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# Wireless Telephony

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If you walk around almost any urban or suburban area and observe carefully, you may notice two related trends—almost everyone from 12 to 75 has a cell phone and seems to be using it constantly. Meanwhile, payphones are disappearing (Bunkley, 2004).

U.S. society has become dependant upon cellular technology and personal communication services (PCS), primarily for instantaneous phone conversations, but also for instant messaging, gaming, taking and sending photos, and a host of other uses. Phones have evolved from large and clunky mobile car phones in the 1970s and 1980s to slim, sleek, multifunctional devices.

## Background

The history of the cellular telephone begins with the history of mobile radio in the 1920s. The first land mobile systems were used by public safety agencies, primarily police departments. The earliest system was tested in Detroit beginning in 1921. World War II demonstrated the superiority of two-way FM transmission—only U.S. forces used significant numbers of FM battlefield systems—which proved easier to use and more difficult to jam than two-way AM systems. Surplus military radio equipment, for example the Motorola "Handie-Talkie," entered civilian life as taxi dispatch radios, particularly in New York (SRI, 1998).

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In 1947, experts marveled at the idea of a cellular phone, a new concept that could improve the coverage of existing mobile phones. Engineers realized that by using a small range of service areas (cells) with frequency reuse, they could increase the traffic capacity of mobile phones substantially (Bellis, 2004a). The technology of the day, however, was not as advanced as theory. The concept of a cellular telephone was still new, and the Federal Communications Commission (FCC) did not support the service at the time.

Lars Magnus Ericsson, founder of Ericsson in 1876, operated the first car telephone at the turn of the 20th century (Privateline, n.d.). The first major step in wireless communication came in 1912 with the passage of the *Radio Act of 1912* by the U.S. government. This law required stations and operators to apply for licenses in order to get on the air. Bell Laboratories is said to have invented the first version of a mobile, two-way, voice-based radio telephone in 1924 (Privateline, n.d.). On March 1, 1948, the first fully automatic radiotelephone service began operating in Richmond (Indiana), eliminating the requirement for a human operator to place calls. Some researchers claim the Swedish Telecommunications Administration's S. Lauhren designed the world's first automatic mobile telephone system, with a Stockholm trial in 1951 (Privateline, n.d.).

The late 1940s were important years for mobile radio. AT&T introduced the first commercial land mobile radio telephone system in St. Louis in 1946. However, the service was limited by a lack of communication channels (frequencies), and the system was cumbersome to use, with "push to talk" features and manual connections via human operator. Nonetheless, 25 U.S. cities had mobile service by year's end (SRI, n.d.).

Later that year, the FCC decided to make available separate radio frequencies for mobile calling. However, the commission only allowed 23 cell phone conversations in any given calling area (Cell phones, n.d.). During the 1950s, the FCC declined to allocate significant frequencies for mobile radio (cellular phones). This resulted in limited research and development in the field. However, scientists and engineers at Bell Labs continued limited investigation into the cellular concept and published several internal papers on the topic (SRI, n.d.).

