are the popular MANET routing protocols:

- Ad Hoc On Demand Distance Vector (AODV)
- Dynamic Source Routing (DSR)
- Geographic Routing Protocol (GRP)
- Optimized Link State Routing (OLSR)
- Open Shortest Path First (OSPF) version 3
- Temporally Ordered Routing Algorithm (TORA)

Table 1 lists and compares the popular MANET routing protocols:

Table 1: Popular Routing Protocols

Characteristic	DSR	AODV	OLSR	TORA	OSPFv3	GRP
Routing Philosophy	Reactive	Reactive	Proactive	Proactive and reactive	Proactive	Proactive
Type of Routing	Source routing	Hop-by-hop routing	Hop-by-hop routing	Hop-by-hop routing	Hop-by-hop routing	Hop-by-hop routing
Frequency of Updates	As needed	As needed	Periodically	Based on mode of operation	Periodically	Periodically
Worst Case	Full flooding	Full flooding	Pure link state	Full flooding	Pure link state	Full flooding
Multiple routes	Yes	No	No	No	Yes	No

5. OSPF Version 2 and Version 3 Protocols:

The Open Shortest Path First (OSPF) protocol is an interior gateway protocol (IGP) used for routing in Internet Protocol (IP) networks. As a link state routing protocol, OSPF is more robust against network topology changes than distance vector protocols such as RIP, IGRP, and EIGRP. Two versions of OSPF are used among research community- OPSFv2 for IPv4 routing and OSPFv3 for IPv6 routing. The comparative analyses of main features of OSPF are summarized in Table 2.

Table 2: Comparison of Main Features of OSPFV2 and OSPFV3 (OPNET, 2010)

Feature	V2	V3
Link-State Routing	Yes	Yes
Equal-cost/Multi-path Routing	Yes	Yes
Classless Inter-Domain Routing (CIDR)	Yes	Yes
Multiple Processes	Yes	Yes
Multiple Areas	Yes	Yes
Traffic Engineering (TE)	Yes	No
Topology Database	Yes	Yes
Virtual Links	Yes	No
Route Aggregation at Area Boundaries	Yes	Yes
Designated Router Election	Yes	Yes
Metric Configuration	Yes	Yes
Hello Protocol	Yes	Yes
Route Redistribution	Yes	Yes
MANET	No	Yes

Furthermore, the OSPF is a link-state routing protocol whereby each node sends out its existing link states and the link-state advertisements (LSAs) are flooded throughout the network, so that each node will have a complete knowledge of the network topology thus each node uses this connectivity information to calculate the shortest path to every other node using algorithms like (Y. Fujita et. al., 2003). To attain this distribution of knowledge among the network nodes, OSPF performs Neighbor Discovery, to detect the quality of adjacent links, and Topology Broadcast, to advertise these links to all the other nodes in the network. As OSPF is a proactive protocol, the Discovery and Broadcast messages are generated periodically. A designated router (DR) is a node, designated to process link-state advertisements (LSAs) and distribute topology updates. A designated router (DR) enforces reliable flooding for all other routers connected to the same network. A backup designated router (BDR) takes over in case of a DR failure.

OSPF is one of those routing protocols which enjoy sufficient autonomy across the board over the Internet. Its IPv6 suite possesses independence in addressing scheme to be used with other addressing schemes. OSPF version3 is widely used in MANETs due to its numerous benefits. Initially OSPF was developed for wired environment but nowadays it enjoys a status of an unambiguous standard. OSPFv3 can provide better interoperation between the ad hoc domain and the Internet, when used in wireless ad hoc networks using proper extensions (Jun et. al., 2006). The problem with using OSPF in MANET is the large flooding overhead due to frequent topology changes (Jun et. al., 2006). This is why AODV is a better option when choosing a routing protocol for a type of model used by us.

