

**FOURTH EDITION**

# Computer Networks

# ANDREW S. TANENBAUM



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Fourth Edition

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## 2.6 THE MOBILE TELEPHONE SYSTEM

The traditional telephone system (even if it some day gets multigigabit end-to-end fiber) will still not be able to satisfy a growing group of users: people on the go. People now expect to make phone calls from airplanes, cars, swimming pools, and while jogging in the park. Within a few years they will also expect to send e-mail and surf the Web from all these locations and more. Consequently, there is a tremendous amount of interest in wireless telephony. In the following sections we will study this topic in some detail.

Wireless telephones come in two basic varieties: cordless phones and mobile phones (sometimes called **cell phones**). **Cordless phones** are devices consisting of a base station and a handset sold as a set for use within the home. These are never used for networking, so we will not examine them further. Instead we will concentrate on the mobile system, which is used for wide area voice and data communication.

**Mobile phones** have gone through three distinct generations, with different technologies:

1. Analog voice.
2. Digital voice.
3. Digital voice and data (Internet, e-mail, etc.).

Although most of our discussion will be about the technology of these systems, it is interesting to note how political and tiny marketing decisions can have a huge impact. The first mobile system was devised in the U.S. by AT&T and mandated for the whole country by the FCC. As a result, the entire U.S. had a single (analog) system and a mobile phone purchased in California also worked in New York. In contrast, when mobile came to Europe, every country devised its own system, which resulted in a fiasco.

Europe learned from its mistake and when digital came around, the government-run PTTs got together and standardized on a single system (GSM), so any European mobile phone will work anywhere in Europe. By then, the U.S. had decided that government should not be in the standardization business, so it left digital to the marketplace. This decision resulted in different equipment manufacturers producing different kinds of mobile phones. As a consequence, the U.S. now has two major incompatible digital mobile phone systems in operation (plus one minor one).

Despite an initial lead by the U.S., mobile phone ownership and usage in Europe is now far greater than in the U.S. Having a single system for all of Europe is part of the reason, but there is more. A second area where the U.S. and Europe differed is in the humble matter of phone numbers. In the U.S. mobile phones are mixed in with regular (fixed) telephones. Thus, there is no way for a



caller to see if, say, (212) 234-5678 is a fixed telephone (cheap or free call) or a mobile phone (expensive call). To keep people from getting nervous about using the telephone, the telephone companies decided to make the mobile phone owner pay for incoming calls. As a consequence, many people hesitated to buy a mobile phone for fear of running up a big bill by just receiving calls. In Europe, mobile phones have a special area code (analogous to 800 and 900 numbers) so they are instantly recognizable. Consequently, the usual rule of "caller pays" also applies to mobile phones in Europe (except for international calls where costs are split).

A third issue that has had a large impact on adoption is the widespread use of prepaid mobile phones in Europe (up to 75% in some areas). These can be purchased in many stores with no more formality than buying a radio. You pay and you go. They are preloaded with, for example, 20 or 50 euro and can be recharged (using a secret PIN code) when the balance drops to zero. As a consequence, practically every teenager and many small children in Europe have (usually prepaid) mobile phones so their parents can locate them, without the danger of the child running up a huge bill. If the mobile phone is used only occasionally, its use is essentially free since there is no monthly charge or charge for incoming calls.

### 2.6.1 First-Generation Mobile Phones: Analog Voice

Enough about the politics and marketing aspects of mobile phones. Now let us look at the technology, starting with the earliest system. Mobile radiotelephones were used sporadically for maritime and military communication during the early decades of the 20th century. In 1946, the first system for car-based telephones was set up in St. Louis. This system used a single large transmitter on top of a tall building and had a single channel, used for both sending and receiving. To talk, the user had to push a button that enabled the transmitter and disabled the receiver. Such systems, known as **push-to-talk systems**, were installed in several cities beginning in the late 1950s. CB-radio, taxis, and police cars on television programs often use this technology.

In the 1960s, **IMTS (Improved Mobile Telephone System)** was installed. It, too, used a high-powered (200-watt) transmitter, on top of a hill, but now had two frequencies, one for sending and one for receiving, so the push-to-talk button was no longer needed. Since all communication from the mobile telephones went inbound on a different channel than the outbound signals, the mobile users could not hear each other (unlike the push-to-talk system used in taxis).

IMTS supported 23 channels spread out from 150 MHz to 450 MHz. Due to the small number of channels, users often had to wait a long time before getting a dial tone. Also, due to the large power of the hilltop transmitter, adjacent systems had to be several hundred kilometers apart to avoid interference. All in all, the limited capacity made the system impractical.

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