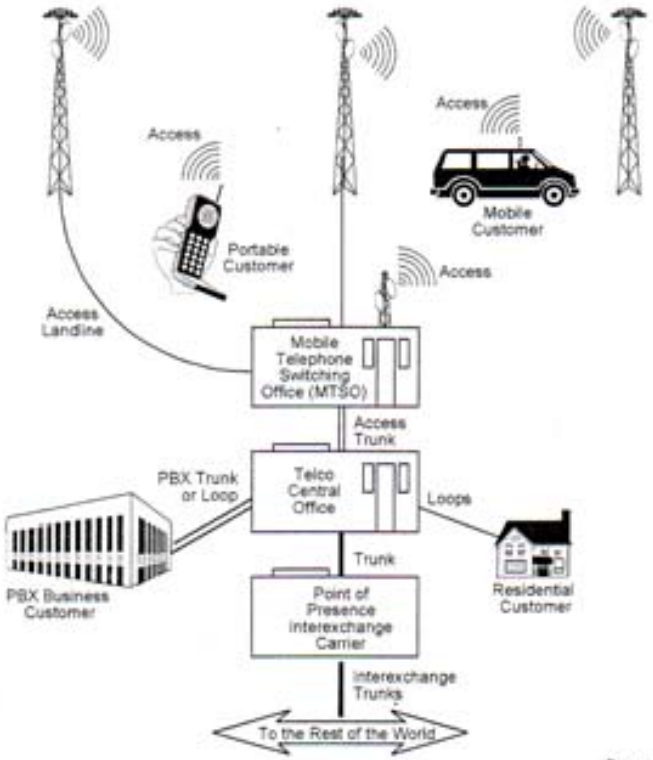
Two decades passed with limited growth in the area of cellular telephony. Public radiophone testing began in 1977 with a trial run of service in Chicago. Bell signed up 2,000 customers for this initial run. This was soon followed by trial service in Washington, DC and Baltimore by American Radio Telephone Service, Inc. (ARTS) (a progenitor of CellularOne), in partnership with Motorola (Cell phones, n.d.; SRI, n.d.). In 1979, the first commercial cellular system was installed by NTT in Tokyo. From there, the concept of cellular technology took off. In 1983, both the Illinois Bell and ARTS trial services began regular commercial operation. Technology was, to say the least, both rudimentary and expensive. Motorola shipped the first commercial portable cellular telephone in 1984 with the suggested retail price of $3,000 to $4,000. Initial systems were big, bulky bag phones and equally large car phones. Competition first entered the arena in 1984 in Washington, DC. Services were popular with businesses and upper-income individuals. Basic analog cellular services grew tremendously in the 1980s. By 1988, cellular systems in Los Angeles and New York had become overloaded by high demand.

In 1990, there were an estimated five million cellular subscribers. By 1995, the number quintupled to over 25 million subscribers and, by 1997, it was estimated to be over 50 million subscribers. According to the Cellular Telecommunications & Internet Association (CTIA), a trade organization,

the number of U.S. cellular subscribers was nearly 117 million by 2002 (Robinson, 2002). This number jumped to 155 million by the end of 2003 and has been projected to climb to over 245 million by 2007 (Matteo, 2004).

One of the reasons cell phones were adopted so quickly was because all mobile telephones are interconnected with the public switched telephone network (PSTN). Because of that connection, all wireless phone adopters can immediately reach or be reached by anyone with a phone. Figure 25.1 shows cellular telephone network architecture. Users make a call, and the cell phone tower relays the signal to the mobile telephone switching office (MTSO). If the call is going to another wireless customer, it is routed to the recipient's cell phone through the corresponding tower. If the call is to someone on a landline phone, the signal is routed from the MTSO to the PSTN through an access trunk.

Figure 25.1
Cellular Telephone Network Architecture




*Source*: Technology Futures, Inc.

Although cell phones are thought of as an added convenience by many people, they have also been labeled a nuisance by many others. Legislators in many states are trying to ban the use of cell phones while driving. For example, in 2001, New York banned talking on hand-held phones while driving (Robinson, 2002).

The cellular telecommunications industry is facing other battles, as well. The Food and Drug Administration (FDA) has issued warnings of health risks possibly linked to excessive use of cell phones, ranging from headaches to brain tumors. Testing is still being conducted, and no conclusive evidence of health risks from cellular telephone transmissions has been found.

April 3, 2003 marked the 30th anniversary of the first cellular phone call made by Martin Cooper, now chairman, chief executive officer, and co-founder of ArrayComm, Inc. He placed the call on April 3, 1973 when he was general manager of Motorola's Communications Systems Division. Who did he call? He called one of his rival's at AT&T's Bell Labs from the streets of New York City (Bellis, 2004b).

