Palestine Polytechnic University

College of Engineering & Technology
Electrical & computer Engineering Department

Graduation Project

Modeling Of Communication System And Network Performance Prediction For AMR

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Abstract

These Days, the dependence of computer networking systems become essentially to save time and money, Organizing and implementing this aim, we should use the the network simulator to improve the performance prediction and to prevent the problems which faces the computers networks implementations.

A future technical strategy is to build and install in each buildings, houses, and homes "Power Meter – Web Server", helping to collect the reading information and bills paying. In the very near future all of the devices in our houses and offices will be web enabled, hence each device or group of devices will be generating more and more information. Such information is most likely to be presented to the required clients using database web access techniques. Also the way of collecting and monitoring such data or information is considered as one of the most challenging problems.

Depending on the previous information we will study and simulate the idea of power meter networks using different technologies; this includes telephone lines, local area network technologies, wireless, and the power line carrier or PLC. We model and simulate some of these techniques, show the result and observed the suggestions of how to use these technologies in the power metering systems modeling with better performance.

الملخص

نظرا إلى الحاجة الماسة لاستخدام الشبكات والاستفادة منها في التطبيقات العملية التي تخدم الإنسان وتسهل حياته كان لابد من وجود آلية تقلل الأخطاء الناتجة من بناء الشبكات فيزيائيا على ارض الواقع فكان الحل هو استخدام محاكي الشبكة الذي يعمل على اكتشاف الأخطاء والتنبؤ بها واختيار الحل الأمثل والأفضل والأكثر كفاءة .

ولخدمة الإنسان وتوفير الوقت والجهد لصالحه كانت فكرة المشروع قائمة على تمثيل وحده خاصة بعداد الطاقة داخل محاكي الشبكة (OPNET) الذي يقوم بقراءة البيانات وإرسالها إلى مزود الخدمة في شركه الكهرباء من خلال الانترنت ، ودراسة بعض التطبيقات العملية المحتملة لتمثيل عداد الطاقه سواء استخدام الشبكه المحليه السلكيه او اللاسلكيه ببناء سينوريهات مختلفة وعمل محاكاة لها ودراسة كفاءة كل منها واستخلاص نتائج يمكن تقديمها كنصائح لشركه الكهرباء في تفعيل وبناء عدادات الكهرباء بما يتناسب مع الاماكانيات المادية والتقنية .

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Glossary

Delay: The communication delay over different types of links, due to distance. For point-to-point links, the delay is usually a constant, while he delays for bus links is measured per unit-distance. Radio link delays are based on the distance separating the transmitter from the receiver.

Dropped data packets: due to the overflow of higher-layer buffer, so they are not part of the load.

OPNET: Optimized Network Engineering Tool, the general name for OPNET's modeling software products. OPNET refers to all programs, scripts, model libraries, and other components.

Packet: A structured message that carries information between network components.OPNET lets you define the size, format, and fields of the packets in a system.

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

Receiver: An entity within a node that receives information across a link.

Scenario: A single instance of a network model, containing all related information (such as simulation settings and results).

Simulation: An activity hat provides a way to observe model behavior and obtain performance statistics for analysis.

Statistic: A numeric variable representing the behavior of a node or link model or of an entire system (network model).The value of a statistic may change during a simulation run or it may change only from one simulation run to the next.

Load: Total number of bits received from the higher layer to the MAC layer. Packets arriving from the higher layer are stored in the higher layer queue.

Throughput: Total number of bits sent to the higher layer from the MAC layer. The data packets received at the physical layer are sent to the higher layer if they are destined for this station, and they will arrive to the IP layer if they are rerouted to other station.

Throughput for link: represents the average number of packets successfully received or transmitted by the receiver or transmitter channel per second.

Traffic: it is the upper layers packets forwarded downstream to the network, all this traffic is supposed to be converted to load after adding the headers of the network and the data link layers. If the traffic size exceeds the capacity of the lower layers, part of the traffic will be dropped and the load is only the acceptable part of the traffic.

Transmitter: An entity within a node that sends information across a link.

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

CHAPTER ONE: INTRODUCTION

1.1 Introduction

The world we are living in, is a world which is developed very rapidly , the need to have a fastest communication system are necessary to minimize the time and to save energy, money and costs, these demands pressing to find the proper technology ideas to satisfied these important aims.

Computer networks, recently are the most technological solutions for many different communication problems, which are defined as an accumulation of computers, modems, control switches, software, protocol ..etc.
Many technical problems occurred when we are using the regular network communication systems such as, interface error problems, connecting with the main network server, wiring and data transmission.

In our project we are spotting the light for the necessity at the using of network simulation and using the simulation to build a network of automatic meter reading system represent the real network, Simulations are usually used to analyze the conceptual design of the network the initial conceptual design is usually refined several times until a final decision is made to implement the design one of our objectives is to have a design that maximizes the network performance, taking into consideration the cost constraints and the required services to be offered to different types of users, After the network has been implemented, network optimization should be performed periodically throughout the lifetime of the network to ensure maximum performance of the network and to monitor the utilization of the network resources.

Every home nowadays contains power meter, to collect the reading and pay the bill by traditional way of Kwatt reading that may causing an real information submission at the electrical power consuming data beside the bill collections, so we decide in this project to avoid this technique and problems of it by replace it with Automatic power meter system with Ethernet port provide a very cost effective way of sending the information to the end users or to the database servers. The network is always on, connection that provides data streaming and data updates for real time data information. All meters transmit the stored data over the internet to the data collection servers that store, calculate and aggregate the energy information. Portfolios are created which bring all the metered data to a centralized, So to satisfy this replacement we use OPNET simulator, which provides a comprehensive development environment supporting the modeling of communication networks and distributed systems, Both behavior and performance of modeled systems can be analyzed by performing discrete event simulations, the OPNET environment incorporates tools for all phases of a study, including model design, simulation, data collection, and data analysis.
OPNET provides a Virtual Network Environment that models the behavior of our entire network, including its routers, switches, protocols and servers.

We illustrated in this project how we modeled and simulated a part of Hebron city power meters using OPNET simulator, and study the performance of different techniques used to implement the automatic power meter.

1.2 Estimated Cost

Hardware cost:

Table 1.1: hardware cost

Component	Price
Personal computer(p4)	1000$
RAM 512	50$
Hard disk 40G(at least)	50$
Monitor	40$
CD ROM	20$
Floppy drive	12$
FLASH(256M)	20$
Printed papers	500$
Total	1692$

Software cost:

Table 1.2: software cost

Component	Price
OPNET SW	5000$
Windows XP	200$
Office XP	100$
Capture SW	100$
Total	1400$

1.3 Time plane

In the first semester we have modeled part of Palestine polytechnic university network and the aim for this work was to trained for using OPNET simulator for more information see appendix (1).

Table 1.3 : Time Plane For PPU Network

Task	Duration (weekly)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Choose the project & Supervisor																
Collecting Data and reading																
Install OPNET and applied labs.																
Draw and simulate the ppu network.																
Documentation for case1.																

In the second semester we have model the automatic power meter reading .

Table1.4: time plane for AMR

Task	Duration (weekly)															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Collecting information from municipality																
Create different scenarios of automatic meter reading																
Implementation and obtain the results.																
Documentation..																

1.4 System Requirement

- Hardware requirement:

- Intel Pentium III, 4 or compatible (500 MHz or better)
- 256 MB RAM min
- Hard disk 40GB

- software requirement:

- OPNET simulator (version 8)

1.5 Report content

This project contain six chapters each chapter divided into branches in chapter one which talk about introduction that contains the general idea and importance of the project ,estimated cost, time planning and risk management.

In chapter two that include the theoretical background about essential clause and definition in the network such as LAN, WAN, types of connecting devices and protocols also talk about the definition and importance of simulator we use (OPNET), wireless technology benefit, limitation and types, xDSL technology and PLC Finally in this chapter included with the basic information about automatic meter reading.

In chapter three which talk about simulation design including project objective general block diagrams, how system works and system modeling.

In chapter four which talk about detailed system design and automatic power meter models will be presented. In chapter five which talk about implementation (simulation) and testing for different number of scenarios and present the performance for each scenario. Finally, A conclusions and future work discussions are presented in chapter 6.

CHAPTER TWO: THEORETICAL BACK GROUND

2.1 Overview of networking

The Internet today is a widespread information infrastructure, but it is inherently an In secure channel for sending messages. When a message (or packet) is sent from one Website to another, the data contained in the message are routed through a number of intermediate sites before reaching its destination through network that can consist of two computers connected together on a desk or it can consist of many Local Area Networks (LANs) connected together to form a Wide Area Network (WAN) across a continent. The key is that 2 or more computers are connected together by a medium and they are sharing resources, the resources can be files, printers and hard drives .

2.1.1 LANs:

LANs (local area networks) are networks that connect computers and resources together in a building or buildings close together.

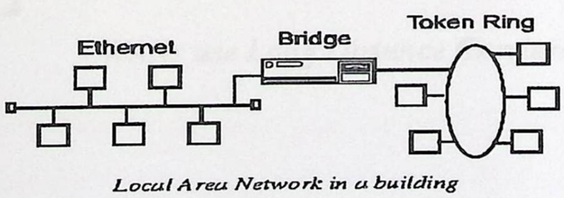


Figure 2.1 LAN

The components used by LANs can be divided into cabling standards, hardware and protocols. Examples of cabling standards used on LANs are:

- Cat 3, 4 and 5 cables
- IBM Type 19 cabling standards
- EIA568A and 568B
- Ethernet cabling standards: IEEE 802.3 (10Base5), IEEE 802.3a (10Base2), IEEE 802.3i (10BaseT)
- Unshielded Twisted Pair (UTP)
- Shielded Twisted Pair (STP)
- Connectors: RJ45, RJ11, , RS232

2.1.2 WAN

Wide Area Networks (WANs) connect LANs together between cities.

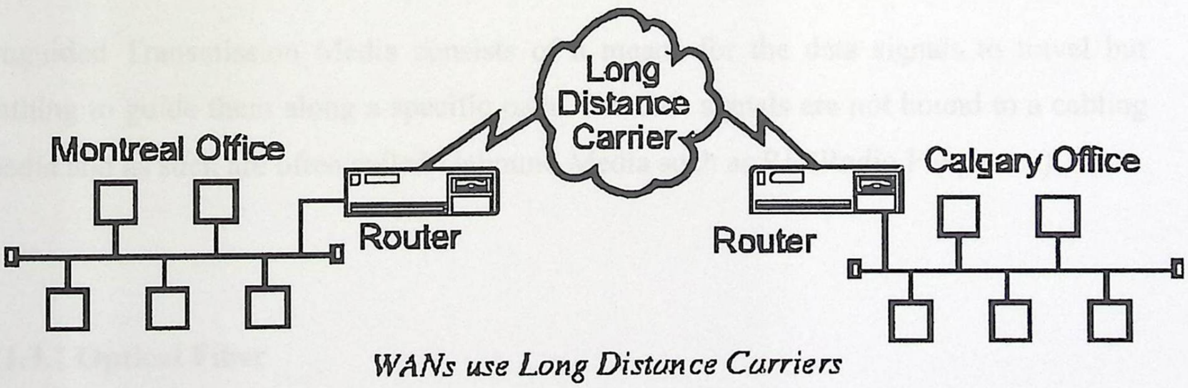


Figure 2.2 WAN

The main difference between a MAN and a WAN is that the WAN uses Long Distance Carriers. Otherwise the same protocols and equipment are used as a MAN.

2.1.3 Transmission Media

There are two basic categories of Transmission Media:

- Guided and
- Unguided.

Guided Transmission Media uses a "cabling" system that guides the data signals along a specific path. The data signals are bound by the "cabling" system. Guided Media is also known as Bound Media. Cabling is meant in a generic sense in the previous sentences and is not meant to be interpreted as copper wire cabling only.
There four basic types of Guided Media Open Wire , Twisted Pair, Coaxial Cable and Optical Fiber .

Unguided Transmission Media consists of a means for the data signals to travel but nothing to guide them along a specific path. The data signals are not bound to a cabling media and as such are often called Unbound Media such as RF (Radio Frequency).

2.1.3.1 Optical Fiber

Optical Fiber consists of thin glass fibers that can carry information at frequencies in the visible light spectrum and beyond. The typical optical fiber consists of a very narrow strand of glass called the Core. Around the Core is a concentric layer of glass called the Cladding [1].

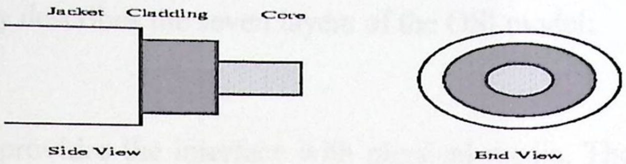


Figure 2.3 Optical Fiber

2.1.4 ISO OSI model

The International Standards Organization (ISO) Open Systems Interconnect (OSI) is a standard set of rules describing the transfer of data between each layer. Each layer has a specific function. For example the Physical layer deals with the electrical and cable specifications.

The OSI Model clearly defines the interfaces between each layer. This allows different network operating systems and protocols to work together by having each manufacture adhere to the standard interfaces. The application of the ISO OSI model has allowed the modern multiprotocol networks that exist today. There are 7 Layers of the OSI model:

- 7. Application Layer (Top Layer)
- 6. Presentation Layer
- 5. Session Layer
- 4. Transport Layer
- 3. Network Layer
- 2. Data Link Layer
- 1. Physical Layer (Bottom Layer)

The following briefly describes the seven layers of the OSI model:

1. Physical layer.

The physical layer provides the interface with physical media. The interface itself is a mechanical connection from the device to the physical medium used to transmit the digital bit stream. The mechanical specifications do not specify the electrical characteristics of the interface, which will depend on the medium being used and the type of interface. This layer is responsible for converting the digital data into a bit stream for transmission over the network. The physical layer includes the method of connection used between the network cable and the network adapter, as well as the basic communication stream of data bits over the network cable.

2. Data link layer.

The data link layer represents the basic communication link that exists between computers and is responsible for sending frames or packets of data without errors. The software in this layer manages transmissions, error acknowledgement and Recovery.

3. Network layer

The network layer is responsible for data transmission across networks. This layer handles the routing of data between computers and also the protocol mechanisms activate data routing by providing network address resolution, flow control in terms of segmentation and blocking and collision control (Ethernet). The network layer also provides service selection, connection resets and expedited data transfers. The Internet Protocol (IP) runs at this layer.

4. Transport layer

The transport layer is responsible for ensuring that messages are delivered error-free and in the correct sequence. This layer splits messages into smaller segments if necessary and provides network traffic control of messages. Traffic control is a technique for ensuring that a source does not overwhelm a destination with data. When data is received, a certain amount of processing must take place before the buffer is clear and ready to receive more data. The transport layer, therefore, controls data transfer and transmission.

5. Session layer

The session layer controls the network connections between the computers in the network. The session layer recognizes nodes on the LAN and sets up tables of source and destination addresses. It establishes a handshake for each session between different nodes. Technically, this layer is responsible for session connection.

6. Presentation layer:

The presentation layer is responsible for the data format, which includes the task of hashing the data to reduce the number of bits (hash code) that will be transferred. This layer transfers information from the application software to the network session layer to the operating system. The interface at this layer performs data transformations, data compression, data encryption, data formatting, and syntax selection.

7. Application layer

The application layer is the highest layer defined in the OSI model and is responsible for providing user-layer applications and network management functions. This layer supports identification of communicating partners, establishes authority to communicate, transfers information and applies privacy mechanisms and cost allocations. It is usually a complex layer with a client/server, a distributed database, data replication and synchronization. The application layer supports file services, print services, remote login and e-mail. [2]

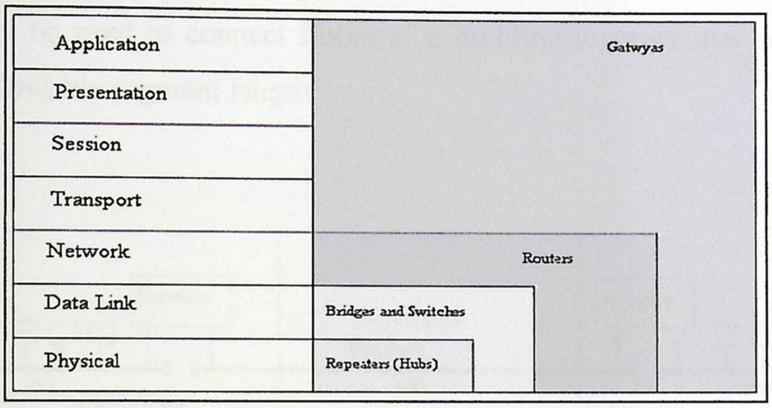


Figure2.4 OSI Layers and Operating Connection Devices

2.1.5 Connecting Devices

Connecting devices are used to connect the segments of a network together or to connect networks to create an internetwork. These devices are classified into five categories: Switches, repeaters, bridges, routers and gateways. Each of these devices except the first one (switches) interacts with protocols at different layers of the OSI model. Repeaters forward all electrical signals and are active only at the physical layer. Bridges store and forward complete packets and affect the flow control of a single LAN. Bridges are active at the physical and data link layers. Routers provide links between two separate LANs and are active in the physical, data link and network layers. Finally, gateways provide translation services between incompatible LANs or applications, and are active in all layers

2.1.5.1 Repeaters

The purpose of a repeater is to extend the LAN Segment beyond its physical limits as defined by the Physical Layer's Standards. Typically, repeaters are used to connect two physically close buildings together that are too far apart to just extend the segment, Can be used to connect floors of a building together that would surpass the maximum allowable segment length.

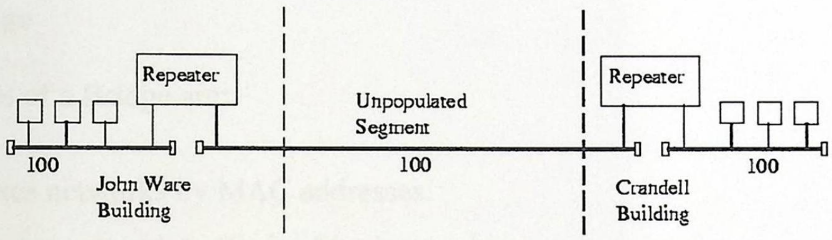


Figure 2.5 Repeater

2.1.5.2 Hubs

Hubs are also called Multiport Repeaters or Concentrators. They are physical hardware devices. Some Hubs are basic hubs with minimum intelligence, no microprocessors Intelligent Hubs can perform basic diagnostics and test the nodes to see if they are operating correctly. If they are not, the Smart Hubs or Intelligent Hubs will remove the node from the network. Some Smart Hubs can be polled and managed remotely; Hubs are used to provide a Physical Star Topology. The Logical Topology is dependant on the Medium Access Control Protocol. At the center of the star is the Hub with the network nodes on the tips of the star.

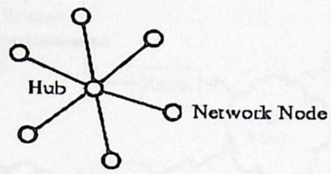


Figure 2.6 Star Topology

2.1.5.3 Bridge

The purposes of a Bridge are:

- Isolates networks by MAC addresses.
- Manages network traffic by filtering packets.
- Translate from one protocol to another.

2.1.5.4 Routers

Routers are hardware and software devices. They can be cards that plug into a collapsed backbone, stand-alone devices (rack mount or desktop) or software that would run on a file server with two NICs.

The purpose of a router is to connect nodes across an internet work regardless of the Physical Layer and Data Link Layer protocol used. Routers are hardware and topology independent. Routers are not aware of the type of medium or frame used (Ethernet, Token Ring, FDDI, X.25, etc...). Routers are aware of the Network Layer protocol used: Novell's IPX, Unix's IP, XNS, Apples DDP…. etc.

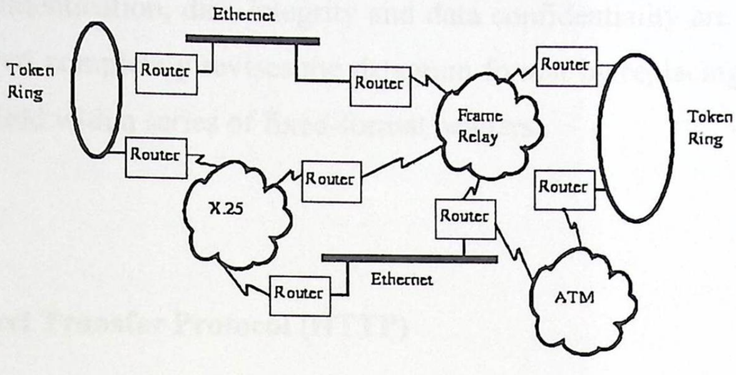


Figure 2.7 Router

2.1.5.5 Gateways

Gateway is the Hardware/Software device that is used to interconnect LANs & WANs with mainframe computers. Often the router that is used to connect a LAN to the Internet will be called a gateway. It will have added capability to direct and filter higher layer protocols (layer 4 and up) to specific devices such as web servers, FTP servers and Email servers. [3]

2.1.6 Protocols

IP Version 6 (IPv6, or IPng):

IPv6 protocol. differs from IPv4 in a number of significant ways:

• The IP address length in IPv6 is increased from 32 to 128 bits.

• IPv6 can automatically configure local addresses and locate IP routers to reduce configuration and setup problems.

• The IPv6 header format is simplified and some header fields dropped. This new header format improves router performance and makes it easier to add new header types.

• Support for authentication, data integrity and data confidentiality are part of the IPv6 Architecture, IPv6 completely revises the datagram format by replacing IPv4's variable length options field with a series of fixed-format headers.

2.1.6.1 Hypertext Transfer Protocol (HTTP)

HTTP is a protocol with the lightness and speed necessary for a distributed collaborative hypermedia information system. It is a generic stateless object-oriented protocol, which may be used for many similar tasks such as name servers, and distributed object-oriented systems, by extending the commands, or "methods", used. A feature if HTTP is the negotiation of data representation, allowing systems to be built independently of the development of new advanced representations.

The protocol used to transfer a Web page between a browser and a Web server is known as Hypertext Transfer Protocol (HTTP). HTTP operates at the application level and is a protocol used mainly to access data on the World Wide Web. HTTP functions like a combination of FTP and SMTP. It is similar to FTP because it transfers files, while HTTP is like SMTP because the data transferred between the client and the server looks like SMTP messages. However, HTTP differs from SMTP in the way that SMTP messages are stored and forwarded, HTTP messages are delivered immediately.

2.1.6.2 File Transfer Protocol (FTP)

File Transfer Protocol, the protocol for exchanging files over the Internet. FTP works in the same way as HTTP for transferring Web pages from a server to a user's browser and SMTP for transferring electronic mail across the Internet in that, like these technologies, FTP uses the Internet's TCP/IP protocols to enable data transfer. FTP is most commonly used to download a file from a server using the Internet or to upload a file to a server (e.g., uploading a Web page file to a server).

2.1.6.3 Simple Mail Transfer Protocol (SMTP)

The Simple Mail Transfer Protocol (SMTP) provides a basic e-mail facility. SMTP is the protocol that transfers e-mail from one server to another. It provides a mechanism for transferring messages among separate servers. Features of SMTP include mailing lists, return receipts and forwarding. SMTP accepts the incoming message and makes use of TCP to send it to an SMTP module on another server. The target SMTP module will make use of a local electronic mail package to store the incoming message in a user's mailbox. Once the SMTP server identifies the IP address for the recipient's e-mail server, it sends the message through standard TCP/IP routing procedures.

Since SMTP is limited in its ability to queue messages at the receiving end, it's usually used with one of two other protocols, POP3 or IMAP that let the user save messages in a server mailbox and download them periodically from the server. In other words, users typically use a program that uses SMTP for sending e-mail and either POP3 or IMAP for receiving messages that have been received for them at their local server. Most mail programs (such as Eudora) let you specify both an SMTP server and a POP server. On UNIX-based systems, send-mail is the most widely used SMTP server for email [2].

2.1.6.4 Routing Information Protocol (RIP)

The Routing Information Protocol (RIP) is a protocol used to propagate routing information inside an autonomous system. Today, the Internet is so large that one routing protocol cannot handle the task of updating the routing tables of all routers. Therefore the Internet is divided into autonomous systems.

World Wide Web:

The World Wide Web Consortium (W3C) develops interoperable technologies (specifications, guidelines, software, and tools) to lead the Web to its full potential. W3C is a forum for information, commerce, communication, and collective understanding. The World Wide Web (WWW) is a repository of information spread all over the world and linked together. The WWW is a distributed client-server service, in which a client using a browser can access a service using a server. The Web consists of Web pages that are accessible over the Internet.

The Web allows users to view documents that contain text and graphics. The Web grew to be the largest source of Internet traffic since 1994 and continues to dominate, with a much higher growth rate than the rest of the internet. By 1995, Web traffic overtook FTP to become the leader.

2.1.6.5 TCP/IP protocol

Transmission Control Protocol/Internet Protocol (TCP/IP),is not simply one protocol ,but rather a suite of specialized protocols including TCP, IP, UDP, ARP,and many others called subprotocols, most network administrator refer to the entire group as "TCP/IP", (the basic backbone of the Internet) .TCP guarantees delivery of data and also guarantees that packets will be delivered in the same order in which they were sent. IP takes care of addressing of packets. HTTP is a simple protocol that is based on a TCP/IP protocol stack. HTTP is based on a simple client/server-concept. HTTP server and client communicate via a TCP connection. The server waits for a request from a client. This request normally refers to transmitting of specific HTML code. This HTML code possibly has to be generated dynamically. As a result of the requests, the server will answer with a response that usually contains the desired HTML code.

The ability to integrate and embed TCP/IP can open the door to a new class of applications. Accordingly remote system control and management is becoming much easier with such integrated systems.

Micro Web Servers:

Micro web-servers are microcontroller systems with an integrated chip that contains a processor and ports. It also contains the required TCP/IP protocol stack to establish an Internet connection. Micro web-servers can be embedded in remote control systems to network-enable remote applications.

Many web-server options are available to construct, achieve the connectivity and controlling tasks, Micro web server applications now include remote monitoring, industrial automation and process control, home automation, lighting control, environmental monitoring, remote telemetry and test and lab equipment monitoring.

2.2 Wireless LAN Background

Wireless LAN protocol is based on the IEEE 802.11 standard. The standard defines a medium access control (MAC) sub layer and three physical (PHY) layers. The goal of the IEEE 802.11 protocol is to describe a wireless LAN that delivers services commonly found in wired networks, e.g., throughput, reliable data delivery, and continuous network connections, the architecture of the IEEE 802.11 WLAN is designed to support a network where most decision making is distributed across the mobile stations. Some of the components that are the basic building blocks of the 802.11 based networks are described below:

1. Station: In IEEE 802.11 network a station is the component that connects to the wireless medium. The station may be mobile, portable, or stationary, every station supports all station services which include authentication, deauthentication, privacy, and delivery of the data (MAC service data unit).

2. Basic Service Set (BSS): The IEEE 802.11 WLAN architecture is built around a BSS. A BSS is a set of stations that communicate with one another. When all the stations in the BSS can communicate directly with each other and there is no connection to a wired network, the BSS is called an independent BSS (IBSS). IBSS is also known as adhoc network which is typically a short lived network with small number of stations in direct communication range as shown in figure 2.8 . When a BSS includes an access point (AP), the BSS is no longer independent and is called an infrastructure BSS or simply BSS as shown in figure 2.9. In an infrastructure BSS, all mobile stations communicate with the AP. The AP provides both the connection to the wired LAN, if any, and the local relay function within the BSS.

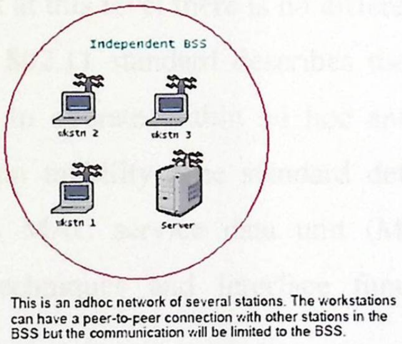


Figure 2.8: Independent BSS

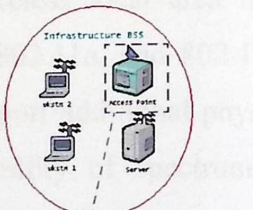


Figure 2.9: Infrastructure BSS

3. Extended Service Set (ESS): ESS is a set of infrastructure BSSs, where the APs communicate among themselves to forward traffic from one BSS to another. The APs perform this communication via distribution system (DS). The DS is the backbone of the WLAN and may be constructed of either wired or wireless networks.

