Chapter 5
Toward an IoT-Based Solution for Emergency Medical System: An Approach to i-medical in Bangladesh

Md. Arif Uz Zaman, Saifur Rahman Sabuj, Romana Yesmin, Sadman Sakib Hasan, and Asif Ahmed

5.1 Introduction

An epitome of high living standards would include convenient and updated medical treatment throughout an individual’s lifetime. In Bangladesh, there are approximately three physicians and one nurse per 10,000 population [1]. In more depth, the density of doctors, nurses, dentists, physicians, and other health-related workforce who are qualified and registered as Healthcare Providers (HCP) is 7.7 per 10,000 populations. Thus, Bangladesh has the lowest number of HCP compared to other Southeast Asian countries. Likewise, they also fall short of the MDG targets projected by WHO. In more general term, there is only 0.58 HCP per 1000 population with a health workforce of 2.3. Therefore, it can be assumed that Bangladesh lacks over 60,000 doctors and 280,000 nurses [2]. As this is a poor ratio, we can see how it leads to a crisis whenever there is a demand for medical experts. Thus, Bangladesh suffers from a lot of incidents where immediate health support is required. And for this, the medical system needs a major renovate in our country.

As this is the era of growing wireless paradigm, wireless technology and the embedded system have been developed a lot. The number of Internet of Things (IoT) enabled devices worldwide is 26.66 billion in 2019; gradually it is increasing, and in 2025 it will be 75.44 billion approximately [3]. In health industry this system can do a lot. This IoT system can face new challenges with improved solutions, providing medical treatment during the emergency situation in the several parts of
the world. As a result, the life of the people around the world will be easier to survive during any emergency period.

A developed country like Canada has the doctor to patient ratio of 220 doctors per 100,000 people, a statistic from the year 2013 [4]. Moreover, it is said that it is improving. Likewise, when it is compared to Bangladesh we can see the severity of the difference. However, it was stated in 2002 how Canada was suffering proper medical health treatment due to long unique geographic, population, and political challenges and other challenges. It was compensated by using e-Health and the help of the Canadian Government through ICT [5]. Moreover, due to geographical and location challenges, Canada is benefitting a lot. An example would be of Michael Humber, who has saved six million kilometers of traveling for patients, by providing health care through telehealth for 8 years to over 8000 patients [6].

Most of the work that has been done so far which is related with the IoT for medical purposes involves data collection with the help of IoT-enabled devices that are connected to the subject’s body. This enables to control many purposes like remote monitoring and data collection from several locations which can improve the emergency medical facilities. In this chapter, we will focus on a group of people in Bangladesh. In Bangladesh, approximately 6.23% of its population is aged above 60 years [7] who lives in rural area. Moreover, 70% of the total population of Bangladesh lives in rural area [1]. They are unaware of the government medical facilities which are reserved for them. For example, there is a telemedicine facility for the people of Bangladesh provided by the government. At present, there are 43 telemedicine centers and these telemedicine centers are equipped with high Internet bandwidth, good quality telemedicine camera, large screen displays, and telemedicine peripherals [8]. The usage of IoT devices can change their living standards. They basically depend on their family members for their health care. The IoT devices have the potentiality to add the independence to take care of their health by a doctor on a regular basis from any locations of Bangladesh.

In this research, we would focus on the possibilities of combining e-Health IoT and GSM technology. Our research is based on the notion of improvement of existing technology using IoT and makes it cost effective for a developing country like Bangladesh. The overall aim of this research is to design a medical emergency system by leveraging the concept of crowdsourcing in order to:

- Establish an IoT-based network to improve existing e-Health monitoring system
- Develop a mathematical model for uplink and downlink scenario and evaluation of our proposed i-medical system
- Develop a mobile application for practical simulation in the context of Bangladesh

The organization of the chapter can be summarized as Sect. 5.2, literature review which talks about the current researches or the research that has been done on the topic. Next is Sect. 5.3, called the problem and the solution approach which gives an overview of the problem and the criteria which will be used to solve them. Furthermore, Sect. 5.4 which is the system model explains the architecture of the methodology. Likewise, Sect. 5.5, system implementation, describes in detail about
the methodology for implementing the system. In addition to that, mobile application integration describes how mobile application can help the overall procedure. For analysis and evaluation, the section system evaluation is involved. Finally, conclusion is added to give a brief overview of everything that has been done and will be planning to do in the future (Fig. 5.1).

