

Setting Wireless LAN in New Academic Building

By

Mohamad Shukor Bin Ahmad @ Salleh

1946

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

JUN 16, 2004

Universiti Teknologi PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

+

TK

5103.2

-W798

2004

1) Wireless Communication Systems

2) IT/IS -- Thesis

CERTIFICATION OF APPROVAL

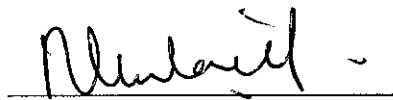
Setting Wireless LAN in New Academic Building

By

Mohamad Shukor Bin Ahmad @ Salleh

A project dissertation submitted to the
Information System Programme
Universiti Teknologi PETRONAS
in partial fulfillment of the requirement for the
BACHELOR OF TECHNOLOGY (Hons)
(INFORMATION SYSTEM)

Approved by,



(Khairul Shafee Kalid)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

Jun 2004



UNIVERSITI
TEKNOLOGI
PETRONAS

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 have not been undertaken or done by unspecified sources or persons.

MOHAMAD SHUKOR BIN AHMAD @ SALLEH

ACKNOWLEDGEMENT

Alhamdulillah, out of a mixture of puzzlement, daring and excitement, I have completed the final report and project for my Final Year Project (FYP). I want to express my sincere and heartiest thanks and appreciation to all the parties involved in giving assistance and contribution for my final year project .I believe this is a result of hardworking and diligence of many parties that willing to lend a hand giving guidance and assistance to help me in doing my final year project. I want to express the highest appreciation and gratitude to:

- Mr. Khairul Shafee Kalid, my final year project supervisor for her great assistance and guidance to me towards completing the project.
- My parents, Ahmad Bin Lazim and Pok Binti Yahaya for their continuous moral and financial support to me.
- Mr. Abu Yazid Ahmad and Puan Norasyikin from Sapura Telecommunication Berhad, Department of Network Management System, for their assistance and contribution in terms of information and material for the project.
- Mr. Shuib Basri, Mrs. Vivian and all other UTP lecturers for your advice, encouragement and help. Without them, it would have been impossible for me to finish this dissertation.
- I appreciate very much the companion and help I got from past and present graduate students, laboratory technicians, researchers, and secretaries I had privilege to meet and work with.
- Finally, and definitely not least I wish to acknowledge all of my friends who have listened to me bitch, moan, rejoice, complain, laugh, cry, and ponder my way through these past years. All of them deserve to sign this dissertation

ABSTRACT

This project is called Setting Wireless LAN in New Academic Building. From this research, I will come out with the frequency of the Access Point in the building, the radius of the LAN, the coverage in the building, distance between one Access Point to another Access Point, cost estimates and locating the Access Point at the right place in the building.

The entire introduction, problem statement, objectives, and the scope of the studies for the project will be further explained in Section 1 – INTRODUCTION.

This document also gives further information about the system the literature review/theory section. This section includes the features of the wireless system, the benefits from using the wireless system, and the connection of the wireless system. It will clearly state the person in charged for setup the wireless system.

The proposed methodology is then discussed in the next section. This section also includes the tools and software that are to be used in developing the system.

Then, continue with the result and discussion for the next section. This section is show the result and discussion of this project.

Then, it also has the conclusion and recommendation for the last section. This section will give the benefit of the wireless LAN.

The references and appendix for the project also has after the conclusion and recommendation.

TABLE OF CONTENTS

CERTIFICATION.....	i
ACKNOWLEDGEMENT.....	iii
ABSTRACT	iv
CHAPTER 1: INTRODUCTION.....	1
1.1. Background of Study.....	2
1.2. Problem Statement	2
1.2.1 Problem Identification.....	2
1.2.1 Significant of the Project.....	2
1.3. Objective and Scope of Study.....	3
1.3.1 Scope of Studies.....	3
1.3.1 The Relevancy of the Project.....	3
CHAPTER 2: LITERATURE REVIEW.....	4
2.1. Introduction of Wireless LAN.....	4
2.2. Why Wireless.....	5
2.3. Wireless LANs Works.....	6
2.4. The Standard Relating to Wireless LANs.....	8
2.5. Benefits of Using Wireless LAN.....	10
2.6. Example of University that Use Wireless LAN.....	11
CHAPTER 3: METHODOLOGIES.....	12
3.1. Methodology.....	12
3.2. Current Progress	13
3.2.1 Project Research and Study.....	13
3.2.1.1 Preliminary Study.....	13
3.2.1.2. Feasibility Study.....	13
3.2.1.3. Project References Research.....	14
3.2.1.4. Prepare the Preliminary Report.....	14

3.2.2 Project Analysis.....	14
3.2.2.1. Problem Analysis.....	15
3.2.2.2. System Requirement Documentation Submission....	15
3.2.3 Project Design	15
3.2.3.1 Architecture Design.....	16
3.2.3.2 Interface Design.....	16
3.2.3 Project Development.....	16
3.2.5 Project Testing and Commissioning.....	16
3.3. Tools.....	17
3.3.1. Hardware.....	17
3.3. 2 Software.....	17
CHAPTER 4: RESULTS AND DISCUSSION.....	19
4.1 Result	19
4.2 Wireless LAN Advantage.....	20
4.3 Reason of Setting Wireless LAN.....	20
4.4 Total of Access Point.....	21
4.5 Try and Error.....	22
CHAPTER 5: CONCLUSION AND RECOMMENDATION.....	23
5.1 Conclusion.....	23
5.2 Limitation.....	25
5.3 Recommendation.....	25
REFERENCES.....	27

APPENDICES

LIST OF FIGURES

Figure 1: Handing off the WLAN Connection between Access Points

Figure 2: Infrastructure WLAN

Figure 3: Access Point with the security cover

Figure 4: Depicts the architecture design of the wireless LAN at UTP.

ABBREVIATIONS AND NOMENCLATURES

LAN – Local Area Network

WLAN – Wireless LAN

IEEE – Institute of Electrical and Electronic Engineers

NOS – Network Operating System

WI-FI – Wireless Fidelity

WEP – Wired Equivalent Protocol

AP – Access Point

UTP – University Technology of PETRONAS

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF STUDY

Today, almost every staff member needs a network connection, but you can't install cables everywhere. Whether it is in the warehouse, conference room, or home office, the simplest, most cost-effective solution for making the connection a wirelessly. Wireless LAN let you extend your network to every square inch of your building, campus or residence.

Wireless LAN enable the user, to establish and maintain a network connection throughout your premises, without the physical limitations of wires or cables. It is an exciting technology that enables computer users to access files stored on a network while moving around or working in a temporary office space.

With wireless LAN, users can access information—like e-mail, the Internet and company computing resources—anywhere and anytime, without looking for a place to plug in. From an IT standpoint, wireless brings great value since it eliminates the need to install expensive fiber infrastructures and also brings network access to older, historical buildings where cabling is impractical or undesirable.

A Wireless LAN is a flexible data communication system implemented as an extension to, or an alternative for, a wired LAN within a building or campus. Using electromagnetic waves, wireless LAN transmit and receive data over the air, minimizing the need for wired connections.

Simply put, wireless is an innovative and affordable way to supplement rather than replace wired networks.

1.2 PROBLEM STATEMENT

For the time being, students have to connect to the wired LAN, so that, they can have the Internet. It is very inconvenience for the student because they have to be at the hostel, Lab or Resource Center for the purpose. To overcome this problem, a wireless LAN will be the best solution to students in enabling them to access the network or Internet from anywhere.

1.2.1 Problem Identification

In UTP, all connection is using wired LAN. So, it is difficult for students to connect to the Internet or network outside the Lab or Resource Center. Wireless LAN is the best solution to settle this problem because when using wireless LAN, student can access Internet or network from anywhere without using a cable or wired. Once configured, wireless LAN can be moved from place to place with little or no modification. So, it is very easy for student to do their work without any problem.

1.2.2 Significant of the Project

The networking in UTP can be more effectively and efficiently when using wireless LAN. So, this project can make the connection in UTP run smoothly without having any problem. A wireless LAN limits the amount of cabling and the labor associated with installation and as result, the cost of installing and maintaining a wireless LAN is generally lower than the cost of installing and maintaining a traditional wired LAN. In addition, because wireless LAN is relatively simple to reconfigure and expand, UTP can reduce the indirect cost resulting from user downtime and administrative overhead. Since only the access point of wireless LAN require cabling, network managers are freed from pulling cables for wireless LAN end users.

1.3 OBJECTIVE AND SCOPE OF STUDY

The objectives of the project are:

1. To make internet access much easier within UTP campus.
2. To provide enhanced user mobility.
3. Identify hardware and software used in setting wireless LAN.

1.3.1 Scopes of Studies

It also covers only certain part in Building 2 at New Academic Building. These projects also fine the distance and coverage of the access point. All the access point that student put at Building 2 will be based on a map at Appendix.

1.3.2 The Relevancy of the Project

Many educations centre using wireless LAN in their campus to give students at universities use wireless connectivity to facilitate access to information, information exchanges, and learning. This is to get better network connection within the campus and access an Internet. Wireless LAN provides all functionality of wired LAN, without the physical constraint of the wire itself. Wireless LAN is an ideal solution for UTP that wishes to avoid large infrastructure, installation and maintenance costs associated with implementing a wired LAN or to improve the flexibility of being able to extend the networks rapidly and as cost effectively as possible.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION of WIRELESS LAN

According to info@fdmtech.co.uk, (2002); a wireless Local Area Network (WLAN / WI-FI) connects to a network using two-way radio. The common standard for developing the technology is IEEE 802.11 and devices are sometimes described as using 802.11 or WI-FI. The standard also details the encryption method for the securing of data during transmission. A wireless LAN's comprise of a wireless hub, or base station, and several wireless access cards. The wireless cards can communicate with the base station over hundreds of meters using radio waves. The base stations will normally then connect to a wired Local Area Network, passing data on from the wireless, to the wired network.

A single access point can support a small group of users, normally within a range of up to 100 meters depending on the local environment (*figure 1*).

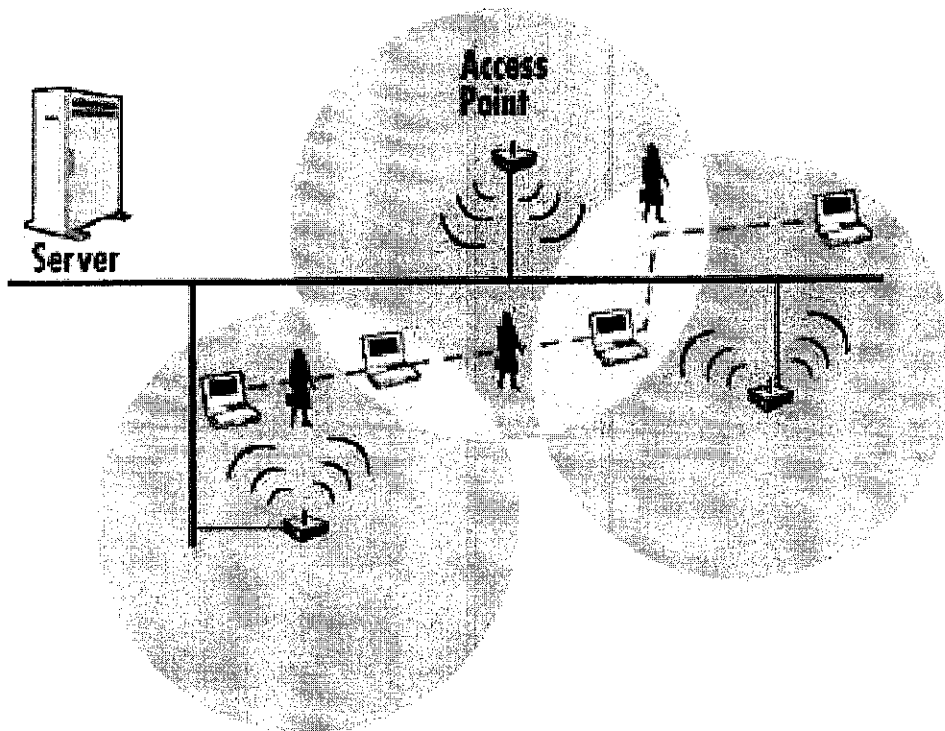


Figure 1: Handing off the WLAN Connection between Access Points

To determine the location of access points, it is essential that a site survey be undertaken with a specialist in this area. A site survey will also determine the number of access points required to give the desired coverage for the Wireless LAN, with larger spaces generally requiring more access points. The access point, or the antenna attached to the access point, will usually be mounted high. However, an access point may be mounted anywhere that is practical as long as the desired radio coverage is obtained.

