Near East University

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Graduation Project

WIRELESS NETWORK AND EMERGING TECHNOLOGY

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Acknowledgement

The writing of this project to some extent is rather unusual. When I decided to take up this as my graduation project, I was informed in advance about the limitation and scarcity of information available on the chosen topic as most of the project information is still in research phase. Still due to my keen interest in this topic which compelled me to take the challenged and by the grace of Allah, I was quite successful in obtaining sufficient data, that not only was necessary for the completion of my project but also resulted in the creation of a remarkable piece of research.

I certainly couldn't have completed this thesis report on my own. Many people contributed a great deal to making this thesis a reality. Special thanks to Ekrem Varoglu (who himself will be submitting his Ph.D. thesis) because the information he gave me prior to this project created my interest in this topic and also for providing me the guidelines that I needed, both for attaining information and for the compilation of the report. I took most his keen suggestion.

Last but not the least comes my friend who helped me through my research, as well as compilation of this report. Kamran Rashid is one of those who can't be retained from being mentioned here.

Ancient Chinese curse reads" May you live in interesting times". So I wish that my thesis report kept all those peoples life interesting as they go along reading it and getting themselves informed.

Abstract

The concept of "Wireless Networks" has been around for more than a decade. With the ever-changing need for anywhere, anytime need of information and faster data rate, it is now being considered as a potential framework for the next generation of wireless communication network capable of supporting wireless network ranging from a office, a university campus to large areas comprising of industrial unit and factory spaces.

In this project, I outlined the technological rationale of wireless network with its different aspect, Wireless LANs, Wireless PANs, Wireless Internet, Wireless ATM, and LMDS presents system-level architecture, and discuss key design issues for both wireless network configuration and radio access. WLANs and WPANs includes configuration, interference, protocols used, applications, implementation, access methods, and modulation techniques. Wireless Internet includes applications, implementation, protocols, data transfer technology and access methods. WATM includes architecture, communication method and future directions. LMDS includes communication methods, infrastructure and integration of different data transfer technology. This project concludes with a brief discussion of all the topics and theories discussed earlier.

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Chapter One

Introduction

Since the earliest times, man has found it essential to communicate with others. Developments in communications technology have always been driven by the need for information to be distributed in the shortest possible time. It may come as a surprise, but the earliest forms of communication were made by using wireless data technology. Long before the telephone was invented, American Indians used smoke signals to communicate over long distances. Sailors were using semaphore with flags, or Morse code with signaling lanterns, to communicate between ships or to the shore. For the first time Morse code allowed normally written characters and symbols to be transmitted over copper wires. The advent of computer communications has changed our perception of data communications from thinking of Morse code to the very high-speed data links of thousands or millions of bits of information per second over tremendous spans of geography. The data transmitted represent many different types of information including multiple voice channels, full-motion video and computer data. Voice communications over radio has rapidly spread with cellular telephone technology all over the world.

Parallel to these developments in wireless technology, the power of personal computing has brought high-speed data processing ability to the desktop. New applications have made PC users more productive; new lightweight and inexpensive portable PCs allow users to take their information and tools with them. The need to share information and resources among personal computer users has spawned the spread of local area networks (LANs), which in turn have required wire-based

connections. The use of wires limits user flexibility to move freely within the office environment. The marriage of wireless communications and mobile computing will transform the way we do business. The convergence of hardware, software, communications and wireless technologies will ensure that information and services will be available to computer users at all times, in all places. Cellular and cordless phones, pagers, portable computers, mobile radio units, and vehicle tracking units all use a wide range of protocols and transport options. Portable products such as Personal Digital Assistants (PDAs), Personal Intelligent Communicators (PICs), WAP-enabled GSM mobile phones and Wireless palm pilot are combining separate voice and data functions in compact portable packages.

These developments clearly show that wireless communication is growing at an explosive rate around the world. Wireless importance depends upon its need. At present Wireless network comprises of Wireless LANs (local area network), Wireless Internet, Wireless Personal Area Network (WPANs) and Wireless ATM (asynchronous transfer mode), and LMDS (local multipoint distribution system). Due to advancement of technology cellular phones have changed to pocket portables weighing the same as a pocket diary. The emergence of mobile end-user devices is becoming "information appliances". The mobility offered by wireless technology is being used by businesses to optimize their use of employee time, become more competitive, make better business decisions and provide better customer service. This has brought increase in the amount of profit margins.

With the ever-growing need of faster management information systems - information "as it happens" is becoming mandatory and with wireless communications access any time and any place, you will expect and get the delivery of information and

services no matter where you are. Un-tethered operations are required for immediacy when moving about (for example, to contact a public safety officer on patrol, or a medical professional in case of a problem), to avoid wiring expenses for temporary communications or in an environment where wiring is impractical (for example, a national landmark building or a staging area where emergency response teams are mobilized), when wire lines are down (for example, in a natural disaster), or where an inadequate, unreliable, or obsolete wired infrastructure exists (for example, underdeveloped areas). All of these can be achieved by Wireless LAN alone. With these advancement it is possible to communicate with small, reliable, energy-constrained mobile devices that are cheap enough for widespread use. At present, other forms of information are being merged into more advanced digital wireless systems, a trend driven by portable computers and digital hand-held data devices. The most important issue, which will dictate the overall development of wireless communications in the next decade and beyond; will be its usage and demand, that is which part of society will help in growing it, how it will be used, cost of service and what will be the advantages and benefits, which will compel the user to connect a personal communicator to a network, speed will play a major role in defining its usability. Mobile phones (WAP enabled phones) have started taking the place of cellular phones and that is due to availability of logical presence through physical roaming, or the ability to stay in touch on ones own terms, are in demand. Today, these requirements are provided to any one who is on move and wants to download E-mail, update their calendars, send or receive a fax, check inventory, place an order, record route status, call a customer, talk to a peer in short a virtual office - anywhere,

anytime. Affordable application solutions are and will be the key ingredient in the rapid acceptance of wireless technologies.

This project clearly analyses and explores the new technology that is "Wireless Networks" including its aspects that it is comprised of. All the information is divided into parts, which clearly explains and ratify the importance, availability, and benefits of wireless network and on the otherhand it covers all the technological information. The different aspects of wireless networks are categorized in chapters that cover topic in detail.

In chapter two I have discussed about Wireless LANs, which explains the need to switch from wired to wireless LANs, the standard that are made by IEEE for modulation, its applications, its benefits to users, what are the technologies used by radio waves for a secure data transfer, how do wireless LANs work, which can be understood easily by provided the figures. Other than this it explains the coverage area of wireless LANs, its data rate, kind of security provided, what are the object that degrade its service quality, it also explains the its configurations and where wireless networks are implemented.

In chapter three Wireless Personal Area Networks (WPANs) is discussed, which clearly distinguishes the properties of WLAN to that of WPAN. The standard that WPAN follows and what are the new standards, which are being considered for it. As this is relatively a new branch of Wireless Network its applications and benefits are not so much explained, due to this it has some interference problem with other wireless devices, which is explained in detail and how to avoid it.

Chapter four gives information of a new branch of Wireless Network responsible of sending data at high bit rate that is Local Multipoint Data Service (LMDS). Here I

have discussed the benefits of LMDS over other technology in its category, how does it works? Its architectural and network overview is thoroughly discussed. Along with this the quality of service with LMDS on the Edge is explained and the future changes in LMDS are included with emphasis on the integration of IP and ATM, with its architectural and service foundation aspect.

The fifth chapter presents the theory about wireless ATM (asynchronous transfer mode). As it is being considered as the potential framework of next-generation wireless communication. This technology is still in its infancy and most of the work related to it is either still in research or in theory. But despite of this it is the most reliable wireless communication network capable of supporting integrated, quality-of-service based multimedia service. Here in this chapter the need of wireless ATM is discussed with its architecture, cell size, physical layer, media access layer, data link layer, virtual circuit management and packet routing, network location and connection establishment. All these topic give a clear view of the present standing of WATM and what are the new topic which are in research and what are the thought about it future and where should it stand in future.

The sixth chapter is about Wireless Internet, which is discussed, in great detail because of its wide application in society. Different data transfer technologies are discussed, it working, Here it has been categorized in accordance with it functionality, along with this the most important factor which made its existence possible, the wireless application protocol (WAP) is discussed with its goals the standards it follows, and the most important is the example of practical application of wireless internet has been discussed.

The last chapter is the conclusion which gives a overview account of the project, what are its limitations how they can be overcome, what new development can be done and lastly there are some view discussed which if taken into consideration can be very beneficial for the advancement of this specific field. After clearly reading these chapter with their topic will give the reader a clear idea of the present technological status of wireless network and give clear idea what are the new development needed to make this field more practical and easily accessible.

Chapter Two

WIRELESS LOCAL AREA NETWORK (WLANs)

2.1 Introduction

Imagine not being tied to your desk for accessing to a LAN (local area network) resource such as the Internet, email server, database files, printers and more. If you can access all of these services in whatever way you want, without going anywhere. Wireless networks can only achieve this.

The term wireless networking refers to technology that enables two or more computers to communicate using standard network protocols, but without network cabling. Strictly speaking, any technology that does this could be called wireless networking. Currently the most talked about are wireless LANs. Wireless LANs allow workstations to communicate and to access the network using radio propagation (electromagnetic waves) as the transmission medium and minimizing the need for wired connection. This technology fuelled by the emergence of cross-vendor industry standards such as IEEE 802.11. The wireless LAN can be connected to an existing wired LAN as an extension, or can form the basis of a new network. Being wireless makes it adaptable to both indoor and outdoor environments, but they are especially suited to indoor locations such as office buildings, manufacturing floors, hospitals, warehousing, retail and universities. This broad application has produced a number of affordable wireless solutions that are growing in popularity with business and schools as well as sophisticated

applications where network wiring is impossible, such as in warehousing or point-of-sale handheld equipment. The application of wireless LAN is greatly defined by the area where it will be in use because the data rate and signal strength are effected by concrete walls and other obstacle which makes the signal difficult to propagate. Thus, WLANs combine data connectivity with user mobility, and, through simplified configuration, enable movable LANs. With these benefits quiet a large number of industries have profited from the productivity gains of using hand-held terminals and notebook computers to transmit real-time information to centralized hosts for processing. Today WLANs are becoming more widely recognized as a general-purpose connectivity alternative for a broad range of business customers.

2.2 Why Wireless?

Here if we do a comparison between wired and wireless LAN we will be in a better position to know the advantages of wireless. The best example for this will be something related to Healthcare. Healthcare centers, such as hospitals and doctor's office, must maintain accurate record to ensure effective patients care. A simple mistake can result in grave consequences. As a result, doctors and nurses must carefully record test results, physical data, pharmaceutical orders, and surgical procedures. These records are maintained both on papers and in main computers. This often is too much for healthcare staff and a lot of time is wasted in maintaining the records in this way. The only solution to this problem is to have mobile computers that are connected to the main computer with the help of wireless. Then the doctors and nurses can access the information of a patient with

only some keystrokes and they can spend more time attending to patients. This is a very important reason why wireless should be used.

2.3 IEEE 802.11 Standard

802.11 is the IEEE (Institute of Electrical and Electronics Engineers) standard for wireless networking - sending Ethernet data packets through the air. The standard allows for wireless integration with wired IEEE 802.3 Ethernet networks using devices called access points or base stations. This means the IEEE 802.11 wireless standard supports all standard Ethernet network protocols including TCP/IP, AppleTalk, NetBEUI and IPX. It has completed the specification for data rates of 2 Megabits per second (2Mbps) with a fallback to 1Mbps if reception is not adequate. Nearly all the wireless related products comply with this IEEE802.11 standard. The 802.11 wireless standard currently includes three different types of radio technologies; diffused infra-red (DFIR), Frequency Hopped Spread Spectrum (FHSS) and Direct Sequence Spread Spectrum (DSSS).

Unfortunately the IEEE802.11 committee allowed more than one modulation technique in the same standard. The other very popular one is direct sequence spread spectrum (DSSS). Both of these are in the same standard called IEEE802.11. They do not inter-operate at all with each other, which can be very confusing. But 802.11 DSSS is the leading wireless technology supported by all major wireless related vendors. There is a new version of the standard that has recently been completed, called IEEE802.11b that uses the DSSS technique at a data rate of 11Mbps. This version should inter-operate with the DSSS 2Mbps

version of IEEE802.11, but does not inter-operate with any FHSS products. All the about mentioned technologies are discussed in detail later in this chapter.

2.4 WLANs Applications

Wireless LAN applications offer computer users the reliable and high performance connectivity of wired LANs with the added flexibility, mobility and affordability of wireless. Wireless LAN connectivity is defined as client access to network resources such as email, the Internet, file servers, printers and database applications without needing to physically connect to the local area network. Wireless LANs frequently augment rather than replace wired LAN networks-often providing the final few meters of connectivity between a backbone network and the mobile user. The following list describes some of the many applications made possible through the power and flexibility of wireless LANs:

- Doctors and nurses in hospitals are more productive because hand-held or notebook computers with wireless LAN capability deliver patient information instantly.
- Consulting or accounting audit engagement teams or small workgroups increase productivity with quick network setup.
- Network managers in dynamic environments minimize the overhead of moves, adds, and changes with wireless LANs, thereby reducing the cost of LAN ownership.
- Training sites at corporations and students at universities use wireless connectivity to facilitate access to information, information exchanges, and learning.

- Network managers installing networked computers in older buildings find that wireless LANs are a cost-effective network infrastructure solution.
- Retail storeowners use wireless networks to simply frequent network reconfiguration.
- Trade show and branch office workers minimize setup requirements by installing pre-configured wireless LANs needing no local MIS support.
- Warehouse workers use wireless LANs to exchange information with central databases and increase their productivity.
- Network managers implements wireless LANs to provide backup for mission-critical applications running on wired networks.
- Senior executives in conference rooms make quicker decisions because they have real-time information at their fingertips.
- Where pulling network wiring is costly and difficult, if not impossible, such as in: large open spaces like auditoriums and conference halls, campus environments with multiple buildings, multi-use spaces that require flexible configuration buildings where materials such as brick, concrete or asbestos are prevalent. With wireless networking there is no need to pull extra wires, stretch cabling across a large space, break through walls or dig trenches to the next building.

2.5 Benefits of WLANs

The widespread strategic reliance on networking among competitive businesses and the meteoric 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, service, convenience, and cost advantages over traditional wired networks:

- Mobility-Wireless LAN systems can provide LAN 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, adds, 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 allows roaming over a broad area.
- Network Expandable to 60 PCs: Supports small to medium office network needs. Great for temporary installations. or difficult-to-wire locations.

- Locate PCs Anywhere Up to a 250-ft. (75m) Range. Great for indoor and outdoor use.
- In addition to being able to build ad hoc labs, wireless LAN networking is key for roaming computer users who need access to services like email, the Internet and printers from various locations. Roaming is the ability for a wireless user to move from room to room, or even building to building on a campus, and not loose their connection with the network.

2.6 Technology Options

Manufacturers of wireless LANs have a range of technologies to choose from when designing a wireless LAN solution. Each technology comes with its own set of advantages and limitations.

2.6.1 Spread Spectrum

Most wireless LAN systems use spread-spectrum technology, a wideband radio frequency technique developed by the military for use in reliable, secure, mission-critical communications systems. Spread-spectrum is designed to trade off bandwidth efficiency for reliability, integrity, and security. In other words, more bandwidth is consumed than in the case of narrowband transmission, but the tradeoff produces a signal that is, in effect, louder and thus easier to detect, provided that the receiver knows the parameters of the spread-spectrum signal being broadcast. If a receiver is not tuned to the right frequency, a spread-spectrum signal looks like background noise. There are two types of spread spectrum radio: frequency hopping and direct sequence.

2.6.2 Narrowband Technology

A narrowband radio system transmits and receives user information on a specific radio frequency. Narrowband radio keeps the radio signal frequency as narrow as possible just to pass the information. Undesirable crosstalk between communications channels is avoided by carefully coordinating different users on different channel frequencies.

A private telephone line is much like a radio frequency. When each home in a neighborhood has its own private telephone line, people in one home cannot listen to calls made to other homes. In a radio system, privacy and noninterference are accomplished by the use of separate radio frequencies. The radio receiver filters out all radio signals except the ones on its designated frequency.

2.6.3 Frequency-Hopping Spread Spectrum Technology

Frequency-hopping spread-spectrum (FHSS) uses a narrowband carrier that changes frequency in a pattern known to both transmitter and receiver. Properly synchronized, the net effect is to maintain a single logical channel. To an unintended receiver, FHSS appears to be short-duration impulse noise.

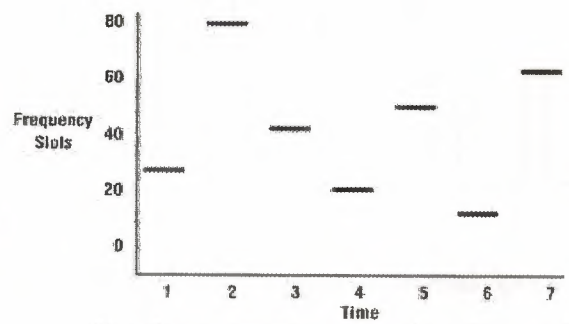

Fig. 2.1 Frequency Hopping Spread Spectrum

2.6.4 Direct-Sequence Spread Spectrum Technology

Direct-sequence spread-spectrum (DSSS) generates a redundant bit pattern for each bit to be transmitted. This bit pattern is called a chip (or chipping code). The longer the chip, the greater the probability that the original data can be recovered (and, of course, the more bandwidth required). Even if one or more bits in the chip are damaged during transmission, statistical techniques embedded in the radio can recover the original data without the need for retransmission. To an unintended receiver, DSSS appears as low-power wideband noise and is rejected (ignored) by most narrowband receivers. 2.4GHz Frequency Band with 14 Channels Allocated 802.11 DSSS works in the 2.4GHz frequency band which does not require a license in most countries and provides higher performance than lower frequencies. Fourteen 2.4GHz channels are allocated for worldwide use; 1-11 for USA, Canada and most of Europe, 10-13 for France, 12-13 for Spain and 1-14 for Japan.