5.2 Literature Review

Several kinds of research have been done in IoT-based technology to bring emergency medical support in the period of emergency. One such significant research is [9] where the researchers come up with a solution focusing on privacy by accessing the patient’s Personal Health Information and caring chronic patients combining with the IoT, medical sensors, and wireless communication to monitor the health-related parameters of the patients to give the best medical solutions in emergency situations and also having a record of their conditions. Again, in [10] the authors developed an IoT-based remote well-being checking framework where the elderly people can take care of themselves by staying at home, and this system contains multiple independently functioning layers (CoAP-based IReHMo implementation). While in [11] the authors discuss an IoT device for rehabilitation and elderly monitoring system with the help of IoT considering two functions – Activity Recognition and Movement Recognition that detect the idleness and illness of the patients. This [12] survey paper discusses an energy proficient and dependable e-Health observing system that focuses on presenting an architecture system to portray the complete
checking life cycle and highlight fundamental benefit components and give some potential solutions on patient remote monitoring system. In [13] there is an architecture of an unused e-Health stage consolidating humanoid robots linked with IoT to a web-centric Diseases Management Hub that supports people to get treatment on diabetes. In [14] authors demonstrate a process on how to coordinate and apply IoT system in a big network.

In [15] authors focused most important perspective of novel IoT innovations for shrewd healthcare-wearable sensors, progressed inescapable healthcare framework, and big data analytic to identify unused points of view and highlight compelling investigate issues and challenges like device-network human interfaces, scalability, and security. In [16] the researchers propose a novel approach to improve IoT-based medical records security by watermarking it using algorithm which is composed of Daubechies-3 and Daubechies-9 wavelet transform in IoT-based Hospital Information System. In [17] researchers developed a multilayer architecture of an integrated medical platform that allows to monitor patient’s medical condition by biomedical data during transfer by an ambulance.

In [18] the researchers promised to build a multilayer architecture of IoT e-Health ecosystem which requires a move from the clinic-centric treatment to patient-centric treatment where hospitals, patients, and other related things will be benefited and connected with each other. In the research paper [19], the authors developed a comprehensive response crowdsourced framework that reduced the reaction time as well as the operating cost during emergency medical services. In article [20] the authors introduced a smart urban city, which collected data through energy consumption model, a new generation of sensing fabric is also introduced as a part of smart urban city. In survey paper [21] the authors proposed a model of distinct IoT that monitor the biological signal using WBANs technology. It uses wearable sensors to collect data to work with WBAN. In [22] the researchers proposed an effective health monitoring system that supervised the health status of the patients very carefully with the help of IoT and data monitoring system and using that data a decision-making system is designed. In [23] the authors proposed an IoT-based Case-Based Learning methodology for medical students that can help to store patient’s data and analyze the imperative signs by using IoT. In [24] the authors described a smart IoT system for real-time health monitoring system using multiple heterogeneous wearable sensors. In [25] the researchers studied a medical control system based on IoT that improves the conditions of medical care and effective medical treatment and also the researchers designed to characterize challenges occurred by technological tools in making strides the conditions of well-being structures and to recreate the working of the framework. In [26] the authors offered an embedded system and IoT-based solution for continuous and noninvasive measuring of cardiac values by using a technology named Pulse Oximetry and also they have made a wearable cardiac monitoring and alert system that can be patients specific and helps to reduce heart-related accidents. They also used embedded system to build their device and make it wireless so anytime people can use it. They came up with a system that uses IoT and other wireless system to get heart-related various data. This data helped them to take medical decisions. Lastly, in [27] the author for
this paper describes the possibility of the 5G technology in the mobile well-being system. The author also proposed a small cell 5G-based mobile technology-based medical system.

