Chapter 2
IoT for Healthcare

2.1 Introduction

The Internet of Things (IoT) represents a set of interconnected smart objects and people at any time and at any place. The IoT incorporates wide spectrum that can impact businesses, healthcare, social and political aspects. It is a platform that extends from sensors, local processors, wireless transmitters, and central management stations [15].

Figure 2.1 shows the trends for IoT healthcare devices. It incorporates wide sectors that involve many individuals. The main feature of IoT healthcare platform is the communication between a wearable sensor and central system where doctors could easily assess patients. In terms of health conditions, it includes early diagnostics, emergency situation, and chronic diseases. Such connected platform also utilizes the existing voice and data communications infrastructures.

2.2 IoT Healthcare Applications

The application of IoT-based healthcare covers wide areas in the healthcare sectors. It extends from individual applications and in healthcare centers. It includes care for children, youths, elderly along with wide diversity of patients through organized system. This section describes the applications for IoT healthcare. The applications are directly related to the end-users and patients. Current connected wearable healthcare devices are a good example for IoT healthcare devices. The next subsections describe numerous IoT healthcare applications.

T. Tekeste Habte et al., *Ultra Low Power ECG Processing System for IoT Devices*, Analog Circuits and Signal Processing,
https://doi.org/10.1007/978-3-319-97016-5_2

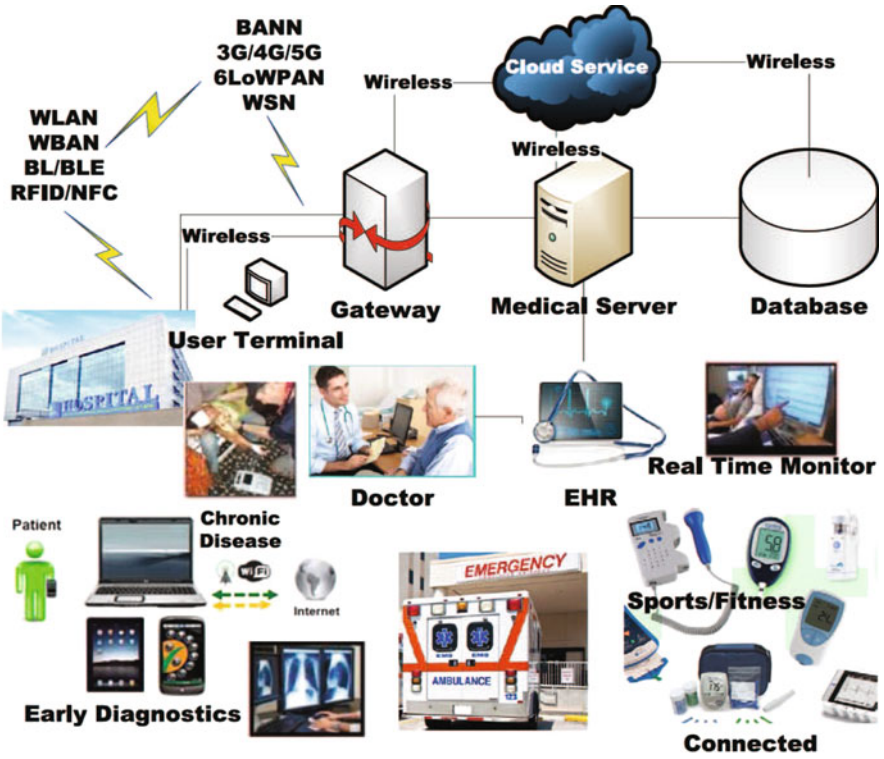

Fig. 2.1 IoT healthcare trends

2.2.1 Glucose Level Sensing

Diabetic patients suffer from uncontrolled blood glucose level during the daily lives. It necessitates the need for periodic monitoring of their blood glucose level, in order to plan their daily meals, medicines, and activities. Real-time glucose level sensing in IoT platform is reported in [16]. The reported technique demonstrates how sensors from patients are connected to respective healthcare centers through IPv6 connectivity.

2.2.2 Electrocardiogram Monitoring

The electrocardiogram (ECG) records the electrical activity of the heart which represents the full cardiac cycle. The ECG is the best known technique to monitor and diagnose the function of the heart. ECG measurements include determining the beat rate and other patterns of the cardiac cycle which is displayed in ECG

waveforms. ECG techniques have been applied in prediction [12] and detection [17] of arrhythmia such as ventricular tachycardia, bradycardia, arterial fibrillation, and myocardial infarction. An IoT-based ECG monitoring platform is reported in liu2012internet and the system comprises wearable wireless ECG sensor and wireless receiving processor. It does real-time cardiac function detection and abnormality classification.

