Implementation of Quality of Services (QoS) for 802.16 Based Wireless Mesh Network

Er. Gurpreet Kaur
Research Scholar, CSE Department
Guru Nanak Dev Engineering College,
Ludhiana (Punjab)

Er. Jasbir Singh Saini
Associate Professor, CSE Department
Guru Nanak Dev Engineering College,
Ludhiana (Punjab)

Abstract

Day by day, the deployments of the networks are going beyond the imagination. Wireless mesh networks (WMNs) is dynamically self-organized and self-configured network with the nodes which automatically establishing and maintaining mesh connectivity among themselves. WiMAX technology provides wireless broadband service for fixed and/or mobile users. WiMAX Mesh Networks have two types of protocols. The Protocols at node level and protocols at the base station or access point level. In this paper, the basic node model has been modified to new node model, the nodes are able to re-route the data packets to other server that causes less packet loss or less data drop and improve the QoS for 802.16 based mesh networks. With the use of standard node model and modified node model simulation starts, accordingly the network discovers the route from source to destination and results have been calculated. OPNET has been used to evaluate the simulation results.

Keywords*: WMN, MANET, AODV, OLSR, BGP, NIC.*

1. Introduction

Wireless mesh networks (WMNs) is dynamically self-organized and self-configured, with the nodes in the network automatically establishing and maintaining the mesh connectivity with each other [1], [2]. This feature gives many advantages to WMNs such as low up-front cost, easy network maintenance, robustness, and reliable service coverage. A WMN includes mesh routers and mesh clients, mesh routers form the backbone of WMNs [1]. They provide network access for both mesh and conventional clients. Mesh clients can be either stationary or mobile and mesh routers have minimal mobility. Conventional nodes (e.g., desktops, laptops, PDAs, Pocket PCs, phones, etc.) can connect directly to wireless mesh routers, which are equipped with wireless network interface cards (NICs) [1]. Day by day, the deployments of the networks are going beyond the imagination. New network standards, new applications, applications of new standards are getting designed or under research. In recent years, the most revolutionary standard is 802.11 that came into picture in 1985. But as the usage of the networks increased, users required the wireless networks more flexible and easy to use. Users always need the networks ready to use and the networks that give the users free to move anywhere facility. By taking 802.11 base, research was carried out and new commercial standards like 802.15 (Wireless Personal Area Networks), 802.16 (WiMAX) came out as a result to meet the user requirements. IEEE standard 802.16 commonly known as Worldwide Interoperability of Microwave Access (WiMAX) [3].New technologies like MANETs, Mesh Networks is also designed for the deployment of different standards.

Mesh Networks are a kind of personal internet. To get connected with different locations over the different geographical locations, firms need to get an internet connection from an Internet Service Provider (ISP) for which the firms have to pay big bounty to the ISPs [8]. Mesh Networks give an alternate to create a network of networks similar to the internet but smaller than the internet by passing to the ISPs. It is very important to understand all the pros and cons of the Mesh Network technology to make it more reliable and sustainable. Wireless broadband networks based on the IEEE 802.11 technology are being increasingly deployed as mesh networks to provide users with extended coverage for wireless Internet access [10].

A lot of research is going in the field of Mesh Networks in these days to extend to geographical limits of Mesh Networks, new optimized applications that could be used over the mesh networks, security procedures to ensure the integrity of the data exchanged over the mesh network etc. As the limits of mesh networks are increasing, users required them to be more flexible. Users required the use of various high data rate services like video conferencing, voice calling, online gaming etc. To deploy these kinds of networks data is affected. To reduce the effects like data drop, congestion etc. new node model, applications being introduced, it is compared and evaluated with the existing techniques efficiency. Performance is represented in graphical form.

2. Routing Protocols

WiMAX Mesh Networks have two types of protocols. Protocols at node level (AODV, OLSR, DSR, DSDV etc) and protocols at the base station or access point level (BGP, RIP, IGRP etc)

2.1. Protocols at Node Level

The Protocols that deals with the communication at the node level such that the communication takes place only between the nodes without the involvement of the access point. The node to node communication is a type of intracellular communication.

