CHAPTER

1 Introduction

ACRONYMS

- FCC : Federal Communications Commissions
- MTS : Mobile Telephone Service
- LEC : Local Exchange Carrier
- RCC : Radio Common Carrier
- IMTS : Improved Mobile Telephone Service
- CGSA : Cellular Geographic Service Area
- AMPS : Advanced Mobile Phone Service
- FDMA : Frequency Division Multiple Access
- Wi–Fi : Wireless–Fidelity

1.1 HISTORY OF RADIO COMMUNICATION

A scientist named 'Heinrich Hertz' was the discoverer of electromagnetic waves, the technical foundation of radio itself. By 1880, Hertz had demonstrated a practical radio communication system. This is the origin of the term 'hertz' the unit of frequency.

Gugliemo Marconi developed the world's first commercial radio service in 1897. It was the first ship-to-shore communication system and provided information about incoming ships. The first human voice transmission via radio was accomplished by Reginald Fessenden in 1900. This was first 'Voice radio link' and marked as the beginning of radio telephony.

Recent Trends

As the decades passed by, new and advanced wireless communication methods and services were developed and improved the existing ones. These have been enthusiastically adopted by people throughout the world. The mobile radio communication has grown many times after the development

of digital technology. This make wireless communication and circuitry easy to use, low costly, less bulky and more reliable. The new technologies and systems in mobile communication are GSM, CDMA, UMTS, IMT-2000 etc. These will be discussed in detail later on in this book. A simple view of wireless network structure is shown in Fig. 1.1.

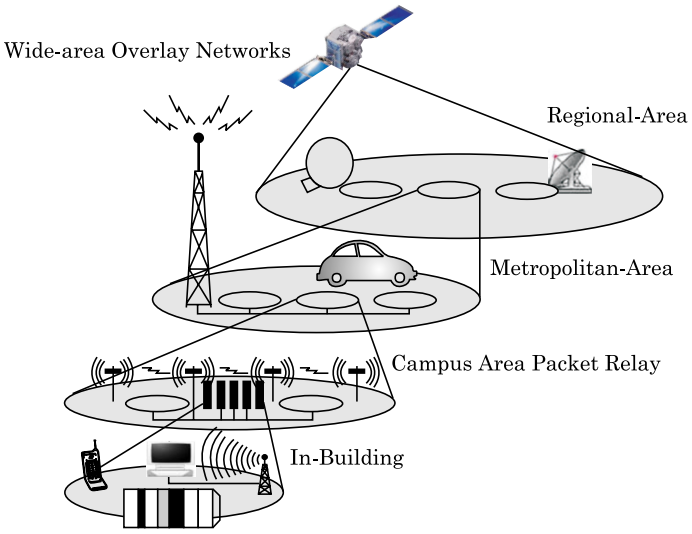

Fig. 1.1 A View of Wireless Network Structure

1.2 WHAT IS WIRELESS COMMUNICATION?

Anyone who is up-to-date with wireless world will definitely say that the dependency on wireless technology has increased over the year and year. These days, any person from the age of 10 to 100 year can hold some sort of wireless portable device. These devices not only allows one to communicate with family and friends, but now one can check his email, his stock portfolios and browse the web all from whatever device he is holding in his hand or nearby on his desk. Therefore wireless communication can be described as–

Wireless Communication is simply a medium to communicate from one device to another device without having any physical link between them.

1.3 MOBILE RADIO SYSTEMS

The development of the mobile radio system can be divided into two parts:

Phase I : produced the earliest systems,

Phase II : began after the federal communications commission's (FCC) classification. It is termed as 'Domestic Public Land Mobile Radio Service'.

The need to increase public safety was key to the origin of today's rapidly growing wireless communications industry. The first use of mobile radio in an automobile was in 1921. In 1932, the New York police department implemented the use of 2MHz band for mobile communication.

But the technology to enable mobile communication services for public safety was not yet available. Early radio telephone systems could be carried on ships but were too large to carry in cars. The key technological breakthrough came in 1935, when scientist 'Edwin Armstrong' unveiled his invention, frequency modulation (FM) to improve radio broadcasting. This technology reduced the required bulk of radio equipment and improved transmission quality.

1.4 MOBILE TELEPHONE SERVICE (MTS)

In 1946, Bell telephone labs inaugurated the first mobile system for the public, in St. Louis. This system was known as Mobile Telephone Service (MTS). MTS transmissions (from radio towers) were designed to cover a very large area, using high power radio transmitters. Often, the towers were placed at geographically high locations. Because they served to a large area, they were subject to noise, interference and signal blocking.

