WIRELESS LOCAL AREA NETWORK CONCEPTUAL DESIGN AND

PLANNING IN CAMPUS (PRACTICE IN UTP)

By

Asma Mohamad Morthir

Dissertation submitted in partial fulfillment of
the requirements for the
Bachelor of Technology (Hons)
(Information Technology)

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Universiti Teknologi PETRONAS
Bandar Seri Iskandar
31750 Tronoh
Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Information Technology Programme
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Approved:

_____
Mr. Izzatdin Abdul Aziz
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

July 2005

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein has not been undertaken or done by unspecified sources or persons.

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Asma Mohamad Morthir

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLE

ABSTRACT

Wireless communication is currently in a state of rapid evolution. This evolution is driven by the numerous advantages of the wireless networks. Wireless Local Area Network (WLAN) is one of the new networking environments where it supports the mobility of the network user without being encumbered by the existing cable. Since the current Local Area Network (LAN) in Universiti Teknologi PETRONAS (UTP) is *fairly growth with good performance reliability,* shifting the current setup to WLAN is locally accepted. This will benefit all the UTP users including students, respective lecturers, and beneficial for administration line of staff. The current planning and setup will cover certain stages in order to build a high reliability and best performance of the WLAN environment. Data transmission and signal strength for the area is practically surveyed in order to obtain best performance and ability to transmit data in bit per second required.

Research and questionnaire have also been done throughout the UTP students and IT Media Services Executives, in order to determine the best design concept to be applied in UTP campus and to determine the best place for WLAN to be implemented. Usage models are required in order to support the activity that will be in the WLAN environment. The conceptual design of WLAN environment will cater the area of the student residential including the Student Centre, cafeteria and student residential. With the design, location of all the devices such as the wireless access point (AP) and security access point (SAP) to roam the signal coverage and to secure the signal for data transmission can be determined. The technology used in data transmission is also being covered in this research paper, which includes the Spread Spectrum LAN. To ensure the system meets the budgeted cost, the author came out with the budgeting plan for all the devices allocated for the WLAN setup. The WLAN planning and setup in UTP will help the UTP management in getting the idea to implement a WLAN environment inside the campus as well to compliance with the current LAN setup.

ACKNOWLEDGEMENTS

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The author would like to take this opportunity to express his utmost respect and deepest gratitude to the supervisor, Mr. Izzatdin bin Abdul Aziz, for his supervision, commitment, professionalism, advice and guidance for completing this project. His readiness and patience in helping me with my project is highly appreciated. Author would also like to thanks Universiti Teknologi PETRONAS, the university which provided a basic module for the students to establish their own project.

This appreciation also goes to the author parents and family who are always supporting and encouraging. Special appreciation and thankful also dedicate to Information technology Department for the support and not to forget to all my colleagues, Mr. Nazri Nasir (Universiti Teknologi PETRONAS IT & Media Services IT Executives), Mr. Ruslan Razali (UTP Data Communication Lab Senior Technician), lecturers, technicians, staffs and students. Last but not least, to those who help directly or indirectly in completing this project. Thank you very much, your contributions are highly regarded and would be remembered.

May Allah bless all of you. Thank You.

CHAPTER 1

INTRODUCTION

1.1 Objective of Report

The objective of this report is to outline the conceptual design and planning of the wireless Local Area Network. The report details the various phases of the project, from initial research through to the preferred simulation. Also included are the project weaknesses and possible ways that it may be extended.

1.2 Background of Project

Wireless Local Area Network (WLAN) is becoming increasingly popular nowadays. The prohibitive cost of building wired network infrastructures has paved the way for wireless networking on a global scale. Developing countries, with more sophisticated network and Internet access than ever before, have surged ahead in the utilization of wireless networks so that even the most remote parts of the globe have coverage undreamed of only a few years ago. Although deployment of wireless LANs in Malaysia has lagged behind the rest of the world, the domestic market is now quickly coming up to speed. It is therefore of critical importance for the corporate network manager to understand not only how the wireless revolution is taking place but how this technological paradigm shift will affect the day-to-day monitoring and management of network data. The aim of this project is to produce a complete proposal of network planning and conceptual design for Wireless Local Network (WLAN) in campus especially in Universiti Teknologi Petronas. The objective of this project is to cater the planning and design that will cover certain preferred area. It also caters the total shifting from Local Area Network (LAN) to Wireless Local Area Network (WLAN). This project will overcome certain problem regarding the Wireless Local Area Network (WLAN) deployment in term of performance, reliability connectivity, interoperability, expandability, manageability, centralization of services for ease support and maintenance as well as the protection of investment

for future upgrades. The scope of this project is divided into four parts which are overview of the Wireless Local Area Network, function and network components, WLAN environment and topology including site surveying, security and conceptual design. Research and Implementation model methodology was applied in implementing this project.

University Teknologi Petronas network was designed as three (3) tiers network with a comprehensive triangle backbone to support an effective link redundancy. All tiers were strengthened by Passport 8600, supporting all edge switches from the distribution sources. This comprehensive triangle backbone taking place on supporting the entire major backbone link and this designed triangle will avoid any downtime from occurred.

Three passports supporting this major backbone are located at three different strategic places, which are Data Centre, Pocket C and Village 5. All these places are definitely strategic in supporting particular cases in this wide campus area of massive activities by students and lecturers.

There are two types of network in Universiti Teknologi Petronas (UTP) which is the Corporate Network and Student Network. Corporate network has a direct link to the PETRONAS webpage and server, known as PETRONET. This corporate Network only grants it access to the UTP staff in every department (Human Resources, IT Media and Services, Finance and etc.). Students have no privilege to access this network. This network has been blocked with firewall located at the Data Centre. It is known that each and everyone of UTP student will be granted a personal access to Student Network. This network allows students to access Internet and local intranet (e-learning and student portal). In order to follow the Petronas policy, every login session should pass Novell Border Manager. The function of this Novel Border Manager is to limit the bandwidth of every packet of data transmission in certain sessions. Every staff and student will be provided a personal ID in order to log-in into the system. The Novell Border Manager Server is located at the Data Centre.

All network setup in UTP will be hosted from the Data Centre (located at Main Chancellor Building basement). From data centre the connection will be routed back to the New Academic Building including Pocket C, D and old administration building and it also covers the connection to all students residential (Village 3, 4 and 5).

In order to adapt the Wireless Local Area Network in the student residential, design should be made based on the current Local Area Network in UTP. Students should only have an access to Student Network and bypass the Novell Border Manager following the PETRONAS policy. (Refer Figure 1: Network Type and Tiers in UTP in appendices)

In this project paper, the shifting of Wireless Local Area Network will be done towards the most suitable place based on its performance of the signal transmission, signal strength and less interference. Usage models and capacity of user in certain location also will be taken into account in order to implement well applicable Wireless Local Area Network (WLAN) area. Considering to the standard of the devices used during installation is compulsory, in order to make it compatible with the current LAN setup within the campus. As a result, the budgeting also will be secured and future upgrading can be easily implemented. Certain technique and discussion with the expert is done in order to get data regarding the usage models and capacity of user in certain area.

Three potential places which are suitable for shifting to Wireless Local Area Network area are as follows:

- New Academic Building
- Student Hostel (Village 3, 4 and 5)
- Student Residential Facilities (cafeteria and student lounge)

Site survey will be done to all of these areas o determine he best place to allocate the Wireless Local Area Network services. The other important thing need to be considered in this project setup is the technology used such as Spread Spectrum LAN, Low Power Narrowband, HiperLAN and Infrared LAN. However, in this project, author will focus on the Spread Spectrum technologies which comply with two methods of data transmission.

- Frequency Hopping Spread Spectrum
- Direct Sequence Spread Spectrum

Security, both corporate and home, is an increasingly important factor of all our lives. WLAN security is also important during the implementation. With regard of the security threats that usually manifest Wireless Local Area Network environment are:

- Unauthorized access
- Eavesdropping
- Attack from within the network neighbourhood

These security issues not only affect Wireless Local Area Network (WLAN) but also the current Local Area Network. To automate the well secured WLAN, the author decided to adhere with the current Local Area Network setup which protects the WLAN environment using certain gateway and firewall and authorization given towards every user into the network.

All the finding and simulation will help the author in designing the conceptual plan of the Wireless Local Area Network in UTP and the coverage area of the best location to be shifted to Wireless Local Area Network environment. The conceptual plan design will include the coverage area of the signals and bit persecond transmitted the location of the access point, antenna and the routing of the network from respecting Wireless Local Area Network server to UTP main core network node. The conceptual design will include the current setup of UTP Local Area Network and network type that will be allowed to bypass certain server. As mentioned earlier, there are two type of network in UTP, which is Corporate and Student Network. Gateway will only allow the person logging in as Corporate Network to access the PETRONAS Internet (PETRONET) from main headquarters (PETRONAS Twin Tower) and not for the person who log in as Student Network. All of these activities will also be protected with certain firewalls as for security concerns. The author's target is to come out in UTP Campus with the lowest budget but in secure system performance and capability in supporting user activities.

1.3 Problem Statement

Significant of the project

- Able to come out with suitable conceptual design plan of Wireless Local Area Network environment in Universiti Teknologi Petronas Campus.
- Be able to simulate the result and findings into certain demonstration. To come out with planning and the allocation of the hardware such as access point and the antenna.
- To determine the best coverage area and the suitable usage model before setting up the Wireless Local Area Network environment.

5

Problem Identification

Replacing wires with wireless & simplicity

WLAN transmits and receives data through the air, eliminating the need for wired physical connection o the network. The signal travel like normal radio signals; it do not require air or any other medium for transmission. They simple transmit information using antennas. Installing WLAN system happened to be fast and easy and can eliminate the need for installing cable through walls and ceilings. Thus, it can results in tremendous time saving in the initial deployment. Wirelesses LAN are far easier to deploy and manage. The entire deployment process will take less than one fourth of the time that will take to deploy a wired LAN. To upgrade the LAN, only a change of APs and network cards will be required. No more pulling all the network cable and reinstalling it again. WLAN provide all the functionality of wired LANs without the physical constrains of the wire itself.

Lost connection

With wired LANs, lost connections to local origin severally occur within working time. Among the most significant results revealed by recent end user surveys is that using wireless LANs allows users to stay connected to their network for approximately five and three-quarter more hours each day. A user with a laptop and a wireless connection can roam their working area without losing their connection, or having to log in again on a new machine in a different location. This translates to a very real increase in productivity, as much as 50% for the average user. With WLAN implementation in appropriate location, respond time for accessing system can be minimize.

Productivity

Due to connectivity and wired devices circumstances, performance productivity are not achieve to it maximum values. Ease of wireless LAN usage and increase of mobility will greatly enhance productivity. Students as well as staff could be able to share ideas, discussion and perform live

6

demonstrations. This factor enhanced productivity as well s indirectly affects the revenue generation process within campus. With wireless connectivity to facilitate access to information and information exchanges and to enhance learning.

Enhanced mobility

With wired LANs, providing access to users could be quite difficult, especially in meeting rooms or in public places such as cafeteria and lounge area where wired connection might not be aesthetically appealing. Via deploying Wireless LANs, computing flexibility are enhanced where it can help user take advantage of mobile networking for e-mail, Internet access, and sharing files regardless of where they are in the campus. This, in turn, can enhance the creative process by letting users meet in the conference room to collaborate on a project, or enable work in non-traditional environments such as the cafeteria and private residential which are not possible with wired networks.

