Positioning of Wireless Broadband

by

Shahril Shamsuddin

B.S. Industrial Technology
California Polytechnic State University
San Luis Obispo, CA

Submitted to the Alfred P. Sloan School of Management and the School of Engineering in Partial Fulfillment of the Requirements for the Degree of

Master of Science in the Management of Technology

at the

Massachusetts Institute of Technology

June 1996

© Shahril Shamsuddin. 1996 - All rights reserved
The author hereby grants to MIT permission to reproduce and to distribute publicly copies of this thesis document in whole or in part

Signature of Author

Shahril Shamsuddin
June 1996

Certified by

Michael A. Cusamano
Associate Professor of Management
Sloan School of Management
Thesis Supervisor

Accepted by

Rochelle Welchman
Director, Management of Technology Program

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
ARCHIVES

JUN 14 1996
Positioning of Wireless Broadband

by

Shahril Shamsuddin

Submitted to the Department of the Management of Technology

on May 15, 1996 in Partial Fulfillment of the

Requirements for the Degree of Masters of Science in the

Management of Technology

ABSTRACT

Wireless telecommunications will contribute significantly to the development of the
global information highway. Broadband services associated with the wireline networks
will set the expectation of the users. Users will demand that these services be made
available when they are mobile and in wireless mode, with no convenient connection to
wireline. This thesis positions wireless communications services in the broadband
context, the technical limits, through the study of standards and manufacturers
perspective and future plans, are explored to determine the positioning of wireless
broadband services.

Thesis Supervisor: Michael A. Cusamano

Title: Associate Professor of Management
# Table of Content

**Introduction** 4  

**Chapter 1** - Current Issues in Wireless Communications 7  

**Chapter 2** - Wireless Technology 13  

**Chapter 3** - Broadband Technology 25  
- Broadband Technologies 26  
  - Frame Relay 27  
  - Ethernet 29  
  - Fast Ethernet 30  
  - FDDI-I/II 31  
  - LAN and Routers 32  
  - SONET and SDH 33  
  - ATM 34  

**Chapter 4** - Regulation and the rollout of New Services 38  
- Historical Background 43  
  - Rate Setting Process 47  
  - Structure of the FCC 49  
  - Trends in the regulation 51  

**Chapter 5** - Mobile Standards 55  
- Analog Cellular Systems 55  
- Digital Cellular Systems 56  
  - European GSM and DCS1800 57  
  - Digital Systems in the U.S. 58  
  - Digital Cordless Systems 60  
- FPLMTS (Future Public Land Mobile Systems) 62  

**Chapter 6** - Questionnaires and the Manufacturer’s Perspective 65  
- Objectives 66  
- Summary 67  
- The Big Picture 69  

**Conclusions** 89
Introduction

This thesis focuses on the technical and marketing positioning of wireless broadband communications. My objective is to examine the technological developments in wireless communications, and its future capabilities. In order to understand the issues in the context of broadband communications, I have examined key issues in wireless communications including key technologies in broadband communications and regulations related to the development of new services. I also interviewed leading manufacturers of cellular wireless communications equipment to obtain their perspectives on wireless environments and future developments.

In chapter 1, I introduce current issues that are being discussed in the mobile telecommunications and information technology arena. Some of these issues include the information intensive nature of today’s decision making process and the mobile nature of today’s workforce. I also discuss the challenges of managing distributed organizations and the challenges this brings to distributed processing in the telecommunications context. I also introduce questions regarding wireless technology that form the basis of my thesis.

In chapter 2, I explain the basic architecture of wireless communications. This chapter illustrates the different technologies that are being used in the operations of wireless systems. I also discuss analog and digital systems that are in existence today.
In chapter 3, I examine key technologies that form the building blocks of broadband systems. This chapter provides a perspective on how the emergence of different technologies in the 1980s and 1990s enabled the development of broadband networks. This chapter illustrates how broadband networks manage the transmission of telecommunications traffic with variable bandwidths.

Chapter 4 explores the role of regulations pertaining to the introduction of new communications services. I focus on emerging integrated personal communications services because these systems promise to deliver both data and voice communications services on the same system. I begin the chapter by focusing on issues that are being discuss in the U.S. Congress regarding the rollout of these systems and I illustrate the implications of these legislative issues on the new services.

Chapter 5 deals with technical standards that exist within the industry. This chapter explores both digital and analog standards that are operational today. The highly technical environment of wireless telecommunications is highly dependent on standards that ensures interoperability. I will also introduce future initiatives that are on going which plans to integrates different wireless systems that exist today.

Chapter 6 is devoted to the questionnaire that I sent out to three wireless communications manufacturers focusing on the future of the wireless industry. This chapter presents and compares the responses to the questions to give the reader a perspective of the market and
the manufacturers’ mindset. This chapter also discusses issues on how future generations of systems will evolve from the manufacturer’s perspective.

In the concluding chapter I discuss the future positioning of wireless broadband services, what will likely take place in terms of market developments. I will also discuss the markets that will benefit from this new wireless technology and those that may lose. This conclusion is based on my findings and research over the past six months. I found that this industry is heavily influenced by technical standards due to the fact that these systems must be interoperable! Also I point out that the standards will only succeed if the manufacturers decide to adopt and manufacture the equipment.
Chapter 1 - Current issues in wireless communications

As we approach the year 2000 new developments in the telecommunication industry will continue to change the face of communications. The wide array of telecommunications will give us an array of information services that will impact the way we use information to conduct our business and manage our day-to-day activities. In the past the provision of these services was largely the responsibility of regulated government-owned enterprises. But towards the last quarter of this century there has been a wave of deregulation and the breakup of traditional services, coupled with privatization of communications networks in Europe and Asia. Here in the United States we have seen forces of the market create a whole new structure in the telecommunications industry. This new structure has posed new challenges to both service providers and regulators. Service providers have had to be creative in order to differentiate themselves from their competitors in a highly competitive environment. As for the regulators, their challenge was to ensure fair competition in the lightning-fast environment of technological change.

The revolution in the information industry has also contributed new to challenges in the telecommunications industry. The speed at which miniaturization of microelectronics made it possible for the geometric increase in computing power, which ultimately caused the demise of the mainframe industry. This in turn triggered the concept of distributed processing and computing, which developed a new structure in the computer industry.
In the competitive business environment that exists today, the increase in computing power is absolutely essential. Given the highly complex nature of data and the information-intensive nature of today’s decision-making process the role of distributed processing cannot be disputed.

However, with distributed processing we need the medium to carry the information from different locations. Distributed processing is one of the drivers in the development of the broadband industry. As computers are able to process more and more data, the need to transfer data across different locations will increase tremendously. The ability of desktop computers to handle images only increases in the bandwidth needed to transport these data.

Two types of revolutions that are taking place in the telecommunications arena. The first is the ability to communicate from person to person, as opposed to person to place. The second is the ability to interact with a multimedia world of vision and sound. In the future, the information-based society will drive these technologies to converge. Due the mobile nature of this information society, it is imperative that a mobile broadband information infrastructure be established to deliver the required service.

This vision is not so far-fetched because today’s technology can convert almost all kinds of information into digital format regardless of whether it is sound, text, or still or moving images. However, accessing this information is the more critical issue; for
information archived in a library or in huge server in the basement of a corporation is of no use. Thus, setting up an infrastructure enabling individuals or organizations to access this information is the ultimate objective of the emerging telecommunication technology.

In attempting to achieve a mobile information society, the challenge is to set up an infrastructure that is transparent and interoperable, not only on a regional basis but on a global basis across, international boundaries. Thus a concerted international effort has required efficient management of the radio frequency spectrum, thus creating a suitable environment to achieve a truly mobile information society. The journey toward this vision is by no means easy; it will need the acceptance of this vision and the determination to make it work.

Second generation systems have been defined by ETSI as being GSM, which stands for Global System for Mobile Telecommunications. In the U.S. there has not really been a dominant standard for second generation digital cellular. There are two standards that have been adopted, IS-54 which is based on code division multiple access, (CDMA) access technology and IS 95, which is based on the time division multiple access, (TDMA) access technique. In Japan the standards have been defined as Personal Digital Cellular (PDC). Having three regional standards fosters a good environment for global mobility. I believe there is a need to develop a system that is globally compatible.

However, what is more important is the service concepts that these second generation digital cellular systems offer. The first generation cellular systems had the goal of
primarily delivering voice to the intended destination, though we see today incremental improvements being made through enabling technologies such as cellular modems that can deliver data. In second generation systems, the concept of data transmission is part and parcel of the service concept. Today, GSM systems are already sending G#3 faxes through the system. This may not seem much, it is only the beginning, where in the previous generation it is the end.

It would be naive to think that a mobile broadband infrastructure will be achieved in the second generation systems. However, the service concept based on broadband communication can be tested and understood. Thus the evolution that hopefully will be achieved in the third generation will be truly mobile broadband systems.

The concept of personal communication would not be complete without mentioning the role of satellite communications. The main objective of satellite networks is to provide an umbrella coverage in the areas that terrestrial mobile systems are not able to service. Systems such as Inmarsat -M are now offering products the size of briefcases that allow for truly global coverage, but these systems need line of sight, and thus require external antennas which make them cumbersome to use indoors. But experts believe that with the advance in miniaturization technology and large-scale integration, production prices and the size of these units will come down. They believe that by the 1998-2000 time frame we will see pocket-sized satellite-based handsets. New satellite-based systems will also contribute to the global mobile networks. These systems will include:
• Geostationary satellites (GEO)
• Medium earth orbiters (MEO)
• Low earth orbiters (LEO)

The next generation systems are expected to offer advanced personal communication services with worldwide interoperability. The general concept is referred to as the Universal Mobile Telecommunication System (UMTS) in Europe and as the Future Public Land Mobile Telecommunication Systems (FPLMTS) within the International Telecommunications Union.

As we can see, there are a myriad of technologies and standards that are used as platforms to deliver mobile telecommunications services. Therefore in attempting to achieve a viable mobile communication systems, there is a need to work toward a truly global standard.

The question is, however, whether we will evolve into these systems in an evolutionary or revolutionary manner. We have the vague idea that the information society will be mobile. But some interesting questions are worth exploring. Among them are:

• What are the kinds of services that will likely be offered?
• Are these services going to be consumer oriented or business oriented?
• Given that business requirements vary significantly, how would a satisfactory mobile system impact the operation of corporations in the future?

We are anticipating broadband to play a role in the seamless provision of mobile services.

The key questions are:
• In what time frame can we expect to see an environment of broadband in the wireless scenario?

• In what way will PCN influence the migration the future of wireless communications?

• What is the real significance of personal mobility and of terminal mobility?

• How do these concepts impact the provision of personal communication services?

• Will the full range of broadband services be offered by mobile services?

We see from initiatives such as Universal Mobile Telephone System (UMTS) and Future Land Mobile Telephone System (FPLMTS), there is a need for close coordination between the present and future systems. However to incorporate these systems requires fundamental changes in system architecture. Two questions arise:

• Will the transition be evolutionary or revolutionary?

• Are the developing standards based on an evolutionary or revolutionary concept?

I have introduced these questions in order to understand the processes that are taking place presently and to understand the evolution towards the positioning of mobile broadband services and to get a better understanding of the future scenario. In the next six chapters, we will survey the supporting technologies, standards and regulations, future organizational trends and industry’s view of the future of the mobile services. We will then conclude by positioning wireless broadband in the context of broadband telecommunications.
Chapter 2- Wireless Technology

Wireless communications is not something new. It is safe to say that since the early beginnings, humankind have developed some form of wireless communication, from drums to smoke signals. Messages were sent over great distances and often repeatedly to avoid errors in the messages being sent. Sometimes the receiving parties would repeat the messages to confirm receipt and data integrity. This may seem crude but the system worked for the level it was intended for. As humankind progressed more sophisticated method were employed such as the semaphore flag. Later men employed methods using light to transmit over modest distances. Coupled with the use of codes, it was possible to send detailed messages with some degree of security. These early systems of wireless transmission had their drawbacks, which included distance unauthorized reception and the complex management of codes (in order too ensure data integrity).

