

MOBILE COMMUNICATIONS SERIES

AN INTRODUCTION TO GSM



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CHAPTER 3

GSM—A DIGITAL CELLULAR MOBILE RADIO SYSTEM

Different requirements and the dedication to meet them led to the development of the GSM standard. An unprecedented effort has been taken by telecommunication authorities, network operators, and industry sectors to establish and maintain a state-of-the-art cellular standard for the benefit of the entire industry and all its customers.

In this chapter, we confine our focus to GSM. We start with a brief review of its history and then follow with the evolution of the GSM standard and its worldwide adoption. We include a description of some of the services offered by a GSM public land mobile network (PLMN), and introduce some basic terms and the general architecture of a cellular network. Also introduced are the new terms and the components of a GSM system, and which come from the structure and operation of analog networks, which may already be known to the reader. We focus especially on security features inherent in a GSM network.

A brief note concerning the term GSM is in order now. Since GSM stands for *global system for mobile communications*, it is redundant to say "GSM system," for this would mean we said "global system for mobile communications system." However, since terms such as *GSM system* are widely used in the industry, it is common to be redundant when using system abbreviations (e.g., ISDN network), since the redundancy in such terms has some clarifying effect. This book will use both the redundant and nonredundant forms with reckless abandon.

3.1 DEVELOPMENT AND INTRODUCTION OF THE GSM STANDARD

In Table 3.1, the milestones in the course of establishing the GSM system specifications and the spread of GSM over the globe are listed [1].

When looking only at the adoption of the GSM standard in Europe, it becomes clear that the unification of cellular mobile radio will finally become a reality. Figure 3.1 illustrates this.

Words cannot easily express the tireless efforts expended to propel the development of the GSM standard, design a network architecture, test and verify technical parameters, prove functionalities, promote the system itself, and design and manufacture the necessary equipment. What we see today is the result of this work.

With teamwork to an extent never before seen in Europe in the whole industry, in administrations and their national or international institutes, and among operators and manufacturers, a rich and detailed standard for a promising, future-proof mobile communications system has been developed.

The new standard has given new momentum to the economy and has created new markets. A common standard for a market whose customers number in the tens of millions leads to minimized costs for the manufacturers of appropriate equipment. They can produce larger numbers of terminals for a large market, which drives down the cost to end users. Together with deregulation, the provision of cellular service means competition, again to the benefit of end users. Tariffs, products, and services become subject to the higher dynamics imposed by this competition.

New services and features, especially the *roaming* and *security* features, as well as the digital advantages, such as reduced power consumption (state-of-the-art semiconductor devices, TDMA technology) and improved speech quality are the keys that convince network operators and potential subscribers to choose GSM. Other attractive features and services, which have not yet appeared in any cellular network, are waiting in line (see following paragraphs).

The standardization work is not yet finished. It will be continued for years to come. The GSM standard can be regarded as an evolving standard. Today, networks are already operational, but to what extent does the equipment and the provision of cellular services comply with the standard? When it became obvious that the whole standardization process could not be completed before an actual launch of the services—necessary because of economic factors—a phased approach to rolling out the specifications and the networks was adopted. This meant that a *subset* of network features was to be introduced. The reduced features were initially designed to be upwardly compatible *add-ons* of services and functions. The subset was called *GSM Phase 1*. The additional supplements to full implementation of all the planned services and network features were called *GSM Phase 2*. Now, there is even thought given to features beyond Phase 2. These future implementations are known by the term *Phase 2+*. The networks, which are operational now, feature GSM Phase 1, whose specifications were frozen as early as 1991. GSM Phase 2 specifications and