5.1 AODV Protocol:

The Ad hoc On-Demand Distance Vector (AODV) routing protocol is a reactive type routing protocol based upon the distance vector algorithm. It executes multi-hop routing between interested nodes to participate, set up and preserve a mobile ad-hoc network (Charles Perkins, et. al., 1999) AODV gets a route on demand and needs not to get nodes to preserve routes to end devices which are silent during the communication. AODV has no role to play for valid route information for the end devices. It, therefore, has the features of multi-casting does not obey Bellman Ford (Internet, 2010) issue of counting up to indefinite period. AODV has also got features of loop independence and link terminations. In order to acknowledge a fresh route, AODV uses destination sequence numbers. AODV uses mechanism of broadcasting according to which a participating node wishing to find a route to other node sends a ROUTE REQUEST command to all its neighboring nodes. This process continues until the broadcast message arrives at the destination node and the route is generated by invoking a sequence (RREP) which is back to its initiating point. There is a special message called HELLO (RREP) in the AODV algorithm which is sent time and again and stoppage of this message is the indication of leaving of that particular node from the network or the link is damaged.

5.2 Gateway Requirement:

MANET is a network comprising of mobile wireless nodes having no infrastructure at all. In our network, we have connected MANET to wired LAN network. A gateway has been used, that enables communication of MANET protocols with the protocols on any other network. In our network the MANET nodes are connected to the LAN servers through a gateway which operates on OSPF protocol. OSPF is probably the most used IGP in the world (Claudio Jeker, 2005). It performs neighbor discovery with minimal need for configuration. OSPF encapsulates its routing messages directly on top of IP as its own protocol type (Claudio Jeker, 2005).

6. Simulation Topology:

Scenario is a very crucial part of the simulation. To support our work, OPNET Modeler 14.5 (OPNET Modeler Version 14.5, 2010) has been used to create various scenarios. Figure 1 shows the simulation model scenario. The simulation parameters that have been used for the simulations are shown in Table 3. It can be seen that the transmission range, pause time and the speed of the nodes have been varied. OPNET has implemented an Internet draft version of OSPFv3 with MANET extensions (R Ogier, et. al., 2005), which we have applied on our gateway.

Table 3: Simulation Parameters

Total Nodes	20 nodes
Data Rate	11 Mbps
Transmission Range	100 & 250m.
Routing Protocol	AODV
Pause Time	0, 50, 100 & 250 sec
Node Speed	2, 15, 30 & 45 m/s
Propagation Model	Random Way Point
Area Size	1000 x 1000 meters
Initial Node Placement	Random
Gateway Protocol	OSPFv3

In the OPNET Modeler, the node model is provided as shown in figure 2 which gives the parameters of the OSPF process model: (OPNET, 2010)

6.1 Simulation Settings:

(i) Deploy wireless network:

WLAN (Ad-hoc)
AODV
Stations: wlan_wkstn
20 nodes

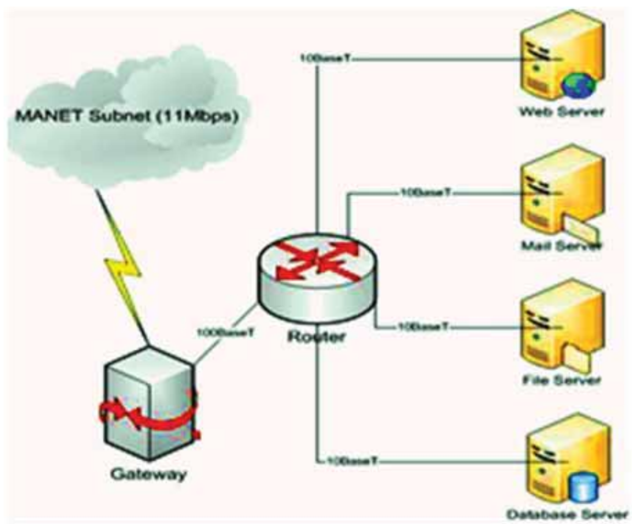

Fig. 1: Simulated Model

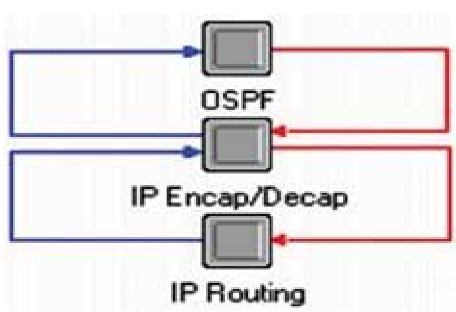

Fig. 2: Node Model Structure Surrounding OSPF

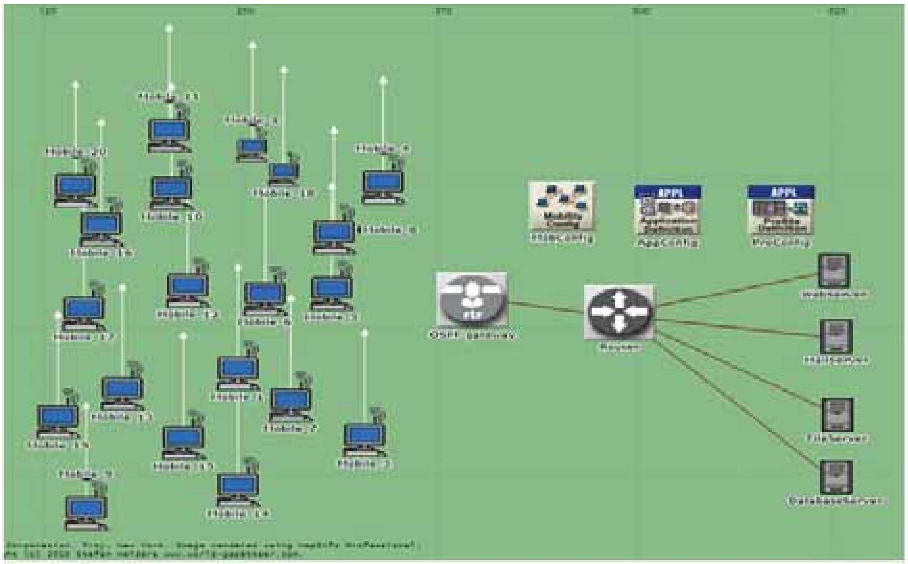

Fig. 3: Simulation Setup in OPNET Modeler 14.5

Adding MANET Gateway
Add router & 4 servers, using Base 100T links

(ii) Deploy Application Configuration:

App Definitions

Name	Load
DBMed	Medium Load
MailLow	Low Load
WebHeavy	Heavy Browsing
FtpLow	Low Load

(iii) Deploy Profile Configuration:

Profile Configuration

Name	Application
DbPro	DBMed
MailPro	MailLow
WebPro	WebHeavy
FtpPro	FtpLow

(iv) Deploy Mobility Configuration:

Random Mobility Profiles
Random Waypoint Parameters
Set pause time and speed

→Select all nodes >>Now go to Topology tab>>Random Mobility>>Set Mobility Profile and choose Default Random Waypoint.

(v) Configure Servers:

DB Server Application:

Application: Supported Profiles:	DbPro
Application: Supported Services:	DbMed
Web server Application	
Application: Supported Profiles:	WebPro
Application: Supported Services:	WebHeavy

Mail server Application
Application: Supported Profiles: MailPro
Application: Supported Services: MailLow
File server Application
Application: Supported Profiles: FtpPro
Application: Supported Services: FtpLow

(vi) Configure Nodes:

Application
Application: Supported Profiles: DbPro, WebPro, FtpPro, MailPro
Wireless LAN
Wireless LAN Parameters: BSS Identifier 0
Transmit Power (W)= 3.4E-005
Calculated using the following formula:

$$P = \left(\frac{4D}{0.12476}\right)^2 \times 10^{-12.5}$$

(vii) Set DES parameters:

Global
AODV
Ethernet
IP
OSPF
OSPF Advanced
OSPF MANET
Wireless LAN

Set DES parameters:

Node Statistics
AODV
Ethernet
IP
OSPF
OSPF Process
Server DB
Server Email
Server Ftp
Server Http
Server Performance
Wireless LAN

(viii) Traffic:

Database	Medium Load
File Transfer	Low Load
Web Browsing	Heavy Browsing
Mail	Low Load

7. Simulation Results:

Fig. 4: Routing Traffic Received-Pause Time= 0 Second

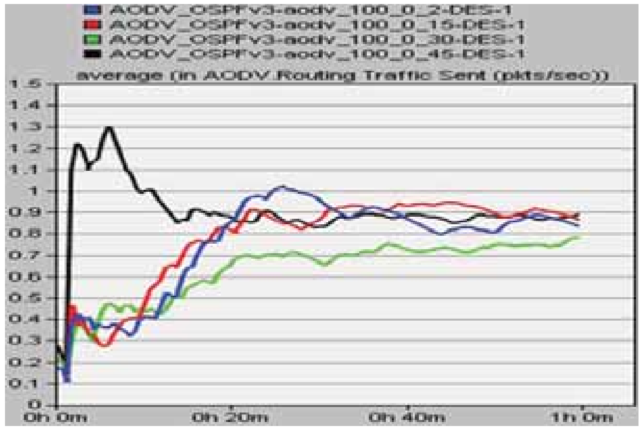

Fig. 5: Routing Traffic Sent Pause Time= 0 Second

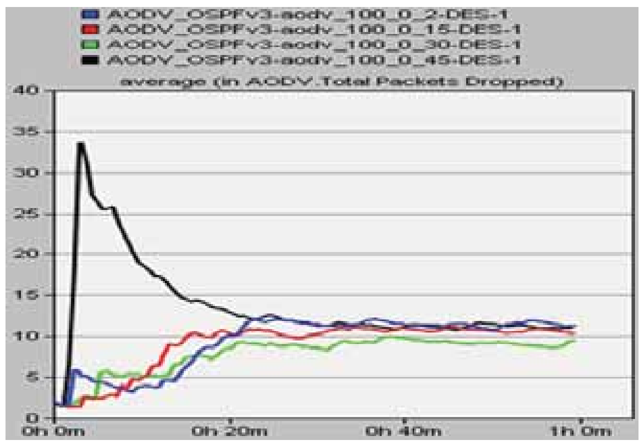

Fig. 6: Total Packets Dropped- Pause Time= 0 Second

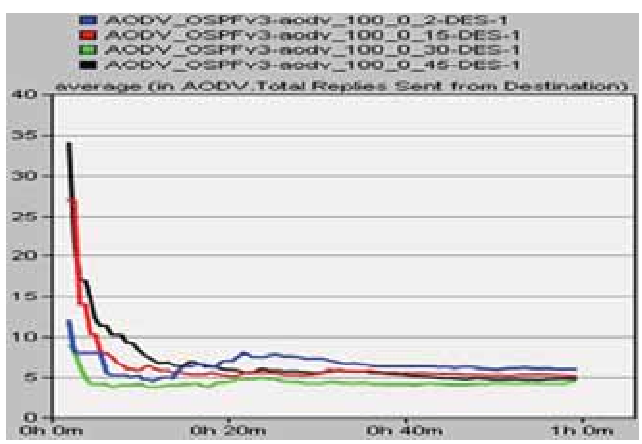

Fig. 7: Total Replies Sent from Destination Pause Time= 0 Second

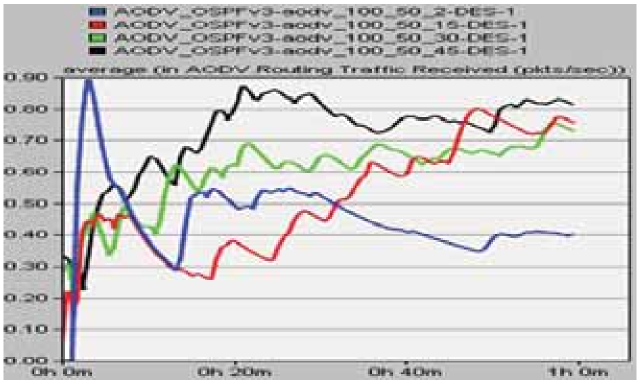

Fig. 8: Routing Traffic Received-Pause Time=50 Seconds

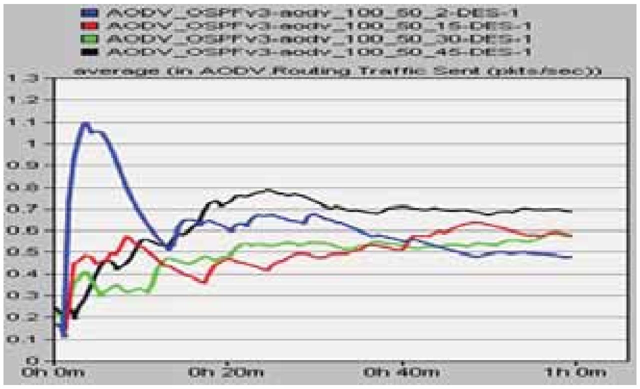

Fig. 9: Routing Traffic Sent Pause Time=50 Seconds

Fig. 10: Total Packets Dropped- Pause Time=50 Seconds

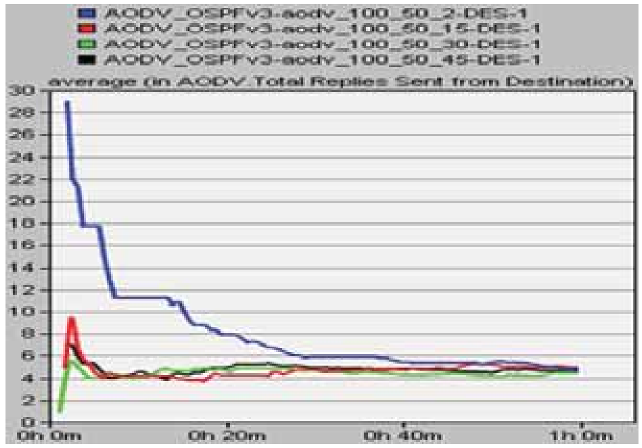

Fig. 11: l Replies Sent from Destination Pause Time= 50 Seconds

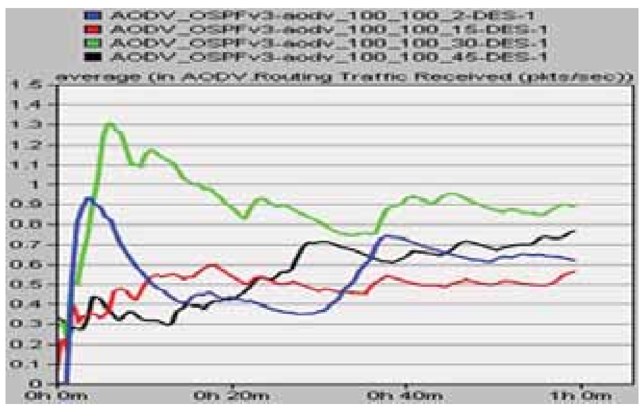

Fig. 12: Routing Traffic Received-Pause Time=100 Second

Fig. 13: Routing Traffic Sent Pause Time= 100 Seconds

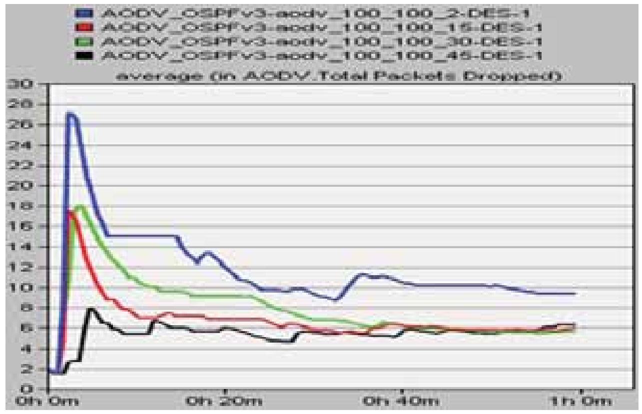