As radio-based systems emerged, wireless communication became more reliable and readily available. Human speech carried by modulated radio waves can be transmitted over far greater distances than human speech carried by older techniques. In radio transmission, human speech is first converted to electrical signal. These signals are then modulated onto the carrier waves that are sent over the air. Knowledge of radio principles is critical to understand how the various communication techniques function. For example, propagation is dependent on the frequency band that is selected. In general the signal is transmitted through the air via an antenna device, the signals than travels along the earth’s curvature in all direction. At lower frequencies the signal follows the earth’s
surface in what is typically called a ground wave. The distance that the wave travels is a function of the power generated by the transmitting device. Power output can be varied to cover specific distances or areas.[1]

At high frequency (HF), the ground wave is absorbed and attenuated quickly. However, the radiated signal also has an upward trajectory in which the signal reaches up to 40-300 miles depending on transmitting power. This type of signal can be directionalized and transmitted at lower power output.[2]

At very high frequency (VHF), signals are transmitted in straight lines. Directional antennas are used to direct signals in line-of-sight paths. Design of this type of transmission requires great care since reflected signals can cause interference. Reflected signals take longer to arrive; this delay may cause a signal that is out of phase.[3]

At ultra high frequency (UHF), the use of a microwave transmission is more prominent. At this frequencies point-to-point communication is most suitable due to the ability to focus and directionalize the carrier signal. In addition, several channels of communication can be multiplexed together and transmitted across the carrier. Microwave is used primarily for trunk or backbone services. This services carries "bulk" traffic from point to point.[4]

So far we have discussed the means by which information is carried across distances through radio communications. By far the most important application of radio is the
ability for the individual to use without the constraint of being in a particular place. It is widely believed in the industry that the evolution of mobile telephony is by far one of the most important innovation in the wireless world.

The first mobile telephone systems were in use as early as 1946. This service was introduced in St. Louis, Missouri. However, this early system suffered from lack of channels, which lead to the problem of difficulty in getting dial tone. The system was difficult to get use due to the simplex nature of the system; one needed to “push to talk.” By 1960, an improved mobile telephone service (IMTS) was introduced. Two separate channels were used to provide duplex service. However channel capacity was still a problem.[5]

1974 was a significant year for mobile telecommunications. In that year cellular telecommunications were born. The 800 to 900 MHz portion of the ultra high frequency band (UHF) was allocated for cellular use. However, it was not till 1981 that the FCC finally set aside 666 radio channels for cellular use in the United States. These frequencies were assigned to two separate carriers.[6]

Cellular technology overcomes the limitation of conventional mobile telephone systems. Capacity is increased by dividing areas of coverage into small honeycombed cells that overlap at the outer boundaries. This also enables frequencies to be divided and reused in the divided cells. By using this method capacity is increased by reusing the frequencies. Controlled supervision and switching of calls is particularly critical in the mobile
environment. Dynamic switching and control facilitates seamless shift as vehicles moves from cell to cell. As the caller moves away from the cell site towards a new cells the call gets “handed off” from one cell to another. In the following paragraphs I will explain how the system works.

Each cellular handset is given a unique identity, called the numeric assigned module (NAM. This function of this module is to allow the mobile telephone switching office (MTSO) to track the cellular phone when it is moving around in the system. The other function of the NAM is to allow the cellular phone to reregister itself when it is outside its operating area. The handset is intelligent enough to determine its locations by “listening” to messages that are constantly being sent out by the base stations.[6]

When a cellular phone is turned on, it monitors the dedicated control channels to get information from the local paging channel. It will then tune itself to a suitable channel and go into an idle state. In this state the phone is able to receive and make calls. Prior to executing a call the phone goes through a process of interrogation with the base station. The base station will reply with a set of instructions for the set to execute the call. These instructions will contain information such as which channels and frequency to use. For incoming calls the system goes through a reverse process.[7]

Handoff is an important process wherein a call in progress is switched from cell to cell. As the mobile phone moves away from the base station the signals starts to fall. In order not to drop the call, the signal must be handed off to the approaching base station in the
adjacent cell. The process starts by the base station sending a distress signal to the MTSO that the signal is getting weaker. The MTSO than orchestrates the passing of the call to the destination cell. MTSO will page all adjacent cell to measure the signal strength of the handset transmission. The MTSO will then instruct the cell that is measuring a gain in signal strength to accept the call. The MTSO than sets up a parallel voice path in order not to drop the call. When the set-up is ready the MTSO will instruct the handset as to the proper operating frequency of the destination cell.[8]

At this point it is useful to clarify how the allocated frequencies are being used. Four signaling path are used in the cellular network for signaling and control purposes as well as voice conversation. They are broken down into two basic functions:

- Call set-up and breakdown.
- Call management and conversation.

In both cases forward and reverse channels provide for directionalized flow of information.[9]

As mentioned earlier, cellular technology has become effective through the use of smaller areas of coverage and lower power output devices. It is based on reuse of frequencies between the cluster of cells. Since the clusters are small and the output limited to 3 watts, the frequencies can be used again and again. This allows for better management of the limited radio frequency.[9]
Second generation cellular radio systems are based on digital access techniques. These techniques are employed in order to maximize the use of the frequency that is allocated. It has always been the radio industry’s challenge to accommodate as many users as possible in what appears to be a finite radio spectrum.

The classic solution to this problem is frequency division multiplex access (FDMA). The spectrum is divided into various services, and each block is subdivided into channels, which may be assigned to specific user and user groups. The method can be further improved by employing subdivision of geographical areas (frequency reuse) and time sharing.[10]

The second technique is time division multiplex access (TDMA). TDMA allows access to the full bandwidth of the frequency spectrum, dividing it into small time slots and allocating data to these time slots. One slot will carry conversations from the base station to the terminal, whereas another slot will carry conversations from the terminal to the base station [11]

The most talk about technology of recent years has been code division multiple access. CDMA was introduced to the commercial cellular market by Qualcomm. CDMA employs spread spectrum technology to deliver signal. This technique works on the following principles:
• Signals are spread over a much wider frequency band than would ordinarily be required by their information content.

• Signals are combined by using a pseudorandom code.

In this technique, data streams are combined with a pseudorandom spreading code and transmitted over the entire spectrum. At the receiving end, the pseudorandom code is used to decode and the signal is reconstructed into its original signal. [12]. The greatest advantage of CDMA is that it permits traffic load to be spread out across the whole radio spectrum, thus allowing for greater capacity. However, CDMA is a complex technology which will require further development to reach its full potential.

In the U.S. the cellular industry is approximately 20 years old, and in my opinion is at a point where the market will soon experience tremendous growth. It is also at a critical turning point. It is time for the U.S. cellular industry to turn digital and enter the second generation of cellular systems. Present analog cellular technology is already facing congestion problems in metropolitan areas. Digital systems will allow for more capacity coupled with feature-rich capabilities.

However, the question is, what will drive the US wireless digitilization. I believe that the following points must be considered:

• Cost of digital infrastructure.

• The customer.
• Regulation.

I would refer to the second generation of cellular technology as personal communication systems because the emerging technology addresses real human needs. Business is also a major driver towards the use of personal communication systems. The reasons for this are as follows:

• Changing employment structures. Increased mobility of labor is leading to leading a dispersed working centers.

• Rising transport and accommodation costs. This will encourage industry to relocate and more people will be working away from the office, thus the need to be contacted “any time anywhere.”

• Demand for effective communication as organizations and individuals respond to increasing social and professional pressures

• Increase in telecommunicating as an addition to rather than a replacement for central meeting places.[13]

A typical customer in the environment described will demand that they are able to access voice, fax, and data services when they are on the move. Also, in the office environment a local wireless network will serve the individuals so that they are not tied their the desks. This “internal mobility” can only enhance productivity by enabling individuals to move around and still be accessible to others through wireless communications.
In the closing years of the 20th century we will live in a society in which communications are seen as a facilitator in a complex world and as a source of competitive advantage. The distinction between telephony and computing will disappear as communication becomes the integrated transmission of information in several media. Terminals such as PDA will offer these different forms of media (voice, data, image and text). I believe that consumers will demand that services offered in the fixed network will also be available to a large extent in the personal mobile environment.

The vision of a personal communication “system” is that it will have to provide an integrated environment through which service providers can deliver their product to the users[14]. Users will also require that they are able to interface from a single migrating terminal, and using whatever combination of transmission and reception is appropriate.

The technical challenge is to arrive at a suitable standard or to create interfaces that can be transparently adopted by several systems. Without a common base it will be difficult for individuals to roam and their services to “follow” them seamlessly.

The ideal solution is to remove the combination of multiple mobile systems that exist. However, this will be difficult to achieve, since different regions of the world have developed their own systems and will back them through political means.

Within the technical community the problem has been approached in two ways. The land-based fixed network is progressing towards a concept of a universal personal network. In
this concept the land-based switches will acquire the functionality of the public land mobile network (PLMN)[14], that is, the ability to register regardless of point of access. On the radio side, developers are working on an interface on the terminals (handsets) to be able to interface with multiple systems. Examples of these exists today in the form of dual mode digital/analog handsets.

In conclusion, I would like to emphasize that it is commercial viability that will sustain growth in this industry. Customers will drive the industry in the following direction:

- Cost of ownership. Customers will demand that the cost to operate PCS devices be low.
- Quality of service. Customers will demand that the quality of speech transmission be excellent; they will also require the PCS service to be seamless and free from blocked or dropped calls.
- Availability of fixed lines services. In order to stay abreast with fixed line services, mobile service providers must also provide service features that are comparable to fixed lines. (fax, high speed data and, images.)

The challenge for the PCS service operator lies in the fact it has to provide new digital services to the public that compete not only with existing analog mobile providers but also with the fixed lines, both of which have lower operating costs and a larger customer base.
The digital systems must compete using their inherent strength, that is, the capability to deliver high capacity transmission coupled with the ability to deliver a range of services such as high speed data, mail box services, call forwarding, as well as short messaging services instantly, free of congestion and interference[15. Last but not least they must be able to provide these services in a way that is customized to the segment that the service providers is targeting. For example, service providers must market their service as part of a business solution not a technical marvel. Because in the final analysis all these technologies must be transparent to the subscriber it is important that a call or information is delivered to the person not to the technology.

References


Chapter 3 - Broadband Technology

Telecommunication networks offers a wide range of narrowband services: circuit switch services, circuit switch data, packet switched data, leased lines, fax, ISDN, electronic imaging, and database retrieval. With the advent of broadband technology, the types of services are even more diverse and require higher bit rate. Switch megabit and full motion video are possible with broadband networks.

The office of the future can benefit from broadband services for the following reasons:

- Broadband services provide corporations with the capability of transmitting a higher volume of data compared to narrowband.
- Still and motion video can enhance information content.
- The increase in speed reduces the complexity in managing corporate activities from different geographical locations.

The ability to move information to and from remote locations is critical in managing today's global industries. For example, Intel manages its fabrications facilities in Malaysia from offices in the United States. Manufacturing parameters are being sent back and forth every second of the day. Managers are video conferencing to discuss short and long term issues over the network. Creative emerging services are making it possible to manage more efficiently in a global competitive market.

The broadband network offers four alternatives in matching requirements to transport technologies:
• Fixed bit rate coding over fixed bandwidth circuits.

• Fixed bit rate coding over fast packet transport.

• Asynchronous data over fixed bandwidth circuits.

• Variable bit rate coding asynchronous service, over fast packet transport.

Future broadband users will require an array of new services to run their businesses. Among them are:

• Achieve simultaneous multimedia voice, text, and data interchange.

• Have addressability to every device on the system, be it a PC or a control system.

• Ensure interoperability between different systems, including narrow band, wide band, and broadband networks.

• Have fully interactive, dynamic and switchable bandwidth capabilities

User’s requirements will continue to develop well into the next century. Therefore, service providers must be able to leverage on the flexibility of a broadband network.