Most wireless LAN uses spread spectrum radio technology to transmit and receive data. Spread spectrum was developed and used by the military, because of its reliability, security and mission-critical communication system of operation.

Spread- spectrum is designed to trade bandwidth efficiency for reliability, integrity and security. More bandwidth is consumed than that of other radio transmission system. The trade-off produces a signal that is, in effect louder and easier to detect, providing the receiver knows the parameter of the spread-spectrum signal being broadcast. Any other receive not tuned to the right frequency will view the transmission as background noise. There are two types of spread-spectrum technologies and they are frequency hopping and direct sequence.

2.2 WHY WIRELESS

According to webmaster@onre.com, (2004), the widespread reliance on networking in business and the rapid growth of the Internet and online services are strong testimonies to the benefits of shared data and shared resources. With wireless LANs, users can access shared information without looking for a place to plug in, and network managers can set up or augment networks without installing or moving wires. Wireless LANs offer the following productivity, convenience, and cost advantages over traditional wired networks:

Mobility: Wireless LAN systems can provide LAN users with access to real-time information anywhere at work and in the home.

Installation Speed and Simplicity: Installing a wireless LAN system can be fast and easy and can eliminate the need to pull cable through walls and ceilings.

Installation Flexibility: Wireless technology allows the network to go where wire cannot go.

Reduced Cost-of-Ownership: While the initial investment required for wireless LAN hardware can be higher than the cost of wired LAN hardware, overall installation expenses and life-cycle costs can be significantly lower. Long-term cost benefits are greatest in dynamic environments requiring frequent moves and changes.

Scalability: Wireless LAN systems can be configured in a variety of topologies to meet the needs of specific applications and installations. Configurations are easily changed and range from peer-to-peer networks suitable for a small number of users to full infrastructure networks of thousands of users that enable roaming over a broad area.

2.3 WIRELESS LANs WORKS

According to cease-wire.co.uk, (2003), wireless LANs use electromagnetic airwaves (radio or 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. By superimposing the transmitted data onto the radio carrier, data 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 one radio frequency while rejecting all other frequencies.

In a typical wireless LAN configuration, a transmitter/receiver (transceiver) device, called an access point, connects to the wired network from a fixed location using standard cabling. At a minimum, the access point receives, buffers, and transmits data between the wireless LAN 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.

End users access the wireless LAN through wireless-LAN adapters, which are implemented as PC cards in notebook or palmtop computers, as cards in desktop computers, or integrated within hand-held computers (*figure 2*). Wireless LAN 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.

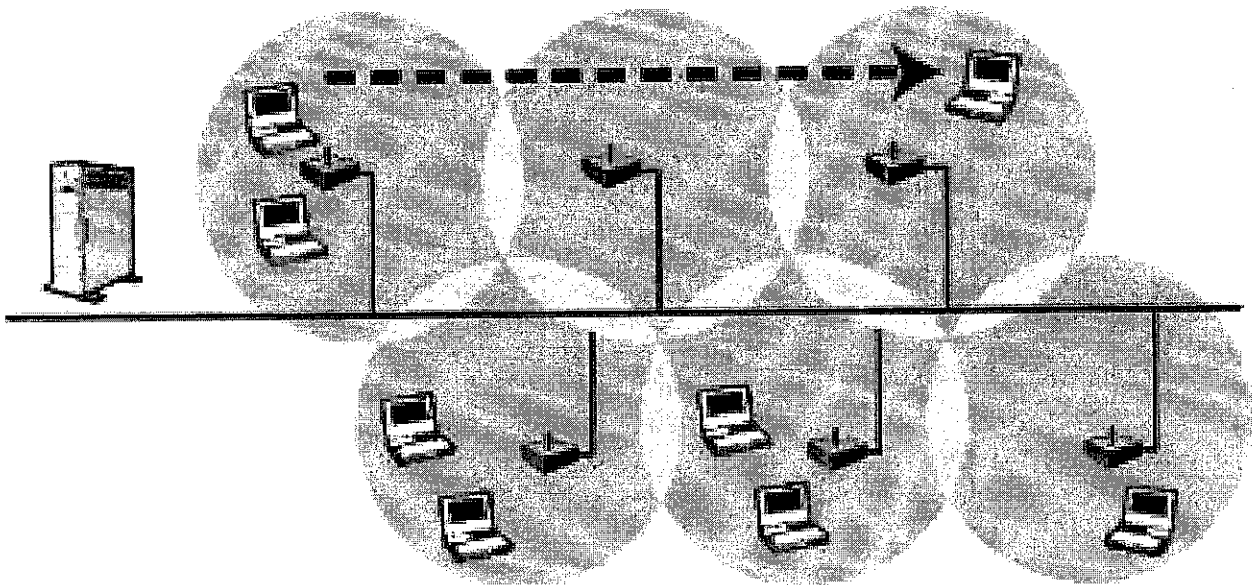


Figure 2: Infrastructure WLAN

2.4 THE STANDARDS RELATING TO WIRELESS LANs

According to info@fdmtech.co.uk, (2003), the Institute of Electrical and Electronics Engineers (IEEE) 802.11b specification is currently the most common standard for Wireless LANs in the UK.

Within the 802.11 specifications, there are two main standards that have been ratified by the IEEE (802.11a and 802.11b), along with one other proposed total standard (802.11g). There are other standards that cover certain aspects such as security (802.11i). 802.11i. Any equipment used for a Wireless LAN must be certified and meet European standards. The specifications that are currently in use, along with those that are expected to become available in the near future, are explained below.

Current standards

802.11b - 802.11b is the most common method for wireless LAN systems today. It can be said that not all 802.11b equipment is compatible as vendors strived to make their products unique. As a consequence the Wireless Fidelity (WI-FI) compatibility mark was developed. A WI-FI product indicates compatibility between 802.11b products from different manufacturers. 802.11b equipment that is not WI-FI branded should be treated with caution. To date, 802.11b is also the only 802.11 specification that is currently certified for use in the UK and elsewhere in Europe.

The 802.11b standard operates in the 2.4GHz spectrum and has a nominal data transfer of 11 Mbps. This is adequate for accessing most data or applications.

Each access point potentially has an access range of approximately 100 to 150 meters indoors, or up to 350 meters outdoors. The range is dependent on the extent that the radio signal is dissipated by transmission through walls and other obstructions.

Presently there are cheap access points which can be bought from the likes of PC world which will not roam when moving between access points, without reconfiguring the PC or the signal dropping out. However the more expensive Access Points will allow

roaming seamlessly from the footprint of one access point to the next, without the signal dropping out.

Future Standards

802.11a - Another wireless standard based on 802.11 specifications, 802.11a, was approved for use in the USA in 2001. In the UK, the use of 802.11a equipment is currently only permitted at a site for evaluation purposes, and a temporary license, available for up to six months at a cost of £50 per month, which must be obtained from the Radio-communications Agency to cover the particular site. Some equipment manufacturers are currently offering to refund the cost of this license to users wishing to evaluate their products. It is expected that during Autumn 2002 the use of 802.11a will become license-exempt. Potential users should seek up-to-date advice on the current licensing situation before purchasing. The long-term future of 802.11a and a related standard, 802.11h, is unclear. 802.11a is a higher speed wireless access technology with a nominal data rate of 54 Mbps, in the 5GHz frequency band.

The main hurdle facing the end-user is that because they operate in different frequencies, 802.11b and 802.11a are incompatible. However manufacturers currently provide, dual mode access points which can hold both 802.11a and 802.11b cards. Dual mode access points may allow users of either type of wireless card to access the network.

The effective range of 802.11a tapers off quicker than 802.11b; however the data rate will always be higher than 802.11b over the same distance.

The 802.11a standard is likely to have advantages over 802.11b in the following circumstances, where there is a need for much higher performance such as to support higher end applications involving video, voice, and the transmission of large images and files. It also significant interference is present within the 2.4 GHz band. The end users are densely populated and there are many users competing for the same access point.

To ensure compatibility with 802.11a equipment, WECA is developing the Wi-Fi5 mark, which all equipment that meets their requirements will carry.

802.11g - The IEEE is in the process of approving 802.11g; however its future is uncertain as it is awaiting approval by regulatory bodies in the USA and Europe. If it does gain approval, it is not likely that products using the standard will become available until at least 2003.

Should 802.11g become available, it is expected to have a data transmission rate of 54 Mbps, similar to 802.11a. 802.11g's advantage is that it offers some degree of backwards compatibility with the existing 802.11b standard, but where 802.11g and 802.11b equipment coexist. The main difference is that 802.11a operates in the 5GHz waveband, while 802.11g operates in the 2.4GHz waveband, the same as the 802.11b standard.

2.5 BENEFITS OF USING WIRELESS LAN

According to Netcon Dr , (2003), it has many benefits and advantage such as faster installation time, literally up and running in minutes, reduced installation costs because no cables, less expensive than running fiber for outdoor applications, excellent backup link for outdoor wired links, outdoor wireless bridges can pay for themselves in less than a year when replacing expensive leased lines, ability to set up an ISP without leasing network access from phone or cable companies, indoor LANs are more flexible, easily move your desk, or entire office, transportable, go anywhere and take the network with you, network your computer in areas difficult to reach with cables, industrial complexes, historic buildings, environmentally sensitive areas where digging is prohibited, network mobile units, forklifts, point of sale terminals, computer carts for schools.

2.6 EXAMPLE OF UNIVERSITY THAT USE WIRELESS LAN

According to University of Maryland, (2001), whether registering for classes, searching the library for resources, reading the latest e-mail, or checking out the day's menu at the dining hall, students at the University of Maryland don't have to go far to connect to the campus computer network for the information they need. Many simply open up their wireless laptop or PDA between classes to get online fast. Located in the busy high-tech corridor between Baltimore and Washington D.C., the 1500 acre University of Maryland College Park campus is rapidly building out campus-wide WiFi coverage to accommodate popular demand for wireless connectivity. The university has long been a technology leader, setting a "port-per-pillow" connectivity standard in its residence halls. Each dormitory room is wired with a high-speed connection to the university's information technology infrastructure. There are a number of hard-wired computer labs, and several classrooms that have Ethernet ports at every seat. Never-the-less, demand for wireless connectivity is growing fast. Today at University of Maryland College Park, there are over 245 WiFi access points installed. That number is set to nearly double in the next quarter. The goal is full WiFi coverage of the sprawling urban campus with an estimated total of 1800 access points. That's a lot of new network infrastructure to manage. And the university quickly realized it needed new tools for the task. "We knew we needed a management solution for our wireless LAN," says Goldman. "Early on, we discovered that physically webbing into each access point was a real pain. You could see them all, but you would have to log in to each one individually to configure them. That took a lot time."

CHAPTER 3

METHODOLOGY / PROJECT WORK

3.1 METHODOLOGY

For implementing a complete wireless LAN system, the methodology chosen consists of 5 phases. The 5 phases are Project Research and Study, Project Analysis, Project Design, Project Development and Testing.