Installation flexibility

Wireless technology allows the network to go where wire cannot. Ireless networks can be designed to be extremely simple or quite complex. Wireless network can support large numbers of nodes and/or large physical areas by adding access points to boot and extend coverage. Today's WLANs provide interconnection with wired networks such as Ethernet. WLAN nodes are supported by network operating system in the same fashion as any other LAN node, through the use of the appropriate drivers. Once installed, the network treats wireless nodes like any other network component.

1.4 Objective and Scope of Study

1.4.1 To come up with suitable wireless transmission technology which are suitable to be used within UTP campus as well as to produce a conceptual design of the wireless signal coverage area and access point allocation and antenna location to cater the best mobility and performance.

1.4.2 Site Survey

   i.   Usage models
   ii.   Capacity of user
   iii. Type of signal interference
   iv.   Coverage area and signal strength

1.4.3 Suitable transmission medium technology concentrating on the Spread Spectrum LAN which can be categorized under two methods:

   - Frequency Hopping Spread Spectrum
   - Direct Sequence Spread Spectrum

1.4.4 Hardware decision for installation

   i.   Surveyed toward hardware suitability and compatibility in UTP.
   ii.   Access point standard comparison (802.11a, 802.11b)
   iii. Hardware allocation taking consideration into constraint (cost, recent operation compatibility, operation performance)
   iv.   Present price quotation and costing towards all the devices installed during the setup.

1.4.5 Able to demonstrate the result and finding into simulations.

   i.   Site survey
   ii.   Access point

CHAPTER 2
LITERATURE REVIEW

The world is going wireless. It has becoming ubiquitous and increasingly relied upon. From airport lounges and hotel meeting room to café and restaurants across the globe, wireless LANs are being built for mobile professionals to stay connected to the Internet. The market for wireless communications has grown rapidly since the introduction of 802.11b wireless local area networking standards, which offer performance more nearly comparable to that of Ethernet [7]. Business organization as well as universities values the simplicity and scalability of wireless LANs and the relative ease of integrating wireless access and the ability to roam with its existing network resources such as servers, printers and Internet connections. Wireless LANs support user demand for seamless connectivity, flexibility and mobility [8]. Wireless is for use in locations that are difficult to wire. Such as building with asbestos, factory floor and temporary installations such as Desert Storm, disaster recovery sites and trade shows. WLAN transfers information, applications, and files through air interface by using radio frequencies electromagnetic waves instead of wires. In addition, productivity is no longer limited to areas where a network connection is located. Users can now move from place to place, and accessing the network when and where they want.

Wireless networks have exploded onto the scene and in the aftermath, they have generated a great deal of confusion about different type of wireless data networks. Basically, there are two primary types of wireless communication: wireless local or campus area network and wireless metropolitan and wide area networks.[13]

There are three main applications of wireless technology that are in use today: wireless application protocol, wireless Internet connections and wireless networks. Wireless application protocol (WAP) is "an Internet protocol developed for

9

Valuable experiences that took place on other campuses, like the ones at Tennessee University or Carnegie Mellon University detailed in [4] and [5] can provide an important insight about the complexities of these networks. Some of the proposed policies there can be taken in consideration here too. Given the wide availability of wireless networking devices, it is must to enable a campus-wide policy to avoid a negligent use of access points. This may happen when users not aware of potential security threats are setting up unprotected access points (APs) anywhere in the campus network. These APs maybe used to get unauthorized access to the campus network from even miles away of the campus. Such uncontrolled access may happen even to protected areas of the campus network where policies are based on the source address of the request. To prevent such a thing to happen it is better to create up-front a specific and independent backbone for wireless devices where the proper security policy will be enforced.

The paper by Bennington and Bartel, entitled "Wireless Andrew: Building a high speed, campus-wide wireless data network", describes their experience with building *Wireless Andrew*, a high-speed campus-area wireless network at Carnegie Mellon University. The network is used both as a research platform and for everyday access to the Internet. As such, this paper is an important addition to the literature.

As wireless LAN applications require higher performance, the design of a wireless LAN needs greater attention. In some cases, however, the decision on what settings to include in the access points becomes somewhat of a guessing game, mainly because of the difficulty in determining the impact of varying levels of user activity, RF interference, and moving propagation boundaries. There are several factors to be considered, in order design the Wireless LANs.

- Interference
- Throughput
- Coverage vs. Capacity.

In order to implement a wireless LAN that meets expectations, author would like to consider the use of site survey. It is important to place the access point at the location with less interference and noise distortion that will distract the signal while

11

transmitting the radio frequency signal. These signals transmit all packets and decoded it to the transmitter and send it back to the receiver via the wireless network interface card. This also involves the process of decoding back the packets into understandable signal to the workstation. Site survey will be done in checking the signal strength in preferred area within the development area. The surveyed include the signal strength percentage coverage area, link quality, link speed and the frequency of the area surveyed.

Usage model need to be considered in implementing the design. This will help in determining the minimum bandwidth for each simultaneous user. The expected usage will be different at different sites. In determine simultaneous user, questionnaire s done to determine the peek hours of the service used ad maximum capacity of user can be allocated in to certain area.

The successful of the Wireless LANs setup is determined if all of the elements required is implemented. The shifting network topology to Wireless LANs will allow users in UTP campus to interact wirelessly without encumbered by cable.

2.1 How WLAN works

According to WLANA.com (1999), wireless LANs use electromagnetic airwaves (radio and infrared) to communicate information from one point to another without relying on any physical connection. Radio waves are often referred to as radio carriers because they simply perform the function of delivering energy to a remote receiver. The data being transmitted is superimposed on the radio carrier so that it can be accurately extracted at the receiving end. This is generally referred to as modulation of the carrier by the information being transmitted. Once data is superimposed (modulated) onto the radio carrier, the radio signal occupies more than a single frequency, since the frequency or bit rate of the modulating information adds to the carrier. Multiple radio carriers can exist in the same space at the same time without interfering with each other if the radio waves are transmitted on different radio frequencies. To extract data, a radio receiver tunes in (or selects) one radio frequency while rejecting all other radio signals on different frequencies.

In a typical WLAN configuration, a transmitter/receiver (transceiver) device, called an *access point*, connects to the wired network from a fixed location using standard Ethernet cable. At a minimum, the access point receives, buffers, and transmits data between the WLAN and the wired network infrastructure. A single access point can support a small group of users and can function within a range of less than one hundred to several hundred feet. The access point (or the antenna attached to the access point) is usually mounted high but may be mounted essentially anywhere that is practical as long as the desired radio coverage is obtained.

End users access the WLAN through wireless LAN adapters, which are implemented as PC cards in notebook computers, or use ISA or PCI adapters in desktop computers, or fully integrated devices within handheld computers. WLAN adapters provide an interface between the client network operating system (NOS) and the airwaves (via an antenna). The nature of the wireless connection is transparent to the NOS.

2.2 WLAN standards

For WLAN, the standard for family of networking specifications that was developed by a working group of the Institute of Electrical and Electronics Engineers (IEEE) is known as the 802.11 standard. The 802.11 standard ensures that WLAN devices from one vendor will interoperate with those from other vendors. However, there are several specifications in the family. The following table identifies 802.11 standards and its specifications:

Table 1   Various 802.11 standards and its specifications as of 10th June 2005.

Standard	Functions and Specifications
802.11	• Family of specifications for WLAN use • Employs phase-shift keying • Provides a wireless alternative to wired Ethernet LANs • Several enhancements as defined below
802.11a	• Enhancement to 802.11 that applies to wireless Asynchronous Transfer Module (ATM) systems • Used in access hubs • Enhanced data speed – 54 Megabits per second (Mbps) • Frequency range 5.725 GHz to 5.850 GHz
802.11b	• Enhancement to 802.11 that employs Complementary Code Keying (CCK) • High data speed – 11 Mbps • Low susceptibility to multipath-propagation interference • Frequency range 2.400 GHz to 2.4835 GHz
802.11d	• Enhancement to 802.11 that allows for global Roaming • Attributes similar to 802.11b • Particulars can be set at Media Access Control (MAC) layer
802.11e	• Enhancement to 802.11 that includes Quality of Service (QoS) features • Facilitates prioritization of data, voice, and video transmissions
802.11g	• Enhancement to 802.11 that offers wireless transmission over relatively short distances • Operates at up to 54 Mbps
802.11h	• Enhancement to 802.11a that resolves interference issues • Dynamic frequency selection (DFS) • Transmit power control (TPC)
802.11i	• Enhancement to 802.11 that offers additional security for WLAN applications
802.11j	• Japanese regulatory extensions to 802.11a specification • Frequency range 4.9 GHz to 5.0 GHz
802.11k	• Radio resource measurements for networks using 802.11 family specifications
802.11m	• Maintenance of 802.11 family specifications • Corrections and amendments to existing documentation
Wi-Fi	• Originally created to ensure compatibility among 802.11b products • Can run under any 802.11 standard • Indicates interoperability certification by Wi-Fi Alliance

14

CHAPTER 3
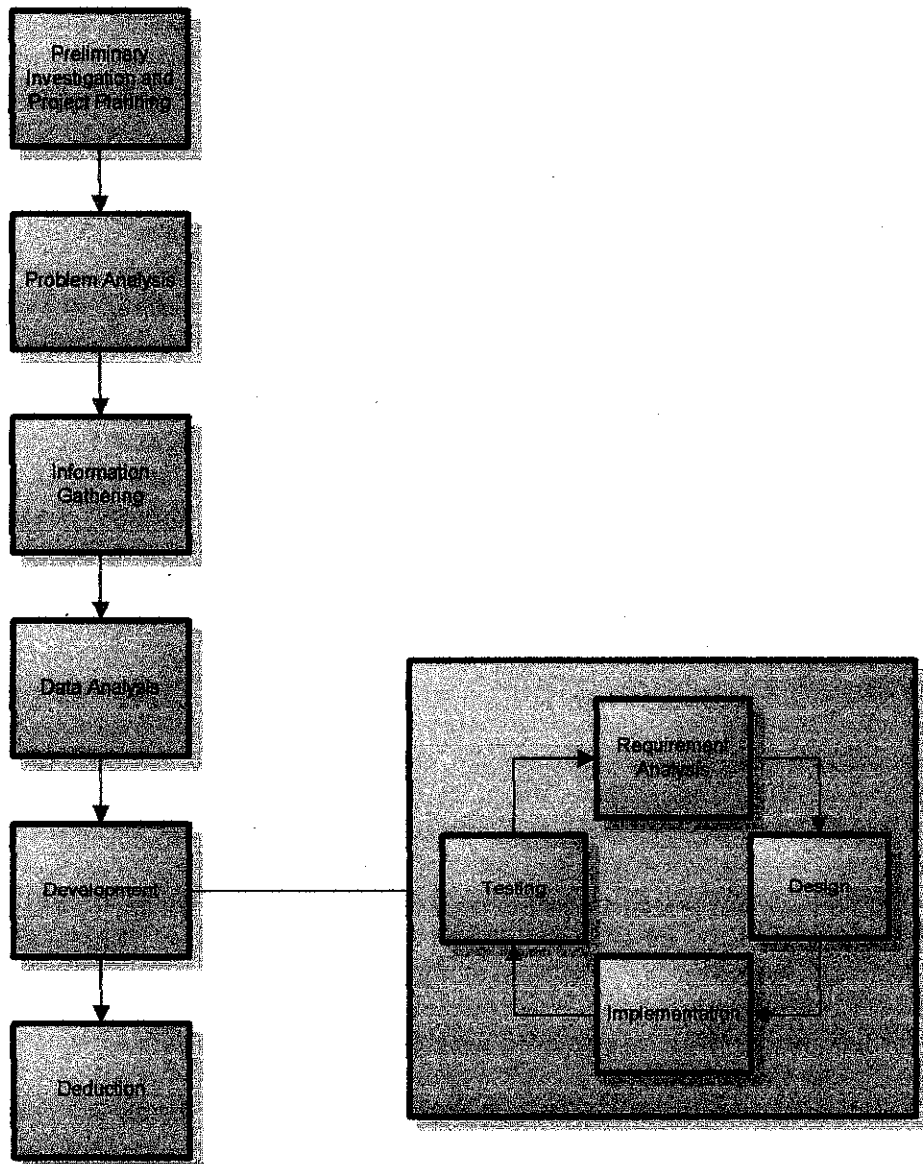
METHODOLOGY

3.1 Procedure Identification

Figure 3.1 Research and Implementation Model

3.1.1 Preliminary Investigation and Project Planning

In this phase, the scope of the research study in wireless technology in focus on wireless local area network. There are five type of network topology which is bus, ring, star, tree and mesh. The characteristics of each topology are studied in order to enhance understanding on this topic before proceeding to the next research phase. A project schedule is planned between the author and supervisor as a guideline to project commission. This is to ensure the project commission such as progress report and interim report meets deadliness. The author will also be describing the major area of research, determining the scope of studies, problem statement and the proposed solution towards the problem. Literature review, journals and thesis have been reviewed for further supporting of the research.