2.2.1 IEEE 802.11 Standards

The aim of the IEEE 802.11 standard was to develop a medium access control layer (MAC) and a physical layer (PHY) for wireless connectivity to fixed, portable and moving stations within a local area . The higher OSI layers in 802.11 are the same as in any other 802 standards, which means that at this level there is no difference perceptible between wired and wireless media. The 802.11 standard describes the functions and services required by a compliant device to operate within ad hoc and infrastructure networks as well as the aspects of station mobility. The standard defines the MAC procedures to support the asynchronous MAC service data unit (MSDU) delivery services, and several PHY signaling techniques and interface functions that are controlled by the IEEE 802.11 MAC [4] .

The MAC and PHY characteristics for wireless local area networks (WLANs) are specified in the 802.11 standards 802.11b, 802.11a, and 802.11g. The MAC layer in these standards is designed to be able to support additional physical layer units as they may be adopted, dependent on the availability of spectrum and new modulation techniques. The logical link control (LLC) layer is the highest layer of the IEEE 802.11 Reference Model. The purpose of the LLC is to exchange data between end users across a LAN that uses 802-based MAC protocols. The LLC provides identification of the upper layer protocol (ULP), data-link control functions, and connection services. It is independent of the topology, transmission medium, and medium access control techniques used at the MAC and PHY layers. Higher layers, such as the network layer, pass user data down to the LLC, expecting error-free transmissions across the network. Figure 2.10 shows the physical and data link layers, the physical layer has different types of medium and spectrum, and data link layer is divided into two sub layers: the medium access control (MAC) and the logical link control (LLC) sub-layers [3].

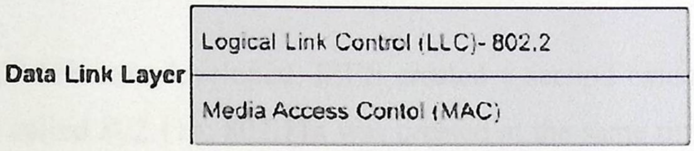


Figure 2.10: 802.11 physical and data link layers

In 1997, the Institute of Electrical and Electronics Engineers (IEEE) created the first WLAN standard. They called it 802.11 after the name of the group formed to oversee its development. Unfortunately at the beginning 802.11 only supported a maximum bandwidth of 2 Mbps which is too slow for most applications. Later newer standards were introduced which support higher bandwidth services [4].

802.11b

IEEE expanded on the original 802.11 standard in July 1999, creating the 802.11b specification, 802.11b supports bandwidth up to 11 Mbps. 802.11b uses the same radio signaling frequency 2.4 GHz as the original 802.11 standard.

802.11a

When 802.11b was developed, IEEE created a second extension to the original 802.11 standard called 802.11a; 802.11a was created at the same time. Due to its higher cost, 802.11a fits predominately in the business market, whereas 802.11b better serves the home market and supports bandwidth up to 54 Mbps and signals in 5 GHz frequency range. Compared to 802.11b, this higher frequency limits the range of 802.11a. The higher frequency also means 802.11a signals have more difficulty penetrating walls and other obstructions. Because 802.11a and 802.11b utilize different frequencies, the two technologies are incompatible with each other [4].

802.11g

In 2002 and 2003, WLAN products supporting a new standard called 802.11g began to appear on the scene. 802.11g attempts to combine the best of both 802.11a and 802.11b. 802.11g supports bandwidth up to 54 Mbps, and it uses the 2.4 GHz frequency for greater range. 802.11g is backwards compatible with 802.11b, meaning that 802.11g access points will work with 802.11b wireless network adapters and vice versa.

802.11h

This standard is supplementary to the MAC layer to comply with European regulations for 5GHz WLANs. European radio regulations for the 5GHz band require products to have transmission power control (TPC) and dynamic frequency selection (DFS). TPC limits the transmitted power to the minimum needed to reach the furthest user. DFS selects the radio channel at the access point to minimize interference with other systems [4].

2.2.2 Challenges in Wireless Networks

There are some of challenges in wireless such as:

1. Standards: Major challenge is compliance with various existing standards and interoperability among them. Presently, Various national and international frequency regulations have to be considered in making wireless devices suitable for global operation.

2. Bandwidth: Bandwidth is the one of the most scarce resource in wireless networks. Even with emerging high speed WLAN technologies, the available bandwidth in wireless networks is far less than the wired links.

3. Link Errors: Channel fading and interference cause link errors and these errors may sometimes be very severe. More over the effect of these errors is often global, i.e. not local to a single node, may effect the entire network.

4. Mobility and Roaming: Existing applications should continue to run over WLANs even while roaming the network. The fact that wireless access and mobility should be hidden if not relevant.

5. Inter-operability with wired Networks: Already a lot of money has been invested on WLANS implementations in wired LANs. Hence new WLAN mechanisms must protect this investment by being inter-operable with the existing networks.

6. Power Constraints: Devices communicating via a WLAN are typically also wireless devices running on battery power. Hence, WLAN must implement special power saving modes and power management functions.

7. Safety and security: Another important concern is of safety and security. WLANs should be safe to operate, especially regarding low radiation. Furthermore, no users should be able to read personal data during transmission i.e., encryption mechanism should be integrated. The network should also take into account user privacy.

2.2.3 Benefit of wireless LAN

- Provides real-time access to data, to simplify purchasing and distribution planning.
- Saves customer service costs by eliminating bill estimates, automating notifications.
- Allows for instant reprogramming, to alter the data collection process.
- Supports regular, increased and unscheduled readings for greater operations efficiency.

- Always on communications for fast notifications of meter tampering.
- Supports value added services to the network for residences, offices and factories.
- Scalable networks allow for addition/subtraction of metering points.

2.3 xDSL Technology

xDSL Refers collectively to all types of digital subscriber lines, the two main categories being ADSL and SDSL. Two other types of xDSL technologies are High-data-rate DSL (HDSL) and Very high DSL (VDSL). DSL technologies use sophisticated modulation schemes to pack data onto copper wires. They are sometimes referred to as last mile technologies because they are used only for connections from a telephone switching station to a home or office, not between switching stations.

xDSL is similar to ISDN in as much as both operate over existing copper telephone lines (POTS) and both require the short runs to a central telephone office (usually less than (20,000 feet). However, xDSL offers much higher speeds up to 32 Mbps for upstream traffic, and from 32 Kbps to over 1 Mbps for downstream traffic.However, to make use of DSL, it helps to understand the basis of the technology. DSL is a technology for pushing a (relatively) large number of bits through wiring that is typical for "last mile" telephone connections .There are a number of different protocols that fall under the DSL: ADSL, RADSL, HDSL and even different sub variations.

xDSL is used to push high bit rates through copper wires that run from point A to point B. For most people, point A will be their home and point B will be the other end of the copper phone wire that is the substation of the local phone company.

Standard telecom modems (e.g. 56k, 28.8k, etc) establish a data stream between two arbitrary points using the entire telecom system that is, from the sender's local loop, through the telephone switching system (mostly digital switches now) and then to the receiver's local loop. Standard modem connections can span continents, with one end being thousands of kilometers from the other end.

DSL modems, on the other hand, establish a connection from one end of a copper wire to the other end of that copper wire; the signal does not pass into the telephone switching system. Consequently, DSL modems are not limited to using only the voice frequencies passed by the standard telephone system (typically 0-4kHz); DSL modems typically use more than 100kHhz.

To reiterate, one end of the DSL link will be at the consumer site, the other end must be at the other end of the copper cable usually this means your local telephone exchange. At your local phone company the local loop first goes into a splitter that splits the data frequencies from the voice frequencies as shown in figure 2.11 . The voice frequencies are wired into a traditional POTS switch and enter the normal telephone switching network. The data frequencies are wired into a corresponding DSL modem at the CO end and the resulting high speed digital data stream coming from (or going to) the consumer is then handled as normal data (not analog voice) and may be hooked into any number of networking technologies for further connection to the data's destination.

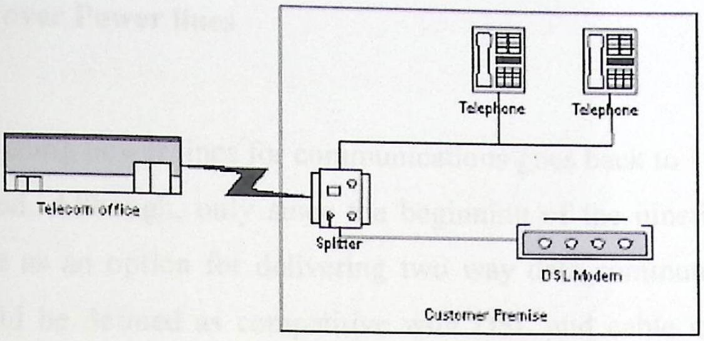


Figure2.11: splitter.

Typically the data will be routed over a LAN/WAN connection (10Base-T Ethernet, T1, T3, ATM, frame relay, whatever) to a business office. The business may be an ISP (the ISP may or may not be the local phone company) which may then route the data onto the Internet, thus providing you with Internet connectivity or the business may be the company you work for and the connection provides high speed access from your home direct to your company's network. Note that if the connection is made to an ISP, you are not connecting to the ISP over its standard modem bank you are coming in over some sort of LAN/WAN data connection that the ISP has arranged with your local phone company. This is the only way an ISP can provide DSL-connected ISP service for customers. Also note that DSL is always "on" the connection is always there, ready to pass bits up and down the pipe there is no calling a remote number and waiting for modems to train up. [5,6].

2.4 Broadband over Power lines

The idea of using power lines for communications goes back to 1899, when the first patent was issued. Although, only since the beginning of the nineties this option has become relevant as an option for delivering two way data communication services at speeds that could be defined as competitive with DSL and cable modem. Broadband over power lines (BPL) architecture aims to take advantage of low cost last mile technology with deployed in-house networking generated by the ubiquitous electrical power network. Power cables were designed to transmit electricity at high voltages at low frequencies of 50 or 60 Hz. These low frequencies did not impose significant requirements for shielding the wires which means that they are not equipped to prevent radiation of radio frequency energy. The central idea of BPL is to transfer data at very high frequencies, ranging between 1 and 30 MHz, compared to earlier 9-525 kHz in old low data rate PLC, which creates two problems of using power lines for transmitting data. First, higher frequencies over unshielded cable generate significant interference. Second, high frequencies mean the signals present higher attenuation along the cables, which leads to shorter effective distances between repeaters.

There is “In-House” and “Last-Mile” BPL. In-House BPL refers to using the power network of a building instead of deploying a new network, so devices can be used only by plugging into the AC. There are four architectures presenting different degrees of integration between fiber, power lines and wireless technologies. At one extreme, there are Fiber-to-the-Premises (home or business). In this case, electric utilities that have connected transformers and substations by fiber networks running internal services, decide extend the reach of the fiber to the user’s premises. This would enable connectivity at the highest bandwidth possible nowadays, but at a very high cost [11].

A second option is Fiber and Low-Voltage (F-LV) architecture. This option presents a less expensive solution. Here, power companies following idea behind HFC architecture for cable modem and deploy fiber until an optical-electrical converter located before each transformer and, from them on, use low-voltage power lines to reach customer premises. F-LV is less expensive than FTTP in that it does not need to reach fiber to each customer premises. Also, F-LV presents a maximum bandwidth of 3 Mbps, which is low compared to cable modem and xDSL.

A third option is a combination of medium-and low-voltage power lines, in what could be defined as a pure broadband over power lines. Analogous to the previous case, each distributing substation provides power to various transformers, but now uses the medium-voltage power line for sending data to a bypass transformer device, which is connected to the customer premises by using low-voltage power line. This architecture, however, produces high level of radio frequency interference from power lines, and presents obstruction of signals between medium-and low-voltage lines at distribution transformers (These transformers are designed for frequencies of 50 or 60 Hz, which imposes constraints for frequencies in the (2-30 MHz).

A fourth architecture is hybrid between medium-voltage and wireless. Here the utility transmit data all the way through medium-voltage power lines between the substation and the pole closest to the customer premise. This allows for transmission of higher quality than in low-voltage lines. This approach, however, presents two problems:

- The cost of antenna.
- Decreasing bandwidth per subscriber.

Each medium-voltage power line connects several low-voltage (LV) lines and, thus, all broadband users in those LV lines would have to share bandwidth [11].

2.4.1 Power Line Carrier Modem

The power line modem (PLC Modem) is a dedicated device for transferring data over low voltage power line. Using the extensive power line cable network in a region that is distributed by a single transformer, one can use a multiple PLC Modem to form a data network among the various data terminals. Thus, a data communication network infrastructure can be formed among all the data terminals. The unit can be used in centralized electric meter reading, remote monitoring of electrical equipment, building automation and security control, stage lighting and street lighting control applications, information displays and it can also play a role in the final leg of Internet connection in special circumstances.

The power line modem uses the power line cable as communication medium. It is convenient as it eliminates the need to lay additional cables. The modem at the transmission end modulates the signal from data terminal through RS-232 interface onto the carrier signal in the power line. At the receiving end, the modem recovers the data from the power line carrier signal by demodulation and sends the data to data terminals through RS-232 interface.

PLC Modem can be used for broadcasting in a one-to-many manner without the need to worry about handshaking. PLC Modem can be either master or slave, depending on the pin definition of RS-232. There is no prior classification of master-slave role for the modem. A PLC Modem acting as master can be designed to work in a 3-phase manner.

Figure 2.12 shows an example of using PLC modems in remote automatic meter reading system. It illustrates the schematic diagram of the connection between power line modem and the data terminals using power line cables.

Figure 2.13 shows a LAN network based on the PLC modems that are connected to each network device, Such LAN can be utilized to connect different Micro web-based power meter systems to communicate and send such meter reading to the central office facility.

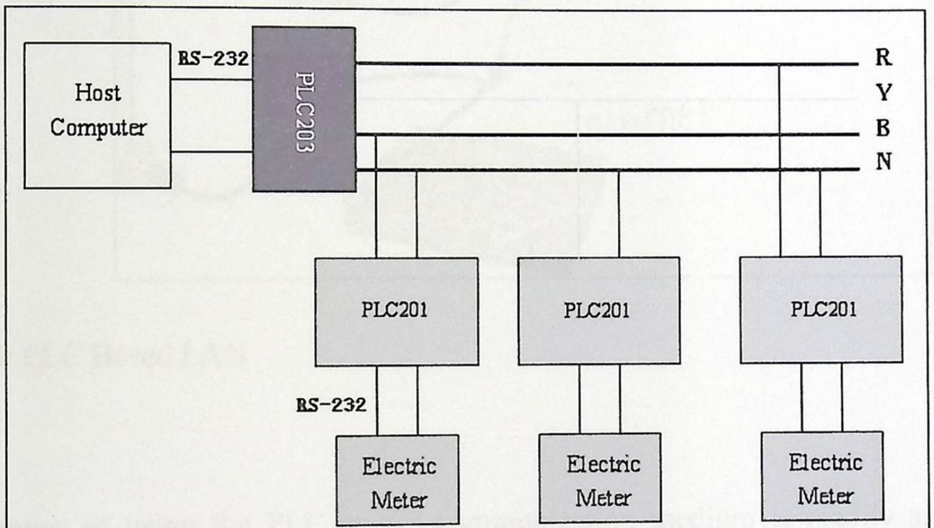


Figure 2.12:PLC Modems In AMR Systems

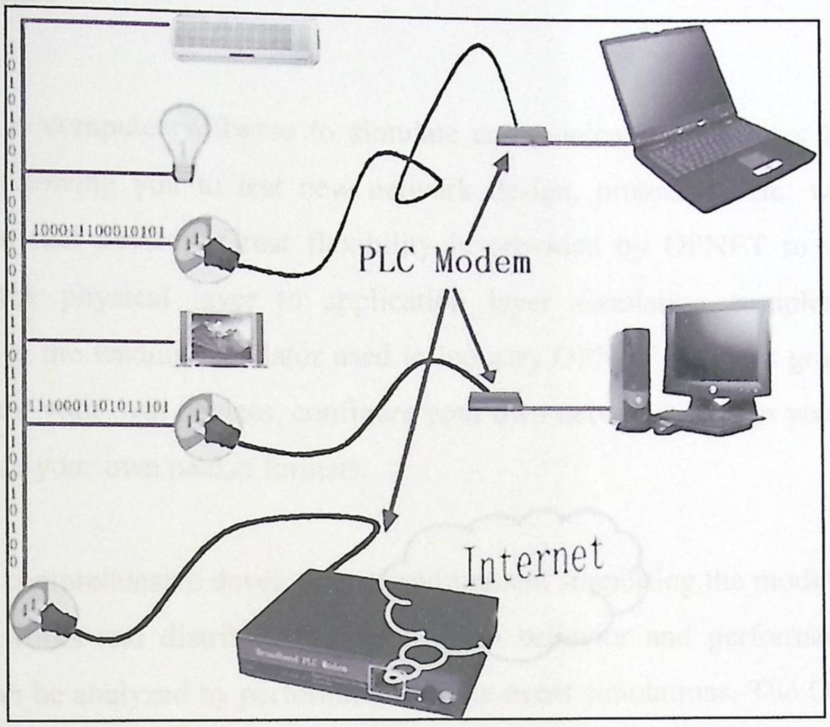


Figure 2.13: PLC Based LAN

The advantages of using the PLC as the communication medium is readily apparent since the power line network are the property of the utility company and its infrastructure is already there. However, power lines are never meant for communication and create much noise. Therefore, various modifications have to be made to make the PLC suitable to be the AMR communication channel. [9].

2.5 OPNET Simulator

OPNET is a computer software to simulate communication networks It is a software package allowing you to test new network design, protocols…etc. without actually having the real devices .Great flexibility is provided by OPNET to set up parameters from the physical layer to application layer simulating complex real scenarios It is one of the leading simulator used in industry OPNET provides graphical editor to users to edit your own devices, configure your own networks, design your own protocols, and define your own packet formats.

OPNET provides a comprehensive development environment supporting the modeling of communication networks and distributed systems. Both behavior and performance of modeled systems can be analyzed by performing discrete event simulations. The OPNET environment incorporates tools for all phases of a study, including model design, simulation, data collection, and data analysis. A brief enumeration of some of the most important capabilities of OPNET [7]

- Object orientation.
- Specialized in communication networks and information systems.
- Hierarchical models.
- Graphical specification.
- Flexibility to develop detailed custom model
- Automatic generation of simulations.
- Application-specific statistics.
- Integrated post-simulation analysis tools.
- Interactive analysis.
- Animation.

2.5.1 OPNET Network Model

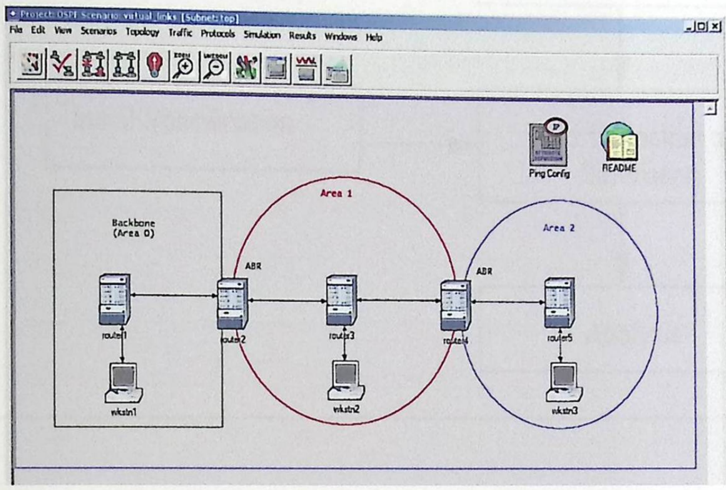


Figure 2.14: OPNET Model

2.5.2 OPNET architecture

OPNET provides a comprehensive development environment for modeling and performance-evaluation of communication networks and distributed systems. The package consists of a number of tools, each one focusing on particular aspects of the modeling task. These tools fall into three major categories that correspond to the three phases of modeling and simulation projects: Specification, Data Collection and Simulation, and Analysis. These phases are necessarily performed in sequence. They generally form a cycle, with a return to Specification following Analysis. Specification is actually divided into two parts: initial specification and re-specification, with only the latter belonging to the cycle, as figure 2.15 [7].

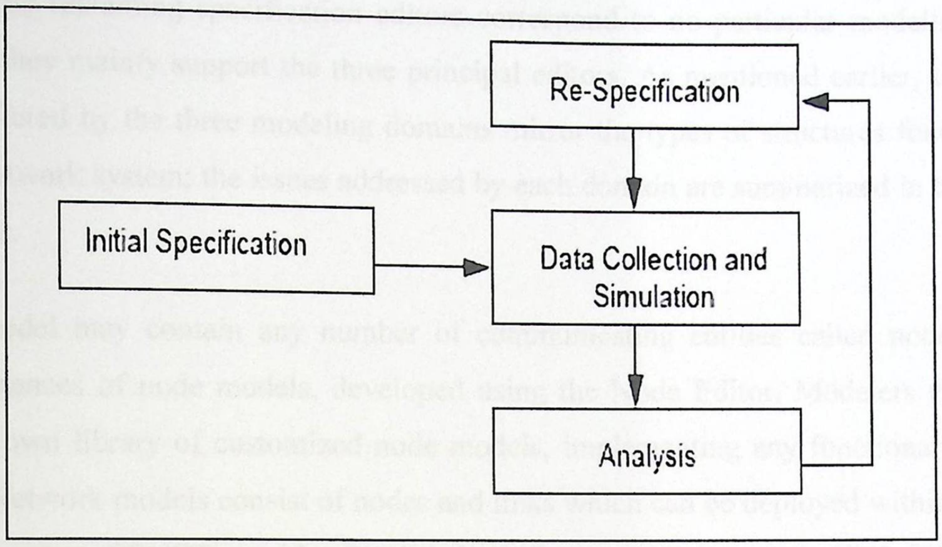


Figure 2.15:Simulation Project Cycle in OPNET

2.5.3 Model Specification

Model specification is the task of developing a representation of the system that is to be studied. OPNET supports the concept of model reuse so that most models are based on lower level models developed beforehand and stored in model libraries. Ultimately, however all models are based on the basic concepts and primitive building blocks supplied by the OPNET environment.

OPNET Models are structured hierarchically, in a manner that parallels real network systems. Specialized editors address issues at different levels of the hierarchy. This provides an intuitive modeling environment and also permits reuse of lower level models.

The Network, Node, and Process modeling environments are sometimes referred to as the modeling domains of OPNET, since they essentially span all the hierarchical levels of a model. The remaining specification editors correspond to no particular modeling domain since they mainly support the three principal editors. As mentioned earlier, the capabilities offered by the three modeling domains mirror the types of structures found in an actual network system; the issues addressed by each domain are summarized in the following table.

A network model may contain any number of communicating entities called nodes. Nodes are instances of node models, developed using the Node Editor. Modelers can develop their own library of customized node models, implementing any functionality they require. Network models consist of nodes and links which can be deployed within a geographical context. OPNET provides fixed nodes and point-to-point and bus links[7].

Table 2.1: OPNET modeling domains.

OPNET Modeling Domains		
Domain	Editor	Modeling Focus
Network	Project	Network topology described in terms of subnetworks, nodes, links, and geographical context.
Node	Node	Node internal architecture described in terms of functional elements and data flow between them.
Process	Process	Behavior of processes (protocols, algorithms, applications), specified using finite state machines and extended high-level language.

Node models consist of modules and connections. Modules are information sources, sinks, and processors. Some modules have predefined behavior; processor and queue modules are programmable via their "process model". Connections (packet streams and statistic wires) allow information to flow between modules.

Process models define behavior for programmable modules. A process is an instance of a process model and operates within one module. Initially, each programmable module contains only one process; however, processes can create additional child processes dynamically.These can in turn create additional processes themselves. This paradigm is well-suited to modeling systems with dynamically instantiated contexts, like certain protocols, or multi-tasking operating systems.

Processes respond to interrupts, which indicate that events of interest have occurred such as the arrival of a message or the expiration of a timer. When a process is interrupted, it takes actions in response and then blocks, awaiting a new interrupt. It may also invoke another process; its execution is suspended until the invoked process blocks. Process models are expressed in Proto-C, a language combining graphical state-transition-diagrams, embedded C/C++ language data items and statements, and a library of Kernel Procedures that provide commonly needed functionality for modeling communications and information processing systems. Objects are the building blocks of OPNET models and appear in each of the modeling domains. Some objects are created explicitly by the user; others are implicitly created by OPNET. During a simulation, certain types of objects can be created dynamically. OPNET objects have behavior and structure that is specified by a model.

Models also specify part or all of an object's interfaces. Some objects have implicit models that cannot be changed; others can be assigned models via their "model" attribute, allowing extensive customization. Models can be parameterized using model attributes. This mechanism provides users of the model with a means of control over some aspect of model behavior without requiring changes to the model internals. Model attributes generalize a model, making it more reusable for diverse applications[7].

2.6 Automatic Meter Reading

2.6.1 Kilowatt-hour meters

Kilowatt-hour meter is a device that used to measure the number of kilowatt power used by load in a unit of time ,kilowatt hour meter may be used for three phase or single phase reading. There are two types of kilowatt-hour meter using for measuring power:

- Analog Kilowatt Hour Meter.
- Electronic Digital Kilowatt Hour Meter.

2.6.1.1 Analog kilowatt Hour Meter

This kind of kilowatt hour meter has a mechanical counting system that counts the revolutions of an aluminum disk and in turn, displays the kilowatts of energy used, Figure 2.16 [10] .The ratio of kilowatts displayed to the turns of the disk is called the disk constant, and this constant is different from one meter to other depending on the rotating disk.

Figure 2.16: Analog Kilowatt Meter

2.6.1.2 Electronic Digital kilowatt Hour Meter

The digital meters determine power by directly multiplying the current by the potential difference and record this result over time to obtain a value for energy used. There are a few advantages of using a digital meter over an analog meter. The primary reason is the fact that digital meters do not have moving parts. This reduces the error due to mechanical parts wearing out after time. Also a digital meter is more accurate; most digital meters have an error of 0.8%. While the error of a standard, analog meter is about 2%. Some digital meters are designed using large scale integration circuits (LSI). An LSI uses a digital voltmeter and an ammeter to measure the instantaneous potential difference and current. Then it is capable of converting the values into digital code. After that, it performs the necessary multiplication to obtain the wattage used and records the amount in a memory.

Another advantage in the digital kilowatt-hour meter is the ability to transmit the current readings to a remote observer. With this capability, the power company can effectively monitor all the meters from a central location instead of physically looking at each meter individually. Even though the newer, digital meters are more reliable they are still not widely used.

2.6.2 Traditional Meter Reading Methods

Meter Reading and Billing are among the most time consuming functions performed in utilities. These functions have a major influence on the utilities cost, efficiency, productivity, structure and cash flow as well. Solutions based on recording readings manually, then entering it into a central billing system are time consuming, prone to errors and delays in delivering bills to customers with negative effect on cash flow.
There are many methods involved in the meter reading process; this includes traditional manual methods up to fully automatic meter reading systems:

- **Traditional Systems**
  - Read by walk: Once by 2 months or by one year. Where a group of persons collect the meter reading by traveling from one customer location to another.
  - Read by customer: where customers will be responsible for reading the meter readings and submitting it to the company phone or when they pay the previous bills.

It should be clear that such methods are very time consuming and does not satisfy the business requirements for the power company, in addition to the large number of errors incorporated in the reading process.

- Hand-Held units for meter reading and billing system: speed, accuracy, and cost effectiveness are the strongest features in this System. In addition of providing a solution that is able to deal with a current billing system which exists or to be integrated with the lunched system; therefore the presented solution is able to provide a middle-tier program that works as translator between any billing system and the HHU. The delay between reading the meter and delivering the bill to customers is reduced to zero.

- Prepaid AMR: Where each meter has a smart card reader and the meter will be on as long as the smart card has credit. Customers can take the card when they leave their houses. They can also buy new cards when they consume the credit of the card, hence the idea of pay as you use is applied. This is very similar to prepaid telephone systems.

The following may summarize the most features in such technology:

- Ability to work offline when there is limited service.
- Save time both while performing meter reading and data entry.
- Ability to handle complex and high number of readings.
- Fast retrieve of the customer information.
- On line calculation and printing of bills, receive payments and printing payment vouchers.
- still needs traveling man reader.

