Literature Review of IEEE 802.16(WiMAX) Implementation in OPNET

Kamini Jaswal
M.Tech (Electronics and communication engineering),
SITM, Sonepat, Haryana, India

Prof. (Dr) Vinay Kumar Nassa
Director Principal, SITM, Sonepat
Haryana, India

Jyoti,
Assistant Professor (ECE),
SITM, Sonepat-131001(Haryana)

Abstract: Network simulation is used to evaluate the performance of different wired and wireless networks and their topologies without real world implementation. Network simulators are widely used by the research community to evaluate new theories and hypotheses. There are a number of network simulators, to name a few, ns-2, ns-3, OMNET++, NetSim, QualNet, OPNET, SSFNET, J-Sim, and GloMoSiM etc. Therefore, the selection of a network simulator for evaluating research work is a crucial task for researchers. According to the previous researches on the performance of OPNET, it has been proved that OPNET is comparatively more reliable, easy to understand and implement network simulation tool than its other counterparts. The main focus of this paper is to study the Wimax performance when implemented with OPNET.

Keywords: Wireless Networks, WiMAX, Simulation, Network Simulators, OPNET.

1. INTRODUCTION

A wireless network is a type of computer network that uses wireless connections for transferring the data between different network nodes. Wireless networks generally use radio waves for communication. The main advantage of wireless networks over fixed networks is that it avoids installations of cables into a building which is a very complex and costly process to employ. Recently wireless networks are getting more and more popular because of its mobility, simplicity and very affordable and cost saving installation [1].

1.1 Types of Wireless Networks

Wireless networks are divided into two main groups that is infrastructure wireless network and Ad hoc or infrastructure-less network.

a. Infrastructure Networks
Fixed network topology is deployed in infrastructure network. These deployed, fixed networks have base stations or access points from which wireless nodes can get connected. All the base stations or access points are connected with the main network through wired links or wireless links. The base station or access point is one of the important units of infrastructure networks. All of the connections will have to pass from the access point. A wireless node can connect to anyone of the access points in its radio range.

b. Ad-Hoc Networks
Ad-Hoc networks have no infrastructure where the nodes are free to join and left the network. The nodes are connected with each other through a wireless link. A node can serve as a router to forward the data to the neighbors' nodes. Therefore this kind of network is also known as infrastructure less networks [2].These networks have no centralized administration. Ad-Hoc networks have the capabilities to handle any malfunctioning in the nodes or any changes that its experience due to topology changes. Whenever a node in the network is down or leaves the network that causes the link between other nodes is broken [3]. The affected nodes in the network simply request for new routes and new links are established Ad-Hoc network can be categorized in to static Ad-Hoc network (SANET) and Mobile Ad-Hoc network (MANET).

Some examples of wireless technologies are Cellular Systems-1G, 2G, 2.5G (GPRS), 3G, B3G, 4G, Satellite Systems, Paging Systems, Cordless Phone, Wireless LAN, Wireless Local Loop, Wireless Data Service, Bluetooth, Ultra Wide Band (UWB) etc [4].

1.2 Wireless Local Area Networks (WLANs)

WLAN is based on the IEEE 802.11 standard, also known as Wireless Fidelity (Wi-Fi) was introduced in the 1990s. It is the best-effort packet access network without using wires. WLANS allow users in a local area, such as a university campus or library, to form a network or gain access to the internet. A temporary network can be formed by a small number of users without the need of an access point; given that they do not need access to network resources.

a. Wi-Fi
Fidelity (Wi-Fi) is based on the IEEE standard 802.11. It operates in 2.4 GHz frequency band and provides data transfer at maximum rate of 54 Mbps. WI-FI has two types of components: a wireless client station and an access point (AP). Wireless client station can be any user device such as

computer or laptop that has a wireless network card. AP acts as a bridge between fixed and wireless networks. It connects to the cable modem or Digital Subscriber Line (DSL) modem, provides Internet services to wireless and wired Ethernet clients, and organizes and grants access from multiple wireless stations to the fixed network. Users can now connect smart phones to the wireless router for Wi-Fi services to access the Internet over mobile phone Wireless [5].

