CHAPTER III

A HISTORICAL PERSPECTIVE OF CELLULAR MARKET
INTRODUCTION

The word “Telephone” is derived from the Greek words for “far” and “sound.” Alexander Graham Bell, inventor of telephone, was born in Edinburgh, Scotland. His mother, who was deaf, was a portrait painter and musician. His father taught the deaf to speak and wrote textbooks on visible speech. In 1870, the family emigrated to Brantford, Ontario, Canada. The following year, Bell moved to Boston, where he lectured and taught elocution to deaf teachers and students. In 1873, he became a professor at Boston University. In 1874, while visiting his father in Branford, Bell realized that to transmit speech electrically he would need an “induced undulating current” or in simple words, continuous electrical waves of the same from as same sound waves.

On his return to Boston, Bell continued to work on his of improving the telegraph by making it talk. On Feb. 14, 1876, Bell’s friend and associate Gardiner Hubbard filed a patent for the talking telegraph. The patent was issued on March 7, 1876. Three days later, on March 10, 1876, Alexander Graham Bell succeeded in speaking the first sentence ever transmitted via electricity: “Mr. Watson, come here, I want you.”

The first telephone company, the Bell Telephone Company, was established on July 9, 1877. Bell always said that he would rather be remembered as a teacher of the deaf. But his invention of the telephone was so important that it will always overshadow his teaching accomplishments. Since its invention, the telephone has undergone many transformations. Some changes dealt with using new technology. Other changes have focused more on fashion, design and form. The earliest telephones came with instructions such as “when you are not talking, you should be listening.” The 1878 “Coffin” style phone used a wooden handle to transmit and receive. In 1879, the “Blake” transmitter was installed in thousands of phones. It used a battery instead of a wooden crank.
By the mid-1890s three different systems were being used to signal the operator or party. The **Magneto System** sent an electric signal by turning a crank. The common **Battery System** signaled the operator when the receiver was taken off the hook. And **Automatic System** used button or a dial to directly signal the party (which eliminated the need for an operator). By the end of the 19th century, telephone design became less decorative and more practical. In the early 1920s, upright or “Candle stick” telephones were popular in urban areas and wood-wall phones were favored in rural areas. The one-piece handset was introduced in Europe as early as the 1890s, but did not become popular in North America until well into the 1920s. In 1927, the first Cross-Atlantic phone service began (at a cost of $75 for the first three minutes). In the 1930s phones began to incorporate the ringer, network and handset into a single unit.

In the 1950s, telephone companies began offering phones in different colors. In some cases they simply painted the old phones new colors. The 1960s saw the introduction of the “Touch-Tone” phone in both desk and wall versions. At this time people did not buy their phones; phones were rented from the telephone company. In the 1970s, “Modular” connections allowed phones to be plugged into a jack. This resulted in people buying phones and a boom in telephone design and fashions. (telephoneymuseum.com)

Cell phones represent a type of technology that has been around for little over fifty years. However, it has only been recently that many people began to use cell phones as a major part of their everyday life. In the past, cell phones were used by business people to conduct their business. In today’s society, one member of every residence owns a cell phone. Cell phones are interesting, useful and play a major role in our lives by bringing people closer together and keeping in constant touch with one another.

**DEFINITION OF A CELL PHONE**

What is a cell phone? Cell phones are defined as sophisticated radios. They are a type of wireless communication device that uses many small cells with a base station and a cell phone tower at the center of each cell. These
cells have extensive frequencies that allow thousands of people to use cell phones at the same time. In this process, cellular calls are transferred from base station to base station as a user travels from cell to cell. For example, if you were traveling from a place to another place, your call would be transferred from several based stations along the way. Cellular phones use a short-wave analog or digital telecommunication in which a subscriber has a wireless connection from a mobile telephone to a relatively nearby transmitter and receiver in the base station. (searchnetworking.techtarget.com)

**HOW CELL PHONE WORK**

The major component of the cell phone system is the cell. The cell phone system divides an area of service into a set of cells on what might look like a hexagonal grid. A phone tower or base station in the center of the cell covers an area of 2 or 3 square miles around the tower. Cell phones transmit to towers, which then connects you to the normal land based telephone system to route the call. In other words, a handoff has to happen when you move from one cell to another. A typical large city has hundreds of towers and each carrier in each city runs what is called a central office, known as the Mobile Telephone Switching Office (MTSO). For example, as you drive from one city to another every couple of miles, the system hands off to another cell. You don't realize that is happening because it is not noticeable. Let us look at what happens when someone calls you. (howstuffworks.com)

First, when you power up the phone, it listens for special frequencies (control channel) that the phone and tower use to talk to one another. If there are no control channels, the phone displays a message no service, because it knows it is out of range. Second, the phone transmits a registration request, so that the MTSO keeps track of your phone location in the data base. It is important for the MTSO to know which cell you are in when it wants to ring your phone. Third, the MTSO gets the call, and it tries to find you by looking into the database to see which cell you are in. Fourth, the MTSO chooses a frequency pair that your phone will use in that cell to take the call. Fifth, the MTSO communicates with your phone over the control channel to tell it what
frequencies to use and when your phone and the tower switch on those frequencies, you are connected and talking. And sixth, as you move toward the edge of the cell, the cell tower notes a diminishing signal. The diminishing signal indicates that it is time for the control channel to hands off you to the next cell. (Brain 2001;p.205)

ANALOG AND DIGITAL SIGNALS

An analog signal has a base carrier's radio frequency signal, which is modified in some way to amplify the strength of the signal or vary the frequency to add information to the signal. An analog signal can be represented as a series signal to a signal carrier known as sine waves because carrier waves are analogous to the fluctuations of the human voice or other sound that is being transmitted. Advanced Mobile Phone System (AMPS), the first common cell phone system in the U.S., uses a range of frequencies between 824MHz and 894 MHz for analog cell phones. A Hertz (Hz) is equal to cycles per second, while a Megahertz (MHz) is equal to one million cycles per second. The frequencies chosen to be used in analog voice channels are 30 kHz wide, because it gives voice quality that is comparable to a wired telephone. The transmitter and receiver frequencies of each voice channel are separated by 45 MHz, to keep them from interfering with each other. Each carrier has 395 voice channels and 21 control channels for activities of registration and paging. Each cell only uses about one-seventh of its frequencies. This helps a hexagonal cell and the six cells in the grid to all use the frequencies. Digital cell phones use the same radio technology in a different way. For example, digital phones change voice into binary information (1 and 0) and then compress it. This compression allows ten digital phones to occupy the same frequency space as one analog cell phone.

