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Introduction to Mobile Terminals

1.1 Introduction to Mobile Terminals

A mobile communication device is a small, portable electronic device, with wireless communication capabilities, which is easy to carry around. There are several types of mobile communication devices, like cell phones or mobile phones, WLAN devices, and GPS navigation devices, but it is the mobile phone that has adopted the term "mobile device," and gradually its purpose has shifted from a verbal communication tool to a multimedia tool.

A mobile phone, which is also known as mobile terminal (MT), cellular phone, cell phone, hand phone, or simply a phone, is a device that can send and receive telephone calls over a radio link while being connected to a cellular base station operated by a cellular network operator. It provides user mobility around a wide geographic area. A feature phone is a low-end mobile phone with limited capabilities and it provides mainly voice calling, text messaging, multimedia, and Internet functionality. In addition to telephone calls, modern multifunctional mobile phones with more computing capabilities, which support a wide variety of other applications and services like SMS, MMS, e-mails, Internet, Web browsing, news, gaming, playing music, movies, calendar management, contact, video, photography, short-range connectivity, location-specific information, WLAN connectivity, and GPS connectivity, are considered as smartphones. Smartphones offer all these services in single device, so they are becoming increasingly important as work tools for users who rely on these services. Today, they have become universal replacements for personal digital assistant (PDA) devices. Typically, a smartphone incorporates handheld computer functionalities along with the communication capabilities of a cell phone by providing support

Mobile Terminal Receiver Design: LTE and LTE-Advanced, First Edition. Sajal Kumar Das.

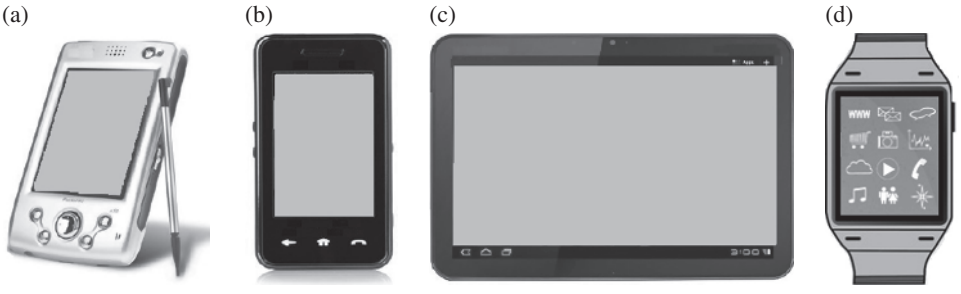


Figure 1.1 (a) PDA, (b) smartphone (c) tablet (d) wearable device

of multimodal, multi-RAT connectivity and user customized applications. Personal digital assistants/enterprise digital assistants, tablet computers, ultramobile PCs, and a lot of wearable devices also provide mobile communication capabilities by integrating communication modems in them. Various types of these devices are shown in Figure 1.1.

1.1.1 Building Blocks of a Smartphone

A system-level block diagram of a smartphone is shown in Figure 1.2. Smartphones are equipped with various functional blocks as given below:

- Mobile terminal modem unit. This unit (cellular systems modem) interfaces with the cellular base stations, and sends/receives user information (voice, data) generated by the application unit. So it interacts with a base station using different cellular air interface standards like GSM, WCDMA, LTE etc. to send/receive information to distantly located called party or server. It also interacts locally with its application units, like speech, video, and data transfer applications for getting/providing the user application data. This is discussed in Chapters 2, 3 and 4. This consists of two main submodules: Radio Frequency (RF) unit and Baseband (BB) unit.
  - RF unit. The RF analog front-end unit's transmitter circuit helps to upconvert the low-frequency baseband signal to a high-frequency amplified RF signal for transmission, and the receiver circuit helps to downconvert the analog amplified received high-frequency signal to a low-frequency baseband signal. The RF unit is discussed in detail in Chapter 6.
  - Baseband unit. The baseband unit helps for digital bit detection, system protocol processing for proper and reliable communication with the network. These are discussed in detail in Chapter 4 and 5.
  - SIM. A subscriber identification module (SIM) is an integrated circuit that securely stores the international mobile subscriber identity (IMSI) and the related key used to identify and authenticate subscribers on mobile telephony devices. A SIM circuit is embedded into a removable plastic card, called "SIM card." This is discussed in detail in Chapter 5.