MTS was a half duplex, push-to-talk system. Therefore, MTS offered communication that was only one way at a time. An operator was needed to connect a customer to the landline local exchange carrier (LEC) network. In 1949, the FCC authorized non-wireline companies known as radio common carriers (RCCs) were generated to provide MTS. An RCC is a wireless carrier that is not affiliated with a local telephone company.

1.5 IMPROVED MOBILE TELEPHONE SERVICE (IMTS)

In 1965, almost 20 years after the introduction of MTS, the Bell system introduced Improved Mobile Telephone Service (IMTS). It was the first automatic mobile system and full duplex in nature. It eliminates the push-to-talk requirement of the older MTS system.

IMTS allowed simultaneous two way conversations. A key advantage of IMTS was that users could dial directly into the PSTN. IMTS narrowed the channel bandwidth, which increased the number of frequencies allowed. With full duplex systems such as IMTS, two radio channels are needed for each conversation; one channel to transmit and other channel to receive the information and data.

As with MTS, IMTS radio towers were installed at high places (e.g. tall buildings) to cover large geographic areas, upto 50 miles in diameter.

1.6 MOBILE RADIO STANDARDS AROUND THE WORLD

There are many mobile radio standards working throughout the world. Tables 1.1. to 1.3 show the major mobile radio standards working in North America, Europe and Japan respectively. These standards are characterized in terms of year of introduction, multiple access, frequency band, modulation technique used and allocated bandwidth.

Table 1.1 *Mobile Radio Standards used in North America*

Standard	*Type*	*Year of Introduction*	*Multiple Access*	*Frequency Band*	*Modulation*	*Channel Bandwidth*
AMPS	Cellular	1983	FDMA	824–894 MHz	FM	30kHz
NAMPS	Cellular	1992	FDMA	824–894 MHz	FM	10kHz
USDC	Cellular	1991	TDMA	824–894 MHz	π/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

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Table 1.1 *(Contd...)*

Standard	*Type*	*Year of Introduction*	*Multiple Access*	*Frequency Band*	*Modulation*	*Channel Bandwidth*
GSC	Paging	1970s	Simplex	Several	FSK	12.5 kHz
POCSAG	Paging	1970s	Simplex	Several	FSK	12.5 kHz
FLEX	Paging	1993	Simplex	Several	4-FSK	15 kHz
DCS-1900 (GSM)	PCS Cordless/	1994	TDMA TDMA/	1.85–1.99 GHz	GMSK π/4–	200 kHz
PACS	PCS	1994	FDMA	1.85–1.99 GHz	DQPSK	300 kHz
MIRS	SMR/PCS	1994	TDMA	Several	16–QAM	25 kHz
iDen	SMR/PCS	1995	TDMA	Several	16-QAM	25 kHz

Table 1.2 *Major Mobile Radio Standards used in Europe*

Standard	*Type*	*Year of Introduction*	*Multiple Access*	*Frequency Band*	*Modulation*	*Channel Bandwidth*
ETACS	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 used 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	π/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	π/4–DQPSK	300 kHz

1.7 DEFINITION OF CELLULAR RADIO

There are two different ways to view the definition of cellular systems:

FCC Definition : A high-capacity land mobile system in which assigned radio spectrum is divided into discrete channels which are assigned in groups to geographic cells covering a cellular geographic service area (CGSA). The discrete channels are capable of being reused in different cells within the service area through a process known as 'frequency reuse' (explained later).

Layman's Definition : A system which uses radio transmission rather than physical wirelines to provide telephone service comparable to that of regular business or residential telephone service.

1.8 THE CELLULAR CONCEPT

Instead of having just a few radio channels that everyone must share (like MTS, IMTS), cellular radio channels are reused simultaneously in nearby geographic areas, yet customers do not interfere with each other's calls.

The cellular system is similar in functional design to the public switched telephone network or landline network. Fundamentally it contains subscribers, transmission systems and switches.