3.1.2 Problem Analysis

The issues of replacing wires with wireless & simplicity, cost, mobility, installation flexibility and data dissemination is identified which include weak connectivity and resource constraint and higher access time. The characteristics of data dissemination techniques are also identified to be analyzed and compared sequentially to come up with suitable wireless transmission technology which is suitable to be used within UTP campus as well as to produce a conceptual design of the wireless signal coverage area and access point allocation and antenna location to cater the best mobility and performance.

3.1.3 Information Gathering

There are three main types of information gathering to support the research hypothesis which are:

1. Observation

Basically, observations consist of sensing the phenomenon around us in order to get most of the research. For example, the author observes the surrounding in UTP and how wireless technology affected their life.

2. Intensive Internet and Library Research

This is a quantitative type of information gathering. The internet research includes articles and journals from other researcher of the same topic, while library research includes books on Wireless Local Area Network and wireless technology. Most of the articles are taken from IEEE website. However, these articles are more detail as most researchers are from Electrical Engineering background. Therefore, the author has to filter the information only to those data related to author's scope of research. By this, understanding on the concept will be much easier.

3. Questionnaires

Questionnaires, qualitative types of information gathering are a special-purpose documents that allow the author to collect information and opinions from respondents. This type of data gathering is inexpensive and suitable for gathering data from a large number of individuals, in this case for students and lecturers. Close ended questionnaires is distributed before developing the mobile prototype application. The questionnaires are to identify which data is most requested to be disseminated and broadcasted to the wireless local area network. Another advantage of questionnaire is that the responses can be tabulated and analyzed quickly.

The factors that affect the author's decision on the sampling size are basically:

1. **The target users of the application**

Since the wireless local area network is targeted to be used by students, staffs and lectures therefore, it is suitable to distribute the questionnaires to these groups. The distribution of questionnaires are scattered across students.

2. **The size of population**

There are approximately 200 students and staff at village 4 building. Therefore, sample size of 50 is enough to present the author's findings.

3.1.4 Data Analysis

The result of the findings from the information gathering phase is analyzed to determine the research hypothesis which is the author's best solution of the data dissemination technique. Therefore, both qualitative and quantitative information that is gathered from the previous phase will be tested through appropriate statistical analysis before being implemented inside development phase. Suitability and compatibility of the data will be further analyzed by supporting ideas from the expert and if there is certain malfunction occur during the installation or hands on deploying the peripherals and site surveyed. This data will be considered back and changes will be done. Alternatives of the changes are listed and tested in order to suit with the best planning.

3.1.5 Development

This phase includes designing the conceptual design prototype based on the findings in Data Analysis phase. The development of the conceptual design is based on the iterative model which consists of:

Requirement Analysis – The data collected from information gathering is considered as the requirement from the users of the wireless LAN application and devices.

Design – The conceptual design will be done based on the findings found during the information gathering phase.

Implementation – Based on the conceptual design, a simple wireless application will be design based on the conceptual design of the wireless LAN.

Testing – The application is tested in order to determine whether the conceptual design can be implement successfully within the campus.

3.1.6 Deduction

Deduction will is phase whereby it concludes the findings of the research by interpreting the meaning of the results of the data analysis. For example, the author would like to evaluate on different data dissemination technique. Therefore, the deduction is to come out with the best conceptual design of the wireless LAN. The finalize data and theory will be compiled into final dissertation and towards the planning of Wireless Local Area Network in UTP.

3.2 Tool required

Tool required on this project is base on the stages of the research progress.

3.2.1 Site survey and signal strength determination towards selected area

    i.   CISCO Aironet System Network Software – design for site surveying and signal transmission setting for Wireless Local Area Network environment.

    ii.   laptop equipped with wireless interface card

    iii.   UTP current Local Area Network connectivity

    iv.   Wireless LAN Mobile Adapter 2201 (with unique 802.11a/11b roaming capability)

    v.   Access point 2220 and the WLAN Security Switch 2250

3.2.2 Hardware (installation)

       i.   Passport 8600

      ii.   Business Policy Switch 2000

     iii.   Wireless LAN Access Point 2221

     iv.   Gigabit Interface Converter Media Dependant Adapters

      v.   Wireless Local Area Network Security Switch 2250

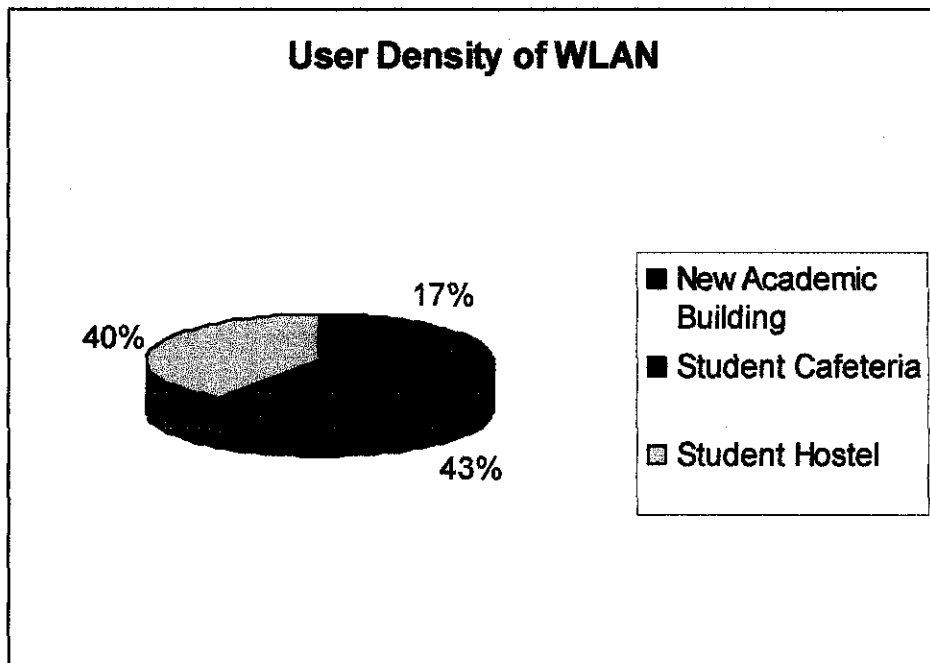### 3.2.3 WLAN Conceptual Design phase

      i.   Microsoft Visio

CHAPTER 4

RESULTS AND DISCUSSION

4.1   Usage Model

It is important to know the layout number of user and the user density of user per unit area. The number of user will determine the bandwidth required. To get the result, questionnaire is segregated to students.

Result:

Discussion:

From the survey it shows that almost 43 % of UTP student prefer Wireless Local Area Network to be deploy in cafeteria since all students do their discussion, study group and spending leisure time within that region.40% of the student prefer to go for

wireless connection in their own room for own convenience and finally 15% of student prefer at the New Academic building.

As the result from the area selected, author will proceed with the next stage where peak hours that student will be coming to café and percentage of activity that will be done in the café based on certain criteria. The time of peak hour will be taken for every 2 hours assuming that student will be in the café from 8 am until 12 midnight.

WLAN PEAK HOURS USAGE
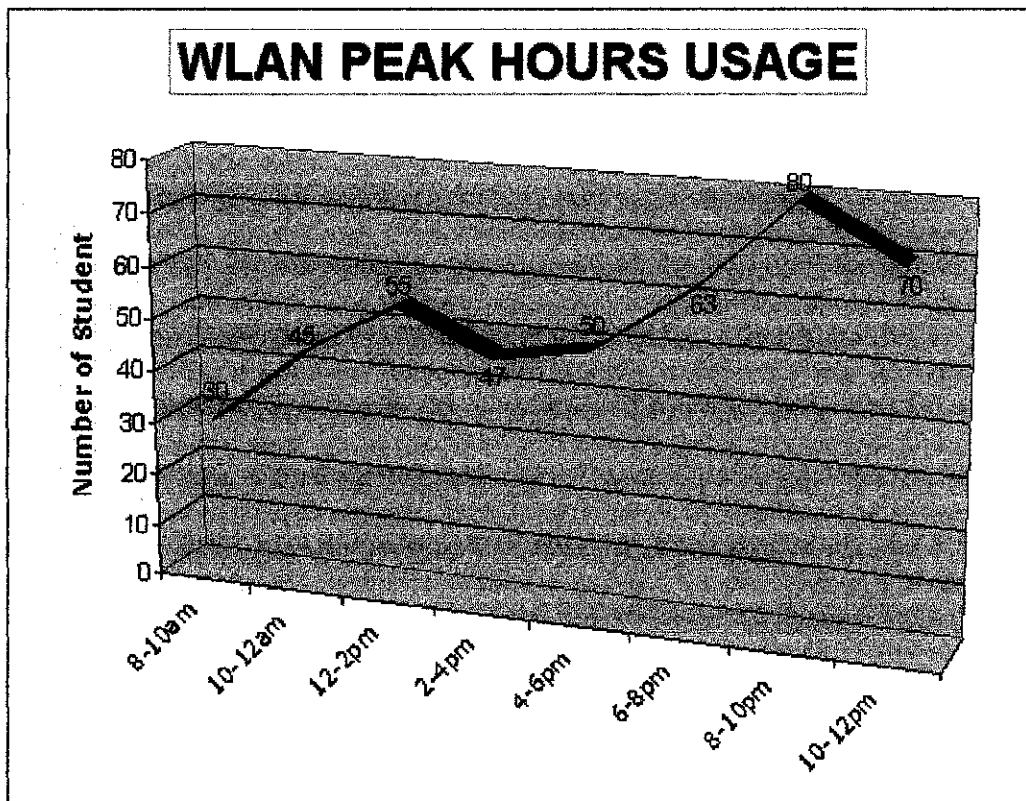
Discussion:

As shown in figure, the best place to implement the Wireless Local Area Network is the student cafeteria. Since the maximum user will be predicted around 80 to 100 people in the area at peak hour (8pm to 12 midnight).

We can determine the maximum bandwidth that will be allocated to one user. In the typical sites it requires at least 200Kbps and multiplies with the simultaneous user.

Assume that simultaneous user is 20

22

200Kbps × 20 simultaneous users = 4000Kbps = 4.0 Mbps bandwidth needed

For the access point (AP), one AP can provide coverage for the physical area of 50 users. During the planning number of AP needed will be 5 for each area. This will cover at least 100 users per session.