CELL ACCESS TECHNOLOGY

Cell phone networks use three common technologies:

1. Frequency-Division Multiple Access (FDMA);
2. Time-Division Multiple Access (TDMA)


First the FDMA puts each call on a separate frequency. It separates the spectrum into distinct voice channels by splitting it into equal pieces of bandwidth and sending it out. This is used mainly for analog and not considered to be effective.

Next, TDMA assigns each cell a certain portion of time on a designated frequency. TDMA is a 30 MHz wide analog channel broken down into 6.7 millisecond time slices with each split into three time slots. Voice data is compressed to digital information with less transmission space than analog. TDMA is the access technology for the global communication system for mobile communication (GSM) and operates at 1.9 GHz in the U.S. It is used in digital cellular.

CDMA gives a unique code to each call and spreads it over the available frequencies by using spreading technology. Each phone will transmit on all the allotted frequencies. Each phone uses a different random number to decide which frequency. It will assign a code and will time stamp each signal. It uses the global positioning system (GPS) to get information. (Brain 2001; 205-206)

THE PARTS OF A CELL PHONE

If you take a cell phone apart, you find that it contains just a few individual parts, such as, an antenna, a Liquid Crystal Display (LCD), a keyboard, a microphone, a speaker, and a battery. Inside the phone there is a circuit board. The circuit board is the heart of the system. Your journey through the computer chips on the circuit board would consist of three rooms. First you would enter in room analog-to-digital and digital-to-analog conversion chips which translate the outgoing audio signal from analog to digital and the incoming signal from digital back to analog. It can process millions of calculations per second in order to compress and decompress the
voice stream. Then you would enter into the second room where the Digital Signal Processor (DSP) is located. Here in this room you would soon discover that the DSP is a highly customized processor designed to perform signal manipulation calculations at high speed. Next, you would enter the third room with the microprocessor. The microprocessor handles all the main functions for the keyboard and display, deals with command and control signaling with the base station (cell tower) and also coordinates the rest of the functions on the board. The Read Only Memory (ROM) and Flash memory chips provide storage for the phone's operating system and customizable features, such as the phone directory. The Radio Frequency (RF) and power section handles power management and recharging, and also deals with the hundreds of FM channel. Finally, the RF amplifiers handle signals traveling to and from the antenna.

THE ADVANTAGES AND DISADVANTAGES OF CELL PHONES

ADVANTAGES OF CELL PHONES

The cell phone is a wonderful invention and there are several advantages to cell phones. Cell phones have changed the way society thinks, operates and communicates. One advantage of cell phones is that it allows its users the advantage of a wider opportunity to communicate by a principle call frequency reuse. Through this principle the same frequency can be used by different cells without creating interference from other cells. Frequency can be used over and over. Cell phones operate within cells and can switch cells as the user moves around. Someone using a cell phone can drive hundreds of miles and maintain a conversation during the entire journey. In any cell, as many as fifty-six people can be talking on their cell phone at one time. This seems to be a more efficient and effective way to communicate. A second advantage of cell phones is that they are small and easy to carry around. Modern digital cell phones can process millions of calculations per second in order to compress and decompress the voice stream. Cell phones have full duplex. This means that you can use one frequency for talking and a second frequency, separate frequency for listening. Both people on a cell phone can talk at once. The cell phone can communicate on 1,664 channels or more. In
addition, cell phones (TDMA) use a dual band. This means that it can operate in both 800 MHz and 1900 MHz bands. (howstuffworks.com)

Other advantages of us cell phones are that it gives you a wide variety of functions, for example, you can store information, make task or to-do lists, keep track of appointments and set reminders. Cell phones have a built-in calculator for math, you can send, receive calls, get information for a variety of sources, such as, news, entertainment, stock quotes, play simple games. Cell phones have great influence in our everyday life and are convenient to have around. Cell phones are a faster and more effective way to transfer information. Some parents use cell phones to keep in contact with their children. Other uses it for business and to keep in contact with loved ones. Cell phones have played a vital role in bringing the world closer together. Indeed, it is an added resource that gives it user's great advantages.

DISADVANTAGES OF CELL PHONES

There are some disadvantages of owning a cell phone. Cell phones are those in which information is sent to one or more receiver by means of a modulated electromagnetic wave. Electromagnetic radiation can occur as a result of electromagnetic waves. The wavelength of electromagnetic wave determines its properties X-rays, infrared microwaves, radio waves and light waves. The frequency of an electromagnetic wave is the number of cycle that occurs in one second. (yale.edu.html-41k)

Part of the radio waves emitted by a mobile telephone handset are absorbed by the human head; the radio waves emitted by a GSM handset, for example, can have a power of up to 2 watts, and an analog phone can have 3.6 watts. Other digital mobile technologies, such as CDMA and TDMA, have today lower rates, under 1 watt. The average radiation rate of cell phones in some countries is regulated and it is mandatory to inform the consumers about it (usually printed in the battery compartment). In some systems the cell phone and the tower (radio base station) check reception quality and signal strength and the power level is increased or decreased automatically, within the above limits, such as inside buildings or vehicles, etc. The rate at which radiation is
absorbed by the human body is measured by the Specific Absorption Rate (SAR), and its maximum levels for modern handsets have been set by governmental regulating agencies in many countries. In the USA, the FCC has set a SAR limit of 1.6 W/kg for most parts of the body.