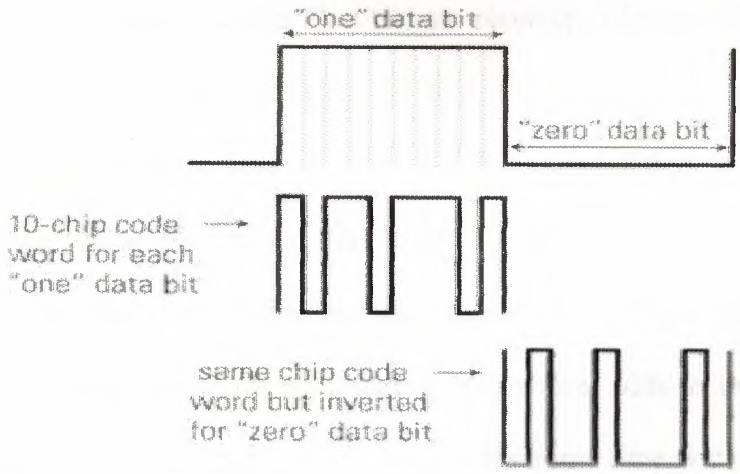

Fig. 2.2 show Direct-Sequence Spread Spectrum Technology

2.6.5 Infrared Technology

Infrared (IR) systems use very high frequencies, just below visible light in the electromagnetic spectrum, to carry data. Like light, IR cannot penetrate opaque objects; it is either directed (line-of-sight) or diffuse technology. Inexpensive directed systems provide very limited range (3 ft) and typically are used for PANs but occasionally are used in specific WLAN applications. High performance directed IR is impractical for mobile users and is therefore used only to implement fixed subnetworks. Diffuse (or reflective) IR WLAN systems do not require line-of-sight, but cells are limited to individual rooms.

2.7 HOW DOES WLANs WORKS

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. The working of Wireless

LAN depends to a great extent on two things: the type of network and the type of vendor. There are only two type of wireless networks at present which are in use:

a) Ad-hoc or peer-to-peer wireless network consists of a number of computers each

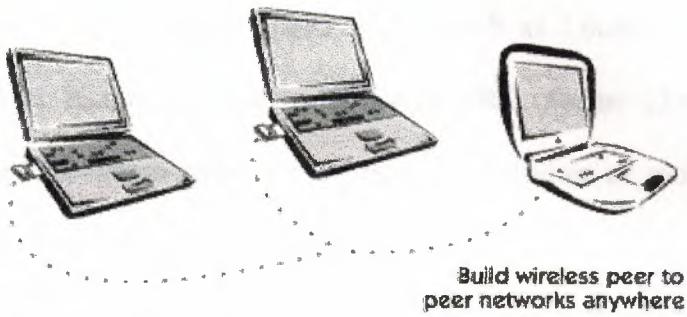

Fig.2.3 shows peer-to-peer network

equipped with a wireless networking interface card. As shown in figure (2.3). Each computer can communicate directly with all of the other wireless enabled computers. They can share files and printers this way, but may not be able to access wired LAN resources, unless one of the computers acts as a bridge to the wired LAN using special software. (This is called "bridging"). Each computer with a wireless interface can communicate directly with all of the others.

b) A wireless network can also use access points, or base station 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 hand-held 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. In this type of network the access point acts like a hub, providing connectivity for the wireless computers. It can connect (or "bridge") the

wireless LAN to a wired LAN, allowing wireless computer access to LAN resources, such as file servers or existing Internet Connectivity. The access points is further divided into two more types:

I). Dedicated hardware access points (HAP) such as Lucent's WaveLAN, Apple's Airport Base Station or WebGear's AviatorPRO. Figure (2.4) shows a hardware access points, which offer a comprehensive support of most wireless features, but they are use according to requirements.

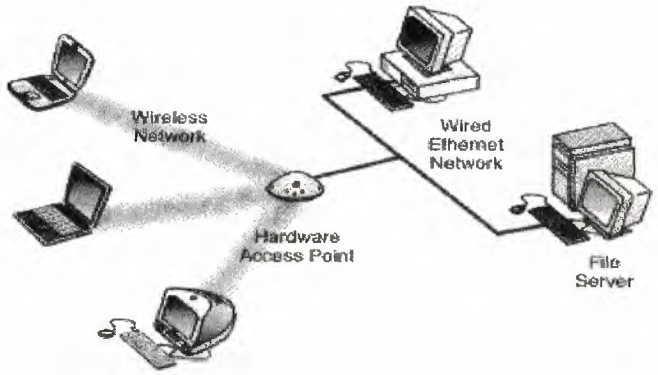

Fig. 2.4 Wireless connected computers using a Hardware Access Point

II) Software Access Points, which run on a computer, equipped with a wireless network interface card as used in an ad-hoc or peer-to-peer wireless network.

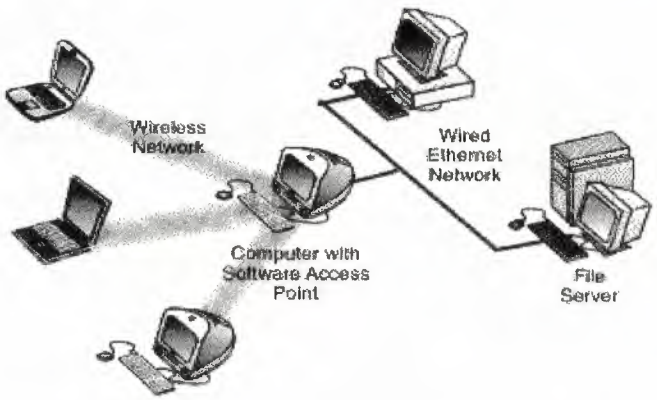

Fig. 2.5 Wireless connected computers using a Software Access Point

Figure (2.5) shows the Vicomsoft SoftRouter or Internet Gateway suites are software routers, that can be used as a basic Software Access Point, and include features not commonly found in hardware solutions, such as Direct PPPoE support and extensive configuration flexibility, but may not offer the full range of wireless features as found defined in the 802.11 standard. With appropriate networking software support, users on the wireless LAN can share files and printers located on the wired LAN and vice versa. Vicomsoft's solutions support file sharing using TCP/IP. The number of computers that can access a access point depends upon the manufacturer. Some hardware access points have a recommended limit of 10, with other more expensive access points supporting up to 100 wireless connections. Using more computers than recommended will cause performance and reliability to suffer. Software access points may also impose user limitations, but this depends upon the specific software, and the host computer's ability to process the required information.

See Fig. (2.6). Sometimes multiple access points can be connected to a wired LAN, or sometimes even to a second wireless LAN if the access point supports this. In

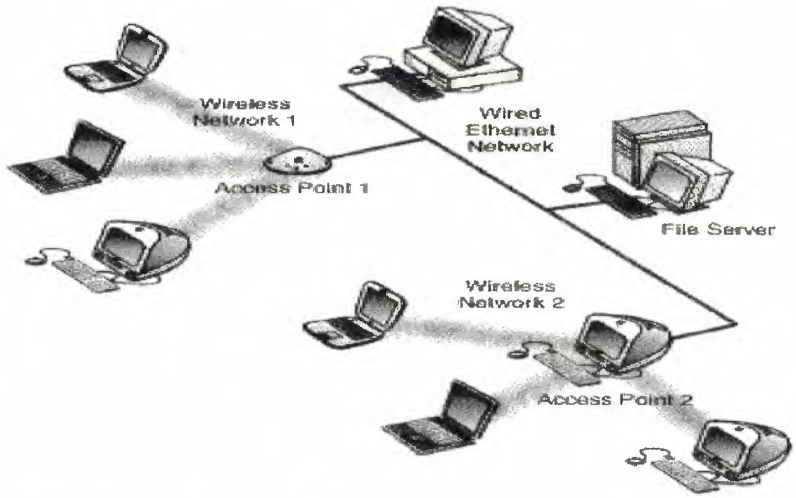

Fig 2.6: Wireless connected computers using Multiple Access Points.

most cases, separate access points are interconnected via a wired LAN, providing wireless connectivity in specific areas such as offices or classrooms, but connected to a main wired LAN for access to network resources, such as file servers.

If a single area is too large to be covered by a single access point, then multiple access points or extension points can be used. -- Note that an "extension point" is not defined in the wireless standard, but have been developed by some manufacturers. When using multiple access points, each access point wireless area should overlap its neighbors. This provides a seamless area for users to move around in using a feature called "roaming. " Some manufacturers produce extension points, which act as wireless relays, extending the range of a single access point. Multiple extension points can be strung together to provide wireless access to far away locations from the central access point. Shown in Fig. (2.7).

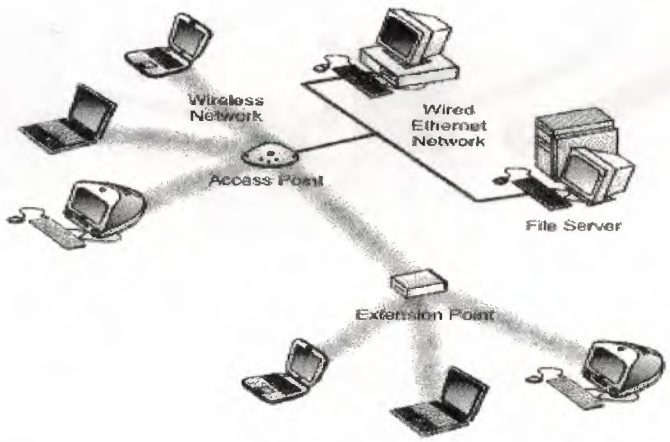

Fig 2.7: Wireless connected computers using an Access Point with an Extension Point.

In the case of AviatorPRO wireless network for any computer to be able to communicate with another computer, both computers must be switched on and be within range. Once the AviatorPRO Wireless Network is operational, you can

switch off any computer at any time, or take a notebook computer outside the range of the AviatorPRO wireless network, without having to modify the network setup. If the network still has two or more networked computers with AviatorPRO PC Cards in the AviatorPRO wireless network, these computers will remain networked together. The computer that was switched off or went outside the range is automatically accepted back into the network when it is switched on or brought back within range. The AviatorPRO wireless network enables these computers to share Internet service,

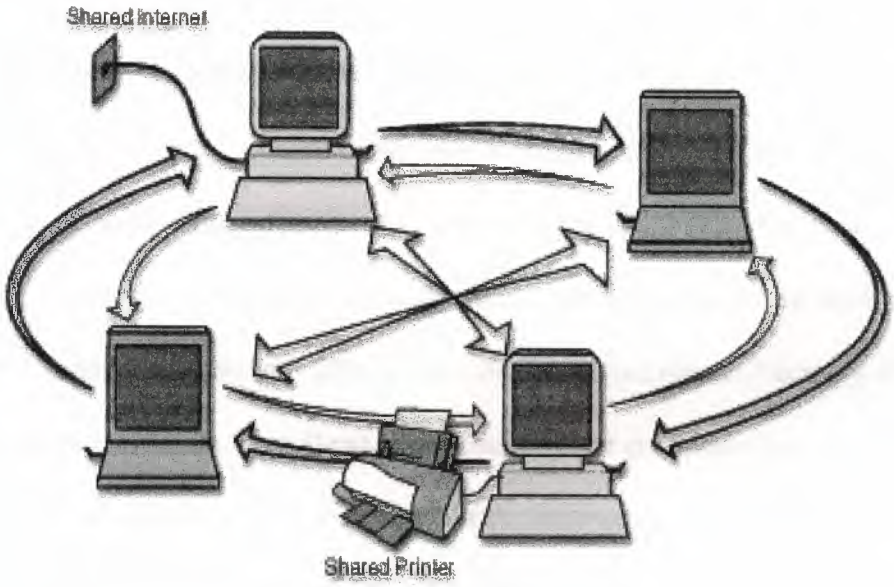

Fig. 2.8 shows the working of AviatorPRO

a printer, and files. Figure (2.8) shows a typical three-user AviatorPRO wireless network where Desktop 1 computer serves as an Internet gateway, and Desktop 2 as a printer server. The notebook can be anywhere within range of both computers. If either the Desktop 2 or the notebook computer user wants to access the Internet, then the user just activates the browser or the email application on the user's computer. This automatically invokes the proxy server software on Desktop 1 to

directly access the Internet through the modem connected to the phone link to the Internet Service Provider. It does not matter if one of the other computers is also accessing the Internet. If any of the computers need to print a document then Desktop 2 is designated as the printer server and it automatically queues up the print jobs, in the order they arrived from any of the computers.

In reality, in many homes it is likely the gateway is the same computer as the printer server. The AviatorPROs do not connect directly to a printer or another peripheral: the link is always computer-to-computer.

2.7.1 Data Transmission Modes and Throughput

There are two modes, encapsulation and translation, for transmitting data over a wireless network. Encapsulation mode encloses the 802.3 Ethernet packets inside 802.11 frames for transmission through the air, where as translation mode converts 802.3 Ethernet packets into 802.11 packets for transmission. Recently translation has emerged as the de-facto standard, but support for encapsulation as well ensures maximum flexibility in networks where both addressing modes may be used.

The 802.11 DSSS wireless standard provides for data throughput of 2Mbps up to 11Mbps. Data transmission speeds can be affected by a variety of factors including number of users on the network, individual processor speeds, application resource requirements, etc. Compared to an Internet connection, 2Mb 802.11 DSSS is comparable to a T1 line of 1.5444Mbps. This means your wireless network will not be a bottleneck to Internet applications such as email and web access.

The 802.11 DSSS wireless standard supports data transmission speeds from 2Mbps up to 11Mbps and ensures backwards compatibility. As the 11Mb standard has just

recently been ratified, environments that deploy available 2Mbps solutions, such as Farallon's SkyLINE Wireless PC Card, will work with the emerging 11Mbps solutions. Farallon will deploy 11Mb solutions once silicon is available and drivers are written.

2.7.2 Sharing Applications

Typical uses for the AviatorPRO Wireless Network are: sharing Internet access between computers, sharing a printer(s), sharing files, and sharing games, as shown in Figures (1.5) and (1.6). These are tasks normally performed by a local area network (LAN). Wired LANs such as Ethernet have been used for many years in office environments. In the case of the AviatorPRO Wireless Network, the same applications can be performed, but without the wiring and on a smaller scale. Any computer in an AviatorPRO Wireless Network can access any other for a particular task. Only the computer that is performing the task is involved, all other computers in the network can continue their normal tasks. Even the computer that is being remotely accessed for the task can still be doing its normal tasks; its user will not be affected by the task.

2.7.3 File transfer

File Transfer involves one computer accessing a file on another computer either to open it remotely and edit it remotely, or to copy it. Users merely access one of the other computers on the network and browse through the relevant windows until the desired file is found. Windows provides a very good utility, Network Neighborhood, to do this. For example, if there is a spreadsheet file on a particular

desktop computer, and someone with a notebook computer joins the network and accesses the file through Network Neighborhood, then the user can double click on that file, edit it from the notebook, and store it back again in the desktop. Conversely the notebook user could have created a file locally on the notebook and wants to save it on the desktop computer. This can be done by displaying the relevant windows of both computers on-screen, and then dragging the file in the notebook across to the desktop computer's window. The task of transferring from the notebook to the desktop can be performed from either computer. The files can be on a hard disk, a CD-ROM, or a floppy diskette, although normal usage is accessing a hard disk drive. Even so, the files could be obtained from a CD-ROM in a CD-ROM drive on one computer, because not all computers have CD-ROM drives. Also some notebooks do not have floppy drives, so a user could transfer a diskette's contents from a computer with a floppy disk drive to the notebook. You can limit sharing of your files if there are other people using the network. This can be done using normal Windows features, refer to the manual.

2.7.4 Printer sharing

It eliminates the need for more than one printer in a network, or extends the use of multiple printers to all users on the network. For example, if a printer is already connected to one computer, other computer users on the AviatorPRO Wireless Network with documents to print can access the printer through the connected computer, and print files on the printer as if it were directly connected. The computer connected to the printer thus becomes a printer server. If one job has

already been sent and is being printed, and a second job is transferred to the printer server, it will be queued up pending completion of the first job.

2.7.5 Internet sharing

It allows more than one computer to access the Internet or a corporate Intranet simultaneously. This is a major advantage over having two or more separate computers link individually to the Internet through their own Internet Service Providers (ISP). WebGear provides additional software in the kit, called WinProxy, for sharing an Internet link simultaneously with two computers. Also if your computer runs Windows98SE, it includes an application called Internet Connection Sharing. ICS allows a number of users to share the Internet. The user needs to select either WinProxy or ICS – both can not be used to share the Internet at the same time. WinProxy has more features than ICS and can be used on more operating systems. For example, two users (or more depending on the proxy application in use) can be accessing the web at the same time, as shown in Figure (1.6). Without the AviatorPROs, both users would either have to take turns to access the Internet, or would need to add an additional telephone line and ISP service. With these savings, the AviatorPRO Wireless Network kit will pay for itself within a few months.

2.8 Coverage Area

Wireless Network uses the 2.4GHz frequency spectrum. The distance over which RF waves can communicate is a function of product design (including transmitted power and receiver design) and the propagation path, especially in indoor

environments. Interactions with typical building objects, including walls, metal, and even people, can affect how energy propagates, and thus what range and coverage a particular system achieves. Most wireless LAN systems use RF because radio waves can penetrate many indoor walls and surfaces. The range (or radius of coverage) for typical WLAN systems varies from under 100 feet to more than 500 feet. Coverage can be extended, and true freedom of mobility via roaming, provided through microcells.

Manufacturers recommend that access points be deployed 150ft (50m) apart to ensure full coverage and maximum data throughput rates for roaming computer users. Additionally, a step down in data transmission speed will increase the operating range. So, a wireless client communicating at 2Mbps will have better range than a client will at 11Mbps. Access points can be used to extend the range of a wireless network even in situations where there is no need to connect back to a wired Ethernet network. By deploying an access point as a "wireless hub" the distance between two remote computers can be extended up to 600 feet (300 feet from each computer to the access point) depending on the configuration of the building and the location of the access point. Most access point manufacturers support anywhere from 10 to 50 simultaneous users per channel while some go as low as 5 and others as high as 100. The same principles that apply to sharing wired bandwidth using a hub apply to sharing wireless bandwidth through an access point. The data bandwidth of a single access point is shared with all the wireless users connected to that access point. So, just like 5 computer users connected through a standard Ethernet hub share the bandwidth, 5 wireless users connected through an access point share the bandwidth.

The AviatorPRO Wireless Network actually segments the data in a file being transferred into short messages or packets. If the communicating AviatorPROs in a link are too far apart, errors will occur in some of the messages. If an error is detected in any message, that message is rejected by the receiving computer and is immediately re-transmitted. The user will not be aware of any errors because the receiving computer's memory only contains correct data. If the distance between two AviatorPROs in a link is too large, the number of errors becomes excessively high, causing more re-transmissions, slowing down the data throughput. Beyond a further distance, the link totally breaks down. In other words if you are experiencing a slower data rate than expected, chances are that the computers are at the limit of their range. Sometimes moving the computers around may help the situation.

2.9 DATA RATE

As with wired LAN systems, actual throughput in wireless LANs is product and set-up dependent. Factors that affect throughput include airwave congestion (number of users), propagation factors such as range and multipath, the type of WLAN system used, as well as the latency and bottlenecks on the wired portions of the WLAN. Typical data rates range from 1 to 11 Mbps. On the other hand data rate depends upon the amount of data that is being sent from one computer to another. It can be small data file or it can be a multimedia file, in both the cases we're talking about large bandwidth. If you need high bandwidth in a wireless medium, you're going to be in trouble. The data rates for wireless LANs, if you use today's standard, the IEEE 802.11, supports 2 Mbits/sec. But there are products in

the market right now that handle up to 10 Mbits/sec. But these data rates are available for limited coverage inside a building. If you go outside the building into a wide area network, the data rate is at most several hundred kbits/sec. The number paths it takes to reach the receiver also effect the data rate.