It can be observed from the papers that they have not associated and combined technologies like IoT, use of Database, and deployment of smart healthcare system which can improve the overall healthcare system. This paper converges those technologies and it also includes mobile application. These ensure that the nearest ambulance, pharmacy, hospital, and neighbors are connected, so they can be reached out any time when an injured person requires help immediately. Likewise, in paper [9] and paper [10] patients cannot be assisted by neighbors in times of emergency. Other than that, in paper [11] a cousin is alerted however; the alerted person can be far away from the patient, hence, providing emergency medical care might be hindered. Similarly, in paper [12] there is a life cycle of the device used; however, there is no network simulation involved or association of IoT. Our work’s significant improvement can help assist the problem of poor doctor to patient ratio in Bangladesh. Also inclusion of IoT can be useful in Bangladesh. In paper [28], the author introduced a telemedicine system that uses ICT and IoT technology to identify patients with intractable diseases. This paper describes reliable alarm system and expected medical IoT features for those patients. In 2020 the world has observed a severe disease called “Covid-19” which is very contagious and deadly. World was not prepared for it and thus many death occurred. In paper [29] the author discussed about a service-oriented smart medical system which can be established to prevent such an event. In this paper they developed an IoT-based medical system which would allow them to proper resource allocation, utilization and efficiency. This management system can be promoted to an intelligent system which would be able to manage the resource more efficiently.

5.3 Problem and Solution Approach

As Bangladesh is yet to develop, expectation of quality medical services is low. Moreover, the integrity of handling medical emergency is yet to grow. As per definition, an emergency situation is such that, it can occur at anyplace or at any time. On that possibility, the researcher must develop a system which would be available at low cost and without the slightest intervention of time.

5.3.1 Problem

In Bangladesh, one of the major problems is unplanned urbanization. Moreover, due to the living condition in Bangladesh, the medical services cannot be provided swiftly. In different cases, it has been observed that medical care could not reach the place due to lack of time and manpower.
To solve this problem, this chapter introduces IoT-based e-Health monitoring system and connect it with mobile application. Similar kind of solution has been proposed in numerous research papers [9, 19, 20, 25].

The goal of this chapter has been set and specified as to introduce an IoT-based medical emergency system for Bangladesh. In this chapter, the system is called i-medical. Bangladesh is the second largest economy in South Asia and the 41st largest economy in the world [30]. The country went through various milestones to finally achieve this position. Despite Bangladesh developing a lot in the last 5–10 years, the emergency medical alert system has not been implemented. Thus, in this chapter, the major target would be solving to

• Not provide low-quality medical treatment on emergency situation
• Provide low cost medical service
• Provide medical services in adverse situations

As mentioned earlier the unplanned urban city is a major problem for the emergency medical system. Moreover, there are other problems which also aggregate like inflated population density and lack of basic emergency treatment knowledge. Furthermore, those who have knowledge due to lack of communication adversities cannot provide treatment to the person in need. Thus, using the latest technology and mobile network this chapter proposes a solution to the problem.

5.3.2 Solution Approach

As mentioned earlier, this paper is proposing a solution with IoT and mobile network. Figure 5.2 shows the detail process of the overall methodology.

In Fig. 5.2 it is possible to observe how the system would work. In the first block, it can be observed that the emergency initiation starts To start an emergency from the patient side the mobile application would be observing if anything is wrong. A physical button (e.g., Volume button or Power button) would be assigned as an emergency button. By pressing that an emergency alert would be observed in IoT network. Through that network, data would be served to database Thingspeak. The Thingspeak would save these new data accordingly. In the Physical Layer, the main work would be done. Patient, Neighbor, Pharmacy, and Ambulance to the hospital all are connected with the network so that communication happens very rapidly. The mobile application would be responsible to do the task. Likewise, all the system would work simultaneously.

5.4 System Model

In [31] the author describes that the emergency response system is divided into four segments. This chapter is the extension of the previous work of the research [31].
The complete work is shown through a flowchart. Flowchart in Fig. 5.3 describes the working diagram.