Many users of mobile handsets have reported feeling several unspecific symptoms during and after its use, such as burning and tingling sensations in the skin of the head and extremities, fatigue, sleep disturbances, dizziness, loss of mental attention, reaction times and memory retentiveness, headaches, malaise, tachycardia (heart palpitations) and disturbances of the digestive system. Some researchers, implying a causal relationship, have named this syndrome as a new diagnostic entity. The World Health Organization prefers to name it "idiopathic environmental intolerance", in order to avoid the implication of causation. This entity is quite controversial, because albeit identified in unmistakable terms by the patients who affirm to suffer from it, in some cases in such a radical way that they avoid using cell phones, it has not been recognized as a separate clinical entity by most medical researchers.

Two recent literature reviews, however, one reviewing 13 published papers in 2003 and 2004, and another reviewing 31 papers published before 2004, have concluded that there is no scientific evidence for a causal relationship between the reported clusters of symptoms and exposure to microwave radiation used in cell phones, well below the safety standards. A workshop conducted by the WHO in Prague in 2004 also reached the same conclusions, viz., that 1) reported symptoms are very unspecific and could have other causes; 2) there is no causal association demonstrated between exposure and symptoms, 3) that patients who display those symptoms should be medically examined for alternative explanations and causes, including psychiatric/psychological ones (since they are typical manifestations of stress and other psychosomatic causes), and that the environment where they work or live should be assessed in order to discover other factors at work that could explain the symptoms; and 4) lowering the safety limits for handset radiation (SAR levels) will not affect the situation.( experiencefestival.com )
There are concerns about cell phones like many other electronic devices. First, the cell phone physically has non-repairable internal parts that can corrode. For example if a cell phone gets wet, you may damage internal parts. Also, extreme heat in a car can damage the battery or the cell-phone electronics and extreme cold may cause a momentary loss of the screen display. Second, analog cell phones may have problems of cloning. Cloning means someone has stolen its ID numbers and makes long distance calls on the owner's account. Third, another disadvantage of cell phones is that it does not have the ability to provide the callers location like a land line telephone. If you do not know where you are, you can not be found, if in trouble, on a cell phone. The tower can be located, but the caller can not because cells use base stations and towers to hand off calls as the user moves from one location to another. Fourth, like all electromagnetic waves, radio waves contain vibrating, electric and magnetic fields. In free space, these electric and magnetic fields are constrained to be perpendicular to each other, and to the direction of propagation. The waves can also be polarized. For example, if the electric field vibrates only in the vertical direction, the wave is vertically polarized. This polarization will not change as the wave travels through free space. In urban areas, radio waves are usually scattered by buildings and other large objects. This type of scattering effectively creates extra polarization states in all three spatial directions at a receiving antenna.

Sometimes cell phone calls in an area of tall buildings have a great deal of interference and dropped signals. The reason is because radio signals from the cell phones and towers all reflect back and forth between buildings around us. There echoes almost overlap at the antennas, but vary on points on the wave form from each reflection caused by the differing lengths the waves travel and the effect of reflection of various surfaces. This cause a great drop in signal strength and clarity and the signal may be dropped. Other disadvantages of the cell phone exist that are noteworthy. It mentioned only a few of these, because of its important to teachers, parents, students and other educators that may teach social skills and other social interactions.
There are reasons to suspect that cell phone may cause cancer of the ear or brain tumors. The more individuals use cell phones and the greater the number of years used by them, the greater the risk of brain tumors. However, the mobile phone industry has long resisted any suggestion of a link to cancer, though it accepts that mobile phone radiation does affect the electrical activity in the brain. (emrnetwork.org)

According to the Federal Drug Administration (FDA), who requires the manufactures of wireless phones to notify users of health hazards, there is not available evidence that show that any health problems are associated with using wireless phones. There is no proof, however, that wireless phones are absolutely safe. (fda.gov/cellphone/qa.html,p.8)

Second, the extensive growth in the wireless communications industry over the past ten years has been accompanied by growing concern for the potential hazards of drivers using wireless communication devices from moving vehicles. There has been increasing concern over the safety of using communications devices while driving, particularly within the public sector. Based on the information collected, many accidents have occurred as a result of the inattention and distraction created by the use of a cellular telephone while driving. People spend substantial amounts of time commuting and members of the public place high importance on keeping up with their tasks and activities. It is fair to assume that individuals will attempt to optimize their time in the automobile by doing other things at the same time.

Third, schools seem to be getting sick of cell phones interrupting the education of students. Many school districts are banning student's use of cell phones in school. School districts and law enforcement agencies say those electronic devices are used more often than not for drug related and gang related activities. Students bringing cell phones to school have place an awesome responsibility on teachers and other educator to provide a safe and orderly environment for students because of student's access to calls in schools and especially in classrooms. Students bringing cell phones to school can be faced with too many temptations that interfere with their schooling.
Fourth, many restaurant owners are telling cell phone users not to use their cell phones in their place of business. Some business establishments and restaurants owners are getting sick of cell phones and people evading the privacy of others during lunch or dinner. People find some of these cell phone users to be annoying and sometimes disruptive. (yale.edu.html)

**MOBILE PHONE HISTORY**

Digital wireless and cellular roots go back to the 1940s when commercial mobile telephony began. Compared to today's furious pace of development, it may seem odd that wireless didn't come along sooner. There are many reasons for that. Technology, disinterest, and to some extent regulation limited early United States radio-telephone development. As the vacuum tube and the transistor made possible the early telephone network, the wireless revolution began only after low cost microprocessors and digital switching became available. And while the Bell System built the finest landline telephone system in the world, they never seemed truly committed to mobile telephony. Their wireless engineers were brilliant and keen but the System itself held them back. Federal regulations also hindered many projects but in Europe, where state run telephone companies controlled their own telecom development, although, admittedly, without competition, wireless came no sooner, and in most cases, later. Starting in 1921 in the United States mobile radios began operating at 2 MHz, just above the present A.M. radio broadcast band. These were chiefly experimental police department radios, with practical systems not implemented until the 1940s. Police and emergency services drove mobile radio pioneering, with little thought given to private telephone use.