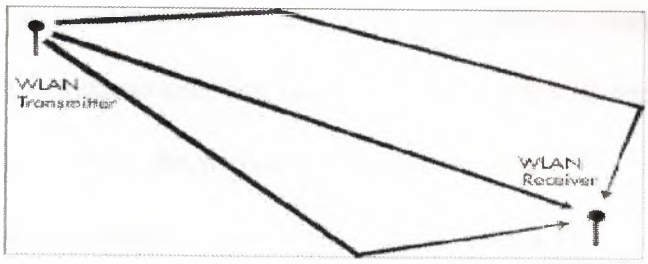

Fig.2.9 Radio signals travelling over multiple path

As Figure (2.9) shows, a radio signal can take multiple paths from a transmitter to a receiver, an attribute called multipath. Reflections of the signals can cause them to become stronger or weaker, which can affect data throughput. Affects of multipath depend on the number of reflective surfaces in the environment, the distance from the transmitter to the receiver, the product design and the radio signal is also taken into account. On the other hand with AvaitorPRO the raw data rate in the Wireless Network totals 2 Megabits per second. The actual useful data being transferred is less, because of additional information that is conveyed between the computers to establish and check a link. As a result the useful data is around 1.5 to 1.7 Mbits per second, which is about 200KBytes per second. This data rate is shared by any active link in the AviatorPRO Wireless Network. This means that if more than one link between any two computers is established, the data transferred for each link will be slowed, the amount depending on how much information is being transferred between the various computers. Having more than one simultaneous link will sometimes occur when there are two or more computers on the network

sharing the Internet, transferring files, or printing to a common printer. It should be clarified that an active link typically exists for a very short time. An active link is a link where data is actually being transferred, such as a particular file transfer is in progress, or a particular print job is being transferred to the Printer Server, or a Web page is being downloaded through the Internet gateway computer. If the files being transferred simultaneously are short ones the users will see no difference in the time taken to complete the transaction. But if the files are a few megabytes, or the web download is a long audio or video stream, a slowdown will be noticeable. In essence, the higher the number of computers connected into the network, the greater the possibility there is that more simultaneous links will be active, depending on how long the files take to transfer. For example, a 10MByte file would typically take about one minute to transfer between two computers, so there is more chance another active link could be made between another two computers during that time, resulting in a slowdown of both links. Conversely, if the file were only a page of 50KBytes, which takes less than a second, then it is not likely someone else would establish another link during that time. For instance, a typical page of text in Microsoft Word is less than 15KB, so a 3 or 4 page letter will transfer in less than a second, as would browsing to a new web page. Another case where data rate can be effected is when an access point is acting as a bridge between an Ethernet and a wireless network, then all the wireless LAN traffic has to go through the Access Point first and then to the wired network, this does reduce the effective data rate between computers in the same wireless LAN.

2.10 INTER-OPERATABILITY

There are several types of interoperability that are possible between wireless LANs. This will depend both on technology choice and on the specific vendor's implementation. Products from different vendors employing the same technology and the same implementation typically allow for the interchange of adapters and access points. An eventual goal of the IEEE 802.11 specification, currently being drafted by a committee of WLAN vendors and users, is to allow compliant products to inter-operate without explicit collaboration between vendors. But it should be taken into consideration explicitly because there are some products, which have already been standardized by IEEE, but they don't inter-operate with other products. Unfortunately the IEEE802.11 committee allowed more than one modulation technique in the same standard. They are Frequency Hopped Spread Spectrum (FHSS) and direct sequence spread spectrum (DSSS). Both of these are in the same standard called IEEE802.11. But they do not inter-operate at all with each other, which can be very confusing

2.11 INTERFERENCE

The unlicensed nature of radio-based wireless LANs means that other products that transmit energy in the same frequency spectrum can potentially provide some measure of interference to a WLAN system. Interference always exists.

Some major sources of interference to the propagated radio waves are discussed in this section, including:

- Multipath propagation.
- Microwave ovens.

- Other ISM (Instrumental, Scientific and Medical Band) interference.

2.11.1 Multipath Propagation

Radio wave signals, when propagated in an indoor environment, "bounce off" reflective and semi-reflective surfaces such as walls, partitions, furniture and equipment. Signals reach the receiver from all directions, but at varying strengths and time dispersions depending on the path they have traveled. This multipath propagation leads to fading of the transmitted signal. To reduce the problems caused by signal fading, the BreezeNET PRO.11 system uses several diversity techniques.

2.11.2 Antenna Diversity

BreezeNET PRO.11 products all use two Omni-directional antennas. These antennas use space diversity to receive signals from different paths. The modem selects which antenna to receive the better quality signal from on a per-frame basis.

2.11.3 Frequency Diversity

The BreezeNET PRO.11 system employs a Frequency Hopping Spread Spectrum technique. Frequency hopping radios perform well in the presence of interference. The 2.4 GHz frequency band used by the BreezeNET PRO.11 is divided into 82 one MHz channels or hops. Radio transmissions are spread over the 79 useable hops, but at any instant in time, only a 1 MHz signal is broadcast on one of the hops. The hops are changed 50 times per second in a pre-defined order as specified by the hopping sequence. No two consecutive hops are closer than 6MHz apart. All

stations in the same cell use the same hopping sequence and synchronize their hop timing. When interference is present, it usually affects only a few hops. Hopping sequences are designed so that successive hop is usually several MHz apart. Interference may interrupt data transmission on a particular hop, but there is only a slight chance that it will affect the next hop in the sequence.

2.11.4 Access Point Diversity

BreezeNET PRO.11 multi-cell architecture provides overlapping area coverage. Stations inside the coverage area automatically choose to associate with the Access Point that provides the best reception.

2.11.5 Microwave Ovens

Microwave ovens are a source of radio interference as they emit radiation in the 2.4GHz frequency. Make sure to position all BreezeNET PRO.11 units as far away as possible from microwave ovens.

2.11.6 ISM Transmissions

Equipment using the 2.4 GHz frequency may cause interference to BreezeNET PRO.11 reception. Examples of such ISM (Instrumental, Scientific and Medical Band) transmissions are medium-distance radio telephone broadcasts and certain medical equipment.

2.11.7 Other WLANs

Another concern is the co-location of multiple WLAN systems. While co-located WLANs from different vendors may interfere with each other, others coexist without interference.

2.11.8 Remedy of Interference

As the AviatorPRO incorporates a radio transmitter and receiver, it could potentially interfere with other radio products and vice versa. If for any reason interference does occur, it is corrected for by re-transmitting any erroneous data, which will slow down the overall time taken. If interference is excessive, the conflicting device can be moved away or turned off.

2.12 SECURITY

Wireless communications obviously provide potential security issues, as an intruder does not need physical access to the traditional wired network in order to gain access to data communications. However, 802.11 wireless communications cannot be received --much less decoded-- by simple scanners, short wave receiver's etc. This has led to the common misconception that wireless communications cannot be eavesdropped at all. However, eavesdropping is possible using specialist equipment. To protect against any potential security issues, 802.11 wireless communications have a function called WEP (Wired Equivalent Privacy), a form of encryption which provides privacy comparable to that of a traditional wired network. If the wireless network has information that should be secure then WEP should be used, ensuring the data is protected at traditional wired network levels.

Also it should be noted that traditional Virtual Private Networking (VPN) techniques will work over wireless networks in the same way as traditional wired networks. As with wired networks, the first line of security defense is the User IDs and Passwords in the Operating System of client computers and servers. Additional security varies from one access point to another. Many access point manufacturers allow network administrators to limit the access point connections by creating a table of wireless client hardware (MAC-Media Access Control) addresses.

There are several mechanisms built into the AviatorPRO wireless network that can provide a high level of security against intrusion from the outside. The AviatorPRO offers a standards-based approach for user identification, called Extended Service Set Identification, or ESSID. Only wireless adapters with a matching ESSID are allowed to communicate with each other, enabling the network administrator to control which users can access the AviatorPRO wireless network. The AviatorPRO allows the use of an ESSID with up to 31 alphanumeric characters, providing up to 6x10 53 possible unique choices.

The highest level of security is achieved by the addition of encryption at the application level across the entire network. The IEEE 802.11 WLAN standard provides for the optional use of the "Wired Equivalency Privacy" (WEP) algorithm. The AviatorPRO PC Card and Access Point support WEP. WEP uses a process of "shared key authentication". Each "key" is a 40-bit code, equivalent to 10 ASCII characters, which is used to initialize a pseudo-random number generator before it processes data for transmission. With the same key and the same pseudo-random number generator at the receiving end, data can be recovered without the key itself ever being transmitted across the wireless link, which would compromise

its security. There are two ways in which WEP is effective. First, in an Infrastructure network it is used by the Access Point to authenticate stations before they are allowed to access the wireless network. Basic shared key authentication relies on having a "shared secret key" known only by all of the Access Points and AviatorPRO-based computers authorized to use the encryption feature of the AviatorPRO wireless network. To authenticate (log on) to an AviatorPRO Access Point that has encryption enabled, a computer first sends an authentication request to the AviatorPRO Access Point, which responds with a string of bits called "challenge text". The computer then applies the secret, shared key to the challenge text and sends the challenge text, now encrypted, back to the Access Point. The Access Point decrypts the encrypted text using its copy of the secret key. If the decrypted text is the same as the clear challenge text it sent to the original computer, the Access Point approves authentication. WEP is effective in both infrastructure and peer-to-peer networks to encrypt data before it is transmitted across the AviatorPRO wireless network. Users without the correct key will not be able to connect to AviatorPRO Access Points, and eavesdroppers who do not possess the proper key will not be able to decrypt wireless data being sent over the airwaves. The above options offer security of the AviatorPRO wireless network itself from outside eavesdroppers. They do not necessarily offer security to users within the network who have access to the previous options. Users can also make all or certain of their own files private, not to be shared by anyone. This can be achieved by using features available in the Windows operating systems. For example, you may want just one file called TEMP to be shared by other users, and all the other files to be private, or you may want to share some files with a

password. Refer to the AviatorPRO User's Manual for protection of your own data from others within the AviatorPRO wireless network

2.13 COST

Initially the cost of wireless network is more than that of the wired network, but it is compensated with the vast advantages that are provided by wireless network. The area for which the wireless network will be used to determines the cost, and they 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. These will ofcourse increase the cost.

2.14 SAFETY

It has been read and heard a lot that electromagnetic waves are harmful for the user as well as for people around it. This is not the case with Wireless LANs. 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.

2.15 WLANs Configuration

The best feature of wireless LANs is that they can be configured for any type physical installation. This feature clearly defines what kind of products has to be

used for setting up the wireless LAN. This can be possible in campuses, hospitals or businesses with more than one location in immediate proximity but separated by public thoroughfare. This type of installation requires two access points. Each access point acts as a bridge or router connecting its own LAN to the wireless connection. The wireless connection allows the two access points to communicate with each other, and therefore interconnect the two LAN's.

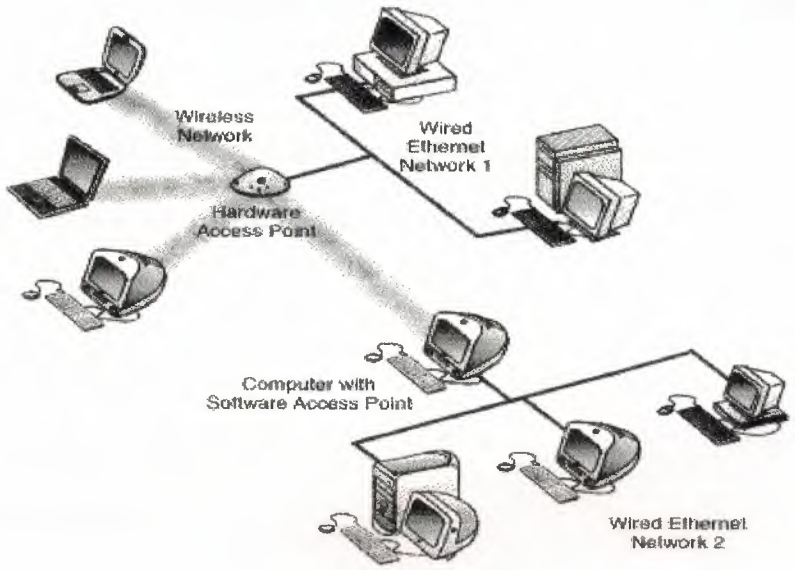

Figure 2.10: LAN to LAN Wireless Communications

In the Figure(2.10) above, hardware Access Point providing wireless connectivity to local computers and software access point. The software access point provides Wired Ethernet network 2 computers access to Wired Network 1.

Note that not all hardware access points have the ability to directly interconnect to another hardware access point, and that the subject of interconnecting LAN's over wireless connections is a large and complex one, and is beyond the scope of this introduction. See the reference links at the end of this section if you require further information.

Although wireless networking offers obvious benefits to users of laptops who move from location to location throughout the day, there are benefits for users of fixed position computers as well: Many schools and businesses have unsuitable building layouts or walls that cannot be wired for various reasons making it difficult or impossible to build a wired network. Wireless networking in these environments is a very cost-effective alternative also providing future flexibility. In cases where a small number of computers are separated from a main network a wireless link may be more cost effective than network cabling although the latter is perfectly feasible. Temporary wireless LANs can easily be created for exhibitions, school or business projects, all without any trailing cabling. Following are some of the type wireless LAN configurations.

- Stand-alone cells
- Cells connected to Ethernet
- Overlapping cells
- Linked cells
- Multi-cells

2.15.1 Stand-alone cells

As shown in the figure (1.9). The basic cell is comprised of an access point and all associated wireless stations. The number of wireless stations per cell depends on the amount and type of data traffic. In a "busy" environment a cell might contain 50 stations while in a more "relaxed" environment 200 stations might be supported.

The stations communicate with each other via the access point, which manages the data traffic in the cell. A stand-alone cell is an ideal method of setting up a small to

medium-sized LAN between a number of workstations or workgroups. This type of cell requires no cabling. An example of a stand-alone BreezeNET Pro cell is shown in the figure to the right.

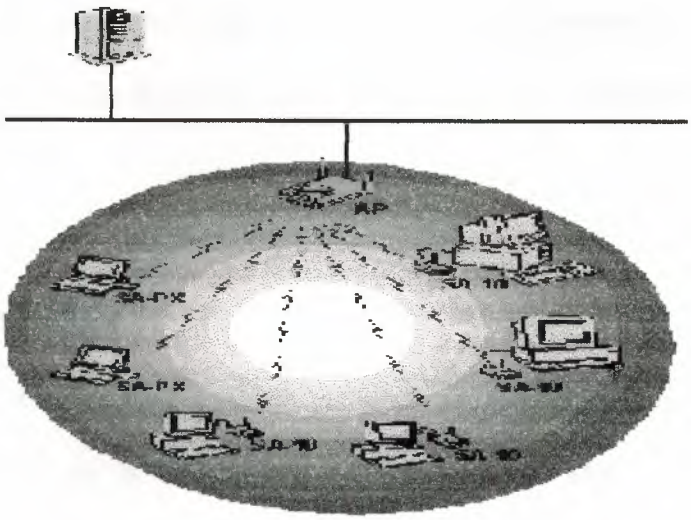

Figure (2.11) stand-alone cells

2.15.2 Cells connected to Ethernet

BreezeNET PRO.11 cells can be connected to:

- A wired Ethernet LAN via an Access Point.
- Remote LANs via a wireless bridge.

2.15.2.1 Wired Bridging

The access point connects to the backbone of a wired Ethernet LAN via a simple cable. The access point functions as a bridge between the cell and the wired LAN. Stations in the cell and in other linked cells can now access all wired LAN facilities. Once connected to a wired LAN, the network management functions of the wired and the wireless LANs can also be integrated.

2.15.2.2 Wireless Bridging

BreezeNET PRO.11 cells can be connected to remote BreezeNET PRO.11 LANs by using a wireless bridge. The bridge can be mounted back-to-back with an access point enabling connectivity between a cloud of networks and linking buildings that are miles apart.

2.15.3 Overlapping

When any area in the building is within reception range of more than one access point, the cells' coverage is said to overlap. Each wireless station automatically establishes the best possible connection with one of the access points. Overlapping coverage area is an important attribute of the wireless LAN setup, because it enables seamless roaming between the overlapping cells. As shown in figure 2.12.

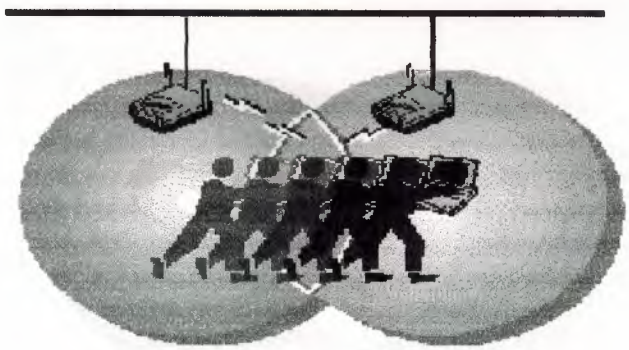

Fig. (2.12) shows overlapping cells

2.15.4 Linked Cells

A notebook computer user, for example, can walk from Cell A to overlapping Cell B without interrupting a work session. The handover from cell to cell is not noticeable to the user.

2.15.5 Multi-Cells

Several access points can be positioned in such a way that their coverage areas converge, thus creating a multi-cell. One way of creating a multi-cell is by connecting several Access Points to external directional antennas instead of to their built-in Omni-directional antennas. The Access Points are positioned at different locations in the coverage area with their directional antennas pointing towards the area that will form the focus of the multi-cell. Stations inside the multi-cell area automatically "choose" the best Access Point to communicate with. This is useful in areas where heavy network traffic is expected as the throughput capacity of a BreezeNET PRO.11 multi-cell is multiplied by using WIX(tm) technology - the BreezeNET PRO.11 automatic wireless switching mechanism. A multi-cell, with its multiplicity of Access Points, provides constant system backup capability and ensures reliable fail-safe operation of the wireless LAN. As shown in the fig. (2.13).

