Class: 4th

MOBILE COMMUNICATIONS

Chapter One

Introduction to Wireless Communication System

By

Msc. Musadaq Mahir

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Chapter 1

1.1 History of wireless communications

Guglielmo Marconi invented the wireless telegraph in 1896. In 1901, he sent telegraphic signals across the Atlantic Ocean (about 3200 km). His invention allowed two parties to communicate by sending each other alphanumeric characters encoded in an analog signal. Over the last century, advances in wireless technologies have led to the radio, the television, the mobile telephone, and communications satellites. All types of information can now be sent to almost every corner of the world. Recently, a great deal of attention has been focused on satellite communications, wireless networking, and cellular technology. Wireless networking is allowing businesses to develop WANs, MANs, and LANs without a cable plant. The cellular or mobile telephone is the modern equivalent of Marconi's wireless telegraph, offering two-party, two-way communication. The first-generation wireless phones used analog technology. These devices were heavy and coverage was patchy, but they successfully demonstrated the inherent convenience of mobile communications. The current generation of wireless devices is built using digital technology. Digital networks carry much more traffic and provide better reception and security than analog networks.

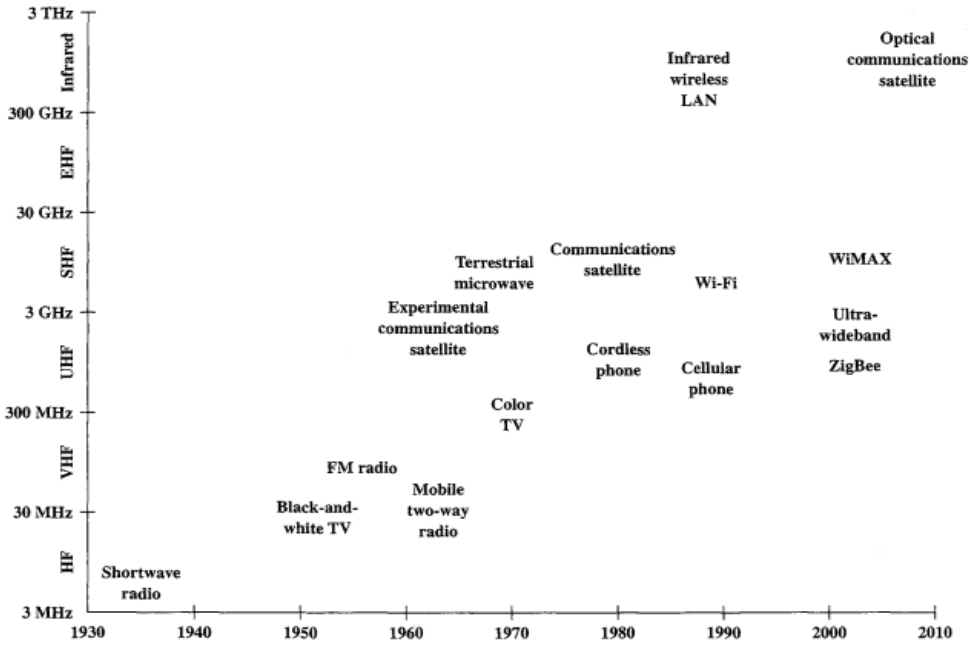


Fig. (1) Some milestones in Wireless Communications

1.2 Classification of mobile radio transmission system

Mobile radio transmission systems may be classified as simplex, half-duplex or full-duplex.

a. **Simplex systems**: communication is possible in only one direction.
b. **Half-duplex**: radio systems allow two-way communication using the same radio channel for both transmission and reception.
c. **Full duplex**: systems allow simultaneous radio transmission and reception between a subscriber and a base station, by providing two simultaneous but separate channels (frequency division duplex, or FDD) or adjacent time slots on a single radio channel (time division duplex, or TDD) for communication to and from the user.

1.3 Frequency division & Time division

Provides simultaneous radio transmission channels for the subscriber and the base station, so that they both may constantly transmit while simultaneously receiving signals from one another.