The first phase would be research and study phase that will include the preliminary and feasibility study on potential hardware, software and concept that will be used throughout this project. This so called researching will identify the relevant material and information for this project. The next phase would be analysis phase that includes the problem analysis for the project, specification of the selected hardware, software, tools and specification for the system.

The design phase mainly aim to properly arrange the combination of hardware and relevant testing for each hardware involved. The detailed design will include the target and range to be achieved in system performance. The next phase would be development which is to start use trial & error method until we hit the target. The testing phases may vary on certain performance review based on the selected hardware. The testing may involve many time as one proper testing sometimes need one daytime to be completed.

3.2 CURRENT PROGRESS

3.2.1 Project Research and Study

3.2.1.1 Preliminary Study

In preliminary study phase, the project starts with do a research on the topic. The research is done using several data gathering method such as internet searching, e-mail, experience from the industrial internship, and also from the books, magazines and journals. The preliminary study discussed about the overview of the topic, Setting Wireless LAN in New Academic Building. The project only focused on questions of what is Wireless LAN, what are the advantages of Wireless LAN, types of Wireless LAN, and many more which not detail on the Wireless LAN itself. Student gathers the data and information about Wireless LAN and then the information will be translated into knowledge based. The study focused on research part of the Wireless LAN part. From this preliminary study, it took all the information and knowledge of Wireless LAN and brings it to the next phase, Feasibility Study.

3.2.1.2 Feasibility Study

Feasibility study is one of the important parts in the project planning. In feasibility study, it must consider some constraints in completing the project. Three most important constraint for the project are time, scope and cost. Time is the highest priority where must determine all the tasks must accomplished in order to complete the project. From the tasks, it must determine time needed for each of the tasks. Gantt chart is the tool that will use in planning the time frame for the project. The time given is fixed and it must overcome and managed effectively for successful of the project. Scope of the project has been determined earlier at the preliminary phase. Scope is important where it can guide in completing each tasks and objective of the project. The topics that determine must relate to the project and the Wireless LAN. The topics have been discussed with the supervisor to get more details on the requirement. Cost is considered as own cost where the project

will use own money to overcome cost occurred during the progress of the project. From the feasibility study, it will know the feasibility of the project, how to manage time which has been given, in order to complete the project, the scope regarding project research and system development and cost that will occur and how to manage it.

3.2.1.3 Project References Research

This phase involves gathering of information from various sources such as internet, e-mail, books, magazine and journals. The finding must be related to the topic, Setting Wireless LAN in New Academic Building. From the finding, all these material (information) will be used in completing the project and to support the system development.

3.2.1.4 Prepare the Preliminary Report

Preliminary report is the final output from the project planning phase. In the preliminary report, it discussed the objective of the project, introduction of the project, scope, methodology being used for the project, literature review to support the project, discussion and recommendation for the project.

3.2.2 Project Analysis

Project analysis phase involve analyze problem statement from the preliminary report and solve it as the project's product. It will specify certain problem and aimed to solve the problem as the project objectives. The final outcome of this project analysis phase would be the completion of system requirement documentation which detailed about the problem analysis, requirement analysis and specification.

3.2.2.1 Problem analysis

Problem analysis is done in order to get the problem statement which was stated earlier in the preliminary and feasibility study. The analysis shows the relevancy of the topic with the current problem. From the analysis, it divided into two parts, the research and the system development parts. This project must divide two parts equally and time must be managed carefully as the time constraint is very limited.

In research part, this project identify the overall problem in business environment in term of wireless LAN and technical specification of wireless LAN. To make the case or the problem more detail, student has selected University of Technology Petronas (UTP) as the entity of the business in the research. Since UTP has traditional wired LAN and according to some research that has done, traditional wired LAN has some problem for student that want to access Internet from anywhere in new academic building because, must have a cabling system connect to their PC or notebook. In term of network usage, UTP has a quiet number of users such as student, lecturers' and so forth.

3.2.2.2 System Requirement Documentation Submission

The output of analysis phase would be the submission of system requirement documentation. In this documentation, student will explain more detail about the project than the preliminary report. The report specified more detail on architecture and the technical review of wireless LAN.

3.2.3 Project Design

This design phase will include architecture design and interface design. The project phase is the most important phase in project development where if the project design failed, the other phases in the project development cannot be continued. Student must keep alert in this phase and the outcome from this phase, design and requirement review will be used in the development phase later.

3.2.3.1 Architecture Design

In architecture design (*figure 4*) the architecture consists of two parts; the first is the front end architecture where it uses notebook to setup the IP address for the access point. The second part is the back-end architecture where it uses pocket PC for finds distance between one access points to another access point. It also shows the connection for the access point.

3.2.3.2 Interface Design

In interface design phase, storyboard is designed for the wireless LAN. The storyboard shows how the interface for the system will be. From the storyboard, it will transfer the interface design into the real environment using the hardware and software that use in this project.

3.2.4 Project Development

In the development phase, the trial & error method is used until the target is achieved. Firstly, the access point is configured using the software called RoamAbout R2 AP Manager. This software will set up the network properties such as the IP address, the subnet mask, default gateway, MAC address, the location name for the access point and the name for the access point. The entire step of configuring the access point using the RoamAbout R2 AP Manager is attached in Appendix section.

3.2.4 Project Testing and Commissioning

This phase may vary on certain performance review based on the selected hardware. The testing may involve long periods of time as one proper testing sometimes needs one daytime or more to be completed. All the testing must be done properly to ensure that the system runs smoothly without having any problem. The testing is divided into three sections which are:

- Unit Testing - Testing of each small portion of the configuration
- Module Testing - Testing of a few unit combined together

- System Testing - Testing of the system as a whole.

3.3 TOOLS

3.3.1 Hardware

- Enterasys RoamAbout R2 – Wireless Access Platform
- Enterasys RoamAbout 802.11a Super Rate Wireless LAN Access Point PC Card
- Pocket PC with PC Card slot
- RJ45 – Cable
- Notebook – For configuration

3.3.2 Software

- RoamAbout R2 AP Manager – Software for configuration

RoamAbout R2 Physical Specifications (with security cover)

Parameter	Approximate Specification
Width	173.4 mm (6.84in.)
Depth	62.3 mm (2.45 in)
Length	200.8 mm (7.90 in)
Weight	1.47 kg (3.25 lbs)

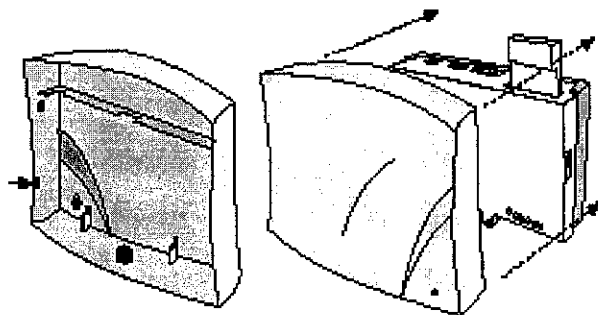


Figure 3: RoamAbout R2 with the security cover

FACEPLATE

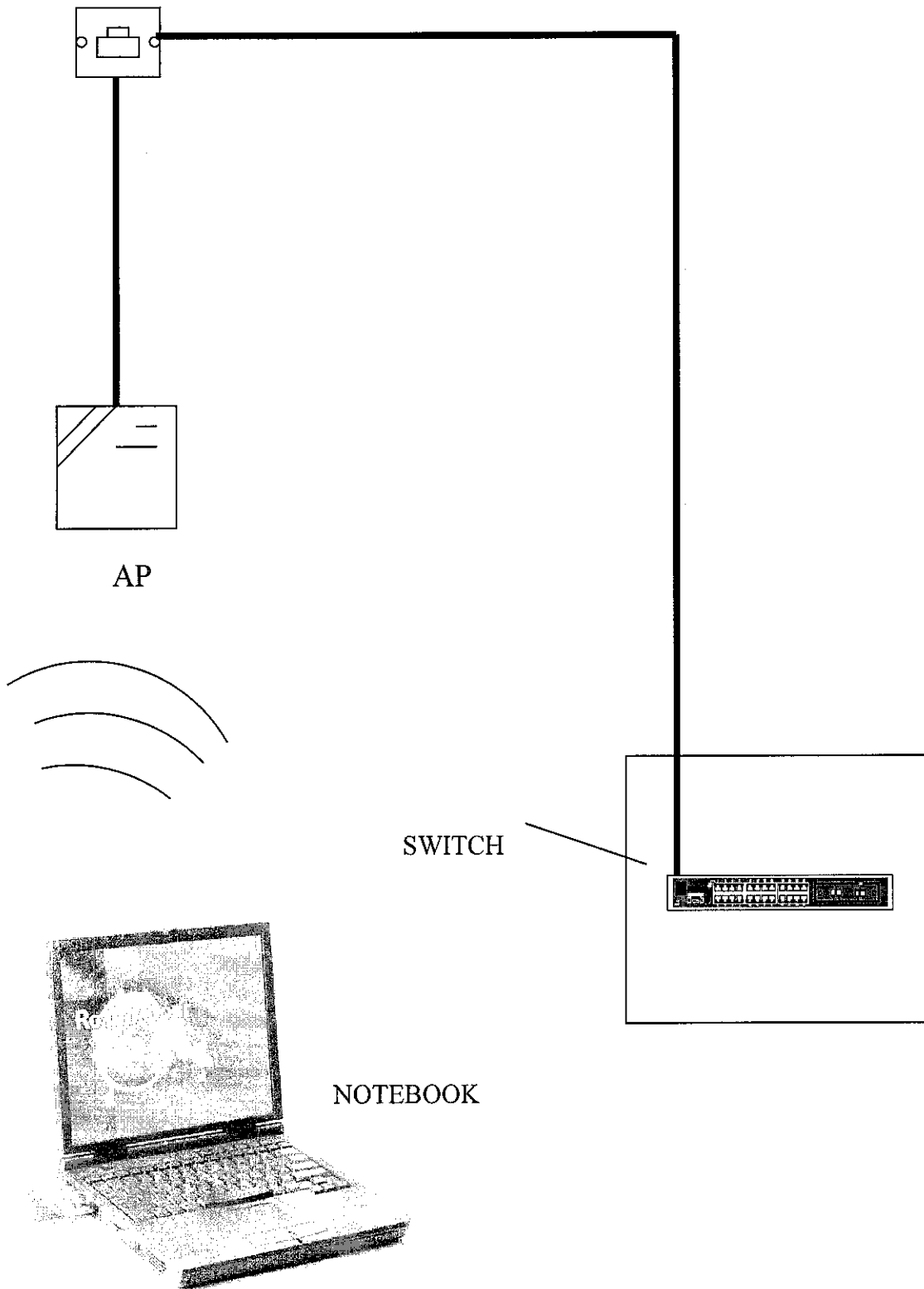


Figure 4: Depicts the architecture design of the wireless LAN at UTP.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 RESULTS

In a typical wireless LAN configuration, a transmitter/receiver (transceiver) device, called an access point, connects to the wired network from a fixed location using standard Ethernet cable. An access point performs a role similar to a hub in a wired network, and provides bridging functionality. A single access point can support a small group of users and can function within a range of up to one hundred meters. The access point (or the antenna attached to the access point) is usually mounted on a wall or ceiling.

End users access the wireless LAN through wireless adapters or cards, which are installed in the PCMCIA slots of notebook computers, or using ISA or PCI adapters in desktop computers, or fully integrated devices within hand-held computers. Wireless LAN adapters provide an interface between the client network operating system and the airwaves. Typical data rates range from 1 to 7 Mbps.