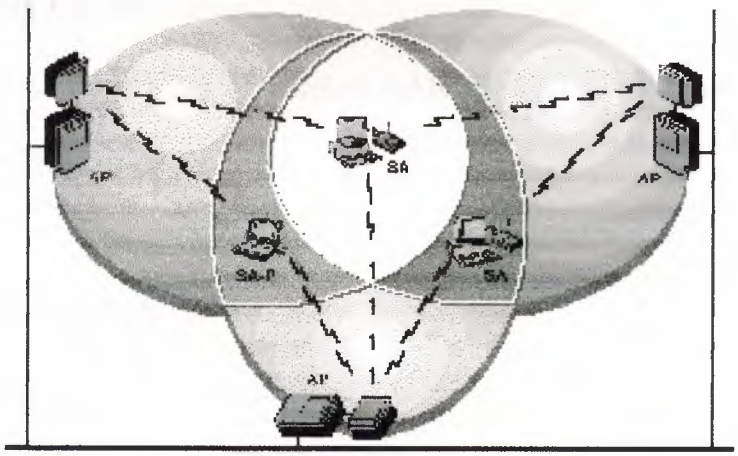

Figure (2.13) shows the functionality of Multicells

2.16 Access Point

An access point, or base station, is a radio receiver and transmitter that connects to your wired Ethernet network. Through these devices wireless nodes, such as a Macintosh PowerBooks or PC notebooks equipped with a Farallon SkyLINE Wireless PC Card, have access to wired LAN network services like email, Internet, printers and more. Operating range, management capabilities, wireless network security and number of users supported are determined by the capabilities of the access point.

A "Soft" Access Point is an alternative to deploying an access point for wireless connectivity to a wired Ethernet network, a computer that is physically connected to an Ethernet network, outfitted with a wireless card such as SkyLINE, and running a software routing solution such as Vicomsoft Internet Gateway, can act as the gateway between the wired network and the wireless network.

2.17 Wireless LANs

Typically, there are three types of wireless LAN configurations: base-to-remote, peer-to-peer or microcellular.

2.17.1 Base-to-remote

In base-to-remote, distant workstations and personal computers are linked to a central base workstation. Because the base workstation is located at the center of the LAN, excellent coverage, good range, high security levels and more management functions across the network are the result. For commercial uses such as those found within a single building or integrated set of buildings, base-to-

remote works well either as a standalone wireless LAN or as an extension to a wired LAN.

2.17.2 Peer-to-peer

Peer-to-peer wireless LANs are self-defining since they permit direct communication between devices without going through a base station. As such these networks are quick to install and therefore well suited to ad hoc networking. The downside to peer-to-peer is that security and network management concerns are not easily addressed and the range of communications is limited. This latter concern can be resolved, however, by adding an access point product for attachment of the wireless peer-to-peer LAN to a wired LAN. Microcellular wireless LANs are those that use access points on a wired backbone that permit the client devices to communicate to any backbone connected device or to any other wireless device connected to the backbone through the same or another access point. This configuration also permits seamless roaming from cell to cell when the coverage of those cells via the access points provides sufficient overlap. This configuration is analogous to the technique used in cellular telephones -now on a local area basis due to the restricted range of LAN radios. Currently, IBM offers a family of products for building a wireless LAN. Each of the IBM 2480 Wireless LAN components perform a unique function but the key is that they all utilize the same radio component, a 2.4GHz direct-sequence spread-spectrum radio.

2.18 PRODUCTS

At present there are a number products related wireless LANs and their usability depends upon the area where they will be in used. The following companies manufacture wireless products:

BreezeNET PRO.11, IBM, Nortel Network, Farallon Skyline Lucent's WaveLAN, Apple's Airport Base Station or WebGear's AviatorPRO. Vicomsoft.

2.19 ROAMING

A wireless computer can "roam" from one access point to another, with the software and hardware maintaining a steady network connection by monitoring the signal strength from in-range access points and locking on to the one with the best quality. Usually this is completely transparent to the user; they are not aware that a different access point is being used from area to area. Some access point configurations require security authentication when swapping access points, usually in the form of a password dialog box. Access points are required to have overlapping wireless areas to achieve this as can be seen in the figure (2.12) and (2.13). Where the user can freely move from one area to the other area without any change in the reception of signals.

The Wireless networking hardware automatically swaps to the Access Point with the best signal. Not all access points are capable of being configured to support roaming. Also of note is that any access points for a single vendor should be used when implementing roaming, as there is no official standard for this feature.

2.19.1 ROAMING BETWEEN CELLS

Users with portable stations such as notebooks, notepads and pen-based computers can move freely between overlapping BreezeNET PRO.11 cells, continuously maintaining their network connection. This ability to move around the wireless campus is called "Roaming". Roaming is seamless, that is, a work session can be maintained when moving from cell to cell while the user experiences, depending on the traffic, only a momentary break in the data flow. A station implements its roaming capabilities by "choosing" the access point in its area that provides the clearest signal.

Farallon has made roaming much easier. On both the MacOS and Windows sides, the Farallon SkyLINE Wireless PC Card simplifies roaming provided all the access points have the same name. For example, the user enters this name, WirelessAP for instance, in the access point configuration screen. When a user is in one location connected wirelessly to an access point called WirelessAP and moves to a new location, SkyLINE will automatically connect to a new access point called WirelessAP that is within range. On the Mac OS side, users have the second option of using a wild card. By placing an asterisk in the access point (SSID) configuration field, SkyLINE will connect to the nearest, strongest access point it finds. When the user moves out of range of that access point, SkyLINE will go into hunt mode and find a new access point, no matter what the name. This feature also allows the user to roam between access points from different vendors.

The AviatorPRO wireless network offers the user mobility within its range. This has a number of advantages over a wired network, even for desktops, because you can move your desktop computers around into different offices at work or different

rooms at home. The AviatorPRO is also very well suited for notebook computers. The AviatorPRO is lightweight, small enough to fit in a jacket pocket, and needs no external power supply. And because it takes so little power it does not noticeably drain the battery of a notebook computer. The AviatorPRO Wireless Network is ideally suited for use with a notebook computer because you can move anywhere within range. You may be at home and wish to use the notebook computer in any room or outside in the yard. The notebook computer user can be browsing on the Internet, printing at a printer already connected to another computer, or likewise transferring files. If you travel a lot, it is an easy task to download information at the office or at home between the resident computer and the notebook, in either direction. All it requires is for the resident computer at each location to have an AviatorPRO module attached, and some additional software for switching between the different networks. In this role the AviatorPRO performs a docking function for the notebook computer - at a substantially reduced cost.

Roaming with a Notebook in Multiple access points can provide wireless coverage for an entire building or campus. Providing each access point supports roaming, a notebook computer user with an AviatorPRO PC Card can roam freely within a large network provided there are sufficient access points to maintain a constant connection. An example would be a doctor going round the different wards in a hospital, or people working in a company with offices on different floors in a multi-story building. All the AviatorPRO Access Points must be linked together through the Ethernet backbone network, and must be powered on. The AviatorPRO Access Points pass standards-based messages to the next Access Point whenever a user roams from one AP to another, as shown in Figure (2.12) and (2.13). This allows

continuous connection during transfer to the next access point. Different companies' access points can be linked to the network provided that they are IEEE802.11 FHSS compliant and inter-operate with the AviatorPRO PC Card.

2.20 Implementations

2.20.1 Creating Wireless Computer Labs

Wireless LANs are ideal for creating anytime, anywhere computer labs. Multi-purpose computers can easily be moved, and a small network can quickly be set-up in multi-purpose spaces that may not be conveniently wired. There are two configurations for setting-up a wireless computer lab; peer-to-peer or by using an access point, such as the Apple Airport, to act as a wireless hub.

2.20.1.1 Ad Hoc Peer-to-Peer Wireless Lab

A peer-to-peer wireless lab allows the wireless nodes to share files directly without using an access point. Each wireless-equipped node is simply set to ad hoc mode for communication.

2.20.1.2 Small Wireless Lab with Apple's AirPort

A small wireless lab can also easily be set-up with an access point such as the Apple Airport. Instead of communicating directly with each other as in the previous Peer-to-peer example, the wireless nodes all connect wirelessly through the access point. The access point acts as a wireless hub, and since it is equipped with an

Ethernet port, a wired connection to a printer or Ethernet drop in the room can also be made.

If Internet access is needed and connection to the network backbone is not convenient or possible, the Apple AirPort base station's 56K modem can be used for direct wireless client access to the Internet through the AirPort modem.

Since Apple's AirPort base station follows the 802.11 DSSS wireless specification, the lab computers all need to be equipped with 802.11 DSSS solutions such as Farallon's SkyLINE Wireless PC Card for Macintosh PowerBooks or PC notebooks. Apple iBooks would need to be equipped with the AirPort wireless option.

2.20.1.3 Wireless Integration with an Ethernet LAN

As described earlier, wireless nodes gain access to wired Ethernet network services through Access Points or Base Stations. The access point and wireless nodes must all be using the same wireless standard in order to inter-operate on the same network. Hence, deploying the leading 802.11 DSSS wireless LAN standard requires an 802.11 DSSS access point to be connected to your wired Ethernet LAN and the use of 802.11 DSSS-equipped wireless nodes.

Just like other Ethernet devices such as desktops, servers, printers, routers, and hubs and switches, an access point comes with Ethernet on board for a direct physical connection to the wired network. Wireless communication is conducted through a radio antenna built into the access point.

As long as the access point can be plugged in to the wired network and is positioned to get maximum area coverage for wireless nodes (up high, with as little

obstruction as possible), it can be located in a room, network closet, common area, etc. Every access point offers its own set of features and the operating range, number of users supported, security features, and management capabilities all vary from one model to the next. Once the access point is set-up on the Ethernet LAN, all wireless-equipped nodes will have access to the LAN resources, just like the wired nodes.

2.20.1.4 Designing a Wireless Campus Area Network

In the previous section we explained how to integrate a wireless network with a wired Ethernet LAN. On a campus area network, where wireless clients are likely to roam around campus and between buildings, multiple access points can be deployed to provide campus area wireless access to the Ethernet LAN. For example, a university may want to provide wireless access to students and faculty from multiple locations on campus. In order to accomplish this, the university would deploy an access point in each of the locations from which they want to provide wireless access to users.

As mentioned before, access point manufacturers recommend the implementation of an access point for every 150ft of range required for wireless network access. Each access point operates on a channel, and wireless devices using channel 1 are on a separate network from wireless devices on channel 7. In order to avoid interference from adjacent channel traffic when setting-up separate wireless networks, a 5 to 6 channel spread is recommended.

Wireless nodes have the capability to connect to one access point or another, but since the 802.11 DSSS specification for wireless networking does not specifically

address roaming, there are differences in how wireless client solutions handle multiple access points and roaming between them. Some wireless client solutions require the user to reconfigure the wireless node every time a network connection is lost and connection to a different access point is required to regain network access. Other wireless client solutions, such as Farallon's SkyLINE Wireless PC Card, can be configured to automatically connect to an access point within range.

2.20.1.5 Wireless in your Home or Small Office

Similarly to a small wireless computer lab in a school or business environment, a small wireless network can be set-up in your home. As explained, an ad hoc peer-to-peer wireless network can be created for file sharing, but in the home you would most likely also want to share printers, an Internet connection and other network devices or services.

Apple's AirPort base station is ideal for setting-up a small network at home to share a single Internet connection, play multi-user games, share printers, files and more. With the addition of a small 10Base-T hub, such as a Farallon Starlet, the AirPort Ethernet connection can be expanded to connect printers, desktop computers and other wired network devices.

Note: Since Apple's AirPort base station follows the 802.11 DSSS wireless specification, any wireless node in your home must be equipped with an 802.11 DSSS solution such as Farallon's SkyLINE Wireless PC Card for Macintosh PowerBooks or PC notebooks. Apple iBooks would need to be equipped with the AirPort wireless option.

2.21 EASE OF INSTALATION

Users need very little new information to take advantage of wireless LANs. Because the wireless nature of a WLAN is transparent to a user's 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.

In the case of AviatorPRO, which has been designed from the outset to be installed on all personal computers, including all Pentium class computers, both desktop and notebook. It is Plug and Play compatible with most of these computers, because once connected and a driver has been installed, the computer recognizes the AviatorPRO as a networking device adapter (after a reboot). The AviatorPRO therefore offers a very simple approach to setting up a local area network. Within a few minutes per computer, a home or small office can have its own LAN. There is no need to bring an expert in to set up the server and install adapter cards inside each computer. No need to arrange for new wiring to link the computers. And no

need for someone to constantly administer the network. With a desktop computer, it is easy to install the PC Card adapter by opening up the PC and plugging the ISA card provided into any ISA slot available in the PC. In this case the AviatorPRO PC Card is plugged in to the PCMCIA receptacle on the ISA card.

Chapter Three

Wireless personal area network (WPANs)

3.1 Introduction

Imagine the feeling you would have, when you are in a conference room and everyone with you has a "companion" small hand-held PC or perhaps a PDA for taking notes. Your manager leads off the meeting by sharing the agenda on a large monitor from his companion PC. Everyone else can have a copy of the agenda by simply sharing that same file. Within two to three years it will possible with the introduction of low-cost, low-power Wireless Personal Area Networks (WPANs). WPANs is a networking scheme that enables computing devices such as PCs, laptop computers, printers and personal digital assistants (PDAs) to wireless communicate with each other over short distances. WPANs are at present in its infancy and a large amount developmental work is in progress. The development is towards a 20Mbps or faster high rate WPAN that can be widely deployed for short range information transfer, particularly multimedia and digital imaging. It also cuts down the need to carry your notebooks in your office, as these wireless handsets will provide all the necessary functions. The need for WPANs can be easily understood from the following example: A person carrying a watch, pager, cellular phone, personal stereo, and personal digital assistant (PDA) has atleast four displays, two input interfaces, four speakers, one microphone and two longer range

communication links. Redundant data entry, duplication of information, hardware I/O components, and software functions are partly due to lack of good WPAN technology to support sharing resources.

3.2 Standards

There are some standards on which WPANs is based and more are in development phase. WPANs follow technology standards such as IEEE 802.15, Bluetooth and HomeRF. Here it should be explicitly defined that HomeRF is characterized as a trimmed down version of 802.11 where as Bluetooth comes closer in satisfying WPAN requirement. Here Bluetooth will be discussed in detail while the rest will be covered in the next topic. Bluetooth is a wireless networking protocol with voice and data capabilities. It provides mechanisms to synchronize data carried in personal devices and eventually will enable "anywhere, anytime" access to the Internet through bridging devices. The idea behind this is to provide a low-power wireless data standard that will help personal devices share information, typically in the same room. The device s may be owned by the same person who wants to synchronize information between them, or by different people. The Bluetooth alternative is simple: Each hand-held or portable device receives a small transceiver that has an effective range of about 10 meters (30 feet) within a room. The transceivers operate at the globally available unlicensed spectrum of 2.45 GHz. The Bluetooth specification supports seven data and three voice channels. Add to this a common communications protocol through which individual units can share information. The base speed for Bluetooth is 721Kbps. Which is quiet respectable for an office area. Although it is a communication protocol, this initiative should

enable the creation of WPAN (Wireless personal area network), which will join LAN and WAN as important metrologies.

3.3 IEEE Standards

The IEEE 802.11(Institute of Electrical and Electronic Engineers) standard defines interfaces and protocols for wireless nodes to communicate with each other and with various access points on a network. The IEEE 802.11 has devised a working group for WPANs as IEEE 802.15 which is investigating the need for supplemental wireless network standard specially targeted to provide very low-power consumption, low complexity, wireless connectivity among devices within or entering a Personal Operating Space (POS). This includes devices that are carried, worn, or located near the body. Here it is important to state that the scope of IEEE 802.15 is to define PHY and MAC specifications for wireless connectivity with fixed, portable and moving devices within or entering a Personal Operating Space (POS) and also to achieve a level of interoperability which could allow the transfer of data between a WPAN device and an 802.11 device To provide a standard for low complexity, low power consumption wireless connectivity to support interoperability among devices within or entering the Personal Operating Space (POS).

3.4 WPANs Applications

Although the WPAN application model(s) are still being defined, two of the preliminary application models or applications envisioned are for the Mobile Worker and Physiological Monitoring. The Mobile Worker could be a courier

whose job requires coordination between printers, scanners, computers, etc. An example of this usage is in package delivery applications, such as FedEx. Alternatively, the mobile worker could be a "road warrior" who works at the office, home, hotel and in the automobile and communicates between laptops, HPCs, pagers, cellular phones, scanners, a gateway to a WAN, etc. An example of Physiological Monitoring is the placement of body sensors that are connected by a PAN to a LAN gateway and is used in a hospital for collecting and monitoring life signs. Alternatively, physiological monitoring can be used for sports activities, such as communication between Shoe Sensors, Body Sensors, Personal Data Collection Devices, and a training application on a notebook computer. There will be many more applications to come in the future.

3.5 WPAN Functional Requirement

As WPAN is still uncompleted and research is under way to bring it up as a full fledge network for which there are some functional requirement. Functional requirements were developed to provide initial guideposts in the development of this standard. The following is a composite list of the WPAN functional requirements, broken down into three groups, and sorted in order of importance A through C.

3.5.1 Group A

- Worldwide spectrum allocations for unlicensed bands such as 2.45 GHz
- Low cost relative to target device
- Small size, for example, ~.5 cubic inches, excluding antenna and battery

- Very low current consumption, for example, average 20 mW or less @ a 10 percent Tx/Rx load
- Asynchronous or connectionless data links
- Permit coexistence of multiple wireless PANs in the same area (20 within 400 square feet)
- Permit coexistence of multiple wireless systems, such as P802.11, in the same area
- WPAN Network Access Control

3.5.2 Group B

- Data delivered to the application from the MAC at 19.2 to 100 Kb/s
- Ability for all devices within a WPAN to communicate with each other
- Networking support for a minimum of 16 devices
- Address QoS to support a variety of traffic classes, including voice
- Synchronous, and connection-oriented links
- Range of 0–10 meters
- Attach within one (1) second, once within range
- Bridge or gateway connectivity to other data networks.

3.5.3 Group C

- No single element of failure
- Video
- Roaming ability to hand-off to another PAN

devices transmit at the same time near each other. This causes a destruction of data bits, prompting the system to retransmit entire data packets. As a result, the interference lowers throughput of the system and presents sluggish performance to end-users.

The likelihood is that Bluetooth products will likely jam the operation of 802.11, not the other way around. The reason is that Bluetooth hops through frequencies 600 times faster than 802.11. While an 802.11 device is transmitting on a particular frequency, a nearby Bluetooth product will most likely interfere with the 802.11 transmission many times before the 802.11 device hops to the next frequency. This barrage of radio signals emanating from Bluetooth products could seriously degrade the operation of an 802.11 network.

3.7.2 Actions to Reduce Interference

Because the FCC doesn't directly mediate frequency conflicts between products within unlicensed ISM bands, Bluetooth and IEEE standards groups are left on their own to haggle over resolving the interference problems. The IEEE has recently taken a positive step forward by forming the 802.15 Coexistence Task Group 2. This group is developing recommended practices for coexistence of wireless PANs that operate in the 2.4 GHz frequency spectrum, and they've done preliminary analysis of the interference potential between 802.11 and Bluetooth. In addition, the group has made preliminary recommendations on how to solve the problem. The ultimate goal is to decrease the probability of Bluetooth and 802.11 devices transmitting at the same time. To make implementation easier,

modifications to both 802.11 and Bluetooth will hopefully take the form of firmware changes, not product replacement.