At the base station, separate transmit and receive antennas are used to accommodate the two separate channels.

At the subscriber unit a single antenna is used for both transmission to and reception from the base station, and a device called a duplexer is used inside the subscriber unit to enable the same antenna to be used for simultaneous transmission and reception.

(A) Frequency division duplexing (FDD)

A pair of simplex channels with a fixed and known frequency separation is used to define a specific radio channel in the system.

- The channel used to convey traffic to the mobile user from a base station is called the forward channel.
- The channel used to carry traffic from the mobile user to a base station is called the reverse channel. FDD is used exclusively in analog mobile radio systems.

(B) Time division duplexing (TDD)

Uses the fact that it is possible to share a single radio channel in time, so that a portion of the 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 only possible with digital transmission formats and digital modulation, and is very sensitive to timing. It is for this reason that TDD has only recently been used, and only for indoor or small area wireless applications.

1.4 Transmission types

•**Unicast** (point-to-point) transmission is made from one device to a single other device. It means that the packet is addressed to one receiver.

•**Broadcast** transmission is made from one device to all other devices. In this case there is just one sender, but the information is sent to all connected receivers.

•**Multicast** transmission is made from one device to a subset of the other available devices. In this case there is just one sender, but the information is sent to a group of receivers.

1.5 Types of wireless communication systems

The major types of wireless communication systems are:

1- Paging Systems
2- Cordless Telephone Systems
3- Satellite communication systems
4- Wireless LAN systems
5- Cellular Telephone Systems

The cost, complexity, performance, and types of services offered by each of these mobile systems are different.

1- Paging Systems

Paging systems are communication systems that send brief messages to a subscriber. Depending on the type of service, the message may be either text or voice messages. In modern paging systems, news headlines, stock quotations, and faxes may be sent.

The issued message is called a page. The paging system then transmits the page throughout the service area using base stations which broadcast the page on a radio carrier.

- Paging systems vary widely in their complexity and coverage area.
- Paging systems are designed to provide reliable communication to subscribers. This necessitates large transmitter powers and low data rates for maximum coverage from each base station.

Simple paging systems may cover a limited range of 2 to 5 km, or may even be confined to within individual buildings,

Wide area paging systems can provide worldwide coverage. Wide area paging systems consist of a network of telephone lines, many base station transmitters, and large radio towers that simultaneously broadcast a page from each base station (this is called simulcasting)

2- Cordless Telephone Systems

• Provide wireless extension to the telephone network within a limited area
• Two-way (duplex) communications
• Consists of a portable handset, connected to dedicated base station, which is connected to the telephone network
• **1st generation**: household environment
• **2nd generation**: allow mobility in workplace and public use with limited coverage in urban areas

3- Satellite communication Systems

The main feature of the satellite communication systems

- Very wide range and coverage
- Very useful in sparsely populated areas: rural areas, sea, mountains, etc.
- Target: Vehicles and/or other stationary/mobile uses
- Expensive base station (satellites) systems

4- Wireless LAN (WLAN)

Characterized by

- Low mobility (not for vehicular use)
- High speed data transmission
- Confined regions – buildings and campuses
- Coverage: 100m – 300m per base station
- Uses the following bands (902-928 MHz, 2400-2483.5 MHz, 5725-5850 MHz)

5- Cellular Telephone Systems

The basic cellular system consists of: Mobile station (MS), Base stations (BS) and Mobile switching center (MSC) or called Mobile telecommunications switching office (MTSO).

- Cellular systems accommodate a large number of users over a large geographic area, within a limited frequency spectrum.
- Cellular radio systems provide high quality service that is often comparable to that of the landline telephone systems.
- High capacity is achieved by limiting the coverage of each base station transmitter to a small geographic area called a cell so that the same radio channels may be reused by another base station located some distance away.
- Handoff: is a switching technique that enables a call to proceed uninterrupted when the user moves from one cell to another.