Users need very little information to take advantage of wireless LAN. The nature of a wireless LAN is transparent to a user's computer, so all applications work the same as they do on wired LAN.

The simplest WLAN configuration is an independent (or peer-to-peer) WLAN that connects a set of PCs with wireless adapters. Any time two or more wireless adapters are within range of each other they can set up an independent network.

The output power of wireless LAN systems is very low, much less than that of a hand-held cellular phone. Since radio waves fade rapidly over distance, very little exposure to RF energy is provided to those in the area of a wireless LAN

system. Wireless LANs must meet stringent government and industry regulations for safety. To date, no adverse health affects have ever been attributed to wireless LANs.

4.2 WIRELESS LAN ADVANTAGE

Mobility - Wireless LAN systems can provide network users with access to real-time information anywhere in their organization. This mobility supports productivity and service opportunities not possible with wired networks.

Installation Speed and Simplicity - Installing a wireless LAN system can be fast and easy and can eliminate the need to pull cable through walls and ceilings.

Installation Flexibility - Wireless technology allows the network to go where wire cannot go.

Reduced Cost-of-Ownership - While the initial investment required for wireless LAN hardware can be higher than the cost of wired LAN hardware, overall installation expenses and life-cycle costs can be significantly lower. Long-term cost benefits are greatest in dynamic environments requiring frequent moves, additions and changes.

Scalability - Wireless LAN systems can be configured in a variety of topologies to meet the needs of specific applications and installations. Configurations are easily changed and range from peer-to-peer networks suitable for a small number of users to full infrastructure networks of thousands of users, allowing for roaming over a broad area.

4.3 REASON OF SETTING WIRELESS LAN

Mobility; Flexibility; Ease of Installation. Applying wireless LAN technology provides an organization with flexibility that would not be possible using a traditional LAN. Desktop computers can be located in places where running cable is impractical or

impossible. PCs can be redeployed anywhere within a facility as needed, making wireless ideal for temporary workgroups and rapidly growing organizations.

4.4 TOTAL OF ACCESS POINT

Floor	Level G	Level 1	Level 2	Level 3
Access Point	1	1	1	2

Total of Access Point = 5

* The project only use 5 access point at Building 2 because it depends on these criteria:

- The place for the access point must be secure from the unauthorized physical access. Unauthorized physical access here means any intrusion or harm being done directly to the access point by a person or any living thing. Usually, the access point is placed in high places and hard to reach places.
- The place for the access point must not have a blocking wall or blocking material that may interrupt the frequency or waves. An open area is very ideal for placing one. This is because the waves of the access point can be blocked by certain materials such as plywood, bricks and concrete. To overcome this problem easily, the access point is placed at an open area.
- To place the access point, the frequency and range of the area of the access point must also be considered. Calculations and testing within the area must first be done to ensure that the waves of the access point can reach the user thus, giving them access to the wireless LAN.
- The amount of access points placed at a certain area is also based on the expected user at the area itself. It would be a waste if there is an abundant of access point at an area but the users are not that many. So to cut cost and to minimize resources, a certain amount of access point is identified, which is not too much and not too little.

4.6 “Trial and Error”

From this testing, it has problems such as cannot load the IP address to Access Point. So, console cable is used to load the IP address. After testing, the IP address will load successfully. The configuration part also has problem when IP address cannot load. So, the configuration for access point is done 5 to 6 times until successful.

CHAPTER 5

5.1 CONCLUSION

Wireless LAN can provide many benefits. Wireless LAN can dramatically reduce the management costs and complexity of these environments while providing significant technical advantages. The conclusion and why the student recommends the wireless LAN system in UTP because:

Simplicity/Ease of Use

Users needs very little information to take advantage of wireless LAN. Because the wireless nature of a wireless LAN (WLAN) is transparent to a user's Network Operating System (NOS), applications work the same as they do on tethered LANs. WLAN products incorporate a variety of diagnostic tools to address issues associated with the wireless elements of the system; however, products are designed so that most users rarely need these tools.

WLANs simplify many of the installation and configuration issues that plague network managers. Since only the access points of WLANs require cabling, network managers are freed from pulling cables for WLAN end users. Lack of cabling also makes moves, adds, and changes trivial operations on WLANs. Finally, the portable nature of WLANs lets network managers pre-configure and troubleshoot entire networks before installing them at remote locations. Once configured, WLANs can be moved from place to place with little or no modification.

Security

Wireless technology has roots in military applications; security has long been a design criterion for wireless devices. Security provisions are typically built into wireless LANs, making them more secure than most wired LANs. This is because, it will using Wired Equivalent Protocol (WEP). WEP is used to protect wireless communication from eavesdropping, because wireless transmissions are easier to intercept than transmissions

over wired networks, and wireless is a shared medium, everything that is transmitted or received over a wireless network can be intercepted.

WEP relies on a secret key that is shared between a mobile station (e.g. a laptop with a wireless Ethernet card) and an access point (i.e. a base station). The secret key is used to encrypt packets before they are transmitted, and an integrity check is used to ensure that packages are not modified during the transition. The standard does not discuss how the shared key is established. In practice, most installations use a single key that is shared between all mobile stations and access points APs.

The goal of these security features is to make wireless traffic as secure as wired traffic. On the side: WEP security is not available in ad hoc (or peer-to-peer) 802.11 networks that do not use APs.

Cost

A wireless LAN implementation includes both infrastructure costs for the wireless access points and user costs for the wireless LAN adapters. Infrastructure costs depend primarily on the number of access points deployed; access points range in price from RM800.00 to RM2,000.00. The number of access points typically depends on the required coverage region and/or the number and types of users to be serviced. The coverage area is proportional to the square of the product range.

Wireless LAN adapters are required for standard computer platforms, and range in price from RM200.00 to RM700.00. The cost of installing and maintaining a wireless LAN is generally lower than the cost of installing and maintaining a wired LAN for two reasons. First, a WLAN eliminates the direct costs of cabling and the labor associated with installing and repairing it. Second, because WLANs simplify moves, adds, and changes, they reduce the indirect costs of user downtime and administrative overhead.

Scalability

Wireless networks can be designed to be extremely simple or quite complex. Wireless networks can support large numbers of nodes and/or large physical areas by adding access points to boost or extend coverage.

Battery Life for Mobile Platforms

End-user wireless products is capable of being completely untethered, and run off the battery power from their host notebook or hand-held computer. WLAN vendors typically employ special design techniques to maximize the host computer's energy usage and battery life.

Safety

The output power of wireless LAN systems is very low, much less than that of a hand-held cellular phone. Since radio waves fade rapidly over distance, very little exposure to RF energy is provided to those in the area of a wireless LAN system. Wireless LANs must meet stringent government and industry regulations for safety. No adverse health affects have ever been attributed to wireless LANs.

5.2 LIMITATION

There are several limitations when deploying a Wireless LAN:

- Interference from either other radio transmitting devices or other co-located Wireless LANs.
- Different vendor equipment may not be compatible with each other so they get stuck with a single provider. This is especially true because many vendors have additional non standards based features to compensate for the lack of security.

5.3 RECOMMENDATION

This is the future holds for the wireless LAN where the IEEE 802.11 WLAN standard will be one of the first generations of standardization for wireless LAN networks. This standard will set the pace for the next generation standard, addressing the demands for higher performance higher data rates and higher frequency bands. Interoperability between WLAN products from different equipment manufacturers will be important to the success of the standard. These products will be implemented on ISA, or PCMCIA cards for use in handheld personal computers, PDAs, laptops or desktop

applications. Wireless LAN applications are currently mostly in vertical markets. It is expected that many horizontal applications will follow as 802.11 network infrastructures is installed. Over time the increase in demand for 802.11 products is expected to increase competition and to make wireless LANs more competitive and economical for virtually all applications requiring wireless connectivity. On the horizon is the need for higher data rates, for applications requiring wireless connectivity at 10Mbps and higher. This will allow WLANs to match the data rate of the majority of wired LANs. There is no current definition of the characteristics for the higher data rate signal. However, for many of the options available to achieve it there is a clear upgrade path for to maintain interoperability with 1 and 2 Mbps systems while providing the higher data rate as well.

REFERENCES

1. Ian Sommerville, 2001, Software Engineering 6th Edition, Addison Wesley
2. Enterasys.com
URL: <http://www.enterasys.com>
3. Breeding, 2002, School Library Journal
http://www.findarticles.com/cf_0/m1299/8_48/90573748/p1/article.jhtml
4. Wireless Networking Industry's Information Source
URL: <http://www.wlana.org/>
5. Nouveau Solutions Limited, Complete Computing Solutions
URL: <http://www.cease-wire.co.uk>.
6. Smart Home Forum
URL: <http://www.smarthomeforum.com>
7. Kongshem, Lars, 2002, "Colorado's 'cursor cowboy' helps schools go wireless and save money." Electronic School Online <http://www.electronic-school.com/0197f1.html>
8. University of Utah
URL: <http://www.uusec.utah.edu/>
9. Wilson, Nancy, 2001, "Wireless Networking at Colorado State University"
URL:<http://www.colostate.edu/acns/wireless>

APPENDIX

FEATURES

Expandable architecture for higher performance, seamless interoperability

First to market that supports 802.11b, 802.11a and 802.11g technologies, bringing performance to 54 Mbps. Then, dual slot for multiple technology support simultaneously. Also offers forward compatibility/upgradeability to higher speed WLAN standards

Total system manageability — including policy management

Management scales to support thousands of wireless nodes. Then it manageable from RoamAbout AP Manager, NetSight Atlas, SNMPv3, Telnet and a web browser and dynamic load balancing spreads traffic across multiple access platforms

Industry-leading security features

The first one is client authentication through static ACLs and RADIUS client. Then Protocol Filtering and Broadcast Rate Limiting. Also have an IEEE 802.1x Authentication (MD5, EAP/TLS, PEAP, TTLS). Then Pairwise keys with 802.11a PC Card and VLAN in LAN to LAN Mode

Standards-based functionality protects investments

Support for current and future radio technologies, including existing 802.11b radios. Then it will support IEEE 802.11i, the proposed standard for security, and IEEE 802.11e Quality of Service for wireless.

DIFFERENTIATORS

The differentiators for the hardware refer to the www.enterasys.com are:

Advanced Network Functionality

Thanks to Layer 3/4 technology, the RoamAbout R2 will deliver nearly all the functionality commonly expected from the industry's highest-functioning wiring-closet switches. RoamAbout R2 supports IEEE 802.1x/Extensible Authentication Protocol and SNMPv3 for secure network management.

Additionally, through future firmware releases, RoamAbout R2 will support 802.11e Security and 802.11f Inter-Access Point Protocol. RoamAbout R2 also supports two radios, providing double aggregate bandwidth availability or simultaneous outdoor bridging and indoor WLAN support, or standalone bridging as part of a wireless mesh topology.

The RoamAbout suite was the first to deliver power-over-copper capabilities. This functionality is also supported in the RoamAbout R2. Its advanced networking functionality makes the RoamAbout R2 the most flexible wireless access platform in the industry.

Superior Management

InternetWeek has recognized the RoamAbout product suite for its superior approach to management. RoamAbout R2 is no exception. With management to support networks that scale from one to thousands of wireless nodes, RoamAbout R2 is fully manageable from the NetSight platform, enabling advanced management features such as policy-based management. RoamAbout R2 also supports SNMP v3, Telnet and web management.