2.1.1. Ad-hoc On-Demand Distance Vector Routing Protocol (AODV). Ad Hoc on Demand Vector Routing Protocol (AODV) [5] adopts a very different mechanism to maintain routing information. The basic operations of AODV are Route (Path) Discovery for creating route from source to destination and Route (Path) Maintenance for dealing with topology changes. AODV is based upon the distance vector algorithm [7]. RREQ (Route REQuest), RREP (Route REPly), RERR (Route ERRor) packets are used by AODV. AODV routing protocol requests a route, when needed and there is no need to maintain routes to destinations that are not actively used in communication. Features of AODV protocol includes the loop freedom and the link breakages cause immediate notification to be sent to the affected nodes.

It also uses routing tables to contain the information about the route and it relies on table entries to route RREP packets. Whenever a node wants to find or try to find a route to another node, it broadcasts a Route Request packet (RREQ) to all its neighbors. [4] The RREQ packet goes through the network until it reaches the destination of the packet [9]. RREP packet is generated to reply according to RREQ of the source node using the information of the route from the routing table. RREP is in reversible direction to RREQ. If any link breaks then RERR packet is generated to inform the neighboring nodes then all routes are discarded using that link. If source node moves and route to destination is still required then the Route Discovery process is reinitialized for the Route Maintenance operation.

2.1.2. Optimized Link State Routing Protocol (OLSR). Optimized Link State Routing Protocols is a proactive protocol [6]. The periodic nature of the protocol creates a large amount of overhead. In order to reduce the overhead, it limits the number of mobile nodes that can forward network wide traffic and for this purpose it uses Multi Point Relays (MPRs), which are responsible for forwarding routing messages. Mobile nodes which are selected as MPRs, can forward control traffic and reduce the size of control message. Every node selects a group of MPRs from its one hop neighbors. MPRs are selected by a node such that it may reach the two hop neighbor via at least one MPR. The MPRs used for forwarding the control traffic generated by that node. All the mobile nodes periodically broadcast a list of its MPR selectors instead of the whole list of neighbors. MPRs advertise link state information periodically in control messages for MPR selection. The routes are changed due to mobility and topology control (TC) messages are broadcasted throughout the network. All mobile nodes have the routing table that have the information of the routes to all reachable destination nodes. OLSR does not immediately notify the source after detecting a broken link and source node comes to know that route is broken, when the intermediate node broadcast its next packets.

2.2. Protocols at Access Point Level

The Protocols that deals with inter cell communication and route the data between the nodes from one cell to others.

2.2.1. Border Gateway Protocol (BGP). Border Gateway Protocol (BGP) is protocol that is design to exchange information between the Autonomous Systems (AS). This routing protocol is designed for internet and it is responsible for maintenance of table of Internet protocol networks which authorize network reaching capability between AS. The Border Gateway Protocol (BGP) is also expressed as path vector protocol. It takes the routing decisions according to the policies, rules and path. It is developed to replace the Exterior Gateway Protocol (EGP) routing protocol. It plays key role for internet service.