4.2 Technology

The transmission of the data is crucial in a wireless environment. There are certain categories of technologies used within this environment.

i. Spread Spectrum LAN
ii. Low Power Narrowband
iii. Infrared LAN
iv. Hyper LAN

For this project, it will only concentrate on the spectrum modulation technology for the Wireless Local Area Network in this campus. Spread spectrum is a technique that spread a narrow signal over a broader portion of the radio frequency band. Spread spectrum is more resistant to outside interference. This is because any interference would only affect a small portion of the signals instead of the entire signal. Spread spectrum likewise resulted in less interference and fewer errors. It is also difficult to detect and intercept the signals during the transmission. It also reduces errors as the signal undergoes demodulation process at the receiver end. This is due to the fact that any interference would only affect a small portion of the spread signal. The usage of the spread spectrum signal does not require any special licence from authorities, provided that the devices used meet the preferred requirement such as frequency and coverage.

In the spread spectrum technology there are two common methods in the data transmission:

     i.   Frequency Hopping Spread Spectrum - FHSS

     ii.   Direct Sequence Spread Spectrum – DSSS

Frequency Hopping Spread Spectrum - FHSS

FHSS transmits a short burst at one frequency then another short bursting at another frequency and so on until the entire signal have been sent. Frequency hoping can also reduce the impact of interference from other radio signals. An interfering signal will only affect the FHSS signal when both transmitted at the same frequency. Because FHSS transmit a short burst over a wide range of frequencies; the extent of any interference will be very small and can easily be corrected by error checking. FHSS transmit a short burst on one frequency that is typically 1 MHz. As a result it will create a minimal interference of other signals.

Direct Sequence Spread Spectrum – DSSS

While DSSS generate redundant bit pattern to represent the bit needed to be transmitted. This pattern bit is known as chipping code. The recovery code is depending on how long the chipping code would make the recovery of the original data. In this process a large bandwidth is required for the whole network. DSSS require a high cost and utilize more power than FHSS. However DSSS wireless LAN has a potential for greater transmission speed rather than FHSS. DSSS transmit on a frequency that is 22 Hz wide.

In this project, after considering the location ad the area of the project, it is better to utilize FHSS as the transmission medium. It is because FHSS involves in dividing a range of the radio spectrum into individual channels. Each of the channels is presenting one specific frequency. Data signals will then hop from frequency as a function of time according to a specific pattern known as hopping code. In order to get the signal, the receiver must use the same hopping code while listening to the incoming data signal at right time and on the correct frequency. It will also eliminate enormous error.

24

4.3 Security

The element is crucial in implementing a WLAN to prevent certain hacking and intrusion risk. Nonetheless, the problems of security affect not only a WLAN but also the wired LAN environment. These are the common threats that usually occurred:

    i.   Eavesdropping

    ii.   Attacks from or within neighbourhood

    iii.   Unauthorized access

4.3.1 FHSS Technology

The reason why FHSS is implemented as a transmission medium because it can be used to provides security for the data signal. This transmission runs through the channels in a random sequence and allows the data to be on a channel for a fixed amount of time and then transfer it to the next channel in the sequences. Without information concerning the "dwell time" (time spent on each channel) and the hopping pattern, it is impossible for the non-participating station to receive and encoded the data.

4.3.2 User Authentication or Local Station Password

This is important and it is a regular practice to the entire user to have their own login id as to authenticate them using the system, since it is more concerning the fact that WLAN support mobile users. Network OS such as Microsoft NT and Novell Netware provide built in security measurement such as user login and password. A strict passwords policy can ensure that a station can only be handled by the person assigned to. Ethically, password must be changed frequently.

4.3.3 Data Encryption

Data encryption can be installed using the third party software or hardware. This can be classified into the highest level of security that can be implemented in WLAN in UTP campus, since it deals with a large numbers of users with different transactions. Basically all the data transmitted through the packets will be scrambled before it send

25

over the LAN. The receiver from the other site must be able to encode or decrypt back the data using the decryption key and read the data.

4.3.2 Station Authentication System or ESS ID

For the station to access the network o ESS, the access point would first check the station 32 characters ESS ID matches its on. Outside nodes, even having the same products, it can participate in the network nor learn the hopping pattern, thus eliminate the possibility to eavesdrop. This ESS ID is programmed into wireless adapter (SA-10 PRO, SA-40 PRO, SA-PCR and AP-10), under the control of an installer password and the changers can only be made on the adapters itself using HyperTerminal.

4.4 WLAN Testing

3 WLAN tests were done on separate occasions as the results of each testing and experiment helps the author in designing the best and suitable WLAN for the implementation in UTP.

4.4.1 First WLAN Implementation in Building 2

The following results were captured during a WLAN test, done in the Data Communication Laboratory in Building 2. The objective of conducting this WLAN test is to analyze and measure the strength and quality of the signal from laboratory using Aironet Client Utility. The results were based on the position of the antenna.

Building 2 - Inside data communication laboratory	Building 2 - Inside multimedia laboratory
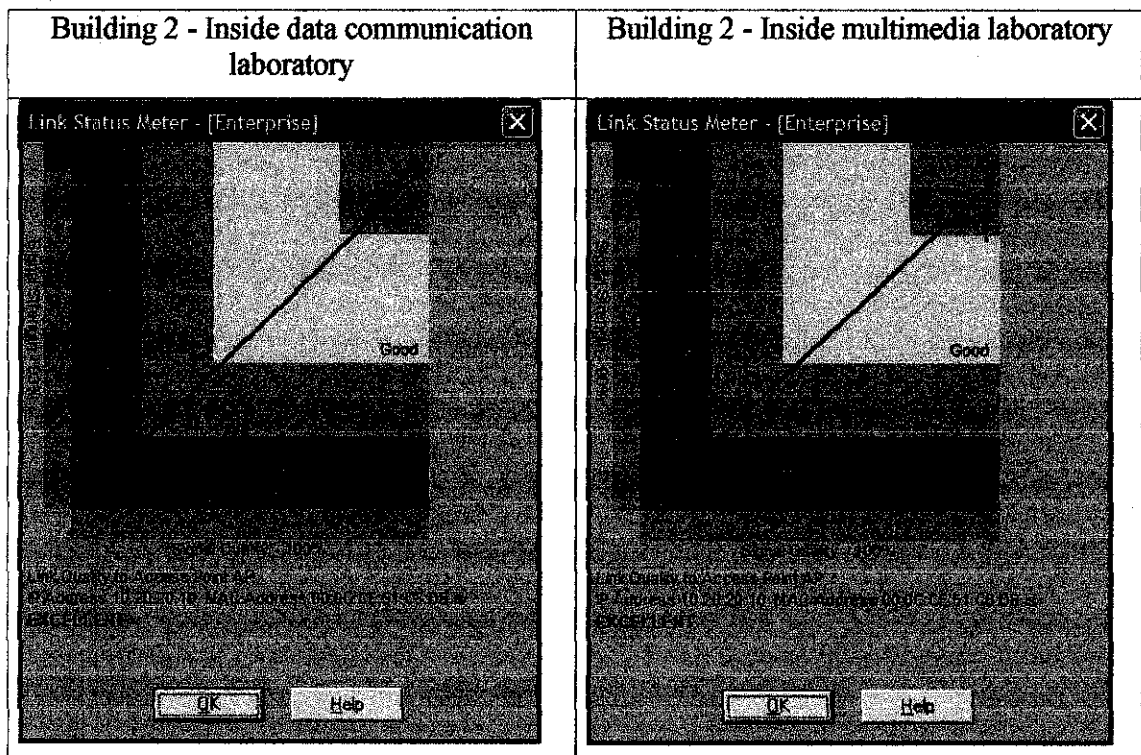
First WLAN test was conducted on 14th October 2005. The objectives of this testing are:

1. To create a Cisco Infrastructure Networked WLAN.

27

2. To see whether 2 separate WLANs (the newly created and the existing connection) can be linked or connected together and tested out by streaming television input from one connection to another.

The two separate WLANs also known as islands were set up in the laboratory. Both WLANs are Infrastructure Networked WLAN which uses access points that are connected to a wired network. This allows the stations on the network to communicate among themselves as well as with clients on the wired network.

Island 1: The existing WLAN connection connected to the codec server.

Island 2: New WLAN connection connected to the decoder server.

Island 2 was configured to have similar settings and configuration as Island 1 in order to allow the two islands to connect and communicate with each other. The WLAN test was then carried out by streaming a television input, provided by Island 1 from the following address: http://radius01/rtm01.htm. Later, more users (PCs) were tuned to stream the television input from the same address. This is to investigate whether the number of users would affect the speed of the WLAN connection.
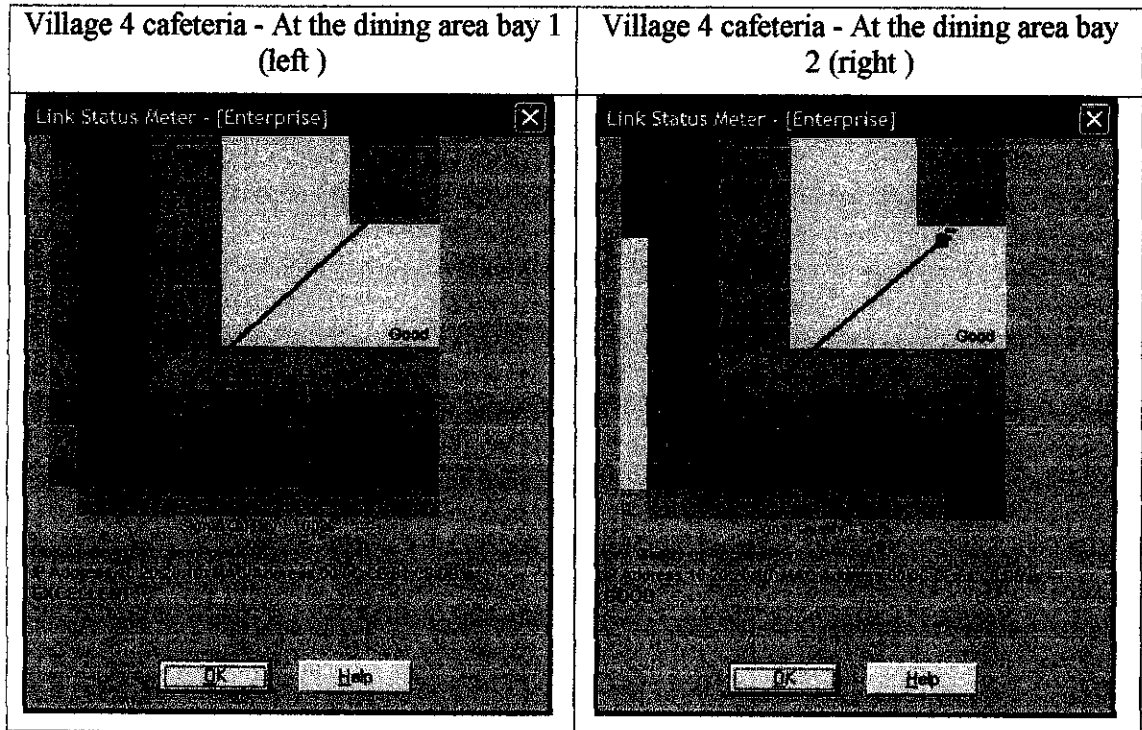
Results

The quality of streaming proved to be satisfying. The television quality remains the same although many users are tuned to the same television input or streaming source. However, a bit of delay was experienced as streaming users are placed in buffer based on first come first serve basis.