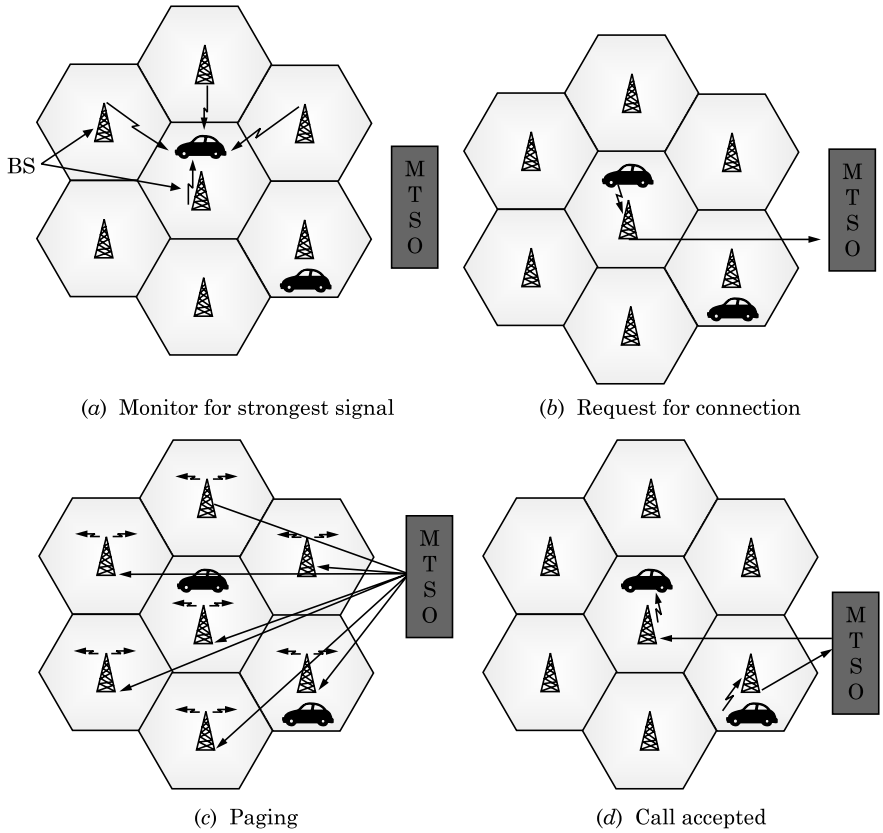
Several fundamental attributes are needed for the realization of cellular service:

1. Low power transmitters and small coverage zones.
2. A continuous arrangement of radio cells so that the mobile unit can always operate at acceptable radio signal levels.
3. Frequency reuse.
4. Call handoff capability.
5. A fully integrated, transparent fixed-network to manage these operations.
6. Paging facility

Operation of Cellular System

In cellular system, there is a BS (or BTS) at centre of each cell. This base station includes an antenna, a controller and transceivers for communicating on the channels assigned to that cell.

Each BS is connected to one MTSO and one MTSO can control/ command more than one BS's. MTSO is also connected to PSTN and can make a connection between public network with mobile unit.



(*a*) Monitor for strongest signal (*b*) Request for connection

(*c*) Paging (*d*) Call accepted

Fig. 1.2 Mobile Cellular calls

When a mobile unit is turned on, it searches the strongest signal set up with the BS. When BS has been identified then a hand shake takes place between the mobile unit and the MTSO controlling this cell, through the BS of the cell. Through this way the user is identified and its location is registered. Few examples of mobile cellular call is given in Fig. 1.2.

1.9 AMPS : THE AMERICAN CELLULAR STANDARD

In an effort to use the air-waves more efficiently, AT&T engineers decided to stretch the limited number of radio frequencies available for mobile service by scattering multiple low-power transmitters throughout a metropolitan area. This new technique would allow more customers to access the system simultaneously and when more capacity was needed, the area served by each transmitter could be divided again. This was the birth of wireless technology.

Advanced Mobile Phone Service (AMPS) is the American analog cellular standard. In 1970, several key developments occured:

1. The FCC set aside new radio frequencies for land-mobile communications. These frequencies were UHF television channels in the 800 MHz band.
2. In the same year, AT&T proposed to build the first high capacity cellular telephone system. It developed the system AMPS.

1.9.1 AMPS Technical Specifications

AMPS cellular systems use FM radio transmission, where available spectral bandwidth is divided into 30 kHz channels, each channel capable of carrying one conversation or serial data stream at a time. Frequency division multiple access (FDMA) describes the process of subdividing a large block of radio spectrum into many smaller blocks of spectrum.

Until the year 1992, cellular radio had always used analog transmission. The radio communication between base stations and mobile phones was transmitted as analog FM signal.

Around 1992, digital radio was developed, initially using time division multiple access (TDMA) technology. Since 1992, cellular carriers have deployed digital radio technology and service in order to increase the capacity of their systems.

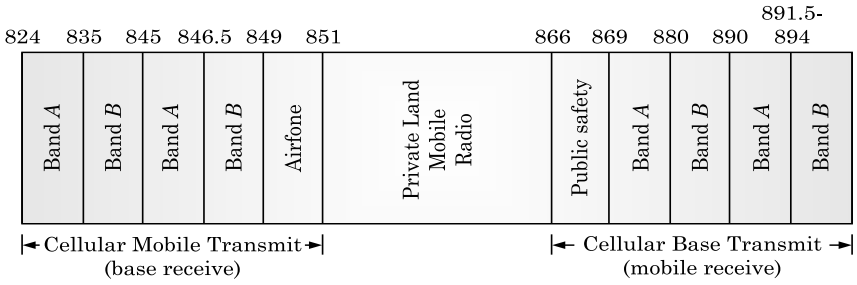


Fig. 1.3 AMPS Cellular–frequency Allocations

AMPS cellular frequencies in the US are :

Mobile Transmit : 824–849 MHz (base receive)

Base Transmit : 869 – 894 MHz (mobile receive)

Fig. 1.3 shows AMPS cellular frequency allocations for different bands.