3. Simulation and Performance Metrics

3.1. Simulation Environment

The OPNET modeler 14.0 has been used to evaluate the Quality of Services for 802.16 based mesh networks to gather the results about the performance of the networks. Different networks having different features have been developed. To implement the 802.16 functionalities 15 servers, 15 Base Stations having 20 SSs (Subscriber Stations) in each cell have been used in scenarios. Each BS covers hexagonal structure geographic area in which node to node communication without the involvement of access points is done that is a type of intracellular communication. If the communication is between the different cells with the involvement of the access points then it is intercellular communication. So the nodes can communication with and without the involvement of the access points. WiMAX Mesh Networks have two types of protocols. Protocols at node level and protocols at the base station or access point level. The node level protocols are those in which communication takes place only between the nodes with intracellular communication. The node level protocol includes both proactive and reactive protocols such as AODV, OLSR, DSR, DSDV etc. The Access Point Level protocols are the protocols that deal with inter cell communication and route the data between the nodes from one cell to others. The access point level protocol includes BGP, RIP, IGRP etc. Client-Server applications are those that runs on client node and makes request to remote server and must installed on each node. Three different applications have been taken based on client-server architecture. Those are Email, FTP (File Transfer Protocol), HTTP (HyperText Transfer Protocol). Two ad-hoc routing protocols have been used at the node level which are AODV and OLSR. At access point level BGP routing protocol is used. Priority queuing is used for networks. A queue which has more packets than its maximum queue size those packets are dropped. A queue can store packets whatever the size of queue when this value is reached network is in the state of congestion. This means that a queue which has more packets than its maximum queue size will drop incoming packets until either maximum number of packets drops. While this value is not reached, a queue can store packets, whatever the size of the queue. When this value is reached the interface is in a state of congestion. RED (Random Early Detection) algorithm is used to avoid the congestion. RED has the ability to recognize and act upon congestion on output direction of interface so as to reduce or minimize the effect of that congestion by dropping packets randomly.

Figure 3.1 shows the simulation environment of scenarios.

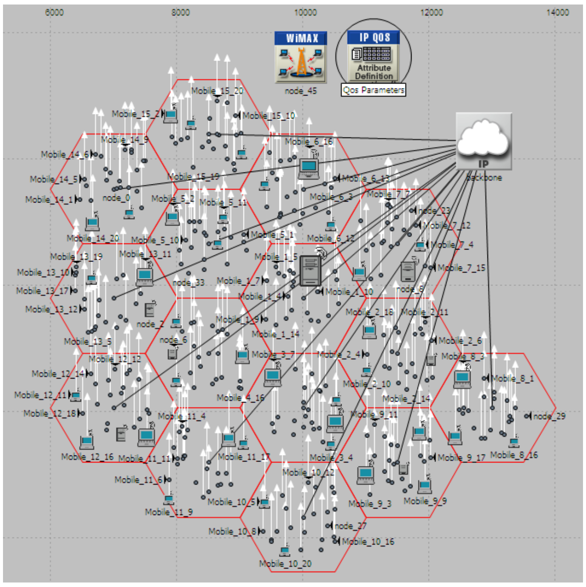

Figure 3.1 Scenario deploying WiMAX

The parameters are used with some specific values to evaluate the performance of scenarios. The parameters that have been used in the following experiments are summarized in Table 1.

Table 1. Parameters for Simulation

ATTRIBUTE	VALUES
Technology	WiMAX
Model Family	WiMAX
Physical Profile	Wireless OFDMA 20MHz
Applications	Email/FTP/HTTP
Nodes	300
Simulation Time	3600 Seconds
Routing Protocols	AODV/OLSR/BGP

When the simulation starts, the network discovers the optimal route from source to destination. When there is lot of load of packets for destination nodes or intermediate nodes. Then the load of network, throughput, utilization, and queuing delay metrics are affected. To reduce load, packet loss, buffer overflow, congestion the node model has been slightly modified. The new or modified node model perform as standard node model but it can re-route the path of packet when it is sent from source to destination if queue of receiving node is full and there is condition of data drop. In the scenarios using new node model, the nodes are able to re-route the data packets to other server on achieving the threshold of a server that cause in the less buffer overflow and less data dropped. There is less data drop and congestion because the re-routing of the data packets from the overflowed server to the under flowed server can make the data packets not be dropped and make their delivery more reliable. Then performance of new node model has been calculated using different metrics.

3.2. Performance Metrics

Performance metrics are used for evaluation of performance. They represent different characteristics of the overall network performance.

- **Average Queuing Delay(sec)**

The Average Queuing Delay represents instantaneous measurements of packet waiting times in the transmitter channel's queue. Measurements are taken from the time a packet enters the transmitter channel queue to the time the last bit of the packet is transmitted.

- **Average Throughput(packet/sec)**

The Average Throughput represents the average number of packets successfully received or transmitted by the receiver or transmitter channel per second.