Discussion

An access point or bridge can hold up to 250 or 300 users in a single network. However, in actual practice, the number should be fewer. The main reason for this is the impact of distance has on bandwidth: stations that are farther away suffer a decrease in the speed of transmission. Although it would be ideal for all stations to have a bandwidth of 11Mbps, it would be difficult to design the layout of a WLAN so

28

that 300 users were all squeezed within 50 meters of an access point. Furthermore, as more users are added to the network, the amount of network traffic increases, which again has a negative impact on bandwidth.

4.4.2 Second WLAN Implementation in Village 4

Village 4 cafeteria - At the dining area bay 1 (left)	Village 4 cafeteria - At the dining area bay 2 (right)

Results

Based on the figure, signal and strength received by user at dining bay 1 are excellent where it gives 93%. On the other side of the café which is at the bay 2, the strength and signal achieve only 72%. Both places can receive the signal from the antenna.
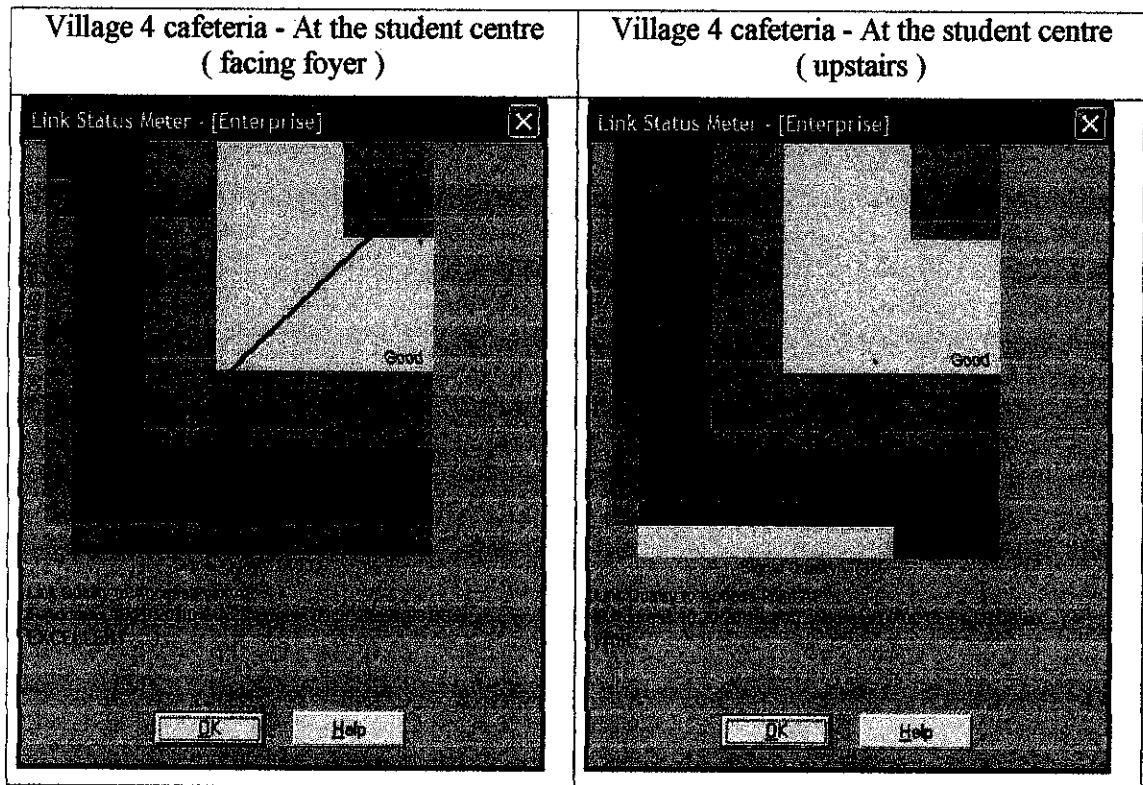
Discussion

After conducting the simple WLAN test in Village 4 cafeteria, it is found that:

1. The strength and quality of the signal increases by placing the antenna towards the direction of the intended area. This shows that the antenna used (AIR-ANT 1949 Yagi antenna) is not an omni directional antenna. Therefore, the placement of the antenna is very crucial, in order to get the better signal strength and quality.

29

2. The antenna would provide better signal strength and quality when placed outside of the laboratory, since the laboratory has a lot of interferences such as metal and glass doors, fluorescent lights, computers, printers and so forth.

3. Although some of the areas tested had weak signals strength, the computer was still connected to the network. By conducting site surveys, areas with weak signal can be enhanced and strengthen by placing another access points which acts as repeaters (within the same building) or bridges (other buildings).

4.4.2 Third WLAN Implementation in Village 4

Village 4 cafeteria - At the student centre (facing foyer)	Village 4 cafeteria - At the student centre (upstairs)

Results

The strength and quality of the signal was proved to be satisfying. This is done by placing the antenna towards the direction of the intended area. The antenna would provide better signal strength and quality when it is placed in the middle of the cafeteria. Because of the antenna provide only a directional signal, the strength and signal received by place 2 (At the student centre - upstairs) was only happened to be 34%.

30

Discussion

After conducting the WLAN test, it is found that:

1. WLAN can be implemented in Village 4 easily by duplicating the same WLAN configuration done in Building 2.

2. The devices must be placed outdoors in order to maximize the signal strength and the area of coverage.

4.5 Hardware

Passport 8600

The Nortel Networks Passport 8600 series Ethernet Switch delivers a highly available, operationally simplistic, and intelligent network routing solution. In addition, hardware based wire speed performance enables fast and efficient traffic classification, policy enforcement, and filtering. The Passport 8600 series Ethernet Switch delivers a robust, secure, and intelligent solution that provides a true competitive edge.

Passport 8600 will take place as the main back bone for UTP in delivering the data flow seamlessly all over the UTP wide area Network. The Passport 8600 switch modules provide a full complement of core routing and switching capabilities in a Passport 8000 Series chassis. The Passport 8600 modules provide 10/100 megabit per second (Mb/s) auto-negotiating twisted pair Ethernet ports, 100 Mb/s fiber Ethernet ports, fiber and copper Gigabit Ethernet ports, packet over SONET, and ATM.

A Passport 8000 Series chassis with installed Passport 8600 modules constitutes a single switching entity with distributed management and full redundancy that delivers wire-speed routing and layer switching.

The Passport 8600 modules include a switch fabric module and eight different input/output (I/O) modules. One switch fabric module is required for each Passport 8600 switch; for CPU system redundancy and double switch fabric capacity, you can install two switch fabric modules. You can install up to eight Passport 8600 I/O modules in a Passport 8010 chassis, and up to four I/O modules in a Passport 8006 chassis. The I/O modules support different types of Ethernet interfaces with different speeds, port counts, and media types, as well as packet over SONET and ATM.

Passport 8600 Key features and benefits

32

i. High availability - A Passport 8600 Ethernet Switch with Split-MLT improves reliability, redundancy and applications performance for the entire network.

ii. Operational simplicity - Passport 8600 technologies like multimedia filters reduce configuration time and speed up network deployment and fault finding.

iii. Superior intelligence - Integrated Layer 4 thru Layer 7 forwarding capabilities improve applications performance by allowing you to balance and direct requests to the most effective resource.

iv. Lower cost of ownership - Hot swappable components and full network utilization are designed to let you use what you pay for all the time. The lean architecture of the Passport 8600 decreases the number of network components. Further reducing costs. Figure shown a model of single Passport 8600
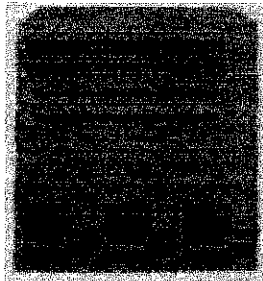
Figure: Passport 8600 Accessories

Business Policy Switch 2000

Business Policy Switch is a stackable Ethernet solution that delivers the industry's highest level of network availability, density, manageability and reliability. The Business Policy Switch is a stackable 10/100+1000 megabit-per-second (Mbps) Ethernet system.

Business Policy Switch 2000 will task force as the edge switches, the inter media from the end users PC to the backbone. It is critical for edge switches to perform in a high availability and capacities manner to support the massive and robust users in using a high end superhighway like Passport 8600 backbone.

Key features and benefits

The Business Policy Switch delivers the high-performance IP infrastructure that can support the advanced IP telephony applications and requirements of the Business Communications Manager and the i2004 Ethernet Sets (IP Phones).

The Business Policy Switch acts as the stackable Ethernet edge or closet element in conjunction with the Passport routing switches in the network core, complements the Policy Enabled Networks line of products from Nortel Networks, and delivers end-to end QoS.
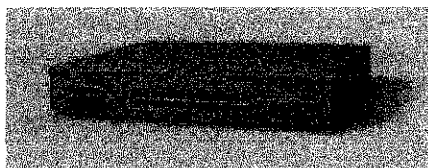

Figure 8: Model of single BPS2000

WLAN Access Point 2221

Nortel Network WAN Access Point 2221 provides wireless solution for the new Village Network. The wireless access point will be placed at selected places to give the students the wireless features availability.

With its unique feature set and flexible architecture, Nortel Networks WAN 2221 series offers an enhanced user experience through true mobility, total security and integrated management, with the intelligence and performance for mass deployment of multi-service wireless network. The WAN 2221 access point offers 802.11b -radio technologies, which offer transmitting signal throughput of 11 Mbps.

Anytime, anywhere access - that is the promise wireless brings; the ability to use the same applications you have access to from your desktop - no matter where you are. The nature of wireless - unrestricted by walls or doors - brings with it an inherent challenge: security. Add to this total cost of ownership, functionality, and manageability and you realize that up until now wireless LAN offerings have been unable to make the grade for the majority of enterprise customers.

Corporations want their wireless network to be an extension of their wired network. They seek standards-based solutions, which address security, QoS, interoperability and are capable of being managed by one system. The Nortel Networks WAN 2200 Series makes it possible, by bringing the combination of True Mobility, Total Security, and Integrated Management into the enterprise.

Key features and benefits

True ability for users to maintain uninterrupted connectivity as user seamlessly roam across access points, different wireless technologies, subnets and buildings within the campus.

A layered approach to security, where modular or stand-alone solutions are available to suite customer requirements.

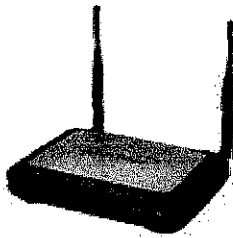Below is the single model of WLAN 2221 Access Point.

Figure: WLAN Access Point 2221

Baystack 460-24T-PWR

The BayStack 460-24T-PWR Power over Ethernet (PoE) Switch is an IEEE P802.3af draft-compliant switch to power devices such as IP phones, wireless access points, and net cameras. It has 24 10/100 Mbps ports, one MDA (Media Dependent Adapter) slot for uplink connectivity, and one cascade module slot for stacking.

This 10/100 Mbps stackable Ethernet switch is compliant with IEEE P802.3af standard. IP phones or wireless access points from any manufacturer that complies with this standard can be powered from the BayStack 460-24T-PWR. It enables enterprises to power IP devices (IP phones, wireless access points, net cameras) while maintaining connectivity to standard 10/100 Mbps Ethernet devices simultaneously. The BayStack 460-24T-PWR delivers all of the features of the Business Policy Switch such as advanced QoS and high-resiliency with the addition of Power over Ethernet capability. Below shown a model of single BayStack 460-24T-PWR
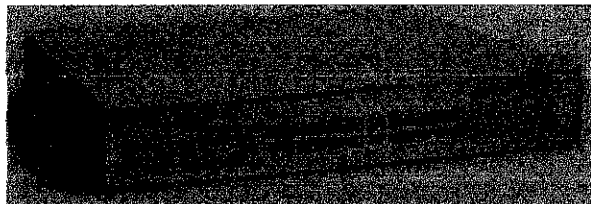

Figure: BayStack 460-24T-PWR

WLAN Security Switch 2250

Nortel Networks WLAN - Security Switch 2250 simplifies management and provides 3ecurity to the total wireless LAN from a central point. Centralized Security features include Mobile AAA, Global Filters and Mobile Adaptive Tunneling. Centralized Management includes Multiple Authentication Options and MultiService capabilities enabling voice prioritization.