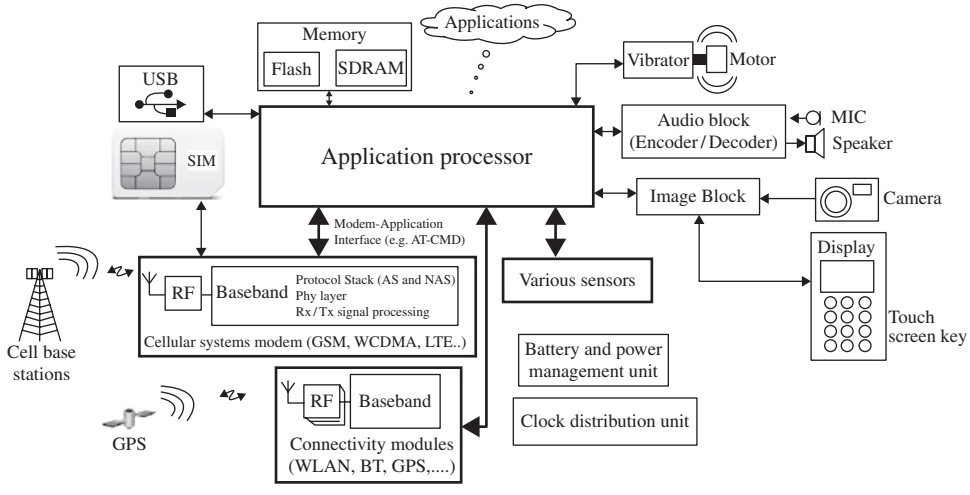


Figure 1.2 System-level block diagram of a typical smartphone

- Application unit. This unit is in charge of running various applications. It interacts with the modem and connectivity modules to send/receive information from remote devices, and uses that data to drive various applications. It provides the functions that users want to execute on the smart phone and these may include speech, audio playback, fax transmission/reception, Internet, e-mail, Web browsing, image reproduction, streaming video, games, and so forth. This unit also handles the interface functions such as keyboard, display, and speech recognition, and it interfaces and manages other connectivity modules such as GPS and WLAN. Depending on the smartphone device complexity, there could one or several application processors in a mobile phone. The architecture design and selection details are provided in Chapter 5 and 7. The application processor consists of components like the processor core and device interfaces, which communicate with other peripheral devices attached to the application processor like the LCD screen, camera, keypad, universal serial bus (USB), and multimedia card (MMC) via interfaces. These are discussed in detail in Chapter 5.
  - Peripheral devices. There are several peripheral devices placed in the smart phone for different purposes. Like, for data transfer with other devices or PC, an USB device is placed in the phone. Similarly, UART, I2S etc. are used for intermodule or interdevice communication. The other devices are like, SD/MMC, LCD display, keyboard, microphone, and speaker are also used in a mobile phone. These are discussed in detail in Chapter 5.
  - Multimedia modules. It performs multimedia related functions like, speech encoding/decoding, audio encoding/decoding, video encoding/decoding by employing various multimedia standards (MP3, JPEG, MPEG, and so forth). As multimedia-related functions are time consuming, so these are generally implemented in dedicated hardware block. Also, smartphone contain graphics processing unit (GPU) for rapid processing of multimedia functions. These are discussed in detail in Chapters 5 and 7.