1.10 DIFFERENT GENERATIONS OF WIRELESS SYSTEMS

All wireless networks are divided into three generations. The detail of these generations is given as follows :

1.10.1 First Generation (1G)

Main characteristics of first generation systems are given as follows:

- Based on analog technology
- Use frequency modulation
- Its transport architecture has the mobile unit, the base station and mobile switching centre (MSC)
- Provides low rate data transmission between the base station and the mobile user.
- Speech signals are digitized on time division multiplex format for transmission.

Table 1.4 provides a summery of the first generation cellular systems.

Table 1.4 *First Generation Analog Cellular Systems*

Standard	*Region*	*Frequency (MHZ)*	*Channel Spacing (kHz)*	*No. of Channels*	*Modul-ation*	*Data Rate (kbps)*
AMPS	USA	824–849 869–894	30	832	FM	10
TACS	Europe	890–915 935–960	25	1000	FM	8
ETACS	UK	872–905 917–950	25	1240	FM	8
NMT 450	Europe	453–457.5 463–467.5	25	180	FM	1.2
NMT 900	Europe	890–915 935–960	12.5	1999	FM	1.2
C–450	Germany Portugal	450–455.74 460–465.74	10	573	FM	5.28
RTMS	Italy	450–455 460–465	25	200	FM	—
Radiocom 2000	France	414.8–418 424.8–428	12.5	256	FM	—
NTT	Japan	870–885 925–940	25	600	FM	0.3
JTACS/ NTACS	Japan	860–870 915–925	25	400	FM	8.0

Note: AMPS was most popular 1G system in North America in early 1980s. AMPS is an abbreviation of "Advanced Mobile Phone Services". It was developed by AT&T. AMPS Parameters are listed below–

Channel Bandwidth: 30 KHz
Cell radius (in Km): 2 of 20 Km
Data transmission rate: 10 Kbps
Base station Transmission Band: 869–894 MHz
Mobile Unit Transimission Bond: 824–849 MHz

1.10.2 Second Generation (2G)

Second generation wireless systems have some advancements over first generation systems. Main characteristics of second generation are as follows :

- Uses digital modulation technique
- Reduced the computational burden of the MSC
- Introduced the concept of base station controller (BSC) over several base stations.
- Digital voice coding is employed.
- Dedicated control channels for simultaneous exchange of voice and control information.
- Provides paging, facsimile and high data rate network access.
- Hand-off process is mobile controlled and is known as mobile assisted handoff (MAHO).
- Mobile unit performs several other functions except voice transmission and reception. These are data encoding, data encryption, adjacent base station scanning, received power level reporting etc.

Table 1.5 shows second generation cellular and cordless systems.

Table 1.5 *Second Generation Cellular and Cordless Systems*

System → / *Parameters ↓*	*IS–54 Country USA*	*GSM Europe*	*IS–95 USA*	*CT-2 Europe, Asia*	*CT-3 DCT-90 Sweden*	*DECT Europe*
Access Technology	TDMA/ FDMA	TDMA/ FDMA	CDMA/ FDMA (DS)	FDMA	TDMA/ FDMA	TDMA/ FDMA
Primary use	cellular	cellular	cellular	cordless	cordless	cordless/ cellular
Frequency Band						
BS(MHz)	869–894	935–960	869–894	864–868	862–866	1800–1900
MS(MHz)	824–849	890–915	824–549			
Duplexing	FDD*	FDD	FDD	TDD**	TDD	TDD

(Contd...)

Table 1.5 *(Contd...)*

System → / *Parameters ↓*	*IS–54 Country USA*	*GSM Europe*	*IS–95 USA*	*CT-2 Europe, Asia*	*CT-3 DCT-90 Sweden*	*DECT Europe*
RF Channel Spacing (kHz)	30	200	1250	100	1000	1728
Modulation	π/4 DQPSK	GMSK	BPSK/ QPSK	GFSK	GFSK	GFSK
Handset Power, Maximum/ Average in megawatts (MW)	600/200	1000/125	600	10/5	80/5	250/10
Frequency Assignment	Fixed	Fixed	Fixed	Dynamic	Dynamic	Dynamic
Power Control						
MS	Y	Y	Y	N	N	N
BS	Y	Y	Y	N	N	N
Speech Coding	VSELP	RPE-LTP	QCELP	ADPCM	ADPCM	ADPCM
Speech rate (kbps)	7.95	13	8(variable rate)	32	32	32
Speech channel per RF Channel	3	8	13–40	1	8	12
Channel Bit Rate (kbps)	48.6	270.833	1228.8	72	640	1152
Channel Coding	1/2 rate convolutional	1/2 rate convolutional	1/2 rate forward, volutional	None 1/3 rate reverse, CRC	CRC	CRC
Frame Duration (ms)	40	4.615	20	2	16	10

*Frequency Division Duplex.
**Time-Division Duplex.