Simultaneous Support for Current and Future Wireless Technologies

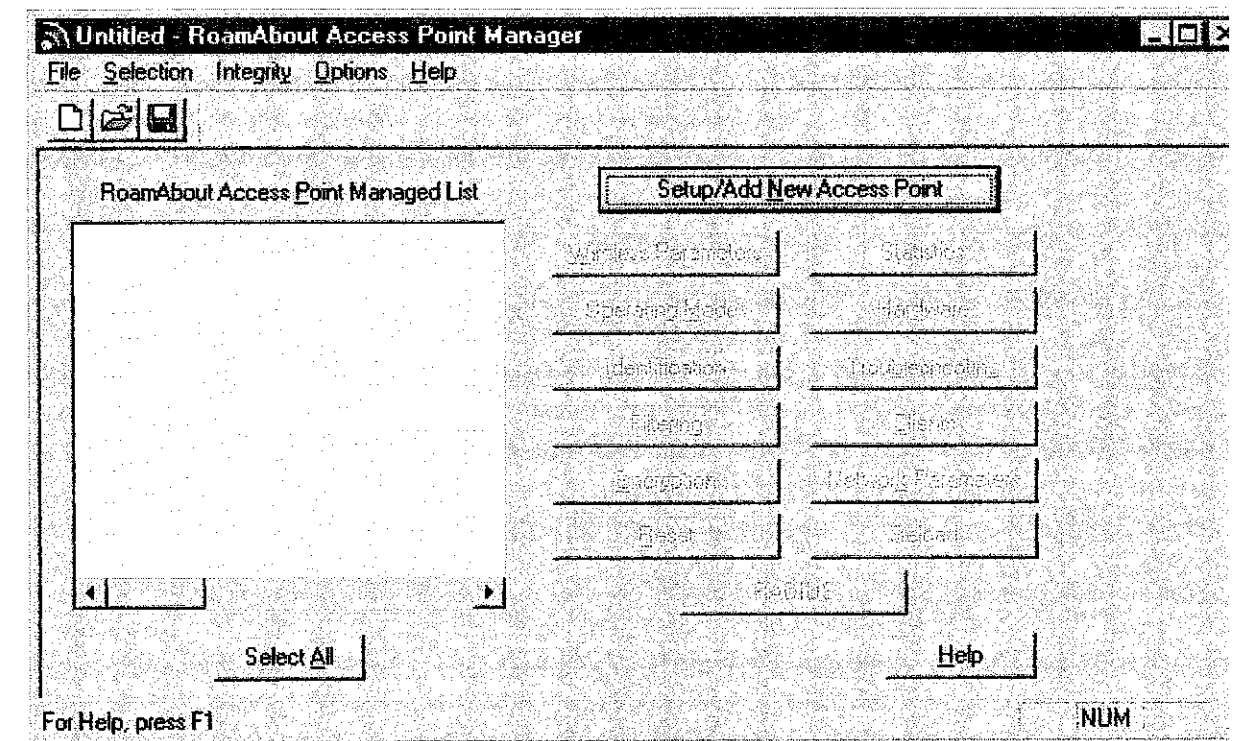
RoamAbout R2 is an 802.11b wireless access platform, but is fully upgradable to accommodate the technologies of new, higher-rate radios. Because it is designed to support two radios simultaneously, the RoamAbout R2 will be able to operate as both an 802.11a and an 802.11b access device, supporting high-rate radios and 802.11g radios simultaneously and ensuring true investment protection for users with an earlier solution. The RoamAbout R2 will also support two 802.11a or two 802.11b radio cards, when they are available.

CONFIGURATION

The activity that the student did in configuration part is identifying the IP address, the VLAN, the MAC address and which room that the Access Point is connected. The process that the student did in configuration part is shown at below:

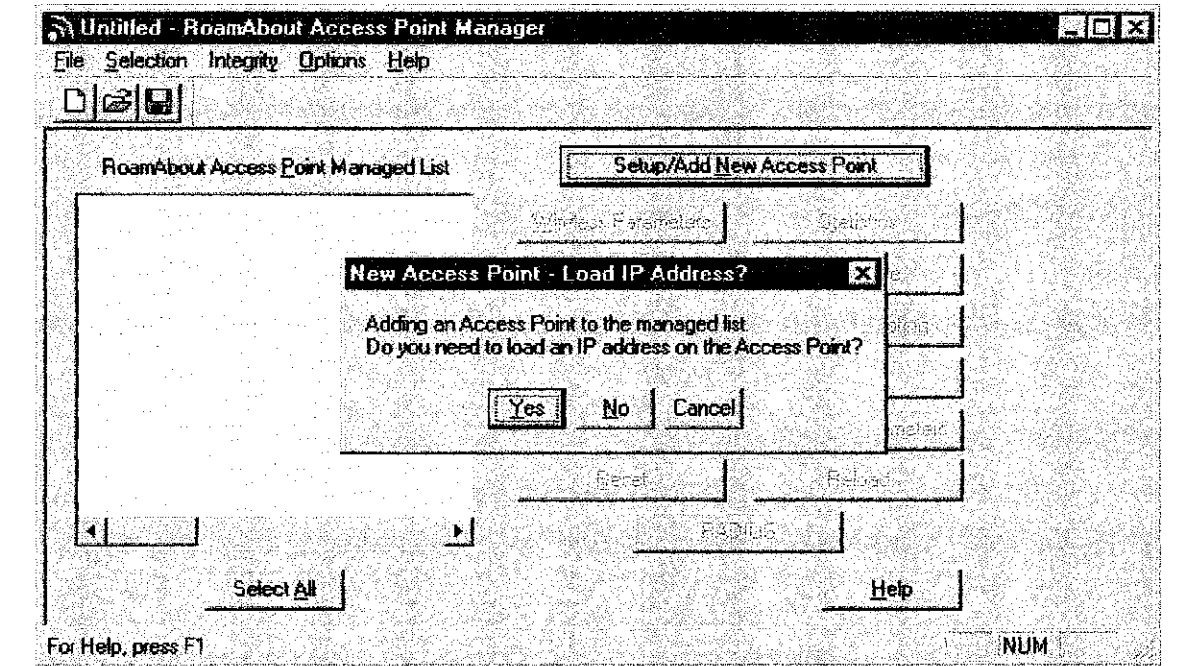
Managing the Access Point - (Using the Access Point Manager (SNMP))

Click "**Setup/Add New Access Point**" to add a new Access Point.



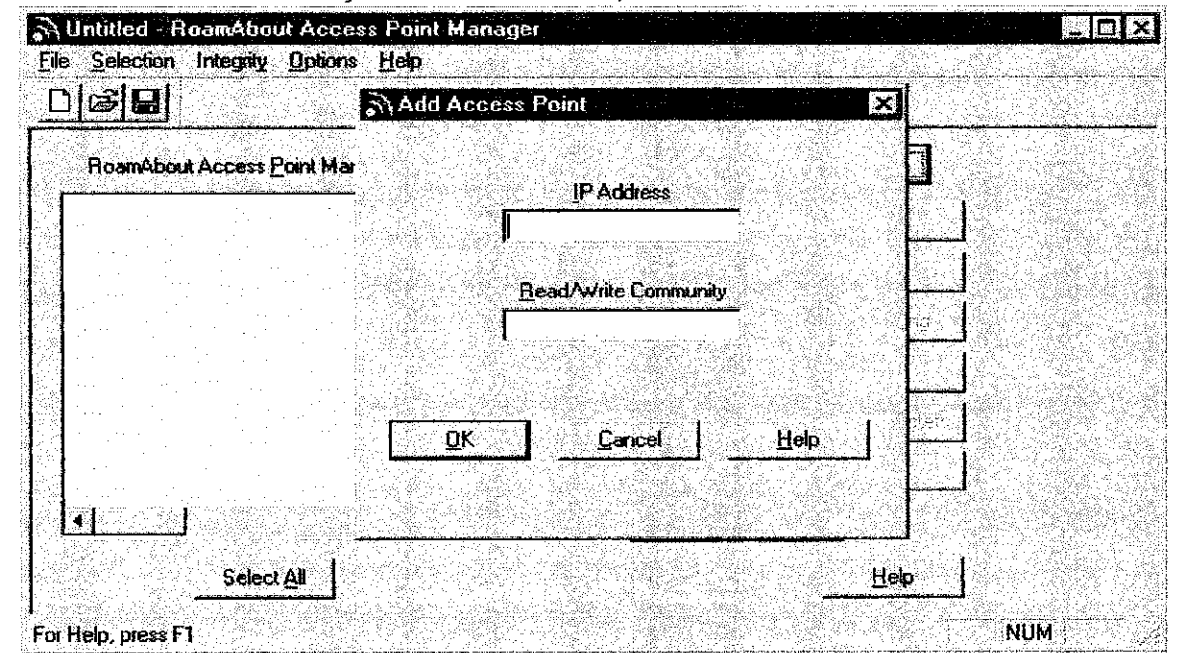
Managing the Access Point - (Using the Access Point Manager (SNMP))

Note: This utility will allow an IP address to be loaded via **BootP**. In this example, the IP address was previously loaded in local management. Click "**No**".



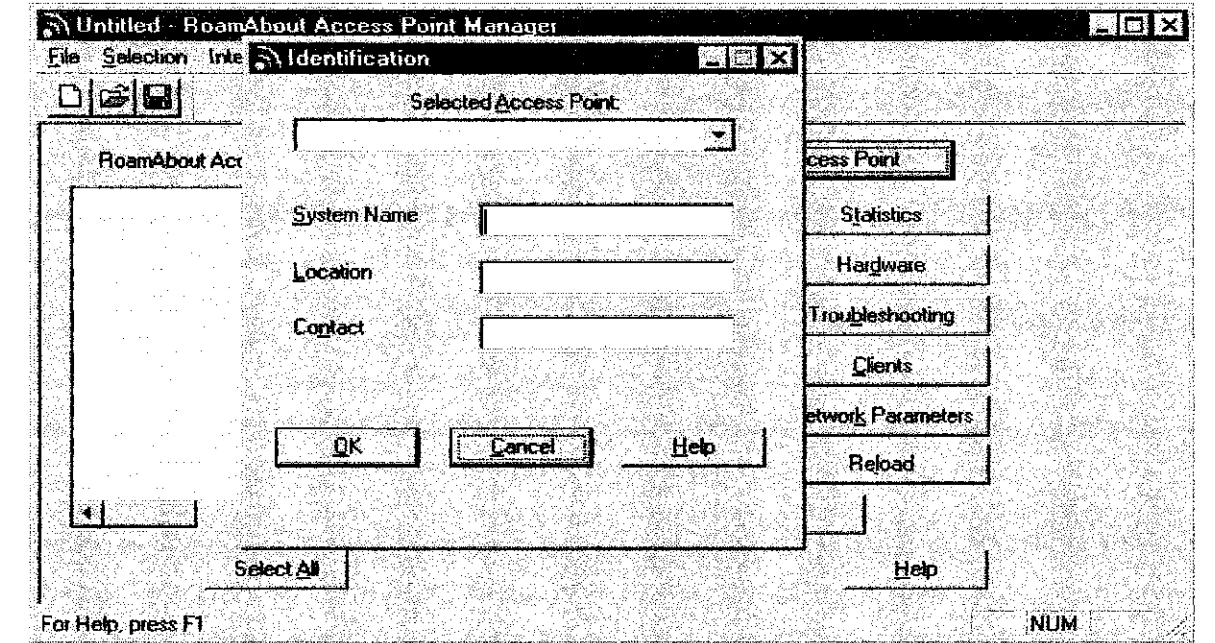
Managing the Access Point - (Using the Access Point Manager (SNMP))

Add the appropriate IP address for the Access Point to be managed in the "**IP Address**" field. If the **SNMP** community string was set, enter this information into the "Read/Write Community" field. When finished, click "**OK**".