In 1934 the United States Congress created the Federal Communications Commission [FCC]. In addition to regulating landline interstate telephone business, they also began managing the radio spectrum. It decided who would get what frequencies. It gave priority to emergency services, government agencies, utility companies, and services it thought helped the most people. Radio users like a taxi service or a tow truck dispatch company required little spectrum to conduct their business. Radio telephone
used large frequency allocations to serve a few people. The FCC designated no radio-telephone channels until after World War II.

On June 17, 1946 in Saint Louis, Missouri, AT&T and Southwestern Bell introduced the first American commercial mobile radio-telephone service. Mobiles used newly issued vehicle radio-telephone licenses granted to Southwestern Bell by the FCC. They operated on six channels in the 150 MHz band with 60 kHz channel spacing. Bad cross channel interference, something like cross talk in a landline phone, soon forced Bell to use only three channels. In a rare exception to Bell System practice, subscribers could buy their own radio sets and not AT&T's equipment. Installed high above Southwestern Bell’s headquarters at 1010 Pine Street, a centrally located antenna transmitting 250 watts paged mobiles and provided radio-telephone traffic on the downlink. Operation was straightforward, as the following describes.

How mobile telephone calls are handled? There are following steps for making a mobile telephone call:

1. Telephone customer dials 'Long Distance' and asks to be connected with the mobile services operator, to whom he gives the telephone number of the vehicle he wants to call.

2. The operator sends out a signal from the radio control terminal which causes a lamp to light and a bell to ring in the mobile unit.

3. Occupant answers his telephone, his voice traveling by radio to the nearest receiver.

4. Thence by telephone wire.

To place a call from a vehicle, the occupant merely lifts his telephone and presses a 'talk' button. This sends out a radio signal which is picked up by the nearest receiver and transmitted to the operator. The 20 watt mobile sets did not transmit back to the central tower but to one of five receivers placed across the city. Once a mobile went off hook all five receivers opened. The Mobile Telephone Service or MTS system combined signals from one or more
receivers into a unified signal, amplifying it and sending it on to the toll switchboard. This allowed roaming from one city neighborhood to another. Can't visualize how this worked? Imagine someone walking through a house with several telephones off hook. A party on the other end of the line would hear the person moving from one room to another, as each telephone gathered a part of the sound.

One party talked at a time with MTS. You pushed a handset button to talk, and then released the button to listen. (This eliminated echo problems which took years to solve before natural, full duplex communications were possible.) Mobile telephone service was not simplex operation as many writers describe, but half duplex operation. Simplex uses only one frequency to both transmit and receive. In MTS the base station frequency and mobile frequency were offset by five kHz. Privacy is one reason to do this; eavesdroppers could hear only one side of a conversation. Like a citizen's band radio, a caller searched manually for an unused frequency before placing a call. But since there were so few channels this wasn't much of a problem. This does point out radio-telephones’ greatest problem of the time: too few channels.

This system presaged many cellular developments; indeed, Bell Laboratories' D.H. Ring articulated the cellular concept one year later in an unpublished paper. Young states all the elements were known then: a network of small geographical areas called cells, a low powered transmitter in each, the cell traffic controlled by a central switch, frequencies reused by different cells and so on. Young states that from 1947 Bell teams "had faith that the means for administering and connecting to many small cells would evolve by the time they were needed." While recognizing the Laboratories' prescience, more mobile telephones were always needed. In every city where mobile telephone service was introduced waiting lists developed, growing every year. By 1976 only 545 customers in New York City had Bell System mobiles, with 3,700 customers on the waiting list. Around the country 44,000 Bell subscribers had AT&T mobiles but 20,000 people sat on five to ten year waiting lists. Despite this incredible demand it took cellular 37 years to go commercial from the
mobile phone's introduction. But the FCC's regulatory foot dragging slowed cellular as well. Until the 1980s they never made enough channels available; as late as 1978 the Bell System, the Independents, and the non-wire line carriers divided just 54 channels nationwide. That compares to the 666 channels the first AMPS systems needed to work.

In mobile telephony a channel is a pair of frequencies, one frequency to transmit on and one to receive. It makes up a circuit or a complete communication path. Yet the radio spectrum is extremely crowded. In the late 1940s little space existed at the lower frequencies most equipment used. Inefficient radios contributed to the crowding, using 60 kHz to send a signal that can now be done with 10 kHz or less. But what could you do with just six channels, no matter what the technology? Users by the scores vied for an open frequency. You had, in effect, a wireless party line, with perhaps forty subscribers fighting to place calls on each channel. Most mobile telephone systems couldn't accommodate more than 250 people. There were other problems.

Radio waves at lower frequencies travel great distances, sometimes hundreds of miles when they skip across the atmosphere. High powered transmitters gave mobiles a wide operating range but added to the dilemma. Telephone companies couldn't reuse their precious channels in nearby cities, lest they interfere with their own systems. They needed at least seventy five miles between systems before they could use them again. While better frequency reuse techniques might have helped, something doubtful with the technology of the times, the FCC held the key to opening more channels for wireless.

