MOBILE SYSTEM

1.1 MOBILE SYSTEM

Mobile system includes **mobile device, mobile operating system, wire- less network, mobile app, and app platform**.

The mobile device consists of not only smartphones but also other handheld computers, such as a tablet and Personal Digital Assistant **(PDA)**. A mobile device has a mobile operating system and can run various types of apps. **The most important parts of a mobile device** are Central Processing Unit **(CPU), memory, and storage**, which are similar to a desktop but perform weaker than an on premise device. Most mobile devices can also be **equipped with Wi-Fi, Bluetooth, and Global Positioning System (GPS) capabilities**, and they can connect to the Internet, other Bluetooth-capable device and the satellite navigation system. Meanwhile, a mobile device can be equipped with some human - computer interaction capabilities, such as camera, microphone, audio systems, and some sensors.

All kinds of mobile devices run on various mobile Operating Systems (OS), also referred to mobile OSs, such as iOS from Apple Inc., Android from Google Inc., Windows Phone from Microsoft, Blackberry from BlackBerry, Firefox OS from Mozilla, and Sailfish OS from Jolla. Mobile devices actually run two mobile operating systems. Besides the mobile operating systems that end users can see, mobile devices also run a small operating system that manages everything related to the radio. Because of the high time dependence, the system is a low-level proprietary real-time operating system. However, this low-level system is security vulnerable if some malicious base station gains high levels of control over the mobile.

Mobile devices can connect to the Internet by wireless networks. There are **two popular wireless networks for mobile devices**: **cellular network and Wi-Fi**. **The cellular network** is peculiar to portable transceivers. A cellular network is served by at least one fixed-location transceiver, called cell site or base station, as shown in Fig. 1.1. Each mobile device uses a different set of frequencies from neighboring ones, which means a mobile device must connect to the base station before it accesses to the Internet. Similarly, when a mobile device using a cellular network wants to connect another mobile device, it must connect to some base stations before it communicates with the target device via the base stations.

Figure 1.1 Structure of a cellular network.

Figure 1.2 Logo of Wi-Fi.

Wi-Fi is a local area wireless technology, which allows mobile de- vices to participate in computer networks using 2.4 GHz 1 and 5 GHz radio bands. Fig. 1.2 represents two common logos of Wi-Fi. Mobile devices can connect to the Internet via a wireless networking access point. The valid range of an access point is limited, and the signal intensity descends as the distance increases. Wi-Fi allows cheaper deployment of Local Area Networks (LAN), especially for spaces where cables cannot be run. Wi-Fi Protected Access encryption (WPA2) is considered a secure approach by providing a strong passphrase. A Wi- Fi signal occupies five channels in the 2.4 GHz band. Any two channel numbers differ by five or more. Many newer consumer devices support the latest 802.11ac 2 standard, which uses the 5 GHz and is capable of multistation WLAN throughput of at least 1 gigabit per second.

1. *Hz is the unit of frequency in the International System of Units and is defined as one cycle per second. One gigahertz (GHz) represents* 109 *Hz.*

2. *IEEE 802.11ac was approved in January 2014 by IEEE Standards Association.*

A mobile app is a program designed to run on smartphones, tablet computers, and other mobile devices. Mobile apps emerged in 2008 and are operated by the owner of the mobile operating systems. Currently, the most popular digital distribution platforms for mobile apps are App Store, Google Play, Windows Phone Store, and BlackBerry App World, as shown in Fig. 1.3. These platforms are developed by Apple Inc., Google, Microsoft, and BlackBerry Ltd., respectively, and provide different apps, which only can be used on their own operating systems.

Figure 1.3 Four dominate platforms for mobile apps.

1.2 MOBILE INTERFACE AND APPLICATIONS

Mobile devices, to some extent, are much more powerful than desk- tops. They are highly personal, always on, always with users, usually connected, and directly addressable. Furthermore, they are crawling with powerful sensors with various functions that detect location, ac- celeration, orientation, movement, proximity, and surrounding condi- tions. The portability of mobile devices combined with powerful sensors makes mobile interface extremely valuable for using mobile devices.

The User Interface (UI) is the look and feel of the on-screen sys- tem, including how it works, its color scheme, and how it responds to users' operation. The interactions include not only users' active op- erations, but also the passive ones. Users' passive operations include users' locations, movements, and other information that does not need users' active operations. We will take telehealth as an example of mobile interface. Telehealth is the delivery of health-related services and information via telecommunications technologies [7].

