Appendix

A Brief History of Wireless Telephony

The public wireless telephony business has seen a number of significant changes throughout its fifty-year life. The first systems offering mobile telephone service (car phone) were introduced in the late 1940s in the United States and in the early 1950s in Europe. Those early single cell systems were severely constrained by restricted mobility, low capacity, limited service and poor speech quality. The equipment was heavy, bulky, expensive and susceptible to interference. Because of those limitations, less than one million subscribers were registered worldwide by the early 1980s.

First Generation (1G): Analog Cellular

The introduction of cellular systems in the early 1980s represented a quantum leap in mobile communication (especially in capacity and mobility). Semiconductor technology and microprocessors made smaller, lighter weight and more sophisticated mobile systems a practical reality for many more users. These "1G" cellular systems carry only analog voice or data information. The most prominent 1G systems are Advanced Mobile Phone System (AMPS), Nordic Mobile Telephone (NMT) and Total Access Communication System (TACS). With the 1G introduction, the mobile market grew to nearly 20 million subscribers by 1990.

Second Generation (2G): Multiple Digital Systems

Since 1990, the industry has been rapidly shifting from analog to digital communications standards. "2G" digital systems introduced smaller handsets, enhanced services and improved transmission quality, system capacity and coverage. 2G cellular systems include GSM, IS-136 (TDMA), cdmaOne and Personal Digital Communication (PDC). By 1998, multiple 1G and 2G mobile communications systems were serving hundreds of millions of cellular subscribers, worldwide. Speech transmission still dominated the airways, but the growing demands for fax, short message and data transmissions called for further enhancements to the systems.

Evolution to the 3rd Generation: 2.5G and IMT-2000

The phenomenal growth of wireless technology has created a complex landscape of services and regional systems. Different standards serve different applications with different levels of mobility, capability and service area (paging systems, cordless telephone, wireless local loop, private mobile radio, cellular systems and mobile satellite systems). In 1998, standards developing organizations (SDO's) around the world addressed the multiplicity of standards and performance limitations in existing systems with definitions of a new 3rd Generation (3G) of standards.

The objective of 3G standards, known collectively as IMT–2000, was to create a single family of compatible definitions that have the following characteristics:

- used worldwide
- used for all mobile applications
- support both packet-switched (PS) and circuit-switched (CS) data transmission
- offer high data rates up to 2 Mbps (depending on mobility/velocity)
- offer high spectrum efficiency

IMT stands for International Mobile Telecommunications and "2000" represents both the year for initial trial systems and the frequency range of 2000 MHz. In total, proposals for 17 different IMT–2000 standards for various aspects of wireless systems were submitted by regional SDO's to International Telecommunications Union (ITU). All 17 proposals were refined and adopted by ITU and the specification for the Radio Transmission Technology (RTT) was released at the end of 1999. 3G systems are expected to be phased in over the coming ten years and will coexist with 1G and 2G systems in most locations.

As the wireless world evolves into 3G, existing systems continue to be enhanced with the introduction of IS-95 revisions to add intelligent network data transmission services and to improve the performance of both voice and data transmissions.

Access Methods for Wireless Communications

Subscriber access to each of the wireless cellular systems is provided by one of several types of RF transceiver systems. In analog cellular systems, such as AMPS, each user occupies a unique transmit and receive frequency, a method known as Frequency Division Multiple Access (FDMA). In digital Time Division Multiple Access (TDMA) systems, such as GSM, individual users occupy time slots on a given frequency; each user has a unique period of time for receiving the transmission from the base station. In Code Division Multiple Access (CDMA) digital systems, each user is assigned a unique digital code that is used to modulate the RF carrier with multiple users, sharing the same transmission signal in any given period. Diagrams of each method are shown in Figure 10.

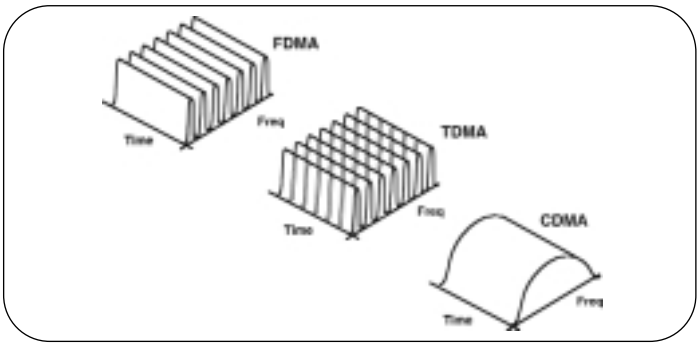

Figure 10. *Basic waveform structures of FDMA, TDMA and CDMA signals.*

In analog FDMA systems, the user occupies one frequency channel (30 kHz bandwidth for AMPS) for transmission and another for reception. These transmit/receive channels are dedicated for the duration of a phone call, so they are unavailable for further use until the call has been completed. During peak hours, subscribers are often unable to access the system, which results in lost revenue for a network operator and frustration for the user.

Digital systems, such as TDMA and CDMA, offer far greater efficiency than FDMA. In both methods, the caller's speech is converted to a digital bit stream that can be more easily manipulated and compressed to increase capacity and improve utilization.

TDMA systems subdivide a given frequency channel bandwidth into time slots. This compression allows more conversations to occupy the same frequency space. In IS-136, for example, a 30 kHz frequency bandwidth is divided into multiple time slots with each slot allocated to a specific user. In this way, multiple users can share the same duplex pair simultaneously. IS-136 and GSM are popular systems that use a TDMA access method.

CDMA systems use a much broader bandwidth than either FDMA or TDMA systems. Instead of dividing users by frequency or time slot, the system assigns a unique digital code to each user and transmits that code along with the conversation. When the receiver applies the correct code, the appropriate conversation of that user is extracted and reconstructed. In a CDMA system, multiple users' signals occupy the same RF frequency band at the same time. The layer of unique user codes is used to identify each of the multiple users in the transmission.