3.7.3 Advice to End Users for Avoiding Interference

Bluetooth products are likely to be implemented amongst 802.11 LANs before interference countermeasures are agreed upon and put in action by the standards groups. In the meantime. To reduce the possibility of interference between Bluetooth and 802.11 products, consider using direct sequence instead of frequency hopping IEEE 802.11 wireless LAN radio cards and access points. Preliminary analysis conducted by the IEEE 802.15 group indicates that the 802.11 direct sequence high rate devices are very reliable in the presence of transmitting Bluetooth products. Another recommendation is to avoid having Bluetooth products transmit within 50 feet of 802.11 radios and access points. The relatively low power signals of the Bluetooth devices diminish rapidly over longer distances. If these tactics aren't feasible or don't provide adequate results, also consider decreasing the distances between 802.11 radios and access points. This strengthens the 802.11 signals, which reduces the affects of Bluetooth interference. Unfortunately, this could require the cost of additional access points.

With a few adjustments from both standards groups, Bluetooth and IEEE may do just that. The result will surely be an increase in wireless network products that delight end users.

Chapter Four

Local Multipoint Distribution System (LMDS)

4.1 Introduction

The past decade has seen explosive innovation by the telecommunications industry as it strives to satisfy a worldwide appetite for greater bandwidth. Several developments are fueling this growth--the proliferation of the Internet, increased dependence on data and a global trend toward deregulation of the industry.

Nowhere is the phenomenon more evident than in the quest to alleviate the local-loop bottleneck. This constriction occurs where local-area networks, which link devices. Within a building or a campus, join two wide-area networks which criss-cross countries and holds the Internet together. Of the variety of technologies developed for high-speed wireless access, Local Multipoint Distribution Service (LMDS) offers an ideal way to break through the local-access bottleneck. Like cell phone networks, LMDS is a wireless system but is designed to deliver data through the air at rates of up to 155 Mbps (typical cell phone voice calls use a mere 64 kbps, or 8 kbps in compressed digital systems). LMDS may be the key to bringing multimedia data to millions of customers worldwide. It supports voice connections, the Internet, videoconferencing, interactive gaming, video streaming and other high-speed data applications.

4.2 Benefits of LMDS:

Some of the qualities of LMDS are as follows:

- Fixed Wireless @28 GHz.
- Line of Sight Coverage (LOS).
- Multiple Service Offerings.
- Target Deployment/Customers.
- Multi-Sectored Node Sites.
- 3-5 Km Radius "Cell" Sizes.

On the otherhand LMDS is the fastest, most flexible and economical broadband network that can be deployed today. A major advantage of LMDS technology is that it can be deployed quickly and relatively inexpensively. Wherever there is a need for a new wireless network, LMDS can rapidly be build to an advanced wireless network. LMDS is also attractive to incumbent operators who need to complement or expand existing networks. For example, operators who are setting up a service primarily based on digital subscriber lines but who want their service to be universally available could use LMDS to fill in gaps in their coverage. And while cable modems are making inroads in the residential and home-office markets, the business market (where little to no cable network exists) remains a prime niche for LMDS. The higher capacity of LMDS is possible because it operates in a large, previously unallocated expanse of the electromagnetic spectrum.

4.3 How It Works

Sending digital signals of the required complexity at 28 GHz is made practical by recent improvements in the cost and performance of technologies such as digital signal processors, advanced modulation systems and gallium arsenide integrated circuits, which are cheaper and function much better than silicon chips at these high frequencies.

LMDS uses wireless cells that cover geographic areas typically from two to five kilometers in radius. Unlike a mobile phone, which a user can move from cell to cell, the transceiver of an LMDS customer has a fixed location and remains within a single cell. A common design puts the customers' antennas on rooftops, to get a good line of sight to the hub transceiver.

The LMDS cell size is limited by "rain fade"--distortions of the signal caused by raindrops scattering and absorbing the millimeter waves by the same process that heats food in a microwave oven. Also, walls, hills and even leafy trees block, reflect and distort the signal, creating significant shadow areas for a single transmitter. Some operators have proposed serving each cell with several transmitters to increase coverage; most will have one transmitter per cell, sited to target as many users as possible. Of value to operators, in an industry with a high rate of turnover of customers, is the ability to pick up the hub equipment and move it to a different location, as market economics dictates--an impossibility with networks of telephone wires, television cable and optical fiber. Most, if not all, LMDS systems send data using a technique called asynchronous transfer mode, which is used extensively in wide-area networks and allows a mixture of data types to be interleaved. Thus, a high-quality voice service can run concurrently over the

same data stream as Internet, data and video applications. In summary, LMDS will be a versatile, cost-effective option for both providers and users of broadband services, with the rapid and inexpensive deployment being particularly attractive to the providers.

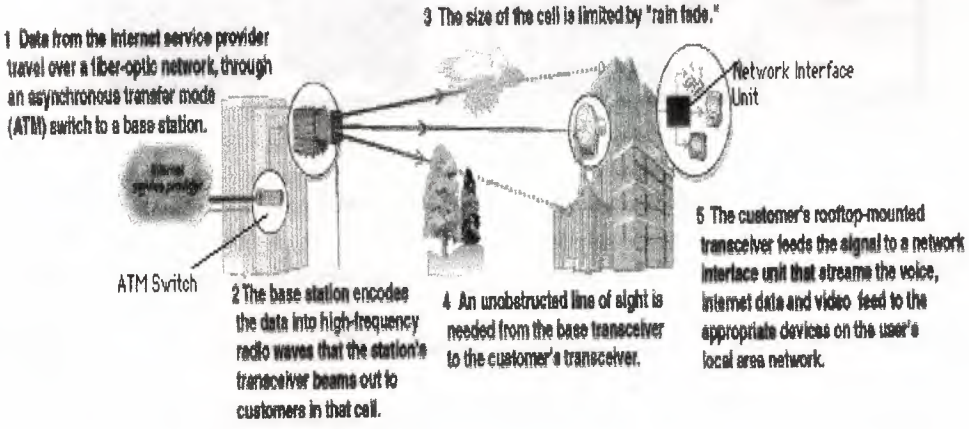

Figure 4.1 Shows working of LMDS

4.4 LMDS – Architectural Overview

Local Multipoint Distribution Service (LMDS) is a regulatory designation for broadband fixed wireless systems that operate in the 28 GHz band and offer up to several gigahertz of licensed spectrum (1.3 GHz in the United States). LMDS is designed for line-of-sight coverage over a range of 3 to 5 kilometers and has the capacity to provide data and telephony services for up to 80,000 customers from a single node.

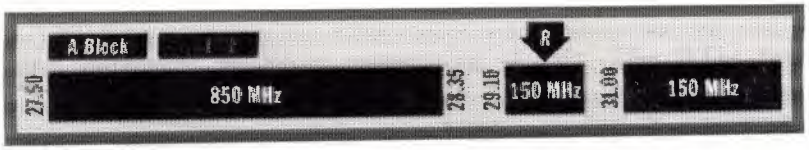

Figure. 4.2 Shows the frequency distribution of LMDS

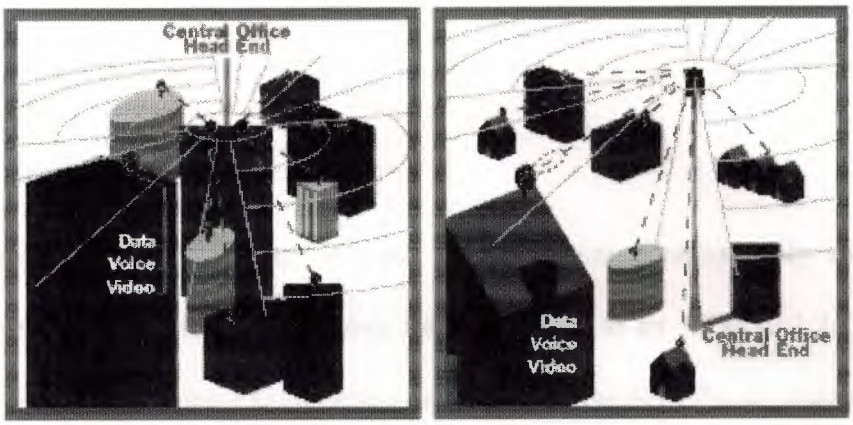

Figure. 4.3 Show that data travels in line of sight.

A 360-degree radio transmission pattern is nominally sectorized to quadrants of alternating antenna polarity. This allows effective reuse of all spectrum resources and an overlapping node pattern that drastically improves coverage for a targeted customer base. LMDS is initially best suited for areas of concentrated traffic, but will support low-traffic-density scenarios as the networks are more broadly deployed.

Schematically, LMDS systems employ cellular-like designs that provide transport and services utilizing three functional partitions (Subscriber Premises, Base/Node and Backbone Network) that define the overall network architecture.

4.4.1 Subscriber Premises

The typical equipment suite consists of a rooftop unit (RTU), a network interface unit (NIU) and customer premises equipment (CPE). The RTU provides the wireless transport capabilities, while the NIU acts as the LMDS point of demarcation, delivering a set of standard service interfaces to the CPE. The CPE platforms encompass a wide variety of equipment including LAN switches, campus

ATM switches, multiservice access platforms, and midrange to high-end enterprise routers.

4.4.2 Base/Node

These equipment suite consists of node transmit/receive radio units and base channel groups for service provisioning interconnected to an ATM or L2/L3 edge switch. The range of architectural options available at the Base/Node suggests that LMDS networks will reflect a wide variety of network designs and topologies driven by local market characteristics, business plans, service offerings and technology choices.

4.4.3 Backbone Network

The Backbone Network will similarly reflect a wide range of business and technical choices. Generally, LMDS service providers will look to their backbone networks to serve as gateways into the Public Switched Telephone Network (PSTN) as well as the Internet and other public and private networks. Some operators will choose to build their own backbone networks, while others will choose to leverage partnerships with IXCs, ISPs and PCS operators.

What's important, however, is the flexibility LMDS service providers have in how they approach this decision. This flexibility ultimately converts to strategic leverage as LMDS operators gain momentum in the market and fine-tune their business plans accordingly. Architecturally, LMDS operators have advantages shared by no other type of service provider, and the decisions they make in the early stages will be leading determinants of their longer-term success.

4.5 LMDS – Network Overview

Here in the LMDS network overview, we have to consider two conditions and those are what kind of network should be built, given the many degrees of freedom in design? and what kinds of services should an LMDS network be built to provide?. The explanation of these conditions defines a clear path for LMDS to embody the New World Network. If the three functional layers of LMDS networks – Subscriber Premises, Base/Node and Backbone Network – are generalized as Access, Edge and Core respectively, you will see that LMDS, like any access technology, ultimately will make its mark at the edge of the network.

4.5.1 Access

The "Access" layer of the network, the point of service delivery at the customer premises represents the demarcation between LAN and WANS. The Access platform generally will be supplied by the LMDS service provider and will satisfy a principal requirement of supporting multiple services. In addition, the Access platform must be cost-optimized or at least designed to support future cost optimization.

The Access layer gives LMDS service providers an opportunity for tight integration with customer premises networks. This in turn is a ready-made foundation for service differentiation through offerings such as managed LAN services. Ultimately, the LMDS service provider must be mindful of the value of "future-proof" Access platforms. This ensures that as LAN and enterprise networking technologies evolve, the LMDS operator is in lock step with those innovations.

4.5.2 Edge

Key functions of the "Edge" network include creating and delivering services on a variety of physical interfaces (including wireless), and providing service quality and differentiation. And the word "service" is appropriate: the Edge exists to serve the customer. The Edge includes the interfaces that bring in end-user traffic and revenue. The Edge also provides the "meet point" between service provider and service customer.

The customer's perception of service quality largely depends on the performance of the Edge platform, the time to deployment of the service depends on provisioning activity on the Edge platform, and any value-added service enhancements are enabled by the Edge platform. Also, because service providers "meet" their customers at the network Edge, the Edge provides the biggest opportunity for service differentiation relative to the competition.

4.5.3 Core

The "Core" optimizes cost by providing efficient transport and bandwidth optimization of Edge-provided traffic. To support cost-effective transport of Edge-provided traffic, the Core network must support a variety of service types. The Core does not contribute directly to revenue (since it does not deliver services).

Therefore, to support an LMDS service provider's return-on-assets goals, the Core should be capable of IP- and ATM-based traffic. This implies more flexibility than "one-traffic-type" Core platforms have allowed in the past, along with an expanded set of standards-based, resilient routing protocols, such as Private Network-

Network Interface (PNNI) for ATM-based traffic, and Multiprotocol Label Switching (MPLS) for IP traffic.

4.6 LMDS on the Edge

In a world of increased demand for services and bandwidth, coupled with a competitive need for faster deployment and turn-up of those services; the implications for the Edge are obvious. The most profitable network Edges will be those with maximum service flexibility – in other words, the ability to accommodate new services with speed and high-quality service.

Service flexibility at the Edge also relates to time-to-market requirements. Further, the enterprise target market for LMDS services clearly establishes IP as playing a key role in satisfying the service flexibility requirement. Thus, LMDS service providers seeking to increase margins and overall profitability by deploying higher-value services will most likely be deploying IP-aware or IP-based services (such as Virtual Private Networks).

The LMDS network Edge with the capability to flexibly deliver high-value services has a happy problem: the network Edge quickly fills with revenue-generating traffic. This requires that the LMDS Edge platform have more switching/routing capacity and higher-speed interfaces than would be required of a "single-service" platform. In this scenario, innovative integration of IP and ATM becomes a deciding factor. Thus, for LMDS networks to embody the New World Network they must accomplish IP+ATM integration on a single platform that can translate sophisticated, multiband radio access methods onto an ATM traffic management

scheme while simultaneously providing the flexibility to create and deliver high-value IP services.

4.7 LMDS and the New World Network

The "New World Network" is much more than a slogan. It is a signal that the world is becoming smaller, and that revolutionary changes in telecommunications are leading the way. The New World Network offers a blueprint for competition where data, voice, and video traverse a global communications infrastructure.

4.8 Multiservice IP+ATM Architecture

Historically, service providers have had to provision Internet and data services over separate IP and ATM networks. This approach is costly and difficult to manage. However, IP+ATM network architecture combines the application-layer visibility of IP and the traffic-management capabilities of ATM, all on a single platform. In this architecture, intelligent L2/L3 edge switches dynamically forward IP traffic in parallel with Frame Relay and ATM traffic over the same ATM network.

Tag Switching, based on MPLS (Multiprotocol Label Switching), is built upon the simple, yet powerful, concept of attaching labels (or tags) to IP packets traversing an ATM network. Each tag represents an Edge port in the network, and together they provide the ATM network with the information required facilitating cut-through switching.

4.9 IP+ATM Service Foundation

To survive and prosper, LMDS service providers must be able to quickly provision new services and expand into new markets, as well as add value to basic services that encourage customer retention. This means continually seeking new "killer

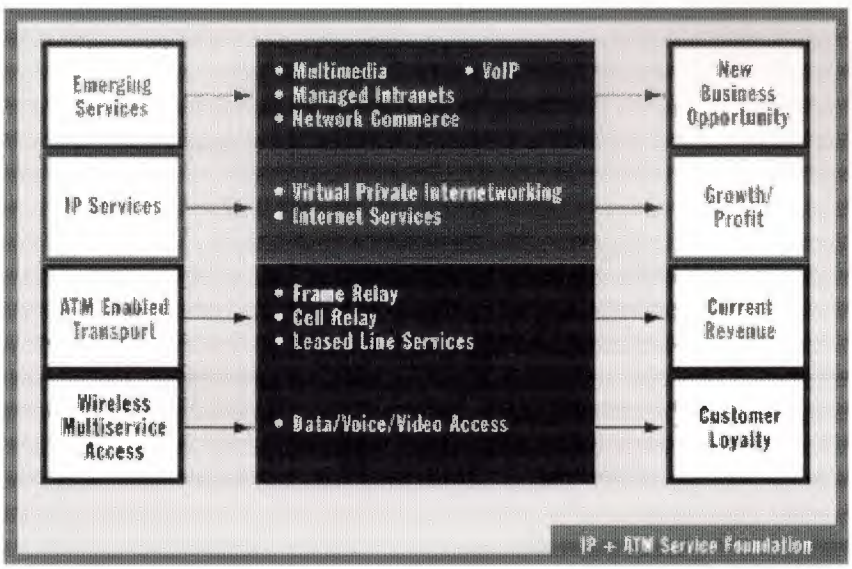

Figure 4.4 Show the IP+ATM Service Foundation.

applications," such as voice-over IP, that will drive tomorrow's revenue, as well as maintaining traditional services such as Frame Relay, SNA, dial access and leased-line, which pay the bills today.

As the LMDS industry evolves, service providers who can best balance the service mix between legacy and next-generation services stand to win a substantial competitive advantage.

The great opportunity for LMDS service providers is to embody the New World Network. IP+ATM infrastructure solutions, based on MPLS Tag Switching and incorporating tight integration of innovative radio access protocols in total turnkey network solutions, enable the New World Network service foundation. This service

foundation empowers LMDS service providers to compete and prosper by offering the most complete portfolio of differentiated services in a way that fulfills their potential to shape the future of telecommunications. LMDS service providers are standing squarely at the front line of the New World Network future.

Chapter Five

Wireless Asynchronous Transfer Mode (WATM)

5.1 Introduction

ATM (Asynchronous Transfer Mode) has been advocated as an important technology for the wide area interconnection of heterogeneous networks. In ATM networks, the data is divided into small, fixed length units called cells. The cell is 53 bytes. Each cell contains a 5-byte header, which comprises of identification, control priority and routing information. The rest 48 bytes are the actual data. ATM does not provide any error detection operations on the user payload inside the cell, and also provides no retransmission services, and only few operations are performed on the small header.

ATM switches support two kinds of interfaces: user-network interface (UNI) and network-node interface (NNI). UNI connects ATM end systems (hosts, routers etc.) to an ATM switch, while an NNI may be imprecisely defined as an interface connection two ATM switches together. The ITU-T Recommendation requires that an ATM connection be identified with connection identifiers that are assigned for each user connection in the ATM network. At the UNI, the connection is identified by two values in the cell header: the virtual path identifier (VPI) and the virtual channel identifier (VCI). Both these VPI and VCI combines together to form a virtual circuit identifier.

5.2 Types of ATM

There are two fundamental types of ATM connections:

5.2.1 Permanent Virtual Connections (PVC)

A PVC is a connection set up by some external mechanism, typically network management, in which a set of switches between an ATM source and destination ATM systems are programmed with the appropriate VPI/VCI values. PVCs always require some manual configuration.

