

# Mobile Communications

## Introduction to Wireless Communication Systems

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Wireless Communications

Principles and Practice

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# *Introduction*

- **During the past ten years, the mobile radio communications industry has grown because:**
  1. It fueled by digital and RF circuit fabrication improvements
  2. New large-scale circuit integration
  3. Miniaturization technologies which make portable radio equipment smaller, cheaper and more reliable.
  4. Easy to use radio communication networks (digital switching techniques)

# Evolution of mobile radio communications

- The ability to provide wireless communications to an entire population when Bell Laboratories developed the highly reliable, miniature, solid-state radio frequency hardware in 1970s.
- Because of using AM (1930s) mobile communication systems only limited number of subscribers were installed in mobile and vehicle ignition noise was a major problem.
- In 1935, Edwin Armstrong demonstrated FM and it has been the primary modulation technique used for mobile communication systems throughout the world.

# Mobile Radiotelephony in the USA

(Figure 1.2 and table 1.1)

- 1946: High powered transmitter and large tower in order to cover distances over 50 km where used 120 kHz of RF bandwidth in half-duplex mode.
- With IMTS (Improved Mobile Telephone Service), was offered full duplex, auto dial, auto-trunking systems.
- 1950s: Developed the theory techniques of cellular radiotelephony to increase spectrum usage by mean of spectrum reuse.
- 1983: FCC allocated AMPS (Advanced Mobile Phone System).
- 1991: first US digital cellular (USDC) system hardware was installed in major U.S. cities (IS-136)[ Electronic Industry Association Interim Standard]. TDMA used instead of FM and FDMA.
- 1993: CDMA was developed by Qualcomm.(IS-95)
- 1990s: new specialized mobile radio service (SMR) was developed.

# *Mobile Radio Systems around the World*

*(Table 1.2 and 1.3)*

- (1970s) Post Office Code Standard Advisory Group (POCSAG) was developed by British Post Office using BFSK.
- CT2 and Digital European Cordless Telephone (DECT) standards Developed in Europe with base stations mounted on street lights or on sides of buildings with no handoff because it is a short range access to PSTN.
- In 1979 the first cellular system was implemented in Japan using 600 FM channels (25 kHz for each one way link) in the 800 MHz bandwidth.
- GSM (Global System for Mobile) is the first universal digital cellular system (900 and 1800 MHz).

**Table 1.1 Major Mobile Radio Standards in North America**

Standard	Type	Year of Introduction	Multiple Access	Frequency Band	Modulation	Channel Bandwidth
AMPS	Cellular	1983	FDMA	824-894 MHz	FM	30 kHz
NAMPS	Cellular	1992	FDMA	824-894 MHz	FM	10 kHz
USDC	Cellular	1991	TDMA	824-894 MHz	$\pi/4$ -DQPSK	30 kHz
CDPD	Cellular	1993	FH/ Packet	824-894 MHz	GMSK	30 kHz
IS-95	Cellular/ PCS	1993	CDMA	824-894 MHz 1.8-2.0 GHz	QPSK/ BPSK	1.25 MHz
GSC	Paging	1970's	Simplex	Several	FSK	12.5 kHz
POCSAG	Paging	1970's	Simplex	Several	FSK	12.5 kHz
FLEX	Paging	1993	Simplex	Several	4-FSK	15 kHz
DCS-1900 (GSM)	PCS	1994	TDMA	1.85-1.99 GHz	GMSK	200 kHz
PACS	Cordless/ PCS	1994	TDMA/ FDMA	1.85-1.99 GHz	$\pi/4$ -DQPSK	300 kHz
MIRS	SMR/PCS	1994	TDMA	Several	16-QAM	25 kHz

**Table 1.2 Major Mobile Radio Standards in Europe**

Standard	Type	Year of Introduction	Multiple Access	Frequency Band	Modulation	Channel Bandwidth
E-TACS	Cellular	1985	FDMA	900 MHz	FM	25 kHz
NMT-450	Cellular	1981	FDMA	450-470 MHz	FM	25 kHz
NMT-900	Cellular	1986	FDMA	890-960 MHz	FM	12.5 kHz
GSM	Cellular /PCS	1990	TDMA	890-960 MHz	GMSK	200 kHz
C-450	Cellular	1985	FDMA	450-465 MHz	FM	20 kHz/ 10 kHz
ERMES	Paging	1993	FDMA	Several	4-FSK	25 kHz
CT2	Cordless	1989	FDMA	864-868 MHz	GFSK	100 kHz
DECT	Cordless	1993	TDMA	1880-1900 MHz	GFSK	1.728 MHz
DCS-1800	Cordless /PCS	1993	TDMA	1710-1880 MHz	GMSK	200 kHz