Development and Spread of GSM	
Year	Event
1982	CEPT decides to establish a group (GSM) to develop a standard for European cellular mobile communications.
1984	Establishment of three Working Groups (WG1, WG2, WG3) to develop the specifications for the services offered in a GSM system.
1985	signaling protocols, interworking with other systems.
1986	Discussion and adoption of the GSM standard by the group >100 recommendations.
1987	A so-called <i>permanent</i> maintenance group, which is intensely working, which is intensely working.
1987	Initial Memorandum of Understanding (MoU) between network operator organizations.
1988	Major objectives: • Coordinating the introduction of GSM. • Planning of service introduction. • Routing, billing, and tariffing.
1988/89	Validations and trials (partially in the field).
1990/1991	With the establishment of the European Telecommunications Standards Institute (ETSI), the specifications are finalized. GSM becomes a standard.
1991/1992	GSM groups 1-4, later 5, which are technical specifications eventually become the European Telecommunications Standards Institute (ETSI) specifications. GSM finally standardized.
1990	The GSM specifications for the <i>Cellular System</i> on the 900 MHz band are application initiated in the field.
1991	The GSM Recommendation for the <i>Mobile System</i> on the 900 MHz band, including more than 5,000 pages of specifications.
1991	July: Planned commercial launch of GSM in Europe is delayed to 1992 because of technical problems (GSM then stands for <i>Global System for Mobile communications</i>).
1992	Official commercial launch of GSM in Europe.
1993	The GSM-MoU has 62 member states. In addition 32 potential member states are countries [2].
1993	The end of 1993 shows over 100 million mobile phones more than 80% of them are GSM.

Table 3.1
Development and Spread of the GSM Standard

Year	Events/Decisions/Achievements
1982	CEPT decides to establish a <i>Groupe Spéciale Mobile</i> (the initial origin of the term GSM) to develop a set of common standards for a future pan-European cellular mobile network.
1984	Establishment of three <i>Working Parties</i> (WP1-3) to define and describe the services offered in a GSM PLMN, the radio interface, transmission, signaling protocols, interfaces, and network architecture.
1985	Discussion and adoption of a list of recommendations to be generated by the group >100 recommendations in a series of 12 volumes).
1986	A so-called <i>permanent nucleus</i> is established to continuously coordinate the work, which is intensely supported by industry delegates.
1987	Initial <i>Memorandum of Understanding</i> (MoU) signed by telecommunication network operator organizations (representing 12 countries). Major objectives: • Coordinating the introduction of the standard and time scales • Planning of service introduction • Routing, billing, and tariff coordination
1988	Validations and trials (particularly the radio interface) show that GSM will work.
1988/89 to 1991/1992	With the establishment of the <i>European Telecommunications Standards Institute</i> (ETSI), the specification work was moved to this international body. GSM becomes a <i>technical committee</i> within ETSI and splits up into GSM groups 1-4, later called <i>Special Mobile Groups</i> (SMG) 1-4, which are technical subcommittees. Recommendations and Technical Specifications eventually become <i>Interim European Telecommunications Standards</i> (I-ETS), and after approval will become <i>European Telecommunications Standards</i> (ETS) some time in the future. GSM finally stands for <i>Global System for Mobile Communications</i> .
1990	The GSM specifications for the 900-MHz band are also applied to a <i>Digital Cellular System</i> on the 1,800-MHz band (DCS 1800), a PCN application initiated in the United Kingdom.
1991	The GSM Recommendations comprise more than 130 single documents including more than 5,000 pages.
1991	July: Planned commercial launch of GSM service in Europe (MoU plan) delayed to 1992 because of nonavailability of type-approved terminals (GSM then stands for <i>God Send Mobiles</i>).
1992	Official commercial launch of GSM service in Europe (<i>God Has Sent Mobiles</i>).
1993	The GSM-MoU has 62 members (<i>signatories</i>) in 39 countries worldwide. In addition 32 potential members (<i>observers/applicants</i>) in 19 other countries [2].
1993	The end of 1993 shows one million subscribers to GSM networks; however, more than 80% of them are to be found in Germany alone.