**Broadband Technologies**

We will now survey the different technologies that are building blocks of the broadband environment, frame relay, Ethernet, FDDI/II, ATM, LAN, and Routers.
Frame Relay

Frame relay is a packet transport technology suited for telecommunications networks designed for the early part of the 1990’s. A characteristic of the network of the first half of the 1990’s was a low error rate in transmission of digital signals. This is in contrast to the X.25 type of packet switching transport that was designed to handle higher bit error rates.

Frame relay technology leverages on lease lines, other forms of packet, and circuit transport technology. It is able to offer the user low end-to-end delay typical of leased and circuit transport. At the same time it is able to handle bursty data that is characteristic of today’s requirement.

The objective of frame relay are to provide:

1. An alternative to leased lines and circuit transport. The advantages over the traditional method are:
   - Ability to handle variable data bit rates thus extra bandwidth.
   - Ability to handle variability in bandwidth even during the call setup.
   - Multiplexing ability over a single access line.

2. Frame relay is considered an alternative to X.25 but with the following advantages:
   - Higher speed. Frame relay can reach speeds up to 45Mbps compared to 1.5 In the fastest X.25 systems.
• Lower delays because it was designed for networks with low error rates. Errors control that existed in the X.25 systems are eliminated, thus, reducing transport delay.

• An evolution path to asynchronous transfer mode (ATM). Within the network the frames can be divided and switched in hardware to provide access to ATM networks.

3. Frame relay is standardized technology accepted by a broad range of equipment of vendors. This technology is being adopted by manufacturers of multiplexers, switches, and LAN interconnect products. Standardization of frame relay is at an international level, thus providing connectivity from different vendors.

**Applications.** Frame relay found its application in the LAN interconnect environment. Prior to frame relay LANs were connected through leased lines. This is not the most efficient method since data in a corporate wide network is bursty. Bursty data are well suited for a frame relay environment. The major driver of the use of frame relay is the growth in corporate-wide networks itself. Since in early 1990’s LAN has grown at a rate of 20% a year. Their use is compounded by the fact that these LANs are being interconnected by wide area networks at the rate of 20% per annum.

Frame relay’s ability to handle variability of bandwidth makes it suitable for image transfer. Frame relay a suitable technology to use with the increase in the use of images
as part of process data. Examples of these are easy to see in today’s corporations and medical institutions. An example in the medical industry the use of imaging technology such as MRI being sent between specialist at different sites.

The other “killer” application that is well suited for frame relay is bursty data caused by distributed processing. Communications to and from host systems increase traffic in the network. The use of frame relay and multiplexing techniques facilitates the flow traffic efficiently.

**Ethernet**

With millions of networks in place, Ethernet is an important enabling technology development in the context of broadband networks. Because it is the key technology in LAN it is considered the building block of the broadband network. It is from the LAN that the frame relay concept evolved. In the early 70’s a coalition of DEC, Intel, and Xerox developed this standard to allow computers on a network equal access to a linear bus.

Information transported by Ethernet is reduced to small frames that include source and destination addresses as well as an error protection mechanism. The Ethernet architecture was designed to transfer data at a rate of 10Mb/s. CSMA/CD access method is used to regulate the way the terminals access the bus.
Ethernet uses three types of cables for its transportation medium; thin coax, thick coax, and twisted pair—refereed to as 10 base 2, 10 base 5 and 10 base T. The IEEE 802.3 standard specifies that a 500-meter cable length is allowed without repeaters. Repeaters can be used from 2500 meters up to 2.5 miles.

**Fast Ethernet**

Ethernet performance is limited in several ways. Namely it does not support voice traffic and a shared media LAN limits bandwidth. As more and more users log on, each receives a smaller percentage that is available, thus causing congestion.

Compared with its big brother, Fast Ethernet delivers up to 10 times more bandwidth. Standards have been developed to allow applications such as video conferencing to be available on this medium.

Advantages of Fast Ethernet are:

- Guaranteed bandwidth, thus allowing scalability, these two qualities are essential for multimedia applications.
- Works on existing infrastructure, which means it can be implemented economically.
FDDI/FDDI-11

FDDI is a 100 Mb/s fiberoptic LAN backbone supporting high performance work station and local area networks. A FDDI LAN can support up to 1000 workstation with physical connections of up to 200 kilometers. Advantages of FDDI are:

- Archiving. FDDI can minimize the time to backup files.
- Network backbone: Lower speed LAN can be connected to FDDI LAN. For Ethernet this will provide more bandwidth.
- FDDI LAN can be connected in a star configuration to FDDI-equipped compute work stations.
- File Servers can be connected to directly to the backbone, hence speeding up flow of information.
- The high bandwidth makes image-intensive file transfer fast. This makes medical applications such as remote medical imaging in real time a reality.

FDDI uses a token access method, similar to the token ring in LAN networks, but over two counter-rotating optical fiber rings. These dual access rings are known as dual access stations. FDDI allocates bandwidth both synchronously and asynchronously.

Synchronous dialog allows continuous, fixed data rate conversations. Asynchronous dialogs allows two terminals to keep both token and exchange data between themselves for extended periods.
LAN and Routers

With the proliferation of intra corporate LAN networks it has been necessary to connect them together. We will now survey hardware that manages the flow of information among these corporate networks.

Repeaters. Repeaters are the simplest equipment to interconnect LANs. Repeaters are necessary because distances in a LAN network may be too far causing distortions in signals which can be rectified using repeaters.

Gateways. Gateways are devices that ensure interoperability between systems that may have different protocols. These devices translate the protocols that are going to and from different systems. For example, gateways are often used in e-mail systems, their function would be to leave information intact by translating the address headers between different mail systems. The most important of these protocols is the Internet protocol X.400 which serves as the standard CCITT e-mail protocol.

Router. Routers are the most important internetworking device. Within networks messages and information are typically broadcast. The function of the routers are to separate the messages that are not directed to a particular destination.

SONET and SDH

SONET (synchronous optical network) and SDH (synchronous digital hierarchy) specify the electrical and optical standards that interfaces as well as protocols at different points
of the communication line, permitting use of different vendor's equipment along the optical fiber span. In this way the customer gets better bandwidth at a reduced cost. Because SONET/SDH compliant equipment is interoperable its ability to concatenate signals consistently at any bit rate make multiplexing low cost to implement in optical fiber systems.

SONET NETWORK ARCHITECTURE

SONET/SDH technology combines elements of LANs and WANs and has evolved from the computer industry. For example, the SONET in-band management ANS.1 protocol derives from the OSI standards on object definition developed for the computers. This implies that communication standards are reflecting a convergence of LAN and WAN technology. SONET architecture integrates existing point-to-point fiber links into true networks without the need for multiplexing and de-multiplexing.

SONET advantages are:

- Provides standard interfaces.
- Higher transmission speed.
- Reduced maintenance.
- Provide controllable network with centralized network management.
- Highly scalable bandwidth.

SONET/SDH will be the vehicle that will deliver a number of emerging broadband services, such as frame relay, SMDS, BISDN, and ATM. The challenge is, however, for
the PTT to integrate SONET/SDH in an environment that is still fluid in relation to equipment that is coming on to the market. This is compounded by the fact that services demanded by the corporate customers are not always defined.

**ATM (Asynchronous Transfer Mode)**

ATM has been defined as the transfer mode for future broadband ISDN networks by ITU-T. By definition ATM is a form of packet switching technique used to transfer data. In the acronym ATM, asynchronous refers to the operation of the senders clock and the receiving clock. In ATM, the difference between the sender’s clock and the receiver’s clock is resolved by removing or inserting “cells” or “packets” in the information steam. The information is than “reconstructed” at the receiving end. (De Pryker)

The objectives of ATM are:

- Providing low and high bandwidth services. In order to deliver B-ISDN ATM must be capable of carrying high bandwidth services such as a HDTV together with low bandwidth application such as voice in the same system.

- Providing high bandwidth transport. This means that ATM must also be capable of transporting high bandwidth information between network, both between the central office environment and in the internal corporate environment or between site of different corporate locations.

- Providing a single network for all services. A major attraction of an ATM network is not just delivery of high bandwidth but also the ability to integrate a variety of
different services onto a single mode of transmission and switching. The attraction of this is, reduced equipment cost, reduced operating cost, reduced maintenance cost.

- The integration of LAN and WAN. Prior to ATM, the protocols that existed in the LAN and WAN were different. Thus these protocols had to be converted in order to transfer data from the LAN to the WAN. With the implementation of ATM there is no need for protocol conversion. This results in improved performance due to the reduction of end-to-end delay.

- Free user bandwidth granularity. The aim of ATM is to allow users the flexibility to choose the bandwidth that they need for their application. Unlike prior systems that forces the user to choose bandwidths in multiples of 64Kbs. ATM allows the user to match the bandwidth needed to their application.

- Dynamic changing of bandwidth. An ATM system allows the user to vary the bandwidth in the course of a call, which is needed because of the bursty nature of data transfer that exists in the LAN environment. This characteristic is derived from the nature of raw data that is being transported. For example, voice contains pauses in between conversation, faxes and still images contain areas will more detail in some and less detail in. These variations are coded into constant bit rates and fed into a fixed bandwidth. In ATM, areas where there are no information are filtered out; information are then coded and transported. This methodology ensures the maximum utilization of available resources in the system.

In conclusion the primary technology of the technologies that make up a broadband network are:
• ATM
• SONET/SDH
• Ethernet/Fast Ethernet
• FDDI/FDDI-II

They enable network designers to configure systems that cater for services that are customer driven. These services, as mentioned earlier require high bandwidth and some are interactive in nature.

However, there are some challenges to overcome before we achieve a truly broadband network based on ATM technology. I would categorize them as technical and commercial challenges. Technically, there are still developments to enhance protocols at the transport level that links the different systems in ATM based broadband networks. Also, further developments in physical interconnect technology to the “last mile” need to be realized. For example, development in ADSL (Asynchronous Digital Subscriber Line) and HDSL (High Speed Digital Subscriber Line) will enhance the capability of ATM networks to be more accessible to users, because it utilizes existing copper cables that are already in place.

I believe that the challenges are greater commercially. First, the embedded systems that exist presently, are based on circuit switched systems, in contrast to ATM-based switching. The huge investment in circuit switched systems will be an inhibitor to the deployment of ATM based systems. The reasons for this are listed below:
• Human factor: The mindset and management and technical resource of the organization are based on circuit switch systems.

• Commercial factor: Charging mechanism and allocation must be capable of handling on a “per bit” based charging in contrast to a “per call” basis. Customers also have to manage this change to normalize towards a bit rate charging basis.

In conclusion, I emphasize that operators need to implement ATM networks as soon as possible in order to address their customers. These requirements are listed below:

• Achieve simultaneous multimedia voice, text, and data interchange.

• Have addressability to every device on the system, be it a PC or a control system.

• Ensure interoperability between different type of systems, including narrowband, wideband, and broadband networks.

• Have a fully interactive, dynamic, and switchable bandwidth capabilities.

The challenge for operators will be to match user demand to the rollout of broadband networks, to develop human resources, and to manage the changing environment.
Chapter 4-Regulation and the Rollout of New Services

In order to relate regulation to the rollout of services, this chapter focuses on the forthcoming PCS industry. Telecommunication Policy and Standard has a direct impact on new and existing services. Especially with the auction value being so high it is important for the operators to know exactly what they have purchased.

In 1994 the Wireless Telecommunication Bureau was setup to oversee the brave new principle of parity, competition, deregulation and market driven licensing(auction). Reed Hundt the FCC Chairman, has applied these principle to cellular and the next generation personal communication service.[1]

In order to get a better understanding of the current issue, we will study some examples that are being discussed in the industry, by local governments and in Congress. One issue at hand is the resale of wireless air time, a proposal championed by Joe Barton, R-Texas. His proposal calls for the unbundling of interconnection , which will allow resellers to install switches and purchase airtime wireless services provided by facilities- based wireless carriers. These resellers believe that these would promote better price competition.[2]

The cellular industry believes (Radiocom report) that this is not necessary since there are already six PCS licenses in every market. The FCC has not supported the resale proposal but may change its position before finalizing its policy. From this we can see that these
type of uncertainty can make it difficult for the rollout of new PCS services due to difficulty in pricing competitively. Resale of airtime will lessen PCS operator’s influence over pricing and the delivery of their services.