b. WiMAX

Worldwide Interoperability for Microwave Access (WiMAX) provides broadband connectivity by connecting to the Internet Service Provider. WiMAX network is a proficient alternative to 3G or wireless networks for providing connectivity over large coverage area with low cost of deployment and high speed data rates and Can support fixed and mobile users simultaneously. WiMAX technology is the only wireless system capable of offering high QoS at high data rates for IP networks. It supports data rates of 70 Mbps over ranges of 50 km with mobility support at vehicular speeds. Consequently, WiMAX data rates between 1.5 to 75 Mbps are achievable. One of the top applications for the 802.16 is Voice over Internet protocol (VoIP) service to support bidirectional voice conversation.

1.3 Wi-Fi v/s WiMAX

Wireless Fidelity (Wi-Fi) and Worldwide Interoperability for Microwave Access (WiMAX) are Wireless Local Area Network (WLANs) technologies. Wi-Fi is based on the IEEE standard 802.11 while WIMAX operates based on IEEE 802.16. Both standards are designed for the Internet protocol applications. Wi-Fi is optimized for a very high speed WLAN while WiMAX is intended for a high speed Wireless Wide Area Network (WWAN). Both of existing Wi-Fi and WiMAX wireless networks support real-time applications such as VoIP and are frequently used for wireless internet access. The IEEE 802.11 (Wi-Fi) technology shows great success as inexpensive wireless Internet access while the IEEE 802.16 (WiMAX) provides large coverage area (approximately 50 km) and high data rates (up to 75 Mbps) using radio links. Although WiMAX greatly outperforms Wi-Fi, user devices such as desktops, laptops and cell phones need to have WiMAX capability to be able to connect to WiMAX sources. Currently, only few users have WiMAX enabled devices and the majority has Wi-Fi capability. WiMAX is more efficient for delivering more data with less queuing delay when compared to Wi-Fi [6]. The best way **to** enjoy the advantage of the WiMAX system is to combine the WiMAX and Wi-Fi systems together. By combining these two standards service providers can offer a more complete high speed broadband service to more users in different geographical areas. Users could also purchase a WiMAX-Wi-Fi router and then send data to their computers via Wi-Fi.

II. WIRELESS NETWORK SIMULATORS

A network simulator is a software that predicts the behavior of a computer network which is typically modeled with devices, links, applications etc. and the performance is analyzed. Typically, users can then customize the simulator according to their specific analysis needs. Simulators typically come with support for the most popular protocols and networks in use today, such as WLAN, WiMax, TCP, WSN, cognitive radio etc.

Most of the commercial simulators are GUI driven, while some network simulators are CLI driven. An important output of simulations is the trace files. Trace files log every packet, every event that occurred in the simulation and are used for analysis. Most network simulators use discrete event simulation, in which a list of pending "events" is stored, and those events are processed in order, with some events triggering future events—such as the event of the arrival of a packet at one node triggering the event of the arrival of that packet at a downstream node.

Wireless network simulation softwares provide modeling, simulation and analysis of wireless networks.

a)   Modeling

Network simulation software allows modeling a network topology containing a wide variety of mobile devices using multiple protocols. For example, you may need to model various types of cellular networks, including GSM, CDMA or WiMAX, or even personal area networks, such as Bluetooth.

b)   Simulation

Network simulation is a technique where a program models the behavior of a network or we can say that the behavior of a network can be modeled by calculating the interaction between the different network components (they can be end-host or network entities such as routers, physical links or packets) using mathematical formulas. Wireless network simulations can incorporate ground, wireless and satellite systems. These simulations allow you to study networking issues, such as protocol interaction, congestion control and scalability. Fully realistic simulation reproduces the results of laboratory experiments or estimates the performance and behavior of network use by end users.

c)   Analysis

Wireless network simulation software includes built-in algorithms for analyzing simulations. Often, you can generate charts and graphs as well as export raw data to spreadsheets or math software for additional analysis. Some simulation software packages also have application programming interface for further customization [7].