## Recent Developments

Actions and events that took place since the beginning of 2003 will drastically affect the future development of cell phone service, technological advances, and costs to the consumer. On February 17, 2004, AT&T Wireless agreed to be acquired by Cingular, to the tune of $41 billion (Cingular agrees, 2004). The combined entity will have $32 billion per year revenue, subscribers in 49 states, and 97% of top market service. Other companies such as Sprint PCS are predicted to "ramp up" to handle the competition. A merger of Verizon and Sprint's wireless divisions could be a possible outcome (Shafer, 2004). Cingular's action happens in a period when telecom stocks are performing well on the market. Consumer groups believe that the deal will negatively impact customers—some say mergers create poorer service; others say less competition equals higher prices. Industry insiders, of course, say otherwise.

Interestingly, business deals in early 2004 have taken on an international flavor. In a reaction to the (at the time) proposed AT&T/Cingular merger, Japan's largest cellular outfit, NTT DoCoMo, made overtures to negotiate with Cingular (they had been a sizable stakeholder in AT&T since 2000) (Williams, 2004).

Another important development is mobile number portability (MNP). This hot-button issue garnered much controversy and discussion in the press from late 2003 through mid-2004. MNP was mandated in the United States beginning on November 24, 2003. The decision was quite expensive and resulted in over 7,000 complaints as of April 2004 (Kimball, 2004). The FCC ruling stipulates that companies in various areas must allow consumers to retain their phone number if they decide to switch from hard to wireless lines (or vice versa), and that they can also take their numbers from one wireless carrier to another (CTIA, n.d.). Attorneys for Verizon and a trade association tried to halt the measure, saying the FCC was overstepping its bounds (Court won't halt, 2003). Verizon eventually bowed out of the fight, which may have been a factor in pushing the decision through.

The decision produced no immediate rush of customer switching, as was predicted. Just over one million took advantage. As one observer said, only "those in pain" ported. Early adopters experienced technical difficulties. The supposed three-hour switching procedure often was slow, or did not work properly. AT&T Wireless lost the most subscribers to competitors.

In the months surrounding the portability decision, predictions surfaced as to the long-term effects on both price and service. In a thorough listing of the possible effects of portability, San Diego

wireless consulting firm inCode warned that telemarketers could easily infiltrate switched cell numbers because of the way the portable technology works (inCode releases, 2003).

Cellular providers are also implementing a litany of technical advances. Wireless data transmission may be the most important. Transmission of data (anything other than voice) constitutes only 3% of cellular industry revenue as of mid-2004 (of an annual $81 billion) (Trewyn, 2004). Data includes photos, motion graphics, text, games, and the World Wide Web.

New developments are also occurring on the hardware side. A significant problem with wireless phones is battery life. Direct-methanol fuel cells are a point of discussion among technologists (Ashok, 2003). At present, the technology boasts three times the life of conventional power supplies (PolyFuel delivers, 2004). In a minor but interesting note, Celldar—a passive technology that is part cellular and part radar—is emerging, and is discussed mainly in terms of military applications (Port, 2003). In development since 1997, the technology could be used to track how signals from cell phone base stations interact with objects such as cars, trucks, or planes. Minor but interesting hardware entries include a Bluetooth wireless headset that connects Bluetooth-enabled cell phones to a wireless hands-free environment (Cardo launches, n.d.).

## Current Status

Despite the economic slowdown after the "dot com crash," cell phone use continues to grow, particularly among young adults. Competition and legislation are driving the cost of service down, even as technological advancements increase the availability of a wide variety of enhanced services such as color Web browsing, e-mail, and file transfer. Cell phone penetration in the United States continues to grow, even though it lags behind Europe and Japan. The most recent report by Scarborough Research shows that national average penetration in 2003 was 66%, a growth rate of over 30% since 1999. Many larger cities such as Houston, Miami, and Atlanta had broken 70% penetration (McFarland & Mongrain, 2003). From culture to culture, it seems that cell phone "have-nots" tend to be older, more likely female, and with lower education and household income than "haves" (Leung & Wei, 1999).