- **Average Utilization**

The Average Utilization represents the percentage of the consumption to date of an available channel bandwidth, where a value of 100.0 would indicate full usage.

- **Load(bits/sec)**

Load represents the total load (in bits/sec) submitted to WiMAX layers by all higher layers in all WiMAX nodes of the network.

4. Results and Analysis

Comparison of original and modified node model is shown in these figures according to the parameters of different scenarios.

4.1. Load for AODV

The figure 4.1 depicts the load possessed by the network using standard node model and modified node model under different types of data traffic generated by using different types of applications (Email, FTP and HTTP). In the graphs, it has shown that for Email application, the load for the network new node model has decreased by 4.435%. Similarly, for HTTP the load is decreased by 2.587% .But a minute increase of 1.202% in the load has seen for FTP.

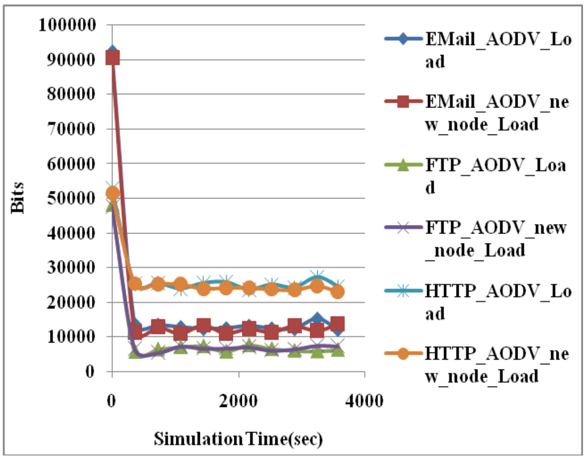

Figure 4.1 Load for AODV Protocol

4.2. Load for OLSR

In figure 4.2, the load for OLSR protocol has increased for all the networks using new node model except the network using HTTP application.

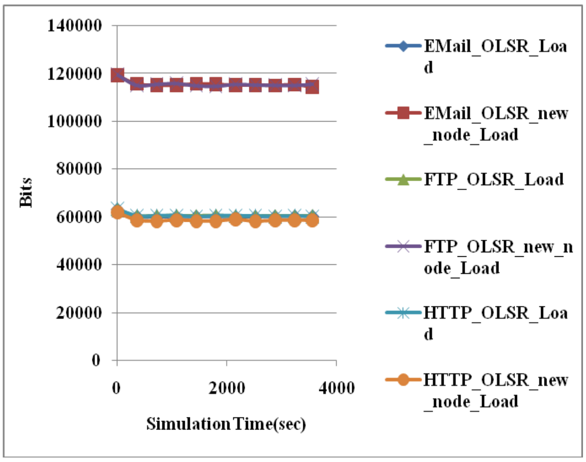

Figure 4.2 Load for OLSR Protocol

In the case of the new node model based networks using Email and FTP applications, the network load has increased by 47.56% for both networks from the networks using the standard node models. Whereas for the new node model based network using HTTP application, the load possessed has decreased by 3.19%.

4.3. Average Queuing Delay for AODV

For Email application, the queuing delay has decreased by 75.22% for the new node model based network configured by using a reactive protocol i.e. AODV. The queuing delay has decreased by 38.52% as well for FTP application for new node model network. The highest decrement in queuing delay has shown by HTTP application that is of 78.01 % for AODV protocol because of the less intermediate processing shown in figure 4.3.