Fig. 14: Total Packets Dropped- Pause Time=100 Second

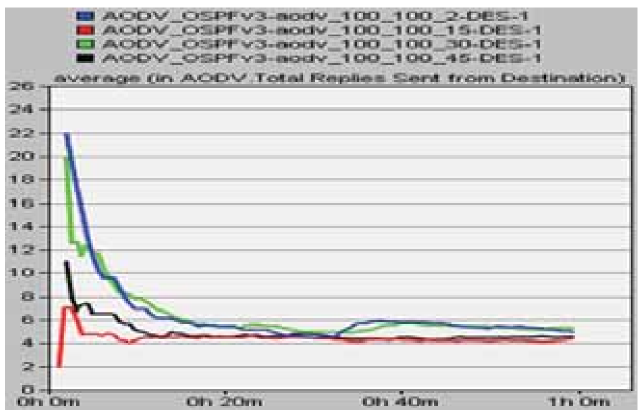

Fig. 15: l Replies Sent from Destination Pause Time= 100 Seconds

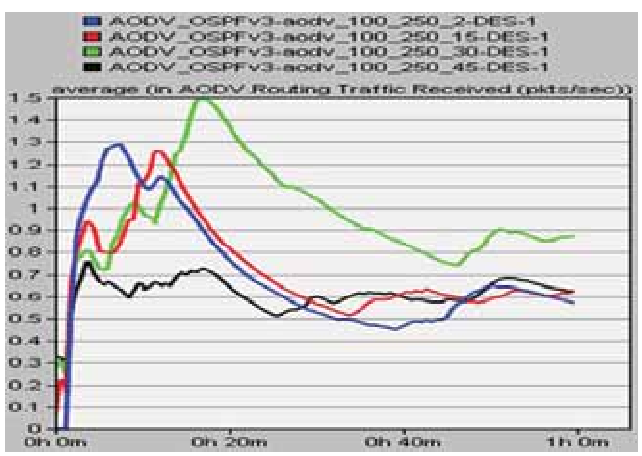

Fig. 16: Routing Traffic Received-Pause Time=250 Second

Fig. 17: Routing Traffic Sent Pause Time= 250 Seconds

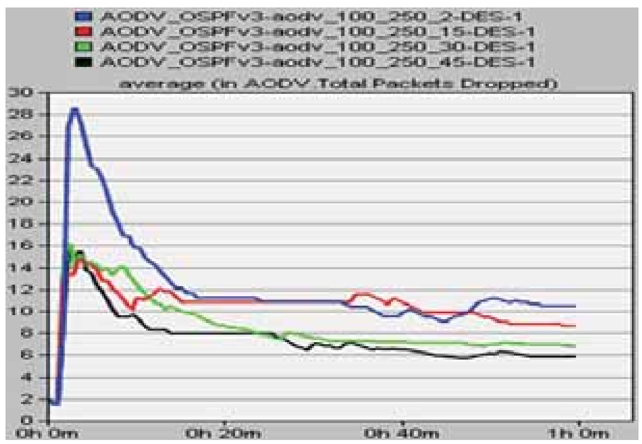

Fig. 18: Total Packets Dropped- Pause Time=250 Seconds

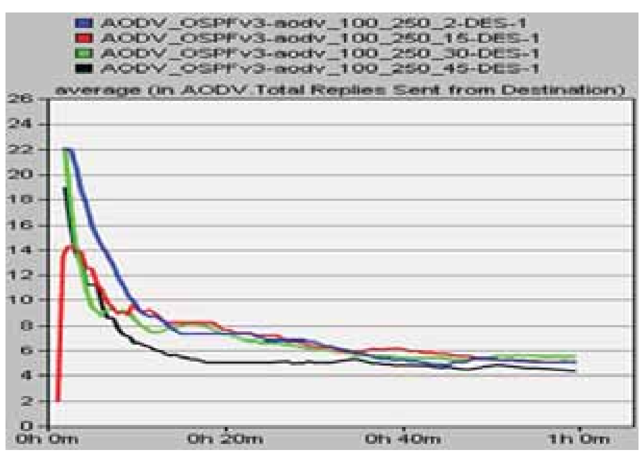

Fig. 19: l Replies Sent from Destination Pause Time= 250 Seconds

RESULTS AND DISCUSSION

During the simulation phase of this research 20 nodes are selected for each scenario with radius of 100 meters and the propagation model is the "Random Way Point" in the OPNET Modeler environment. With constant radius in each scenario, maximum speed and pause time are varied. For each scenario, speeds of 2 (Pedestrian), 15, 30, 45 m/sec are used with pause times of 0, 15, 30, 45 and 100 seconds. The AODV routing protocol is run over OSPFv3 using Internet gateway router. OPNET provides several options to be compared and analyzed for variety of scenarios. However important attributes over which the performance is studied in this work are total packets dropped, routing traffic received (packets/sec), routing traffic sent (packets/sec) and