Time spent using cell phones appears to be on the rise, but research has pointed out the disparity between self-report measures of cell phone use and real-time observance of usage levels (Cohen & Lemish, 2003). Although there were predictions of a small (9%) adoption rate among adults overall, the growth trend seems to be in the adolescent (12 to 17) and younger adult (18 to 24) segments of the market (Charny, 2002; McFarland & Mongrain, 2002; McVicker, 2001; Wrolstad, 2002). The youth market—currently with a penetration rate of only 25%, but growing fast—is considered a "gold mine" of opportunities to increase flagging industry profits (Charny, 2002; McVicker, 2002).

U.S. mobile phone subscribers predominantly fall into one of two categories: 800 MHz cellular and 1900 MHz PCS. The primary digital technology in the United States is CDMA (code division multiple access), although GSM (global system for mobile communication) is popular in other regions of the world and gaining here. AT&T Wireless uses GSM. Worldwide, both technologies are replacing analog. This is happening a bit more slowly in the United States where a large analog cell phone base arose before the development of digital cellular technologies (Robbins & Turner, 2002). While the trend toward digital service continues to rise, there is a significant analog infrastructure that

is both costly to replace and, interestingly, utilizes a system that requires fewer towers. While providers scramble to upgrade their networks, companies such as Analog Devices work to reduce infrastructure costs while improving signal service (Analog Devices launches, 2004).

Enhanced 911 services are being implemented that provide emergency services with the caller's location. This technology uses a variant of the global positioning system (GPS) to identify a caller's location, which is a significant advance from the previous system that could only give the location of the tower closest to the person making a cellular phone call. One concern is that the service essentially makes cell phone homing devices that could allow the government and others to track someone's every move (Robbins & Turner, 2002).

Even as mobile phone penetration has increased in the United States, user demographics have changed. Women now represent the majority of U.S. cell phone users. The mean age and income level of cell phone users has also declined over the years (McFarland, 2002; Robbins & Turner, 2002), contrary to research done earlier in the adoption cycle of the cell phone and in other cultures (e.g., Leung & Wei, 1999). The primary reason for use appears to have shifted from business to personal communication (McFarland, 2002; Robbins & Turner, 2002). Growth and penetration trends seem to lean toward younger potential customers. People most likely to fail to adopt cell phones now or in the future tend to be much older, have a lower education, and no children (Leung & Wei, 1999; Robbins & Turner, 2002). These trends become more pronounced when looking at potential users of advanced cell phone technologies—such as text messaging and Internet access—that go beyond the confines of conventional voice communication (Robbins & Turner, 2002).

Prepaid phone cards have made it even easier for adolescents and young adults to obtain cell phone service despite limited funding and essentially no line of credit. The purchase of these cards—often the responsibility of the adolescent, not his or her parent—has increased the accessibility of cell phones to this demographic, while alleviating the concerns of parents that their children will use excessive amount of minutes, resulting in an extremely high bill at the end of the month (Ling & Yttri, 2002). Limited adolescent finances appear to have also resulted in their making strategic communication choices such as waiting until "nighttime" minutes (often unlimited) start or sending text messages that do not count against daytime minutes.

Although usage overall is certainly up, research is showing that much use is concentrated on interpersonal voice communication. A recent study of college-aged cell phone users shows that predominant usage patterns centered around features such as caller ID, voice messaging, call screening, and voice communication. These early adopters of new technologies and features had little interest in games, cameras, and other high-tech features (Auter, 2004).

## Factors to Watch

Cell phone penetration in the United States should continue to increase dramatically as companies target younger and younger users as well as traditional technology laggards. In the second quarter of 2002, mobile worldwide phone sales jumped .8%. A 2003 report by In-Stat/MDR predicted that, despite the sluggishness at the time of writing, there will be more than 931 million new subscribers over the next five years. This is echoed by forecasts from the Semiconductor Industry Association—

they reported in January 2004 that cell phone sales would increase by 10% and cameras by 14% (Davis, 2003).