Antenna siting policy is another major factor in effecting the role out of a wireless service. Scott Klug, and Thomas Manton, D-NY, are promoting the establishment of a national antenna policy. They feel that a policy is necessary because the newer generation of cellular communication have cell sizes that are much smaller thus needing more sites. With multiple new service providers coming on line, local zoning boards may be overwhelmed, thus delaying the progress of these new technologies. PCS operators will be under pressure to site antennas and base stations in order to get coverage. Delays in site approval for antennas will cause disruption in the delivery and quality of service. Delays in capital intensive investments such as PCS usually ends up in the bottom line.

By far one of the biggest challenges facing the PCS operators is the migration of the microwave trunk carriers out of their allocated frequency band (1850-1950Mhz). The industry foresees a long, drawn-out and expensive battle in relocating these users to another band. It has been resolved that migration costs borne will be by the PCS operators on a negotiated basis. In monitoring the time frame stipulated by the FCC, must also consider its task in migrating the present microwave user out of its operating frequency. As mentioned earlier this is time consuming and expensive. One published estimate is that the relocation of a 2Ghz microwave link can cost up to $125000 per link. It also said that relocation could become the regulatory equivalent of moving a cemetery,
one of the slowest projects known to humankind. [3] (New PCS rules, William J,Franklin, Nov 1993,Celluler Business). Microwave links is are a critical part of a network. They carry trunk traffic, which contains voice, data together with signaling and controlling functions of the system. This problem exists because the allocated frequency band for PCS overlaps with the bands allocated to the private microwave networks.

In terms of frequency allocation, the FCC had already decided to issue licenses in term of geography and blocks of frequency bands. The FCC had rejected the former method of relatively small MSA/RSA cellular market definitions. PCS licensing is issued base on Major Trading Area and Basic Trading Area. These area are based on the Rand McNally Atlas, the FCC divided into 51 MTAs and 492 BTAs.

BTA are based on county lines. Counties are grouped into BTAs to reflect trading and transportation patterns. BTAs are than grouped together to form MTAs, again reflecting trading patterns and transportation patterns.

In terms of spectrum, the FCC allocated a total of 120 MHz of spectrum for licensed PCS service and 40MHz for unlicensed operations. The lower PCS frequency(1850-1890MHz and 1930-1970 MHz) is broken up into two 30 MHz block for MTA wide licensing and one 20Mhz block of BTA-wide licensing. However, in the upper band the FCC decided to divide the frequencies into four 10Mhz blocks of BTA licensing. Many feel that chopping up the frequency into these narrow bands is not viable. Among them is Commissioner Barrett an FCC board member. He believes that these will be trading chips
for aggregating larger PCS systems. The FCC has established that it is possible that frequency blocks can be aggregated by one licensee.

Initially it was viewed by most that the two 30 MHz MTAs as the cream of the crop. But after careful analysis it may turn into a liability if due attention is not given. For example, by definition the MTAs also includes rural areas that comes with the major cities. These rural areas are huge, as in the Denver MTAs which includes virtually all of Colorado and Wyoming and the Western parts of South Dakota and Nebraska. PCS licensee are also encouraged by the FCC for rapid deployment. The FCC stipulates that 33% of the population will be covered within five years, 67% within seven years and 90% within 10 years. If the FCC rules that all these areas must be covered in a stipulated time frame than this will puts severe strain on capital investment and thus cashflow of the licensee.

There is also the issue of universal service obligation to which the cellular operators must contribute. However, it is still unclear how it is going to be executed. It seems that cellular operators may end up paying directly into a fund. It is also envisioned that operators may draw from the universal service fund.[4]. This issue is unsettling because it may crop up sometime in the future as unexpected cost. Universal service represent an obligation that carriers must contribute to cover the cost of bringing services to unprofitable areas by the fixed line providers.

In general the view is that the FCC role in the regulation of the market will decrease. Many see that the role of FCC is to ensure on the wireless side that system design be
interference free meaning that its role will focus more on technical the integrity of the operating systems. The economics of the business will shift more and more toward market forces. With the new telecommunications act it is believed that most restrictions on the RBOCS and the long-distance carriers will be removed by the end of the decade.[6]

However, it is viewed that this transition toward a complete deregulation will be neither smooth nor predictable. With regard to wireless system there will be many questions. Among them are:

- What are the limits of the services that the PCS operator can offer? There are talks now that more frequency will be allocated for high frequency broadband applications. This must raise some questions about why did the bidders paid so much for the license, but before they even start to operate the FCC is already talking about offering more licenses. Anticipation of how regulators are going to behave is difficult; this represent a risk that is difficult to diversify.

- Is the FCC going to allow severe price competition? With so many operators coming on line this may well be the case. I believe that if this occurs than there will be less to reinvest. This may jeopardize the hope that the US will have a seamless PCS system nationwide due to the lack of reinvestment. The issue here is whether there should be price regulation by the regulator. In the U.S. traditionally it has been free market
forces. But in the long run I would argue that a dominant player will evolve and will be in control of the pricing, thus increasing the cost to subscribers.

- The view of not driving for a national standard also have pushed the US into a situation where multiple systems will coexist, making it difficult to have a true seamless PCS system without having a price penalty.

**Historical Background**

Historically in the US, regulation was brought about to prevent any one organization from amassing too much economic power. The desire to prevent the buildup of power led to the institution of public utility regulation. Historically it was the role of the government to ensure that the rates applied were “just and reasonable” and the supplier do not discriminate either against its enemies or in favor of its friends. The government also had to ensure that the utilities could earn a “reasonable rate of return” on their investments since their tariffs were regulated. Since the government also used the utilities as a tool for social engineering, it prevented by law the entry of competition.[7]

In return for protection from the competition the concept of universal service obligation was born. There are several concepts embedded in the concept of universal service.

- One is that the value of the network is increased as each of us is able to be in contact with more people. Thus we should price connection to the network such that more and more people can be on line.
There is also a social welfare concept. Telephony services can be considered as a lifeline service thus it made the obligation of the service provider to provide services under these conditions.

Geographical coverage: it is part of the obligation that the service provider brings its service to certain rural location although these areas are not profitable.

Tied to the concept of Universal Service is the concept of Carrier Of the Last Resort. This means that if the service provider wants to be a monopoly then it must bring its service to the rural area although these areas are unprofitable.

In the U.S. the regulation of interstate telephone services began in 1910 when the authority of the Interstate Commerce Commission was extended to interstate telephone rates, but the ICC never took active interest in exercising active power over the industry. As a result of this the Secretary of Commerce under Roosevelt set up a committee to existing communications industry structure.

The existing industry at that time was privately owned with regulatory authority split into four different types:

- State regulatory agencies, with authority over interstate rates.
- The ICC, with authority over interstate telephone common carriers.
- The Federal Radio Commission, with authority over the assignment of radio spectrum
- The executive branch, with authority over cable landing license for international communication and shared with authority with the Federal Radio Commission.
The committee recommended continued private ownership of communication subject to more centralized and stronger regulation. This recommendations than resulted in the Communications Act of 1934 under the sponsorship of Roosevelt. Numerous amendments have been made since, however the basic law governing the regulation of telecommunication remains unchanged. The law established the FCC and gave it authority to regulate the telecommunications industry. The frequently quoted mission of the FCC is as stated:

For the purpose of regulating interstate and foreign commerce in communication by wire and radio so as to make available, so far as possible, to all people of the United States a rapid, efficient, nationwide, worldwide wire and radio communication service with adequate facilities at reasonable charges, for the purpose of national defense, for the purpose of promoting the safety of life and property through the use of wire and radio communication, and for the securing a more effective execution of this policy by centralizing authority heretofore granted by law to several agencies and by granting additional authority with respect to interstate and foreign commerce in wire and radio communication, there is hereby created a commission to be known as the “Federal Communication Commission,” which shall be constituted as in hereafter provided, and which shall execute and enforce the provision of the Act.[8]

Although some matters pertaining to regulation of the industry were specific. “the Commission may perform any or all acts, make the rules and regulation and issue orders, not consistent with the Act, as may be seen necessary in the execution of its function.”
The provisions establishing the FCC were adapted from the Interstate Commerce Commission Act originally written for the railroads. However, the Act provided for a stronger regulatory environment than the one for railroads. The FCC had the authority to force interconnection and to suspend tariffs.

The primary common carrier provision of the act are as listed:

- Common carrier obligation to serve all who request service.
- The right of the commission to require interconnection with other carriers.
- Rates to be just and reasonable.
- Unreasonable discrimination prohibited.
- Publicly available tariffs for all communication charges must be filed and followed in a non discriminatory manner.
- The Commission may suspend new tariffs for up to five month to hold hearings of lawfulness.
- The commission is given the authority to prescribe tariffs after an appropriate hearing.
- Authorized to investigate complaints against carriers and to awards damages after a hearing (alternate to going to US district Courts.)
- The Commission has the authority to provide accounting procedure sand to prescribe depreciation charges for the carriers.
- The Commission has the right to get complete information from the carriers with regard to carrying out its functions.
The Rate Setting Process

The rate setting process is a major item that impacts the rollout of a new service. The process is complicated by the fact that it not only affects one organization but also those it interconnect with. The rate process is divided into two parts the revenue requirement and the rate design.

Revenue Requirement. The intent of the revenue requirement process is to ensure that the investing companies get a reasonable rate of return; typically it describes a monopolistic environment. However, this same principle has been modified to be a basis of interconnect negotiation. The formula used as a basis for this principle is:

\[ RR = (v-d) \times r + e \]

\( RR = \) revenue requirement
\( v = \) the value of the rate base
\( d = \) amount of depreciation of the rate base
\( r = \) rate of return
\( e = \) expenses.

We can see from the equation above that the formula represents a cost plus type formula where the rate of return can be determined by the governing authorities. The rate base \( v \) represents capital investments made by the company to serve its customer base, while \( d \) is the depreciation of the base. The rate of return \( r \), is the amount of return that the authority would allow as a reasonable rate of return to the company. The expense portion of the equation \( e \) can be controversial since it determines what portion of the companies expenses are “reasonable and necessary”.
After the revenue requirement is set, the parameters in the equation are then put through the “test” year. In this period, these figures are then reviewed to see whether they turn out as expected. If not the figures are readjusted or renegotiated. The criticism about this process is that a snapshot in time of these parameters may not be reflective of the conditions in the future.

**Rate Design.** Traditionally after the revenue requirement is set, the companies go through a process of determining how costs are going to be apportioned. Some have the opinion that this may be the most complicated process in the chain of rate design, especially in an era in which equipment are able to provide multiple features. This same equipment are providing services to multiple segments of the market, such as business and residential. Today’s switching equipment are able to provide services like caller ID, conference calls, and a whole host of other features. Thus, a methodology must be developed to split up the cost of delivering these services. The complication arises because traditionally services are priced based on the general price of the switch. Regulators’ solution to this has been to come up with a rate manual based on what the “think” the rate should be.

**Residual Rate Making.** It is not possible to fully implement a strict cost-based system since such a system would mean that the economics would cause the residential users to pay high tariffs which would go against the concept of universal service. As a solution to this, regulator developed the concepts of value of service and residual rate making. Basically it means that the operator can charge a premium on the services that are
considered “not basic.” For example, for call waiting, answering service, etc., the operator can charge a premium to the amount the market would pay. However, the biggest contributor to residual rate making are the long distance carriers. These operators are required to pay “access fees” to local access companies in order to access their networks. Access charges were developed during the divestiture of AT&T. The principle is to compensate the local carriers for the loss of revenue (revenue replacement) due to the divestiture. A bulk of these charges also goes into Universal Service.