In 1947 AT&T began operating a "highway service", a radio-telephone offering that provided service between New York and Boston. It operated in the 35 to 44MHz band and caused interference from to time with other distant services. Even AT&T thought the system unsuccessful. In that same year the Bell System asked the FCC for more frequencies. The FCC allocated a few more channels in 1949, but gave half to other companies wanting to sell mobile telephone service.
Berresford says "these radio common carriers or RCCs, were the first FCC-created competition for the Bell System" He elaborates on the radio common carriers, a group of market driven businessmen who pushed mobile telephony in the early years further and faster than the Bell System. The telephone companies and the RCCs evolved differently in the early mobile telephone business. The telephone companies were primarily interested in providing ordinary, 'basic' telephone service to the masses and, therefore, gave scant attention to mobile services throughout the 1950s and 1960s. The RCCs were generally small entrepreneurs that were involved in several related businesses-- telephone answering services, private radio systems for taxicab and delivery companies, maritime and air-to-ground services, and 'beeper' paging services. As a class, the RCCs were more sales-oriented than the telephone companies and won many more customers; a few became rich in the paging business. The RCCs were also highly independent of each other; aside from sales, their specialty was litigation, often tying telephone companies (and each other) up in regulatory proceedings for years.

As proof of their competitiveness, the RCCs serviced 80,000 mobile units by 1978, twice as many as Bell. This growth built on a strong start, the introduction of automatic dialing in 1948. On March 1, 1948 the first fully automatic radiotelephone service began operating in Richmond, Indiana, eliminating the operator to place most calls. The Richmond Radiotelephone Company bested the Bell System by 16 years. AT&T didn't provide automated dialing for most mobiles until 1964, lagging behind automatic switching for wireless as they had done with landline telephony. (As an aside, the Bell System did not retire their last cord switchboard until 1978.) Most systems, though, RCCs included, still operated manually until the 1960s. Interestingly, some claim the Swedish Telecommunications Administration's S. Lauhrén designed the world's first automatic mobile telephone system, with a Stockholm trial starting in 1951. There is no literature to support a claim they were the first, before the 1948 Richmond Telephone Company service.

European radio-telephone unit was something similar to American installations. It was in the mid-1950 that the first phone- equipped cars took to
the road. This was in Stockholm - home of Ericsson's corporate headquarters - and the first users were a doctor-on-call and a bank-on-wheels. The apparatus consisted of receiver, transmitter and logic unit mounted in the boot of the car, with the dial and handset fixed to a board hanging over the back of the front seat. It was like driving around with a complete telephone station in the car. With all the functions of an ordinary telephone, the telephone was powered by the car battery. Rumor has it that the equipment devoured so much power that you were only able to make two calls. These first car phones were just too heavy and cumbersome and too expensive to use. It was not until the mid-1960s that new equipment using transistors were brought onto the market. Weighing a lot less and drawing not nearly so much power, mobile phones now left plenty of room in the boot - but you still needed a car to be able to move them around.

In 1956 the Bell System began providing manual radio-telephone service at 450 MHz, a new frequency band assigned to overcrowding. AT&T did not automate this service until 1969. In 1958 the innovative Richmond Radiotelephone Company improved their automatic dialing system. They added new features to it, including direct mobile to mobile communications. Other independent telephone companies and the Radio Common Carriers made similar advances to mobile-telephony throughout the 1950s and 1960s. The Independent Radio Engineer Transactions on Vehicle Communications, later renamed the IEEE Transactions on Vehicle Communications, is the publication to read during those years. In that same year the Bell System petitioned the FCC to grant 75 MHz worth of spectrum to radio-telephones in the 800 MHz band. The FCC had not yet allowed any channels below 500 MHz, where there was not enough continuous spectrum to develop an efficient radio system. Despite the Bell System's forward thinking, the FCC sat on this proposal for ten years and only considered it in 1968 when requests for more frequencies became so backlogged that they could not ignore them.

In 1964 the Bell System introduced Improved Mobile Telephone Service or IMTS, a replacement to the badly aging Mobile Telephone System. It worked in full-duplex so people didn't have to press a button to talk. Talk
went back and forth just like a regular telephone. It finally permitted direct
dialing, automatic channel selection and reduced bandwidth to 25-30 kHz.

Before leaving conventional radio telephony I should mention fraud. As telephone folks were well acquainted with landline toll fraud, begun in earnest in the late 1960s, so they were aware of wireless fraud. Here's a summary from a 1985 article in Personal Communications Technology Magazine: "The earliest form of mobile telephony, unsquelched manual Mobile Telephone Service (MTS), was vulnerable to interception and eavesdropping. To place a call, the user listened for a free channel. When he found one, he would key his microphone to for service: 'Operator, this is Mobile 1234; may I please have 555-7890.' The operator knew to submit a billing ticket for account number 1234 to pay for the call. So did anybody else listening to the channel--hence the potential for spoofing and fraud.

Squelched channel MTS hid the problem only slightly because users ordinarily didn't overhear channels being used by other parties. Fraud was still easy for those who turned off the squelch long enough to overhear account numbers. Direct-dial mobile telephone services such as Improved Mobile Telephone Service (IMTS) obscured the problem a bit more because subscriber identification was made automatically rather than by spoken exchange between caller and operator. Each time a user originated a call, the mobile telephone transmitted its identification number to the serving base station using some form of Audio Frequency Shift Keying (AFSK), which was not so easy for eavesdroppers to understand.

Committing fraud under IMTS required modification of the mobile--rest rapping of jumpers in the radio unit, or operating magic keyboard combinations in later units--to reprogram the unit to transmit an unauthorized identification number. Some mobile control heads even had convenient thumb wheel switches installed on them to facilitate easy and frequent ANI (Automatic Number Identification) changes." (privateline.com)
MODERN MOBILE PHONE NETWORKS

WHY A NEW SYSTEM?