1.10.3 Differences in 1G and 2G:

S.N	*Parameter*	*1G*	*2G*
1.	Channel type	1G systems are purely analog.	2G systems are digital in nature.
2.	Voice transmission	1G Systems were designed to support voice channels using FM.	In 2G systems, voice traffic is first encoded in digital form before transmission.
3.	Security	1G systems were lacking in security as these send the user data without any coding.	All 2G systems provide encryption facility to support security requirement.
4.	Error detection and correction	The data is analog in nature therefore error detection and correction techniques can not be applied with 1G systems.	Error detection and correction techiquies are available with the digital traffic scheme of 2G systems which leads very clear voice reception.
5.	Channel assignment stratagy	1G systems provide a number of channels per cell but each channel is **dedicated** to its user.	2G systems also provide multiple channels per cell and each channel is **dynamically shared** by a number of users using TDMA or CDMA schemes.
6.	Signal quantity and capacity	Signal quality is low along with low capacity.	High quality signals with higher data rate and greater capacity.

1.10.4 Third Generation (3G)

Third generation systems came into existence from mature second generation systems. These systems have a wide range of wireless applications and are used throughout the world to provide a single set of standard. Main characteristics of third generation systems are:

- Provides world wide access
- Accesses information through Broadband Integrated Services Digital Network (BISDN)

- Information may be in the form of voice, data or video.
- Enables a person to communicate with anyone at any time, at any place.
- Global roaming facility.
- Provides more reliable service.
- Examples of 3G systems are :

  1. International Mobile Telecommunications (IMT–2000)

  2. Universal Mobile Telecommunication System (UMTS)

  3. Mobile Broadband System (MBS)

  4. Wireless Local Area Network (WLAN).

1.10.5 Evolution of Wireless Generations and Services in Brief

The first generation (1G) wireless network was analog. The first in North America was advanced mobile phone system (AMPS), which was based on frequency division multiple access. A total of 1664 channels were available in the 824 to 849 MHz and 869 to 894 MHz band, providing 832 downlink (DL) and 832 uplink (UL) channels. AMPS, widely used in North America, supports frequency reuse. The underlying network is a cellular network where a geographical region is divided into cells. A base station (BS) at the center of the cell transmits signals to and from users within the cell.

The second generation (2G) systems onward are digital. Digital systems make possible an array of new services such as caller ID. The Global System for Mobile Communications (GSM) is a popular 2G system. GSM offers a data rate of 9.6 to 14.4 kbps. It supports international roaming, which means users may have access to wireless services even when traveling abroad. The most popular service offered by GSM is the Short Message Service (SMS), which allows users to send text messages up to 160 characters long.

2.5G systems support more than just voice communications. In addition to text messaging, 2.5G systems offer a data rate of the order of 100 kbps to support various data technologies, such as Internet access. Most 2.5G systems implement packet switching. The 2.5G systems help provide seamless transition technology between 2G and third generation (3G) systems. The following are 2.5G systems.

High-Speed Circuit- Switched Data (HSCSD): Even though most 2.5G systems implement packet switching, HSCSD continues support for circuit-switched, data. It offers a data rate of 115 kbps and is designed to enhance GSM networks. The access technology used is time division multiple access (TDMA), It provides support for Web browsing and file transfers.

General Packet Radio Service (GPRS): GPRS offers a data rate of 168 kbps. It enhances the performance and transmission speeds of GSM. GPRS provides always-on connectivity, which means users do not have to reconnect to the network for each transmission. Because there is a maximum of eight slots to transmit calls on one device, it allows more than one transmission at one time; for example, a voice call and an incoming text message can be handled simultaneously.

Enhanced Data Rates for GSM Evolution (EDGE): EDGE works in conjunction with GPRS and TDMA over GSM networks. Its offered data rate is 384 kbps. EDGE supports data communications while voice communications are supported using the technology on existing networks.

Third-generation (3G) wireless systems are designed to support high bit rate telecommunications. 3G systems are designed to meet the requirements of multimedia applications and Internet services. The bit rate offered ranges from 144 kbps for full mobility applications, 384 kbps for limited mobility applications in macro- and microcellular environments, and 2 Mbps for low-mobility applications in micro- and picocellular environments. A very useful service provided by 3G systems is an emergency service with the ability to identify a user's location.