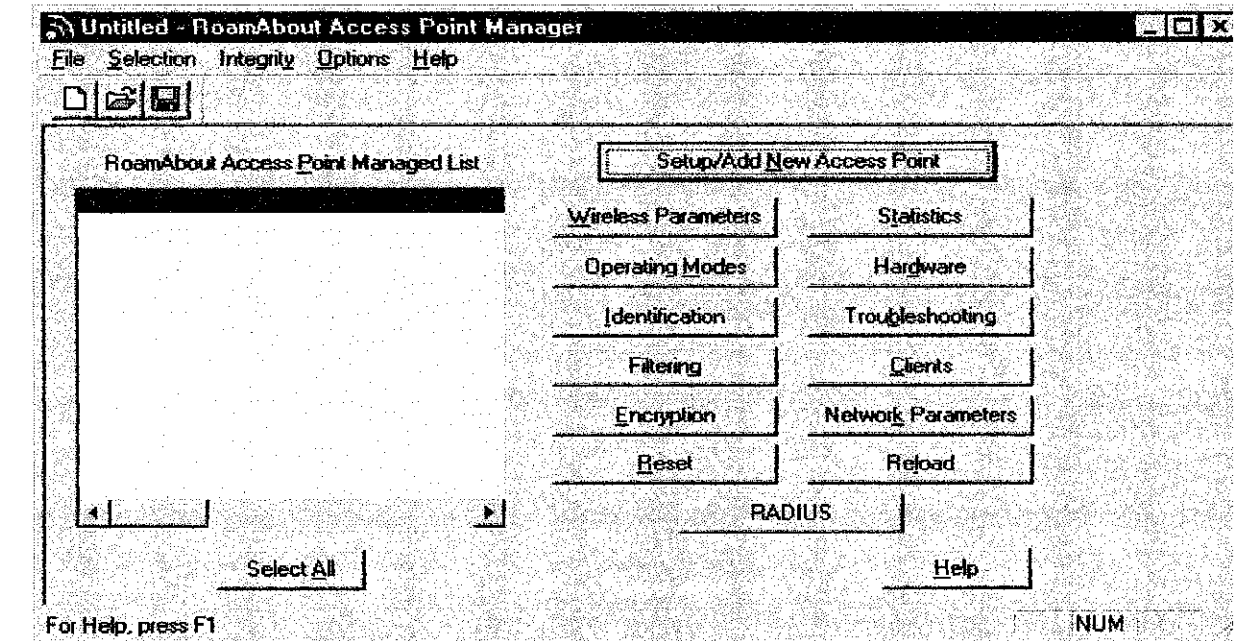
Managing the Access Point - (Using the Access Point Manager (SNMP))

Enter identification information in each field as necessary to identify each Access Point. Click "OK" when finished.



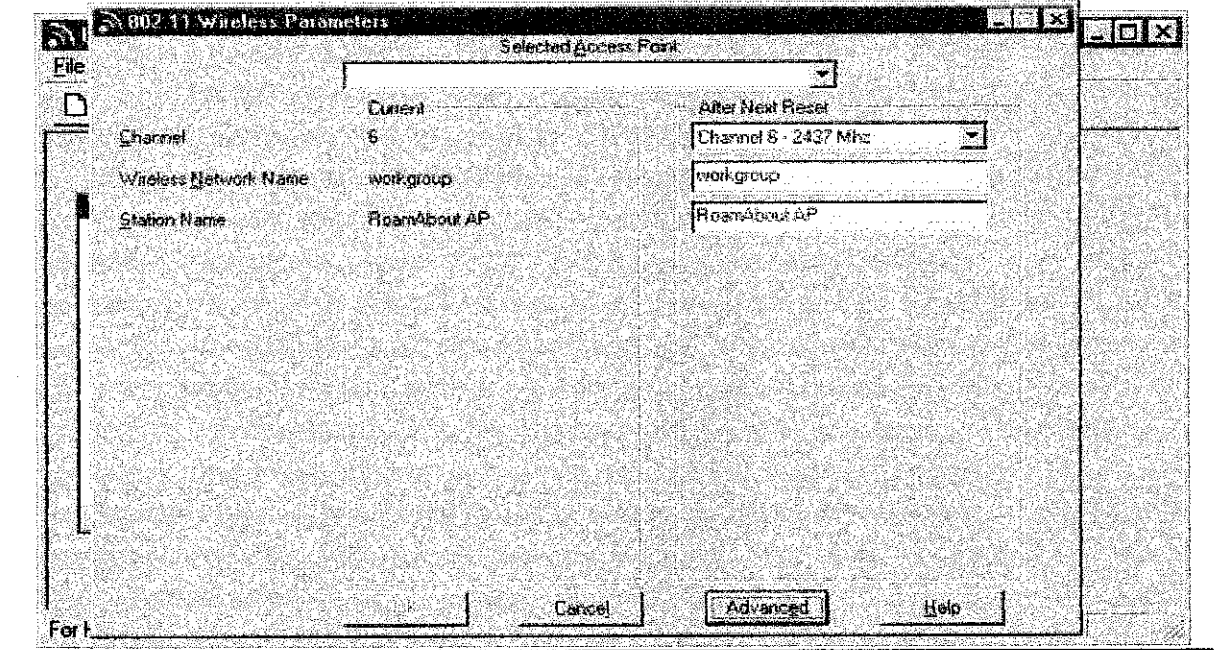
Configuring the LAN-to-LAN Mode

To begin *LAN-to-LAN* mode configuration, click "Wireless Parameters".



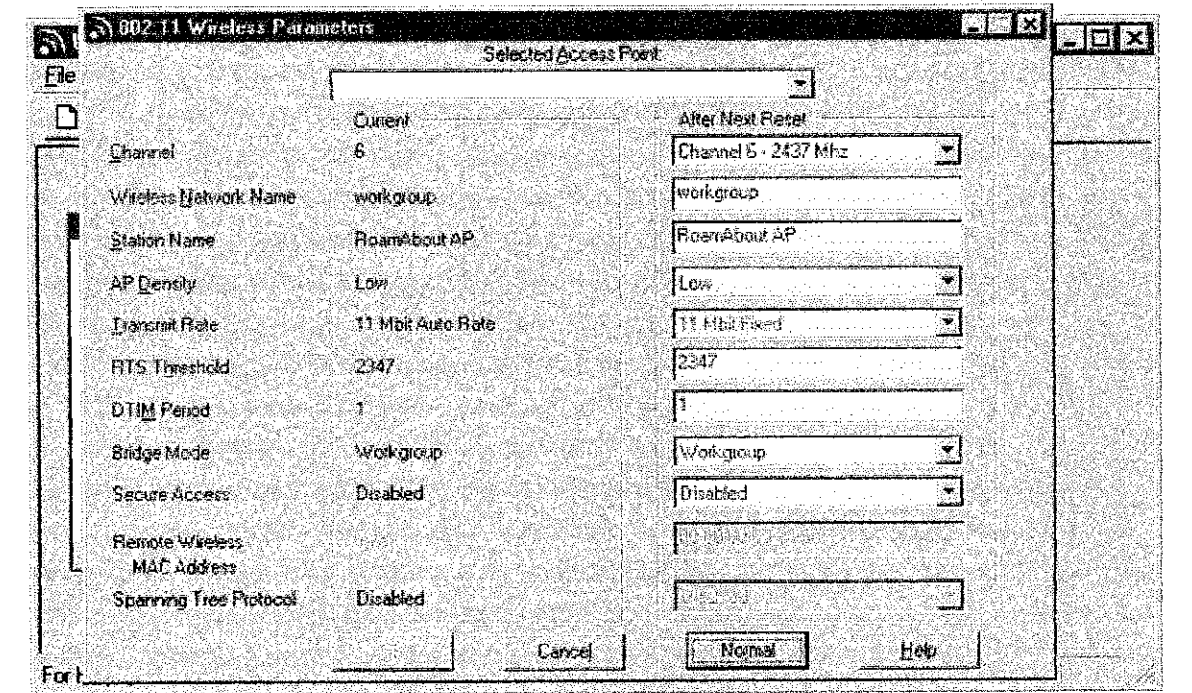
Configuring the LAN-to-LAN Mode

Click "**Advanced**" to further open the Wireless Parameters window.



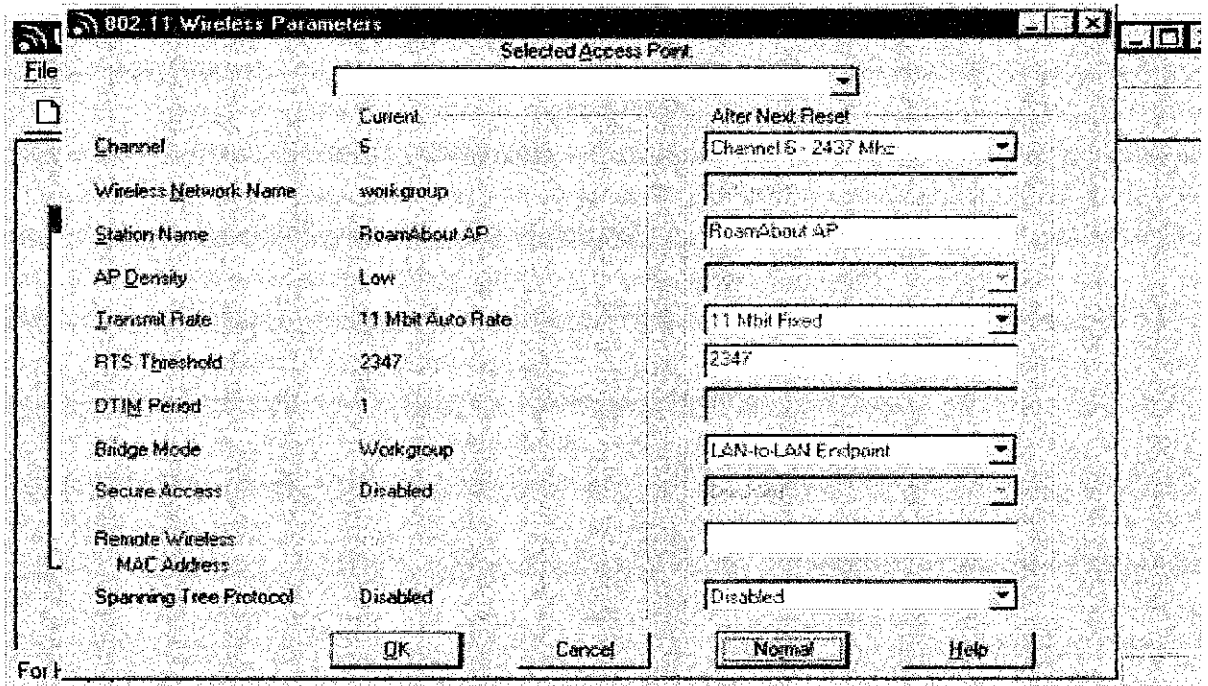
Configuring the LAN-to-LAN Mode

Select "**LAN-to-LAN Endpoint**" from the Bridge Mode pull down menu. Note: If the RA transmit rate is set to autorate, it is strongly recommended that you set it to fixed rate.