2.1 Types of Network simulators

There are many both free/open-source and proprietary network simulators. Some of the network simulators are commercial which means that they would not provide the source code of its software or the affiliated packages to the general users for free. All the user s have to pay to get the license to use their software or pay to order specific packages for their own specific usage requirements. One typical example is the OPNET.

On the other hand, the open source network simulator has the advantage that everything is very open and everyone or organization can contribute to it and find bugs in it. The interface is also open for future improvement.

Some examples of notable network simulation software are:
I) Commercial simulators
      a) OPNET
      b) QualNet
      c) NetSim

II) Open source simulators
      a) NS2
      b) NS3
      c) OMNET++
      d) SSFNET
      e) J-SIM

III. OPNET

Optimized Network Engineering Tool (OPNET) is one of the most famous and popular commercial network simulators which offer relatively much powerful visual or graphical support for the users which is also used to build network topology and entities from the application layer to the physical layer. It is basically a research oriented network simulation tool used to study communication networks, devices, protocols, and applications and also provides a development environment for modeling and simulation of deployed wired as well as wireless networks and also provides multiple solutions for managing networks and applications e.g. network operation, planning, research and development (R&D), network engineering and performance management. User can create customized models and simulate various network scenarios [8]. It is possible to simulate various wireless communication technologies such as MANET, 802.11, 3G/4G, Ultra Wide Band, WiMAX, Bluetooth, ZigBee using OPNET tool. OPNET is based on a mechanism called discrete event system which means that the system behavior can simulate by modeling the events in the system in the order of scenarios the user has set up. Hierarchical structure is used to organize the networks. As other network simulators, OPNET also provides programming tools for users to define the packet format of the protocol. The programming tools are also required to accomplish the tasks of defining the state transition machine, defining network model and the process module. OPNET is quite expensive for commercial usage but there are also free licenses for educational purposes [9].

The OPNET modeler is object oriented and employs a hierarchical approach to model communication networks. The OPNET usability can be divided into four main steps.

- Modeling : This module is used to build or create a network model
- Choose and select statistics: We can choose different statistics to collect from each network.
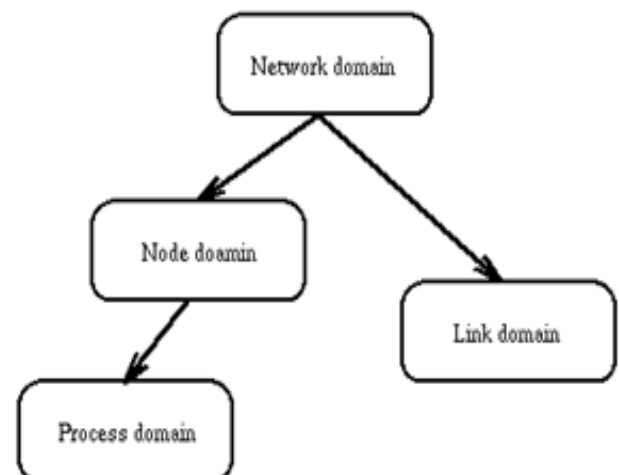- Simulate the network.
- View and analyze results.

According to the OPNET whitepaper, OPNET's detailed features include [10]:
1. Fast discrete event simulation engine
2. Large component library with source code
3. Object-oriented modeling
4. Hierarchical modeling environment
5. Scalable wireless simulations support
6. 32-bit and 64-bit graphical user interface
7. Customizable wireless modeling
8. Discrete Event, Hybrid, and Analytical simulation
9. 32-bit and 64-bit parallel simulation kernel
10. Grid computing support
11. Integrated, GUI-based debugging and analysis
12. Open interface for integrating external component libraries

These features make OPNET uniquely distinguishable from other network simulators.

3.1 OPNET Hierarchy

There are mainly three domains in OPNET: network, node, and process.

. Fig1Model structure with OPNET

• Network model consists of nodes (fixed, mobile, satellite), links (point to point, wireless, bus) and subnets.

• Node model specifies object in network domain. It represents protocol and application functions and the flow of data internal to the device.