total replies sent from destination. The simulations are run for a period of approximately 3600 seconds and results are compiled as shown in graphs (Figure 4 to Figure 19). The results conclude how AODV performs/behaves over OSPFv3 in the different scenarios.

From Figure 4 to Figure 7, it is evident that for higher speeds all the selected parameters such as routing traffic, total replies sent from destination and packets loss are also showing rapid rise for some initial periods but after some time relative stability is observed. This is true when the radius and pause time is constant that is zero, but the speeds are varied.

Later four results from Figure 8 to Figure 11 are graphs when pause time is fixed as 50 seconds with same radius and varying speeds. In these four cases initial rapid rise in routing traffic, packet drop and total replies sent from destination is noted for least speed that is 2 m/sec. The scenario in Figure 8 is also interesting to see that that for all selected speeds at pause time 50 seconds, the response of traffic received per second is good enough whereas for the traffic sent (Figure 9) is medium. However the replies sent from destinations is slow at speeds of 45 m/sec due to heavy traffic load and protocol overhead of AODV over OSPFv3 using Internet gateway router. When the pause time is set as 100 seconds, the results in Figure 12 indicates a rapid initial jump for received routing traffic at a speed of 30 m/sec and fast sent routing traffic at least speed of 2 m/sec (Figure 13). This result is also encouraging as far as protocol performance of AODV and OSPFv3 is concerned in a dynamic environment. Also for higher speeds (Figure 14) that is 45 m/sec, the ratio of packets dropped is least as compared to lower a speed which is also a healthy sign but due to congestion in the network, responses received from destination is poor for higher speeds and little bit encouraging at lower speeds particularly at 2 m/sec (Figure 15).

For the highest pause time selected in this research that is 250 seconds the response of the selected parameters are given in Figure 16 to Figure 19. The received AODV routing traffic for speed of 30 m/sec is fast enough to be observed in Figure 16. However the ratio of packets loss is medium for higher speeds like 45 m/sec (Figure 17). Response received from destination at high speeds (30 m/sec) is also rapid (Figure 19) but this appears to be decaying after passage of time for all selected speeds due to traffic load and congestion in the network.