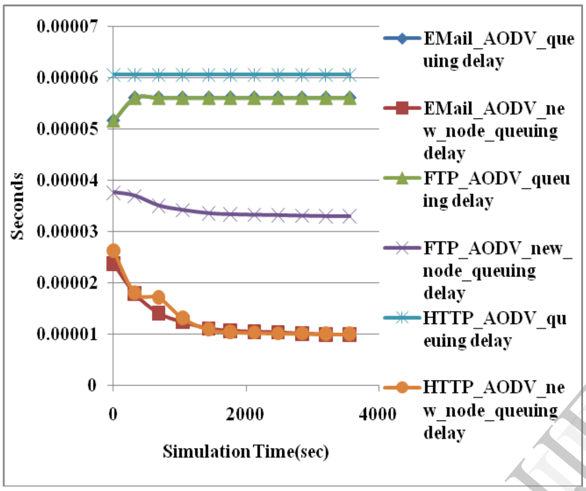

Figure 4.3 Average Queuing Delay for AODV

4.4. Average Queuing Delay for OLSR

In figure 4.4, the average queuing delay has decreased by 74.17% for the new node model based network using Email application. For the new node model based network using FTP application, the queuing delay has decreased by 38.78% and for the network using HTTP application; the delay has decreased by 79.97%. It is due to its proactive nature, generally OLSR always possess less queuing delay for the data packets in the network because in reactive protocols i.e. AODV, once the packet has generated, it has to wait in the queue of the sender for its dispatch till the formation of the route between the sender and the receiver. But in the case of proactive protocols i.e. OLSR, in spite of creating routes on demand, all the routes are available in the route cache of every node. Once the packet has generated, the route has chosen according to the destination address present in the data packet. This helps to reduce the average queuing delay in the network.

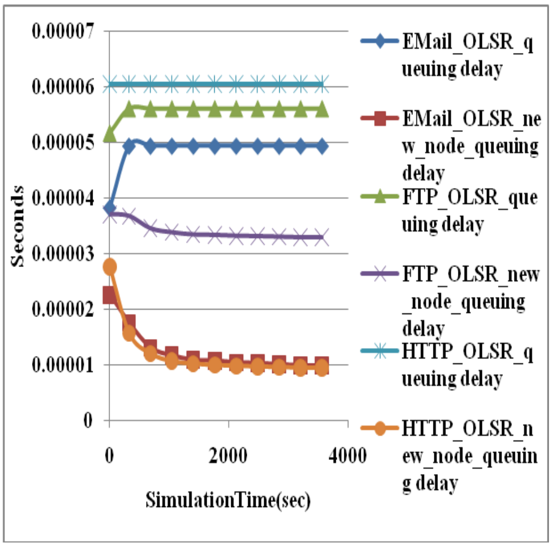

Figure 4.4 Average Queuing Delay for OLSR

4.5. Average Utilization for AODV

Figure 4.5 shows the average utilization for reactive protocol, such that AODV .

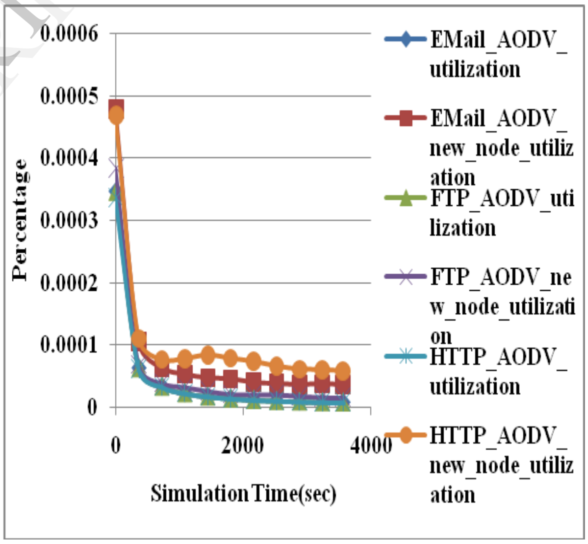

Figure 4.5 Average Utilization for AODV

The graph depicts that the average utilization for the network deployed by using newly designed node models using Email application has increased by 44.81% and for the network using FTP application for data generation has increased by 18.36%. Due to which there is always under utilization of the available bandwidth for FTP application. The maximum increment in bandwidth utilization has seen for the network using HTTP, such that the utilization has increased by 56.83%.