(continued)

Table 3.1
Development and Spread of the GSM Standard (*continued*)

1993	First commercial services also start outside Europe: Australia, Hong Kong, New Zealand. GSM networks are operational in Denmark, Finland, France, Greece, Ireland, Italy, Luxembourg, Norway, Portugal, Sweden, Switzerland, United Kingdom [2].
1994 onwards	GSM services can be expected in the following additional countries: Andorra, Austria, Belgium, Brunei, Cameroon, Cyprus, Estonia, Iceland, Iran, Kuwait, Latvia, Malaysia, Netherlands, Pakistan, Qatar, Singapore, South Africa, Spain, Syria, Thailand, Turkey, United Arab Emirates, and many others [2].

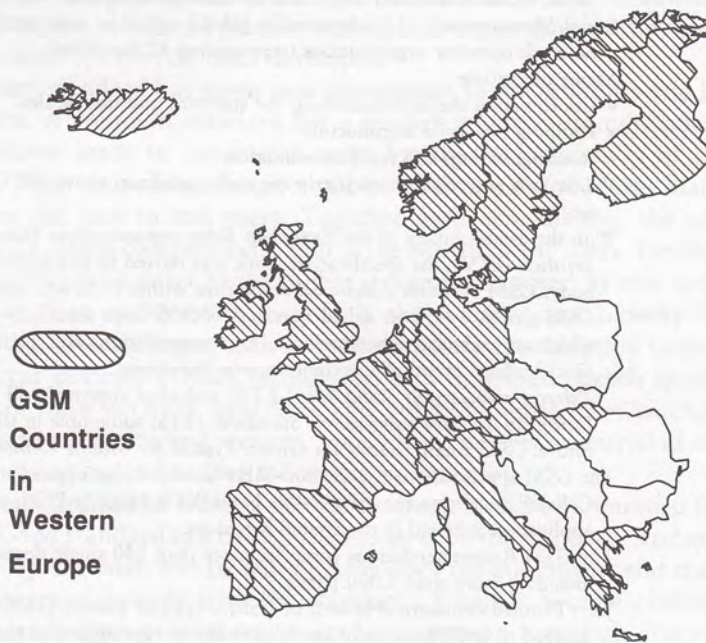


Figure 3.1 The GSM standard in Europe.

products should be available in 1994. Phase 2+ addendums are intended to be updated on a regular basis according to market needs and the availability of specifications.

An appropriate comment on this chapter comes from Jonas Twingler, GSM coordinator of ETSI [3]:

Originally, GSM was seen as a Pan-European version and a fixed step towards the final version, that it would be more beneficial to produce the full version of GSM-Phase 2, news, situations and experience gained.

By this, the GSM platform was seen as a set of hooks, mechanisms and not at least as a framework and to provide mobile communication services. Even before the Phase 2 standard was completed, the system had grown far beyond its original geographical boundaries. Phase 2, and in particular with Phase 2+, beyond its originally intended function, new applications, new access methods, and new categories of markets.

It looks promising.

3.2 SERVICES OFFERED IN A GSM SYSTEM

The features and benefits expected in the new system are: (1) a high level of service quality (equal to or better than the existing analog system), (2) a high level of operational, and service costs, (3) a high level of security (prevention), (4) international roaming (understanding of low-power hand-portable terminals and network facilities. This section explores the PLMN.

It was only a logical consequence of the interworking compatibility with the services provided by existing networks was sought. In particular, the standard can be found in the ISDN concept.

We can distinguish three categories of services, and (3) supplementary services. A systematic approach to introducing the services led to the introduction of Phase 1, and another set of services added in Phase 2, and are listed according to their phases (1 and 2). Complete PLMN can be found in [4].

3.2.1 GSM Phase 1 Services

The Phase 1 technical specifications, valid for the entire GSM system, provide the definitions for the set of services.

Originally, GSM was seen as a Pan-European “only” system, in one single version and a fixed step towards the future. It turned out, for several reasons, that it would be more beneficial for all parties, to launch an interim version of the standard at an early point in time—Phase 1—and to produce the full version of GSM—Phase 2—adapted to the “latest” news, situations and experience gained in Phase 1.