2.6.3 AMR Systems components

In general, AMR systems have three major components:

1. The meter interface unit (MIU).
2. Communication system.
3. Central office system.

The meter interface unit (MIU) collects data from the meter, controls electronics and manages communications. The communication interface allows two-way data transfer. If needed, the MIU might share capacity among different types of demand reading (electricity, gas, or water). The MIU takes the readings from meter dials and transform them into digital format. The communication system is responsible for data transmission between central office and MIU. The options for data transmission are telephone networks, fiber, wireless and power line. Unfortunately, there is no best option for setting up the communication system.

The third component is the equipment required for the central office systems which requires modems, receivers and data concentrators, controllers, host upload links, and hosts (servers, routers and personal computers). Their function is to assist the central billing computer and other data or clients in providing the data they need from the installed user base. [8]

2.6.4 Communication Technology In AMR Network

There are many different forms of network communication technologies that can be utilized as the communication medium in an AMR (automatic meter reading) accordingly, these technologies can be incorporated in AMR systems in both LAN and WAN scales.

For the AMR LANs, it is necessary to connect power or energy meters inside each building or neighbor buildings together so as they can communicate to each other or to the central facility through the incorporated WAN technologies.

For the WAN part, the most common technology options for providing broadband services for AMR networking includes: xDSL, Cable Modem, Fiber-to-the-Home, Free Wireless, Satellite, and broadband over power lines (PL).

In this project will model and simulate different technologies, this includes local area network technologies, wireless,. And show the result and observed the suggestions of how to use these technologies in the power metering systems modeling with better performance.

CHAPTER THREE: SIMULATION DESIGN

3.1 Introduction

This project is divided into two parts:

First is to simulate part of the PPU network using OPNET simulator. The second part is to design and simulate different scenario for automatic power meter system to see more information about what we did in the first see appendix [1].

3.2 Objectives

The first semester:

1. Study the features of networking and the environment of OPNET simulation
2. Modeling the Palestine polytechnic university(PPU, Wadi Al-Hareih) netwok using the OPNET modeling tools and simulation .
3. Study the performance ,bandwidth, efficiency parameter of PPU network

The second semester:

1. study the Power meter systems
2. Studying the idea of power meter networks using different technologies and the suggestions of how to use these technologies in the power metering systems.
3. Modeling of the Power meter system using the OPNET modeling tools and simulation. and study of the bandwidth (utilization), throughput and delay parameters of the Power metering networks.

3.3 General Processes Of Project

- process for steps of simulation any network:

First we create a network model, choose statistics to collect from each network object or from the whole network, execute a simulation, and view results.

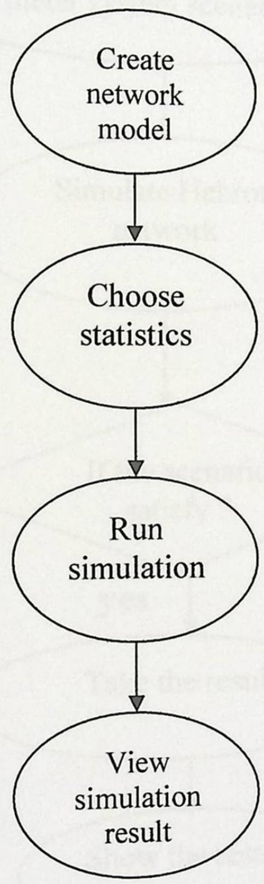


Figure 3.1: Processes For Steps Of Simulation.

- Process for Automatic Meter Reading

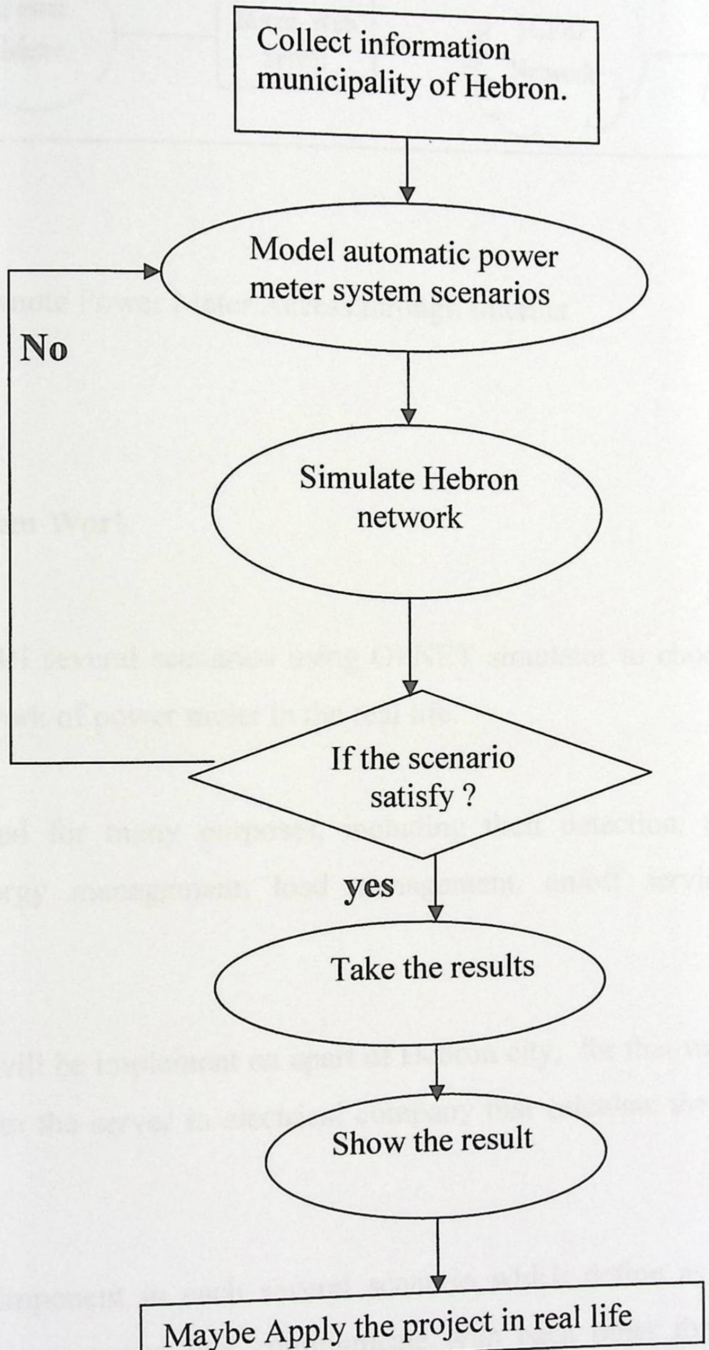


Figure3.2: Process For Power Meter Reader Simulation

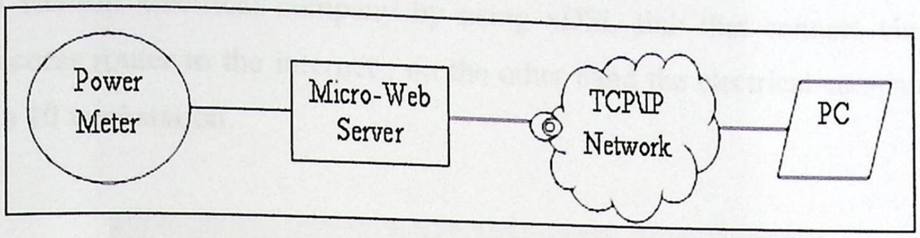


Figure 3.3: Remote Power Meter Access through Internet

3.4 How System Work

We model several scenarios using OPNET simulator to choose the best way for build the network of power meter in the real life.

AMR are used for many purposes, including theft detection, outage management, customer energy management, load management, on/off services, and distributed automation.

This method will be implement on apart of Hebron city, for that we suppose each AMR send reading to the server in electrical company that calculate the bill and resend it to customer

Two main component in each several scenario which define as part of Hebron and Hebron electric company that communicate with each other through the internet as shown in the figure 3.4 , inside part of Hebron there are many region that contain number of power meter, all power meters send reading using FTP or email to the server reside in Hebron electrical company by using xDSL link that connect via DSLAM through access router to the internet , on the other hand the electrical company contain LAN with 10 workstation.

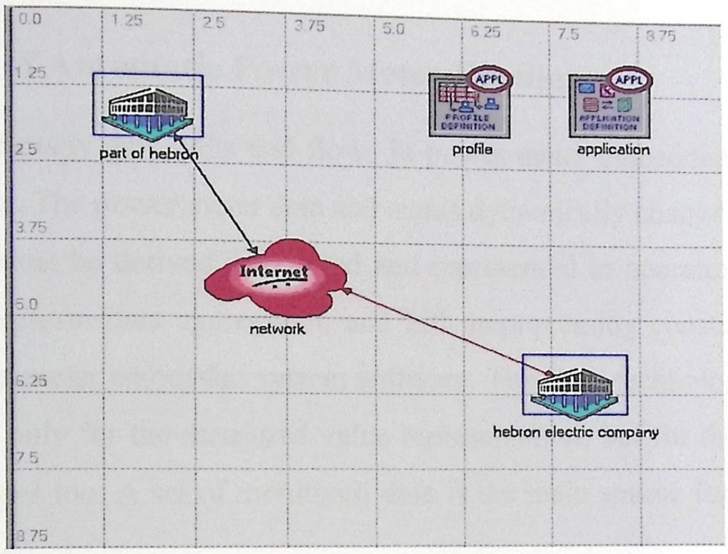


Figure 3.4:Modeling Part Of Hebron And Hebron Company Via Internet .

CHAPTER FOUR: DETAILED SYSTEM DESIGN

4.1 Modeling of Automatic Power Meter Reading

There are many data units and flows in power meter embedded systems and its controlled objects. The power meter data and status dynamically change in time. A set of monitored data must be derived, processed and represented to operators and or clients. Processes that perform data aggregation and bill preprocessing constitute an essential part of the power meter embedded system software. The Web technology offers unified mechanisms not only for the measured value representation, but for the control of data capturing processes too. A set of monitored data is the main source for embedded Web server.

Accordingly and as far as we are concerned in power meter with embedded controller modeling, and since the OPNET does not have a special model for this component a new model should be built to model the processes incorporated in this components. However and since the Micro web-server can be modeled as a normal web server with limited functionality we have used a modified version of the normal server model. in this model we use a Micro web-server in designing a power meter reader to facilitate the Automatic Meter reading process as shown in figure 4.1.

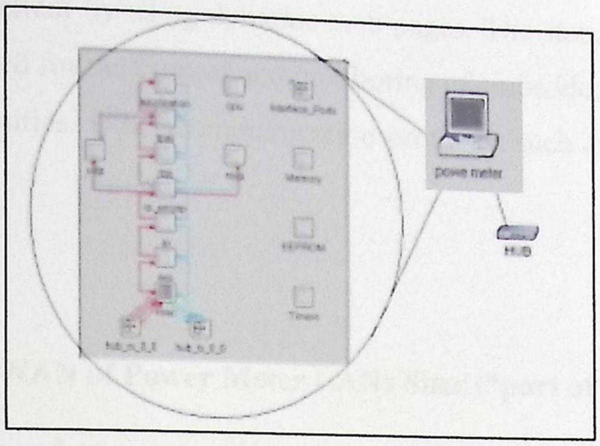


Figure 4.1: Modeling the Power Meter

In the previous figure, the right part models the components of a traditional microcontroller with interface to the power meter ports that are dealing with the real electric power measurements, the left part represents the networking part of the model which represents the TCP/IP connectivity and activity that are inherited in each process node. Hence the model can behave as a Web, Mail, or FTP server that are capable to serve requests from other clients. This makes it easy to let each power meter communicate with the central facility and or other meters on the same building.

4.2 Network Of Power Metering Systems

Nowadays one of the most popular and general technologies for information resources access and information representation is the World Wide Web technology (Web technology) which is widespread in the global computer network Internet. The main characteristics of the Web technology are: client stations platform independence, using HTTP and HTML or JAVA and ASP [1,2], server part low expenses on data granting. The Web-technology allows not only to represent information, but to carry out interaction with the client by using dynamic web pages. The standard methods of Web-navigation can be used for the control and monitoring of embedded power meter systems and its controlled entities. Other communication protocols such as FTP and E-Mail can also be used as well.

4.2.1 Modeling the WAN of Power Meter LANs Sites ("part of Hebron, region")

The networking and communication system is responsible for data access between different MIU's with the Hebron electrical company. Different networking methods for data transmission are used; this includes telephone lines, LANs, fiber, wireless and power line. And we use in our project to connect region with each other to electrical company by using WAN and wireless technology .

In our project we use the xDSL model to route and connect the IP packets from each "hara" to DSLAM that is connected to an access router, The access router is connected to and internet that is a medium of communication with Hebron electrical company to allow the power meter send readings they are collect, It should be noted that the communication between the xDSL and the DSLAM are handled using a down-stream and up-stream channels with different bandwidths. The used up and down stream bandwidths for this example is adjusted to 64 kbps. Also each DSLAM can connect up to 32 or 64 xDSL modems. Figure 4.2 shows the network for 20 "regions" connected to a single DSLAM modem. Only 2 of them are utilized in the simulation because of RAM limitations.

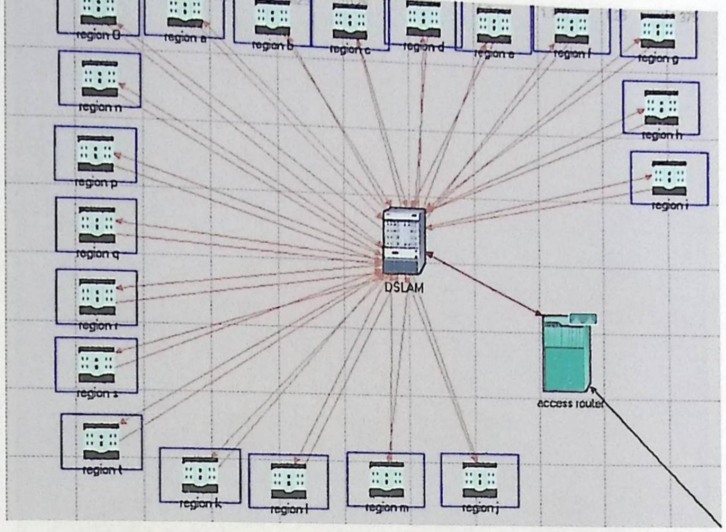


Figure 4.2: Modeling the 20 region connecting to DSLAM

The bandwidth of the access line used to connect the DSLAM and the access router is used as a leased line with DS0 bandwidth (64 kbps). The access Router has up to 16 ports and can connect up to 16 DSLAMs. Figure 4.3 shows the first level of the whole network which connects the facilities in each part of Hebron (20 part), However and because of the large network and huge memory requirements only one part of the network is really considered in the simulation process. The other part of the network is modeled to be the Hebron electric company which has all the IT facilities to collect, process, and manage all the meters in the grid. Assumingly each meter is polled to send its data to the electric company. FTP and E-mail protocols can be used to send this data.

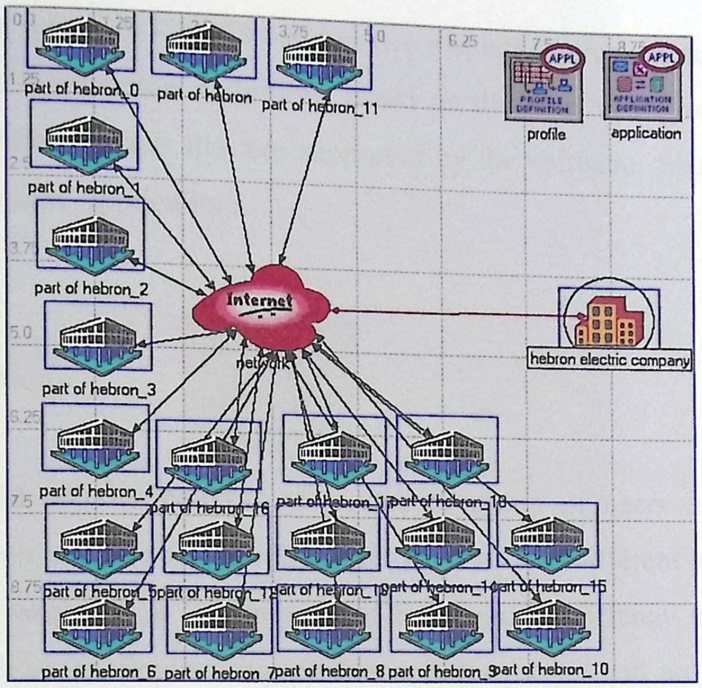


Figure 4.3: Modeling all part of Hebron connecting to the internet

4.2.2 Model Component

4.2.2.1 Main Component

In this project we have used different main components which illustrate below:

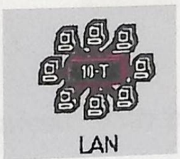
1. Application Configuration : 

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. You can also create application definitions based on different workgroups. There are two types of application models that are supported by the software: Standard Network Applications and custom Applications.

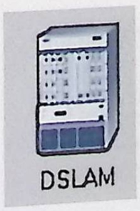
2. Profile Configuration

Profiles describe the activity patterns of a user or group of users in terms of the applications used over a period of time. You can have several different profiles running 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 to depict typical applications used for each employee group.

3. 10BaseT_LAN: use 10BaseT_LAN object to represent an Ethernet LAN in a switched topology. The object contains any number of clients as well as one server. Client traffic can be directed to the internal server as well's external servers.Supported applications include: FTP ,Email, Database, HTTP etc.

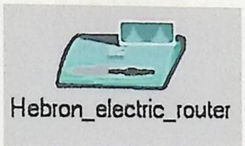


4. DSLAM : the DSLAM_fr1_ip32 model represents a DSLAM with 32 DSL or IP over DSL port sand a single frame relay uplink port.

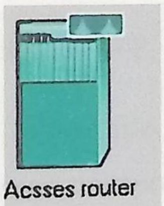


5. xDSL Modem: this device represents a typical client-side network termination device. It also represents IP over DSL.

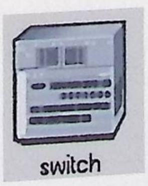
6. Hebrn_electric_router : use the CS_1601_e1_s2 model represents Cisco's solution for small-office and home-office data access. It houses one 10BaseT Ethernet port, one serial port, and room for one WAN interface card used one port in Ethernet technology



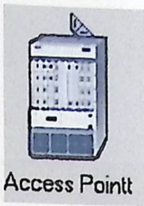
7. Acsses router: a typical use of this device is to route data between two ethernet LAN segments connection via an IP network.



8. Switch: Switches communicate with each other by sending Bridge Protocol Data Units (BPDU's). Packets are received and processed by the switch based on the current configuration of the spanning tree. The switch can only connect LAN's of the same type (Ethernet to Ethernet, FDDI to FDDI, or Token Ring to Token Ring).



9. Acess point: acting as a portal to wire line network



10. Wlan_wkstn: the wlan_wkstn node model represents a workstation with client-server applications running over TCP/IP and UDP/IP. The workstation supports one underlying WLAN connection at 1 Mbps, 2 Mbps, 5.5 Mbps, and 11 Mbps.

4.2.2.2 Application Description

The following applications are described: FTP, and E-mail.

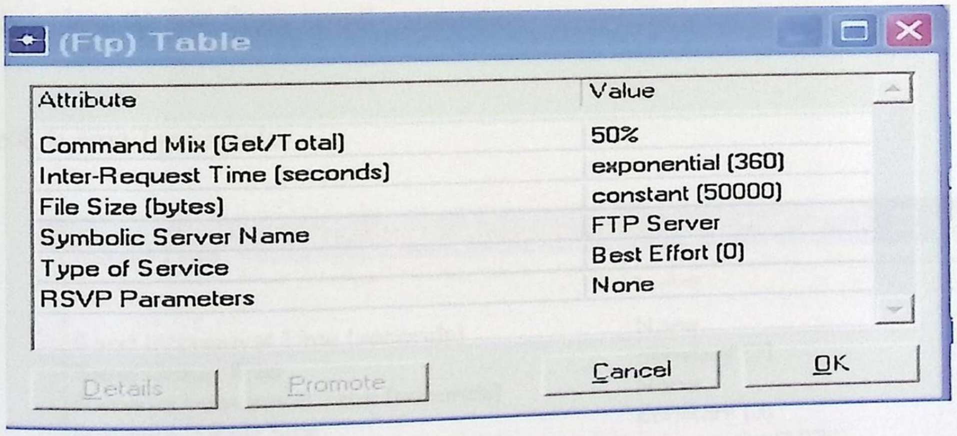
- **FTP:** An FTP application allows file transfers between a client and a server. For connection-oriented transport protocols, (*e.g.* TCP), Some of the important FTP attributes are described in the table below:

Table 4.1: important FTP attributes

Attribute	Description
Command Mix (get/total)	Ratio of "*get*" (download) to the total number of commands (sum of "gets" and "puts").
Inter-Request Time (seconds)	Time between subsequent file requests.
File Size (bytes)	Average size of a file being transferred.
Symbolic Server Name	Symbolic name of the file server to which the client connects
Type of Service	Quality-of-service parameter for assigning priority to this application's traffic.
RSVP Parameters	RSVP parameters for making bandwidth reservations.

In our project we have used these FTP parameters

Table 4.2: FTP parameter



(Ftp) Table

Attribute	Value
Command Mix (Get/Total)	50%
Inter-Request Time (seconds)	exponential (360)
File Size (bytes)	constant (50000)
Symbolic Server Name	FTP Server
Type of Service	Best Effort (0)
RSVP Parameters	None

- **E-mail:** The default transport protocol used in the e-mail application provided with the software is TCP, i.e., messages are sent and received using TCP. Modern e-mail packages use a combination of SMTP (Simple Mail

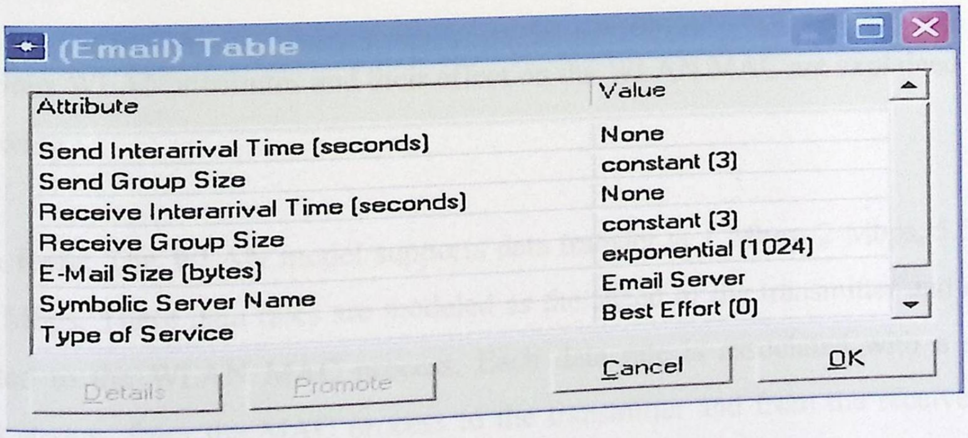
Transfer Protocol) and POP (Post Office Protocol). Some of the important e-mail attributes are described in the table below.

Table 4.3: important e-mail attributes

Attribute	Description
Send Interarrival Time (seconds)	Time between emails sent from the client to the server.
Send Group Size	Number of email messages grouped before transmission.
Receive Interarrival Time (seconds)	Time between emails received from the server at the client.
Receive Group Size	Number of email messages grouped before reception.
Symbolic Server Name	Symbolic name of the server to which the client connects.
E-mail Size (bytes)	Average size of an e-mail message.

In our project we use these email parameter:

Table 4.4: email parameter



4.2.2.3 WLAN Parameters

The WLAN related configurable parameters available as part of the simulation model suite. Note that there are two types of attributes: model attributes, which have local significance on nodes, and simulation attributes, which are applicable across all nodes in the network. Each wireless node has the same set of wireless LAN attributes. These attributes are grouped under Wireless LAN Parameters. There is also a Wireless LAN MAC Address parameter which is an internal station address and is usually set as auto assigned unless specific configuration is required. Figure 4.5 show the global parameters for the MAC layer in the stations.

Table 4.5: wireless LAN parameter

Attribute	Value
Data Rates	1 Mbps
buffer size	256000 bits
RTS threshold(bytes)	None
Fragmentation threshold	None

The various WLAN attributes and their effect on the WLAN MAC are explained as following :

1. Data Rate: The WLAN model supports data transfer at 1 Mbps, 2 Mbps, 5.5 Mbps, and 11 Mbps. These data rates are modeled as the speed of the transmitter and receiver connected to the WLAN MAC process. Each data rate is associated with a separate channel stream, from the MAC process to the transmitter and from the receiver to the MAC process. A station can only transmit data packets at the data rate specified by the attribute. However, it can receive data at any data rate. Finally, all control packets are transmitted at a data rate of 1 Mbps as specified by the standard.

2. Buffer size: specifies the maximum size of the higer layer data buffer in bits. Once the buffer limit is reached ,the data packet arrived from higer layer will be discard until some packets are removed from the buffer so that the buffer has some free space to store these new packets.

3. Rts Threshold: Specifies a threshold to determine whether or not Rts/Cts frame exchange is required for a particular data frame. If the MAC service data unit (MSDU), Received from higher layers in the protocol stack, has a size greater than the Rts threshold then Rts/Cts exchange is needed for media reservation. The default Wireless LAN Model value for this attribute is NONE which means that no Rts/Cts exchange will take place regardless of the MSDU size.

4. Fragmentation Threshold: Specifies a threshold to decide if a MSDU received from the higher layer needs fragmentation before transmission. The number of fragments to be transmitted is calculated based on the MSDU size and the fragmentation threshold. The default value for this attribute is NONE which means that fragmentation will not take place regardless of the MSDU size.

CHAPTER FIVE: SIMULATION AND TESTING

5.1 Introduction

In this project we have simulated The KWHR meters for parts of Hebron city by using OPNET simulator and we have done different scenarios to examine performance, bandwidth, utilization, queuing delay and throughput for these scenarios During simulation we are interested in measuring the following parameters :

- **Utilization (%)**: represents the percentage of the consumption to date of an available channel bandwidth, where a value of 100.0 would indicate full usage.

- **Throughput (packet/sec)**: represents the average number of packets successful received or transmitted by the receiver or transmitter channel per second.

- **Queuing delay (sec)**: 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.

Here we describe some types of links used in our scenarios

1. **xDSL link**

The xDSL ADV is the base link model for all xDSL links. It supports all packet formats and will post a warning to the Simulation Log if the length of the link is over

3000 meters, and the maximum data rate is 7Mbps but we choose 1Mbps in all these scenarios.

2. PPP_DS0

Connects two nodes running IP with data rate 64 k bps.

3. PPP _adv

The PPP_adv point-to-point link connects two nodes with serial interfaces (e.g., routers with PPP ports) at a selectable data rate (e.g., DS0, DS1, DS3, T1, T3, OC3, OC12, OC36, OC48), and the default data rate is 64 Kbps.

4. PPP_DS1

Connects two nodes running IP with data rate 1.544Mbps

5.1.1 The following figures show the different parts of our system

Figure 5.1 show the model for part of Hebron of one region and how to connect part of Hebron through internet with PPP_ DS0 cable to Hebron electric company through PPP _DS1, with profile and application configuration. The supported profiles for this model are "send reading pro." and "send by email" and application configuration supported "sending reading app." and "sending email" respectively.

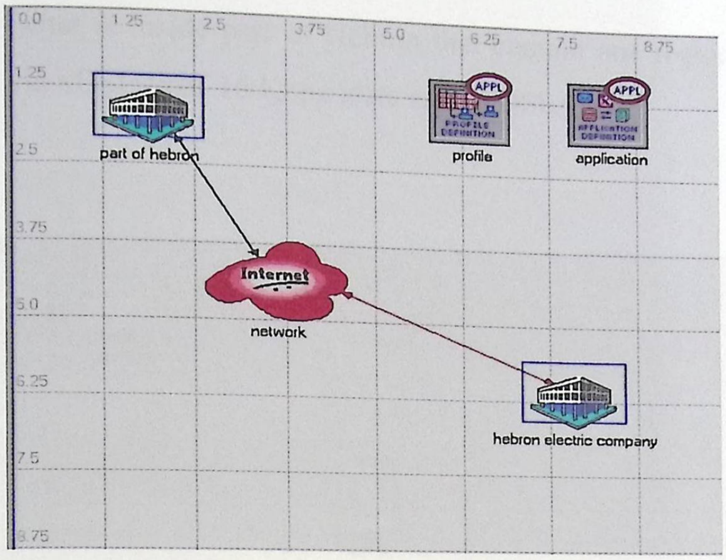


Figure 5.1: modeling one region

Figure 5.2 show what is inside Hebron electric company and how to connect LAN that contain 10 workstations inside it through router.