2.2.3 Blood Pressure Monitoring

IoT is also applied in the blood pressure monitoring as described in [18]. In this paper, the combination of a touch blood pressure (BP) meter and a near-field-communication for a BP monitoring systems, where also a mobile phone is utilized.

2.2.4 Oxygen Saturation Monitoring

Blood oxygen saturation is monitored using pulse oximetry technique in portable healthcare devices. Hence, it is beneficial to integrate pulse oximetry into the IoT platform. The potential for implementing an IoT-based pulse oximetry is illustrated in [19]. An IoT-centered low-power and economic low-cost blood oxygen saturation meter for remote patient monitoring is proposed in [20]. The proposed system provides continuous measurements by operating from battery.

2.3 IoT Healthcare Technologies

IoT-based solution has been enabled through wide range of technologies. Advanced electronic solutions have profound effect on the fast growth of IoT solutions. IoT healthcare solution is supported through many technologies. This section discusses the core technologies that have the capability to enhance IoT-based healthcare services.

2.3.1 Ultra-Low Power Sensing

Ultra-low power sensors that include sensors, analog front end, and digitization form a key part for signal acquisition in IoT healthcare devices. These components which have ultra-low power dissipation, could be integrated in battery powered systems and attain long battery lifetime.

2.3.2 IoT Processors

The processing part of an IoT device could perform from simple to complicated tasks based on the desired application. Some of the main tasks are signal acquisition, local processing, data transmission, security, and encryption. Local processors could support an operating system, firmware, and device management. The main constraint of local processors is power consumption. There is a trade-off between power dissipation, supported features, hardware costs, and software costs. Hence, deep analysis of the system is necessary to select appropriate selection of the processor.

2.3.3 Cloud Computing

Cloud computing facilitates resource sharing among various IoT healthcare technologies and devices. Its capability enables service upon request for specific resources through the network.

2.3.4 Grid Computing

Since medical sensor nodes have limited processing capabilities, complicated computational processing is supported by grid computing. Grid computing forms the backbone of cloud computing.

2.3.5 Big Data

Large amount of data is normally collected by wide range of medical sensors. Systematic handling and processing of big data improves the efficiency of the health diagnosis and monitoring. Moreover, disease classification is performed through big-data analysis.

2.3.6 Communication Networks

IoT-based healthcare networks share the existing communication networks that could be short range (WLAN, 6LoWPANs, WBANs, WBANs, and WSNs) or long-range communications (cellular networks). Moreover, other wireless communication networks such as bluetooth, near-field communication, and RFID communication technologies are powerful instruments in achieving ultra-low power IoT healthcare sensors.

2.3.7 Wearable

Wearable technology has enabled continuous monitoring and active engagement of patients. Wearable devices bridge the communication between the patient and the doctors. Local processing in wearable sensors has also a life saving benefits through alerting patients on time before they reach critical situations.

2.4 IoT Challenges in Healthcare

IoT-based healthcare services have several challenges that arise from the sensors, communication networks, and central servers. Here, we will describe some of the main challenges of IoT healthcare devices.

2.4.1 IoT Healthcare Security

Since the IoT connected devices are increasing day by day, security is a major issue that we have to develop. The IoT is growing rapidly and it is expected widespread adoption of the IoT healthcare systems. Healthcare devices and applications are expected to deal with vital private information such as personal healthcare data. In addition, such smart devices may be connected to global information networks for their access anytime, anywhere. The protection of captured health data from various sensors and devices from illicit access is crucial. Therefore, stringent policies and technical security measures should be introduced to share health data with authorized users, organizations, and applications. This tradition of confidentiality is the most essential thing, which personal data must be obtained for a specified purpose, and must not be disclosed to any third party except in a manner compatible with that purpose. A robust system security must be introduced to prevent an attack, vulnerability, or data loss.

2.4.2 Energy Consumption of IoT Healthcare Devices

There are many devices in IoT healthcare scenarios, and such devices tend to be heterogeneous in terms of their sleep, deep-sleep, receive, transmit, and composite states, among others. In addition, in terms of service availability, each communications layer faces an additional challenge in terms of power requirements. Regardless of the type of connection behind an IoT product, minimizing power use can be a challenge. However, it is also critical to attain low energy and low costs. Radios are a key component of the energy budget for IoT products. Instead of WiFi, cellular

or Bluetooth, combined with smart design, and component selection, will help developers create low-energy systems.

2.4.3 Communication Network

Various networks ranging from networks for short-range communications to long-range communications are part of the physical infrastructure of the IoT-based healthcare network. In addition, the employment of ultra-wideband (UWB), BLE, NFC, and RFID technologies can help achieve low-power medical sensor devices as well as communication protocols.

2.4.4 Data Storage and Continuous Monitoring

There is a trade-off between local processing and transmission in continuous monitoring. Moreover there is a trade-off between local data storage and central data storage. Such situations are decided based on the application and the architectural choices.