5.2.2 Switched Virtual Connections (SVC)

A SVC is a connection that is set up automatically through signaling protocol. SVCs does not require the manual interaction needed to set up PVCs and, as such, are likely to be much more widely used. All higher layer protocols operating over ATM primarily uses SVCs. ATM adaption layers (AALs) provide mechanisms for supporting transport protocols over ATM cells. AAL1 and AAL2 have been defined by the CCITT for use in the wide area for support of constant and variable bit rate services respectively and AAL 3/4 for connection-less data transport. However, AAL5 is being proposed by the ATM-Forum for all types of computer oriented multiservice traffic especially for the local area. AAL5 has lower payload overhead per cell and relies on quality of service and statistical mechanisms to provide multi-service capability.

5.3 Why Wireless ATM?

Since the beginning, the concept of ATM is end-to-end communications i.e. in a Wide Area Network environment, the communication protocol will be the same i.e. ATM, and companies will no longer have to buy extra equipment (like routers or gateways) to interconnect their LANs (local area networks). Also, ATM is considered to reduce the complexity of the network and improve the flexibility while providing end-end consideration of traffic performance. That is why researchers have been stressing that an ATM cell-relay paradigm be adopted as the basis for next generation wireless transport architectures. Both ATM and Wireless are in it's infancy, there are no fixed standards being defined for Wireless ATM, and papers and research is still going on in this area. Therefore I will try to analyze and discuss different ideas and protocols put forward by various researchers in Wireless ATM.

5.4 Wireless ATM

There are several factors that tend to favor the use of ATM cell transport for personal communication network (PCN), including: flexible bandwidth allocation and service type selection for a range of applications, some of which are yet to be defined; efficient multiplexing of traffic from bursty data/multimedia sources; end-to-end provisioning of broadband services over wireless and wireline networks; suitability of available ATM switching equipment for inter-cell switching; improved service reliability with packet switching techniques; ease of interfacing with wired B-ISDN systems that will form the telecommunications backbone .

Due to the above factors, it was recommended that adoption of an ATM compatible fixed length cell-relay format for PCN. This will result in a relatively transparent interface to an ATM backbone. By using ATM switching for inter-cell traffic, the crucial problem of developing a new backbone network with sufficient throughput to support intercommunication among large numbers of small cells is avoided.

It is noted that for PCN micro and pico cells with relatively low traffic volumes rather than direct connection to an ATM switch, it may be appropriate to use a lower cost shared media approach (such as TDM passive optical network or IEEE 802.6 optical bus) to interconnect several base stations.

5.5 Key Issues

The following are the key issues pertaining to wireless ATM network.

5.5.1 Architecture

The architecture proposed by most researchers, composed of a large number of small transmission cells, called pico cells. Each pico cell is served by a base station. All the base station in the network is connected via the wired ATM network. The use of ATM switching for inter-cell traffic also avoids the crucial problem of developing a new backbone network with sufficient throughput to support intercommunication among large number of small cells. To avoid hard boundaries between pico-cells, the base stations can operate on the same frequency. Reducing the size of the pico-cells has major advantages in mitigating some of the major problems associated with in-building wireless LANs. The main difficulties encountered are the delay appeared due to multi-path effects and the lack of a line-

of-sight path resulting in high attenuation. Pico-cells can also have some drawbacks as compared to larger cells. There are a small number of mobiles, on average, within range of any base-station, so base-station cost and connectivity is critical. As cell size is reduced, hand-over rate also increases. By using the same frequency, no hand-over will be required at the physical layer. The small cell sizes also gives us the flexibility of reusing the same frequency, thus avoiding the problem of running out of bandwidth. The mobile units in the cell communicate with only the base-station serving that particular cell, and not with other mobile units. The basic role of the base station is interconnection between the LAN or WAN and the wireless subnets, and also to transfer packets and converting them to the wired ATM network from the mobile units. In traditional mobile networks, transmission-cells are "coloured" using frequency division multiplexing or code division multiplexing to prevent interference between cells. Colouring is a wasteful of bandwidth since in order for it to be successful there must be areas between re-use of the colour in which it is idle. These inactive areas could potentially be used for transmission.

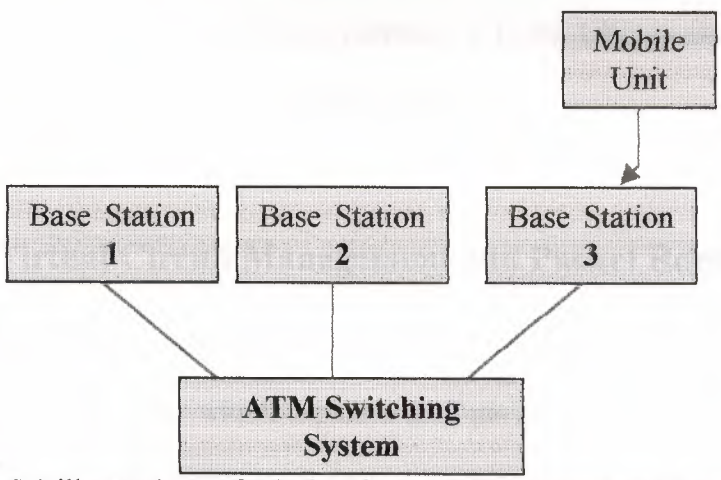

Fig. 5.1 illustrations of wireless base stations connected through an ATM Switch

5.5.2 Cell Size

The ATM cell size (53 bytes) is designed for 64kbps or higher, which may be too big for some wireless LANs (due to low speed and high error rates), therefore wireless LANs may use 16 or 24 byte payload. The ATM header can also be compressed and be expanded to standard ATM at the base station. An example of ATM header compression is to use 2 bytes containing 12-bit VCI (virtual channel identifier) and 4 bit control (payload type, cell loss priority etc.). One of the cell format proposed by Porter and Hopper is to have a compatible pay-load size and addressing scheme, which should be different from the standard ATM cell format. Mobility should be as transparent as possible to the end-points and therefore the VCIs used by the end-points should not change during hand-over. The allocation of the VCI should remain valid as the mobile moves through different pico-cells within the same domain. The translation of the VCIs should be as simple as possible due to movement between domains. This can be done by splitting the VCI space into a number of fields like Domain Identifier, Mobile Identifier, Base Station Identifier and Virtual Circuit number. A 16 bit CRC is also used to detect bit errors, due to high error rate of mobile networks.

5.5.3 Virtual Circuit Management and Packet Routing

Each processor that attaches to the ATM switch maintains a virtual connection to each other processor over which it passes data packets. In addition, the processors use a second, separate virtual circuit for routing updates. Therefore, each wireless base station will have two virtual circuits open to each other base station and to each router. As the packet arrives the base station from the mobile wireless unit, it

chooses the circuit that leads to the correct destination. Using two connections guarantees that routing information will not be confused with data because data packets never travel on the virtual circuits used for routing, and routing packets never travel on the circuits used for data. The circuits can also be assigned priority to guarantee that stations receive and process routing updates quickly. The standard hop-by-hop routing method for datagrams is not adequate to cope with wireless systems, because then every node of the wireless network must store the location of every mobile system to which a route exists, which represents a large amount of information and database. Secondly, it will become impossible to keep the routing information up to date and consistent throughout the network, since a very larger number of mobile will exist. Due to the above factors a proposed method by which mobile end-systems may be added to an internetwork with the minimum of disruption. A "mobile controller" node is required in every subnet of the wireless network. Each of these controllers has its network-layer software enhanced by an additional sublayer, which performs routing to mobile systems. Mobile systems are free to move between the subnets, and a network wide name server provides location information when communication with a mobile is to be initiated. A system of local caching of location information and forwarding of data allows movements to be hidden from the Transport Layer. In a wide or local area network, virtual connection establishment is reasonably fast, but is likely to take longer time in wireless network's. Therefore it may not be practical to re-establish all virtual circuits whenever a mobile moves between pico-cells. The solution provided by Porter [2] is to isolate the small scale mobility of the mobile from the rest of the wired network latent virtual paths and the Mobile Switching Point (MSP) are used.

The MSP provides a routing point through which all virtual circuits to the mobile are routed. From the mobile switching point there may be a number of potential base-stations which can be used to contact the mobile. Each of these routes for virtual circuits is termed a virtual path, which can be manipulated by a single signaling command at the MSP. Whenever a virtual path is active, all of the associated virtual circuits will also be active, other virtual paths are latent - the virtual circuits have been established but no traffic is flowing [2].

5.5.4 Physical Layer

The basic design issue for next generation private communication network (PCN) is the selection of modulation methods, and a set of bit rates. A bit rate in the range of 5 -10 Mpbs can be achieved using the existing wireless technologies, in a picocellular enviroment. Thus, with the exception of HDTV, most other ATM applications can be supported. The preferred technique may actually vary with the specific PCN application scenario to be addressed, so that it is likely that both TDMA and CDMA solutions will co-exist [1]. CDMA provides an efficient integrated solution for frequency reuse and multiple access, and can typically achieve a net bandwidth efficiency 2 -4 times that of comparable narrowband approaches [1][7]. However, a major weakness of CDMA for multiservice PCN is that for a given system bandwidth, spectrum spreading limits the peak user data rate to a relatively low value [1]. Narrow band (TDMA) can be used to achieve high bit rates, as the implementation is well understood, and has been with us for a long time. In a pico-cellular enviroment, we can achieve a bit rate in the range of 8 -16 Mb/s, by using the narrow band approach. Overall, with a good physical level

design, it should be possible for macro (5-10 km), micro (0.5 km), and pico (100m) cells to support baud rates of the order 0.1-0.25 Msym/s, 0.5-1.5 Msym/s and 2-4 Msym/s [1]. These rates should be sufficient enough to accommodate many of the broadband services.

5.5.5 Media Access Control (MAC)

One of the major problem of Wireless ATM is to find a suitable channel sharing/media access control technique at the data-link layer. Shared media access leads to poor quantitative performance in wireless networks. When spread spectrum modulation is used, CDMA is the de-facto mode of operation [1]. Performance results from earlier studies shows that packet CDMA can achieve good traffic multiplexing efficiency and performance for CBR, VBR and low-speed interactive data services [1], but CDMA is limited to less than or equal to 1 Mb/sec at higher speed. Narrow band modulation (TDMA) can also be used, and researchers also suggested slotted ALOHA with exponential back off, as the protocol used for MAC. Slotted ALOHA has considerably better delay performance at low utilization than a fixed allocation scheme and fits well with the statistical multiplexing of ATM [2]. Younger [4] argues that ALOHA and its derivatives are ruled out since less collisions are desirable in a wireless network. CSMA/CD protocol gives the required performance on copper, but is ill suitable for wireless, where all the systems in a cell are not in communication with each other. What he suggests is a reverse channel over which the base station echoes the incoming signal. This could be done at the expense of doubling the bandwidth required, and a busy/idle signal could be broadcast on a separate narrow-band channel. One of the problem to this

kind of contention-based method is that in a mixed-media applications access cannot be prioritized, though contention algorithms can be devised which increase the probability that a high-priority message will succeed in capturing the resources it requires [4]. The system proposed by Acampora et al [11][4] uses a form of TDMA (Time Division Multiple Access), in which the mobiles in a cell are polled to determine which of them have data to send. The mobiles are then allowed to transmit in turn on receipt of a token from the base station. After the polling, priority is then given to units, which have speech, or other continuous services, which can send it during the first part of the frame, and the remainder of the frame can be used for data. When the traffic is light, the unit may be allowed to send data in most of the frame. A flag bit can also be used in the packet header, which is set, *if the mobile has more data queued for transmission. This reduces the polling* overhead [4]. The challenge in designing the MAC protocol for Wireless ATM is to identify a wireless, multimedia capable MAC, which provides a sufficient degree of transparency for many ATM app.

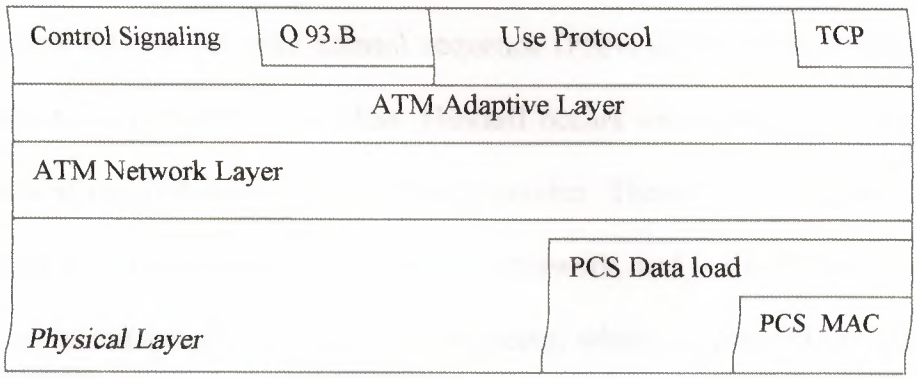

Fig 5.2. Relation of W.Network (PCN) Protocol layer of ATM

5.5.6 Data Link Layer

Wireless ATM needs a custom data link layer protocol, and it should be as transparent as possible. A custom data link protocol is needed due to high error rate and different packet size of Wireless ATM. Wireless ATM may use 16 or 24-byte payload, as 53 byte may be too long for Wireless ATMs. The data link protocol may contain service type definition, error control, segmentation and reassemble, and handoff support.

A service type field is needed so as to indicate whether a packet is of type supervisory/control, CBR, VBR, ABR etc. The service type field simplifies base station protocol processing. Wireless ATM should provide an error control due to high noise interference and poor physical level characteristics of the wireless medium. This is achieved using a PCN packet sequence number filed (e.g. 10 bits) in the header along with a standard 2-byte CRC frame check sequence trailer [1]. HDLC style retransmission can be used for connectionless data. Since Wireless ATM may use 16 or 24 byte cells, segmentation and reassembly is required. This can be achieved with a segment counter that uses, for example, the two least significant bits of the error control sequence (PSN) number [1]. Handoff is an important characteristic of wireless. Handoff occurs when the mobile unit leaves the area of one cell and enters the area of another. Therefore soft handoff without any data loss is important for any wireless network, and it should be transparent. This can be implemented by using bits in header, which indicates PDUs before and after the handoff.

5.5.7 Network Location and Connection Establishment

In order to establish connections between the mobile unit and the base station, the mobile must be located. Searching and registration can pose problems. According to Porter [2] Searching: Involves a form of broadcast in which the whole network is queried. Registration: Objects are responsible for their own registration at a well-known registration point. Subsequent inquiries about the object are directed to this register using static routing mechanism. The architecture explained by Porter [2] uses a hierarchical registration scheme. When a mobile is within a domain, it is registered at the appropriate Domain Location Server (DLS) and this registers the mobile at its Home Register (HR). The HR keeps a record of the mobiles current DLS location. Each mobile has a statically bound home address, which is mapped to the HR address.

One of the basic requirement of mobile units, is that the units should be allowed to roam freely from cell to cell. This process should not require any user intervention. Detection of movement in the TACS system is performed by having the base-station monitor the received signal strength from the mobile [4]. If the signal falls below a preset limit, the switching center looks for another base-station, which is receiving a stronger signal and transfers the call to that station. An interval can be set aside in each frame, during which newly arrived or activated mobiles attempt to inform the base-station of their presence. Connection Establishment is explained in detail by Porter [2]. In connection establishment, the host generates a connection signal, specifying the network address of the two end-points. If the destination address is that of the mobile unit, then the local Domain Location Server (DLS) is contacted. If the local DLS have no knowledge of the unit, then the routing

information is forwarded to the Home Registry (HR) of the mobile. The HR returns the address of the remote DLS, which in turn returns, the address of the mobiles MR (mobile registration). Once the address of the MR is known, then all the requests are directed to that particular MR. When the connection request arrives at the MR, it first consults the Mobile, which in turn decides whether to accept the call or not. If the mobile accepts the call then it allocates a virtual circuit number and returns it to the MR. The MR then creates the virtual circuits between the Mobile Switching Point (MSP) and the remote end-point and adds the new virtual circuit to the active and inactive virtual paths between the MSP and the base stations close to the mobile.

5.6 Future Directions

As WATM technology is migrating from R&D stage to standardization, service trials, and early products. In view of the growing significance of both multimedia

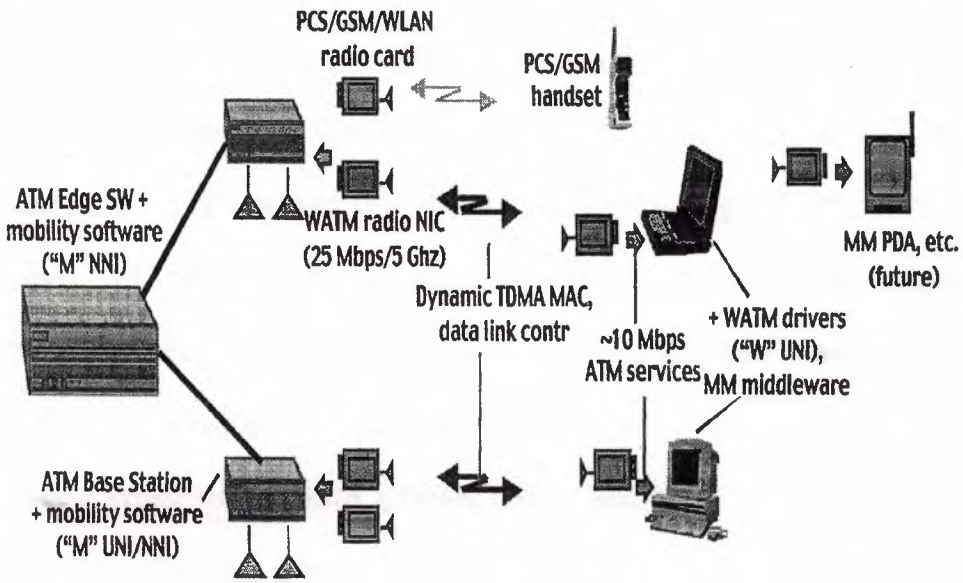

Figure 5.3

and portable computing in various aspects of everyday life, there should be a large potential market for such broadband wireless network technologies if they can be offered at the right cost/performance points. Thus, an immediate challenge for WATM is to develop technical standards that facilitate production of high-volume, generic LSI and software modules needed to build a cost-effective system. Significant technology development efforts on radio, modem, and MAC/SAR LSI designs will be needed to achieve this objective. In parallel, it will be necessary to start consumer-level field trials to demonstrate the use of WATM technology and evaluate its effectiveness in different vertical and horizontal market scenarios.

The figure 5.3 shows the major components of a field-trial capable system ("WATMnet 2.0") we are currently developing for use in both public and private microcellular scenarios. This system will include compact 5-GHz/25-Mb/s WATM NIC's, ATM radio ports supporting both ATM and non-ATM wireless access, and mobile ATM switches (based on the future ATM Forum "M" specification).