• Process model specifies object in node domain. It uses extended finite state machines to define protocol logic and control flow. C/C++ code controls the behavior of each state.
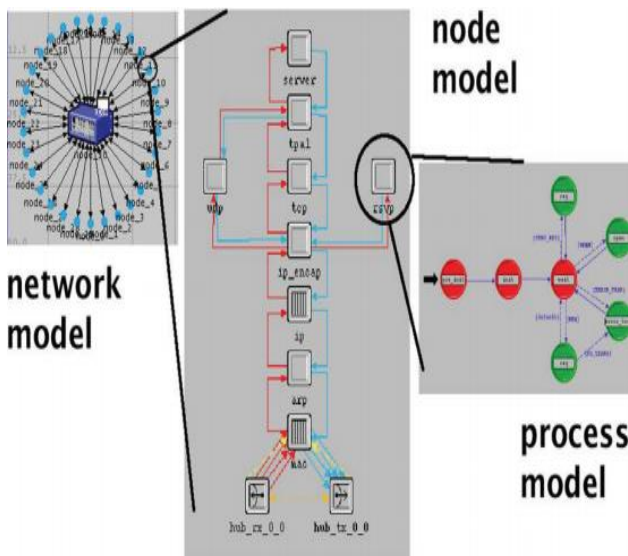
Fig2.OPNET graphic editors for network, node and process models

3.2 OPNET implementation in WiMAX

Our purpose is to test the performance of WiMAX network by using the OPNET software. The global configuration object is used to configure parameters such as service classes and PHY profiles. In the WiMAX configuration object, the contention parameters, efficiency mode and MAC service class Definitions are chosen.

The fixed WiMAX base station node model with router functionality, this node has Ethernet interfaces and WiMAX interfaces. For the 4 WiMAX SS (Subscriber Station) workstations, stand for the mobile subscribe station node model with workstation functionality. On base station node models and the subscriber station node

Models, all of the parameters needed to specify to match the attributes included in the WiMAX configuration. The MAC address is auto assigned and distance based, PHY profile is OFDM. One important characteristic of WiMAX is OFDM, which is based on modulation by multiple carriers and Frequency Division Multiplexing. In OFDM, the bandwidth is divided into parallel sub carriers with different channels. OFDM uses sub carriers that are mathematically orthogonal and the information is sent in parallel to the different sub channels.

3.3 WiMAX Connection model

A project is a collection of related network scenarios in which each explores a different aspect of network design. Each project contains at least one scenario which presents a unique configuration for the network. The basic components of WiMAX connection in OPNET is the fixed or mobile work station and WiMAX base station. The most common connections of Wimax are PMP which means point to multipoint. In this topology, a group of subscriber terminals are connected to a base station separately.
The nodes we used are listed below:

- Application config
- Profile config
- WiMAX config
- WiMAX base station

- Application server
- WiMAX WLAN router
- WiMAX work stations

Profile Configuration is used to choose the applications using corresponding to different scenarios. The Wimax configuration defines the contention parameters, efficiency mode and MAC service class Definitions. The application server which is the mobile subscriber station node model offers the functionality to the server. Mobile subscriber station node can route the signal transferred from the WiMAX base station functionality to the wireless work stations.

3.4 General steps to construct the WiMAX network

The typical configuration steps to build WiMAX in network model include four steps:
1. Creating the Topology.
2. Configuring Node Mobility
3. Adding Traffic to the WiMAX Network Model
4. Configuring WiMAX Parameters

In order to run the simulation, the service class, configure efficiency mode, and some other parameters need to be defined. When we do the analysis of the WiMAX network model, the statics can be collected which includes:
- Global statistics: delay, load, throughput etc.
- WiMAX node statistics: Initial range activity, BLER, delay, load, throughput.

After all these steps final step is to simulate the network and obtain the results in forms of graph using any of the various available filters.

IV. CONCLUSION

With the consistent application and endeavors of OPNET Inc., OPNET is becoming greatly popular with network simulation and its products maintain a better quality assurance among that of other simulators. OPNET Inc. keeps improving their product which make it very competitive compared with other commercial network simulators in the near expectable future. In this review paper we implemented WiMAX with OPNET and described its stepwise construction and performance evaluation.

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