4.6. Average Utilization for OLSR

Figure 4.6 shows the average utilization of the channel bandwidth possessed by the network configured by using OLSR protocol using different applications. The average utilization of channel for the new node model based network using Email application to generate data has increased by 40.85%. For the network using FTP application, the increment in the utilization is of 27.76% and for HTTP application deployed in new node model network; the utilization of the channel bandwidth has increased by 63.16 % from the utilization of channel possessed by the network of standard node models.

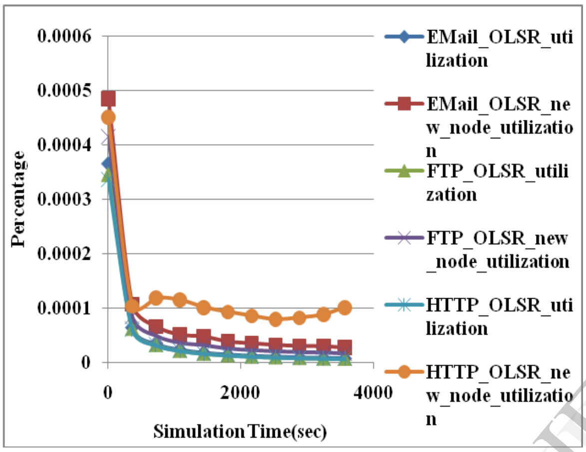

Figure 4.6 Average Utilization for OLSR

4.7. Average Throughput for AODV

The Figure 4.7 shown the average throughput possessed by the network configured by using a reactive protocol, AODV under different applications generating different types of data. The rendered graph depicts that the average throughput for the network designed by using new node model using Email application to generate data in the network has increased by 44.61% from the network using standard node models using same application under same configuration. For the network based on new node model using FTP application, the average throughput has increased by 18.08% and the same network using HTTP application, the average throughput has increased by 56.18% from the network based on standard node models using same applications.

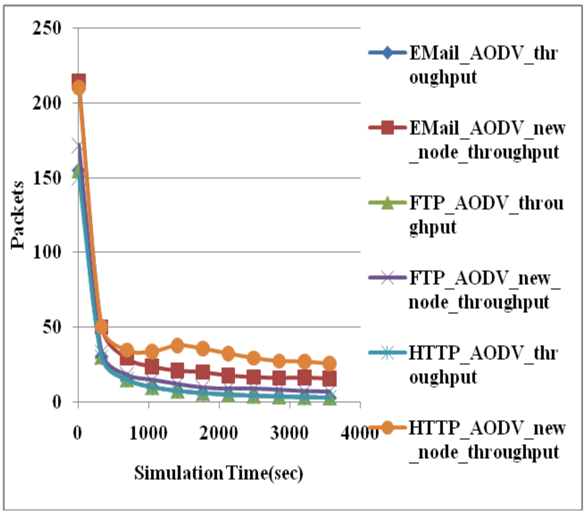

Figure 4.7 Average Throughput for AODV

4.8. Average Throughput for OLSR

Average Throughput of the networks based on new node model and standard node model using different types of applications configured by using a proactive protocol, such that OLSR has shown in figure 4.8. For the new node model network using Email application for the data generation and configured by using OLSR routing protocol, the average throughput has increased by 40.58%.

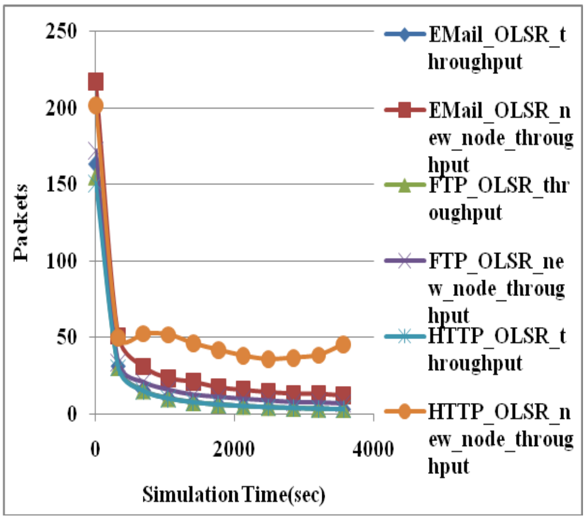

Figure 4.8 Average Throughput for OLSR

When the data generated in the network is of FTP application then the average throughput of the network has increased by 20.02% and for HTTP application, the average throughput has increased by 62.68%.