In Fig. 5.3 the first phase of the system is shown. Likewise, in Fig. 5.4 the second phase of the system is shown.

In the first phase of an emergency situation, this system explains how patient and neighbor interact with each other. When a person has a medical condition, he or she uses his or her mobile phone to send an emergency notification. There would be a mobile application to govern all the actions. After initiating emergency, mobile takes the location data of the patient from the GPS and sends this information to the database (Thingspeak). Thingspeak saves this information and actuates a notification to all the neighbors near to the location of the patient. This updates the data on Thingspeak. After this, the database sends a push notification to all the neighbors nearby of that patient. Mobile application in neighbor’s mobile would then show a notification along with the emergency sound. This would happen only to the nearest neighbors. The first neighbor who would accept the emergency would get the location data along with a specific direction to the patient. Neighbor would go to the location and start treatment for the patient. This includes checking the patient (i.e., checking blood pressure, pulse system, etc.). The neighbor would give primary treatment with first aid. With this, the first phase of the system ends.
In the second phase, the neighbor would take the treatment to the next step. If the first aid treatment is not sufficient, then neighbor would take the decision on what to do next. If the neighbor thinks the patient needs further examination, the neighbor should call pharmacy for help. Otherwise, if the patient is very sick, then neighbor would call for an ambulance to take the patient to the nearest hospital. If the neighbor calls for pharmacy, then the mobile app would take the location and send it to the database. With the help of the IoT network, it would launch a search for the nearest pharmacy. It would send an emergency notification to all the nearest pharmacies. When a pharmacy accepts the emergency, the pharmacy would get the necessary data uploaded by the neighbor. With the data, the pharmacy person would know what is necessary to the neighbor for the treatment. The pharmacy would take all medicines and equipment to patient’s location. The neighbor would use those to give proper treatment to the patient.

If the neighbor thinks that the help from the pharmacy would not be significant, then the neighbor would go to the ambulance service. The ambulance would take the patient to the adjacent hospital. Lastly, the hospital doctor would take the rest of the responsibility.

Fig. 5.3 System model and working plan first phase
5.5 System Implementation

5.5.1 Device Description

We have used some devices that have given us the best results for analyzing the emergency medical situation. For our device implementation, we have used SIM808 made by Simcom. Along with that, Arduino pro mini, GPS, and GSM antennas were also used. Thus, our experimental setup basically consists of four parts: (i) A Arduino Pro mini, (ii) SIM808, (iii) GPS antenna, and (iv) GSM antenna (Fig. 5.5).

Arduino Pro-mini is a microcontroller board based on ATmega328 with 14 digital input/output pins [32]. We have considered this device as the brain of our system. It contains the program that runs the system to collect and transfer the data.
SIM808 is a complete Quad-Band GSM/GPRS module that combines GSM technology. It has GPRS multi-slot class 12/10 [33]. It is controlled by AT commands which are similar for every model. This device requires a cellphone SIM. In our experimental setup, we have used a 4G enabled SIM from the mobile network operator Grameenphone and used their coding schemes (e.g., CS 1, 2, 3, 4) [33]. SIM808 can connect with the database with FTP or HTTP and uses TCP/UDP protocol. We have also imbedded two antennas GPS and GSM. For these reasons, we selected to use this module. These antennas assist to link and obtain the data from the servers [34].

We have used a GPS antenna that is associated with the SIM808 module for gathering the various location data in the form of latitude and longitude. The latitude and longitude we received are in the mathematical floating point value. Later, this data was sent to the server which was created beforehand and the data would be stored there. Then the stored data was sorted into an excel sheet [35].

GSM antenna is used for Internet connection and mobile network. In our research, we connect this device with the mobile network to transfer the data.
5.5.2 **Circuit Diagram**

In Fig. 5.6 the circuit diagram is shown to represent how the components are connected inside the device.

5.5.3 **Data Collection**

With the help of the device, data have been collected from various locations within Dhaka city of Bangladesh. Table 5.1 shows some of the sample data for the simulation.