Key features and benefit.

Multi Adaptive Tunneling (MAT) - Provide granular access control to corporate network, enabling administrator to dynamically provide full or limited access to corporate resources based on user profile, access type and device security. Multiple authenticate options, for the administration to authenticate without the need to duplicate the authentications server.

Robust security, the switch deliver high security features. This enables all traffic to be encrypted using WEP, SSL, IPSec and PPTP as well as support for dynamics session tokens.
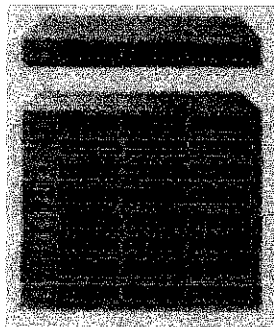

Figure: WLAN Security Switch 2250

4.6 Cost

Table 4.5.1 - Price quotation for Nortel Networks 2221 Series meant for 5 access point only (covering the student cafeteria)

Product Description	Quantity	Unit Price (RM)	Total Amount (RM)
Access Point	5	1579	7895
Wireless Bridge	8	10324	82592
Wireless PC Card	20	3298	65960
OMNI 6/3 Antenna	5	1589	7945
GRAND TOTAL			**164392**

Table 4.5.2 - Price quotation for CISCO AIRONET Series 2 meant for 5 access point only (covering the student cafeteria)

Product Description	Quantity	Unit Price (RM)	Total Amount (RM)
Access Point	5	1348	6740
Wireless Bridge	8	9324	81332
Wireless PC Card	20	2228	44560
OMNI 6/3 Antenna	5	1231	6155
GRAND TOTAL			**138787**

The installation of the wireless card should be done step by step in phases. In the preliminary installation, 20 Wireless PC cards will be enough to cater the coverage areas. Adding of the wireless card will be done as the demand grows and the number of potential user increases. As the mobility concerns, every students are recommended to have own laptops or handheld devices.

CHAPTER 5

WIRELESS LAN CONCEPTUAL DESIGN

5.1 Conceptual Design

After completion in determining all the suitable and compatible devices with adheres to its standards, the conceptual design will be constructed. The conceptual design will cover the Student centre area, student cafeteria and student residential. The conceptual design will specify only in village 4 residential area. However, the same conceptual design also applicable in other students residential including village 1, 3 and 5. Before allocating the access point needed, three of the below factors are made into consideration:-

    i.   area of coverage area

    ii.   number of supported users

    iii. network utilization

5.2 Coverage Area and Bandwidth

Upon designing the layout of the station, distance between station and receiver have to be considered as its affects the speed of the network. Figure 5.2.1 will illustrate typical speed in a semi open environment, which is defined as a workspace divided by shoulder height, hollow walls. A station with 11 Mbps wireless Network Interface card can communicate with another client up to distance of 375 feet (115 meters) in a semi open environment. Only station within the first 165 feet (50 meters) can communicate at 11Mbps. Station between 300 and 375 feet (90 to 115Mbps) will communicate at only 1Mbps.

Table 5.2.1: Area of coverage and bandwidth

165	50	11
230	70	6
300	90	2
375	115	1

There are certain mode of access point (AP) allocation that need to be determine before setting up the exact location of the access point. Figures 5.2.2 (refer appendices) illustrate the WLAN environment that uses an access point (infrastructure mode). Infrastructure mode is design where all the station is connected with one or many access point. It is capable to cover a larger area since multiple access point is deployed It is also connected in the same wired network.

A second factor is the number of support red user. A single access point can support between 250 and 300 users, in practice it should be less. Adding more access point will increase the throughput of the Wireless LAN because fewer users will be contending for access. Figure 5.2.3 (refer appendices) show how additional access point can cater number of users.

Student cafeteria and student centre including student lounge, KOPETRO and residential are selected as the area to be shifted to wireless local area network environment. This is due to this area is semi-open area that cause less interference of signal transmission and low percentage of noise level. Figure 5.2.4 (refer appendices) shows the access point allocation at the area. Two access points is located at Bay 1 and Bay 2, since this area caters the most students utilizing the wireless local area network. Based on the site survey result, the cafeteria distance measured approximately 45 meters. These lengths still cater the bandwidth of 11Mbps. As a result signals can be transmitted at 11 Mbps within this cafeteria area. Based on the result of user density, 60% of UTP student frequently visit the cafeteria. UTP cafeteria can allocate approximately 100 to 150 students at one time. To increase the throughput of Wireless local area network two Access Point (AP) will be allocated in each bay and done Access Point (AP) will be allocated at the Student Centre.
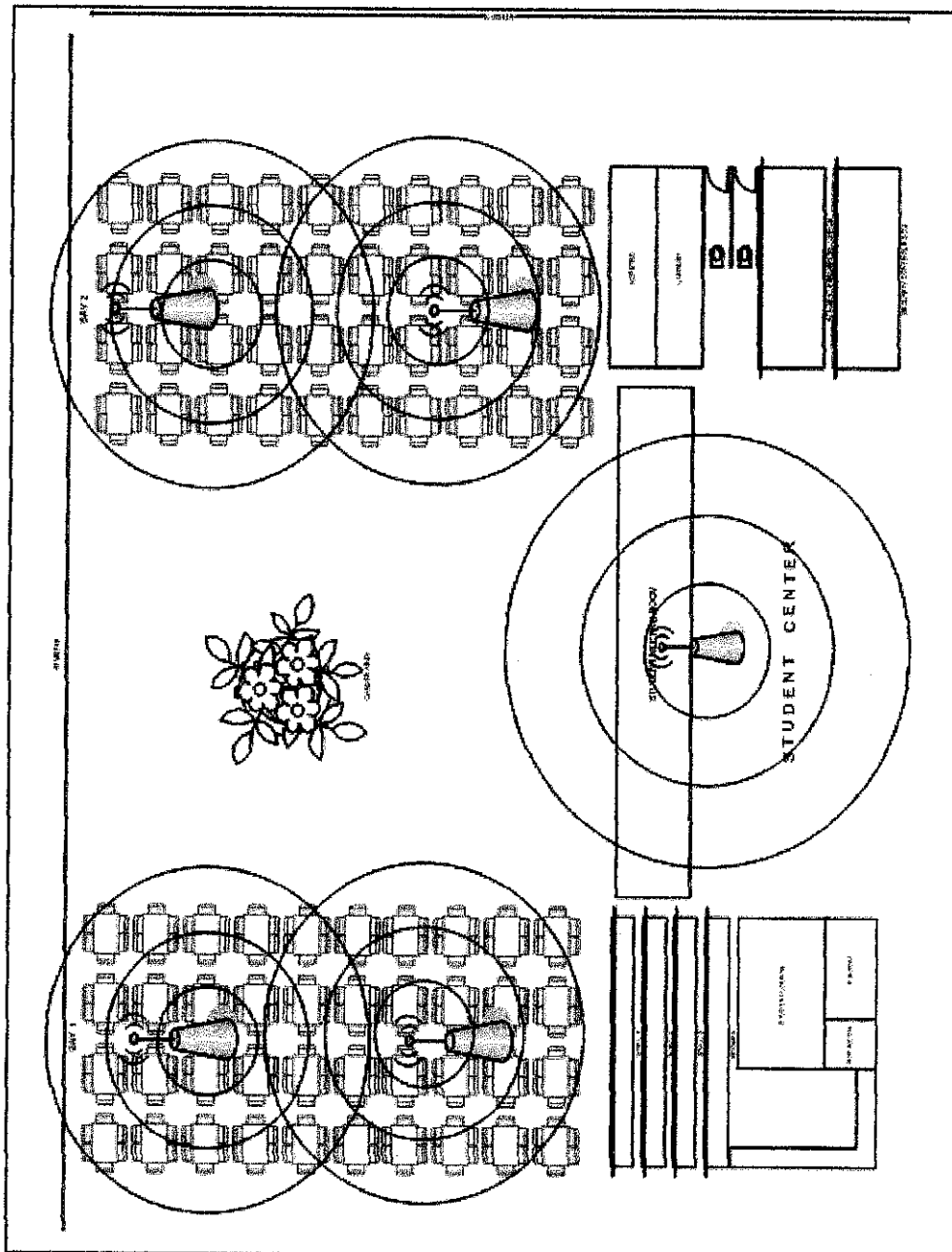
Figure 5.2.4: Access Point Allocation and coverage area in Cafeteria

43

5.3 Conceptual Design and Outdoor Antenna Allocation for whole UTP Cafeteria based on Student Residential (Village 1, 2, 3, 4 and 5)

As shown in the figure 5.3.1, are the conceptual design designs of devices that will be connected to deploy the wireless LAN in whole cafeteria area in UTP. In UTP, there are five student residential (Village 1,2,3,4 and 5). Every residential has their own cafeteria, which cater the same number of users at certain period of time. The main Outdoor Antenna (Omni Antenna) will be located at the centre of the student residential area. The switch will route the connection to the Security Access Point (SAPCR) to ensure that the signal transmitted is well secured. The signal will be transmitted and receives through out all the access point (AP) located at the cafeteria area. The DHCP server will determine the Internet Protocol (IP) address of the entire signal based on unique Service Set Identification (SSID) that has been configure through all the access point located at the cafeteria area. The SSID of each access point (AP) in every student residential (Village 1, 2, 3, 4 and 5) should be unique due to avoid IP conflict.
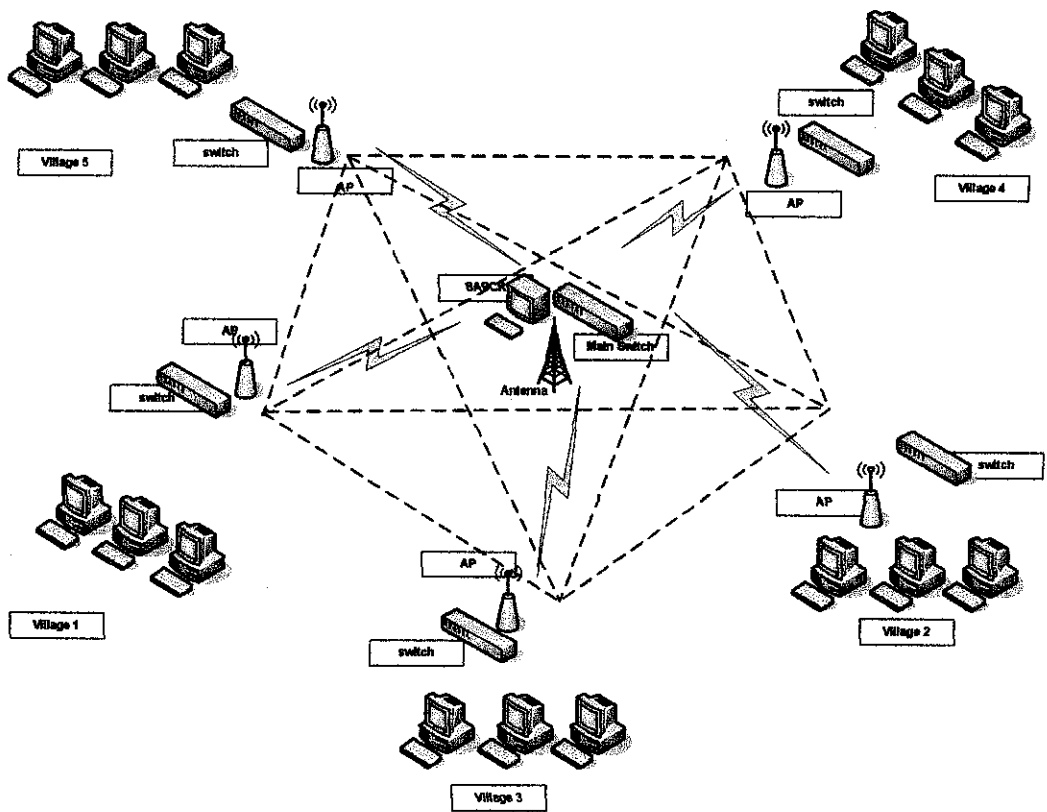
Figure 5.3.1: Conceptual Design of whole UTP cafeteria