1.6 First Generation (1G) systems

The original cellular telephone networks provided **analog** traffic channels; these are now referred to as first-generation systems. Since the early 1980s the most common first-generation system in North America has been the **Advanced Mobile Phone Service (AMPS)**. This approach is also common in South America, Australia, and China.

- Two 25-MHz bands are allocated to AMPS.
- Each of these bands is split in two to encourage competition (i.e., so that in each market two operators can be accommodated). An operator is allocated only 12.5 MHz in each direction for its system.
- The channels are spaced 30 kHz apart, which allows a total of 416 channels per operator.
- 21 channels are allocated for control, leaving 395 to carry calls.
- The control channels are data channels operating at 10 kbps.
- The conversation channels carry the conversations in analog using FM.

European Total Access Communication Systems (TACS):

- Deployed in 1985.
- Almost identical to AMPS except that the channel bandwidth is scaled to 25 kHz instead of 30 kHz as in AMPS.

1.7 Second Generation (2G) systems

Second-generation systems have been developed in early 90s to provide higher quality signals, higher data rates for support of digital services, and greater capacity. Moreover, The 2G systems provide:

- Digital voice coding and modulation
- Security (Encryption).
- Error detection and correction.
- Multiple channels per cell.
-

Beginning around 1990, a number of different second-generation systems have been deployed, such as Global system for mobile communications (GSM), and Interim Standard (IS-95) scheme. The table below lists some key characteristics of three of the most important of these systems.

	GSM	IS-95
Year introduced	1990	1993
Developed in	Europe	North America
BS transmission band	935~960 MHz	869~894 MHz
MS transmission band	890~915 MHz	824~849 MHz
Spacing between forward and reverse channels	45 MHz	45 MHz
Channel bandwidth	200 KHz	1250 KHz
No. of duplex channels	125	20
Mobile unit maximum power	20 W	0.2 W
Users per channel	8	35
Modulation	GMSK	QPSK
Carrier bit rate	270.8 kbps	9.6 kbps

The GSM standard has gained worldwide acceptance as the first universal digital cellular system with modern network features extended to each mobile user

1.8 Third Generation (3G) systems

The objective of the third generation (3G) of wireless communication is to provide fairly high-speed wireless communications to support multimedia, data, and video in addition to voice. 3G developed in the early 2000s, the main features of the 3G systems are:

- **High transmission rate and the support of multimedia services:** Multiple-megabit internet services, video calls, and mobile TV using a single mobile device.
- **Data rate:** around 2Mbps. Bandwidth: in the order of MHz

The ITU's International Mobile Telecommunications for the year 2000 (IMT-2000) initiative has defined the ITU's view of third-generation capabilities as

- Voice quality comparable to the public switched telephone network.
- 144-kbps data rate available to users in high-speed motor vehicles over large areas.

- 384 kbps available to pedestrians standing or moving slowly over small areas.
- Support for 2.048 Mbps for office use.
- Support for both packet-switched and circuit-switched data services.
- An adaptive interface to the Internet.

Generally, the technology planned is digital using TDMA or CDMA to provide efficient use of the spectrum and high capacity.

3G enhancements

3G has the following enhancements over previous networks:

1. Enhanced audio and video streaming
2. Several times higher data speed
3. Video-conferencing support
4. Web and WAP browsing at higher speeds
5. IPTV (TV through the Internet) support

High Speed Packet Access (HSPA)

HSPA extends and improves the performance of existing 3G mobile telecommunication networks utilizing the WCDMA protocols (also referred to as 3.5G). The HSPA specifications:

- increased peak data rates of up to
  - 14 Mbit/s in the downlink
  - 5.76 Mbit/s in the uplink.
- reduced latency
- Up to five times more system capacity in the downlink up to twice as much system capacity in the uplink compared with WCDMA.