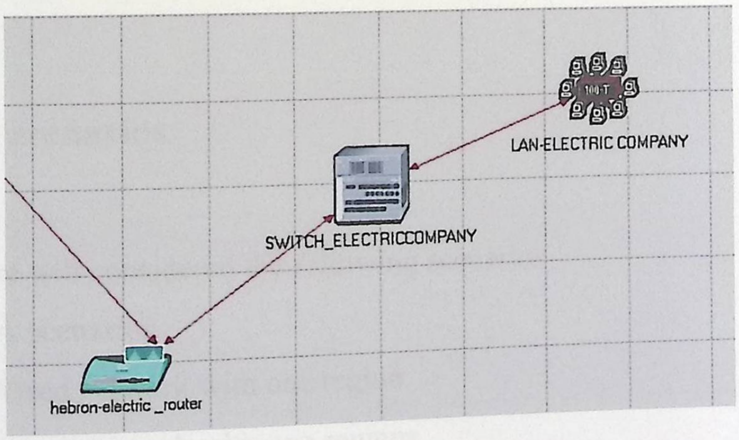


Figure 5.2: modeling the electrical company.

Figure 5.3 show what is inside part of Hebron that contain one region with 23 power meter connected via xDSL link(16 Kbps)data rate to DSLAM.

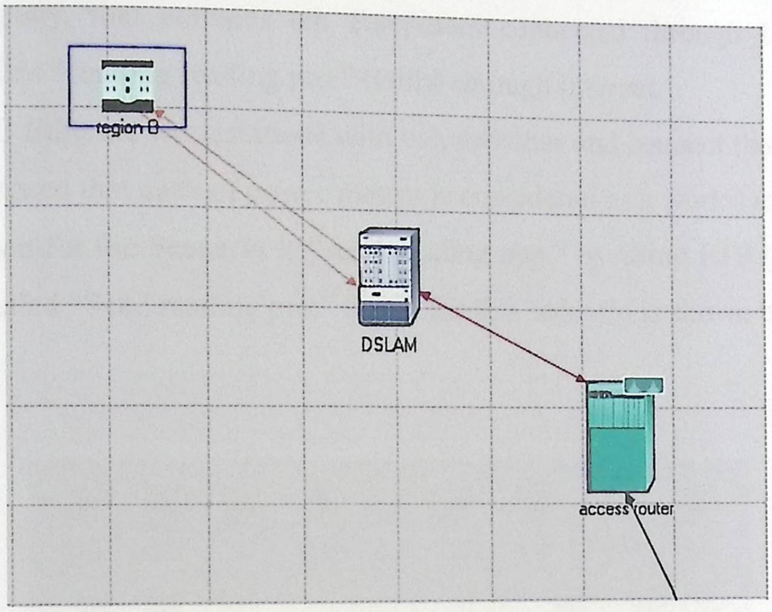


Figure 5.3: connecting the region with DSLAM

5.2 Modeling scenarios

In this section we will considered the following scenarios

1. Wired network scenarios
    - Wired network with one region.
    - Wired network with two regions.
2. Wireless network scenarios
    - Wireless network with one region.
    - Wireless network with two regions.

5.2.1 Wired network with one region

At this scenario we've connected only one region using wire connection through xDSL link (16 Kbps) upstream downstream which is connected with The Hebron electrical company, that contains ten computers connected through LAN and they supported profiles "sending reading pro." (Bills) through internet.

- Connecting 23 Ethernet work stations with two switches and connect them to DSLAM.
- We have supposed that each of power meters is considered as a workstation.
- The application for the Scenario is "send reading app." by using FTP (high load) and the profile is called "Send reading pro." figure for this scenario is shown below.

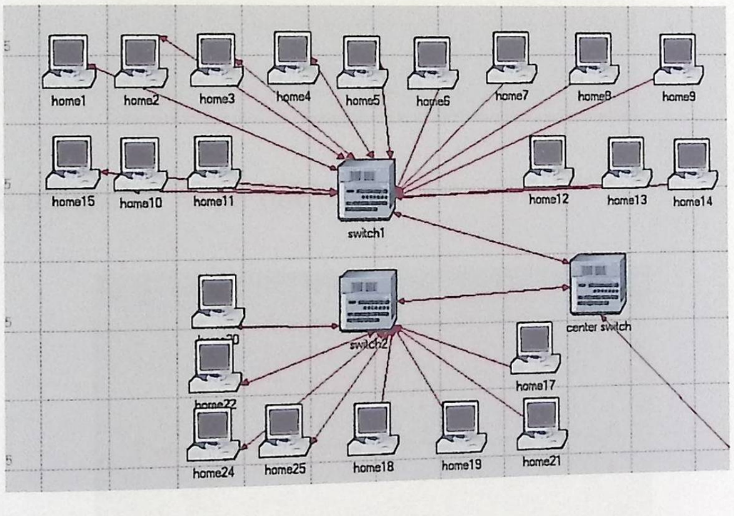


Figure 5.4: modeling 23 power meters inside region (O).

Simulation results for this scenario are:

In figures 5.5, 5.6 and 5.7 shows the results of xDSL link with data (16Kbps) that connect the region in each part of Hebron via DSLAM with the access router.

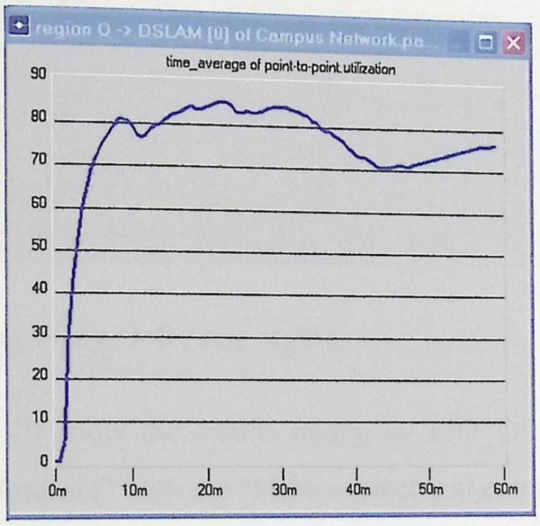


Figure 5.5: xDSL utilization → for one region

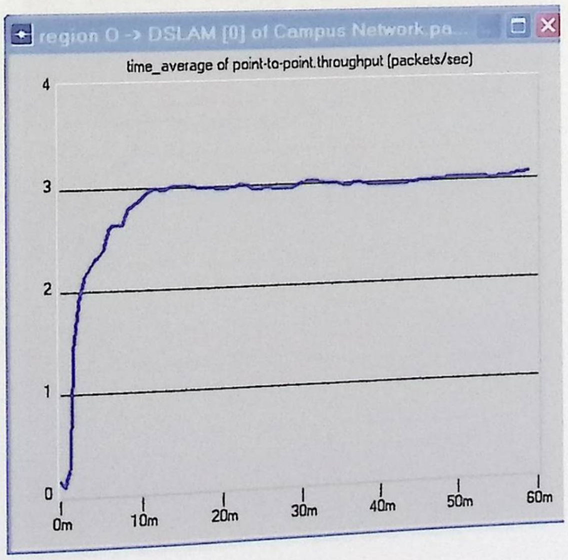


Figure 5.6: xDSL throughput → for one region.

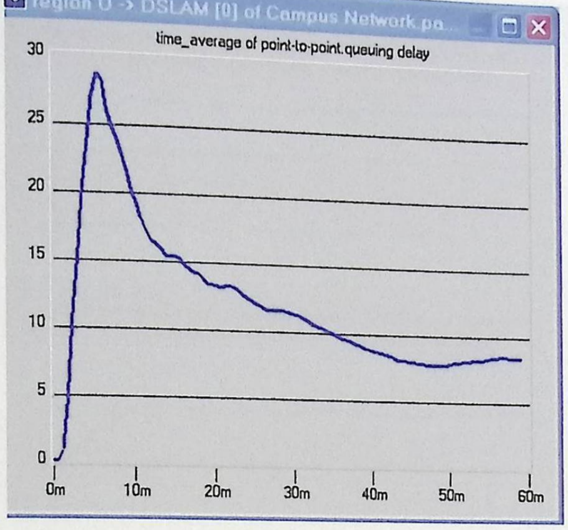


Figure 5.7:xDSL queuing delay → for one region.

In figure 5.8,5.9 and 5.10 show the results taking on PPP_DS1 with data rate (1.544 Mbps) which connect "Internet" with the "Hebron electrical company".

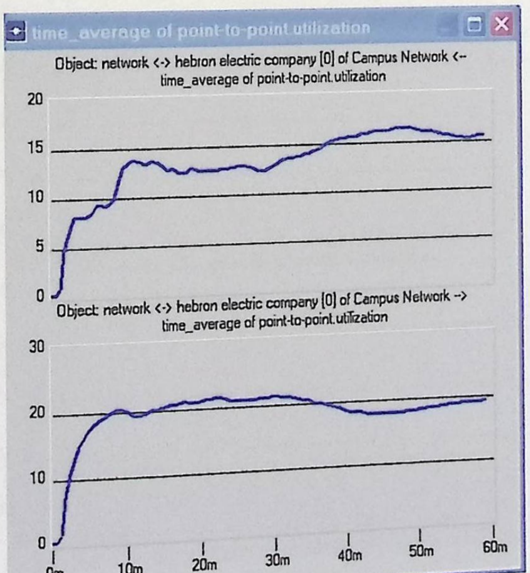


Figure 5.8: PPP_DS1 utilization → &← for one region.

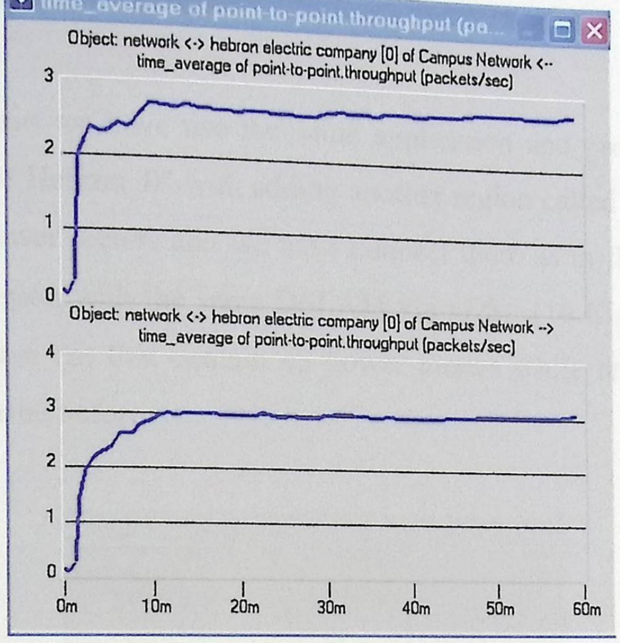


Figure 5.9: PPP_DS1 throughput (packet/sec)→ &← for one region

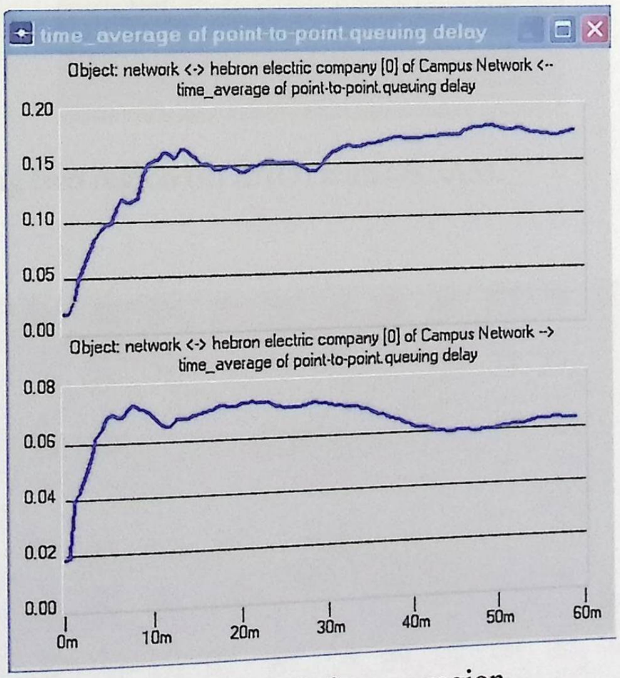


Figure 5.10: PPP_DS1 queuing delay→&← for one region.

5.2.2 Wired network with two region

In this scenario we have use the same application and profile as the previous scenarios in "part of Hebron_0" with adding another region called "region N " and this region contain 43 power meters and we have connect them as in figure 5.10 that show modeling the two region with the same DSLAM via xDSL (16 Kbps) link, figure 5.11 show inside the region (n) that contain 43 power meters while region (O) contain 23 power meter as describe before.

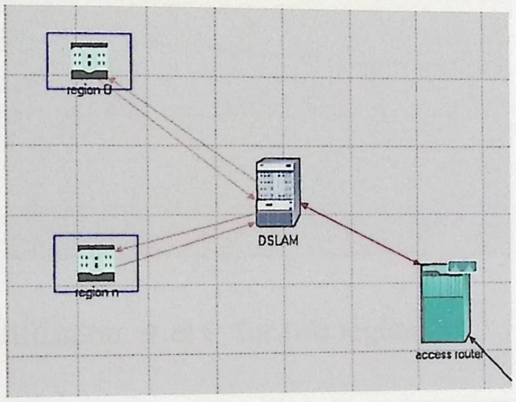


Figure 5.11: Modeling two region (n) & (O) with DSLAM.

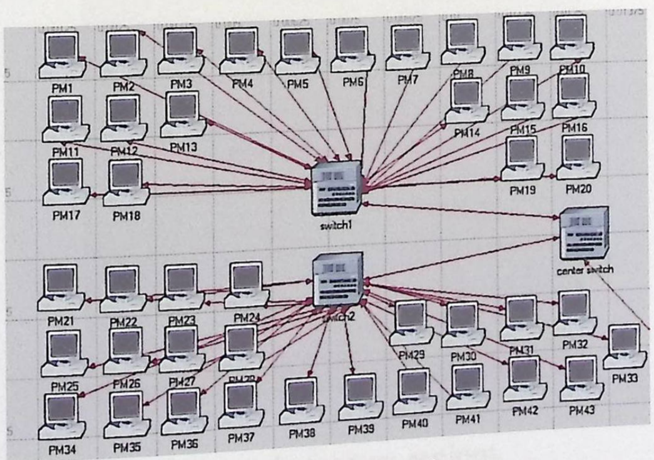


Figure 5.12: modeling 43 power meters in region (n).

Simulation results for PPP_DS1link that join sites ("part of Hebron with two regions") with data rate (1.544 Mbps) that connect "internet" with "Hebron electrical company" shown in figures 5.12, 5.13 and 5.14 respectively.

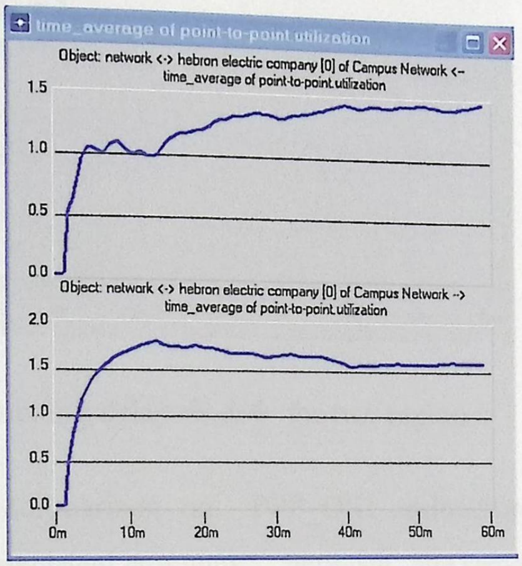


Figure 5.13: PPP_DS1 utilization → &← for two regions

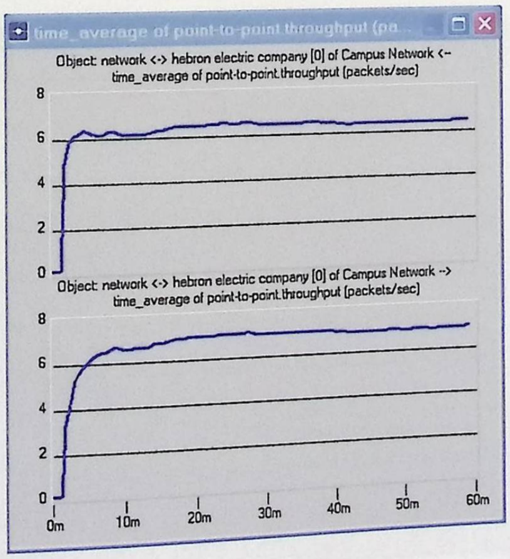


Figure 5.14: PPP_DS1 throughput→&← for two regions.

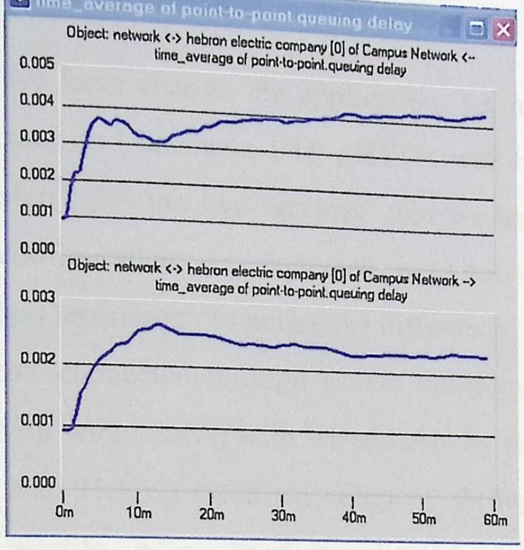


Figure 5.15: PPP_DS1 queuing delay → &← for two regions.

Figure 5.16 show the comparison on PPP_DS1 utilization that connect between "internet" and "Hebron electrical company" between one region and two region wired network and we observed that utilization is higher in two region than one region .

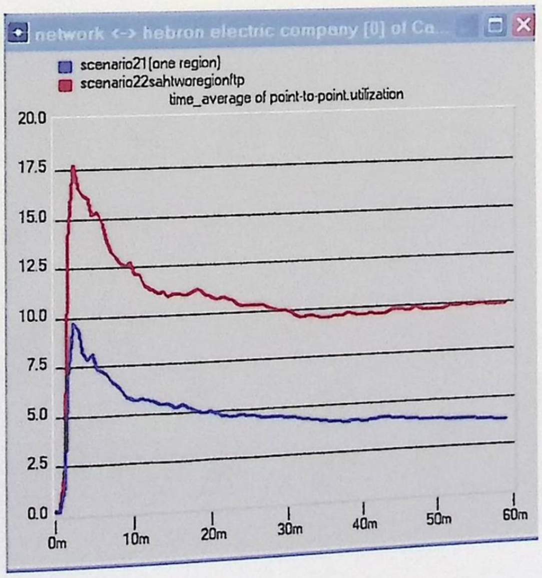


Figure 5.16:PPP _DS1 utilization → between one and two region wired.

5.2.3 Wireless network with one region

In this scenario we have change the application, set it to default which mean support all applications such as (database, FTP , HTTP, web browsing and Email) and we determine file transfer(light) the two services that we have deal with, which are specified in the profile configuration, we connected only one region by connecting the power meter using wireless technology to notice the difference with wired power meters ,the wireless power meter connected through access point (which act as a relay and connect wireless LAN with wired LAN) with wired LAN by using xDSL upstream and downstream connected with Hebron electrical company through internet that support email and file transfer profile. After statistics collected on PPP_ DS0 that connect between part of Hebron and internet, PPP _DS1 that connect between internet and Hebron electric company and xDSL that connect region with DSLAM , after run the simulation we have obtained the results that will shown below, also in this scenario we have connected 23 wireless workstation with access point connect them to DSLAM we suppose here each power meter is workstation as shown below .

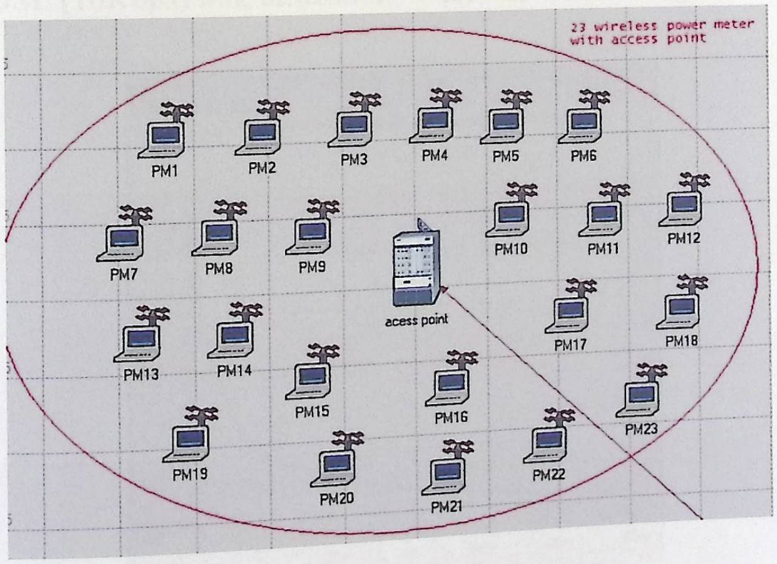


Figure5.17: Modeling 23 power meters wireless for one region.

Simulation results for this scenario (wireless with one regions) as shown below:

In figure 5.16, 5.17 and 5.18 show the results of parameters (utilization, throughput and queuing delay) on xDSL link with data rate (16 Kbps) which connect between "region" via DSLAM to the "internet".

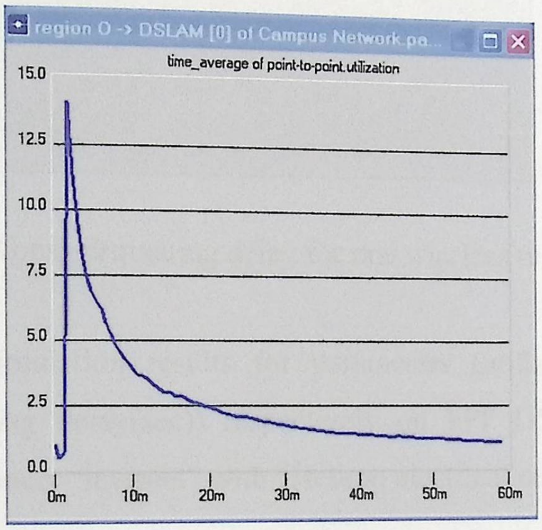


Figure 5.18: xDSL (16Kbps) link utilization → for one wireless region

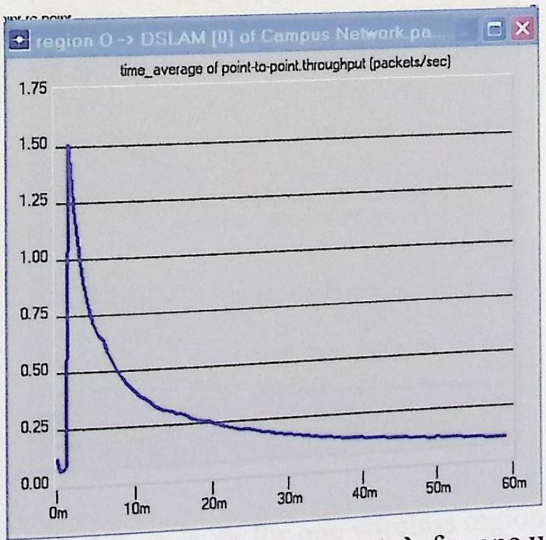


Figure 5.19: xDSL (16Kbps) throughput (packet/sec)→ for one wireless region

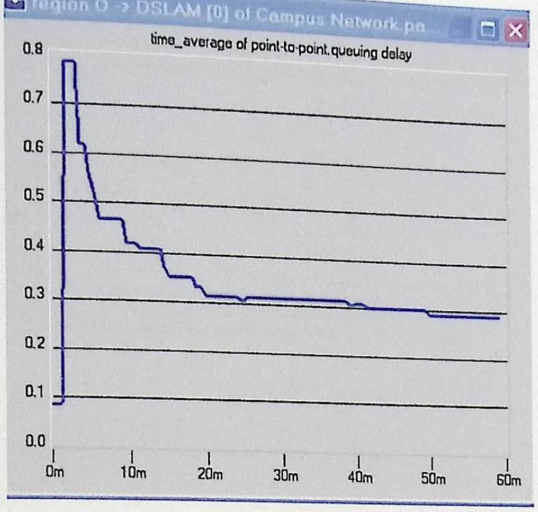


Figure 5.20: xDSL (16Kbps) →queuing delay for one wireless region.

Here we show the simulation results for parameters (utilization (%), throughput (packet/sec) and queuing delay(sec)) respectively on PPP_DS1 link with data rate (1.544Mbps) which connect "internet" with "Hebron electrical company".

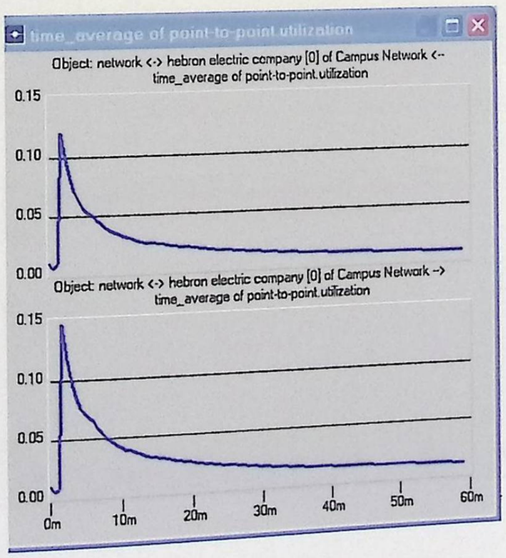


Figure 5.21: PPP_DS1 utilization→ & ← for one wireless region.

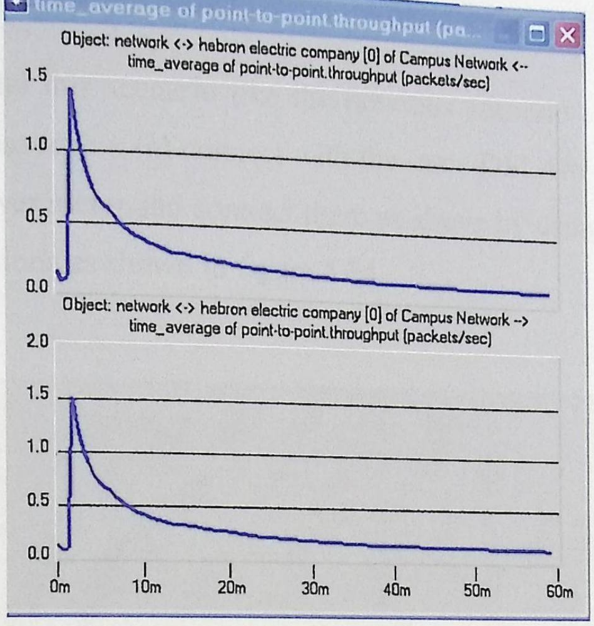


Figure 5.22: PPP_DS1 throughput (packet/sec)→&← for one wireless region.

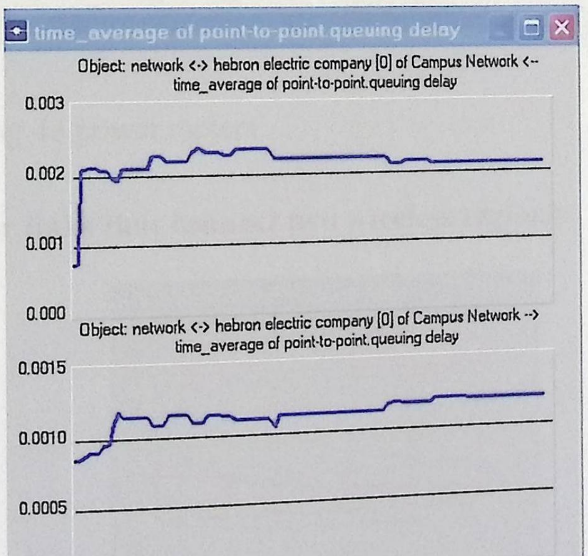


Figure 5.23: PPP_DS1 queuing delay → & ← for one wireless region.