**Long run Incremental Cost.** This methodology illustrates the cost of providing a service in the long run. This concept is similar to the concept of marginal costing. For example, the cost of delivering the new service is only incremental because a major portion of the infrastructure is shared with the rest of the system. The objective of this concept is to convince that your plan meets long run incremental cost and contributes to universal service.

**Structure of the FCC**

The FCC was originally established with seven original members serving seven-year terms; no more than four could be from the same political party. In 1983 the members of the commission were reduced to five, with one term expiring each year and no more than three coming from the same party. The Chairman of the commission is designated Chief Executive Officer and is appointed by the President of the United States.
**Communication Act.** The Communication Act delegates the regulation of interstate rates to the state commissions. Although the regulating organization varies from state to state their basic function is to regulate telephone, natural gas, electricity and, some other basic utilities. However, under certain conditions the FCC can preempt the state regulatory function.

Frequent conflicts arise due to ambiguity in the regulation of intrastate and interstate rates. The seemingly simple distinction is complicated by the fact that the same equipment is used to conduct intrastate and interstate business. Thus the regulatory procedures are complex and ambiguous. The issues become complex because it is difficult to determine the allocation of cost between the interstate activities and interstate activities. Conflict arises because each has the right to make decisions independent of others. A Joint Board exist to review and coordinate certain issues that may affect both jurisdictions.

**Congress.** Congress in many ways has a major influence over the evolution of telecommunications policy. It has the ability to rewrite the Communications Act as it see fit. This ensures that there is an avenue to review and change the Act if need be due to changing environment and technology.

Both the House and Senate hold hearings to deliberate on current issues effecting the business environment concerning telecommunications.
Judicial Review. The appeals court is an avenue by which the decisions of the FCC can be challenged or overturned. However, the courts can only determine the correctness of the procedures in relationship to the record and statute. Due to the advancement of technology in the past twenty years, the strict interpretation of the Act severely limits the ability of the FCC to substitute market forces instead of traditional regulation.

Department Of Justice. Antitrust action has been a crucial component in the administration on the telecommunication Industry. When an antitrust action is brought about by consent decree, the decree is sponsored by a federal, judge who retains jurisdiction over the interpretation and the modification of the said decree.

Other Executive Branch Agency. The National Telecommunication and Information Administration is responsible for coordinating the executive branch of telecommunications policy. Supervises the allocation of spectrum for government use also provides formal and informal inputs. NTIA derives its influence through its role in allocating spectrum to the Department of Defense. Thus it has a continuing interest in influencing the private sector through telecommunications policy.[10]

Trends in regulation

The evolution process that the information industry is going through will present a challenge to the present regulations and standards. This implies that it will also be a challenge to the process that establishes these regulations and standards because the
mechanism that is in place now will be inadequate. For example, the concept of broadcast that only existed in the broadcasting industry also exists in the computer/information arena, when messages are “broadcast” over the Internet. When we set tariffs for our broadband network do we make reference to the telephone industry or do we choose some other benchmark.

I believe that the approach must differ because of changes in the services that this new network offers. Traditional regulatory concept that is based on industries from the last century cannot apply to the dynamic and changing environment of today’s technology. For example, the PCS licenses were auctioned for approximately fourteen billion dollars, which is a huge investment by any standards. Old concepts of regulation cannot justifiably govern this industry because they were based in an era when obtaining a license was based on a lottery system, since the cost of acquiring the license were much lower. The challenge facing the both the regulators and the new service providers is to uphold the concept of universal service and at the same time satisfy the capitalistic goals of the industry.

This issue represents a challenge the concept of equity. The Communication Act’s goal is to make service available to “all people,” but in the face of deregulation the concept of universal service will be threatened as this industry deregulates.

This initiates a new dynamic, that will create an information gap between the ones who have access and the ones who don’t have access. For the future service providers, this represent an unstable situation. As the gap gets bigger and bigger, discontent will brew.
Especially in the United States this usually transforms itself into a strong lobby in Congress. This issue will probably find its way to the Supreme Court and in time may come back in the form of decree that translates to unexpected costs to the service providers. In conclusion, any new service provider must not only consider regulation that is set in the present, but also consider the trends in technology in regulating for the future. Thus the business model needs to be flexible to absorb uncertainties that may arise in a highly deregulated environment.
References


Chapter 5-Mobile Standards

Analog Cellular Systems

Cellular radio can be regarded as the earliest form of "personal communication." It allows subscribers to place and receive calls when they are not at their home base. As mentioned earlier the difference between cellular and traditional mobile radio systems is that in cellular systems the use of cells that are small in radius has resulted in the efficient reuse of frequency allowed for the increase in capacity. Cellular technology was developed in Bell Labs in the 70's. This standard is known as AMPS (Advance Mobile Phone System). Several regional evolved in the TACs (Total Access Communications) in the UK, NMT (Nordic Mobile Telephone) in the Nordic region, C-450 in Germany, RTMS in Italy, Radiocom in France, and NTT, JTACS/NTACS.[1]

Most of these regional standards developed a market in their own region except for AMPS, ETACS, and NMT. Their success was attributed to the ability of these standards to be adopted. The reason were as listed below:

- Established manufacturers support the standards.
- The historical relationship of the countries determined the type of standard that was adopted.
- Economies of scale determined the economic viability of the system.

Table 1 shows the breakdown of the various standards.
<table>
<thead>
<tr>
<th>Standard</th>
<th>Mobile Tx/Base Tx (MHz)</th>
<th>Channel Spacing (kHz)</th>
<th>Number of Channels</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amps</td>
<td>824-849/869-849</td>
<td>30</td>
<td>832</td>
<td>America</td>
</tr>
<tr>
<td>TACS</td>
<td>890-915/935-960</td>
<td>25</td>
<td>1000</td>
<td>Europe</td>
</tr>
<tr>
<td>E-TACS</td>
<td>872-915/917-950</td>
<td>25</td>
<td>1240</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>NMT 450</td>
<td>453-457.5/463-467.5</td>
<td>12.5</td>
<td>1999</td>
<td>Europe</td>
</tr>
<tr>
<td>NMT 900</td>
<td>890-915/935-960</td>
<td>12.5</td>
<td>1999</td>
<td>Europe</td>
</tr>
<tr>
<td>C-450</td>
<td>450-455/460-465</td>
<td>10</td>
<td>573</td>
<td>Germany</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Portugal</td>
</tr>
<tr>
<td>RTMS</td>
<td>450-455/460/4.5</td>
<td>25</td>
<td>200</td>
<td>Italy</td>
</tr>
<tr>
<td>Radiocom 2000</td>
<td>192.5/199.5/200.5-207.5</td>
<td>12.5</td>
<td>560</td>
<td>France</td>
</tr>
<tr>
<td></td>
<td>215.5-233.5/207.5/215.5</td>
<td></td>
<td>640</td>
<td></td>
</tr>
<tr>
<td></td>
<td>165.2-168.4/169.8-173</td>
<td></td>
<td>256</td>
<td></td>
</tr>
<tr>
<td></td>
<td>414.8-418/424.8-428</td>
<td></td>
<td>256</td>
<td></td>
</tr>
<tr>
<td>NTT</td>
<td>925-940/870-885</td>
<td>25/6.25</td>
<td>600/2400</td>
<td>Japan</td>
</tr>
<tr>
<td></td>
<td>915-918.5/860-863.5</td>
<td>6.25</td>
<td>560</td>
<td></td>
</tr>
<tr>
<td></td>
<td>922-925/867-870</td>
<td>6.25</td>
<td>480</td>
<td></td>
</tr>
<tr>
<td>J-TAC</td>
<td>915-925/860-870</td>
<td>25/12.5</td>
<td>400/800</td>
<td>Japan</td>
</tr>
<tr>
<td></td>
<td>898-901/843-846</td>
<td>25/12.5</td>
<td>120/240</td>
<td></td>
</tr>
<tr>
<td></td>
<td>918.5-922/863.5-867</td>
<td>12.5</td>
<td>280</td>
<td></td>
</tr>
</tbody>
</table>

**Table1**

Source: IEEE magazine, Jan 1995

**Digital Cellular Systems**

These second-generation cellular systems were made possible through the developments of integrated circuits and progress in digital speech coding techniques. Digitalization allows the use of time division multiple access (TDMA) and code division multiple access (CDMA) as an alternative to analog frequency division multiple access (FDMA), resulting in digital systems being able to support more users per MHz of frequency.

Advantages are as listed below:

- More natural integration with digital wireline.
- Flexible of voice/data transmission and the support of new services.
• Potential of further capacity increase as coding and compression improves.

• Reduction of RF transmission power.

• Encryption capabilities increase network security.

Table 2 shows the dominant regional standards being deployed to date.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Mobile Tx/Base Tx (MHz)</th>
<th>Channel Spacing (khz)</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS-54</td>
<td>824-849/869-894</td>
<td>30</td>
<td>America/Asia</td>
</tr>
<tr>
<td>IS-95</td>
<td>824-849/869-894</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GSM</td>
<td>880-915/925-960</td>
<td>30</td>
<td>Europe/Asia</td>
</tr>
<tr>
<td>PDC</td>
<td>810-826/940-956</td>
<td>25</td>
<td>Japan</td>
</tr>
</tbody>
</table>

All these digital systems also have frequency up-shifted versions that operate in the 1800 MH (GSM), 1900 (IS-54, 95) and 1500Mhz (PDC) frequency bands

**Table 2**

Source: IEEE magazine, Jan 1995

**The European GSM and DCS 1800**

The large number of different analog services in Europe drove the need to have a single compatible standard across national borders. This led to an initiative by CEPT (Conference European des Poste Telecommunications (CEPT)) to establish a group called Group Speciale Mobile in 1982. This group was renamed Global System for Mobile telecommunications. Its objective are as listed below;
To provide better roaming.

To design lower cost implementation and higher spectral efficiency.

To leverage digital technology to incorporate data application as part and parcel of system design.

To design an open system that may include future development in digital communication technology.

The original GSM standards were intended to be used in the 900MHz band of the frequency spectrum. However, due the high rate of adopters of this system, developers saw a need to migrate to higher frequencies to create capacity for the GSM standard. In early 1989 the UK Department of Trade and Industry started an initiative which led to the assignment of 150MHz in the 1.8GHz region for personal communication in Europe. This system is called DCS 1800. DCS 1800 represents an evolution of the GSM standard. For the most part the protocols are based on GSM especially in the network management and mobile switching systems.[2]

**Digital Systems in the US**

**IS-54.** In order to meet the growing need for capacity in the cellular market in the United States the Electronic Industry association (EIA) and the Telecoms Industry Association (TIA) adopted the IS-54 standard based on TDMA. This standard uses the 30 kHz channel spacing of AMPS to facilitate evolution from analog to digital systems.
IS-54 occupies the same spectrum as its analog predecessor. This system is required to be “dual mode,” meaning it provides both analog and digital functionalities. This approach was adopted to facilitate migration from analog to digital. AMPS has a large embedded base of analog users; to facilitate roaming for these users it is necessary that the system still caters for these early analog adopters. At the same time the cities are already congested, thus requiring migration toward a digital system. With dual mode application roaming, will be possible between the two areas.

**IS-95.** As described in the earlier chapters, IS-95 (CDMA) uses spread spectrum techniques as its radio interface instead of TDMA or FDMA. A spreading code is used to spread the signal across the whole spectrum; the signal is then reassembled at the receiving end using the assigned code. Using these different codes in different cells will optimize the reuse of available spectrum, thus making IS-95 more efficient.