5.5.4 **Database**

Thingspeak is an online platform for researcher, scientist, and other people to work with numerous data from sensors.

IoT is a system where different sensors send data to the cloud server for analysis. In this chapter, the research was conducted using IoT. To save the data, online platform Thingspeak was used [36]. Thingspeak specializes in IoT connectivity. Also, it helps to monitor the data in real time and analyze it as per need. In Fig. 5.7 we can see the connectivity between computer, smart device, and cloud service (Thingspeak). A number of smart devices are connected with each other. A router is connected which controls the flow of data within the network. Using the network, the data is transferred to the cloud server Thingspeak.

In this research, our device is used to collect data and send it to Thingspeak. This data is monitored by Thingspeak. Thingspeak is a free database for storing sensor data.
data for IoT connection. Also, it is directly connected with MATLAB. MATLAB can fetch data from Thingspeak directly. So we can analyze the data through Thingspeak or MATLAB. It helps to develop algorithm in MATLAB that would make the simulation. Simulation results would help us to understand the data in the real world. Also simulation would show us visually how it would work in the real world. The data flow is shown in Sect. 5.6.

**Table 5.1** Sample dataset from our experiment

| Patient  | Neighbor  | Pharmacy  | Ambulance |
|----------|-----------|-----------|-----------|
| Latitude | Longitude | Latitude | Longitude |
| 23.602572 | 90.167521 | 23.102468 | 90.167635 |
| 23.602533 | 90.167533 | 23.102492 | 90.167568 |
| 23.602497 | 90.167625 | 23.202425 | 90.236757 |
| 23.180243 | 90.167652 | 23.202397 | 90.267656 |
| 23.148025 | 90.267583 | 23.302332 | 90.367572 |
| – – – – – – | – – – – – – | – – – – – – | – – – – – – |
| 23.180246 | 90.267663 | 23.888025 | 90.476915 |
| 23.602452 | 90.267756 | 23.991217 | 90.475552 |
| 23.702422 | 90.267592 | 23.502477 | 90.567567 |
| 23.280242 | 90.267673 | 23.602422 | 90.667572 |
| 23.772417 | 90.267772 | 23.602377 | 90.637656 |
| 23.702442 | 90.167565 | 23.502448 | 90.567658 |
| 23.702372 | 90.177562 | 23.780693 | 90.772718 |
| 23.702372 | 90.177592 | 23.780088 | 90.770975 |
| 23.280237 | 90.787562 | 23.890183 | 90.876052 |
| – – – – – – | – – – – – – | – – – – – – | – – – – – – |
| – – – – – – | – – – – – – | – – – – – – | – – – – – – |

**Fig. 5.7** Thingspeak connection with proposed network
5.5.5 Collaboration with Google Map, Google Earth

To see the location, we have used Google Earth plot [37]. This plot shows us how the location is spread throughout the Dhaka City. Figures 5.7 and 5.8 represent the normal view and satellite view of Google Earth (Fig. 5.9).

![Google Earth plot (normal view)](image1)

Fig. 5.8 Google Earth plot (normal view)

![Google Earth plot (satellite view)](image2)

Fig. 5.9 Google Earth plot (satellite view)
5.5.6 Algorithm Flowchart

The flowchart of our proposed algorithm is given below [38].

5.6 Mobile Application Integration

This section discusses the mobile application that was developed for this system. For user-friendly experience, mobile application is the best option. For this research, two mobile apps which would work collectively are described. One app is called “Patient Helper” and the other is “FindMyPatient.”
The first application is responsible for sending the emergency notification if anyone is in a medical emergency. This app would track the location of the person, and upon emergency initiation, it would send it to the database. The second application is used by Neighbors. A neighbor would get the emergency signals from the nearest patient. Among the signals, the neighbor would take the decision which one to attend (Table 5.2).

For developing the current application, the model is implemented in the Android operating system. The application was developed using Android Studio which is the official Integrated Development Environment, which is established upon IntelliJ IDEA [39, 40]. After development, the file was in Android Package (APK) format and not published in Google Play Store [41].