The other major challenge is to ensure that wireless and mobile ATM systems being developed provide a reasonable migration path from existing cellular, PCS, and Internet-based wireless data services toward broadband. In this context, key technical issues to be resolved are cellular/PCS interworking and efficient support of IP over WATM networks. Integration of legacy cellular/PCS services into a WATM framework was briefly discussed in Section II-B, where it was pointed out that the mobile ATM infrastructure may be used generically to support existing radio access protocols like GSM, CDMA, GPRS, and 802.11, in addition to broad-band WATM. The core mobile ATM network provides capabilities for handoff, location management, authentication, etc., making it possible to terminate various

radio protocols and map these onto the generic "M" UNI interface at the edge of the network (i.e., base station). Such a concept of using a generic ATM or IP-based mobile network for migration to third-generation cellular systems is currently being discussed in applicable standards committees related to UMTS or IMT2000. Efficient support for IP is, of course, a major consideration for any new access network technology such as WATM. The traditional way of supporting IP over ATM (called MPOA) can readily be extended to fit within the mobile ATM framework.

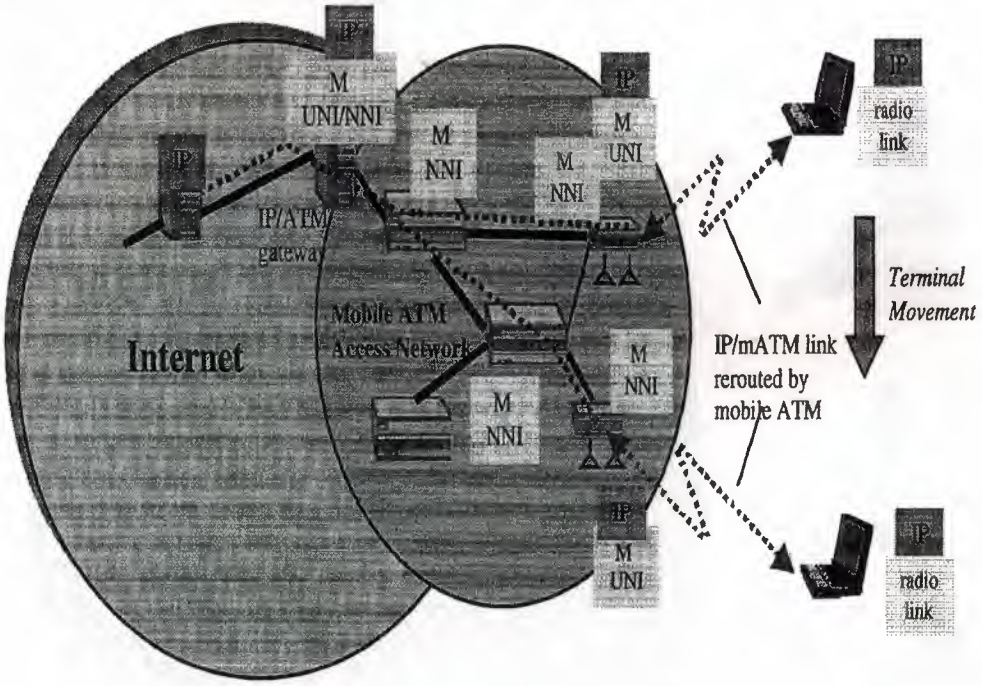

Figure 5.4

In this approach (illustrated in figure 5.4), the mobile ATM network acts as a transparent mobility-enhanced link layer for the global IP network, so that mobile IP needs to be invoked only for global roaming. For IP-centric scenarios, it is also possible to use WATM hardware as a link level substrate for mobile IP services with QoS control, etc. in the same way as ATM hardware is being used as a core

for gigabit IP routers. In particular, we are currently in the process of implementing a proof-of-concept demonstration of a specific IP switching technique [10], [11] running on a seamless wired + wireless ATM network. In this system (shown in Fig. 5.5), IP is used on a hop-by-hop basis at routers implemented in the control processor of each ATM switch or base station. IP flows are subsequently mapped on to the ATM and WATM hardware using appropriate flow < - > VC and QoS mapping rules [12]. Another alternative for a predominantly IP network would be to use only the WATM NIC hardware to provide a QoS-capable wireless access link which interfaces directly with level 3 IP routers.

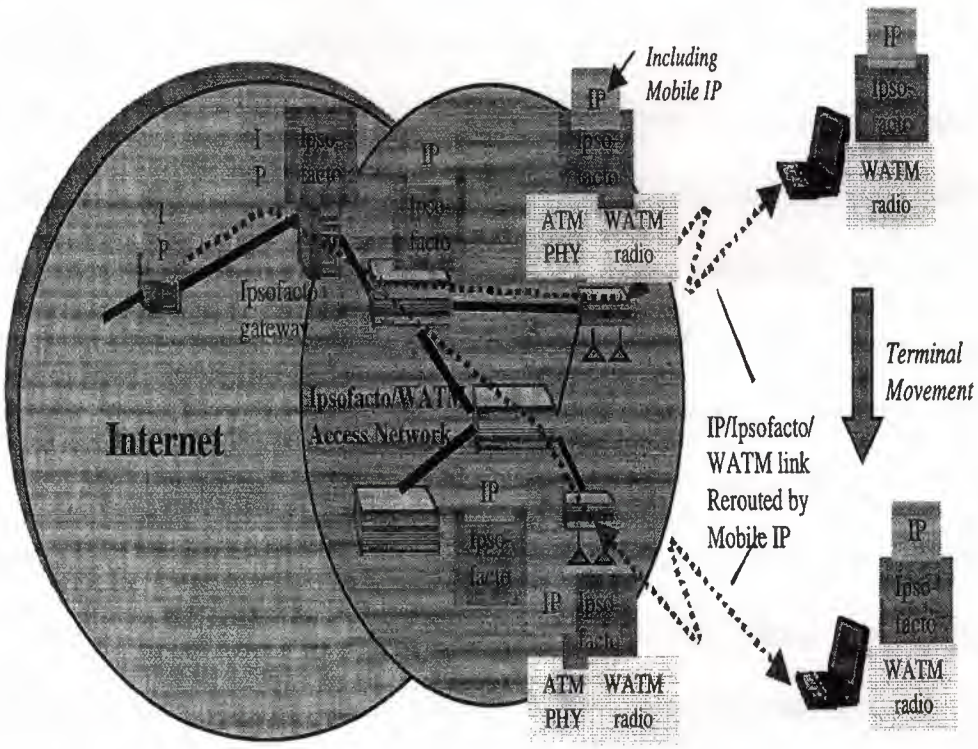

Figure 5.5

In this case, mobile IP and/or mobility-enhanced RSVP (for QoS support, etc.) can be used for handoff and location management functions [13]. Techniques such as these make it possible to convert WATM components into a broadband wireless IP

network that is fully compatible with today's Internet services. The relative roles of IP and ATM in future broad-band wireless networks will continue to evolve and should become somewhat clearer over the next three to five years.

If broad-band wireless technologies such as WATM successfully enter the mainstream, this will have an important impact on portable terminal hardware and software. A high-bandwidth wireless connection will enable compact portable devices to retrieve multimedia streams from the network with low latency, thus enabling a variety of new applications. Since the concept of WATM is to provide a uniform API at both fixed and portable terminals, we look forward to a gradual blurring of the distinction between services available on stationary and mobile terminals. Further work will be required on mobility middleware [9], [14], [15] to deal with issues such as application scaling, adaptive QoS control, and wireless link disconnection while using mainstream transport protocols and API's at portable devices. In terms of terminal hardware [16], [17], the availability of a WATM connection would tend to stimulate development of a new generation of multimedia-oriented laptops, PDA's, or personal information appliances (PIA's) with high-resolution displays and hardware support for media streaming, video decoding, etc. Such devices would be ideal for web-based media browsing, as well as for new location-aware mobile applications. Portable digital cameras now entering the mass market represent a different class of mobile multimedia devices with high-bandwidth uplink requirements, which can also be effectively supported by WATM.

Chapter Six

Wireless Internet

6.1 Introduction

As we know the importance of internet in our daily routine, and what it has done and can do for us, is unquestionable, which clearly define its standing among its user, irrespective of their profession. Nowadays we do almost all our major work via the internet, that is writing emails, doing e-commerce, booking reservations, video conferencing and whole lot more. As the need arises for faster and ubiquitous communication whether for computer network or cellular phones, Internet can't be left behind. Its practical usage can't be measured if the Internet becomes wireless. It has happened. The Internet and wireless already have intersected and the road ahead threads towards new horizons, limited only by imagination. As days pass by more and more innovations are being carried out, to make the Wireless Internet (Mobile Internet) such a medium where nearly all the service of the Internet and cellular phones will be just a single touch away. This technological influx is somewhat slow but moving on in a healthy speed.

The main driving force behind the Wireless Internet is Wireless Application Protocol (WAP) which really made it possible to surf the Web on a hand held device. It has done wondered in most parts of the world where it is being used just like another cellular phone, people access their email, reserve cinema tickets, check

the weather, news and other services being connected everywhere anywhere all the time and paying for only that duration when using the Internet.

6.2 A Futuristic Approach

As most of the development in the Wireless Internet field has either been completed or is in the process of being developed, but at this moment it is not possible to state that whatever has been done is enough or has fulfilled the requirement of the planners. But in fact there is always a factor of improvement that drives towards excellence. Here in case of mobile Internet, most of the talk is, to some extent in its infancy. The true results can be seen within the next two to three years and that will be: writing and sending emails, surfing the web, you can search the market for the cheapest product by simply writing the item code, find the cheapest hotel and get a room reserved just by using your credit card, find the location of your loved one by tracking his handheld device, do e-commerce, as it will always online you can get instant knowledge about stocks. On the business front, there will be more advertisement on the device that will give a boost to the particular business. Some of the services mentioned above are at present in use and the rest of them will be there to be used, may be tomorrow or after a year. But whenever it will be here, there will be a lot of choices and life will be a lot easier.

6.3 How Does It Works

Wireless Internet offers some obstacles in transmitting and sending data. These obstacles are taken care in the following way. Digital circuit switched data is available for CDMA, TDMA and GSM technologies, typically at two data rates,

9.6 and 14.4 kilobits per second. For the most part, CDMA carriers have emphasized Internet-related services, but that's primarily due to marketing rather than a technology advantage. The transmission rates lag behind the preferred wireline rate of 56 kbps because of bandwidth constraints and all the fancy coordination required among wireless network elements .In most instances, wireline Internet connections rely on a modem to generate tones carried over a phone line. However, all digital wireless systems are designed for voice and use voice sampling, coding and compression schemes. When the network "hears" a modem tone, it tries to sample and code it as if it were a human voice, resulting only in representative information about the tone, rather than an intact transmission. Its not possible to just connect a modem over the digital airlink because the voice coding doesn't translate modem tones. So the wireless device must signal to the network that the call is data rather than voice. The answer to this data dilemma and the basis for all digital circuit switched data calls is to turn off the voice coding and send raw data right from the handset. The phone signals what kind of session it wants and leaves it up to the switch to do the data translation. But this new data functionality isn't part of the traditional mobile switching center, so equipment must be added to the system. Generically called the Inter-Working Function or IWF, this equipment terminates the wireless-specific protocols and initiates a modem-based connection to the public telephone network. Think of it as a mediation device, translating the way a wireless network "talks" into the language of services, such as America Online. The process involves the equivalent of two phone calls as the IWF terminates the first call from the handset and initiates the second through the phone network. A variation on this theme involves a quick- or

fast-connect option- a de facto standard among most vendors to connect to the user's desired content source. This option allows operators to go directly off the IWF via an IP connection vs. a modem connection. That's useful if you know you're [headed for] an IP network. The option's primary benefit is the connection time is much faster In a nutshell, that's the digital circuit switched process behind the Internet access plans offered by CDMA carriers Sprint PCS and Bell Atlantic Mobile. Sprint PCS offers three Internet access services incorporating the technology: browser, information "push" and dial-up. Browser capability allows user access to specially formatted Internet content through Wireless Application Protocol devices. Push capability works in reverse, letting content providers drive information, such as stock quotes and weather reports, to subscribers. For dial-up, users are connected through the IWF to specific non-Internet data sites, such as a corporate local area network. Eventually you'll be able to access your corporate LAN through your [browser] phone, but that is not possible today because of company firewalls and related issues. The other option we have is to use CDPD that discussed later in the chapter.

6.4 Types of Wireless Internet

To understand Wireless Internet in detail it is better to divide it into two main categories: client-server and client resident applications.

WAP is the first example of client-server applications. Today most of the applications that we see are WAP applications or using similar technologies (web clipping, I-Mode). That is good, because the success of upcoming wireless applications will be very much driven by WAP. Most of these applications that we

see today are browser-like menus that you navigate through, with the content on a remote server. As we move into the future of the Mobile Internet we will see WAP evolve into an advanced environment, supporting things like multimedia and streaming, enabling richer experiences. The other main access technology is the regular http/html web access. This is foreseen to continue to be important, due to the vast number of sites available, but probably mostly for bigger devices, like laptops. WAP and ultra-light clients are very appealing, as they don't require any skills from the user. You don't have to download, install or configure each application. The updates are done at the central server, and therefore instant to the user. For those reasons, WAP is expected to be the mass-market access medium, where all major phone vendors will have it in all their phones. What about client resident applications then? Today we are seeing more than just web browsing as applications for the Internet. You can have a stock trading application that is constantly online, giving you a level of interactivity that is beyond what you get with browsing. Streaming video and online gaming are other applications that are more than just navigation through hyperlinks. It is thought that the second wave of wireless applications, that starts with GPRS (1xRTT for the IS-95 CDMA track), will be the wireless version of this. This change happens at the end of 2000, when you are going to be Always Online, but probably only paying for it when you use it. One of the reasons why these kinds of applications are not widespread on the Internet today is that online access is not taken for granted. Most people are still stuck with dial-up connections, which makes that market for pure Internet applications limited. I think that this shows why the impact of GPRS as a

connective technology is likely to be huge, you will have the Mobile Internet always at hand.

6.5 Protocols

The convergence of mobile, telephony, handheld computing and the Internet has created a latent demand for common standards to ignite the next phase of market growth. The Wireless Application Protocol (WAP) is a new advanced intelligent messaging service for digital mobile phones and other mobile terminals that will allow you to see Internet content in special text format on special WAP-enabled GSM mobile phones. The number one goal of the WAP Forum is to foster the implementation of one compatible global Internet standard for small handheld devices on all wireless networks. In addition the original constraints WAP was designed for -- intermittent coverage, small screens, low power consumption, wide scalability over bearers and devices and one-handed operation -- are still valid in 3G networks. The purpose of WAP is to enable easy fast delivery of relevant information and services to mobile users. Through the WAP Forum, WAP has become the *de facto* global industry standard for providing data to wireless handheld mobile terminals. Essentially, WAP specifies a thin-client microbrowser using a new standard called WML that is optimized for wireless handheld mobile terminals. WAP also specifies a proxy server that acts as a gateway between the wireless network and the wire-line Internet, providing protocol translation and optimizing data transfer for the wireless handset.

WAP also specifies a computer-telephony integration API, called WTAI, between data and voice. This enables applications to take full advantage of the fact that this

wireless mobile terminal is most often a phone and the mobile user's constant companion.

On-board memory on a WAP phone can be used for off-line content, enhanced address books, bookmarks and text-input methods. Some of the WAP-enabled phones are Nokia 7110, Alcatel OneTouch, Siemens S25, Motorola Timeport L7389, Ericsson R320, or the Ericsson R380, Motorola v2282, Nokia 6250, Nokia 6210, or WAP-enabled palmtops like the Siemens IC35 (Unifier) and the Ericsson MC218 you'll be able to:

- Surf the Internet in text format.
- Send/Receive e-mail.
- Get/Buy stocks.
- Book and buy Metro and theatre tickets.
- Get traffic directions.
- Order flowers for your loved one.

WAP is the first truly open standard in the area, removing the barrier of proprietary solutions. WAP will make wireless data boom for the mass market. However to get the info, your GSM network will have to implement the WAP protocol that strips ordinary HTML into the special XML format of WAP! WAP hides the complexity of GSM on the application layer, just as the Web has done for the Internet. It spans a variety of transport options and devices, including SMS, 9.6 kbps GSM data, HSCSD, and GPRS, making the underlying network technologies blend together from the user's standpoint.

6.6 Goals of the Wireless Application Protocol

- Independent of wireless network standard.
- Open to all.
- Will be proposed to the appropriate standards bodies.
- Applications scale across transport options.
- Applications scale across device types.
- Extensible over time to new networks and transports.

6.7 Mobile data applications

We're looking at anytime, anywhere access to mobile relevant content and e-killer applications such as messaging and banking. Indeed, the wireless Web is not only about news, sports and weather, but more about personalized Internet content and messaging. It will also lend itself particularly well to some e-commerce applications like ticketing, along with any other areas where there is a pre-existing online relationship and a quick decision is needed, like a response to a special offer. Admittedly, the available content and services for these devices is sparse right now. But we're seeing an increasing number of wireless service providers gearing up to deliver dynamic, real-time, personalized Internet content to mobile users through a variety of mobile devices, including a new generation of smart phones with integrated Internet micro-browsers.

M-commerce (Mobile commerce) will have you buying movie tickets while you're stuck in traffic. Parking meters and vending machines will accept smart cards, which you'll recharge through your cellphone. In fact, your cellular phone bill will read like your credit card statement - which it just might replace.

WAP empowers mobile users of wireless devices to easily access live interactive information services and applications from the screens of mobile phones. Services and applications include email, customer care, call management, unified messaging, weather and traffic alerts, news, sports and information services, electronic commerce transactions and banking services, online address book and directory services, as well as corporate intranet applications.

To leverage today's extremely large market penetration of mobile devices, WML's user interface components map well onto existing mobile phone user interfaces. This means end-users can immediately use WAP-enabled mobile phones and services without re-education. WAP specifications enable products, which employ standard Internet technology to optimize content and airlink protocols to better suit the characteristics and limitations of existing and future wireless networks and devices.

6.8 Services rendered by WAP

The services that we can access by using WAP can be understood by the following example: Imagine stepping out of an office building to go to the airport, using your WAP-enabled wireless device to check the traffic congestion, followed by the train timetable and then purchasing a train ticket on-line instead of driving. On the way to the airport, you select your aisle seat and check in for the flight, reserving a special meal. Unpack your raincoat after looking up the weather at your destination. Other types of services which can benefit from WAP technology are: Customer care and provisioning, message notification and call management, e-mail, telephony value-added services and unified messaging, mapping and locator

services, weather and traffic alerts, news, sports and information services, e-commerce transactions and banking services, online address books, directory services and corporate intranet applications.