5.2.4 Wireless network with two region

We have model this scenario like the previous scenario" part of hebron_1" by adding another wireless region (n) connect with the same DSLAM as region (O) and this region contain 43 power meter and connect them as above by using the same application and profile configurations as shown in figure 5.24.

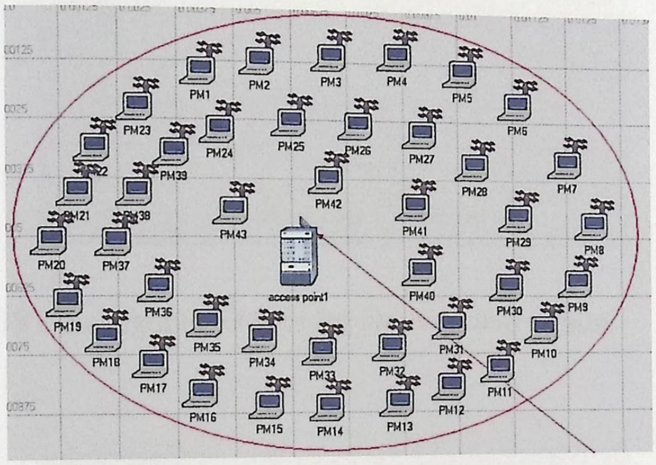


Figure 5.24: Modeling 43 power meters.

Simulation results for links that connect two wireless regions:

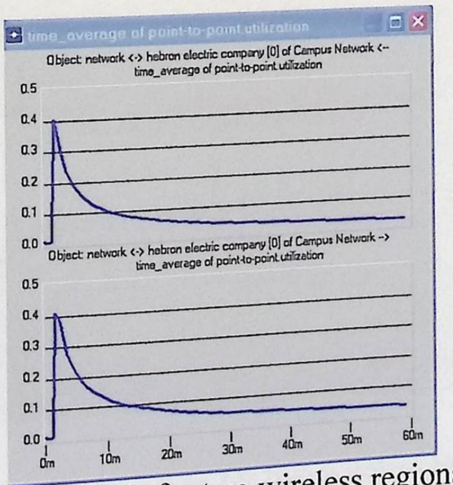


Figure 5.25: PPP_DS1 utilization→&← for two wireless regions

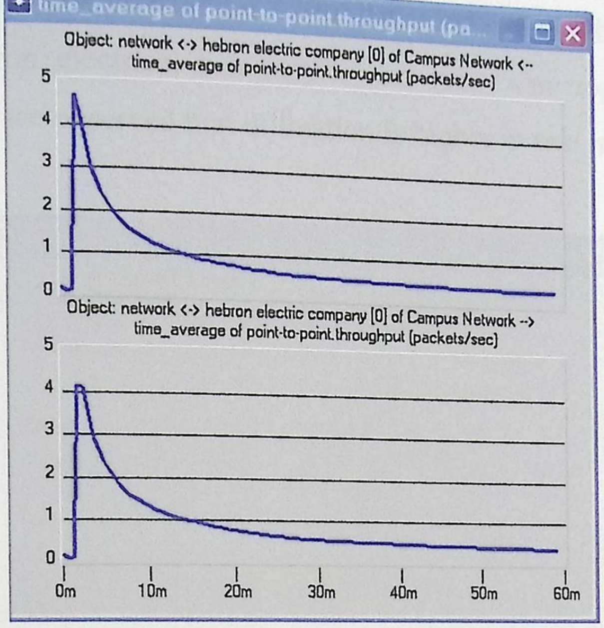


Figure 5.26: PPP_DS1 throughput →&← for two wireless region.

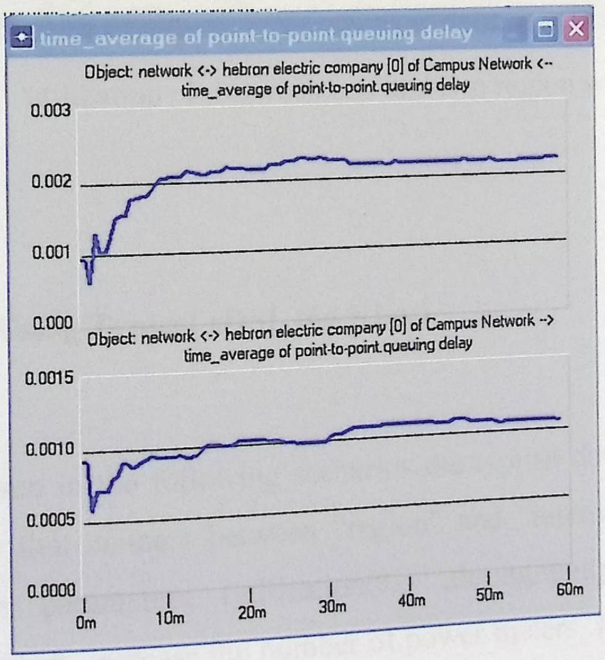


Figure 5.27: PPP_DS1 queuing delay →&← for two wireless region

Figure 5.28 show the comparison on PPP_DS1 utilization that connect between "internet" and "Hebron electrical company" between one region and two region wireless network and we observed that utilization is higher in two region than one region

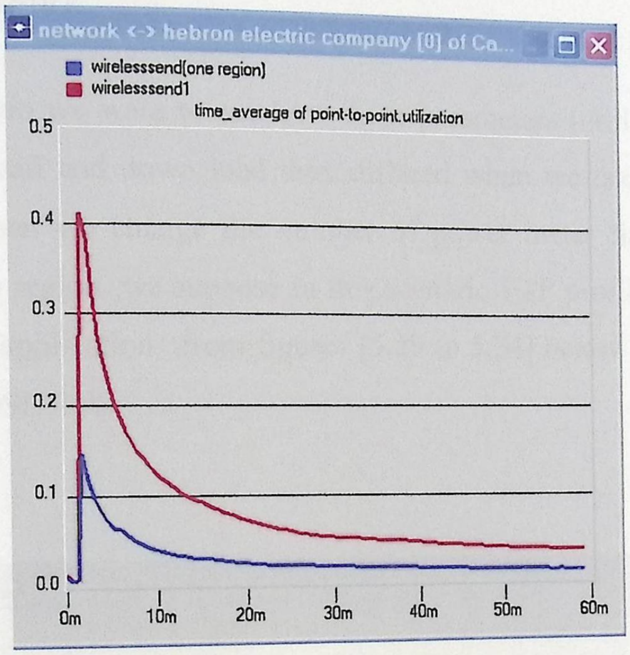


Figure 5.28: PPP_DS1 utilization → between one and two region wireless.

5.3 Model Scenario Using Typical xDSL (64 Kbps)

We have chosen in the following scenarios the typical data rate for xDSL link that equal (64 kbps) that connect between "region" and "internet" via DSLAM and compared how the parameters (utilization(%) ,throughput(packet/sec) ,queuing delay(sec)) various when increase the number of power meters .for example the delay, utilization and throughput are increase very clearly when increase the number of power meters so we must increase the xDSL data rate when number of power meter increase largely and this scenario was applied on wired and wireless network.

5.3.1 For wired network

In this scenario we want to see how these parameters (utilization, throughput , queuing delay) upload and down load they differed when we take the results on the same xDSL link when we change the number of power meter from one to hundred power meters in one region ,we suppose in this scenario FTP profile configuration that support file transfer application. ,from figures [5.29 to 5.34] below show the simulation results on typical xDSL link.

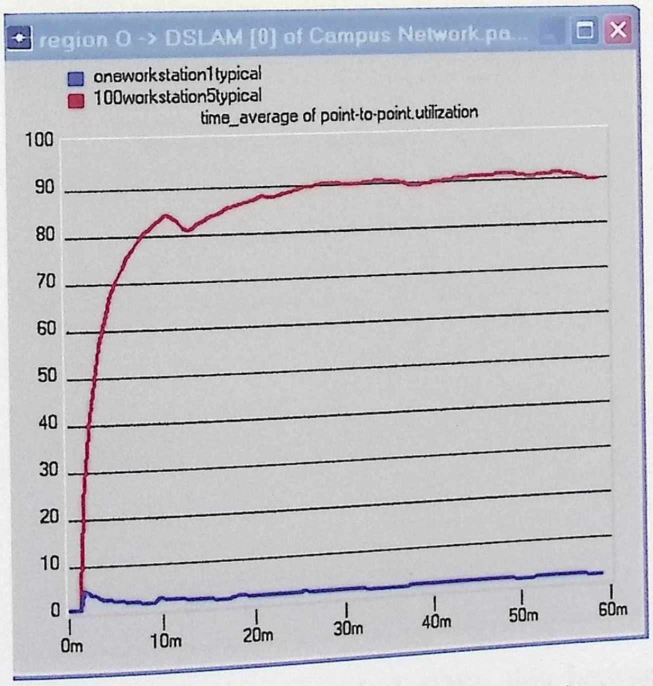


Figure 5.29: Compare utilization→ for typical xDSL link between one and hundred power meters in wired networ

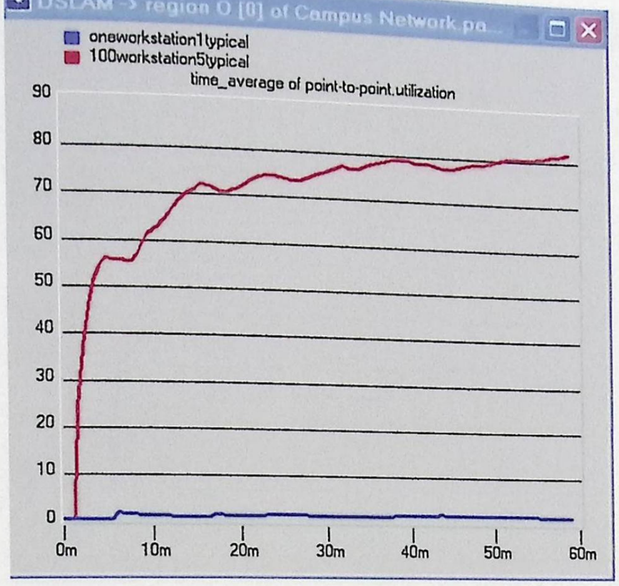


Figure 5.30: Compare utilization← for typical xDSL link between one and hundred power meters in wired network.

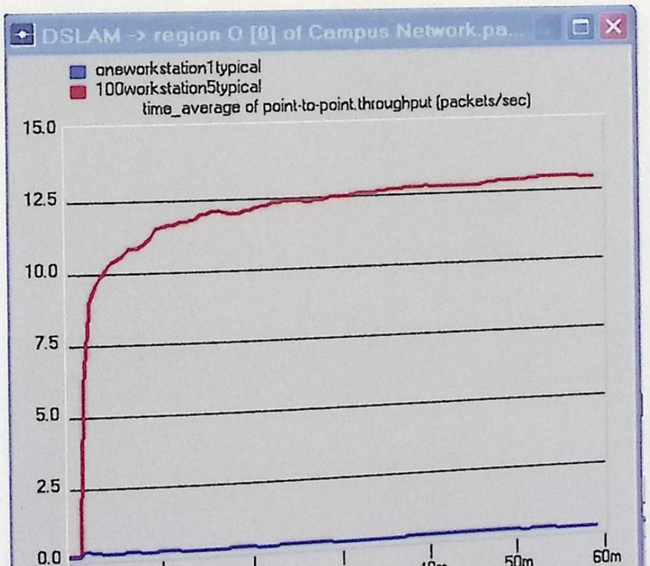


Figure 5.31: Compare throughput← for typical xDSL link between one and hundred power meters in wired network.

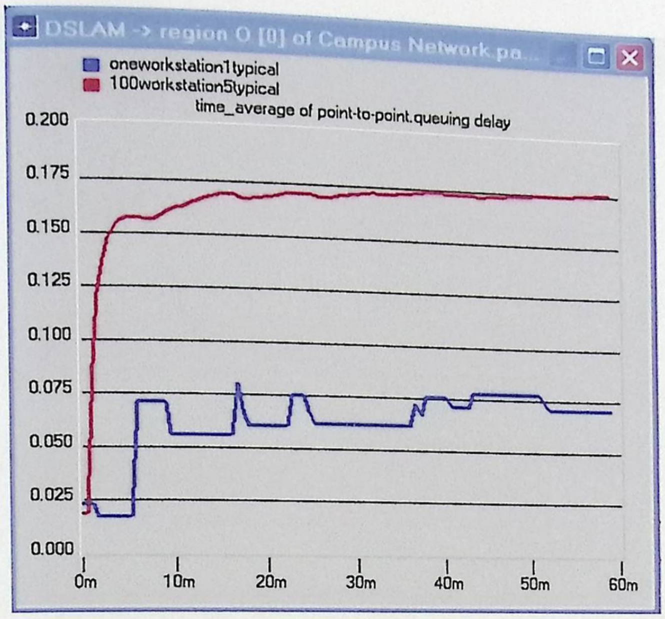


Figure 5.32: Compare delay← for typical xDSL link. between one and hundred power meters in wired network.

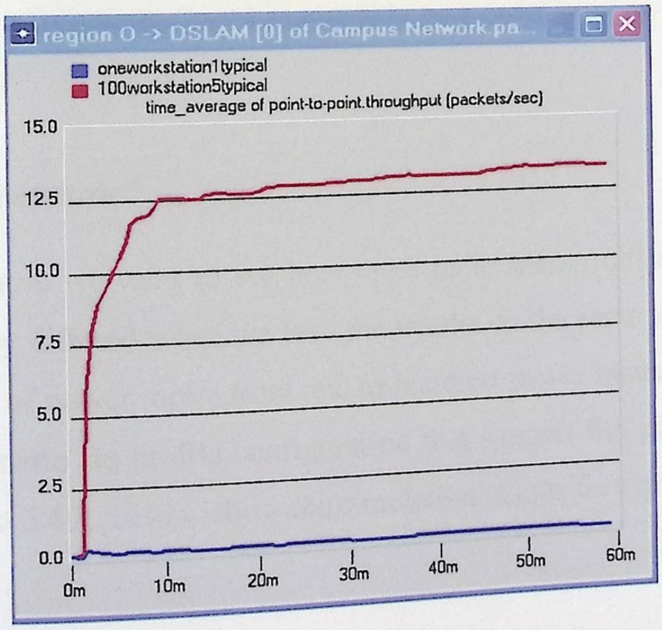


Figure 5.33: Compare throughput → for typical xDSL link between one and hundred power meters in wired network

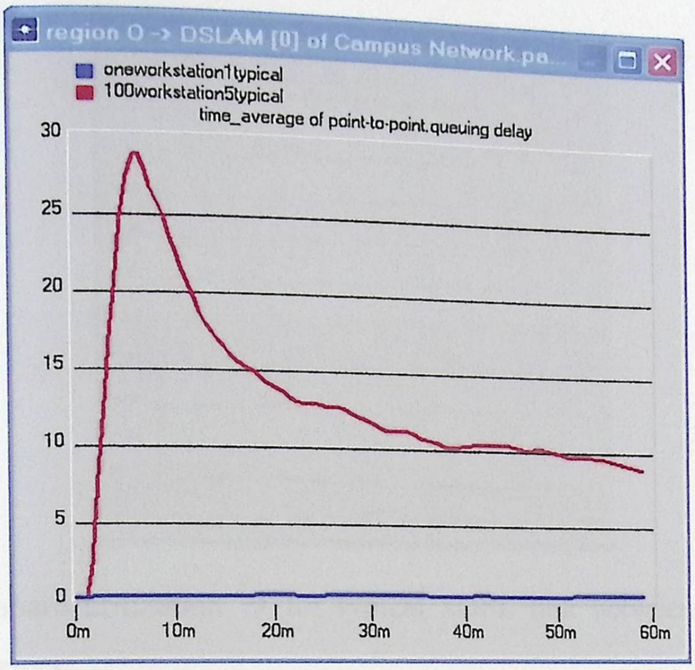


Figure 5.34: Compare queuing delay → for typical xDSL link between one and hundred power meters in wired network.

5.3.2 For wireless network

In this scenario we want to see how these parameters (utilization , throughput , queuing delay) they differed when we take the results on the same xDSL link when we change the number of power meter from one to hundred power meters in one region ,we suppose in this scenario ftp profile configuration that support file transfer application. , from figures[5.35 to 5.40] below show the simulation results for typical xDSL link .

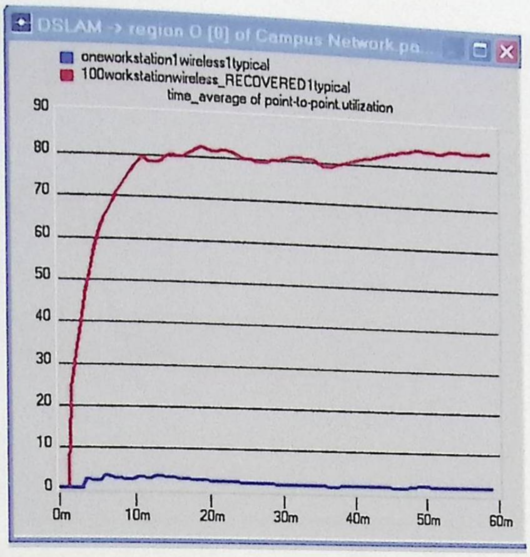


Figure 5.35: Compare utilization → for typical xDSL link between one and hundred wireless power meters.

Figure 5.36: Compare throughput→ for typical xDSL link between one and hundred wireless power meters

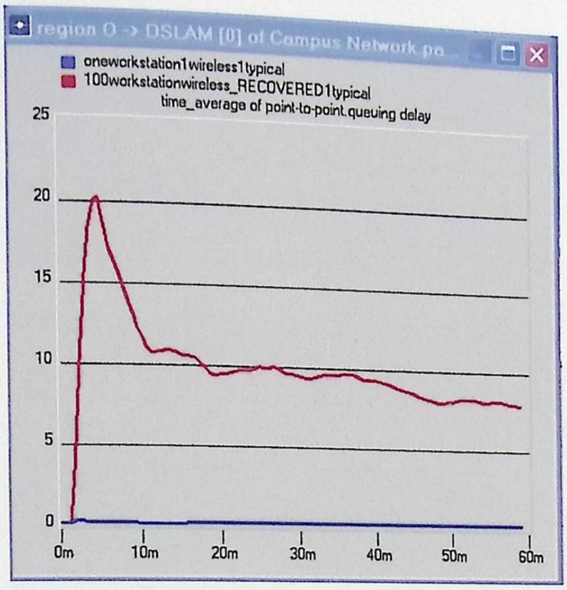


Figure 5.37: Compare queuing delay→ for typical xDSL link between one and hundred wireless power meters.

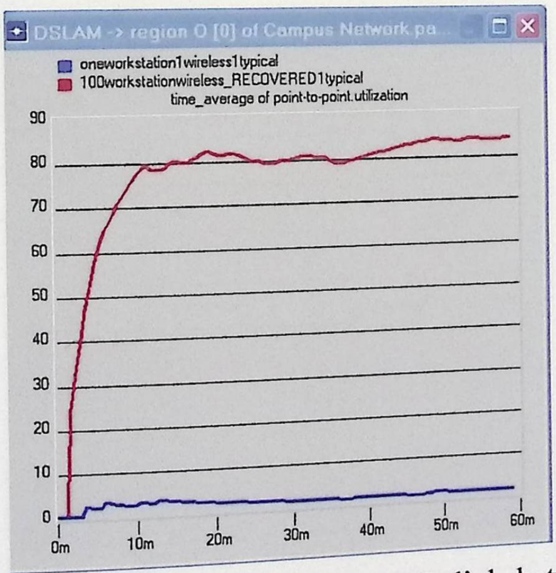


Figure 5.38: Compare utilization ← for typical xDSL link between one and hundred wireless power meters

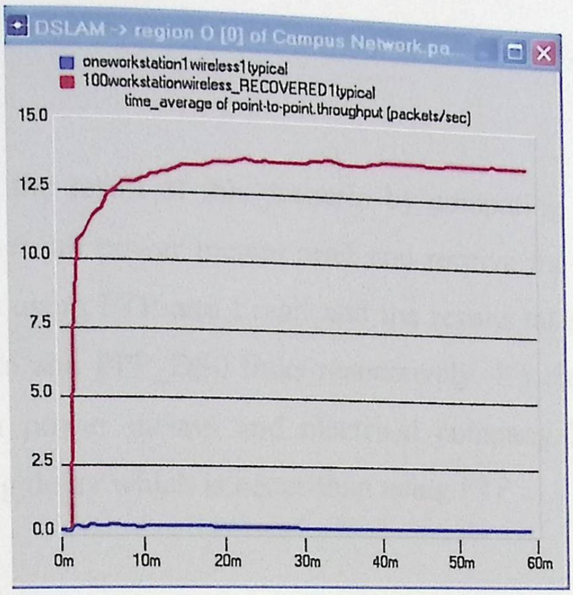


Figure: 5.39: Compare throughput ← for typical xDSL link between one and hundred wireless power meters.

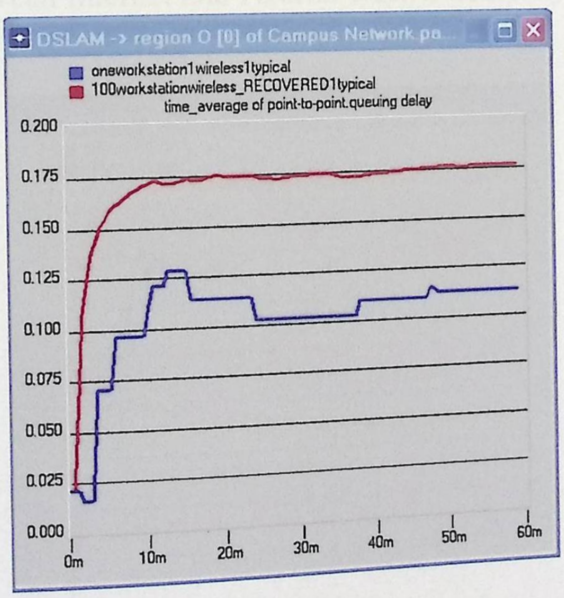


Figure 5.40: Compare queuing delay← for typical xDSL link between one and hundred wireless power meters

5.4 Compare Result Between FTP And Email For The Same Scenarios (one region).

Here we show the result of this scenario by comparing utilization, throughput and queuing delay when all power meters send and receive the readings from Hebron electrical company by using FTP and Email and the results taken on PPP_DS1, xDSL with 16 Kbps data rate and PPP_DS0 links respectively. It's clear that using Email in transfer data between power meters and electrical company lead usually to low utilization and queuing delay which is better than using FTP .

5.4.1 Result for PPP_DS1 upload (←) and down load (→)

PPP_DS1 connect between internet and Hebron electric company with 1.544 Mbps data rate.

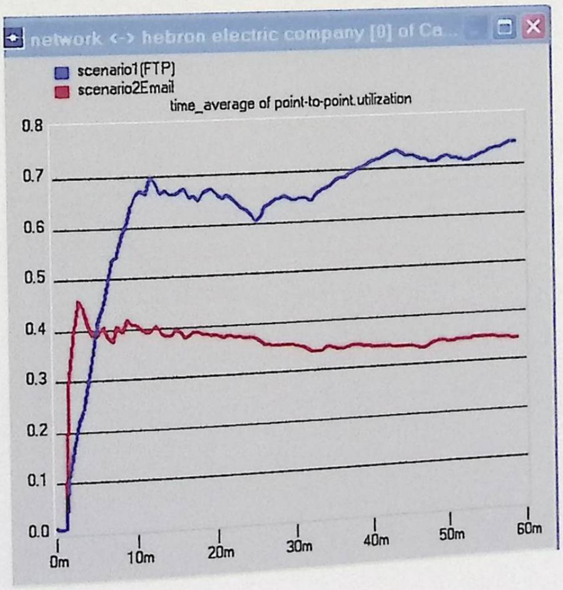


Figure 5.41: Compare utilization← between FTP & Email on PPP_DS1 for wired network with one region

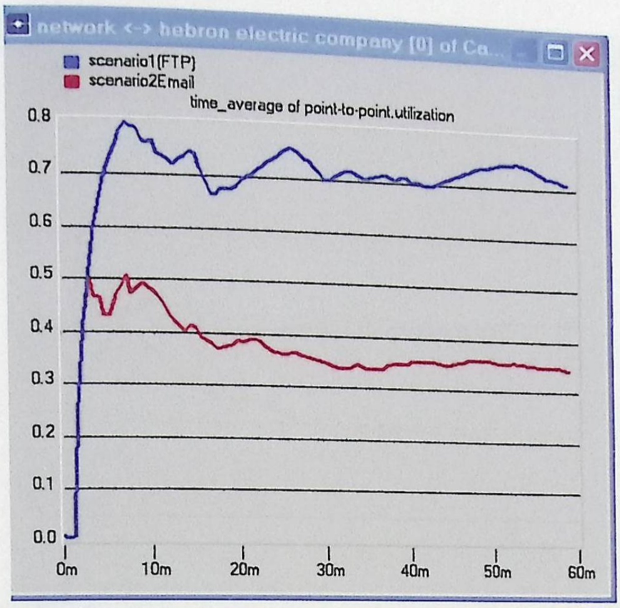


Figure 5.42: Compare utilization→ between FTP & Email on PPP_DS1 for wired network with one region .

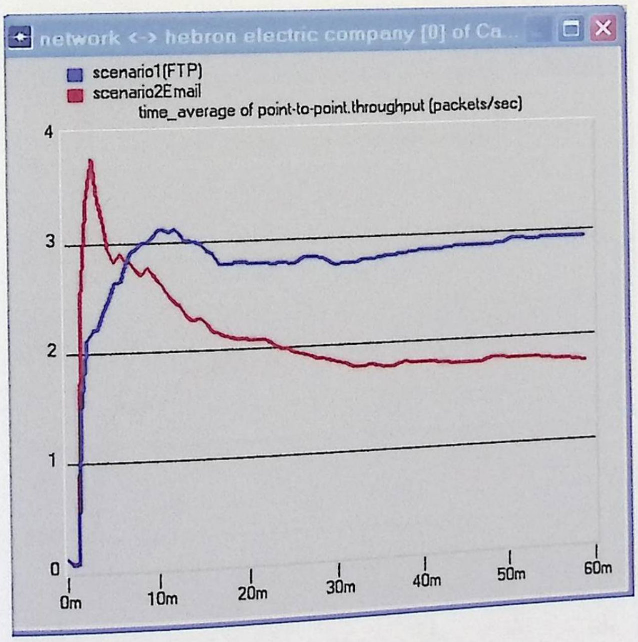


Figure 5.43: Compare throughput ← between FTP & Email on PPP_DS1 for wired network with one region .

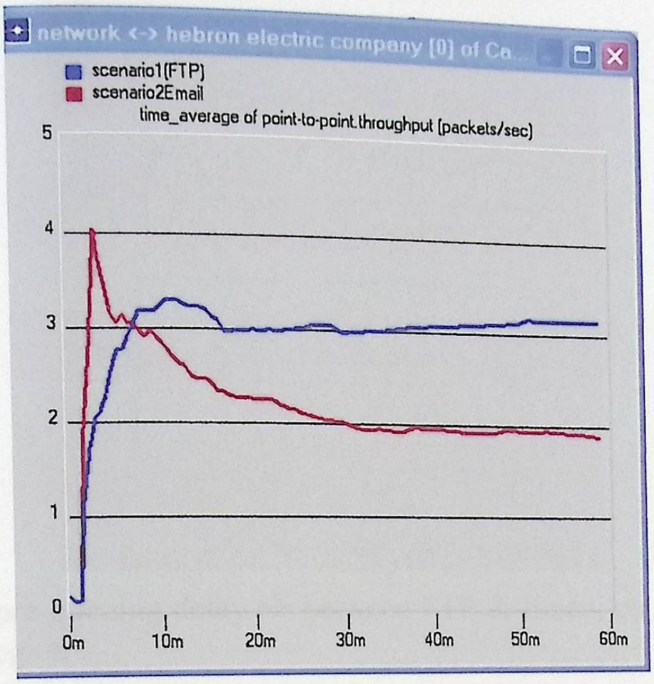


Figure 5.44: compare throughput download→ between FTP & Email. on PPP_DS1 for wired network with one region .