The hot-button issues and gadgets of the next wave center around 3G technology. 3G networks have a standard, IMT-2000 (International Mobile Communications 2000 Initiative) issued by the ITU in 1999. Table 25.1 reviews the important capabilities of 3G systems including data transmission rates up to 2 Mb/s. As of January 2004, it was reported that wireless carries are working overtime to "upgrade their networks" to meet 3G standards, which consist of five operating modes, including three based on CDMA technology.

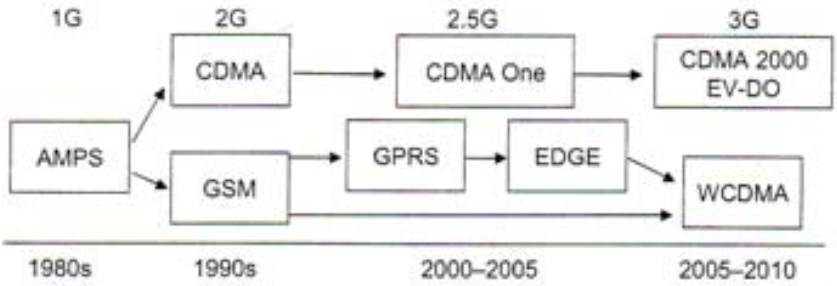
The migration from 2G digital standards (CDMA, GSM) to 3G standards is difficult. There is an intermediate step, referred to as 2.5G. These services are digital like 2G, but they employ packet switched data transmission. GSM networks use GRPS for 2.5G and will go to EDGE and W-CDMA (wideband CDMA) for 3G. CDMA networks migrate to cdmaOne for 2.5G and cdma2000 or EV-DO for 3G. Figure 23.2 reviews the migration to 3G.

Table 25.1
3G System Capabilities

| |
|---|
| Capability to support circuit and packet data at high bit rates: |
| 144 kilobits/second or higher in high mobility (vehicular) traffic |
| 384 kilobits/second for pedestrian traffic |
| 2 Megabits/second or higher for indoor traffic |
| Interoperability and roaming |
| Common billing/user profiles: |
| Sharing of usage/rate information between service providers |
| Standardized call detail recording |
| Standardized user profiles |
| Capability to determine geographic position of mobiles and report it to both the network and the mobile terminal |
| Support of multimedia services/capabilities: |
| Fixed and variable rate bit traffic |
| Bandwidth on demand |
| Asymmetric data rates in the forward and reverse links |
| Multimedia mail store and forward |
| Broadband access up to 2 Megabits/second |

*Source*: FCC

Figure 25.2
3G Migration




*Source*: J. Meadows

These upgrades are packet-based and are at the center of advanced wireless networks. CDMA is used by 71 million people in the United States; GSM is used by 22 million. The new standard, EV-DO (evolution-data optimized), is planned for national introduction (as of January 27, 2004) by Verizon in late 2004. It is actually a data only system; it requires a "dedicated slice of spectrum," but is exceedingly fast at 300 Kb/s to 600 Kb/s. Sprint has picked a similar technology, EV-DV, which handles data and voice. The EVs up the ante on quality and quantity. GRPS (General Radio Packet Service) has been in use by AT&T wireless since 2002 and provides speeds up to 144 Kb/s.

The advent and proliferation of these wireless standards facilitates the convergence of multiple applications and technologies into a single unit.

There are many newfangled applications and hardware that could be converged including camera phones with up to 640 pixels, video streaming, tracking devices, GPS, e-mail attached animation, and complex role-playing games. Indeed, six million camera phones were sold in the United States in 2003, and cameras are predicted to be standard on all phones in 2005. Three-dimensional content—primarily games—is also on the horizon (ATI Technologies Inc., 2004). In its ultimate expression, users could interface with home appliances with the wireless phone as a remote control. Companies such as BlueTie, Incorporated are working on ways to allow cell phone users to secure real-time access to business data (BlueTie Inc., 2004).

Not everyone is banking on convergence though. Some are leery of too much technology shoved into one tiny package, and a recent survey found that many consumers want more practical applications such as services that provide step-by-step instructions.

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