Work on CDMA has been focused largely on perfecting the radio interface. To date, only trial systems are available in the US. However, the theoretical capabilities in the system promise superior performance compared to other systems available today. See Table 3
<table>
<thead>
<tr>
<th>Channel/MHz</th>
<th>Analog FDMA</th>
<th>FDMA</th>
<th>TDMA</th>
<th>CDMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calls/MHz</td>
<td>30</td>
<td>30</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Reuse Pattern</td>
<td>7</td>
<td>7</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Calls/MHz/cell</td>
<td>2</td>
<td>2</td>
<td>7</td>
<td>12.5</td>
</tr>
<tr>
<td>Capacity gain</td>
<td>1</td>
<td>3.5</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3**

A comparison of Analog FDMA, Digital FDMA, TDMA, and CDMA.

Source: Wireless: The Revolution in Personal Telecommunication, Artech House

**Digital Cordless Systems**

**CT2 Common Air interface.** CT2 is a UK led standard optimized for cost. (The summary of key specifications for this standard is in Table 4). This standard was a standard for Telepoint system. In this system subscribers can make phone calls at specified locations; mobility is restricted to a radius of about 100 feet. There are also no facilities for incoming calls.

<table>
<thead>
<tr>
<th>Region</th>
<th>CT2</th>
<th>CT2+</th>
<th>DECT</th>
<th>PHS</th>
<th>PACS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Europe</td>
<td>Canada</td>
<td>Europe</td>
<td>Japan</td>
<td>United States</td>
</tr>
<tr>
<td>Duplexing</td>
<td>TDD</td>
<td>TDD</td>
<td>FDD</td>
<td>FDD</td>
<td></td>
</tr>
<tr>
<td>Carrier Spacing (khz)</td>
<td>100</td>
<td>1728</td>
<td>300</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Number of carriers</td>
<td>40</td>
<td>10</td>
<td>77</td>
<td>16 pair/10Mhz</td>
<td></td>
</tr>
<tr>
<td>Bearer channels/carriers</td>
<td>1</td>
<td>12</td>
<td>4</td>
<td>8/pair</td>
<td></td>
</tr>
<tr>
<td>channels bit rate(kb/s)</td>
<td>72</td>
<td>1152</td>
<td>384</td>
<td>384</td>
<td></td>
</tr>
<tr>
<td>Modulation</td>
<td>GFSK</td>
<td>GFSK</td>
<td>Pi/4DQPSK</td>
<td>Pi/4QPSK</td>
<td></td>
</tr>
<tr>
<td>Speech Coding</td>
<td>32kb/s</td>
<td>32kb/s</td>
<td>32kb/s</td>
<td>32kb/s</td>
<td></td>
</tr>
<tr>
<td>Average Handset TX power (mW)</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Peak Handset TX</td>
<td>10</td>
<td>250</td>
<td>80</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>power (mW)</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>Frame Duration (millisecond)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Summary of key specifications for cordless systems.

**Table 4**

Source: IEEE Magazine June 1995

**DECT-Digital European Cordless Telecommunications.** DECT is designed for cost effective operation of wireless telecommunication in the pico-cell environment. The application is intended for application in domestic cordless telephony, cordless PBX and radio in the local loop. Functionally, DECT is closer to cellular systems and has interface that is consistent with ISDN and central switches. DECT uses TDMA as its radio interface protocol.[3]

For flexibility and broad applicability DECT, uses the Open System Interconnect Model. This will allow the system to interface with future digital systems with minimum complications.

**Personal Handy Phone System.**

The concept of this system is similar to the European DECT system but developed for the Japanese market. Specifications in table 4.
**FPLMTS (Future Public Land Mobile Telecommunication System)**

These are standards that are being developed by ITU-T and ITU-R that will scope the third generation wireless system. The objective is consolidate the range of mobility standard under one global standard. The FPLMTS standard is intended to ensure to interoperability across the different wireless environments. A similar initiative is also being carried out under ETSI called the “Universal Mobile Telecommunication System.”

Incorporated in thus standard will be the concept of Universal Personal Telecommunication (UPT) issues of personal mobility services such as call forwarding, call waiting and personal numbering will addressed by utilizing intelligent networks (IN). IN and ISDN will be used as platform to provide network functionality for personal and service mobility.

ITU-R Specification for FPLMTS are as listed:

- Digital system using 1.8-2.2 GHz band.
- Multiple radio environment (cellular, cordless, satellites, and fixed wireless).
- Multimode terminal to facilitate roaming.
- Wide range of telecommunication services.
- High quality and integrity.
- International roaming and intersystem handover capability.
- Use of IN for mobility management.
- Flexible and open network architecture.
The open architecture of FPLMTS will allow third generation wireless system to stand alone with gateways connected to the public networks. However through the use of IN it can also be viewed as an integrated fixed network system in which mobility management and call control functionality are part of the network element of the fixed network. [4]

It is proposed that implementation of these systems will be in the 2000 to 2005 time frame, because SS7 signaling and IN will be widely deployed thus facilitating the use of IN for mobility and service management. Regulation and market demand are factors that needs to be considered enroute to implementing an integrated telecommunication network. [5]

In conclusion, I would like to emphasize that the ultimate goal of these emerging standards is to provide a wide range of location and equipment-independent services to a large number of users. It would be a system where every user can exchange information with anyone, at anytime, by using a mobile or fixed terminal.

The main features of the intended services would be as listed below:

- Multiple environments: These future systems will provide ubiquitous access to services, independent of location, FPLMTS will integrate the public switched telephone network (PSTN), integrated services digital network (ISDN), the cordless systems and wireless PBX, to provide seamless communication services.

- Multimedia Services: FPLMTS promises to provide a wide range of services to the users, including high quality voice, variable rate data, and high resolution images, etc.
• Multiple User Types: FPLMTS will provide services to various users with varied requirements, e.g. different error performance, different service delays, etc.

• Global Roaming Capabilities: FPLMTS will be able to provide global roaming facilities to its users.

• Single Personal Number: FPLMTS promises to provide users with a single personal number that an individual can be identified with.

• High capacity: Further advances in air interface techniques, such as CDMA, and the use of micro and pico cells will enhance the handling capacity of FPLMTS.

Together with future development in enabling technologies (e.g. faster processors, miniaturization etc.), FPLMTS will be seen as a network that is multi-environment, multi-operator and multi-service type system.

References

Chapter 6-Questionnaires and Manufacturer's Perspective

I chose to send my questionnaire to three companies Motorola, Nokia, and Erricson. However, I only received written response from Nokia and Motorola. The response from the two companies were sufficient for me to draw my conclusions for the positioning of wireless broadband communications. In addition to my questionnaires, I also conducted personal interviews with Nokia in January 1996.

The people involved in my in answering my question are:

Nokia:

1) Dr. Neuvo, Vice President RND, Nokia Mobile Phones
2) Khalifa Khalifa, Marketing Manager, Switching Systems
3) Phones Petri Poyhonen, Product Manager, Wireless Data Systems

Motorola:

1) Dr. Avril Slater, Director of Startegy, Motorola, Cellular Infrastructure Group.
2) Robert Stozek, Director of Switching Systems, Cellular Infrastructure Group
3) Anna Balakrishna, Sr. Product Manager, IN products, Cellular Infrastructure Group
4) Mike Lurie Sr. Product Manager, Switching, Cellular Infrastructure Group

Although my questionnaire are sent only to three companies because I believe that these companies are industry leaders in the field of wireless communications, and because of
the highly technical nature of the industry, the evolution and positioning of the services in the industry will be technology and standards driven.

**Objectives**

The objective of my questionnaires was to seek the perspective that manufacturers have in the development of wireless technology and services, specifically in the broadband context, these questions were introduced in the first chapter of my thesis.

The three main categories of questions are as listed below:

1. What are the types of services that will be available in the future and how they will evolve. This category also questions the role of users in driving the evolution of these future services.

2. The second category of questions cover the role of wireless systems in the context of a broadband network. This set of questions seeks to clarify the role of the different wireless systems, to see whether these emerging systems are competing or complementary. Questions on time frames in which these wireless broadband systems will evolve, and be integrated are also introduced. There are also questions on how the needs of mobile users are addressed.

3. The third category of questions addresses the integration of wireless systems into the broadband systems. They address the infrastructure that is needed to provide these broadband services. For example, will these systems be stand alone or will they be an evolution from present wireless systems. Questions are also introduced to determine developments in standards for these systems to confirm their responses.
Summary

Table 1 below is a summary of the responses from the manufacturers. A more detailed version will be illustrated in a later section.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The types of services that will be available in the future and how they will evolve. This category also questions the role of users in driving the evolution of these future services.</td>
<td>Both manufacturers broadly agree that the future wireless systems will provide the following services:</td>
</tr>
<tr>
<td></td>
<td>- Seamless service</td>
</tr>
<tr>
<td></td>
<td>- Voice</td>
</tr>
<tr>
<td></td>
<td>- E-mail</td>
</tr>
<tr>
<td></td>
<td>- Point to point data</td>
</tr>
<tr>
<td></td>
<td>- Corporate to remote client connections</td>
</tr>
<tr>
<td></td>
<td>- Internet browsing</td>
</tr>
<tr>
<td></td>
<td>Motorola believes data rates up to 2Mb/s will be possible and Java applications by the turn of the century.</td>
</tr>
<tr>
<td></td>
<td>Both manufacturers also agree that business users will be the major driver for wireless data services</td>
</tr>
<tr>
<td></td>
<td>Both manufacturers agree that the migration towards an integrated future wireless system will take an evolutionary path, building on the multiple systems that exist presently.</td>
</tr>
<tr>
<td>2. The second category of questions cover the role of wireless systems in the context of a broadband network. These set of questions seeks to clarify the role of the different wireless systems, to see whether these emerging systems are competing or complementary. Questions on time frames in which these wireless broadband systems will evolve, and be integrated are also introduced. There are also questions on how the needs of mobile users are addressed.</td>
<td>Both manufacturers agree that an integrated broadband environment will be achieved by the turn of the century.</td>
</tr>
<tr>
<td></td>
<td>- Due to the limitation of bandwidth, only a segment of future broadband services will be ported to the wireless environment.</td>
</tr>
<tr>
<td></td>
<td>- Both agree evolution of different systems will be complementary and exist in an integrated environment. For example, satellite systems will cover areas that are not serviced by terrestrial systems</td>
</tr>
<tr>
<td></td>
<td>- Both, agree that different services will be available for different segments of the market. For example, regional systems will provide higher bandwidth</td>
</tr>
</tbody>
</table>
that can cater for more intensive wireless data applications, whereas other systems that provides greater mobility will provide less bandwidth which are suited to application that needs less bandwidth, but greater mobility.

| 3. The third category of questions addresses the integration of wireless systems into the broadband systems. They address the infrastructure that is needed to provide these broadband services. For example, will these systems be stand alone or will they be an evolution from present wireless systems. Questions are also introduced to determine developments in standards for these systems to confirm the responses. | Both manufacturers agree that standards will drive future systems to integrate. Future systems will be a seamless integration of both fixed and mobile networks. This will be made possible because:
- Future network will share common transport level protocol (TCP/PIP and OSI).
- Intelligent Networks will manage user services profiles across networks. For example, value added services, such as call waiting will be portable across different networks.
- Both manufacturers believe future systems will not be stand alone systems, present systems will evolve into third generation systems through incremental improvements in network management and enhanced air interface (e.g. CDMA) |

**Table 1**
The Big Picture

The responses from the interview characterizes the future mobile systems as being complementary and integrated, further integration of these mobile systems into the fixed are also envisioned by the manufacturers.

Broadband services will ported from the fixed network, but will be limited by the bandwidth capacity of the wireless systems. Bandwidth limitation will be one of the mechanism that will position the use of wireless broadband. Manufacturers expect that by the turn of the century, application that require up to 2 Mb/s will be possible with wireless systems. These applications will characterize the positioning of wireless broadband services. Examples of these applications are as listed below:

- Wireless data.
- E-mail.
- Internet browsing.
- Corporate to remote client connections.
- Point to point data retrieval and transfers.
- Image transfer.