  - Various sensors and actuators. A sensor is a device that measures a physical quantity and converts it into a signal (electrical or optical) by an instrument. They sense the changes in the environment and send them to the application processor. The commonly used sensors in handsets include accelerometers, gyroscopes, proximity sensors, ambient light sensors, barometers, and so forth. On the other hand, an actuator is a type of motor that is responsible for moving or controlling a mechanism or a system. These are discussed in detail in Chapter 5.
  - Vibrator. A vibra alert device is used to give a silent alert signal to the phone user. Generally the vibration is made using an improperly balanced motor and controlled with a pulse width modulation (PWM) signal via the battery terminal. These are discussed in detail in Chapter 5.
  - Connectivity modules. Apart from cellular system modem, the smart phone also houses several other wireless connectivity modules like, Geo Positioning System (GPS), Bluetooth (BT), FM radio, ZigBee, Wireless LAN (WLAN), and so forth. These individual submodules have RF and digital baseband processing unit and interact with the other devices, peripherals like, headset or server through radio interface. These are discussed in detail in Chapter 5.
- Power management module. This unit is responsible for distributing the regulated battery power among various modules, conversion of the battery voltage (generally 3.6 V) according to the different voltage level needed by different modules, which means up or down conversion to various voltages (such as 4.8 V, 2.8 V, 1.8 V and 1.6 V) using, for example, a DC-DC converter, a battery power consumption control device, sleep-related functionalities management, battery-charging control. The battery-charging component is responsible for charging the battery of the smartphone. These are discussed in detail in Chapter 8.
- Clock distribution module. This distributes a clock signal to the mobile phone. The clock signal is required in every digital blocks in the system and also it is required in RF unit for scheduling transmission and reception at a specific time. These are discussed in detail in Chapter 5.
- Memory. Various types of memory are used in the mobile phone for storing code and data. Generally, Flash memory, EPROM, and DRAM memory are used in a mobile phone. These are discussed in detail in Chapter 5.

Apart from all these hardware blocks, firmware and software components reside in the memory and are executed by processors to configure, control, and process different hardware modules, applications, and protocols. These are discussed in Chapter 7.

1.2 History of the Mobile Phone

Prior to 1973, mobile telephony was limited to phones installed in cars, trains and other vehicles, mainly due to the larger size and weight of the equipment. On April 3, 1973, Martin Cooper, a senior engineer at Motorola, made the first mobile telephone call from

handheld subscriber equipment, which was around 23 cm long, 13 cm deep and 4.45 cm wide and weighed 1.1 kg and offered a talk time of just 30 min with 10 h of recharge time. Since then, mobile phones have evolved dramatically, with enriched features like audio, and video players, video cameras, handheld gaming devices and support for Internet access, augmented reality, commercial services and a whole host of other applications. They also reduced in size, weight, and cost.