6.9 WAP follows Internet standards

WAP is using existing Internet standards. The WAP architecture was designed to enable standard off-the-shelf Internet servers to provide services to wireless devices. In addition, when communicating with wireless devices, WAP uses many Internet standards such as XML, UDP and IP. The WAP wireless protocols are based on Internet standards such as HTTP and TLS but have been optimized for the unique constraints of the wireless environment. Internet standards such as HTML, HTTP, TLS and TCP are inefficient over mobile networks, requiring large amounts of mainly text based data to be sent. Standard HTML web content generally cannot be displayed in an effective way on the small size screens of pocket-sized mobile phones and pagers, and navigation around and between screens is not easy in one-handed mode. HTTP and TCP are not optimized for the intermittent coverage, long latencies and limited bandwidth associated with wireless networks. HTTP sends its headers and commands in an inefficient text format instead of compressed binary. Wireless services using these protocols are often slow, costly and difficult to use. The TLS security standard requires many messages to be exchanged between client and server which, with wireless transmission latencies, results in a very slow response for the user. WAP has been optimized to solve these entire problems, utilizing binary transmission for greater compression of data, and is optimized for long latency and low to medium bandwidth. WAP sessions cope with intermittent

coverage and can operate over a wide variety of wireless transports using IP where possible and other optimized protocols where IP is impossible. The WML language used for WAP content makes optimum use of small screens and allows easy navigation with one hand without a full keyboard, and has built-in scalability from two-line text displays through to the full graphic screens on smart phones and communicators.

WAP integrate telephony with Internet based services. WAP v1.1 will include an optional specification known as WTA (Wireless Telephony Applications). This will allow incoming and outgoing calls to be handled within WML and WMLScript, permitting trusted parties such as network operators to deploy combined voice call and Internet services in an easily programmable way, in conjunction with a network WTA server. Example uses are automatically calling a number found in a yellow pages search, and visual interfaces to voicemail systems.

6.10 Data transfer technology

There are quiet a large number of data transfer technologies used for transferring data in Wireless Internet. Those are discussed below.

6.10.1 General Packet Radio Service (GPRS)

A key step towards migration to 3G (3rd Generation) is GPRS, General Packet Radio Services, due at the end of 2000. Here you will see that this technology will make the use of the Mobile Internet much easier, and that it is not competing with IP, WAP or others.

6.10.1.1 Always Online

The wireless/mobile/cellular systems of today are sometimes called 2G (2nd Generation) systems, with the first being the early analog systems. With the boom of the Internet and the massive spread of both computers and cellular phones, it is likely that we will want to get access to more than voice services and applications when we are on the go. The Mobile Internet is something that has started over the last year, with WAP, Wireless Application Protocol (Europe, USA), Palm.net (USA) and I-Mode (Japan). What WAP does to the cell phone is what the web browser did to the computer. It enables people to access the information anytime, anywhere and on any device. If you want to use WAP today, you will connect to the servers with a cell phone using circuit switched data. That works much like computer modems, where you dial in to an ISP (Internet service provider), do your e-mail and surf the web and then disconnect. If you want to do it again, you have to dial in again. Compare that to the connection some of us have at work or at school, where your connection to the Internet is always there, always online. The web browser starts as quickly as a word processor, and the remote Internet services are just one click away. That is exactly the functionality that GPRS adds to the cell phones and the Mobile Internet, enabling the user to be always connected, always online (without necessarily having to pay by the minute). The functionality means a tremendous change in the way we will use the cell phone and probably also the home PC. In order to clarify this new feature, this example shows how the same application, getting a last-minute trip, changes with GPRS. Now consider some examples:

6.10.1.2 Home PC

You go home to your PC and check the website where they have offers on cheap tickets. You dial in, wait and then you can check what is available and what the price is. If you're in luck, the site might even have e-mail alerts that will tell you when something comes up (most of us will have to dial in every hour to check if we have gotten that mail).

6.10.1.3 Cell phone today

With a WAP phone, you can do access a similar site and check if something interesting comes up. You dial in, check if there are any offers, no matter where you are. That procedure is then repeated until you find something interesting.

Cell phone with GPRS and WAP: The GPRS phone is always online, so you can access the site with the tickets, anywhere and anytime. The application that handles the last-minute tickets can then keep that request in mind and notify you whenever something comes up. You can walk around relaxed, not bound to a single location or forced to check something on a regular basis. So, GPRS is the network (like you have a modem at home) and WAP makes the access easy, robust and efficient (like a web browser + much more).

GPRS is not a completely new system, but rather an upgrade that empowers existing GSM and TDMA networks. This means that you are still going to have the same functionality for voice calls and it is even possible to have simultaneous voice and data for some handsets. This smooth migration also means that you are going to enjoy the same coverage for GPRS as for present cellular networks, as opposed to building a completely new network from scratch. That way, your present phone

will work in the future as well, but you will need a new handset in order to access the new features.

6.10.1.4 An integral part of 3G wireless systems

3rd Generation wireless systems will bring high speed multimedia services to the Mobile Internet. You will not only be able to surf the web fast, and download e-mail. You will also see a million new applications where high quality voice, text, pictures and interaction is blended. The always-online functionality for most of these 3G systems (WCDMA, EDGE) will be reused from GPRS. So, in the same way that operators are upgrading to get GPRS functionality this year, they will upgrade in 2001,2002 to get full 3G functionality. The packet data functionality of these systems is GPRS. Also, the future systems are built bottom up to facilitate compatibility with GPRS, so once again, the devices you buy now will work in the future as well.

6.10.1.5 Applications

The area of Mobile Internet applications is one of the most intense in the world. The Mobile Internet applications will be so much more. Imagine what could be done if your device knew roughly where you were? The possibilities of finding the closest Starbucks shop' kind of applications show where that could take us. Coming to a new city and clicking on an icon to see what is happening close to your hotel that weekend (all according to your own preset interests, of course). Also, the mobile device that you will use for all these services is much more personal than any other Internet access device. The things you will have in there will reflect your

interests and personality. The personalization will take the devices into things that make life easier, not more complicated. That is also in essence what GPRS does for the applications. Where you before dialed in and waited, the information will now only be a click away. Checking the weather where you are will be as easy as looking up a number in the phonebook.

Typical GPRS applications will utilize the always online functionality to its full extent. Things that reside inside your device will do things for you, when you have better things to do. Say you want to buy stocks when the NASDAQ drops below 3000, then you can have your GPRS handset vibrate whenever that happens (while you are hanging out at the beach). In developing applications for GPRS it is necessary to understand both the new possibilities and new challenges. The bandwidth will vary and sometimes be very low, you will temporarily lose contact with the network and there will be packet loss. Wireless networks are different and you need to consider these properties when developing applications for them.

6.11 EDGE

The evolution of GSM by Ericsson is the implementation of EDGE (Enhanced Data rates for Global Evolution). This will allow GSM operators to use existing GSM radio bands to offer wireless multimedia IP-based services and applications at speeds up to 384kbit/s – or even higher. EDGE will allow the advantages of GPRS to be fully explored, with fast connection set-up and higher bandwidth than traditional GSM. The combination of GPRS and EDGE will also result in much improved utilization of the radio network. Introducing EDGE will have little technical impact, since it is fully based on GSM, and will require relatively small

changes to network hardware and software. For example, EDGE uses the same TDMA (Time Division Multiple Access) frame structure, logic channel and 200kHz carrier bandwidth as today's GSM networks, which allows existing cell plans to remain intact. This makes the technology particularly beneficial to existing operators seeking a way to roll out wideband services rapidly and cost-efficiently across large areas of existing networks. With EDGE, operators can offer more wireless data applications for both consumer and business users, including wireless multimedia, e-mail, web infotainment and videoconferencing.

6.12 Code Division Multiple Access (CDMA)

Code Division Multiple Access. A digital technology pioneered by QUALCOMM that provides crystal clear voice quality in an exciting new generation of wireless communications products and services. Using digital encoding and "spread spectrum" radio frequency (RF) techniques, CDMA provides much better and cost effective voice quality, privacy, system capacity, and flexibility than other wireless technologies, along with enhanced services such as short messaging, e-mail and Internet access.

CDMA is enabling exciting new products and services, from Palm-size phones to satellite communications. There are many reasons CDMA is the technology of choice for next generation digital wireless communications products and services.

6.12.1 Outstanding Voice and Call Quality

CDMA filters out background noise, cross-talk, and interference so you can enjoy crystal-clear voice quality, greater privacy, and enhanced call quality. QUALCOMM's CDMA variable rate vocoder translates voice into digital transmissions, zeroes and ones, at the highest translation rates possible (8kbps or 13kbps). This allows for crystal clear voice and also maximizes your system capacity.

6.12.2 Greatest Coverage for Lower Cost

CDMA's spread spectrum signal provides the greatest coverage in the wireless industry, allowing networks to be built with far fewer cell sites than is possible with other wireless technologies. Fewer cell sites translates to reduced operating expenses, which results in savings to both operators and consumers.

6.12.3 Packet Data

CDMA networks are built with standard IP packet data protocols. Other networks require costly upgrades to add new packet data equipment in the network and will require new packet data phones. Standard cdmaOne phones already have TCP/IP and PPP protocols built into them.

6.12.4 Longer Talk Time, Longer Battery Life and Smaller Phones

You can leave your phone on with CDMA. CDMA uses power control to monitor the amount of power your system and handset need at any time. CDMA handsets typically transmit at the lowest power levels in the industry, allowing for longer battery life, which results in longer talk time and standby time. CDMA handsets can also incorporate smaller batteries, resulting in smaller, lighter-weight phones. Easier to carry. Easier to use.

6.12.5 Fewer Dropped Calls

CDMA's patented "soft handoff," method of passing calls between cells sharply reduces the risk of disruption or dropped calls during a handoff. The process of soft handoff leads to fewer dropped calls as 2 or 3 cells are monitoring your call at any given time.

6.12.6 Improved Security and Privacy

CDMA's digitally encoded, spread spectrum transmissions resist eaves dropping. Designed with about 4.4 trillion codes, CDMA virtually eliminates cloning and other types of fraud.

6.12.7 Greater Capacity

CDMA allows the largest number of subscribers to share the same radio frequencies, helping service provider's increase their profitability. CDMA uses

spread spectrum technology, which can provide up to 10-20 times the capacity of analog equipment and more than three times the capacity of other digital platforms. With dual-mode phones, CDMA is compatible with other technologies for seamless widespread roaming coverage.

6.12.8 Reduced Background Noise and Interference

CDMA combines multiple signals and improves signal strength. This leads to the near elimination of interference and fading. Both electrical background noise (computer noise) and acoustic background noise (background conversations) are filtered out by using narrow bandwidth, which corresponds to the frequency of the human voice. This keeps background noise out of your conversations.

6.12.9 Rapid Deployment

CDMA systems can be deployed and expanded faster and more cost effectively than most wireline networks. And because they require fewer cell sites, CDMA networks can be deployed faster than other types of wireless networks.

6.13 Wideband Code Division Multiple Access (WCDMA)

WCDMA (Wideband Code Division Multiple Access) is the radio access technology selected by ETSI (European Telecommunications Standards Institute) in January 1998 for wideband radio access to support third-generation multimedia services.

Optimized to allow very high-speed multimedia services such as voice, Internet access and videoconferencing, the technology will provide access speeds at up to

2Mbit/s in the local area and 384kbit/s wide area access with full mobility. These higher data rates require a wide radio frequency band, which is why WCDMA with 5MHz carrier has been selected; compared with 200kHz carrier for narrowband GSM. WCDMA can be added to the existing GSM core network. This will be particularly beneficial when large portions of new spectrum are made available, for example in the new-paired 2GHz bands in Europe and Asia. It will also minimize the investment required for WCDMA rollout - it will, for example, be possible for existing GSM sites and equipment to be reused to a large extent. An agreement on a globally harmonized third-generation CDMA radio standard that addresses the needs of all current wireless communities was reached by the Operators' Harmonization Group in May 1999. There will be three modes in the harmonized 3G CDMA standard; a direct-sequence mode for WCDMA, a multi-carrier mode for CDMA2000 (an evolution of narrowband CDMA), and a time division duplex (TDD) CDMA mode.

6.14 Cellular Digital Packet Data (CDPD)

Wireless communications offers the promise of freedom to mobile professionals. Freedom from having to locate a wall jack to plug a modem into. Freedom to work outside the office in a variety of remote locations such as hotels, airports, and restaurants. Freedom to send and receive critical real-time information when and where its needed. In short, the freedom to be more productive and be in reach and in control.

Cellular Digital Packet Data (CDPD) makes affordable, high-speed wireless data communications a reality over existing wireless voice networks. Customers now

can have access to their data nationwide, when users are in metro or suburban areas with a packet switched CDPD's fast access to achieve subsecond response times. Offering CDPD in conjunction with Advanced Mobile Phone Service (AMPS) or other voice services can generate more revenue from existing voice channels. Carriers offering both voice and packet data services can also gain a competitive advantage over voice-only providers.

The Cellular Digital Packet Data (CDPD) System, supporting packet data transmission over the same frequencies. Modular and flexible, the CDPD System can be integrated with existing AMPS systems from other suppliers. And it can coexist with TDMA and CDMA technologies. The system complies with the specifications set forth by the CDPD Forum, a consortium of leading companies in the wireless communications and computer industries. Subscribers to CDPD services benefit from such advantages as computer-aided dispatch, immediate status information on field technicians, higher productivity per worker, better response time to customers, immediate access to computer-based information that is current and accurate, and rapid responses to emergencies. Payback for subscriber systems is generally less than one year.

6.15 High Speed Circuit Switch Data (HSCSD)

HSCSD (High Speed Circuit Switched Data) is a high-speed, multi slot datacom platform for GSM networks. It removes the barrier to mobile datacom of low network performance, bringing phone users the same - or even higher - performance than wirelline connections. HSCSD could offer data transfer speed up to 57.6 kbps or even higher if combined with compression and filtering products,

such as the WebOnAir Filter Proxy from Ericsson. For a mobile operator HSCSD is very easy to implement and rollout as it is designed for existing GSM structure. Since HSCSD mainly requires software upgrades, it is also a limited investment. This makes HSCSD an ideal preparation tool for future wireless datacom services, such as GPRS. Mobile operators that offer HSCSD will have established themselves as "high-tech" operators in their markets. In addition these operators will have important knowledge of end-user behavior and requirements as well as wireless datacom in general. For the end-user, HSCSD facilitates a number of new new applications for wireless communications. It will speed up web browsing and file transfer. HSCSD also makes it possible to access the Internet and view pages with heavy graphic contents. Users can also take advantage of higher speed in accessing in-house LANs and corporate Internets. Since HSCSD has very good real-time capabilities, it is possible to carry out traffic and security surveillance via video in areas where wireline connections do not reach. Further, video conferencing is an efficient way to hold meetings. Today, video and audio conferencing is possible over 28.8 kbit/s, which is achievable with HSCSD.

SingTel Mobile customers can expect faster data transmissions by early next year. This is made possible by a new GSM technology called High Speed Circuit Switched Data (HSCSD) which allows data to be transmitted to and from mobile phones up to 38.4 kilo bits per second. This is comparable to the transmission rate of modems via a fixed telephone network.

6.16 Available System

I-mode a product from NTT DoCoMo Japan. I-mode provides cellular data and Internet services to over 3 million people. The services provided by I-mode are really something the rest of the world is looking forward to adapt. I-mode phone is really very easy to use, you simply press "i" button, and you enter the "Internet World" and chooses from options including e-mail, mobile banking, airline ticket-booking, games and other services. The popularity of I-mode is because firstly it is in Japanese language, and everyone can afford it. There are nearly 4,000 Web sites in WAP format that increases the number of contents for the user. Content providers include restaurants, concert ticket sellers, stock brokerages, railroads and more than 100 banks, including Sakura Bank, Sumitomo Bank and Citibank. In addition, the service is cheap, about $3 a month. Each transaction, such as a restaurant- listing search or a mobile banking transfer, costs only 2 or 3 cents because it is based on data rather than airtime usage. Which is the most beneficial aspect of this product. The DoCoMo's chairman says, "This is where the cell phone market is going voiceless communication is sure to exceed voice communication in the future."

The good development is that most of the Europe's wireless carriers have started adapting DoCoMo's ideas to their systems and customer needs. This kind of approach will boost the overall development of the Wireless Internet.

Chapter Seven

Conclusion

In this graduation project I have analyzed different issues pertaining to Wireless Network and discussed some of the ideas of different researchers and developmental groups related to this school of thought. As computer networks around for quiet a long time and providing vast amount of functionality to its users in respect to availability of information by sharing of applications and resources. These advantages have been in use for along time and have proven to be very critical to its users. But this is not all, if all of these services are added to a network that can be accessed without the hassle of taking care of cables, wires, and one doesn't need to stick to a PC to access the network that can be a LAN, ATM, internet or some other type of information sharing technique. Or on the other hand the network is Wireless, which can be accessed via Notebook, PDAs, PICs or other handheld devices. So the service provided by wired network doesn't even come close to comparison with the wireless network, and the benefits are so unimaginable and unlimited that couldn't be measured. With wireless network the world for a user becomes a whole new experience where distances though are large among users, but are virtually negligible due to the availability of such system through which a user can access any local area network, surf the internet, call anyone, send information with high bit rate, do video conferencing while on the move.

This thesis potrays the point where computer communication and telecommunication intersect. With this intersection the world is experiencing a revolution in the way the users can communicate to who ever they want to and where ever. Here I have discussed the five major categorizes that are possible subsystems of Wireless Networks.

With wireless LAN one can access and share application of a domain in a certain area (conference halls, university campus) as well as access the Internet by using their Notebook or laptop. This makes the influx of information easier to reach its end users. On the otherhand if we want to share the information in the same way as already discussed in a smaller area then there we use Wireless Personal Area Network (WPAN), which is good for offices or area where more than one device is being used to certain job. If there is a need to send data at a higher bit rate to mobile users then we can use Wireless ATM, which can support high bit rate efficiently for both data transfer as well as multimedia, but it is still in research. The other version of high bit rate transfer for a area of size ranging from three to five kilometers is Local Multipoint Data Service (LMDS) which uses infrared technology to send data with accuracy. The best of all the already discussed system is the Wireless Internet, which really brings the world to a new environment where every kind of information is just a click away and any kind of information, news, e-mails, travelling reservations and you name it can be done with this technology.

Now most of these services are in there initial stage or infancy and most of the talk of providing these services depends initially upon the outcome of the research that is in process or which is complete. So the main hindrance to the availability of these services are some limitations regarding interference with other devices,

bandwidth allocation and most important is the fact of how people are going to use this service and the main factors which have to addressed in order for all these services to be widely used. This need for the technology to be in use by every individual can be achieved if all the glitches and limitations are to be removed by consultation between all those companies and research groups affiliated with this kind communication field either directly or indirectly.

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