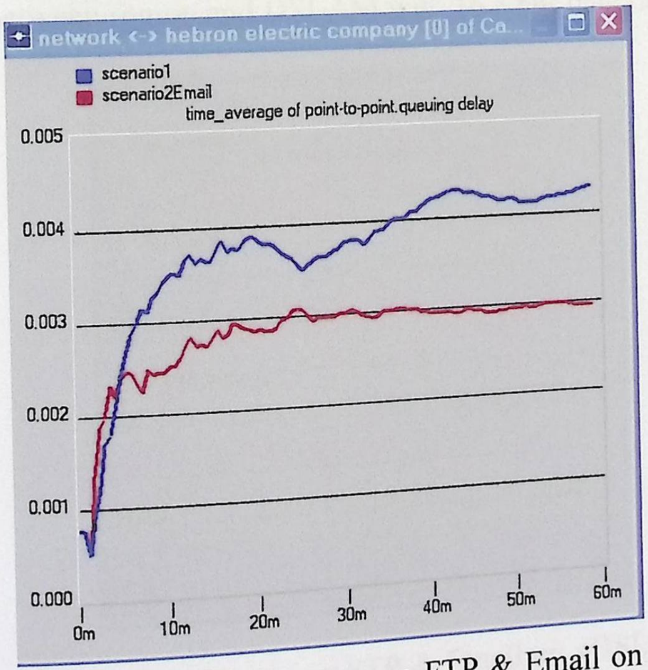


Figure 5.45: Compare queuing delay ← between FTP & Email on PPP_DS1 for wired network with one region.

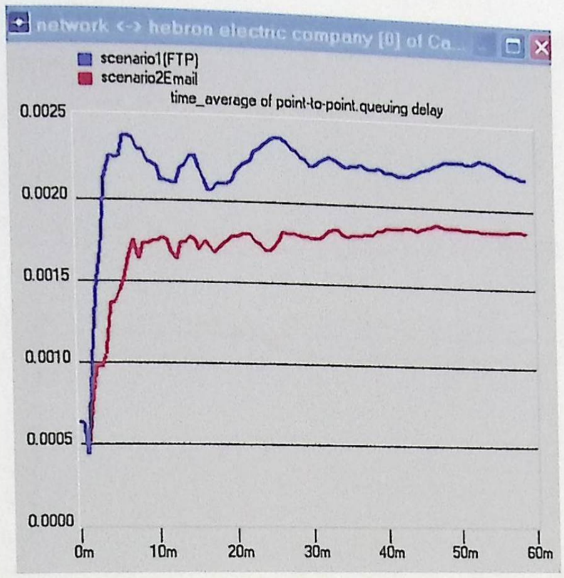


Figure 5.46: Compare queuing delay → between FTP & Email. on PPP_DS1 for wired network with one region .

5.4.2 The Result of xDSL link upload (←) and down load (→)

xDSL link connect between region and DSLAM with 16 Kbps data rate.

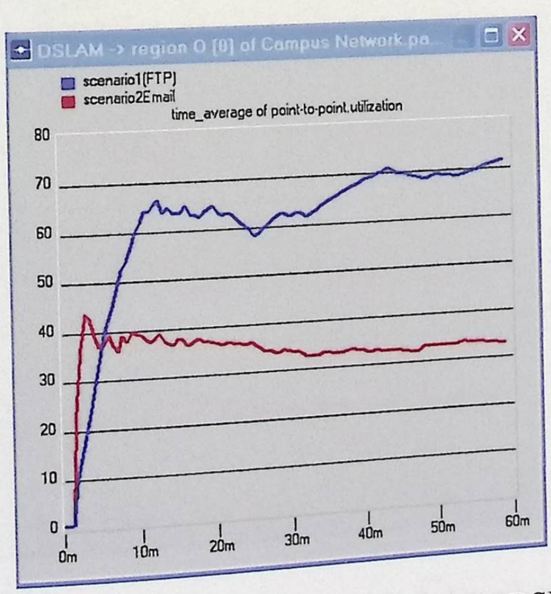


Figure 5.47: Compare utilization←between FTP & Email on xDSL (16Kbps) for wired with one regi

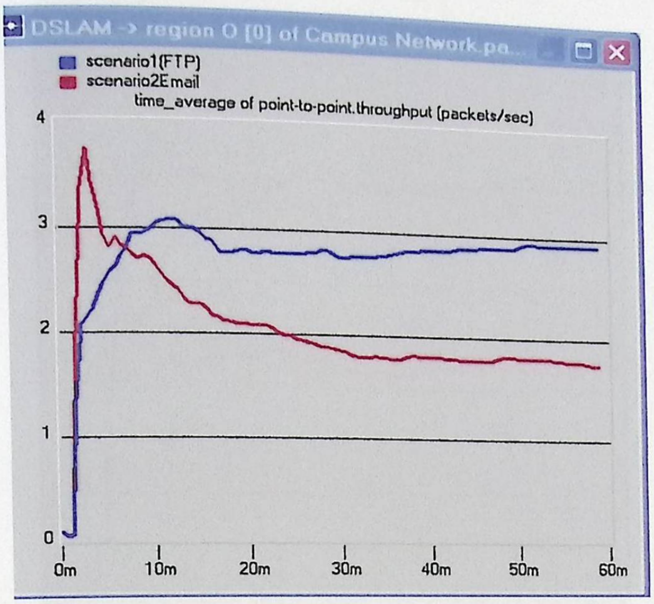


Figure 5.48: Compare throughput ← between FTP & Email on xDSL (16Kbps) for wired with one region.

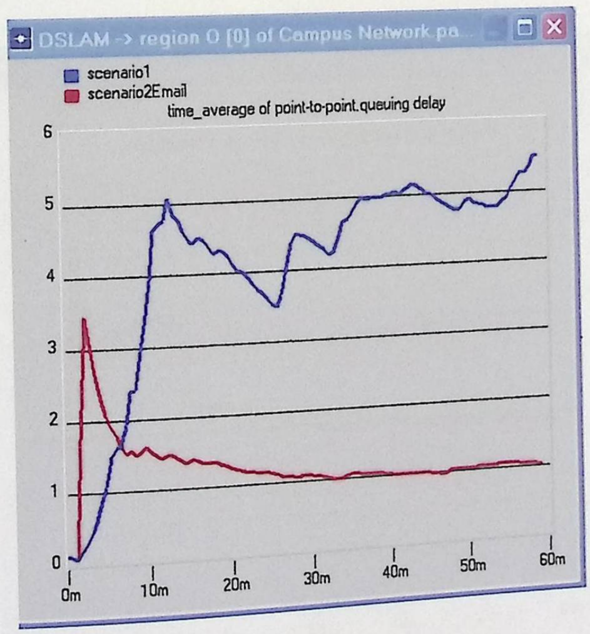


Figure 5.49: Compare queuing delay ← between FTP & Email on xDSL (16Kbps) for wired with one region.

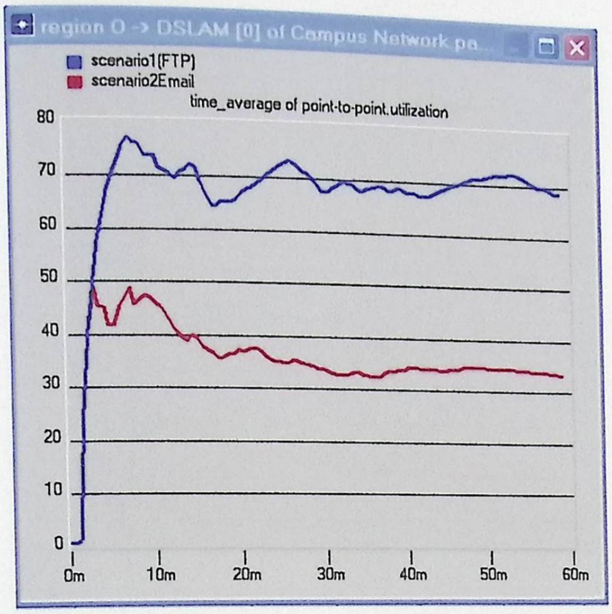


Figure 5.50: Compare utilization→ between FTP & E mail on xDSL (16Kbps) for wired with one region.

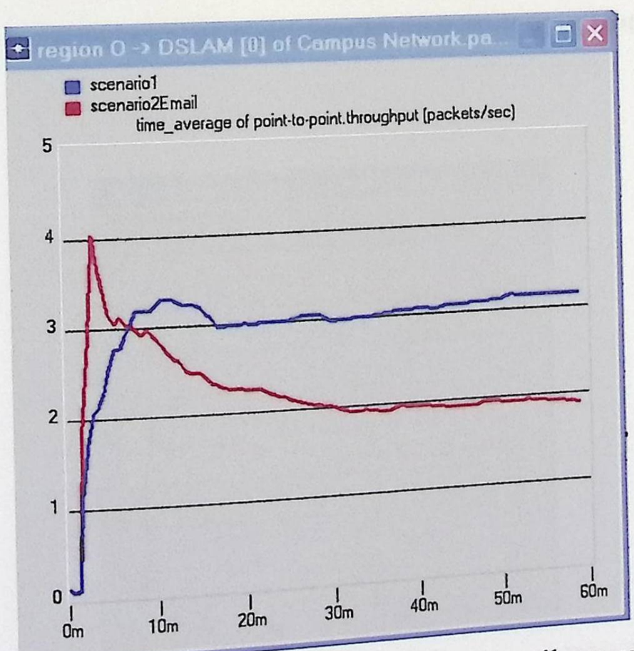


Figure 5.51: Compare throughput → between FTP & Email on xDSL (16Kbps) for wired with one region.

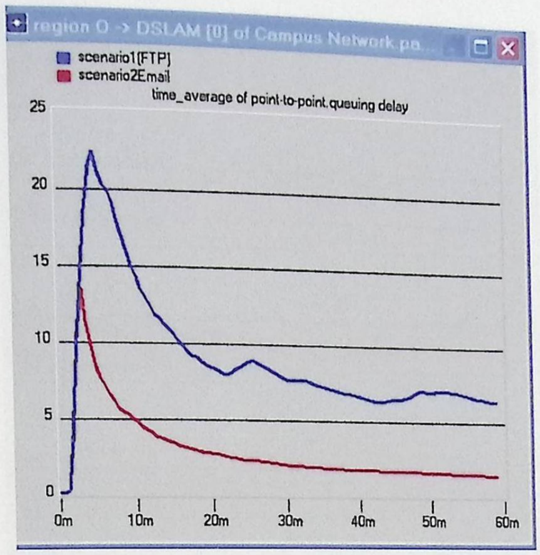


Figure 5.52: Compare queuing delay → between FTP& Email on xDSL (16Kbps) for wired with one region.

5.4.2 The Result for DS0 link upload (←) and download (→)

PPP_DS0 link connect between part of Hebron with one region and internet with 64 Kbps.

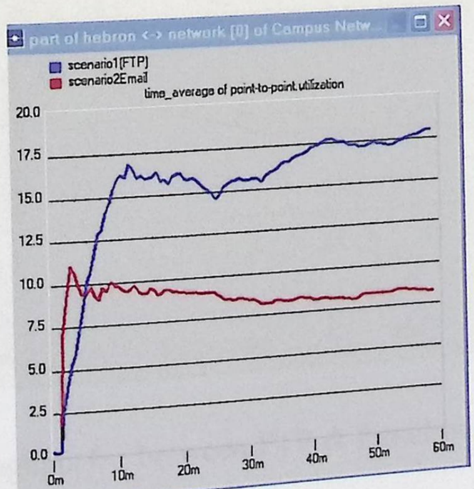


Figure 5.53: Compare utilization←between FTP & Email on PPP_DS0 (64 Kbps) for wired network with one region.

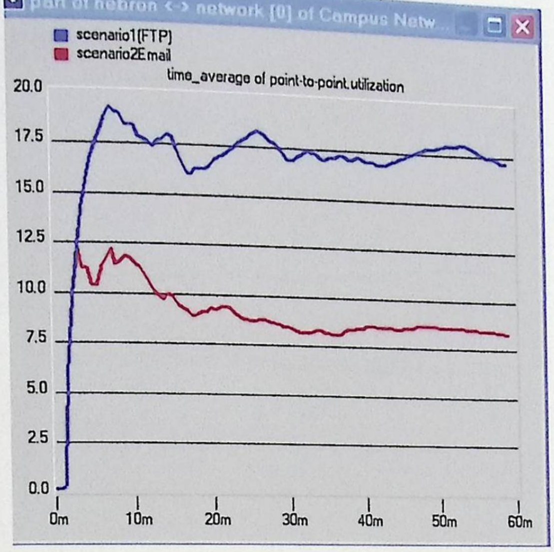


Figure 5.54: Compare utilization→ between FTP & Email on PPP_DS0 (64 Kbps) for wired network with one region.

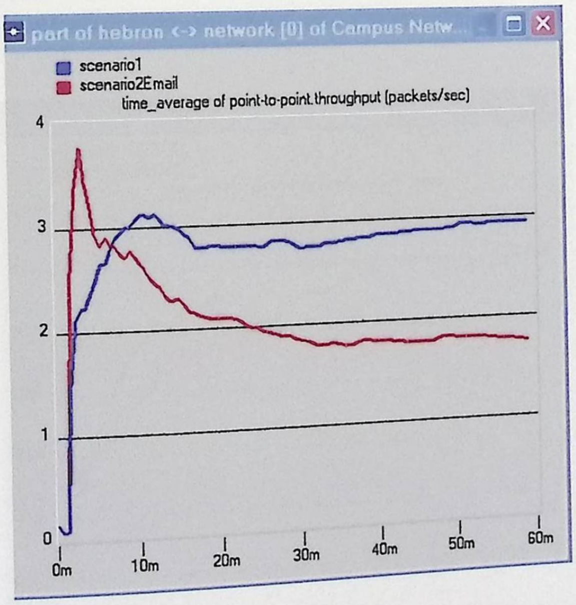


Figure 5.55: Compare throughput← between FTP & Email on PPP_DS0 (64 Kbps) for wired network with one region

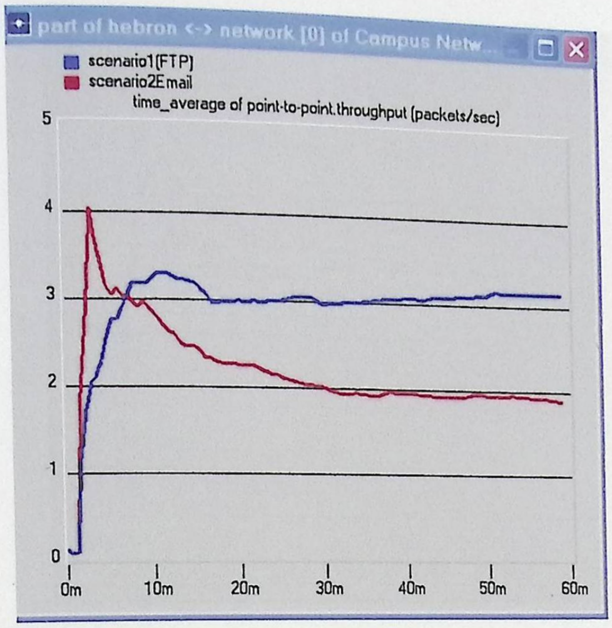


Figure 5.56: Compare throughput → between FTP & Email on PPP_DS0(64 Kbps) for wired network with one region.

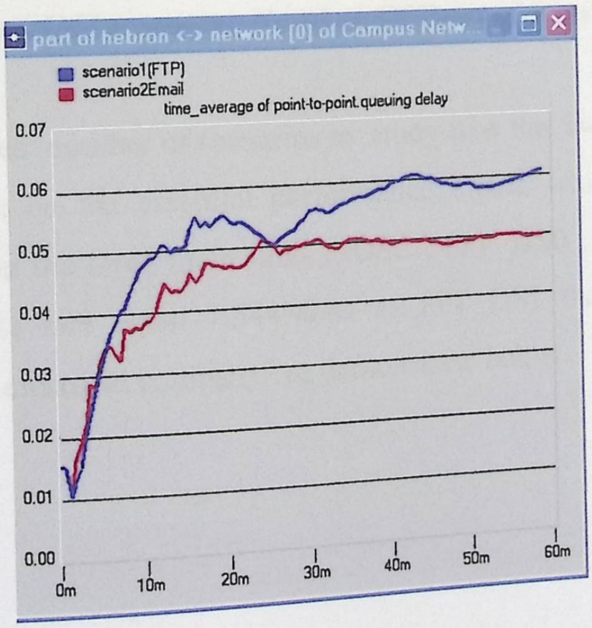


Figure 5.57: Compare queuing delay← between FTP & Email on PPP_DS0 (64 Kbps) for wired network with one region

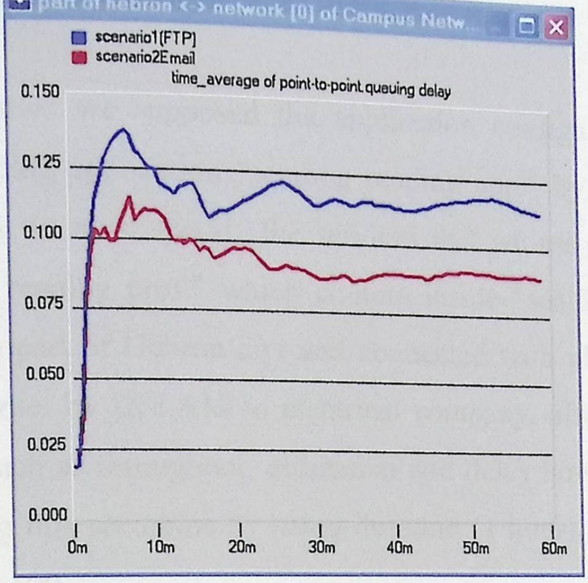


Figure 5.58: Compare queuing delay → between FTP & Email on PPP_DS0(64 Kbps) for wired network with one region.

5.5 Studying The Affect Of Increasing Number Of Power Meter In Performance.

We have modeled number of scenarios to study how the increasing the number of power meters affect on the essential performance metric which are utilization , throughput and delay on the three main links (xDSL , PPP_DS0 , PPP_ADV) which PPP_ADV support data rate equal 1.544Mbps as PPP_DS1 that connect between "internet" and "Hebron electrical company" as demonstrate below .

5.5.1 LAN Scenarios (wired network)

In the all scenarios we supposed the application configuration which is the process of sending reading application "sending reading app." by FTP high load , to activate this application we must specify the services that we are deal with by profile configuration "sending reading prof." which contain inside "sending reading app." to apply this idea we take part of Hebron city and connected with xDSL (1Mbps) which connected through internet by DSLAM to electrical company, after collecting statistic on the different links such as throughput, utilization and delay however downstream or upstream. After running this scenarios by using duration (1 hour), seed equal 128, and value per statistic equal 100.

1. One power meter

The target for this scenario to know throughput, utilization and delay and compare it with the increasing the number of power meter in the other scenario, then take result based on time average as the figures 5.59,5.60and 5.61 that show some model for the scenarios we did.

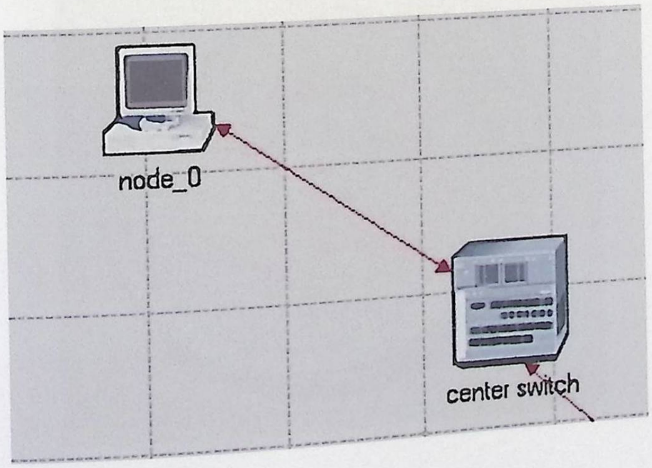


Figure 5.59: Modeling one power meter

2. Fourteen power meters

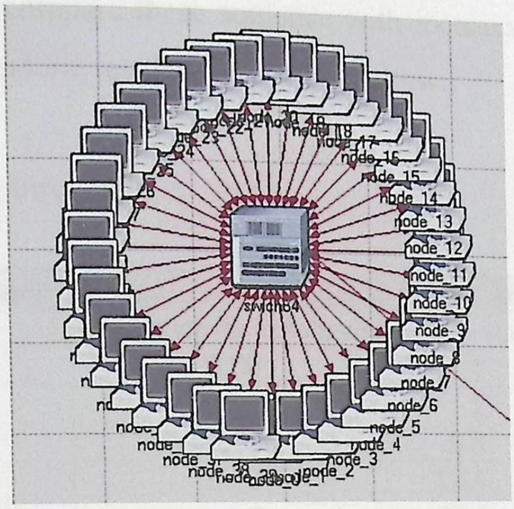


Figure5.60: Modeling fourteen power meters

1.Hundred power meters

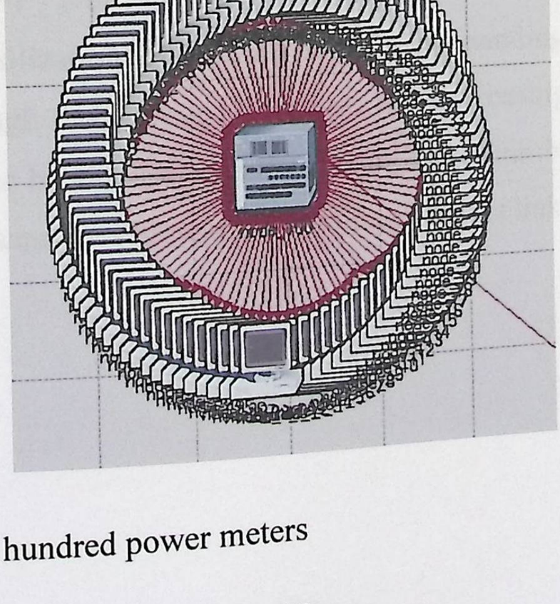


Figure 5.61: Modeling hundred power meters

- **Results for modeling all scenarios in wired network**

After statistics collected for all previous scenarios (throughput, utilization, queuing delay), we determine to compare these statistics with increasing the number of power meter in wired network and the results appeared as follow:

Table 5.1 Utilizations for three links

# of power meter	xDSL<-- utalization %	PPP DS0 LINK utalization<--	DS0 ADV utalization<--
1	0.06	1	1.2
2	0.1	2	1.68
5	0.625	9.3	9.77
10	0.79	12.4	13.3
20	1.2	20.4	18.66
30	2.04	33.7	37.3
40	2.87	46.2	56.8
50	2.97	46.2	46.2
100	4.25	71.1	78.2

Figures 5-62 shows the results of the bandwidth utilization of the xDSL modems to the connecting DSLAM, PPP_ DS0 and PPP_ ADV links from a region using FTP protocol. The figure shows the utilization for both all power meter sending reading to the Hebron electric company through the internet. It is clear that increasing the number of power meter will increased the bandwidth utilization in all three link but the utilization of the xDSL appear higher because we choose the data rate for this link 1 Mbps.

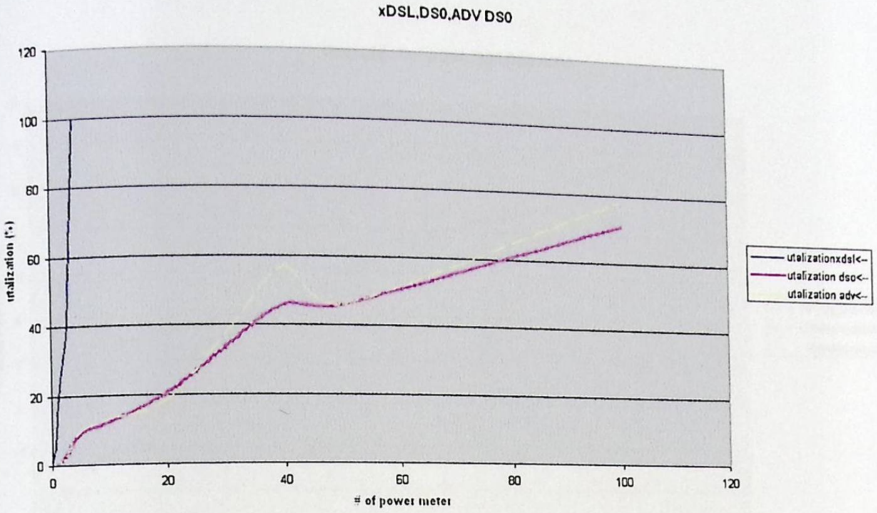


Figure 5.62: Utilization for three links

Table 5.2: throughput Upload for three links

# of power meter	xDSL<-- Throughput <--	PPP DS0 LINK throughput<--	DS0 ADV throughput<--
1	0.2	0.2	0.24
2	0.2	0.21	0.23
5	1	0.88	0.8
10	1.54	1.68	1.77
20	2.75	2.48	3.02
30	4.125	4.97	4.62
40	6.5	6.4	7.4
50	6.5	6.04	6.4
100	8.125	8.88	9.3

From the data in table 5.2 we have figure 5.63 that show throughput upload (←) for the all link (xDSL,PPP_DSO,PPP_ADV) and we notice the throughput increase when increase number of power meter .

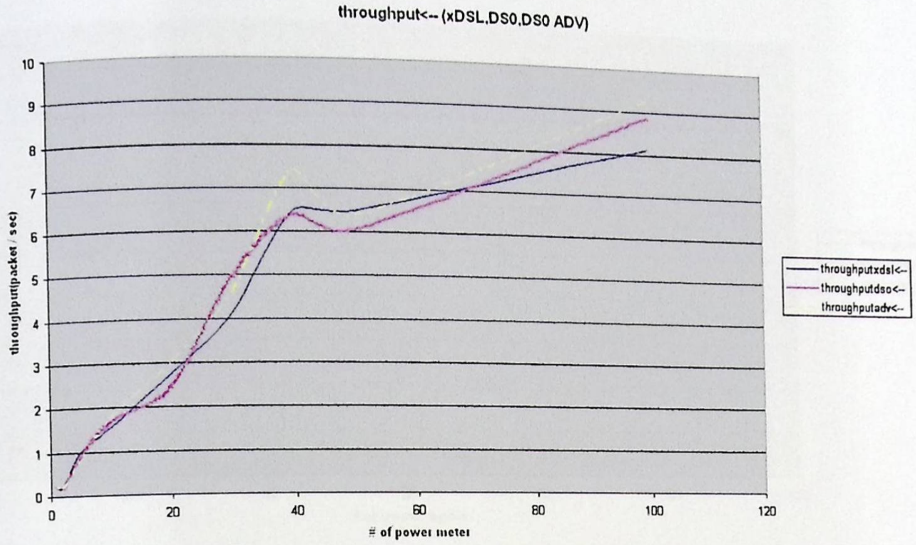


Figure 5.63: Throughput up load for three links

Table 5.3: throughput Download for three links

# of power meter	xDSL<-- throghput-->	PPP DSO LINK throughput-->	DSO ADV throughput-->
1	0.2	0.2	0.24
2	0.2	0.26	0.23
5	1	0.93	1.06
10	1.53	1.7	1.68
20	2.75	3.2	2.84
30	4	4.97	3.9
40	6.75	7.8	7.46
50	6.25	6.04	6.04
100	8.125	8.44	8.88

From the data in table 5.3 we have figure 5.64 that show throughput download(→) for the all link(xDSL, PPP _DSO,PPP_ ADV) and we notice the throughput increase when increase number of power meter and this result approximately become similar to upload.