1.10 Long Term Evolution (LTE)

LTE is a standard for wireless communication of high-speed data for mobile phones and data terminals. It is based on the GSM/EDGE and UMTS network technologies, increasing the capacity and speed using a different radio interface together with core network improvements. The standard is developed by the 3GPP. The LTE features are:

- downlink peak rates of 300 Mbit/s,
- uplink peak rates of 75 Mbit/s
- Quality of Service (QoS) provisions permitting a transfer latency of less than 5 ms in the radio access network (RAN).
- Has the ability to manage fast-moving mobiles
- Supports scalable carrier bandwidths, from 1.4 MHz to 20 MHz.
- Orthogonal frequency-division multiple access (OFDMA) for the downlink, Single-carrier FDMA for the uplink to conserve power.
- Supports both FDD and TDD.

1.11 Fourth Generation (4G) systems

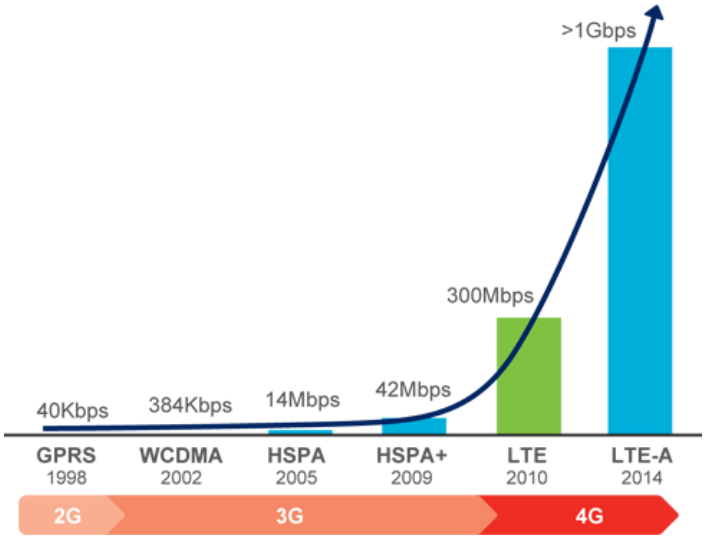
4G provides mobile broadband Internet access, with higher data rate and expanded multimedia services. The main features of the 4G systems are

- ❖ Higher speed 0.1~1 Gbps.
- ❖ More security.
- ❖ Higher capacity.
- ❖ Lower cost than previous generations.
- ❖ Provides digital system with voice over-IP (VOIP) technology.
- ❖ IPv6 Core.
- ❖ Orthogonal frequency-division multiplexing (OFDM) is used instead of CDMA.

The 4G system are able to provide a comprehensive IP solution where voice, data and streamed multimedia can be given to users on an "Anytime, Anywhere" basis.

LTE Advanced (LTE-A)

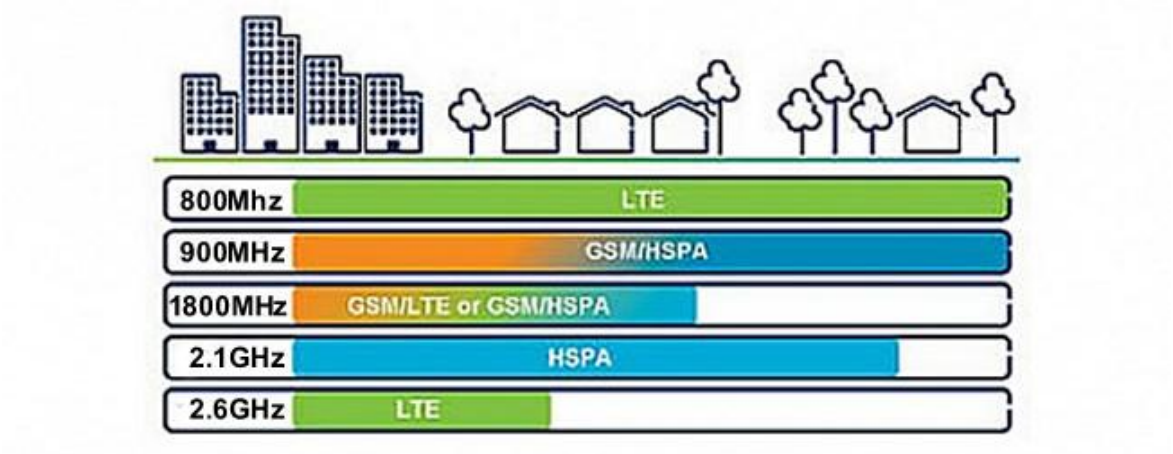
LTE Advanced is a mobile communication standard and a major enhancement of the Long Term Evolution (LTE) standard. It was formally submitted as a candidate 4G system to ITU in late 2009 as meeting the requirements of the IMT-Advanced standard, and was standardized by the 3GPP in March 2011.