As analogue mobile phones were gaining in popularity, it became clear that the design of the system was going to put a hard limitation on the number of mobiles and the call volume the networks could manage. There were issues with security, celebrities' taped mobile conversations being published, and increasing numbers of mobile phones being illegally "cloned". People wanted to use their mobile phones in other countries, which the analogue system did not really support.

GSM COMMITTEE

In 1982 the Conference of European Posts and Telecommunications (CEPT) formed a committee called the Group Special Mobile. This committee was to develop a standard for mobile phones that would use radio spectrum efficiently, provide international roaming, give satisfactory voice quality, have low equipment costs, be compatible with other systems such as ISDN (Integrated Services Digital Network) and be ready to support new services as they were developed. This committee worked together, designing a system which depended on technologies not available at the time, and following 1986 field tests of different radio techniques proposed for the air interface; in 1987 they produced a proposal for a TDMA system which was incorporated in an initial Memorandum of Understanding (MOU), signed by telecommunications operators from twelve countries.

In 1989 CEPT's GSM passed the specifications to the European Telecommunications Standards Institute (ETSI). The following year (1990) phase 1 of the GSM specification was published. In 1991 the first commercial GSM mobile telephone system went into service. In 1992 GSM coverage was restricted to large cities, and around airports. The networks rolled out, more countries signed up to the system, and by 1995 rural areas were seeing GSM coverage. In 1995 Phase 2 of the GSM (by now renamed to Global System for Mobiles) was published, adding additional features and services. In retrospect,
GSM was a wonderful idea, well defined, and able to incorporate new technologies as they became available. GSM is the dominant digital mobile phone service, but there are other mobile phone systems in use across the world, as well as the Total Access Communication System (TACS) previously used in the UK. A new generation of digital networks is now being brought into service, and no doubt more will follow in time. (mobileshop.org.com)

One of the first truly successful public commercial mobile phone networks was the ARP network in Finland, launched in 1971. Posthumously, ARP is sometimes viewed as a zeroth generation (0G) network, being slightly above previous proprietary and limited coverage networks. Modern mobile telephony is often considered to have started on April 3, 1973, when Motorola employee Martin Cooper placed a call to rival AT&T's Bell Labs while walking the streets of New York City talking on Motorola DynaTAC. Motorola (Motor-ola) has a long history of making automotive radio, especially two-way radios for taxicabs and police cruisers.

MOBILE HANDSET DEVELOPMENT

FIRST GENERATION (1G)

Mobile phones began to proliferate through the 1980s with the introduction of "cellular" phones based on cellular networks with multiple base stations located relatively close to each other, and protocols for the automated "handover" between two cells when a phone moved from one cell to the other. At this time analog transmission was in use in all systems. Mobile phones were somewhat larger than current ones, and at first, all were designed for permanent installation in cars (hence the term car phone). Soon, some of these bulky units were converted for use as "transportable" phones the size of a briefcase. Motorola introduced the first truly portable, hand held phone. These systems (NMT, AMPS, and TACS) later became known as first generation (1G) mobile phones. In September 1981 the first cell phone network with automatic roaming was started in Saudi Arabia; it was an NMT system. One month later the Nordic countries started an NMT network with automatic roaming between countries.
SECOND GENERATION (2G)

In the 1990s, second generation (2G) mobile phone systems such as GSM, IS-136 ("TDMA"), IDEN and IS-95 ("CDMA") began to be introduced. The first digital cellular phone call was made in the United States in 1990, in 1991 the first GSM network opened in Europe. 2G phone systems were characterised by digital circuit switched transmission and the introduction of advanced and fast phone to network signaling. In general the frequencies used by 2G systems in Europe were higher though with some overlap, for example the 900 MHz frequency range was used for both 1G and 2G systems in Europe and so such 1G systems were rapidly closed down to make space for 2G systems. In America the IS-54 standard was deployed in the same band as AMPS and displaced some of the existing analog channels.

Coinciding with the introduction of 2G systems were trends which meant that the larger "bricks" disappeared and tiny 100-200g hand-held devices became the norm. These trends included technology improvements such as better battery technologies and lower power electronics, but also are largely related to the higher density of cellular sites caused by increasing usage levels.

THIRD GENERATION (3G)

Not long after the introduction of 2G networks, projects began to develop 3G systems. Inevitably there were many different standards with different contenders pushing their own technologies. Quite differently from 2G systems, however, the meaning of 3G has been standardised in the IMT-2000 standardisation process. This process did not standardise on a technology, but rather on a set of requirements (2Mb/s maximum data rate indoors, 384Kb/s outdoors, for example). At that point, the vision of a single unified worldwide standard broke down and several different standards have been introduced.

During the development of 3G systems, 2.5G systems such as CDMA2000 1x and GPRS were developed as extensions to existing 2G
networks. These provide some of the features of 3G without fulfilling the promised high data rates or full range of multimedia services. For example, CDMA2000-1X delivers theoretical maximum data speeds of up to 307 kbit/s. Just beyond these is the EDGE system which in theory covers the requirements for a 3G system, but is so narrowly above these that any practical system would be sure to fall short. At the beginning of the 21st century, 3G mobile phone systems such as UMTS and CDMA2000 1xEV-DO have now begun to be publicly available. The final success of these systems is still to be determined. (answers.com)

CELLULAR MARKET

CONVERGENCE - BASED INNOVATION DRIVES CONSUMER DEMAND

In a world with more cellular subscribers than wire line phone subscribers, and where the first commercial mobile networks now over twenty years old, it’s possibly a little surprising that the ‘mature’ cellular handset market continues to grow at over 20 percent per year.