5. Conclusions and Future Scope

In this work, various 802.16 Mesh Network test beds have been developed in order to evaluate and enhance the performance in terms of various parameters like Load, Average Queuing Delay, Average Throughput, and Average Utilization. Scenarios have been developed using OPNET simulator having BSs, SSs, and servers. To evaluate the results from scenarios, node level protocols such as reactive AODV, proactive OLSR, access point level BGP protocol and different types of data traffic generated by using different types of applications (Email, FTP and HTTP). The basic node model has been slightly modified to new node model, the nodes are able to re-route the data packets to other server that causes less packet loss or less data drop and improve the Quality of services for 802.16 based mesh networks. The results obtained during the experimentation shows an improvement as compared to the standard.

There is scope to improve the work done by increasing the number of cells in the network along with increasing the number of nodes in each cell to increase the density of the nodes in the networks from the perspective of to generate more data in the network to stretch the working of the networks to their maximum limits. In the given work, only client-server architecture based applications such as HTTP, FTP and Email have been used. To make the designed networks more versatile, peer to peer applications such as video conferencing, voice calling etc may be used and the results of other performance evaluation metrics could be considered to make the concluded results more justified.

6. References

1. Akyildiz, I.F and Wang, X. (2005), "A Survey on Wireless Mesh Networks", In Communications Magazine of IEEE, Vol. 43, pp. S23-S30.
2. Guardalben, L., Villalba, L.J.G., Buiati, F., Camponogara, E. (2011), "Self-Configuration and Self-Optimization Process in Heterogeneous Wireless Networks" Open Access Journal on the Science and Technology of Sensors and Biosensors, ISSN 1424-8220
3. Li, Y., Yang, Y., Cao, C., Zhou, L. (2009), "QoS Issues in IEEE 802.16 Mesh Networks" In proceeding 1st International Conference on Information Science and Engineering, pp. 2687-2690.
4. M., V., Patel, A., Kulkarni, L.(2010), " QOS Parameter Analysis on AODV AND DSDV Protocols in a Wireless Network" In Proceeding Indian Journal of Computer Science and Engineering, Vol. 1, No. 4, pp. 283-294.
5. Rajkumar, G., Kasiram, R., Parthiban, D. (2012), "Optimizing Throughput with Reduction in Power Consumption and Performance Comparison of DSR and AODV Routing Protocols" In proceeding of 2012 International Conference on Computing, Electronics and Electrical Technologies, pp. 943-947.
6. Rao, S.S.N., Krishna Y.K.S., Rao, K.N. (2011), "A Survey: Routing Protocols for Wireless Mesh Networks", Proceeding International Journal of Research and Reviews in Wireless sensor Networks, Vol. 1, No. 3, ISSN: 2047-0037.
7. Royer, E. M., Chai-Keong Toh, S. B. (1999), "A Review of Current Routing Protocols for Ad Hoc Mobile Wireless Networks" IEEE Personal Communications, Vol. 6, Issue 2, pp: 46-55.
8. Seyedzadegan, M., Othman, M., Ali, B. M., Subramaniam, S. (2011), "Wireless Mesh Networks: WMN Overview, WMN Architecture" In proceeding of 2011 International Conference on Communication Engineering and Networks, Vol. 19, pp. 12-18.
9. Tuteja, A., Gujral, R., Thalia, S. (2010), "Comparative Performance Analysis of DSDV,AODV and DSR Routing Protocols in MANET using NS2" In proceeding International Conference on Advances in Computer Engineering, pp. 330-333.
10. Wu, T. and Hsieh, H. (2007), "Interworking Wireless Mesh Networks: Performance Characterization, and Perspectives" In Proceeding of Global Telecommunications Conference, GLOBECOM'07, pp. 4846-4851.