The main features of the LTE-Advanced are

- higher capacity,
- increased peak data rate,
  - Downlink 3 Gbps,
  - Uplink 1.5 Gbps
- Higher spectral efficiency (30 bps/Hz)
- Increased number of simultaneously active subscribers.
- LTE-Advanced can use up to 8x8 MIMO and 128 QAM in downlink direction.

LTE-Advanced is now available in 31 countries (including South Korea, Australia, France, Germany, U.K. and the U.S.).



1.12 Fifth Generation (5G) systems

5G denotes the next major phase of mobile telecommunications standards beyond 4G. 5G can be a complete wireless communication without limitation, which bring us perfect real world wireless, supportable to the World Wide Wireless Web (WWWW). According to the Group Special Mobile Association (GSMA) to qualify for a 5G a connection should meet most of these eight criteria:

1. One to 10Gbps connections to end points in the field
2. One millisecond end-to-end round trip delay
3. 1000x bandwidth per unit area
4. 10 to 100x number of connected devices
5. (Perception of) 99.999 percent availability
6. (Perception of) 100 percent coverage
7. 90 percent reduction in network energy usage
8. Up to ten-year battery life for low power, machine-type devices

The Next Generation Mobile Networks Alliance feels that 5G should be rolled out by 2020 to meet business and consumer demands. In addition to providing simply faster speeds, they predict that 5G networks also will need to meet the needs of new use cases, such as:

- Internet of Things (IoT).
- Broadcast-like services and lifeline communication in times of natural disaster.

Parameters	1G	2G	3G	4G
Introduced in year	1983	1990	2000	2010
Location of first commercialization	USA	Finland	Japan	South Korea
Technology	AMPS (Advanced Mobile Phone System), NMT, TACS	IS-95, GSM	UMTS, HSPA	LTE-A, WiMAX 2
Multiple Address/Access system	FDMA	TDMA, CDMA	WCDMA	OFDMA
Switching type	Circuit switching	Circuit switching for Voice and Packet switching for Data	Packet switching + Circuit switching	Packet switching
Speed (data rates)	2.4 Kbps to 14.4 kbps	14.4 Kbps	3.1 Mbps	> 300 Mbps
Special Characteristic	First wireless communication	Digital version of 1G technology	Digital broadband, speed increments	Very high speeds, All IP
Features	Voice only	Multiple users on single channel	Multimedia features, Video Call	High Speed, real time streaming
Supports	Voice only	Voice and Data	Voice and Data	Voice and Data
Internet service	No Internet	Narrowband	Broadband	Ultra Broadband
Bandwidth	25, 30 KHz	200 KHz	5- 25 MHz	100 MHz
Operating frequencies	800 MHz	GSM: 900MHZ, 1800MHz CDMA: 800MHz	1.6 – 2.1 GHz	2 – 8 GHz
Band (Frequency) type	Narrow band	Narrow band	Wide band	Ultra Wide Band
Advantage	Simpler (less complex) network elements	Multimedia features (SMS, MMS), Internet access and SIM introduced	High security, international roaming	Speed, High speed handoffs, MIMO technology, Global mobility
Disadvantages	Limited capacity, not secure, poor battery life, large phone size, background interference	Low network range, slow data rates	High power consumption, Low network coverage, High cost of spectrum licence	Hard to implement, complicated hardware required
Applications	Voice Calls	Voice calls, Short messages, browsing (partial)	Video conferencing, mobile TV, GPS	High speed applications, mobile TV, Wearable devices