The future mobile systems will also be characterized by the use of intelligent networks (IN). The use of IN will ensure that user service profiles will follow the users as he moves across networks. User service profile is defined as services that are subscribed by the user, for example e-mail, voice mail or call waiting.
Mobility and bandwidth have an inverse relationship, this will drive industry to develop different systems that will cater for different applications. For example, intensive data application will require high bandwidth, but will be limited in terms of mobility.

It is also interesting to note there are little disagreement between the responses from the two manufacturers. This may suggest that standards have a strong influence in the development these future systems. I believe that this is the case because these systems must be interoperable. I have also provided in my thesis, in the next section, the verbatim responses from the manufacturers to provide a more detail appreciation for the future environment in wireless communications.

**Question 1**

The trend in communication is moving toward a personalized communication and information environment. It is well known that IT (and in particular, telecommunications) has a significant impact on the way we live and the way business is done in today's environment.

1. What, in your opinion, are the services that will likely be offered in the future environment?

**Motorola:**

High data rate services up to 2 Mbits/sec covering residential, corporate and public and corporate users. Motorola envisions an integration of current and future service standards and systems offering ubiquitous, seamless services. Future services will include PC to PC video conferencing,
interactive data services such as Internet that use software agents such as Java to retrieve, manipulate and alter data/information on-line in remote auto mode while the wireless IT user works on current active information handling. Other applications include:

- advanced GSM/CDMA networks that will be linked to emulate home network service providers
- provision of LAN- and PBX-type services
- caller software intelligence that will ensure one number for all services seamlessly
- more Internet-type of applications.

Nokia:

The main development will be the provision of Internet connectivity and client-server applications to mobile clients. Internet is the current global lingua franca providing the compatibility standard at various levels (IP routing, TCP/UDP end-to-end connectivity and WWW application. The main aim of wireless data is to provide the benefits of network applications to users of laptop PCs and other portable clients. This represents a major business opportunity to network with operators to expand their business beyond voice services. Leading applications will be e-mail and WWW browsing.

ii. How do you think this service trend will likely evolve. Will these services be driven by the consumer-oriented sector or will businesses be the likely driver? Please explain.
Motorola:

Motorola believes that business will drive the demand for wireless IT services. Services will include accessing corporate information and the Internet. Domestic consumers will largely use wireline to access broadband services such as cable TV and interactive video. In addition to this we can expect to see wireless local loop services providing remote control services for home remote controllers for lighting, heating, and security purposes.

Nokia:

Initially the market will be driven by business related e-mail needs. Small business, which cannot afford a company IT department may acquire e-mail as a service from the network operator. Larger companies already operating e-mail services in house need to provide a remote access to e-mail for their mobile workforce. Wireless remote connectivity is a superior solution for users of portable laptops who need to access their corporate servers from different locations. On top of e-mail, the use of other groupware tools (e.g. for information sharing and managing the flow of routine tasks) is growing to meet the need to keep mobile members of organizations connected.

iii) What services will the consumer-oriented sector be looking for in the future? Is there a possible scenario that your organization is looking at?

Motorola:

Consumer services will include services such as e-mail, voice messaging, video communication and WWW access, information and retrieval services. Motorola envisions that as wireless moves towards coverage of their new "Wireless Access" system, businesses will start to replace wireline
services where these applications are not bandwidth limited. Examples of these are voice traffic, e-mail, retrieval and broadcast information.

**Nokia:**

Consumer services will be looking for:

a) Network commerce (sales of goods, information and services on the network)

b) Tools to encourage customer loyalty

iv) Given that business requirements vary significantly between developed, developing and under-developed countries, to what extent would these future services impact the reengineering of the business process within these three scenarios. Please indicate some possible examples.

**Motorola:**

Business needs will initially vary from under-developed to developed countries, but because developing nations and under-developed countries will be able to leap frog many technologies, they will have a larger wireless-to-wireline communications ratio. By the end of the century wireline will penetrate only 5% of the population of the entire world. Wireless will be widespread in major cities and towns and wireless IT systems will be digital GSM/CDMA-based and will migrate to third-generation systems such as UMTS and FPLMTS.

Business requirements will be more than Plain Old Telephone (POTS) with data in Europe expected to occupy 16% of all GSM traffic by the end of 1999 (link resources). Voice messaging
is expected to be the largest growth area followed by Internet access.

**Nokia:**

Some essential business requirements may not be too different in various markets, whether they be developing or developed countries. Typically, the latest technology provides an opportunity for developing economies to leap from older, less efficient technologies and compete head-on with more mature economies, which may experience a painful transition from out-dated processes to new ones. It is difficult to see why the most efficient e-mail solutions will not be a relevant asset for all businesses which operate in information-intensive industries, where efficient flow of information in the organization is an essential requirement.

**Question 2.**

It is widely believed that the future communications environment will be integrated to offer seamless unified services. Broadband communications is perceived to play a dominant role.

i. What is your opinion on this issue? What time frame are we looking at to realize such an environment?

**Motorola:**

The future will see general purpose ATM switching and transmission systems that will be able to support B-ISDNs and to interact with N- ISDNs. With PCS exploiting its full capability as an
integral wireless-access part of ATM-based broadband networks, telecommunications will make a major leap forward to provide a technically integrated, comprehensive and consistent system of personal communications supported by both fixed and wireless terminals. As a result, wireless access networks (e.g. CDMA based networks) will begin to offer services that have traditionally been provided by fixed networks, including on-demand flexible ATM services, by turn of the century.

**Nokia:**

An integrated seamless communications network is a strong and consistent vision in the industry. This was seen earlier in the desire for an Integrated Services Digital Network technology which has served the industry for years. In particular in GSM, voice and print data are treated equally, data in not a late add-on. This same vision now stimulates discussions on broadband networks, also refereed to as Integrated Broadband Communication Networks (IBCN), with ISDN inheritances, but it has been upgraded for broadband user circuits. The requirements for voice and data communication are different. These differences are manifested in the very different structures of current global telecommunication networks and the Internet. Both networks can benefit from sharing lower level transmission resources. A universal broadband connectivity layer can equally support voice and other isochronous connection as well as packet-oriented Internet traffic.

1. **What role will wireless communications assume in this broadband environment? Will PCN dominate future wireless communications technology or could there be other dominant players? What are their roles? Will these players be competitors or complementary and in**
which market segment will they operate?

Motorola:

ii) Future wireless communication (FPLMTS) will be implemented as an integral part of broadband ISDN (B-ISDN). The B-ISDN network with the support of Intelligent Network (IN) will allow for the commercialization of network resources between operators and the reuse of the existing infrastructure to achieve a multi-service provider environment. Current and future mobile services provided by mobile networks will become increasingly advanced and the difference in quality and feature between wireless and wireline services will continue to diminish. The introduction of personal mobility in the fixed network has begun to blur the distinction between the PSTN/ISDN and public land mobile network (PLMN). The wireless service may be implemented as an individual network, an adjunct to or an integral part of the fixed network.

The impact of mobility on the pace and direction of future deregulation will be significant. Competition between future wireline and wireless operators for the mobility market will create a new dimension to the evolution services. Wireless operators will compete with wireline operators for access to fixed, residential and business subscribers. These services will cut across the traditional regulatory boundaries which constrain the existing wireline and wireless networks.

Nokia:

Radio access is and continues to be inherently bandwidth limited. Wireless communication is therefore the access of choice, in cases, anywhere access is a benefit and where fixed broadband access is not yet implemented. PCN, (DCS 1800) is the likely dominator of the wireless wide
band data market. The DCS 1800 system has sufficient wideband allocation (75Mhz) to easily provide the capacity for a growing number of data users and for future enhancements of GSM (GPRS and HSCSD).

Other wireless systems that challenge the role of DCS 1800 systems cannot be identified for at least for a decade. Wireless LAN solutions would not scale for area coverage, but can be used as indoor solutions. The US CDMA (IS-95) does not provide more benefits than the DCS 1800 but is six years late in terms of systems maturity. The most likely challenger of the DCS 1800 would be "Third generation" system, developed as a radio interface evolution step based on the DCS 1800 Network.

iii) What is the significance of personal mobility and terminal mobility? What is the implication for future services? How does these concepts impact the PCN business? What improvements in service offerings can we expect from such a distinct separation?

Motorola:

Terminal mobility provided by wireless networks involves the ability of the network to keep track of the user's terminal which allows the user to be in continuous motion while accessing and using telecommunication services it represents terminal-to-network relationship the location update and tracking is done automatically.

Personal mobility is the ability of a user to access telecommunication services at any network and terminal (not limited only to wireless) on the basis of a unique personal identifier. Personal deals
with user (not terminal) devices to network relationship. Personal mobility requires a user-initiated registration procedure to inform the network of his or her current location (terminal access).

As complementary or competitive to wireless terminal mobility, personal mobility (e.g. UPT) is offered by wireless or wired operators. It requires additional functions than just a PSTN called, location, security and dynamic re-routing. All of these functions are data- and signaling-intensive and require storage and real time access at various points in the network.

It is our belief that as a viable commercial option, personal mobility such as UPT service may, however, be overtaken by the introduction of a third generation mobile which offers global roaming with personal intelligent handsets.

Nokia:

Personal mobility is a concept introduced to create a type of mobility in the fixed network where terminals generally cannot be moved. Mobile networks providing terminal mobility, and GSM networks providing personalized terminals with the SIM card have a superior tool box to address user mobility needs. Separating personal and terminal mobility does not seem to provide benefits over the current DCS 1800 mobility management.

iv) To what, extend and when, will the issue of personal mobility and terminal mobility dominate the communications scenario? Will this issue be driven from the wireless segment as opposed to the wireline segment?
Motorola:

iv) By the 21st century, ideally, there should be no distinction in service capability between mobile and fixed network access. We expect that there will be a range of services that can be selected in a uniform way within consistent procedures, performance and quality, in respect to the:

- means of access (wired or wireless)
- applications (cellular, cordless, paging, satellite, etc.)
- service provision (public or private)
- environment (home, street, transport, office, shop, etc.)
- location (ranging from service area to global)

This will apply to at least a basic set of fully standardized personal services:

The driving forces are from the wired and wireless segments of the market. After all, such a distinction becomes meaningless by that time every operator can offer access of independent personal communication services.

Nokia:

We expect PCN operators to offer voice and data connections. Data connections will be modemless allowing direct access to TCP/IP Intranet (in the private TCP/IP network domain, where clear commercial obligations for quality of service prevail and the use of the network is an
issue of commercial contracts). Based on transparent TCP/IP connectivity, a wide range of data content can be made available as illustrated by the current growth of WWW sites on the Internet. This is a significant chain the global information highway.

v) **Within this environment, what services would the wireless operator offer? The full range of data, text, image and video?**

**Motorola:**

v) Third generation mobile system currently being specified by both ITU and ETSI can offer a range of services as a result of the TGMS system functioning as an access system to the broadband infra structure. This will enable the provision of:

- multimedia services
- data service with bit rate on demand up to 2 Mbit/s.
- message handling services.
- advanced personal mobility

Attractive application of TGMS will be possible in the fields of:

- security applications (e.g. surveillance)
- general business applications.
- locating applications (vehicle tracking/location, route guidance, emergencies.)
Nokia:

Answered together with the last part.

Question 3

The integration of wireless communication systems into future broadband services requires fundamental changes in the present communications architecture.

i) As an infrastructure provider and terminal equipment supplier, do you think that this evolution will allow the present second-generation infrastructure to evolve into the anticipated new environment of third-generation mobile communications? Please provide an example of this scenario. What are the disadvantages of such a scenario?

Motorola:

i. The realization of TGMS (Total Global Mobile System) requires architecture that supports a vision of personal telecommunications and strikes a balance between a reuse of investments previously made and new technologies so that the impact on existing networks can be minimized. TGMS must integrate the technology used in PSTN, PLMN, ISDN, and private networks to maximize the utilization of existing infrastructure and achieve low-cost data transport. IN must be used to distribute the control of service-to-service providers and users. Technologies applied to second generation systems must be used and tested and further enhanced to support personal communication services and multiple access. Miniaturization of cell structure
is required to cater to high traffic density and to achieve low cost terminal.