THE LURE OF ADDED FEATURES

A recent research report suggests that this continued phenomenal growth in wireless handset sales is being driven by manufacturers adding ‘features that consumers value and the rest of the industry can support’. Considering that, in March 2005, the UK became the 10th European country to reach 100% penetration for mobile phone ownership; the conclusion is that as consumers we just cannot resist the temptation of upgrading our cell phones to get our hands on those new features. According to leading research firm In-Stat, this behaviour will ensure that the mobile handset market continues to thrive for some years to come. The challenge for manufacturers, of course, is to identify features that will have market appeal. In the past, good fortune has played a part. No marketer could possibly predict the mass appeal of GSM SMS (texting), which has been critical in sustaining mobile operator’s revenues over the past few years. Today it’s difficult to buy a handset that doesn’t include a camera, basic organizer, games, MP3 player and, of course,
additional connectivity such as Bluetooth®. The ability to make voice calls has become almost incidental. The industry trend is ‘convergence’. Increasingly, the boundaries that define device functionality are becoming blurred. Is it a wireless PDA or a smart phone? Whatever we call it, the engineering challenge is to cram more and more sophisticated features into a small, battery-powered box.

**THE DESIGN CHALLENGE**

If the marketing people are having a tough time deciding which features will differentiate their handset, the challenge for the design team has become almost unimaginable. *Convergence means managing vastly increased complexity and performance.* While the availability of advanced silicon processes has helped, shrinking feature sizes mean that higher clock speeds are achievable, and lower supply voltages ensure that less power is consumed per transistor, though the move to advanced processes brings a whole new raft of technology and business challenges that must be addressed. Above all, these new features must be accommodated without cost and battery life going through the roof. What’s more, flexibility has become pretty important. While the marketers trade off feature sets against consumer desire, what they really want is the ability to change the specification without starting the design again. For many years the key has been to provide processors that enable designers to balance PPA: Power, Performance and Area (which is a key factor in determining the cost of a chip). Low power credentials have always been an important feature and converged mobile products clearly require a low-power architecture at the heart of the design. However, the needs of converged products now go far beyond simply meeting PPA targets. A platform for mobile product innovation will offer flexibility and design choice; for example the ability to implement a function in hardware for better performance and lower cost, or efficiently in software to accommodate changing specifications. It will recognize that multiple design constraints must be optimized together, because satisfying a single engineering parameter is not good enough. Such a platform will inevitably sit within a reference design environment, which helps the engineer through the development process,
since time to market is critical, and designers strive to deliver a product that is both competitive and works first time.

LOOKING TO THE FUTURE

A look into the future reveals convergence trends that are even more demanding in terms of design issues. Mobile TV is on the horizon, which will drive up the phones’ multimedia performance significantly. Use of the cell phone as a mobile wallet requires security to be taken more seriously. Implementing location-based services in a handset will add further complexity, but will consumers pay for it? If functions can be added without increasing cost, the design team will be applauded. The move to fixed-mobile convergence in telecoms markets has seen the introduction of handsets that are compliant with multiple cellular standards, as well as being WiFi-enabled. In terms of adding connectivity options to phones, wireless USB is just around the corner, presenting another huge market opportunity but another radio interface in the phone. All of these innovations demand something new from the embedded processors that sit inside the handsets, as well as the design infrastructure and technology platforms that engineers depend on.

When a new product is launched to the consumer market, the intellectual property within that design is typically conceived and developed at least two years in advance. Because of this, companies should work closely with partners and customers, and invest significant time and effort in working with technical bodies and standards groups to anticipate and understand the implications for tomorrow’s products. While consumers buy the latest features, ultimately advanced technology provides the platform for innovation that drives real growth in consumer technology markets. (arm.com)

CHANGING FACES OF THE GLOBAL MOBILE HANDSET

Mobile phones have gained a lot of popularity and are considered to be great multimedia tools. Mobile phones are being used for entertainment purposes due the introduction of new features everyday. They have become more than just call making and receiving devices. Mobile phone handsets now have more business-friendly applications that can enhance anybody’s business. With emerging technology, mobile phones have become more than
communication devices; they are the tools to stay ahead of competitors and peers in the present times. The mobile handset sales continue to grow worldwide, going up from 482.5 million in 2003 to 561 million in 2004. This growth rate is expected to gradually slow down over a period of five years. The estimated growth figures for these five years are—10% in 2005, 7.7% in 2006, 6.4% in 2007, 4.8% in 2008 and 2.6% in 2009. Notwithstanding the gradual decline in the growth figures, the annual handset sales are predicted to reach 767 million by 2009. Mobile handsets with innovative features have gained a lot of popularity in the developed nations. But the developing markets, which are not yet saturated, namely, India, Russia, Brazil, Mexico, and China, will mainly carry on the global handset sales. Some of the prominent companies, namely, Samsung, LG, and Sony Ericsson will see remarkable growth in this year. Though maintaining a huge gap from its nearest rival, Motorola, Nokia is expected to lose some market share in this year. (bharatbook.com)

The advent of new, data-oriented services from cellular telephone service providers has created a need for novel handset designs. Handset manufacturers now face the challenge of determining what features to implement in the next generation of handsets to capitalize on these so-called 2.5 and 3G services. At the end of 2001, over 975 million subscribers worldwide relied on mobile handsets for a portion of their daily voice communications. Due to slowing subscriber growth and the decline in revenue per user, carriers are under pressure to make the handset essential for more than just voice service to grow revenues. New-data oriented services for 2.5G and 3G handsets are sought as the solutions. Mobile handset manufacturers also see new data-oriented features as a solution to their problems. Price erosion caused average selling prices for handsets to rapidly decrease, from $226 in 1998 to $169 in 2001. A steady decline in average selling price of basic voice handsets has placed profit pressure on the manufacturers. Adding new features to handsets stabilizes falling selling prices. In addition, the decrease in handsets sold worldwide, from 415 million in 2000 to 403 million units in 2001, has handset makers looking at new features to stimulate replacement sales. (pennnet.com)