By this, the GSM platform was created, a platform which is full of hooks, mechanisms and not at least potential to continue to build on and to provide mobile communication in all its possible forms and varieties. Even before the Phase 2 standard has been completed, GSM has grown far beyond its original geographical “limitations” and the Global System for Mobile communication really starts to deserve its name. With Phase 2, and in particular with Phase 2+, GSM will also expand far beyond its originally intended functional boundaries and open up for new applications, new access methods, new technologies and thus altogether for new categories of markets, needs and users.

It looks promising.

3.2 SERVICES OFFERED IN A GSM SYSTEM

The features and benefits expected in the new system were (1) superior speech quality (equal to or better than the existing analog cellular technology), (2) low terminal, operational, and service costs, (3) a high level of security (confidentiality and fraud prevention), (4) international roaming (under one subscriber directory number), (5) support of low-power hand-portable terminals, and (6) a variety of new services and network facilities. This section explores the services that are offered in a GSM PLMN.

It was only a logical consequence of the prevailing reality that a measure of interworking compatibility with the services offered by other existing telecommunication networks was sought. In particular, the basis for the services in the GSM standard can be found in the ISDN concept.

We can distinguish three categories of services: (1) *teleservices*, (2) *bearer services*, and (3) *supplementary services*. As already mentioned above, the phased approach to introducing the services led to a subset of these services being included in Phase 1, and another set of services added later. In the following, these services are listed according to their phases (1 and 2), and the features supplied in the individual phases are discussed. Complete lists of the services defined for a GSM PLMN can be found in [4].

3.2.1 GSM Phase 1 Services

The Phase 1 technical specifications, valid for the networks in operation since 1992, provide the definitions for the set of services and features listed in Table 3.2 [3]. It

Table 3.2
GSM Phase 1 Services

Service Category	Service	Comment
Teleservices	Telephony (speech)	So-called full rate, 13 kbps
	Emergency calls (speech)	
	Short-message services: point-to-point and point-to-multipoint (cell broadcast)	
Bearer services	Telefax	Alphanumeric information: user-to-user and network to all users
	Asynchronous data	Group 3
	Synchronous data	300–9,600 bps, 1,200/75 bps
	Asynchronous PAD (packet-switched, packet assembler/disassembler) access	300–9,600 bps
Supplementary services	Alternate speech and data	300–9,600 bps
	Call forwarding	For example, subscriber busy, not reachable or does not answer
	Call barring	For example, all calls, international calls, incoming calls

must be noted that bearer services are restricted to a maximum of 9,600 bps for technical reasons. ISDN networks use rates of up to 64 kbps. Adaptations are necessary.

These services are made available, or *can* be made available, by the operator of a Phase 1 network (their implementation is optional for the operators). Of course, the manufacturers and developers of infrastructure equipment and mobile terminals have to cope with the specifications of these services, since they have to provide the specific functions in their products.

3.2.2 GSM Phase 2 Services

Following the availability of the technical specifications for GSM Phase 2, there will be additional services defined that can be made available to end users. There are a number of supplementary services defined for Phase 2. Table 3.3 gives an overview of these [3].

GSM Phase 2 also has many enhancements made possible through the experience with operational Phase 1 networks, through new ideas, and through the dedication of the involved parties to steadily improve the system and its services.

Table 3.3
Services Added Through GSM Phase 2

Service Category	Service
Teleservices	Telephony (speech)
	Short-message services
Bearer services	Synchronous dedicated data access
Supplementary services	Calling/connected presentation
	Calling/connected restriction
	Call waiting
	Call hold
	Multiparty communication
	Closed user group
	Advice of charge
	Unstructured supplementary services data
	Operator-determined time zone

3.3 WHAT IS A CELLULAR NETWORK

Now that we know where GSM stands in the world of cellular networks and what it is supposed to do for its customers, we can start at the very top, at the network level, and see how the GSM system works. First, however, a note on terminology. The book does lots of explaining of how radios work in cellular systems. The radios are referred to with language and terminology that is such as “when the base station ‘discovers’ a mobile station with. . . .” Base stations do not really “discover” mobile stations. Radios in cellular systems do not “discover” each other. A radio’s signaling tasks from everything else. The authors refer to radios as if they were a