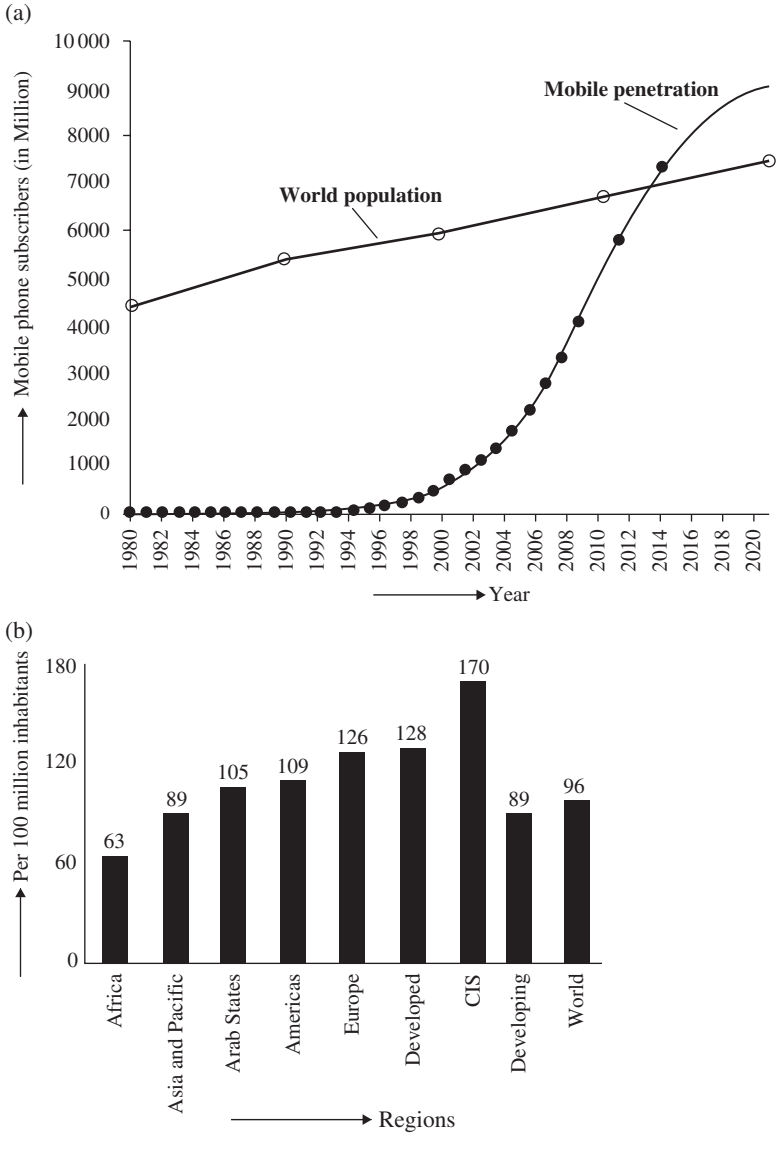
In 1992 Motorola introduced the first digital palm-size mobile telephone named Motorola 3200. In 1992, Nokia developed Nokia 1011, which was first mass-produced GSM phone. In 1992 IBM introduced Simon, a personal communicator with PDA and phone combination, which had a monochrome touchscreen and a stylus. In 1996, Nokia introduced the communicator 9000 series as a smart phone with outward facing dial pad, navigation keys, and monochromatic display. Nokia 7120 supported WAP browser. One year later, Ericsson released the GS 88 smart phone with a touchscreen inside and a stylus. Samsung Uproar cell phone was introduced with MP3 music capabilities. Nokia 8310 was having several premium features such as FM radio, infrared, and a fully functional calendar. Ericsson T39 was a tiny Bluetooth-capable handset. In 1999, NTT DoCoMo pioneered the first mobile Internet service in Japan on existing 2G technologies, which was soon replaced by the first 3G handsets in October 2001. In 2002, the first phones with built-in cameras became publicly available in the Nokia 7650 and the Sanyo SPC-5300. In 2004, Motorola introduced Razor V3, which is a very lightweight sleek phone. In January 2007, Apple launched its first iPhone, combining three products into one handheld device: a mobile phone, an iPod, and a wireless communication device, which had an autorotate and a multitouch sensor. This device helped Apple to capture a significant market share. In 2008, Nokia released a GPS-enabled smartphone with sleek, compact design.

The mobile phone continues to evolve. In 2008 LTE standardization was released and today the most recent phone comes with fourth-generation (4G) technology. This allows users to download music, watch videos, make video calls and join video conferences at much faster speeds. Today, this magical portable technology box has become an essential part of interpersonal communication and its significance is further increasing over time.

1.3 Growth of the Mobile Phone Market

The first mobile subscriptions took place in the early 1980s. During that period the total number of mobile phones in the market were around 0.023 million. Since then aided by affordability of cheap mobile phones and support of newer features fueled the mobile phone growth year after year. Figure 1.3(a) shows the growth of mobile subscribers since 1980 (according to ITU published figures). In 2014, the number of worldwide mobile users reached more than 5.6 billion (whereas world human population was 7.1 billion).