**Table 1.3 Major Mobile Radio Standards in Japan**

Standard	Type	Year of Introduction	Multiple Access	Frequency Band	Modulation	Channel Bandwidth
JTACS	Cellular	1988	FDMA	860-925 MHz	FM	25 kHz
PDC	Cellular	1993	TDMA	810-1501 MHz	$\pi/4$ -DQPSK	25 kHz
NTT	Cellular	1979	FDMA	400/800 MHz	FM	25 kHz
NTACS	Cellular	1993	FDMA	843-925 MHz	FM	12.5 kHz
NTT	Paging	1979	FDMA	280 MHz	FSK	12.5 kHz
NEC	Paging	1979	FDMA	Several	FSK	10 kHz
PHS	Cordless	1993	TDMA	1895-1907 MHz	$\pi/4$ -DQPSK	300 kHz

# *Examples of Mobile Radio Systems*

(Table 1.4)

- Garage door openers, remote controllers for home use, cordless telephones, hand-held walkie-talkies, pagers and cellular systems.
- Mobile: a radio terminal that attached to a high speed mobile platform (high speed vehicle).
- Portable: a radio terminal that can be held and used by someone at walking speed. (Walkie-talkie or cordless telephone inside a home).
- Mobile radio transmission systems: **Simplex** (communication is possible in only one direction-Paging system). **Half-duplex** (two-way communication using the same radio channel for both transmission and reception- Push-to-talk and release-to-listen). **Full duplex** (allow simultaneous radio transmission and reception between subscriber and a base station using FDD or TDD- Cellular systems)



# Frequency Division Duplexing:

*(Table 1.4)*

Base station and Subscriber may transmit and receiving signal from one another at the same time

- At the base station separate antennas are used for transmitting and receiving.
- Subscriber unit a single antenna is used with duplexer.
- Two channels are defined (forward and reverse)
- In AMPS, 45 MHz lower than the forward.
- FDD is used only in analog radio systems

**Table 1.4 Wireless Communications System Definitions**

<b>Base Station</b>	A fixed station in a mobile radio system used for radio communication with mobile stations. Base stations are located at the center or on the edge of a coverage region and consist of radio channels and transmitter and receiver antennas mounted on a tower.
<b>Control Channel</b>	Radio channels used for transmission of call setup, call request, call initiation, and other beacon or control purposes.
<b>Forward Channel</b>	Radio channel used for transmission of information from the base station to the mobile.
<b>Full Duplex Systems</b>	Communication systems which allow simultaneous two-way communication. Transmission and reception is typically on two different channels (FDD) although new cordless/PCS systems are using TDD.
<b>Half Duplex Systems</b>	Communication systems which allow two-way communication by using the same radio channel for both transmission and reception. At any given time, the user can only either transmit or receive information.
<b>Handoff</b>	The process of transferring a mobile station from one channel or base station to another.
<b>Mobile Station</b>	A station in the cellular radio service intended for use while in motion at unspecified locations. Mobile stations may be hand-held personal units (portables) or installed in vehicles (mobiles).
<b>Mobile Switching Center</b>	Switching center which coordinates the routing of calls in a large service area. In a cellular radio system, the MSC connects the cellular base stations and the mobiles to the PSTN. An MSC is also called a mobile telephone switching office (MTSO).
<b>Page</b>	A brief message which is broadcast over the entire service area, usually in a simulcast fashion by many base stations at the same time.
<b>Reverse Channel</b>	Radio channel used for transmission of information from the mobile to base station.
<b>Roamer</b>	A mobile station which operates in a service area (market) other than that from which service has been subscribed.
<b>Simplex Systems</b>	Communication systems which provide only one-way communication.
<b>Subscriber</b>	A user who pays subscription charges for using a mobile communications system.
<b>Transceiver</b>	A device capable of simultaneously transmitting and receiving radio signals.