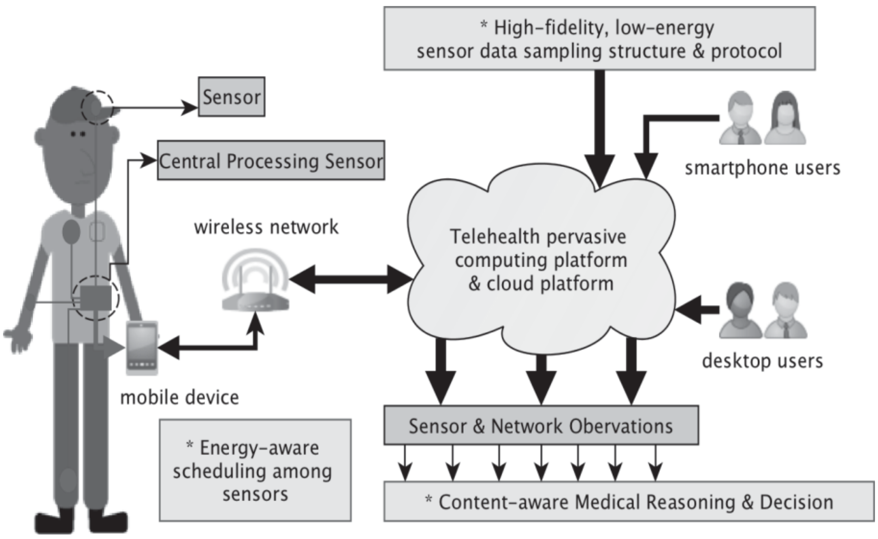

Figure 1.4 Structure of the telehealth systems.

We can separate telehealth system into several modes: store-and- forward, real-time, remote patient monitoring, and electronic consulta- tion, as shown in Fig. 1.4. Each mode finish their job respectively and achieve the whole process of collecting data from users, transmitting this data to medical or clinical organizations, medical reasoning and decision, and sending back to users. In the first step, observations of daily living and clinical data are captured and stored on the mobile device. All the sensors that collect and record data are heterogeneous medical devices with different cost and time features. Then the mobile device transmits this information to the Telehealth pervasive computing platform and cloud platform by wireless network.

Consequently, **main challenges** include finding out the approach of collecting data from users by using sensors and scheduling sensors for achieving energy-aware purposes. The process of transmitting data is a part of real-time system. Different to normal real-time systems, the data transmitting in telehealth is under a wireless condition. Similar to the first step, there are various network paths with different cost and time requirements, which results in a great challenge to security and data integrity.

Furthermore, context-aware medical reasoning and decision is an- other important issue in telehealth system. Context can refer to real world characteristics, such as temperature, time or location. Combining with users' personal information, the medical reasoning and decision focus on data analytic, mining, and profiling issues. In conclusion, all the challenges mentioned above can be summarized as a general problem: how to minimize the total cost of heterogeneous telehealth while finishing the whole diagnosis within certain time constraints .

1.2.1 Optimizations in Mobile Systems

All current mobile devices are battery-powered devices. The high usage of mobile devices makes them hard to keep on charging like desktops, so the improvement of battery life on mobile devices is gaining increasing attention. Besides some energy-saving operations by users, there are some researches focusing on the optimization in mobile system. The optimization problem, to some extent, is a tradeoff among multiple constraints. Before talking about the optimization, let us discuss some constraints in mobile systems.

The first and the most important constraint is the energy. The second one is the performance. The third one is the networking speed to the Internet. The fourth one is the resources of the mobile device. These constraints are interrelated and mutually restrict to each other. Suppose in an extreme situation, someone keeps his/her mobile device off. In this situation, the battery life can last an almost unlimited time without considering the self-discharge of the battery. However, the mobile device in that situation is useless, and no one buys a mobile device just for decoration. It is obvious that the more functions users use, the more energy devices consume. Similarly, the performance is related to the networking speed while constrained by the energy and resource. To solve this problem, many researchers proposed various optimization algorithms and frameworks.

1.2.2 Mobile Embedded System

An embedded system is a computer system with a dedicated function, which is embedded as a part of a complete devices including hardware and mechanical parts. Embedded systems are driving an information revolution with their pervasion. These tiny systems can be found ev- erywhere, ranging from commercial electronics, such as cell phones, cameras, portable health monitoring systems, automobile controllers, robots, and smart security devices, to critical infrastructure, such as telecommunication networks, electrical power grids, financial institu- tions, and nuclear plants. The increasingly complicated embedded systems require extensive design automation and optimization tools. Architectural-level synthesis with code generation is an essential stage toward generating an embedded system satisfying stringent requirements, such as time, area, reliability, and power consumption, while keeping the product cost low and development cycle short.

A mobile device is a typical embedded system, which includes mobile processors, storage, memory, graphics, sensors, camera, battery, and other chips for various functions. The mobile device is a high-level synthesis for real-time embedded systems using heterogeneous functional units (FUs). A functional unit is a part of an embedded system, and it performs the operations and calculations for tasks. As a result, it is critical to select the best FU type for various tasks.