Figure 5.3.2 show the conceptual design focusing on one student residential. In UTP every student residential, there are three building (Village 4A, 4B and 4C). The building amount is the same throughout the entire student residential area. The same conceptual design is being applied. The network routing will be the same as the previous figure.
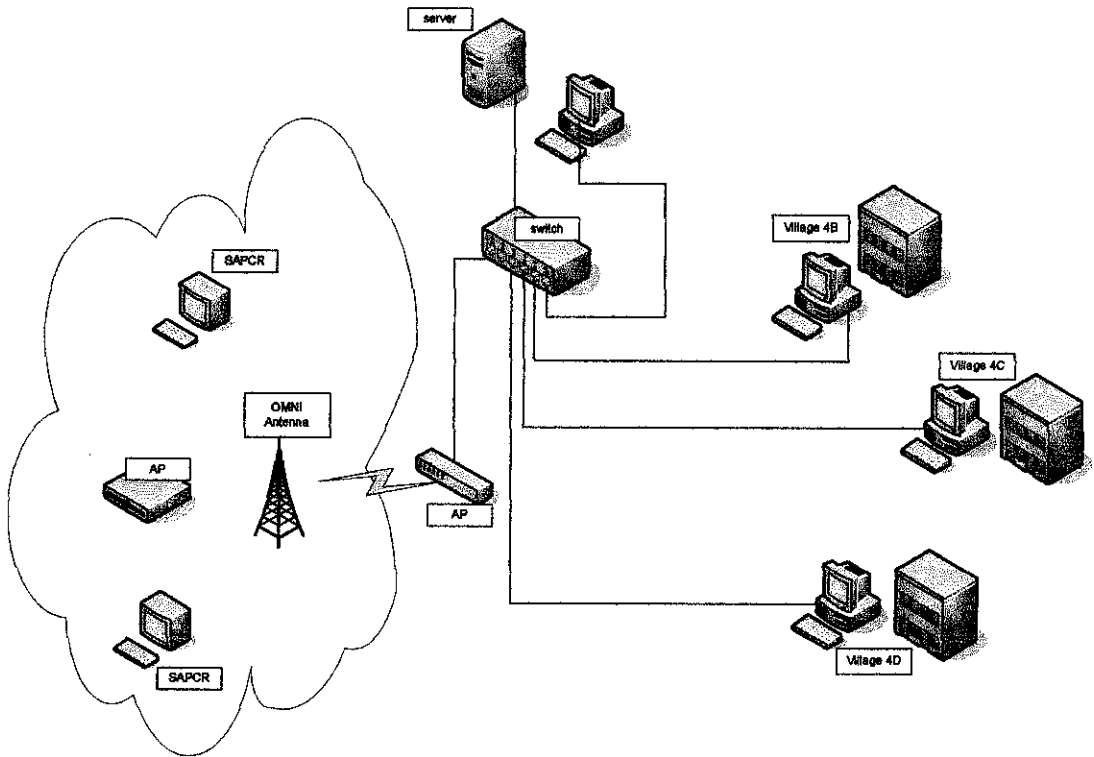

Figure 5.3.2: Conceptual Design focusing on one student residential

46

5.4 Result and finding simulation

To gain all the result from the finding, certain simulation need to be done. The simulation includes:

1. site survey
2. access point setup

This part will include step by step simulation using all the devices from CISCO AIRONET 350. Noted that this is only a part of demo purposes in order to show the wireless connection are successfully deployed. The exact devices installation is still being provided by Nortel Network as to secure the cost and device compatibility. The concept of setting the device is more or less the same.

5.4.1 Site survey

Most Wireless LAN has software utility known as a site survey that assists in the placement of access point. It will display such information as the signal level, the outside noise level and signal to noise ratio which indicate how much of the signal being affected by noise. CISCO Aironet 350 also provided their software for this convenient prediction purpose. This task is important to determine the optimum location and number of access points in the selected area.

Site survey is done by using a laptop on which the site survey software is running; user will roams through the coverage area. A low signal level indicates that the access point may be too far apart. The solutions to this problem are by relocate or add more access points. If noise level is high, user can walk through the area, monitoring the noise level indicator to determine the exact location of the source of interference. Relocating back the access point far from the interferences is crucial.

47

5.4.2 Access Point setup

i. Primary Port setting

This option will all to designate the bridge radio port as the Primary Port and select whether the bridge primary port is Ethernet port which is connected to the wired LAN. The primary port setting is set into number and for the set the radio port as the primary port.

ii. Default IP address

This setting is used to assign an IP for the radio port that is different from the bridge's Ethernet IP address. During the normal operation the radio port adopts the identity of the Ethernet port. When the bridge is in standby mode, different IP address can be assigned to the radio port.

iii. Service Set ID

The SSID is a unique identifier that client devices used to associate with the bridge. SID help client devices distinguish between multiple wireless networks in the same vicinity and provide access ID to VLAN by wireless client devices. Several bridges on a network or sub network can share the SSID. SSID can be configuring to up of 16 SSID on a bridge. It must be an alphanumeric, case sensitive from 2 to 32 characters long. As for the demo, SSID is set to data communication SSID broadcast. This setting is used to broadcast the SSID in search of a bridge to associate with the bridge.

of transaction and the signals strength are the major concern during the installation since it will affect the performance of data transmission will be affected.

People are always get excited about speed, and they often don't realise that the main performance measure of a wireless LAN is the coverage, and by a wide margin. This includes maximum distance between nodes, resistance to interferences and ability to keep connectivity in a wide range of conditions. This includes maximum distance between nodes, resistance to interferences and ability to keep connectivity in a wide range of conditions. The propagation of radio transmissions is influenced by many factors. Walls and floors tend to decrease and reflect the signal, and background noises make it more difficult to extract. The channel qualities vary quite a lot over the time. The main important matter with the implementation of WLAN is its do gives user an advantage in term of mobility. Mobility issue is an important factor to be considered nowadays.

Because of the way radio transmissions are affected by the environment, it is quite difficult to predict the comportment of the system and to define a range. This is where the site surveyed is important to be done in order to determine the best allocation of all the access point in the selected area and the signal coverage strength and bit of data transmitted per second. Site survey simulation is not an easy task, in order to obtain sufficient result several site surveys have to be done.

As for further expansion, some new selected areas in UTP campus can be enhanced to adapt the WLAN environment for example, the New Academic Building areas, Resource Center which include the area of the lecture theaters or other places after considering the usage models and signal strength of each these area.

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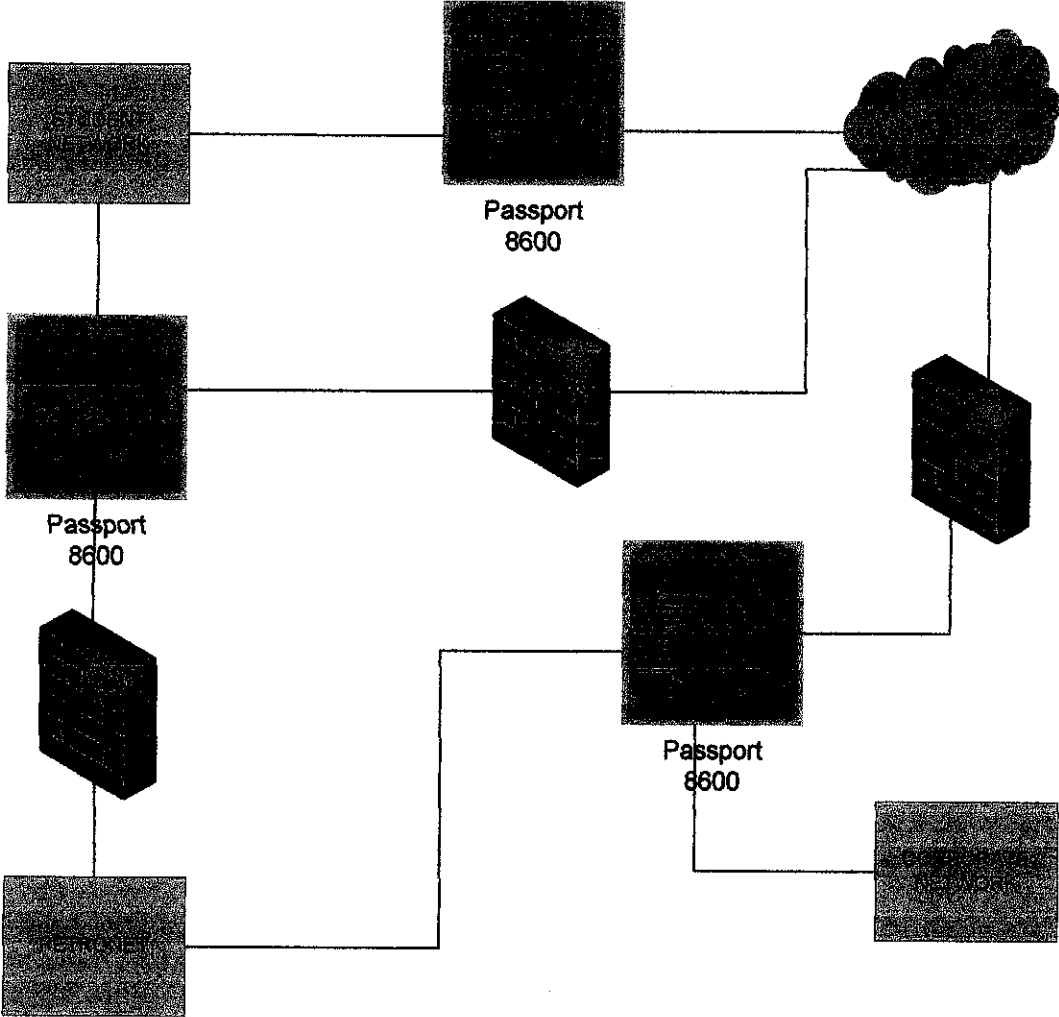
APPENDICES