# Time Division Duplexing:

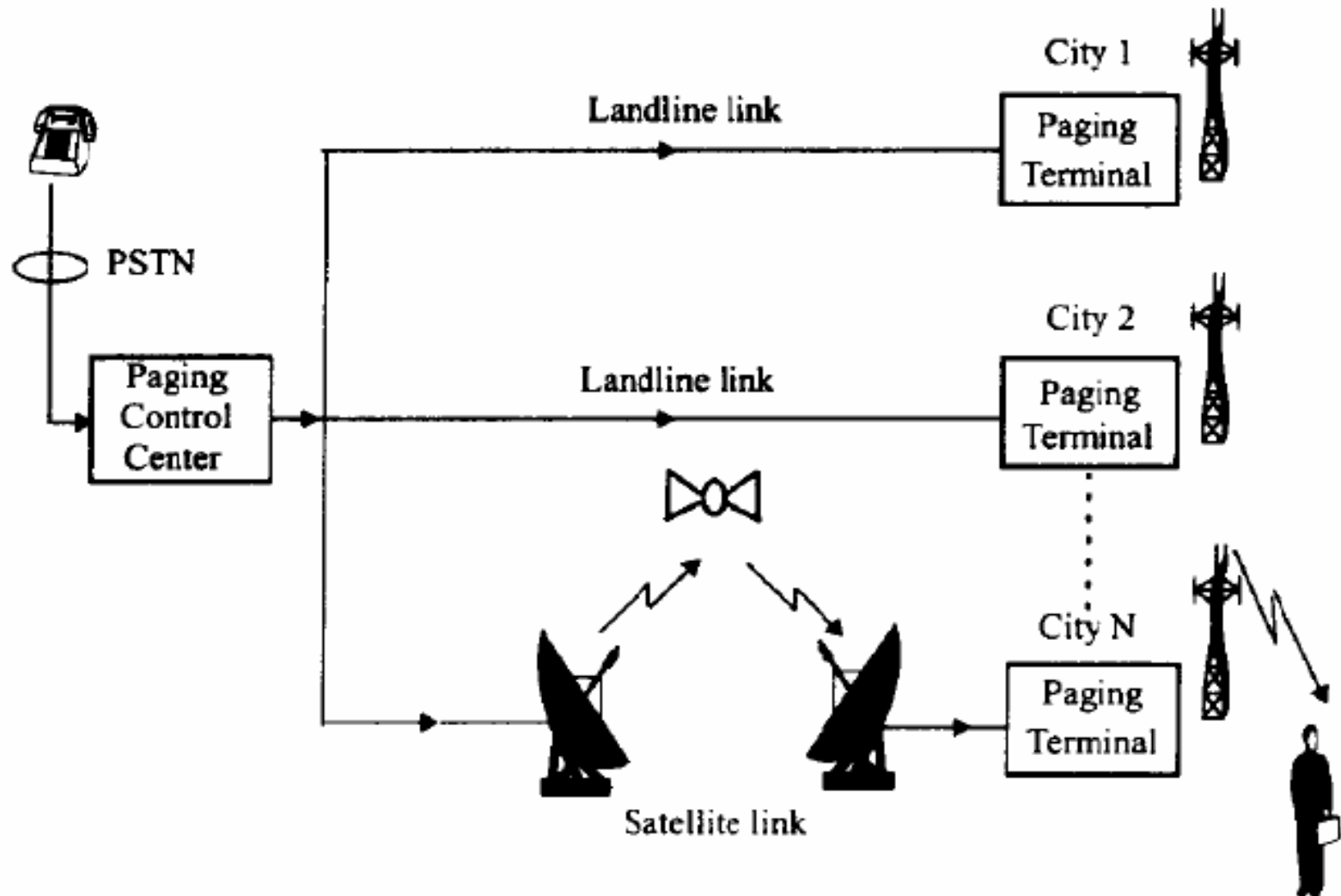
*(Table 1.4)*

Base station and Subscriber are shared a single channel

- Portion of time is used to transmit from the base station to the mobile and the remaining time is used to transmit from the mobile to the base station.
- TDD is possible only with digital transmission formats and digital modulation.
- TDD is very sensitive to timing and it used in small wireless areas.

# Paging Systems

- They are a communication systems that send brief messages (numeric, alphabetic or voice)
- In modern paging systems, news headlines and faxes.
- The paging system transmits a page (issued message) on a radio carrier through the service area.
- Paging receivers are simple and expensive but paging systems are complex and services wide area with a large number of transmitters, telephone lines and networks.
- Paging systems are designed to provide reliable communication to subscribers (see figure 1.3)



**Figure 1.3**

**Diagram of a wide area paging system. The paging control center dispatches pages received from the PSTN throughout several cities at the same time.**

# Cordless Telephone Systems

- They are full duplex communication systems that use radio to connect a portable handset to a dedicated base station, which is then connected to a dedicated telephone line with a specific telephone number on the PSTN.
- In First Generation CTS (1980s), portable unit communicates only with a dedicated base unit over distances of a few tens of meters.
- In Second generation CTS, subscribers can use their handsets at many outdoor locations (Figure 1.4)