Table 3.3
Services Added Through GSM Phase 2

<i>Service Category</i>	<i>Service</i>	<i>Comment</i>
Teleservices	Telephony (speech)	Half rate, 6.5 kbps
	Short-message services	General improvements
Bearer services	Synchronous dedicated packed data access	2,400–9,600 bps
Supplementary services	Calling/connected line identity presentation	Displays calling party's directory number before/after call connection
	Calling/connected line identity restriction	Restricts the display of the calling party's number at called party's side before/after call connection
	Call waiting	Inform the user about a second (incoming) call and allows to answer it
	Call hold	Puts an active call on hold in order to answer or originate another (second) call
	Multiparty communication	Conference calls
	Closed user group	Establishment of groups with limited access
	Advice of charge	Online charge information
	Unstructured supplementary services data	Offers an open communications link for use between network and user for operator-defined services
	Operator-determined barring	Restriction of different services, call types by the operator

3.3 WHAT IS A CELLULAR NETWORK?

Now that we know where GSM stands in the world, how it got to where it is today, and what it is supposed to do for its customers, we take a first look at how it works. We start at the very top, at the network level, to get an initial glimpse of how a GSM system works. First, however, a note on language. From now on, this book does lots of explaining of how radios work in cellular systems. In these explanations, the radios are referred to with language and terms usually reserved for living beings, such as “when the base station ‘discovers’ that . . .,” or “the mobile ‘replies’ with. . .” Base stations do not really “discover” anything, and only people “reply” to commands. Radios in cellular systems do many things, and it helps if one separates a radio's signaling tasks from everything else it does (carry voice traffic). To do this, the authors refer to radios as if they were alive and have personalities and habits,

both good and bad, when describing signaling tasks. Users do not care about all the signaling tasks cellular radios perform; they only want their voices heard at the other end of the channel and to hear what is being said to them. In order for reliable communications to occur in a digital cellular system, radios have to do lots of channel maintenance tasks in the background, and they do all these tasks—invisibly and silently—with signaling routines as if they were, in fact, alive and carrying on their own little private conversations with each other, united in the task of moving the user's voice from one place to another. Think of radios as efficient and busy servants, and you will have much less trouble making sense out of all the details. You may also enjoy this book more.

3.3.1 A Little Bit of History

It was some time since the days of Heinrich Rudolf Hertz until the first real achievements of cellular radio. In the years 1887 and 1888, Hertz discovered that invisible waves which originated from an electric spark were able to transport *influence* or, as we call it today, *information* through the air. Only a few years later, this phenomenon was further investigated and developed until it was possible to actually transmit and receive signals over a distance of several kilometers. Guglielmo Marconi performed a dramatic demonstration of this several years later.

These early experiments formed the basis not only of cellular radio, but also of many types of transmissions. One merely has to think of early radio broadcasting, which was introduced in the early 1920s in the United States and Europe, to see how far these first experiments have taken society. Later applications for radio found quick and numerous paths to mass markets, even though the quality of the early AM transmissions were not very good by today's standards. The introduction of FM by Edwin H. Armstrong in 1929 was a breakthrough for quality of reception, and it became the standard for the remainder of the century. The current analog cellular networks are still based on Armstrong's FM.

Mobile radio applications took a longer and more halting path to their markets. In the days when the first transmitters started broadcasting, people were trying to make use of this technique for mobile applications, but they had a problem in that the transmitters were still very large. In the first applications for mobile radio, only the receiving system was mobile, similar to the paging systems which are so popular today. There were experiments by police departments, which used only one high-power transmitter to cover a whole city. The called police officer had to get out of his car at the next public telephone to report back to his office for further instructions. This awkward procedure and the limited ability of the receiver to withstand the problems of propagation and road hazards were limiting factors for mobile radio [5].

When FM was introduced, the quality of received information increased a great deal, but the applications were still limited by transmitter size and the huge

amounts of power consumed at the those early transmitters.