1.11 CELLULAR SYSTEM OBJECTIVES

When 'Bell Labs' developed the AMPS cellular concept, the major system objectives were efficient use of radio spectrum and widespread availability.

New technologies enabled small, relatively light-weight subscriber equipment to be manufactured cheaply. Vastly improved integrated circuit manufacturing techniques allowed for major advances in computer technology as well as miniaturization for critical equipment elements, especially within portable mobile telephones.

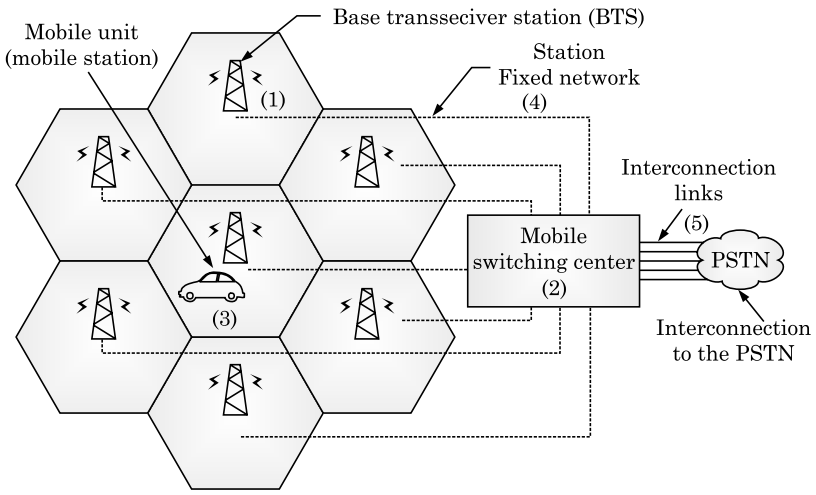


Fig. 1.4 Five main components of wireless system

There are five main components to the cellular telephone system shown in Fig 1.4.

1. The mobile telephone,
2. The cell base station,
3. The mobile switching center (MSC),
4. The fixed network (transmission systems) and
5. The PSTN.

1.12 LOCAL AREA NETWORK (LAN)

Local area network is a communication network that interconnect a variety of devices in a small geographic area, for e.g., in a building, office, schools etc. All the interconnected devices are authorized for information exchange.

Salient Features of LAN

1. Coverage distance is small.
2. Data rate is very high.
3. Data Speed 1–20 Mbps.

Note: The advancement over LAN is high-speed LAN. It works on the data rates 100 Mbps to 10 Gbps.

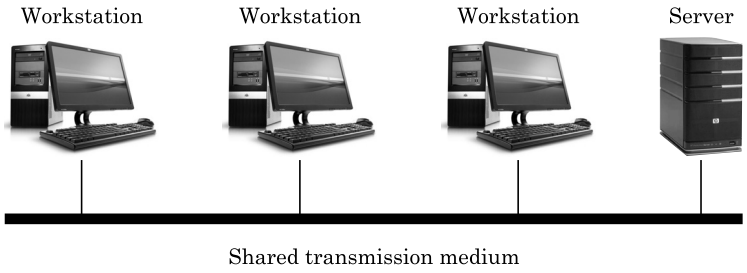


Fig. 1.5 A Simple Local Area Network

1.13 METROPOLITAN AREA NETWORKS (MAN'S)

MAN's can work at some greater distance with more data rates than LAN's.

MAN's were developed considering the requirement for both private and public networks which is

1. High capacity
2. Low cost
3. Large coverage area

The primary market for MAN's is the customer that has high capacity needs in a metropolitan area. It is intended to provide the required capacity at lower cost and greater efficiency than was served by LAN's.

These are basically used by metropolitan cities to communicate and exchange of information.

1.14 WIDE AREA NETWORK

Wide area network is superior in terms of coverage area over LAN's and MAN's but it suffers with low bit data rate.

WAN's cover a large geographical area. It has a number of interconnected switching nodes. A transmission from any one device is routed through these internal nodes to the specified destination device.

1.15 FREQUENCY REUSE AND PLANNING

Wireless system enables mobile communication through the use of a very sophisticated two-way radio link that is maintained between the user's wireless telephone, the wireless network,

and the landline public telephone network. The concept behind two way radio link involves using individual radio frequencies over and over again throughout a city or country with minimal interference, to serve a large number of simultaneous conversations. This concept is the basis of cellular system design and is known as 'frequency reuse'.

The frequency reuse concept is what separates the cellular system from all preceeding systems such as MTS and IMTS.

The major drawback with previous mobile communication system was the inefficient use of allocated radio spectrum. Reusing radio frequency over a given geographic area provides the means for supporting a number of simultaneous conversations.