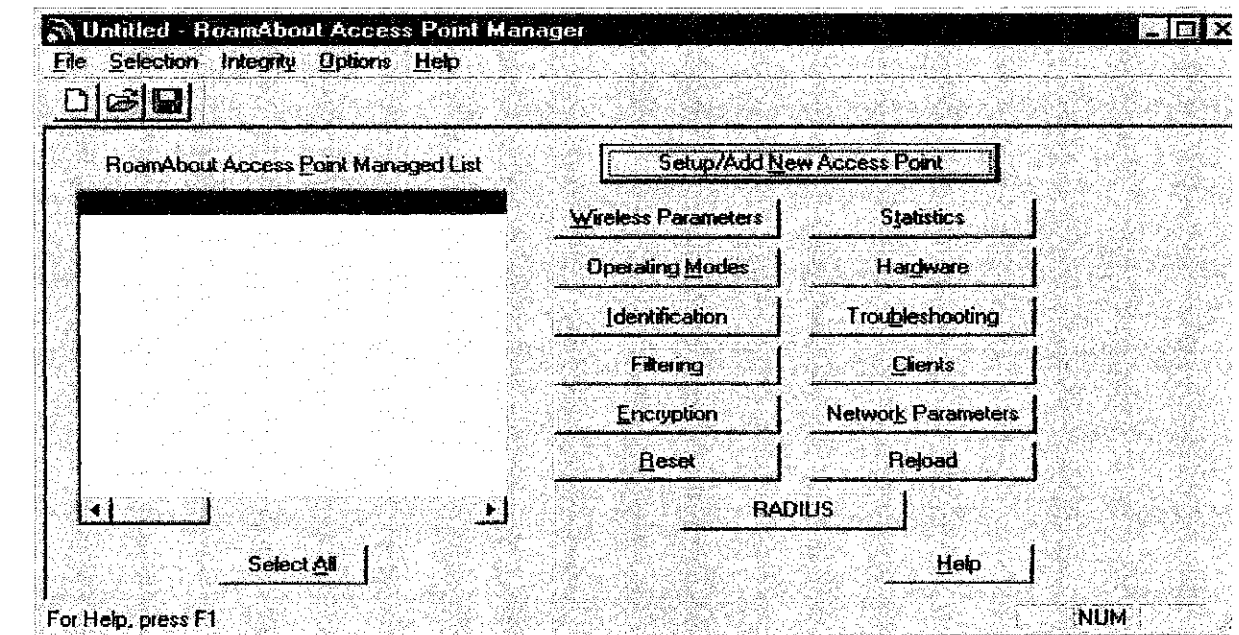
Configuring the LAN-to-LAN Mode

Within the **"Remote Wireless MAC Address"** field, type the wireless MAC address of the Access Point at the other end of the connection and click **"OK"** when finished.



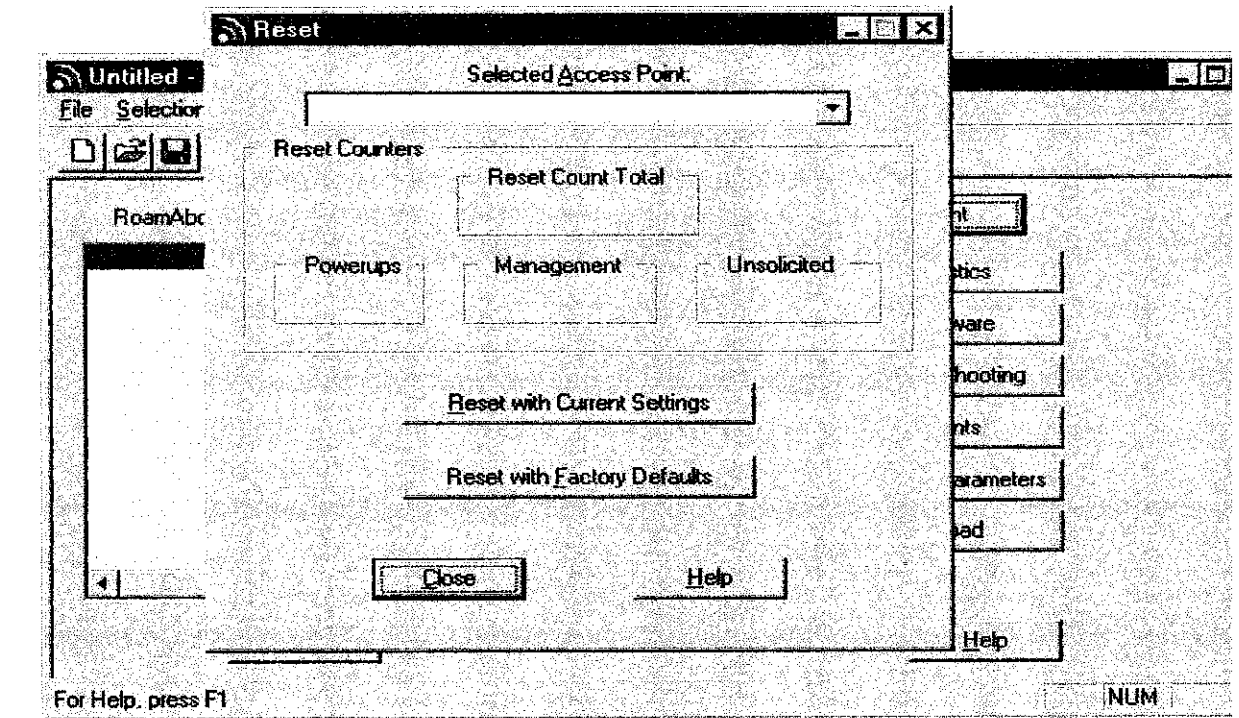
Configuring the LAN-to-LAN Mode

Once the Access Point is configured, the Access Point needs to be reset for the new settings to take effect. Click **"Reset"**.



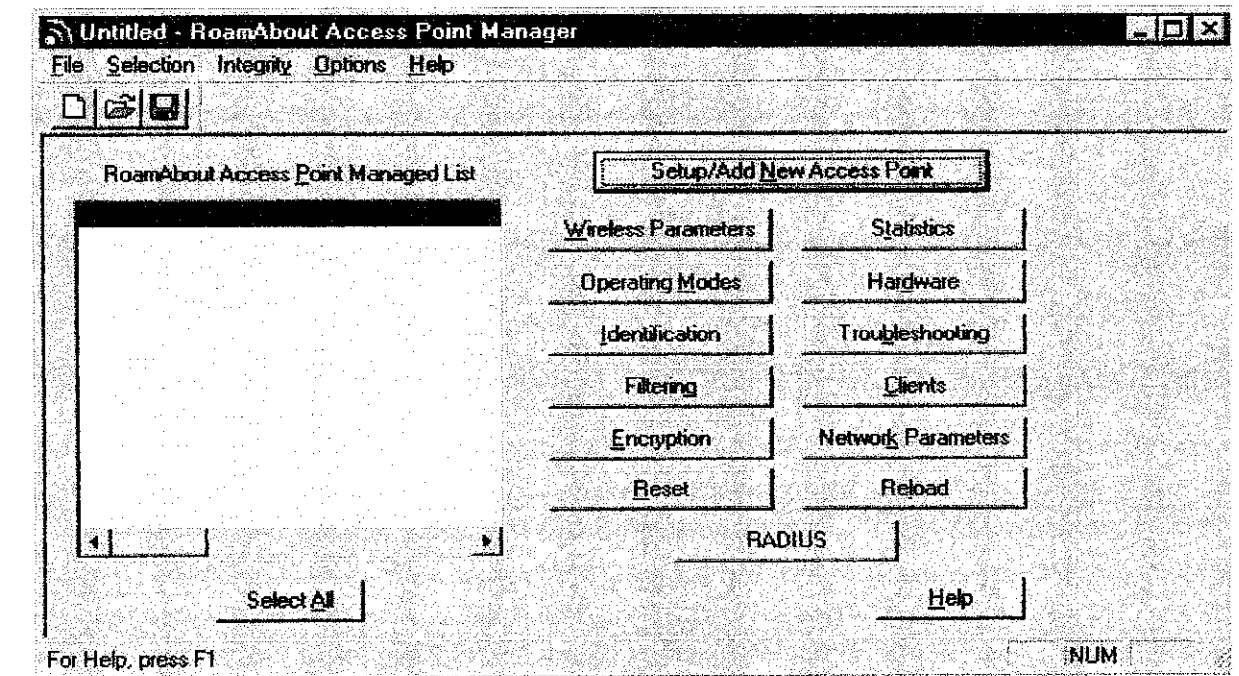
Configuring the LAN-to-LAN Mode

Click "**Reset with Current Settings**" to update the old settings.



Managing the Access Point - (Using the Access Point Manager (SNMP))

The new settings are now updated. Click the "X" in the top right hand corner of the AP Manager window to continue.



Why RoamAbout

A mature and award-winning technology, Enterasys RoamAbout Wireless offers networked solutions specially tailored for enterprise-level computing environments. Look to RoamAbout for increased productivity, investment protection and reduced installation costs, as well as the highest standards in wireless end-to-end security. In addition, RoamAbout is the first solution to support both 802.11a and 802.11b for seamless migration to higher performance 54 Mbps.

Value-Added Features

- **Secure, scalable and seamless interoperability.** Wi-Fi certified, with 11 Mbps performance (upgradeable to 54 Mbps in the RoamAbout R2), RoamAbout supports up to 250 users per Access Point. In addition, the RoamAbout R2 is built on Layer 3/4 switching technology for even greater control.
- **Support for “indoor” LAN-to-client and “outdoor” LAN-to-LAN.** With RoamAbout, one product supports LAN-to-client connectivity, LAN-to-LAN (building-to-building) connectivity, and point-to-multipoint, campus infrastructure connectivity.
- **Mobile network/Internet connectivity for employees and customers.** RoamAbout wireless LAN solutions provide mobile access, enabling users to roam from Access Point to Access Point through the network—without interruption.
- **Standards based for investment protection.** An IEEE 802.11-compliant solution, RoamAbout provides greater wireless extension and seamless interoperability with existing installed wire-based equipment, adding value to previous investments.
- **Total system manageability.** RoamAbout R2 offers complete manageability via RoamAbout AP Manager, which is included at no additional charge. The RoamAbout AP is also manageable via NetSight, enabling advanced management features such as policy-based management, and the RoamAbout R2 supports secure SNMP v3, secure Telnet and secure web management.

- **Highly secure data transmission.** RoamAbout offers 40-bit WEP (Wired Equivalent Privacy) and 128-bit (RC4 Algorithm) to provide the industry's highest level of security.
- **Easy to install.** RoamAbout Access Points are plug-and-play, so you can establish reliable, mobile network connectivity without unsightly and expensive traditional cabling.

Enterasys RoamAbout 802.11a Super Rate Wireless LAN Access Point PC Card

Step Up in Wireless Performance, Quickly and Cost Effectively

A 5.15–5.35 GHz 54 Mbps Direct Sequence Spread Spectrum (DSSS) PC card for the RoamAbout R2 Access Point, the RoamAbout 802.11a wireless LAN PC card uses radio frequencies to transmit data to clients working on desktop PCs, industrystandard notebook PCs, or other handheld devices. The RoamAbout 802.11a wireless PC card has a 32-bit CardBus interface. Compliance with IEEE 802.11a ensures 54 Mbps performance for maximum throughput, as well as vendor interoperability, seamless integration and investment protection.

Since RoamAbout uses the ISM band (Industrial, Scientific and Medical), no US FCC license is required. RoamAbout 802.11a PC cards that meet the requirement of ETSI and other international agencies are also available.