Commercial mobile phone service dispatch systems, such as police and fire (throughs were (1) small, low-power (vehicle), and (2) the move to higher power to decrease the size and weight of mobile phone service appeared with the telephone service (MTS) systems. These were fitted with a special control panel, called commercial use by people who were using RCC and MTS systems could direct calls to mobile, but remained, after all, simple all their calls through a mobile operator. This was added to the MTS system to make it (MTS), which automated to a considerable customer and the fixed telephone network from the mobile phone landscape when it became popular only when carefully designed, like AMPS and TACS started to work.

3.3.2 Cellular Structure

In the beginning of radio, engineers were between a transmitter and a receiver. As links were not even two-way ones, but the people who called the mobiles did not even get a confirmation that their calls had been received. A two-way transmission step was to establish a two-way transmission. This came with mobile transmission, which was simplistic and awkward to use. Service was provided with one transmitter or a small number of cells at a single base site (Figure 3.2). The network size was determined by the transmission of a link between two different cells, or controlling traffic (voice audio) between transmissions. It was important to select the frequency of the cell carefully so that there was no interference with the next town, which would interfere with the next town, which would interfere with the next town. The disadvantage of this is obvious: a small set of frequencies was used for a huge

amounts of power consumed at the mobile end of the communications links by those early transmitters.

Commercial mobile phone service had to wait for the perfection of the public dispatch systems, such as police and other public safety applications. The breakthroughs were (1) small, low-power transmitters (run from motor generators in the vehicle), and (2) the move to higher operating frequencies (above 30 MHz) to further decrease the size and weight of mobile transmitters. An initial step toward viable mobile phone service appeared with the radio common carrier (RCC) and mobile telephone service (MTS) systems. These were simply conventional land mobile radios fitted with a special control panel, called a *control head*, which were suitable for commercial use by people who were unfamiliar with operating two-way radios. The RCC and MTS systems could direct calls from a single transmitter to a particular mobile, but remained, after all, simple dispatch systems in which the users set up all their calls through a mobile operator. Later, some additional inband tone signaling was added to the MTS system to make the newer improved mobile telephone service (IMTS), which automated to a considerable extent the interface between the mobile customer and the fixed telephone network. The mobile operator almost disappeared from the mobile phone landscape when IMTS was introduced. Cellular radio became popular only when carefully designed, engineered, and thoroughly tested systems like AMPS and TACS started to work.

3.3.2 Cellular Structure

In the beginning of radio, engineers were happy to achieve a simple dedicated link between a transmitter and a receiver. As we saw in the previous section, these first links were not even two-way ones, but remained one-way dispatch links; that is, the people who called the mobiles did not get a response right away and did not even get a confirmation that their calls had reached the mobile addressees. The next step was to establish a two-way transmission link that allowed an immediate response. This came with mobile transmitters, but the structure of the network was simplistic and awkward to use. Service was limited to a certain area that could be reached with one transmitter or a small collection of transmitters on different channels at a single base site (Figure 3.2). We call the coverage area a *cell*. The cell or network size was determined by the transmitter's power. It was not possible to have a link between two different cells, or coverage areas, since an orderly means of directing traffic (voice audio) between transmitter sites and moving mobiles was missing. It was important to select the frequency of the transmitter and receiver in the cell carefully so that there was no interference from other systems, perhaps in the next town, which would interfere with the system's local operation.

The disadvantage of this is obvious to everyone from today's perspective. A small set of frequencies was used for a huge area. The transmitters were so powerful

CHAPTER 12



NORTH AMERICAN DIGITAL CELLULAR AND PERSONAL DIGITAL CELLULAR

The United States has the distinction of running the world's largest cellular system (the highly successful AMPS system), and the Japanese hold the honor of installing the world's first commercial system (Nippon Telephone and Telegraph Company's (NTT) MCS system in December 1979). Both of these innovators have proposed and are installing their own versions of TDMA digital cellular: the NADC system in the United States, and the personal digital cellular (PDC) or JDC system in Japan. The two systems have as much in common with each other as they differ from GSM. The differences between them serve to shed additional light on GSM and clarify its prominent place in the world's cellular markets.