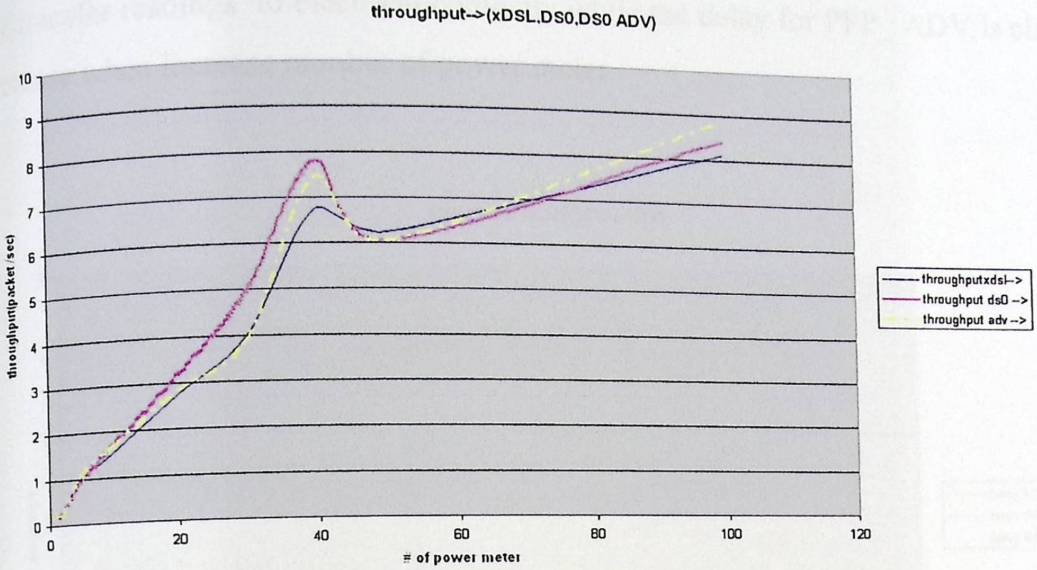


Figure 5.64: Throughput down load for three links

Table 5.4: Upload queuing delay for three links

# of power meter	xDSL<-- delay<--	PPP DS0 LINK delay<--	DS0 ADV delay<--
1	0.003	0.06	0.15
2	0.005	0.09	0.24
5	0.005	0.08	0.39
10	0.005	0.08	0.35
20	0.0056	0.085	0.275
30	0.006	0.092	0.6
40	0.0048	0.0746	1.51
50	0.005	0.08	1.06
100	0.0059	0.088	5.33

Figure 5.65 show the queuing delay for all link and the delay of xDSL link and DS0 is equal zero because the date rate is 1Mbps of xDSL link so the data can not wait

for transfer readings to electrical company while the delay for PPP_ ADV is clearly increase when increase number of power meter.

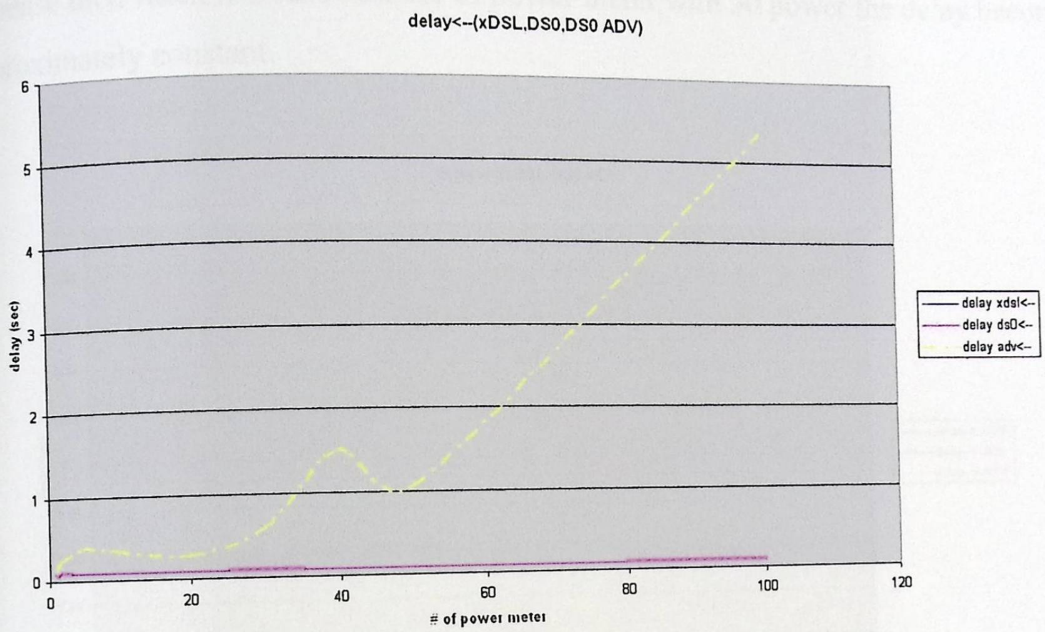


Figure 5.65: queuing delay upload for three links

Table 5.5: download queuing delay for three links

# of power meter	xDSL--> delay-->	PPP DS0 LINK delay-->	DS0 ADV delay-->
1	0.007	0.15	0.12
2	0.008	0.12	0.11
5	0.0056	0.081	0.07
10	0.006	0.085	0.08
20	0.007	0.1	0.078
30	0.007	0.106	0.079
40	0.0093	0.1	0.085
50	0.008	0.128	0.076
100	0.008	0.128	0.064

Figure5.66 show the queuing delay for all link (xDSL ,PPP_ DS0 ,PPP_ ADV) the delay in xDSL link is zero while the delay for DS0 link that connecting the part of Hebron with the internet increase extremely while the delay for PPP_Adv link firstly increase then when increase number of power meter with 50 power the delay become approximately constant.

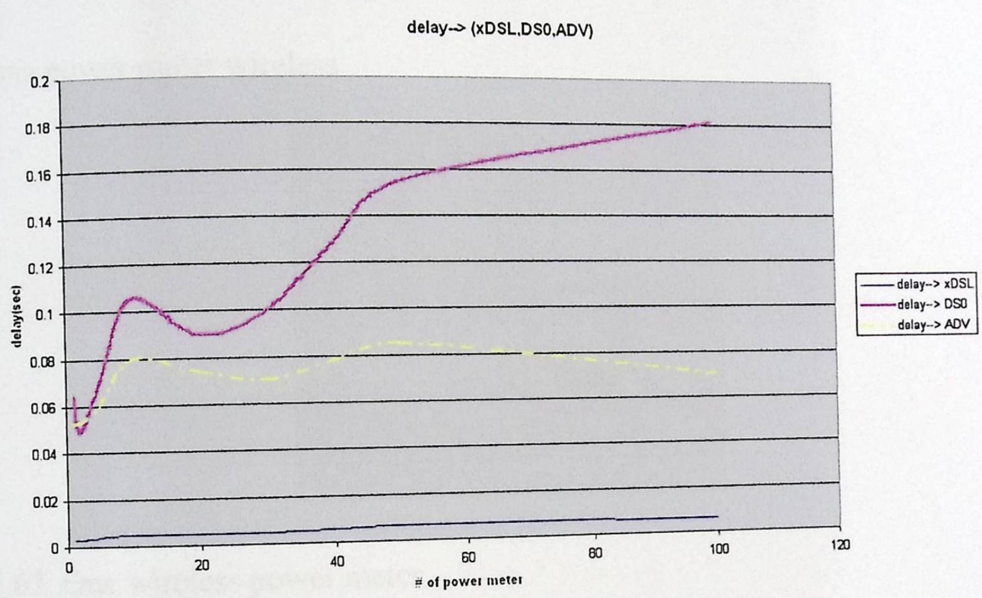


Figure5.66: queuing delay down load (→) for three links

5.5.2 WLAN Scenarios:

We suppose the application configuration which is the process of sending reading application" sending reading app." by FTP high load , to activate this application we must specify the services that we are deal with by profile configuration "sending reading prof." which have inside it "sending reading app." to apply this idea we take part of Hebron city and suppose that it have different number of power meters range from one power meter to hundred power meters connected with xDSL (1Mbps) which connected through internet by DSLAM to electrical company, after collecting statistics on the different links such as throughput ,utilization and delay however downstream or upstream and after running these scenarios by using duration (1 hour),seed equal 128,and value per statistic equal 100 we have a lot of results as below figure 5.67 ,5.68 and 5.69 show models for some scenarios we did .

1. One power meter wireless

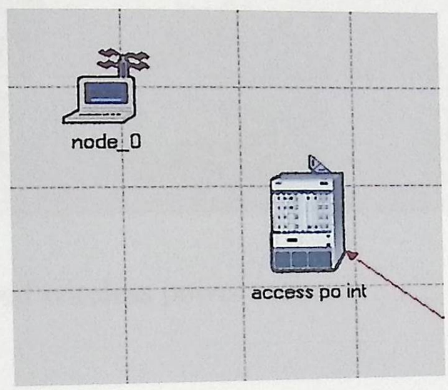


Figure 5.67: One wireless power meter

2. Fourteen power meters

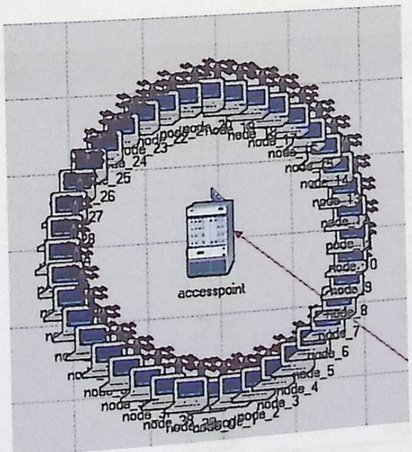


Figure 5.68: Modeling fourteen power meters wireless

3. Hundred wireless power meters

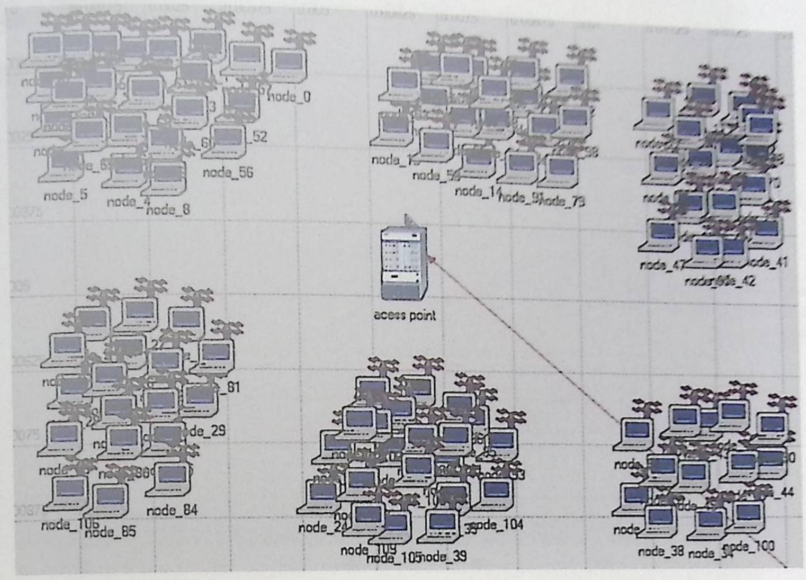


Figure 5.69: Modeling hundred wireless power meters.

- **Simulation Results for WLAN**

Table5.6: Utilization uploads for the three links

# of power meter	xDSL<-- utalization %	PPP DS0 LINK utalization<--	DS0 ADV utalization<--
1	0.09	1.6	1.2
2	0.2	3.55	1.68
5	0.4	8.4	9.77
10	0.72	14.2	13.3
20	1.46	30.2	18.66
30	2.8	44.4	37.3
40	3	49	56.8
50	2.45	46.2	46.2
100	5.06	88.88	78.2

3. Hundred wireless power meters

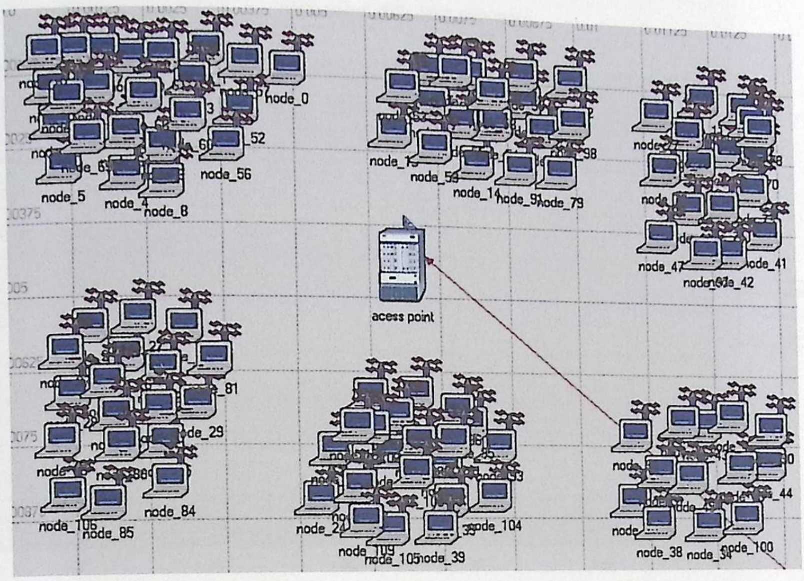


Figure 5.69: Modeling hundred wireless power meters.

- **Simulation Results for WLAN**

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30	2.8	44.4	37.3
40	3	49	56.8
50	2.45	46.2	46.2
100	5.06	88.88	78.2

Figure 5.70 show the utilization for all link in wireless and because we use wireless so the utilization is lower than wire LAN.

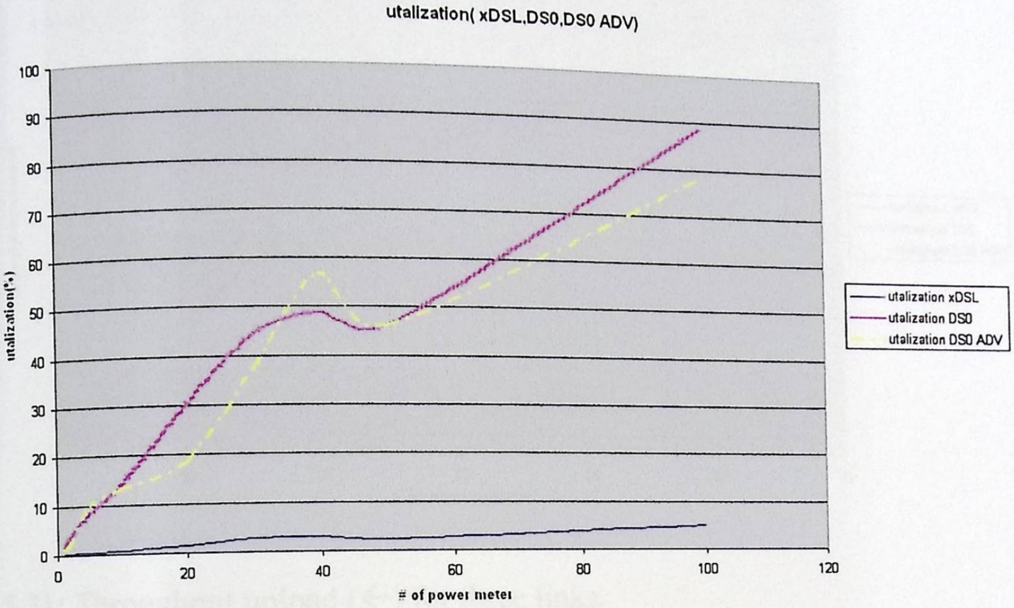

Figure 5.70: utilization for three links

Table 5.7: Throughput uploads for three links

# of power meter	xDSL<-- throughput <--	PPP DSO LINK throughput<--	DSO ADV throughput<--
1	0.2	0.2	0.24
2	0.2	0.21	0.23
5	1	0.88	0.8
10	1.54	1.68	1.77
20	2.75	2.48	3.02
30	4.125	4.97	4.62
40	6.5	6.4	7.4
50	6.5	6.04	6.4
100	8.125	8.88	9.3

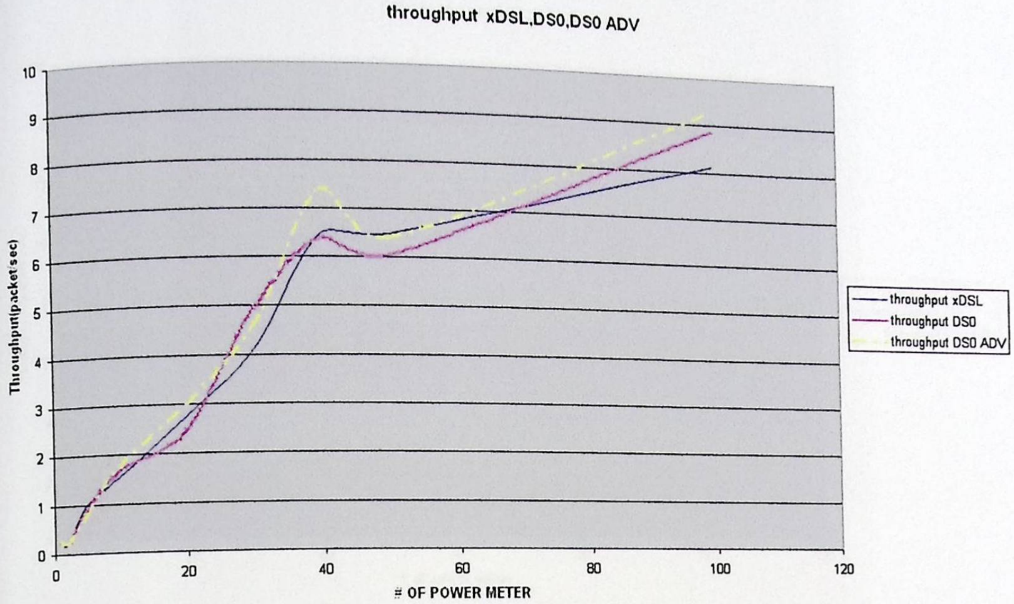

Figure 5.71: Throughput upload (←) for three links.

Table 5.8: Throughput downloads for three links

# of power meter	xDSL-->	PPP DS0 LINK	DS0 ADV
	throughput -->	throughput -->	throughput -->
1	0.133	0.12	0.11
2	0.24	0.19	0.266
5	0.6	0.7	0.66
10	1.45	1.77	1.42
20	2.83	3.02	2.66
30	4.75	4.62	5.33
40	6.5	7.1	6.4
50	7.125	7.82	7.82
100	14.16	14.66	14.22

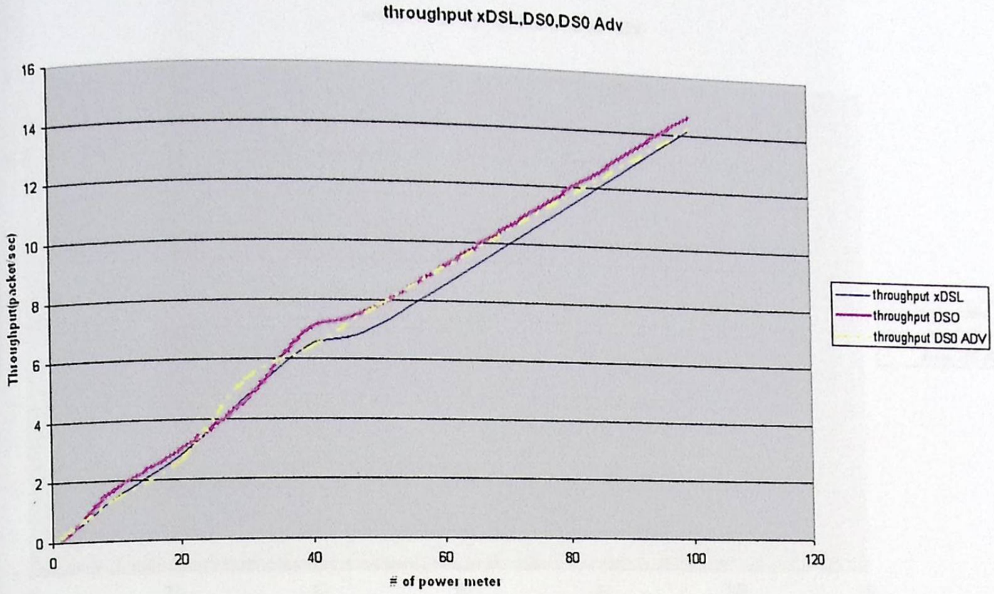

Figure 5.72: Throughput download (→) for three links

Table 5.9: queuing delay uploads for three links

# of power meter	xDSL<--	PPP DS0 LINK	DS0 ADV
	delay<--	delay<--	delay<--
1	0.003	0.06	0.15
2	0.005	0.09	0.24
5	0.005	0.08	0.39
10	0.005	0.08	0.35
20	0.0056	0.085	0.275
30	0.006	0.092	0.6
40	0.0048	0.0746	1.51
50	0.005	0.08	1.06
100	0.0059	0.088	5.33

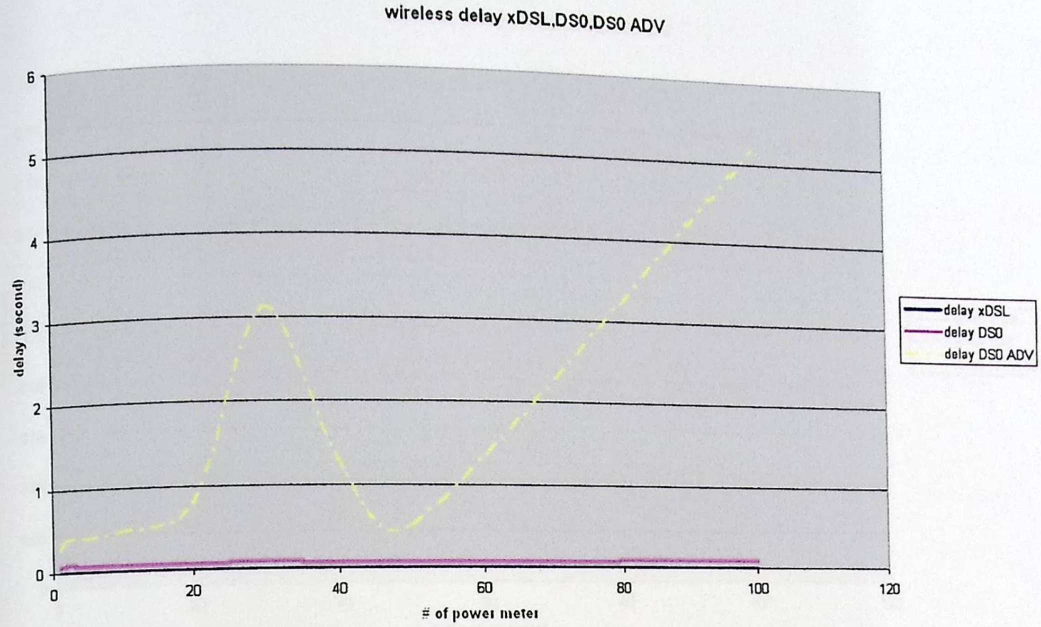

Figure 5.73: queuing delay upload (←) for three links

Table 5.10: delay down load for three links

# of power meter	xDSL-->	PPP DS0 LINK	DS0 ADV
	delay-->	delay-->	delay-->
1	0.007	0.15	0.12
2	0.008	0.12	0.11
5	0.0056	0.081	0.07
10	0.006	0.085	0.08
20	0.007	0.1	0.078
30	0.007	0.106	0.079
40	0.0093	0.1	0.085
50	0.008	0.128	0.076
100	0.008	0.128	0.064

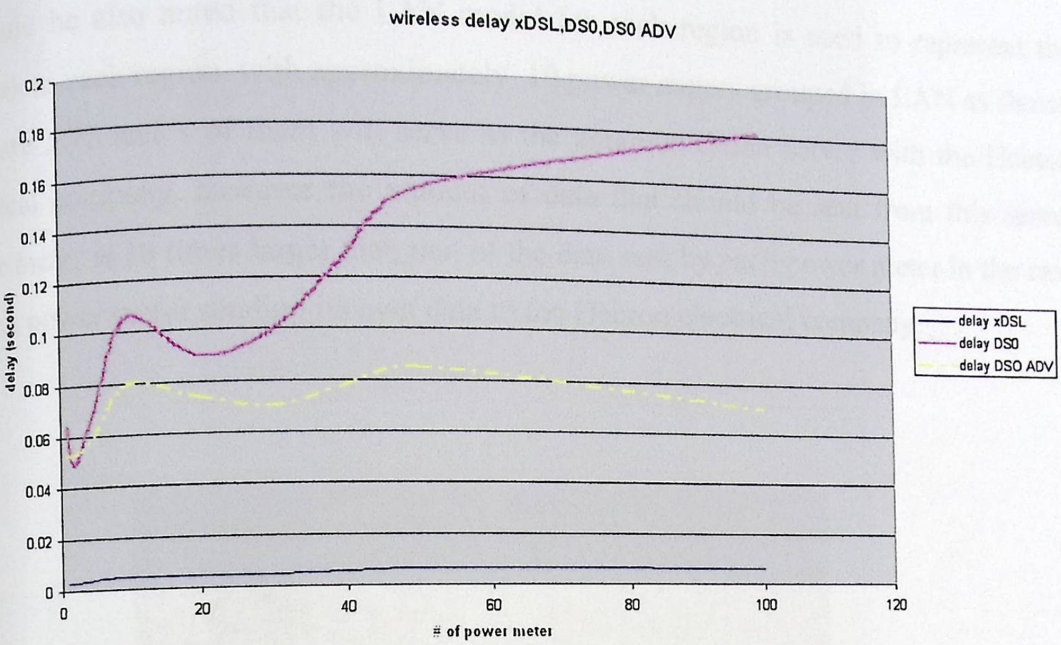

Figure 5.74: queuing delay download (→) for three links

5.6 Modeling Power Meter system LANs Sites ("Hara")

In this section the results of running the simulation to study the effect of utilization, throughput and queuing delay usage of the communication links will be presented. These results are taken for both FTP and E-mail communication protocols between the power meters and the Hebron electrical company. The used computer is a P4 Intel based computer with 512 MByte RAM, unfortunately only partial results were taken since any enlargement of the simulated system will cause the compute system to crash with out of memory problems. However and since the modeling of each "Hara" with the connection xDSL modem is full so the results for this section of the network is complete and can be justified as will be discussed now.

It should be also noted that the LAN model for each region is used to represent the network in each region with approximately 10 power meters grouped in LAN as shown in figure 5.75 and 1 of them will serve as the communication server with the Hebron electrical company, however the amount of data that should be sent from this server power meter is 10 times larger than that of the data sent by each power meter in the case of each power meter sending its own data to the Hebron electrical company.

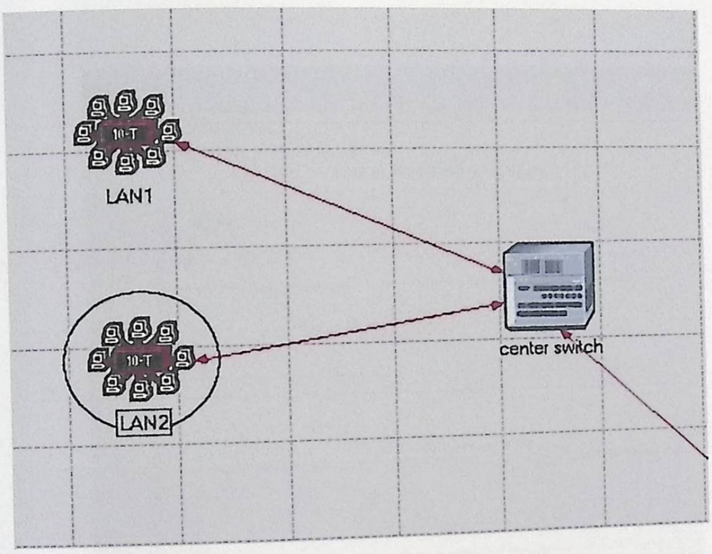

Figure 5.75: Modeling Power Meter system LANs Sites ("Hara")

The OPNET package uses the definition of application protocols and profiles so as to simulate the flow of packets using different realistic statistical distribution to model the real Internet data flow. In this simulation we assumed that each power meter is sending medium load FTP or high load E-mail data since this may be the case in real meter functioning, so we assumed that each power meter sends data only once each 360 second using exponential distribution.

Figures 5.76, 5.77 and 5.78 shows the results of the utilization, throughput (packet/sec) and queuing delay respectively of the xDSL modems from a "Hara" to the connecting DSLAM using the E-mail. The figures show the utilization for both all power meter sending and 1 of 10 power meters sending scenarios. It is observe if the power meter network in one site communicate and collect data from each other and one of the meter send the data to the power company performs better (utilization , throughput , delay) than all meter sending data to the power company.