History shows that the contents of handsets have change quickly. For example, cameras in phones went from zero to over 150 million in just two
years. Other technologies can, and will, move just as fast. In-Stat/MDR has also found that:

- The number of application processors used in handsets is expected to increase dramatically, from 18.725 million this year to 92.070 million in 2008.
- The MPEG-4 chip market for handsets is ripe for growth. With not only video and camera functionality driving demand, but, eventually, Direct Broadcast (DB) services will start to appear in handsets as well, MPEG-4 chips fill the need for those mid-tier handsets supporting these services.
- By 2008, roughly 56% of all handsets shipped will have Bluetooth capability.
- Overall, while unit numbers are steadily increasing, ASPs are dropping, and add-on components to the core handset chipset won’t be able to offset this decline. (instat.com)

A recent report from Telecom Trends International pegged the worldwide wireless headset market at $117.2 billion last year, a 14.9% increase over 2004. The report predicts mobile handset revenue will peak at $129.9 billion in 2008 and then decline to $125 billion in 2012. Although the number of handsets shipped will increase from 815.2 million in 2005 to 1.7 billion in 2012, the revenue drop will occur because of falling prices, according to the report. Naqi Jaffrey, Telecom Trends chief analyst, says mobile handsets are being differentiated on the basis if functionality and their target user group. Buying decisions, he adds, are increasingly motivated by features and functionality other than voice, although voice still dominates the overall mobile hand set market. The report names Nokia, Motorola and Samsung as the top three vendors in both shipments and revenue. Together, the increased their revenue share to more than 60% last year, the report notes. Sony Ericsson was fourth in revenue, while LG was fourth in shipments.

( yale.edu.html )

**MOBILE MANUFACTURERS FACE MARKET DILEMMA**

As phones become increasingly functional, companies are trying to pitch them as 'smart devices' in order to command a premium. But will
consumers buy them at those prices? Mobile phone handsets are becoming ever more gadget ridden. Once upon a time, it was exciting enough to trade in a handset with a black-and-white screen for one with color. The latest phones, however, can support all kinds of multimedia functions. Owners can browse the Web, send e-mail, take high-quality digital photos, record video-clips, listen to the radio and download MP3 files. But as competition intensifies among network operators and mobile phone retailers, handsets are being made available at throw away prices, a phenomenon that is causing growing concern among mobile phone manufacturers. They have spent time and money developing new functions for their handsets for little extra reward. Manufacturers now face a quandary: do they continue to market their handsets as mobile phones, knowing that they will be sold in a price sensitive market controlled by the networks, or do they try to command a premium and broaden their distribution base by marketing their products as "smart devices" with gaming, personal digital assistant (PDA) and video functions? Market leader Nokia is having just such an internal debate in preparation for the launch of a range of multimedia devices, the NSeries. But it is a tough market and whatever route Nokia takes, rivals will be able to keep pace with any functionality offered by its products. At Nokia, general manager of multimedia Anssi Vanjoki is overseeing the launch of the N-Series, fuelling speculation that the device will not be marketed as a phone but as a multimedia player with phone capabilities. He has selected a handful of Interpublic Group agencies, including Lowe, to launch the product across Europe. Nokia is concerned that consumers will soon want a single device for all their wireless needs, and that it will not only have to compete against handset brands but also against the likes of Apple, HP and Microsoft. Microsoft has announced the launch of Peabody, while will offer the latest Windows software, Bluetooth, phone capability and a camera. By pitching the N-Series as a smart device, Nokia could try to give it a higher price-tag, setting it apart from rival handset companies' discounted phones and putting it up against multimedia handheld devices. The trouble with any new technology is that it takes time for consumers to understand and embrace it, says Chris Hirst, managing director of Grey London, which bandies the advertising for Nokia's N-Gage gaming console and mobile phone, which has sold
disappointingly. He adds that, as the industry trendsetter, Nokia has always launched phones and entertainment devices tailored to suit consumers' varied lifestyles and interests. But analyst Neil Mawston, associate director of wireless research company Systems Analytics, is not convinced that the way forward for handset manufacturers is to sell mobile phones as multimedia devices. "This could alienate mass market consumers, who constitute 60 per cent of the total global handset market," he says. In addition, he says, such a strategy will not prevent operators from resorting to massive subsidies every time a customer wants the latest gadget, meaning consumers will still see the devices as something to be obtained for a low up-front price. Though the number of handsets sold globally went up to 684 million last year, from 517 million in 2003. Manufacturers' profits have not kept pace. And the situation could become worse for the companies, which depend on consumers upgrading their phones to generate extra income. Systems Analytics predicts that the growth in the number of phones sold worldwide will slow from 32 per cent in 2004 to eight per cent this year. Marketing phones as multimedia devices at higher margins may not help to offset any loss as the market slows. A recent report on handsets, commissioned by Netonomy, says that consumers are often left wildered and confused by new phone technology. Only four per cent of UK consumers are considering swapping their existing mobile for a new third-generation (3G) handset, for instance. LG Mobile head of marketing at John Bernard says that although many of the company's phones are effectively multimedia devices, it has always marketed them as handsets. "It is important to keep the marketing of our handsets simple and to demystify the jargon and the acronyms. For instance, video calling with 3G is all about being able to see somebody, so one of our campaigns used the strap line 'See what they're thinking.'" But Bernard admits that in the future LG will start to sell its products "as multimedia products with the ability to make phone calls". It may be that handset manufacturers will have little choice but to do just that as technology advances. Already in South Korea trials have begun to beam television channels to special handsets. Will the likes of Nokia soon have to compete against set-top box manufacturers too? (Singh 2005; 23)