The NADC and PDC systems share an interesting type of modulation ($\pi/4$ -DQPSK), which we will explain early in this chapter. The time slot structures, frame structures, and certain details of their air interface definitions are also similar in both systems, though the PDC versions are slightly more reminiscent of GSM. The two systems, however, diverge in all other matters. The PDC system is a purely digital TDMA system just as GSM is, and some of its operating modes, organization, and deployment schemes are similar to GSM. The NADC system graphs digital traffic resources onto the existing AMPS and expanded AMPS (EAMPS) system in a fascinating overlay scheme. It holds almost no resemblance to GSM in this regard.

Since this is a book on GSM, we will not investigate all the details of the NADC and PDC systems. We will reserve such a detailed analysis for the next

chapter, Chapter 13, when we have a close look at CDMA. It is only the differences in certain aspects that distinguish GSM from its TDMA cousins, NADC and PDC. CDMA has nothing in common with GSM. We have to take a broader and closer look at CDMA in order to judge the relative benefits of each system and increase our understanding of GSM in the same way as a selective look at NADC and PDC does.

12.1 TDMA IN THE UNITED STATES

The United States has a long history of and a noted ability to extend the life of various communications systems by devising methods to maintain compatibility between older users of a system with traditional technologies and new users employing enhanced capabilities and technologies. The reasons for this are primarily economic ones. The United States is a large and wealthy country. American communications systems tend to become very large by world standards, so that ripping out one system and replacing it with another is usually too expensive to even consider. This was the case with the American National Television Standard Committee (NTSC) color television system (fully compatible with the black and white receivers of the 1940s and 1950s), and remains true with the NADC cellular system today.

12.1.1 Frequency Bands

Figure 12.1 lays out the frequency bands and channel scheme for the EAMPS and NADC systems. The reader will discern two frequency bands of 25 MHz each. The mobile transmitter's uplink is in the lower 824- to 849-MHz band, and the base station transmitter's downlink is offset 45 MHz up to the 869- to 894-MHz band.

Each of the uplink and downlink segments is divided into 832 channels of 30-kHz width each. The numbering of the channels is a bit strange. The enumeration starts at number 1 near the bottom of the bands, continues up to channel number 799 at the top, then folds back on itself to channel number 991 at the bottom edge of the bands, and finally ends at number 1,023 just below the starting point. The awkward numbering comes from an expansion of the original 666 channels of the AMPS system in the mid-1980s, which had to be coordinated with some existing land mobile services in the 860-MHz band to yield the EAMPS system.

12.1.2 Competing Operators

The two 25-MHz bands in the EAMPS system are further divided into equal-sized A and B channel groups. The A group is indicated by some dark bands in Figure 12.1 (e.g., between channel numbers 666 and 716) to distinguish it from the unmarked B

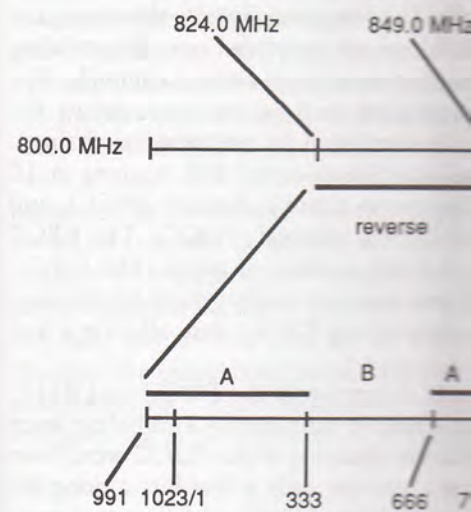


Figure 12.1 U.S. cellular frequencies and channels

group. Each operating area in the U.S. E providers. One is the local fixed-network called the *wire-line operator*, and the other is the *non-wire-line operator*. The number of channels in the region near channel operator for control channels in their re

12.2 DUAL-MODE ACCESS

The most important feature of all the N mode systems. This means that all systems provide an appropriate traffic channel for that may seek cellular phone service.

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