Figure 1: Network Type and Tiers in UTP
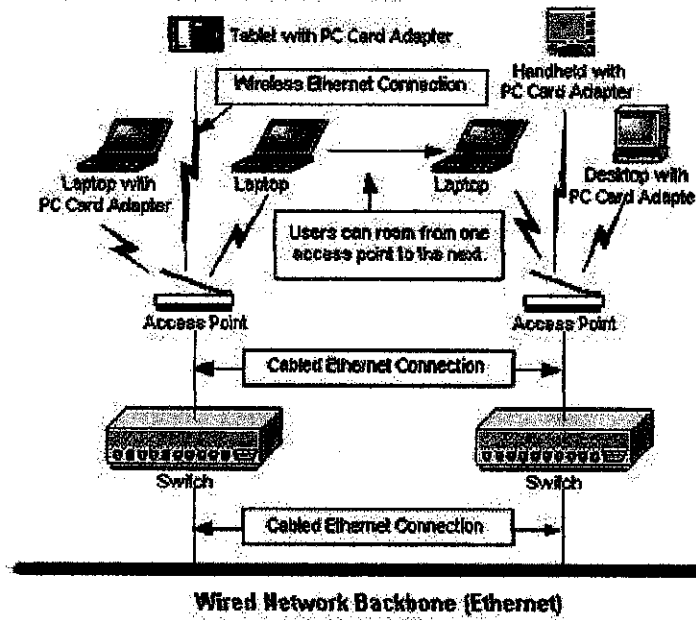
Wireless LAN Architecture
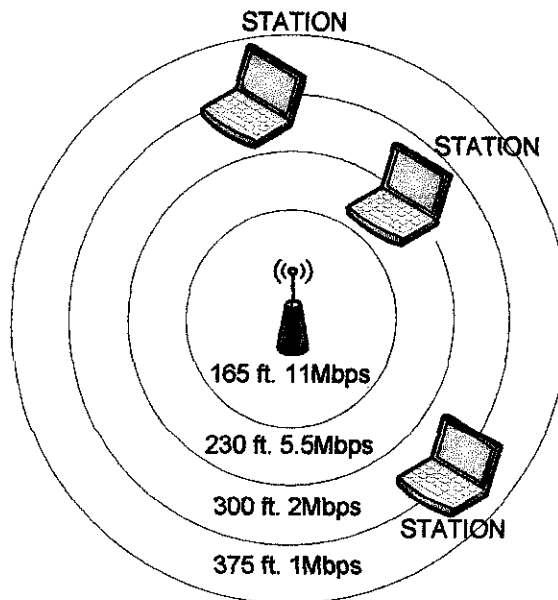

Figure 2: Wireless LAN Architecture

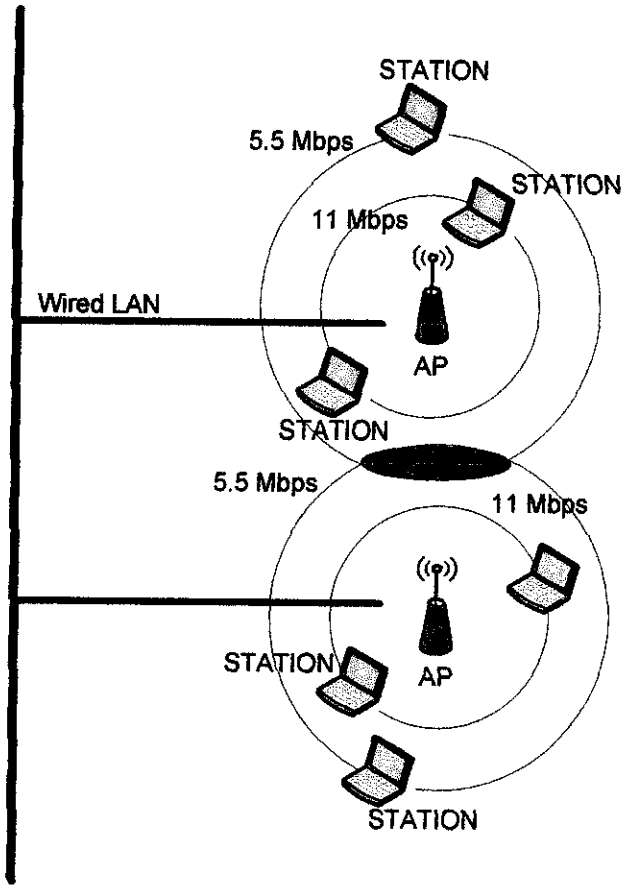Figure 5.2.2: Bandwidth rate with an access point
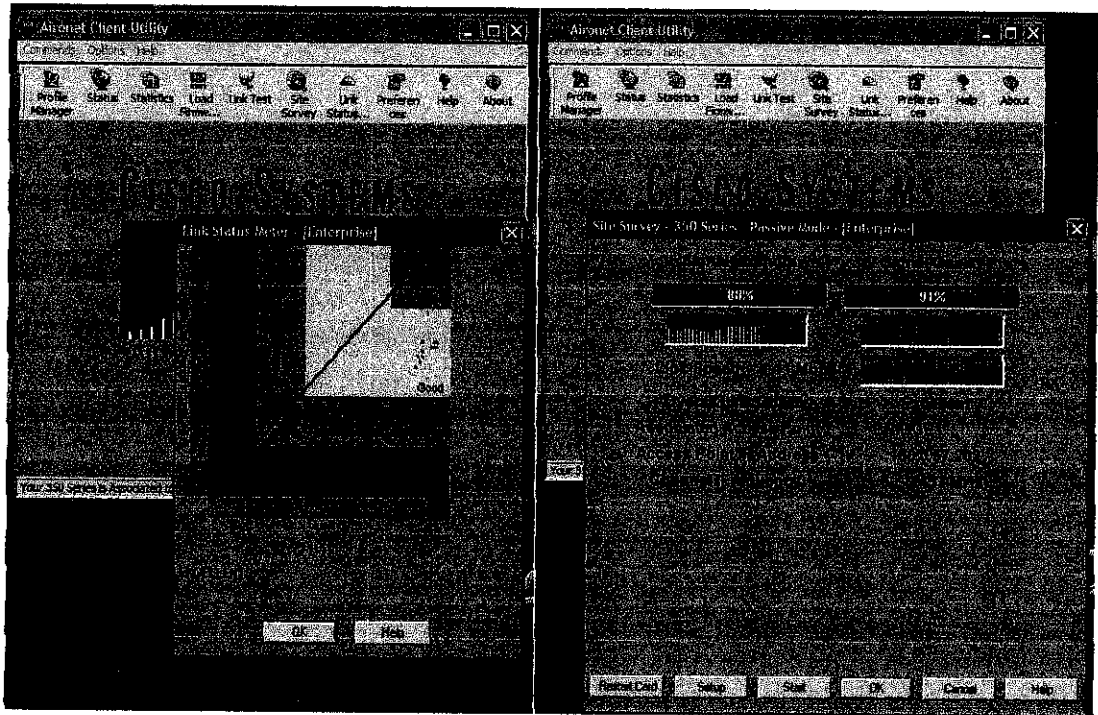
Figure 5.2.3: Additional Access Point

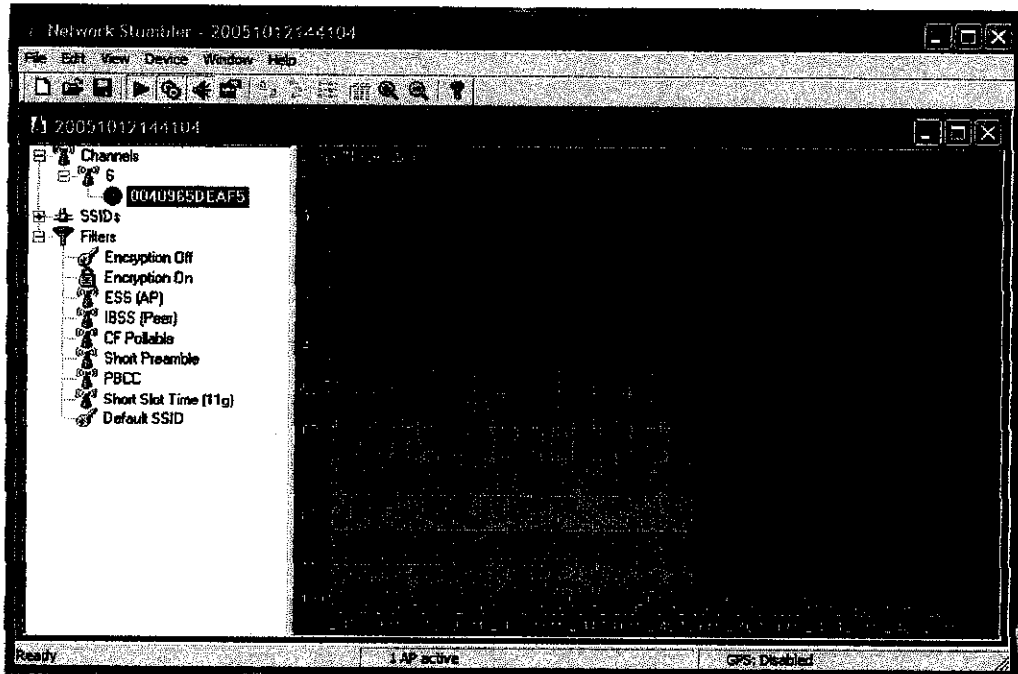Figure 5.4.2.1: CISCO Aironet signal indicator

Figure 5.4.2.2: Network Stumbler signal range
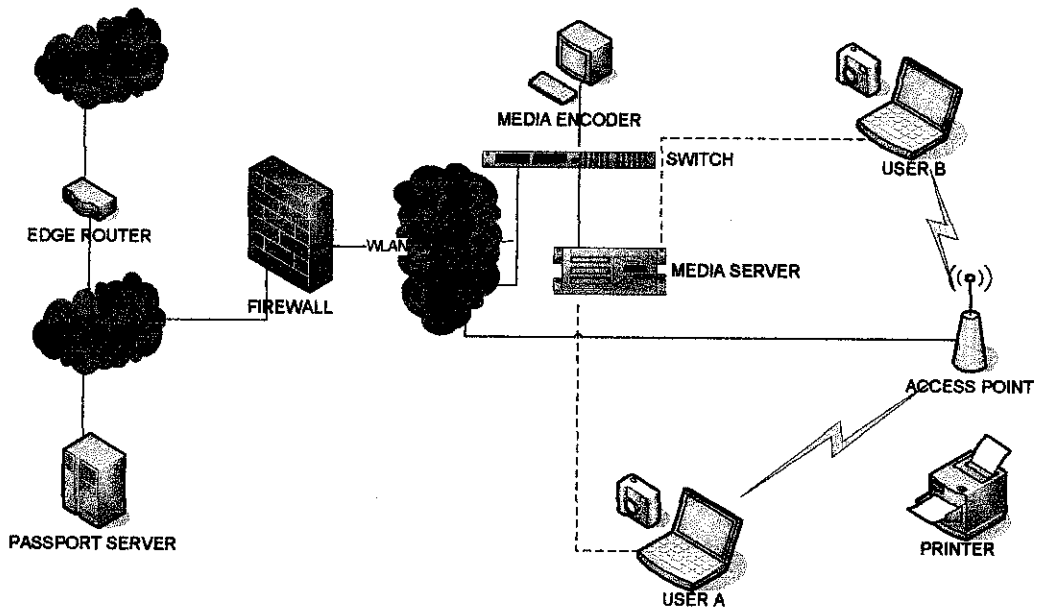
Figure 5.4.2.3: WLAN Prototyping at Data Communication Lab

LIST OF ABBBREVIATION

- AP   Access Point

- DSSS   Direct Sequence Spread Spectrum

- DHCP   Dynamic Hot Configuration Protocol

- FHSS   Frequency Hoping Spread Spectrum

- HTTP   Hypertext Transfer Protocol

- IEEE   Institute of Electrical and Electronic Engineers

- IT   Information Technology

- ISP   Internet Service Provider

- IP   Internet Protocol

- Kbps   Kilo byte per second

- Mbps   Mega byte per second

- MS   Mobile Station

- NIC   Network Interface Card

- OS   Operating System

- QoS   Quality of Service

- SAP   Security Access Point

- SSID   Service Set Identification

- VLAN   Virtual Local Area Network

- WLAN   Wireless Local Area Network