There is no single, straightforward road to TGMS. An evolutionary process is driven by different forces on an increasingly liberalized market, and by different players, and therefore is different in each country. TGMS will not however, be built from scratch. Instead, it will be achieved by extensive reuse of existing investments and technologies that are driven forward by competition by the different players who reward investments with a short payback period. It might be also be the driving force toward a new access network infrastructure built on wireless standards. Second-generation systems will contribute to the evolution of TGMS.

Nokia:

We believe there are strong reasons to prevent the "next generation" from being invented from scratch. The basic function of digital cellular networks (such as ISDN-based call control, mobility management, SIM, handover and radio resource management) have already been perfected in GSM and DCS 1800 and thus there is no point in reinventing this part without the prospect of essentially improving the state of the art.

The single most important area of potential for enhancing GSM systems is in the area of user channel data rate - to enable us to use wireless everywhere access as a better approximation of future fixed network broadband connection. This will enable content providers to deliver more attractive visual information to the users. Such fundamental improvements in the current system will create a revolution in the service. But this revolution in capabilities needs to be achieved as
an evolution of current systems to maintain sufficient continuity.

Furthermore there are certain steps to the next generation capabilities. ETSI is already far advanced in wideband data capabilities specified in GSM and DCS 1800 features known as packed radio service (GPRS) and high-speed circuit switched data (HSCSD) which will move us a good step toward next generation capabilities which will improve the long term competitiveness of current networks.

Some other more incremental improvements must be identified later on.

ii. How likely will the third generation system be a stand-alone system?

What level of interconnectivity (both infrastructure and services) is likely to be available and offered between second- and third-generation systems? What is the implication of the services offered under broadband as a result of this?

ii) It is unlikely that the TGMS will be a stand-alone system. Second-generation systems will evolve to something close to the TGMS (apart from the high data rate). The need for greater capacity enhanced service features and the increasing number of operators competing for subscribers will put specific requirements on the evolution of second-generation systems.

As a matter fact, TGMS and the second-generation systems should, in the long-run, compliment each other and, once the regulatory restrictions are lifted, merge into a single seamless wireless network. There are however, many bridges to cross before that becomes a reality. Many network
capabilities such as mobility management, user security protection and resource allocation addressed in earlier systems, are some of the critical requirements and issues for TGMS.

In service terms, TGMS must offer every service that present wired and wireless technology offers and extend service and applications into new areas that are common to both or unique to TGMS. Typically the future will see local-loop wireless distribution networks, teleworking, home shopping, interactive education and training with vital reality support, navigation, multimedia multiparty, consultation, entertainment, multi-connection surveillance, information seeking and retrieval, communicating with palm-sized PDA and video communications.

Nokia:

By the time of the possible introduction of next generation services (2005), current GSM and PCN networks will enjoy penetration in the range of 30% to 40% in OECD countries. Continuity in the evolution of such mass services will be essential. Next generation functionality is expected to be implemented as a new capability in the network rather than a new network substituting for the current one.

Stand alone "next generation" networks challenging such mature PCN networks with new functions will experience a hard time competing against established networks with coverage and enhanced next generation functions coming on line all the time.

iii. What are the standards that are currently being formulated for third generation systems? How and when will the present system be expected to migrate into the future
system? In what form will the proposed system be integrated into fixed network services?

Motorola:

iii) ITU-T is currently specifying network aspects of TGMS under the name Future Public Land Mobile Telecommunications Systems (FPLMTS), while the radio aspect of FPLMTS is defined by ITU-R. The specification of the European version, called UMTS, is undertaken by ETSI.

In order to evolve towards a fully integrated system solution as an essential step, IN functionality must be introduced in present PLMN.

A phased approach toward a fully integrated system can be expected with a possible first step being the SSP function in the MSC. Thus, the MSC is able to interact with service controls. This first step of integration of the IN and wireless capabilities improves call routing and reduces the set-up time. A second step of integration, i.e. interconnection between SCP and HLR, allows a simplification of the interaction between the switching network and data base, therefore improve call routing. The third step is the integration of SCP and HLR databases that lead to the global optimization of both call routing and database queries.

Along with these activities, integration of wireless and wire networks can take place. This will allow the fixed network to offer a flexible way to interconnect wireless in terms of service, signaling and functions. In this way, wireless networks can exploit the infrastructure of fixed networks and so avoid the need for a separate overlay network. There are many functions that can be integrated to common network elements, e.g. local exchanges may have the functions to
connect base stations. This integrated network should support different wireline and wireless communication devices optimized for their specific environment.

This concept of an integrated interworking network does not imply that all of the sub-network systems or elements are owned or operated by the same network operator. On the contrary, such an integrated network should support a multi-operator multi-vendor environment in order to meet market and regulatory challenges. The future TGMS networks will thus be the integration of multiple sub networks where each will be defined and operated by different network service providers.

**Nokia:**

Next generation capabilities are a subject of intensive efforts to standardize in ETSI, (e.g. in STC SMG 5). Key manufactures such as Ericsson, Seimens and Nokia are working together in a project called Frames to prepare technical contributions for the ETSI standardization process. ITU is also working on next generation wireless services under the title FPLMTS. It is not clear yet how these operations will coincide with each other. It is a possibility that ITU will concentrate on ensuring certain minimal global compatibility of the next generation system. Eventually, there might be more than one generation system implemented, one as a deviation of GSM and some other systems based on other technology choices.

iv. **What mechanism is available to provide a seamless integration over most computing environments. How would the PCN infrastructure be integrated into services such as**
cordless systems as well as the wireless computing environment.

Motorola:

iv) Cordless systems are a solution to the problem of covering in-door high density areas economically and providing high quality services (voice and data in the office environment). Cordless systems such as DECT of PACs can be viewed as just another type of radio access technology to be integrated into the PCN infrastructure providing services to the indoor or pedestrian environment. With dual-mode terminal devices, PCN will be able to support automatic roaming and handover between cordless and cellular cells, the cellular effectively provide a large cell.

Mobile access computing environments require wireless data capability which the PCN system offers, such as CDPD and the General Packet Service Da.a from GSM.

Nokia:

xxxx

v. Will the technologies available on these systems compete with the PCN services? Or will there be complementary services? In what area can the PCN technology and the future third generation mobile services compete in the wireless local networking environment such as Ad Hoc networking, Nomadic Access and Mobile Computing?
Motorola:

v) Cordless radio technologies will be an integral part of PCN and future TGMS infrastructures. Wireless LAN is seen as complimentary to the PCN service. As far as wireless computing is concerned, there are two types of wireless computing services: public such as CDPD, and private such as wireless LAN. Each has a different technology and uses a different spectrum (licensed vs non-licensed), each operates under different rules, (regulated vs unregulated), and meets different sets of service requirements, serves different markets, business vs public. Public wireless data services which are integrated with PCN and third-generation mobile systems offer users narrow-band data service with global roaming and hand over, and on the other hand, wireless LAN which is in the private network, offers high quality high-band width data.
Conclusions

Diagram 1

Wireless telecommunications is well positioned for the application of broadband telecommunications because, technical developments in this field will enable applications that require up to 2 Mb/s be transmitted, with varying degree of mobility via wireless systems. Within the 2Mb/s of bandwidth we will see applications such as the transmission of data, text, still, and video images towards the turn of the century. Factors that influence the positioning on wireless broadband systems are as listed below:

1. The capability of the wireless systems in terms of bandwidth. From diagram 1 we see that wireless system can, by the turn of the century, handle up to 2 Mb/s in systems

Source: Nokia Telecommunications
specified under UMTS and FPLMTS, however we also see other systems that cater for application that require less bandwidth.

2. The positioning of these systems will be determined by economic factors such as supply and demand of these services. This implies that pricing and delivery mechanism will influenced the positioning wireless services.

3. Regulatory framework that governs the implementation of the wireless services.

Due to the variability in bandwidth of broadband communications we see that different systems are developed to cater for this variation. From the diagram 1, we see that the inverse relation between mobility and bandwidth, this in itself is a positioning mechanism for wireless systems.

Diagram 1 illustrates the relationship between mobility and bandwidth capacity of different telecommunications systems. The horizontal axis of the chart represent the bandwidth in Mb/s, from 0 to 600 Mb/s, the operating bandwidth of today’s broadband communications systems. The vertical axis, I have represented mobility, relatively by, wireline systems, premise mobility, local mobility, national mobility, international mobility, and global mobility, wireline being not mobile to satellite being globally mobile. As we can see, there is an inverse relationship between mobility and bandwidth capacity. The chart positions wireless broadband application between 28.8kb/s to 2 Mb/s. This is the technical positioning of wireless broadband networks. This means any application that requires bandwidth between these parameters are possible candidates for wireless transmission.
Data from my interviews suggest that bit rates up 28.8 kb/s currently will allow applications that are listed below:

1. Internet browsing.
2. E-mail services.
3. Connectivity to corporate LAN.
4. Emergency Services. (data for on site telemetry or on site transmission of trauma images).
5. Public Security. (Police data such as still images of security information.).

Further to this, developments of cellular packet data (CDPD) and general packet radio (GPRS) will enable wireless systems to fit into ATM broadband networks. This is possible because both system shares common basic level transport mechanism for data transmission ("packets data"). CDPD and GPRS will enable data that originates in the wireless system to flow into ATM broadband band networks seamlessly.

Relative bandwidth scarcity compared to fixed network will limit the range of broadband services that can be ported to the wireless network. We defined broadband transmission any where from 22.8kb/s to 600 Mb/s and above (systems of 1 tera-bits/s are now being developed). But due to the digital nature, of second and future generation networks, it is possible to download important bits of information through the wireless systems. Users can choose only to download the text portion of the information to shorten download time. Not limiting wireless communications to just text, but it allows the user the
flexibility to download bandwidth hungry application at a more convenient time. The important issue here is the information is delivered to the person “instantly and location independent.” Even more encouraging, Motorola see the possibility that users will be able to leverage Internet applications such as Java. Motorola believes it would possible for users with Java, to retrieve manipulate and alter data in remote auto mode whilst the wireless IT user works on current active information handling.

Standards such as FPLMTS and UMTS are ensuring that these future wireless systems will be integrated and compatible. Standards are driving wireline and wireless network to integrate further in order to ensure high quality of service. Intelligent networks (IN) will ensure the vision of personal and terminal mobility is achieved. The development and deployment of IN will ensure the portability of service between the networks, which is the goal of both terminal and personal mobility. The development on the terminal end, such as PDA with integrated communication functions will also add to the convenience of managing information in the mobile environment. The user will enjoy service that is seamless regardless whether he is in the fix or wireless network.

Economic factors will also influence the positioning of wireless services. For example, cost of transmitting data via wireless systems relative to wireline will have a definite impact on the utility of wireless broadband transmission, thus its positioning. This is reflected in the my data where business will be the initial driver of using wireless for broadband transmission, applications will include e-mail and remote workgroup data sharing.
Regulations will also influence the evolution of wireless broadband networks. Regulator can influence the evolution and positioning in two ways:

1) Through the rate setting process.
2) Through spectrum allocation.

For example, through the rate setting process the regulators can influence the cost of sending data through wireless systems. Regulators may as a policy want to channel broadband traffic through on wireline for whatever reasons, thus by setting high rates, it would be prohibitive to send data by wireless systems. Through spectrum allocation regulators can also influence positioning. For example, regulators may wish to have data only transmitted in certain frequency bands, then in this scenario wireless systems will evolve through a different path.

Wireless telecommunications will contribute significantly to the development of the global information highway. Broadband services associated with the wireline networks will set the expectation of the users. Users will demand that these services be made available when they are mobile and in wireless mode, with no convenient connection to wireline.

Communications is rapidly changing from communication between places to communications between people. The mobile nature of our society will demand that
personal communication services provide the conduit for “information rich data” communications. The direct and convenient access that wireless communications facilitates will surely have a positive impact to our society.