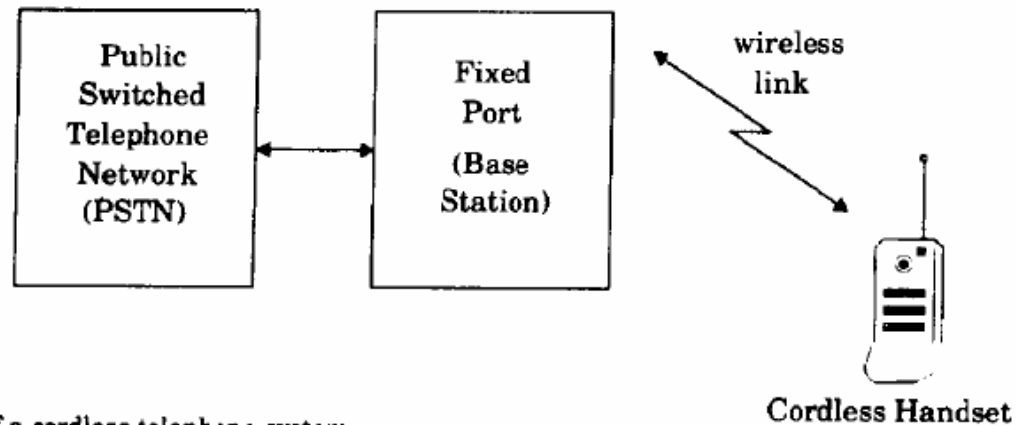


Figure 1.4  
Diagram of a cordless telephone system.

# Cellular Telephone Systems

- Cellular Systems accommodate a large number of users over a large geographic area, within a limited frequency spectrum.
- Using Cells, we can get high capacity (Frequency reuse by base stations) and handoff is used to not interrupt the user when moving from cell to another.

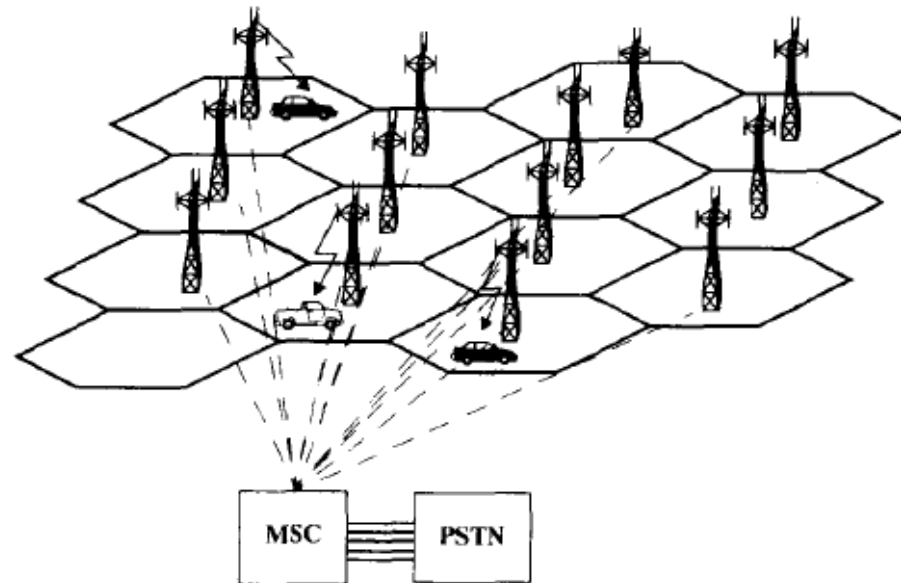


Figure 1.5  
An illustration of a cellular system. The towers represent base stations which provide radio access between mobile users and the Mobile Switching Center (MSC).

# Common Mobile Radio SYSTEMS

**Table 1.5 Comparison of Mobile Communication Systems — Mobile Station**

Service	Coverage Range	Required Infrastructure	Complexity	Hardware Cost	Carrier Frequency	Functionality
TV Remote Control	Low	Low	Low	Low	Infra-red	Transmitter
Garage Door Opener	Low	Low	Low	Low	< 100 MHz	Transmitter
Paging System	High	High	Low	Low	< 1 GHz	Receiver
Cordless Phone	Low	Low	Moderate	Low	< 100 MHz	Transceiver
Cellular Phone	High	High	High	Moderate	< 1 GHz	Transceiver

**Table 1.6 Comparison of Mobile Communication Systems — Base Station**

Service	Coverage Range	Required Infrastructure	Complexity	Hardware Cost	Carrier Frequency	Functionality
TV Remote Control	Low	Low	Low	Low	Infra-red	Receiver
Garage Door Opener	Low	Low	Low	Low	< 100 MHz	Receiver
Paging System	High	High	High	High	< 1 GHz	Transmitter
Cordless Phone	Low	Low	Low	Moderate	< 100 MHz	Transceiver
Cellular Phone	High	High	High	High	< 1 GHz	Transceiver