Conclusion:

In cross domain environment of interconnecting Mobile Ad-hoc Networks with Fixed Infrastructure based networks using routers in the form of internet gateways, various routing protocols are currently being used at either side. One of the solutions in this research has been proposed according to which the AODV routing protocol over OSPFv3 can be the candidate for heterogeneous ubiquitous environment. The experiments in a simulated environment for such a solution have been performed through lab tests using OPNET Research and Development Modeler Software. The simulations show satisfactory performance of AODV over OSPFv3 routing protocols for network of 20 nodes with radius of 100 meters and varying mobility levels and pause times using random waypoint propagation model. The results also prove satisfactory decreased ratio of packet loss during transmission and reception for low, medium and high traffic scenarios of varying pause times and speeds.

ACKNOWLEDGEMENT

The authors acknowledge the cooperation of M/S OPNET Inclusion USA for its software support to Hamdard University Karachi Pakistan under OPNET University Research Program. Indeed without such support the completion of this research work would not have been possible.

REFERENCES

Denko, M.K.C.W, 2005. "An architecture for integrating mobile ad hoc networks with the Internet using multiple mobile gateways", Electrical and Computer Engineering, Canadian Conference, Saskatoon, Sask, 1-4 May 2005, pp: 1097 -1102.

Cedric Adjih, P.M., Paul Muhlethaler, Emmanuel Baccelli, 2008. “Quality of service support, security and OSPF interconnection in a MANET using OLSR”, Journal of telecommunications and information technology, 2/2008.

Danilov, C.H., T.R. Spagnolo, P.A., T. Goff, J.H. Kim, 2008. “MANET multicast with multiple gateways”, Military Communications Conference, IEEE, San Diego, CA 16-19 Nov. 2008, pp: 1-8.

Morgan, Y.L.K., T., 2005. “A design framework for wireless MANET QoS gateway”, First ACIS International Workshop on Self-Assembling Wireless Networks. SNPD/SAWN, 23-25 May 2005.

Rakeshkumar, V.M., M., 2006. “An Efficient Mechanism for Connecting MANET and Internet through Complete Adaptive Gateway Discovery”, Communication System Software and Middleware, Comsware 2006, First International Conference, New Delhi, 2006: 1-5.

Habib Ammari, H.E.R., 2004. “Integration of Mobile Ad Hoc Networks and the Internet Using Mobile Gateways”, 18th International Parallel and Distributed Processing Symposium (IPDPS'04) - Workshop 12, Santa Fe, New Mexico April 26-April 30, 2004.

Malinen, 2002. “AODV and IPv6 internet access for ad hoc networks”, ACM SIGMOBILE Mobile Computing and Communications Review, July 2002, 6(3): 102-103.

An, C.S.S.K.S., 2006. “Stable Gateway Selection Scheme based on MANET with Internet”. Computer and Information Technology, CIT '06, the Sixth IEEE International Conference, Seoul Sept. 2006, pp: 80-80.

Charles Perkins, *et al*., 1999. “Ad-hoc On-Demand Distance Vector Routing”, In Proceedings WMC-SA "99, Second IEEE Workshop on Mobile Computing Systems and Applications, pp: 90-100.

Jeker, C., 2005. “Design and Implementation of Open OSPFD”, in Proceedings of EuroBSDCon.

Jun, J., Sichitiu, L. Mihail, 2006. “Scalable OSPF updates for MANETs”, Proceedings of the IEEE Global Telecommunications Conference (GLOBECOM -2006), pp: 1-6.

OPNET, 2010. www.opnet.com.

Ogier, R., P.S., 2005. “MANET Extension of OSPF using CDS Flooding”, draft-ogier-manet-ospfextension-06.txt”, December 2005.

http://wiki.uni.lu/secan-lab/Count-To-Infinity+Problem.html Website, Last Accessed on October 17, 2010.

Fujita, Y., Y.N., Z. Shiller, 2003. “Dual Dijkstra Search for paths with different topologies”, In Proceedings of IEEE International Conference on Robotics and Automation, Sept 2003.