Low-end mobile phones are often referred to as feature phones. They are limited in their capabilities and primarily designed for basic telephony services. Handsets with more advanced computing ability, hosting a lot of other features apart from voice communication,



Note: CIS – Commonwealth of Independent States

Figure 1.3 (a) Growth of mobile subscribers over years. (b) Mobile cellular subscriptions by regions in 2014

Table 1.1 Smartphone usage data

Smartphone users	Around 80% of the world population now has a mobile phone and the number of mobile phones used is more than 5 billion. The number of smartphone users in the United States is 92 million. Ninety percent of the users use their smartphones throughout the day.
Owners by age group and gender	Age group: 13–17: 7%; 18–24: 18%; 25–34: 27%; 35–44: 22%; 45–54: 14%; 55–64: 7%; 66+: 3%. Gender of users: 47% women; 53% men
Primary usage	92% SMS; 84% Internet browsing; 70% e-mail; 65% games; 60% social networking; 50% music and videos
Community type	Urban: 65% Rural: 35%

are known as smartphones. Recently, smartphone penetration has increased significantly due to greater use of the Internet and complex applications. Global smartphone users surpassed the 1 billion mark in 2012 and in 2014 touched around 1.75 billion. Figure 1.3(b) shows mobile phone penetration by geographic regions.

Some interesting data is shown in Table 1.1.

The mobile phone business is a rapidly growing industry, providing mobile devices, content, and services. As no firm can make everything required for mobile phone devices and network, firms with different resources, capabilities and competences cooperate and form a network to provide products and service to consumers. This is commonly known as a mobile ecosystem, which consists of variety of firms like, network operators (like, Vodafone, Verizon, AT&T), mobile device manufacturers (like Apple, Samsung, Nokia and HP), network infrastructure providers (like Ericsson and Nokia-Siemens), silicon vendors (like Qualcomm, Intel and ST-Ericsson), platform providers (like, Qualcomm and Intel), content providers, system integrators, software providers, application developers, and, of course, consumers. Apart from these players, the growing demand for mobile phone production in recent decades has given rise to so-called original design manufacturers (ODMs) – for example, a company that designs and manufactures a product which is specified and eventually branded by another firm for sale – and original equipment manufacturers (OEMs) – for example, a company that manufactures products or components which are purchased by another company and retailed under that purchasing company's brand name.

Prior to 2010, Nokia was the market leader for mobile device manufacturing and sales. In Q1 2012, based on data from Strategy Analytics, Samsung surpassed Nokia, selling 93.5 million units. In Q3 2014, the top 10 manufacturers were Samsung (20.6%), Nokia (9.5%), Apple Inc. (8.4%), LG (4.2%), Huawei (3.6%), TCL Communication (3.5), Xiaomi (3.5%), Lenovo (3.3%), ZTE (3.0%) and Micromax (2.2%). The top five worldwide mobile phone vendors are shown in Table 1.2.

Table 1.2 Top five worldwide total mobile phone vendors, 2013

Rank	Manufacturer	Source: Gartner (%)	Source: IDC (%)
1	Samsung	24.6	24.5
2	Nokia (now Microsoft)	13.9	13.8
3	Apple Inc.	8.3	8.4
4	LG	3.8	3.8
5	ZTE	3.3	–
6	Huawei	–	3.0
	Others	34.0	46.4

1.4 Past, Present, and Future of Mobile Communication Devices

In the past, the use of a mobile phone was mainly for voice communication, but today there are thousands of applications that a mobile phone offers, including text messaging (SMS), a multimedia messaging service (MMS), Internet access, Web browsing, sending and receiving e-mails, listening to music, reading books, video chat, video recording, location service, time watching, alarm, calendar, calculator. Apart from these, nowadays mobile phones are also used in the field of telemedicine, healthcare, and wearables. In future it has huge potential to be used for watching TV, controlling and tracking remove devices, home automation, object recognition, e-commerce, and so forth.

Further Reading

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