Technical Specifications

Frequency Band	5.15 – 5.35 GHz
Number of Selectable Sub Channels (subject to local regulations)	United States (-AX): 8 Canada (-AX): 8 Japan (-AJ): 4 Europe: country specific APAC: country specific South America: country specific
Modulation Technique	Direct Sequence Spread Spectrum OFDM
Bit Error Rate	Better than 10 ⁻⁵
Media Access Protocol	CSMA/CA (Collision Avoidance) with ACK
Wireless Medium	Orthogonal Frequency Division Multiplexing (OFDM)
Modulation	BPSK at 6 and 9 Mbps, QPSK at 12 and 18 Mbps, 16-QAM at 24 and 36 Mbps, 64-QAM at 48 and 54 Mbps
Interface	32-bit CardBus (PCI) Type II Extended
Data Rate	54 Mbps (with fall-back rates of 48, 36, 24, 18, 12, 9 & 6 Mbps)
Semi Open Office	54 Mbps: 21 meters (70 feet) 48 Mbps: 28 meters (90 feet) 36 Mbps: 50 meters (160 feet)
Available Output Power Settings	14dBm/25mW, 13dBm/20mW, 12dBm/16mW, 10dBm/10mW, 8dBm/6mW, 5dBm/3mW, 0dBm/1mW, -15dBm/0.03mW
Receiver Sensitivity dBm	-69 dBm, -75 dBm, -80 dBm, -86 dBm, -88 dBm

Internal Antenna	Up to 4.5dB of gain on transmit and receive
Power Consumption PC Card	Receive mode: 440 mA Transit mode: 540 mA

Physical Specifications

Dimensions	11.78 cm (4.64") x 5.4 cm (2.12") x 0.87 cm (.34")
-------------------	--

Environmental Specifications

Operating Temperature	-20°C to 50°C (-4°F to 122°F)
Operating Humidity	95% maximum humidity, non-condensing
Power Supply	3.3V power supply
Standards	IEEE 802.11a

Agency and Standards Specifications

Safety	UL60950 Canada: CSA C22.2 No. 950 Europe: EN60950 and 73/23/EEC Australia: AS3260
Electromagnetic Compatibility (EMC)	United States: FCC Parts 2 and 15, OET 65 Canada: CS-03 and ISC RSS210 Europe: EN55022, ETS 301 489-17, ETS 301 489-1, EN55024, EN61000-3-2, EN61000-3-3 Japan: VCCI-V3 and MPT radio regulations Australia: AS3548
Warranty	1 year

802.11a PC Cards

RBTBF-AX	RoamAbout 802.11a 54Mb/s PC Radio Card (5.15 - 5.35GHz) with onboard antenna only. R2 Access Point only
RBTBF-AL	RoamAbout 802.11a PC Radio Card (Low 4 channels) RoamAbout R2

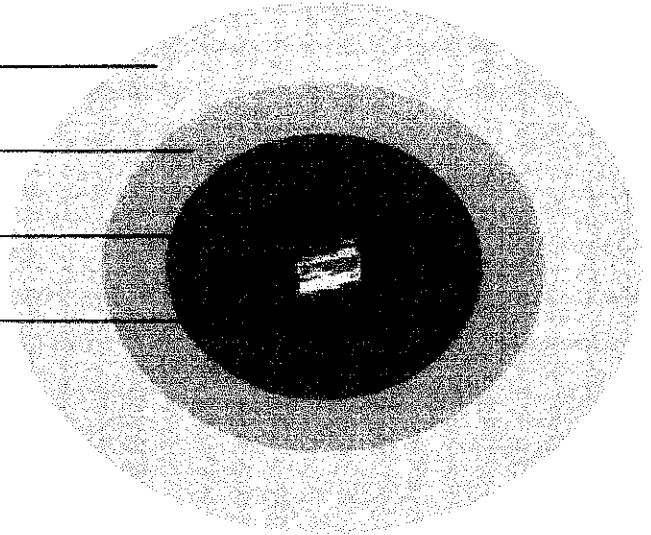
	Wireless Access Platform Only
RBTFB-AJ	RoamAbout 802.11a PC Card (1 pack) for Japan. R2 access point only
RBTBG-AW	RoamAbout 802.11a/b/g Multimode Client Card
<i>RoamAbout R2 Access Points</i>	
RBTR2-AB	RoamAbout Wireless Access Platform with 110/220v (worldwide)
RBTR2-AZ	RoamAbout R2 with Mezzanine
RBTR2-MZ	RoamAbout R2 Mezzanine Adapter for second slot
<i>802.11b PC Cards</i>	
CSICD-AW-128	RoamAbout 802.11DS World PC Card
CSI6CD-AW-128	RoamAbout 802.11DS World PC Card - 6PK
CSI40CD-AW-128	RoamAbout 802.11DS World PC Card - 40PK
<i>802.11b PC Cards for Outdoor Use</i>	
CSIBD-AA-128	RoamAbout PC Radio Card (128 bit encryption) for FCC countries
CSIBD-AB-128	RoamAbout PC Radio Card (128 bit encryption) for ETSI countries
CSIBD-AF-128	RoamAbout PC Radio Card (128 bit encryption) for Singapore countries
CSIBD-AJ-128	RoamAbout PC Radio Card (128 bit encryption) for Japan countries
CSILD-AB-128	RoamAbout High Gain Matched Radio Card with 128 bit encryption (ETSI Countries, Used with directional outdoor antenna)

CSILD-AF-128	RoamAbout High Gain Matched Radio Card with 128 bit encryption (Singapore, Used with directional outdoor antenna)
CSILD-AJ-128	RoamAbout High Gain Matched Radio Card with 128 bit encryption (Japan, Used with directional outdoor antenna)
Bundles	
RBT6D-AW-SP6	R2 Worldwide Starter Kit (6-CSICD-AW-128 Cards)
RBTED-AA	R2 Directional Bundle for North America
RBTED-AB	R2 Directional Bundle for International
RBTED-AA-M07	R2 Omni Directional Bundle for North America
RBTED-AB-M07	R2 Omni Directional Bundle for International
Optional Products	
CSIBB-IA	RoamAbout 802.11b Indoor Antenna - Used for desktop PC applications where you want to extend antenna, or when the AP is not ideally located.
RBTBX-PC	RoamAbout PCI Carrier, 16 & 32 bit bus (requires a PC Radio Card)
RBTR2-PS3	RoamAbout Replacement/Redundant Power Supply 120-240 VAC
CSIWS-RM	RoamAbout Rack Mount for Remote Power Injector (holds three injectors)
CSIWS-RMPER	RoamAbout Remote Power Injector (spare/replacement)

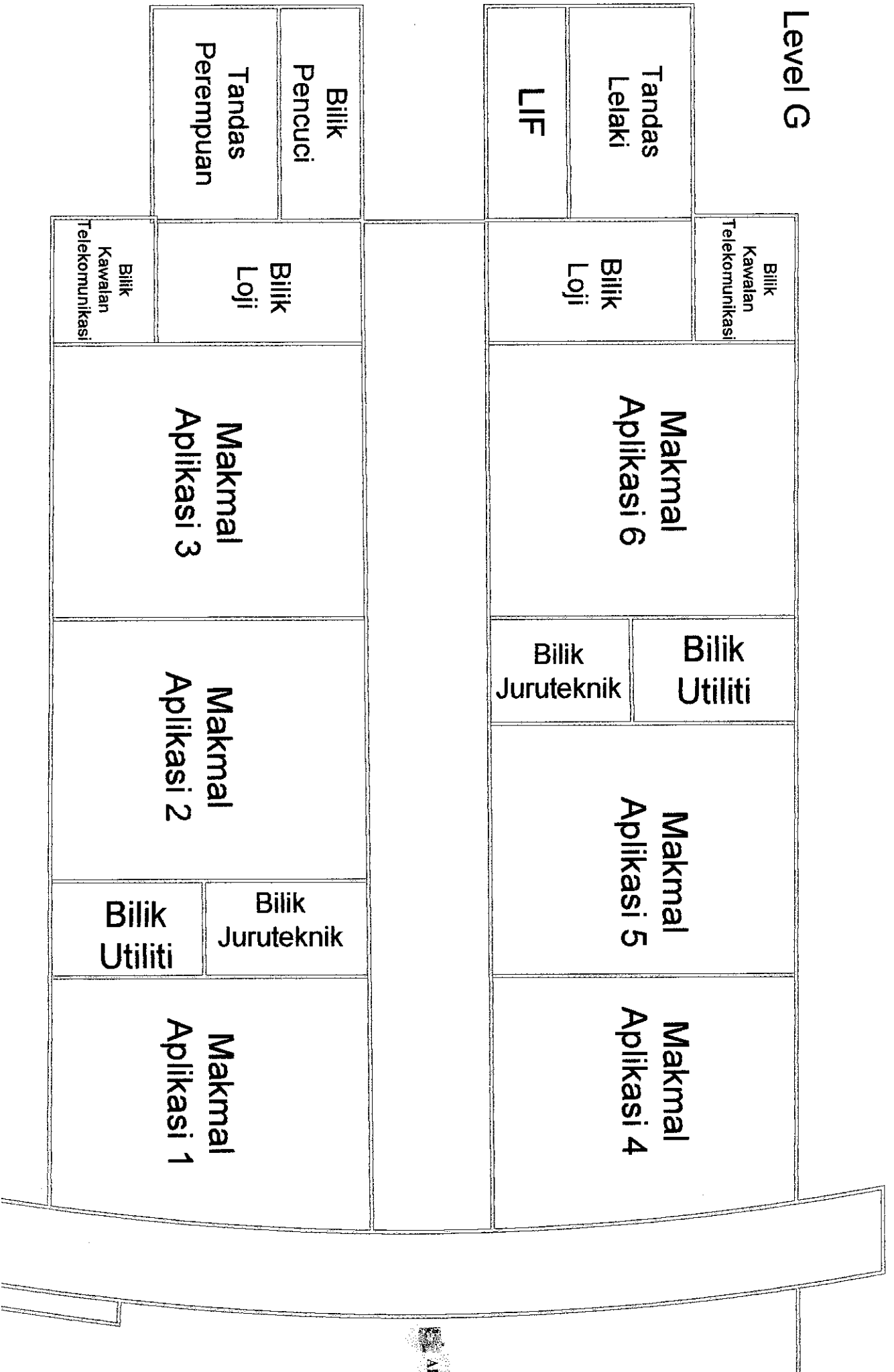
COVERAGE FOR ROAMABOUT R2

The ideal coverage for a RoamAbout PC card used in an open environment follows:

- 560 feet @ 1Mbps
- 410 feet @ 2Mbps
- 298 feet @ 5.5Mbps
- 216.5 feet @ 11Mbps




Level G



Level 1

<p>Tandas Lelaki</p>	<p>LIF</p>	<p>Bilik Kawalan Telekomunikasi</p>	<p>Bilik Loji</p>	<p>Makmal Komunikasi Data</p>	<p>Bilik Server</p>	<p>Bilik Juruteknik</p>	<p>Bilik Utiliti</p>	<p>Bilik Juruteknik</p>	<p>Bilik Utiliti</p>	<p>Makmal Multimedia 5</p>	<p>Makmal Multimedia 4</p>
<p>Bilik Pencuci Tandas Perempuan</p>	<p>Bilik Loji</p>	<p>Bilik Rakaman Audio 1</p>	<p>Bilik Utiliti</p>		<p>Bilik Rakaman Audio 2</p>	<p>Bilik Juruteknik</p>	<p>Makmal Multimedia 3</p>	<p>Makmal Multimedia 2</p>	<p>Bilik Juruteknik</p>		
<p>Bilik Kawalan Telekomunikasi</p>	<p>Makmal Multimedia 3</p>	<p>Makmal Multimedia 2</p>	<p>Makmal Multimedia 1</p>								

Level 2

<p>Tandas Lelaki</p>	<p>LIF</p>	<p>Bilik Kawalan Telekomunikasi</p>	<p>Bilik Utitiiti</p>		<p>Makmal Usabiliti A</p>		<p>Bilik Menunggu Usabiliti</p>		<p>Makmal Realiti Maya 1</p>		<p>Bilik Server</p>		<p>Makmal Realiti Maya 2</p>				
<p>Bilik Pencuci</p>		<p>Bilik Loji</p>		<p>Makmal Usabiliti B</p>		<p>Bilik Kawalan Usabiliti</p>		<p>Bilik Pemerhatian Usabiliti</p>		<p>Bilik Perbincangan</p>		<p>Makmal Multimedia 6</p>		<p>Bilik Seminar</p>		<p>Bilik Pasca - Ijazah</p>	
<p>Tandas Perempuan</p>		<p>Bilik Kawalan Telekomunikasi</p>															

Level 3