The frequency reuse plan is defined as how radio frequency (RF) engineers subdivide and assign the FCC allocated radio spectrum throughout the wireless market.

A frequency reuse plan is produced in a group of 7 cells ($N = 7$) as shown in Fig. 1.6 where N shows the number of cells forming a cluster.

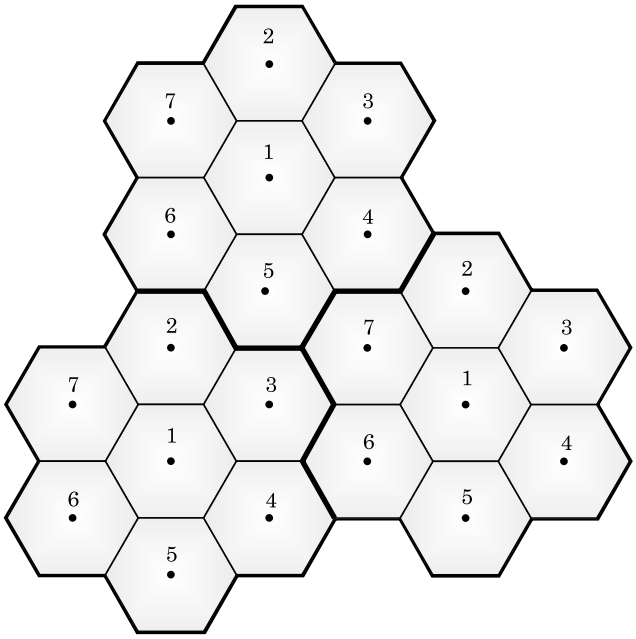


Fig. 1.6 Frequency Reuse (N = 7) format

1.16 CALL HANDOFF

What makes the cellular system work when the subscriber unit (the mobile phone) change frequency (channel) as the unit moves throughout a network. This is done by using '**Call Handoff**' mechanism.

Call handoff is the process where a call in progress is transferred from one cell base station to another cell base station while maintaining the call connection to the cellular system.

Along with frequency reuse, call hand-off capability is the driving force behind wireless technology.

The rationale behind the handoff process is the need to keep the subscriber unit receiving a usable signal. As the MSC sees a mobile's signal level going down, it looks for a neighbouring cell base station that can 'hear' the subscriber better via stronger received signal. The call is then handedoff to the neighbouring cell base station. The call handoff is also known as '**call handover**' process in some parts of the world. In simple words we can understand the call hand-off as–

If the mobile unit moves out of range of one cell and enters into the range of another cell during a call connection, then the traffic channel has to change its BTS. The system makes this change without either interrupting the call or altering the user. [See Fig. 1.7]

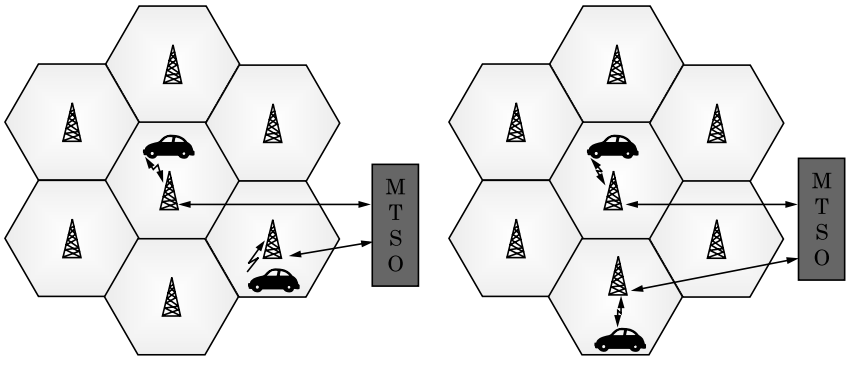


Fig. 1.7 Hand-off during on going call

1.17 RECENT TRENDS IN WIRELESS COMMUNICATION

In recent years, according to customer demands and working standards, considerable research and development is underway. Some innovative technologies showing the future trends in wireless communication. are given as follows:

1. **Bluetooth :** Bluetooth is a radio standard and communication protocol designed for low power consumption, with a short range (1m-100meter). It is also known as IEEE 802.15.1. It is acceptable for situations when two or more devices are in close proximity and all have enabled their bluetooth. Bluetooth lets these devices comminicate with each other without having any physical wired link. Bluetooth uses short range radio frequencies, therefore, it is not as effective as Wi-Fi for setting up networks of remote locations. Some bluetooth applications are given
   - Wireless communication between a *cell phone* and a *hands free headset* or car kit. This is the most popular use.
   - Wireless networking between PCs in a confined space and where little bandwidth is required.
   - Wireless communications with PC input and output devices, the most common being the *mouse*, *keyboard* and *Printer*.
   - Transfer of files between devices.
   - Transfer of contact details, calendar appointments, and reminders between devices.
   - Replacement of traditional wired *serial* communications in test equipment.
   - For remote controls where infrared was traditionally used.
   - Sending small advertisements from Bluetooth enabled advertising hoardings to other Bluetooth devices.
2. **Wi-Fi :** It is known as Wireless-Fidelity. It is a LAN technology based on the IEEE 802.11 standards. Wi-Fi covers not only office-based LANs, but also home housed LANs. It uses the same radio-frequencies as blutooth, but with higher power consumption resulting in a stronger connection. Wi-Fi is better suited for setting up networks as it enables faster connection and better security.
3. **Wi-Max :** Wi-Max is similar to Wi-Fi but has extra range capability. Wi-Max has a range of 40-50 km while Wi-Fi range is limited to several hundred meters. Therefore

Wi-Max provide a wireless alternative to cable and wired communication Wi-Max operation is based on IEE 802.16 standards.

4. **Mobile-Fi :** It is similar to the mobile version of Wi-Max in terms of technology. The objective with Mobile-Fi is to provide internet access to mobile users at data rates even higher than those available in home broadband links. Thus, a Mobile-Fi user could enjoy broadband internet access while traveling in a moving car or train. Mobile-Fi is based on JEEE 802.20 standards specifications.
5. **Ultrawideband :** It is quite different than other technologies. It enables the transfer of bulk data. Ultrawideband enables the movement of massive files at high data rates over short distances.

1.18 CHARACTERISTICS O F A GOOD WIRELESS COMMUNICATION

Given below are general characteristics and goals that a good wireless communication tries to achieve:

1. **Unlimited Roaming and Range:** It means no matter how far or how near a user is from the base provider, data can still be sent and received.
2. **Guaranteed of Delivery:** All messages and data is guranteed to be delivered regardless of where a user is located. Even if the portable device is turned off, when it is turned on again, the user will get his message.
3. **Dependability of Delivery:** All messages are guaranteed of accurate and full transmission.
4. **Notification:** Notifies the user that there is data that has been sent and needs to be looked at.
5. **Connectivity Options:** Sender and receiver are given with a wide range of options in receiving messages, calls etc. for connectivity.
6. **Millions of users:** Ability to engage millions of users.
7. **Priority Alerts:** Able to distinguish between messages and data that are of higher importance than others. Also able to control high frequency priority data traffic correctly and rapidly.

8. **Host Mobility:** One host containing its setting on a network– its internet protocol (ID) address, gateway address, and so on. Now this host decides to move somewhere else, this means that the host will have to change its setting all over gain, but has to let others know that it has moved.

   Flexible mobility allows that host to come and go as it pleases and with not even needing to alert others of its move. Communication with the host is still possible even after it has moved.

SUMMARY

- Marconi developed the worlds first commercial radio service for ship to shore communication.
- Bell telephone labs inaugurated the first mobile system for the public in 1946, known as Mobile Telephone Service (MTS).
- First automatic mobile system that was full duplex in nature was IMTS.
- Cellular service should provide frequency ability, call handoff, frequency reuse and fixed network for better operation and secure communication.
- In the late 1970s, AT&T Bell laboratories developed the first US cellular telephone system called the Advanced Mobile Phone Service (AMPS).
- All the wireless systems are divided into three generations.
- First generation systems were based on analog technology.
- Second generation system uses digital modulation technique.
- Third generation system provide world wide access and enable to communicate with a person at any time at any place.
- Frequency reuse supports the concept that a frequency could be used again and again by having sufficient distance between two same frequency cells.
- 3G systems are designed to support high bit rate telecommunication.
- LAN is a communication network that interconnect a variety of devices in a small geographic area.
- MAN can work at some greater distance with more data rates than LAN.

- WAN is superior in terms of coverage area over LAN's & MAN's.
- **Call handoff** is the process where a call in progress is transferred from one cell base station to another cell base station while maintaining the call connection to the cellular system.

REVIEW QUESTIONS

1. What was the first 'voice radio link'? In which year it is developed?

2. Write down the history of radio communication in brief.

3. Write down the classification of Mobile Radio Systems in brief.

4. How IMTS is different from MTS?

5. What are different mobile radio standards working throughout the world?

6. What do you understand by cellular concept?

7. Write down the AMPS technical specifications.

8. What are the advantages of 3G systems over 2G systems? Explain.

9. Write short notes on the requirement of frequency reuse and planning.

10. How call Handoff is beneficial in wireless communication process? Explain with the help of an example.

11. Write short notes on the future trends in wireless communication.

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