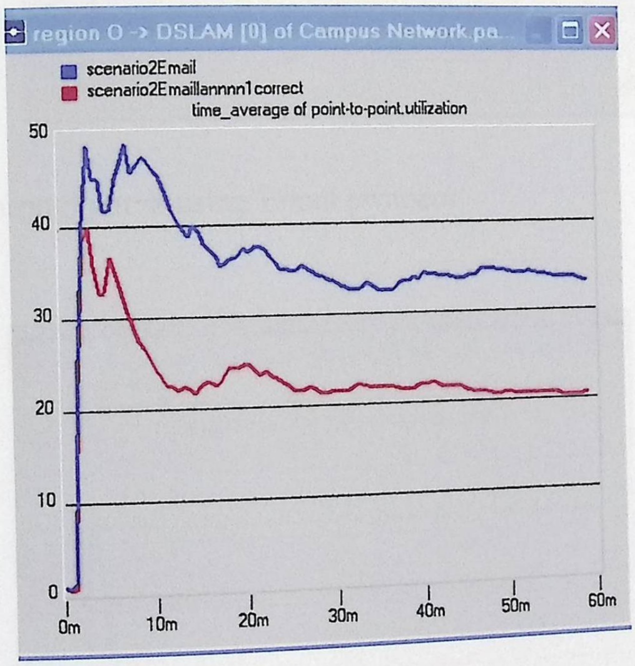

Figure 5.76: xDSL utilization → using Email protocol

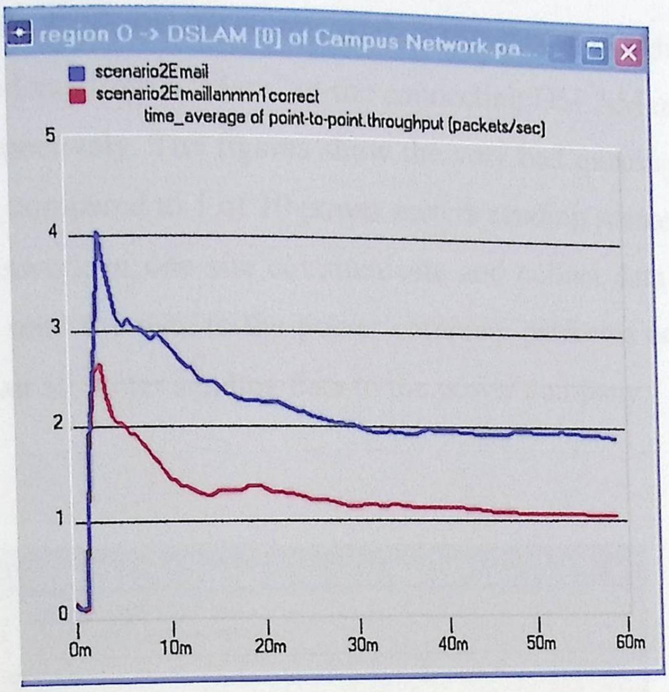

Figure 5.77: xDSL throughput→ using Email protocol

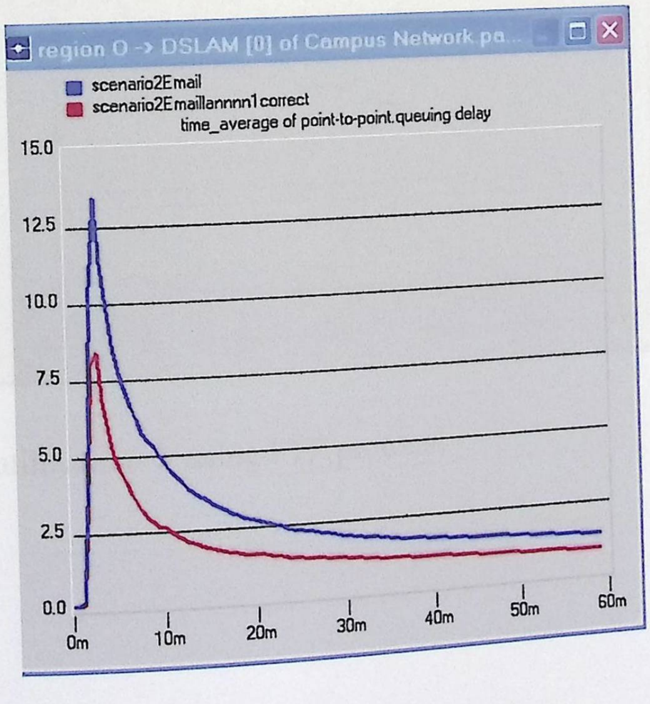

Figure 5.78: xDSL queuing delay→ using Email protocol.

Figures 5.79, 5.80 and 5.81 shows the results of the utilization, throughput and queuing delay of the xDSL modems from a "Hara" to the connecting DSLAM using the medium load FTP protocol respectively. The figures show the very bad queuing delay of the all power meters sending compared to 1 of 10 power meters sending scenarios. It is observe if the power meter network in one site communicate and collect data from each other and one of the meter send the data to the power company performs better (utilization , throughput , delay) than all meter sending data to the power company.

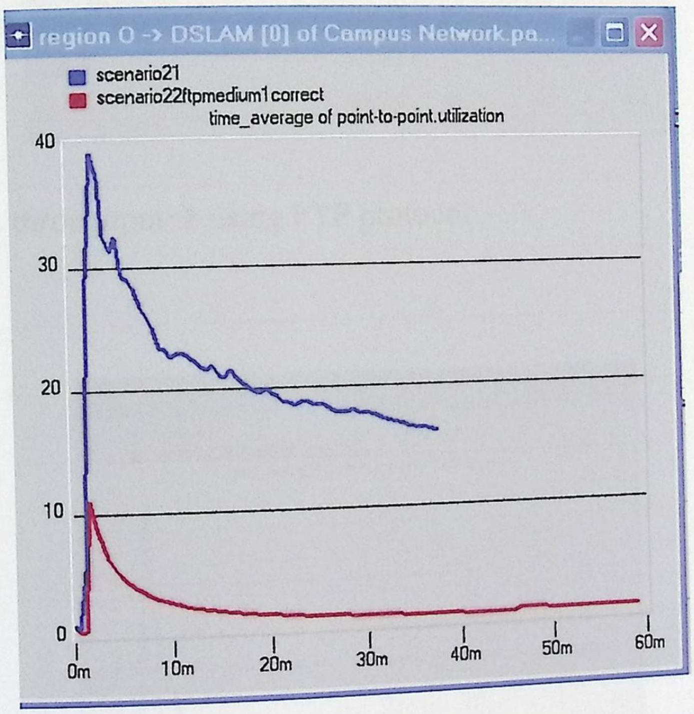

Figure 5.79: xDSL utilization → using FTP protocol

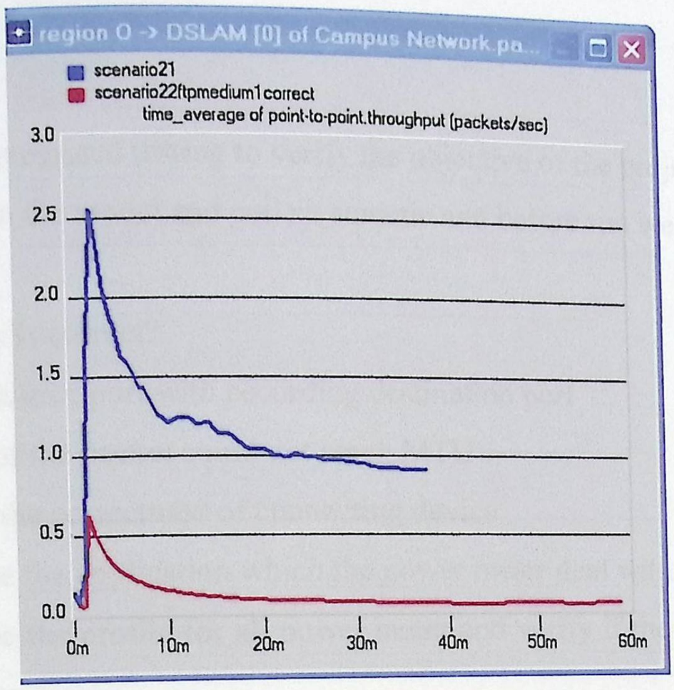

Figure 5.80: xDSL throughput→ using FTP protocol

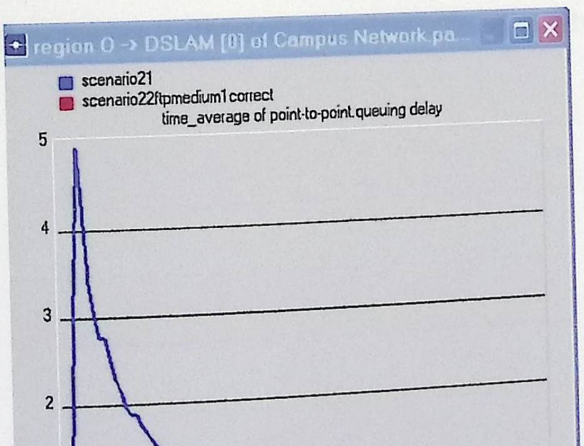

Figure 5.81: xDSL delay→ using FTP protocol.

5.7 Testing

First we use integrated testing to verify the objective of the project in this simulator (OPNET) we design the model and collect statistic and before run we must verify:

1. If all links is correct?
2. Connect source port with according destination port
3. The size of the packet could not reach MTU
4. Examine the correctness of connecting device
5. Determine the application which the power meter deal with
6. Determine the profile for all power meter and verify if the profile is defined in application.

after run complete we choose to view the result and examine the result show it , if there is not any data shown in the figure this mean error occur we repeat until the simulation produce result. Depending on the collected result we can give advice to electric Hebron Company.

CHAPTER SIX: CONCLUSION AND FUTURE WORK

6.1 Results

We observed the following through our simulations of the system

1. We observe increasing the number of power meter in each part of Hebron "Hara" will increase the utilization, throughput and delay of the links connected these power meters to the internet and we here show only the utilization in wired network as figure 6.1.

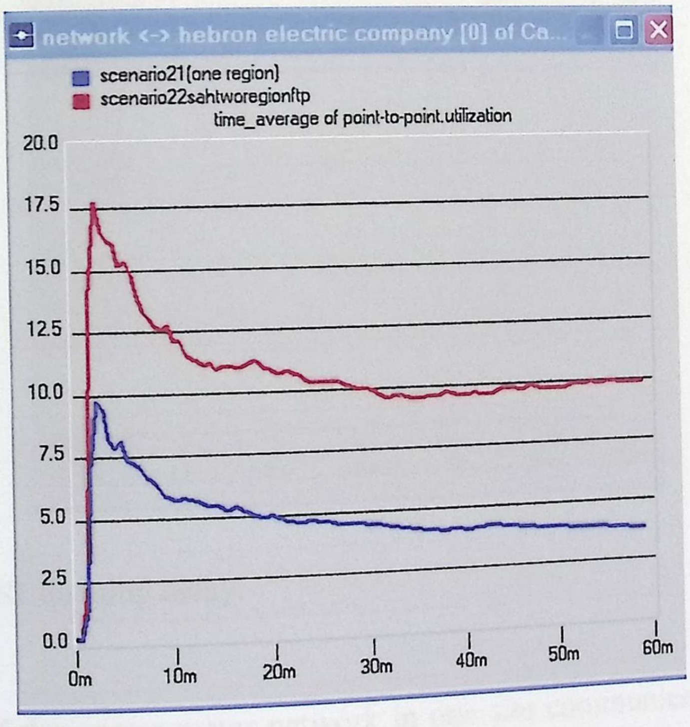

Figure 6.1:PPP_DS1 utilization →.

2. The link bandwidth is limited then the queuing delay will increase the number of power meter accordingly it may be a requirement to increase the link bandwidth if the number of power meters increases in a certain sites

3. Although the connect through wired LAN is more difficult than using wireless to transmit data from the power meters to a certain part of sites, we observed that the utilization , throughput and delay over the xDSL link is better in the wireless network meter over the wireled network meter as described here.

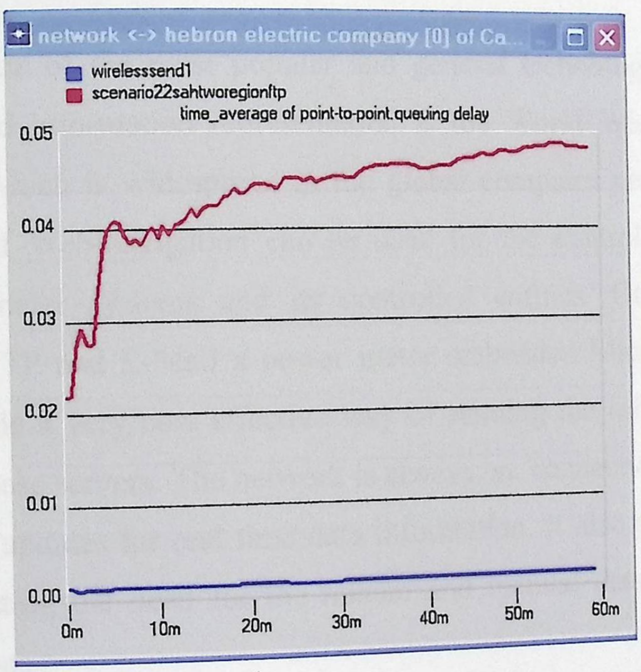

Figure 6.2:PPP_DS1 queuing delay.

4. It is observe if the power meter network in one site communicate and collect data from each other and one of the meter send the data to the power company performs better (utilization , throughput , delay) than all meter sending data to the power company.

For a typical xDSL two internal communication link configuration between power meters and power company , we observed that the number of power meter in each site preferred to be limited about 50 power meter other wise a higher bandwidth should be used.

6.2 Conclusions

Nowadays one of the most popular and general technologies for information resources access and information representation is the World Wide Web technology (Web technology) which is widespread in the global computer network Internet, The standard methods of Web-navigation can be used for the control and monitoring of embedded power meter systems and its controlled entities. Other communication protocols such as FTP and E-Mail a power meter embedded Micro web-servers with Ethernet port provide a very cost effective way of sending the information to the end users or to the database servers. The network is always on, connection that provides data streaming and data updates for real time data information. It also provides further cost benefits by eliminating the need for the human and manual data collection or other telephone connections.

All meters transmit the stored data over the internet to the data collection servers that store, calculate and aggregate the energy information. Portfolios are created which bring all the metered data to a centralized view. This data can be drilled down to a facility, floor, and meter and to each interval. The data is automatically collected and aggregated; one does not need spreadsheets or spend time entering energy usage for multiple areas for energy management.

More over each device in the customer's house may be electrically wired to a load point on the intelligent power meter and it can also be networked to this meter through an internal LAN using either wireless technologies or may be the power line communication techniques. In our project we have show the different types and technologies of communication links can be utilized as the communication medium in an AMR or automatic meter reading systems. This includes local area network technologies, wireless technology, Then we model and simulate each technique and show the result.

In our project, the results of running the simulation to study the effect of bandwidth, throughput and delay usage of the communication links were presented. These results are taken for both FTP and E-mail communication protocols between the power meters and the Hebron electric company. The used computer was a P4 Intel based computer with 512 MByte RAM, unfortunately only partial results were taken since any enlargement of the simulated system caused the compute system to crash with out of memory problems.

6.3 Future Works

- Our approach shows the applicability of Automatic Power Meter Reading mechanisms. Key enhancements to this approach are under study, including modifications to the scheme used to access remote network status information. Also more simulation tests should be considered.
- Multiple sites and subnets with single MAMR will be simulated when a simulation environment is available.

- Study of the power meters themselves and parameters that can be collected from them. In addition to the project already done to design the meter.
- Study of Fault tolerance issues related to AMR.
- Study the security of automatic power meter.
- Simulate the power line carrier or PLC.

Appendix

Appendix (1): Modeling Palestine Polytechnic University Network

The old PPU network connection there is a main switch in the server room connected with router and all the building connecting with serial dial up with band width 100Mbps and enhancing they replaced by fiber optic with band width 1G to reduce traffic so for this purpose we simulate a PPU result network to check performance and efficiency and when the bottleneck is occur , each Building in PPU has a server room that contain a server closet containing a main switch(24port) gather all uplink from all floor .

- Process simulate ppu network:

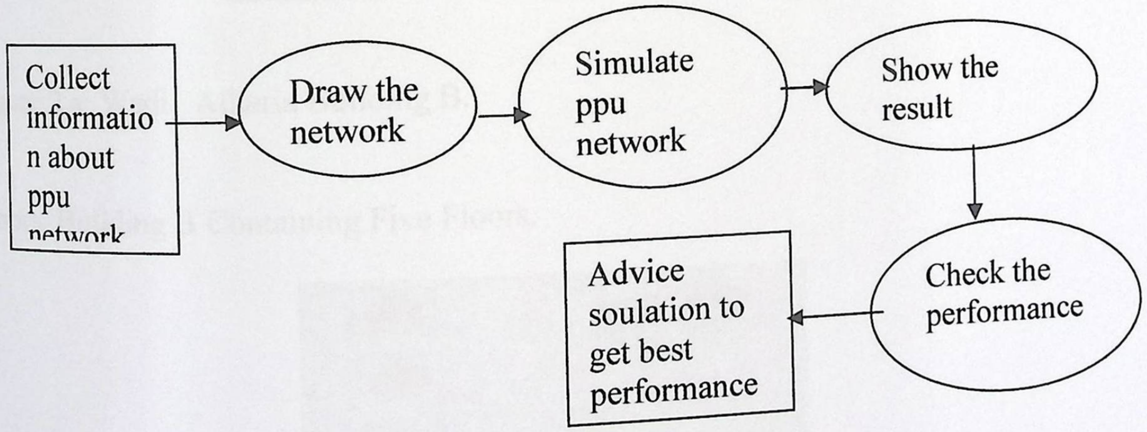

Figure 1.a: Process for PPU Simulation

- **Modeling the PPU network**

OPNET Modeler is the industry's leading environment for network modeling and simulation, allowing you to design and study communication networks, devices, protocols, and applications with unmatched flexibility and scalability.

Building B:

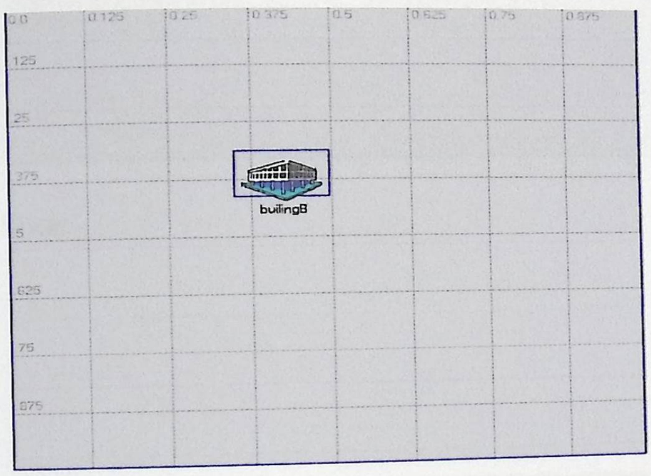

Figure 2.a: Wadi_ Alharia Building B.

Floors: Building B Containing Five Floors.

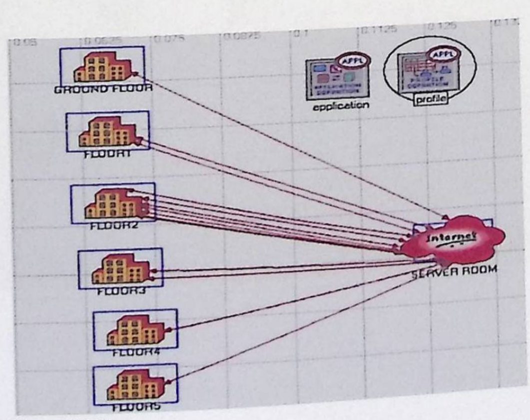

Figure 3.a: Floors in building(B).

Ground Floor: Car Test Center

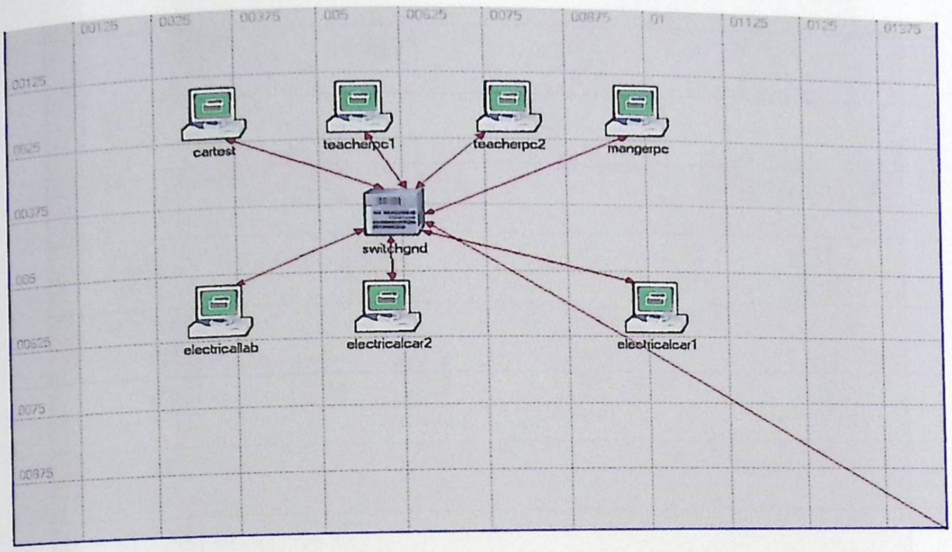

Figure 4.a: Ground Floor.

First Floor:

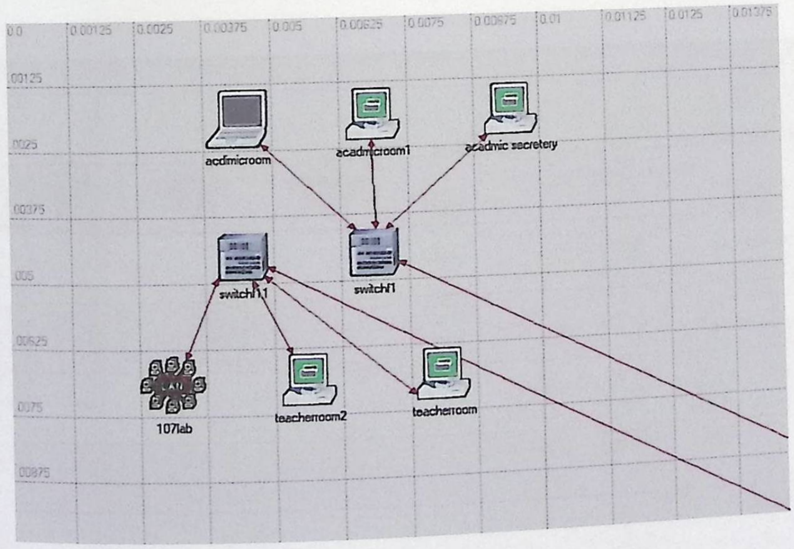

Figure 5.a: First Floor.

Second floor:

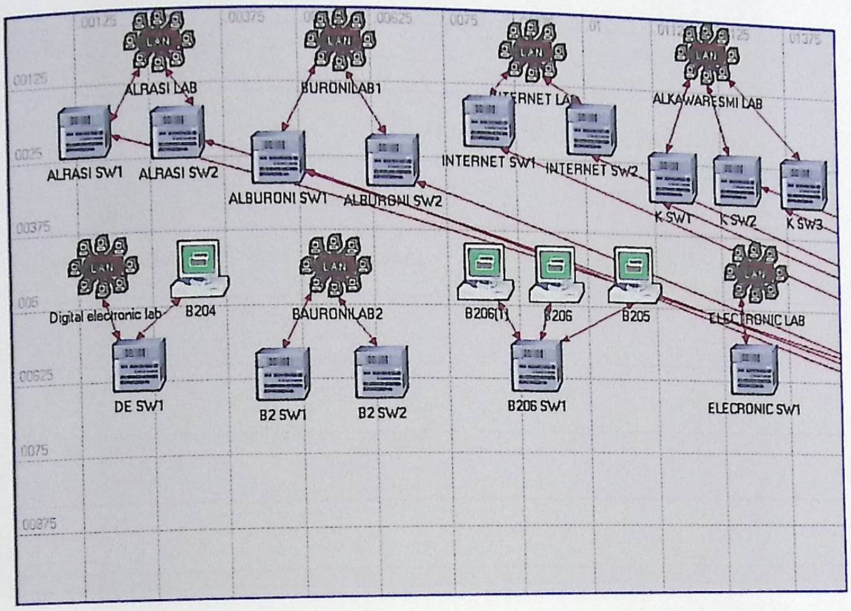

Figure 6.a: Second Floor.

Third floor:

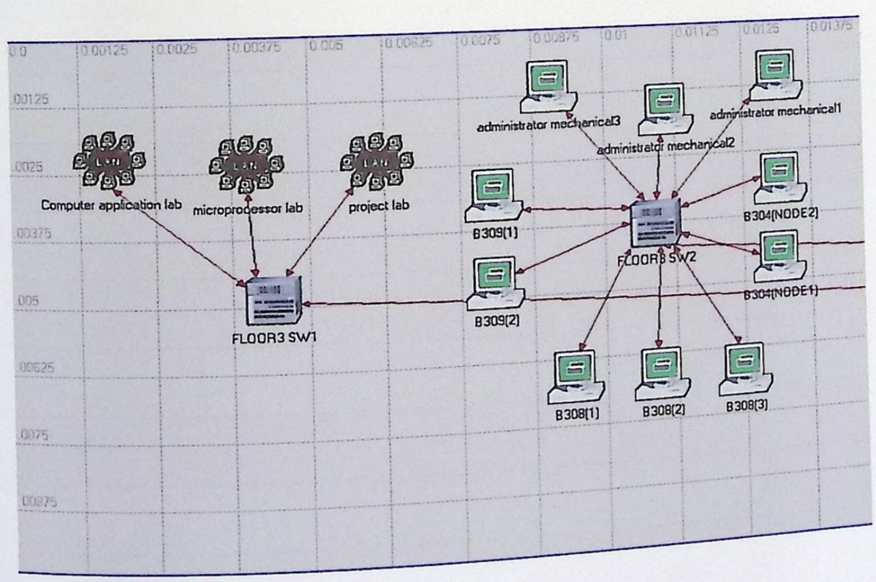

Figure 7.a: Third Floor.

Fourth floor:

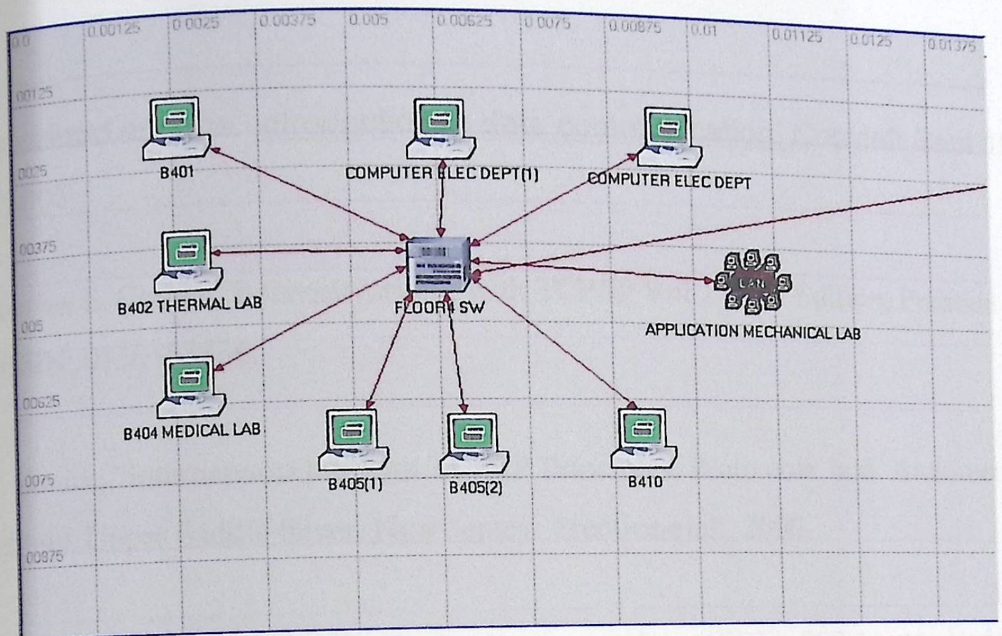

Figure 8.a: fourth floor.

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