Figure 5.10 shows the first application developed for the patient’s convenience, namely “Patient Helper.” Patient Helper requires location access and Internet access to be functioning properly. If at any moment, a patient is in inconvenience, Patient Helper can easily help that person achieve treatment. When the person clicks on the Button in Fig. 5.11, FIND MY LOCATION, the application requests for the last known location of the patient or requests for the location update. In the next step, the person should click on GET HELP as soon as their location is successfully updated which they can see on the screen. In Fig. 5.12, the description of the location is shown in Latitude and Longitude. When GET HELP is pressed, the information is passed to thingspeak.com [36], using the RESTFUL API provided by the thingspeak.com. In Thingspeak, the location of the patients is saved in a database, which is then sent to another application named FINDMYPATIENT for further purposes.

Showing the location of the patients is imperative for this project. Hence, achieving it in an easier way seemed to be by an application. Likewise, this application is developed for Android operating system for experimental purpose and named, FINDMYPATIENT. Initially, the data were fetched from an API which is sent by thingspeak.com. The API sends the file in JSON Array. A JSON Array is similar to JavaScript [42]. The JSON Array consists of four types of data which are being sent: longitude, latitude, the data type, and the date of the entry. At the same time, the Google Map API is called, for displaying the map. When the map has all the data of the markers, the map animates to display all markers of different colors zoomed in the Google Map in Fig. 5.12. For displaying the location of the patient, the orange marker was used; for displaying neighbor’s location, the yellow marker was used; for displaying pharmacy’s location blue marker was used, for displaying hospital green marker was used; and for displaying ambulance red marker was used. The

| Table 5.2 Work flow diagram for mobile application |
|-----------------------------------------------|
| Emergency initiate by a patient               |
| Data uploaded to the Thingspeak               |
| Neighbor app sets alarm for nearest emergency call |
| Neighbor would go to the person for giving treatment |
| For better treatment neighbor would ask for help from pharmacy |
| For better treatment neighbor would ask for help from ambulance |

Figure 5.10 shows the first application developed for the patient’s convenience, namely “Patient Helper.” Patient Helper requires location access and Internet access to be functioning properly. If at any moment, a patient is in inconvenience, Patient Helper can easily help that person achieve treatment. When the person clicks on the Button in Fig. 5.11, FIND MY LOCATION, the application requests for the last known location of the patient or requests for the location update. In the next step, the person should click on GET HELP as soon as their location is successfully updated which they can see on the screen. In Fig. 5.12, the description of the location is shown in Latitude and Longitude. When GET HELP is pressed, the information is passed to thingspeak.com [36], using the RESTFUL API provided by the thingspeak.com. In Thingspeak, the location of the patients is saved in a database, which is then sent to another application named FINDMYPATIENT for further purposes.

Showing the location of the patients is imperative for this project. Hence, achieving it in an easier way seemed to be by an application. Likewise, this application is developed for Android operating system for experimental purpose and named, FINDMYPATIENT. Initially, the data were fetched from an API which is sent by thingspeak.com. The API sends the file in JSON Array. A JSON Array is similar to JavaScript [42]. The JSON Array consists of four types of data which are being sent: longitude, latitude, the data type, and the date of the entry. At the same time, the Google Map API is called, for displaying the map. When the map has all the data of the markers, the map animates to display all markers of different colors zoomed in the Google Map in Fig. 5.12. For displaying the location of the patient, the orange marker was used; for displaying neighbor’s location, the yellow marker was used; for displaying pharmacy’s location blue marker was used, for displaying hospital green marker was used; and for displaying ambulance red marker was used. The

| Table 5.2 Work flow diagram for mobile application |
|-----------------------------------------------|
| Emergency initiate by a patient               |
| Data uploaded to the Thingspeak               |
| Neighbor app sets alarm for nearest emergency call |
| Neighbor would go to the person for giving treatment |
| For better treatment neighbor would ask for help from pharmacy |
| For better treatment neighbor would ask for help from ambulance |

Figure 5.10 shows the first application developed for the patient’s convenience, namely “Patient Helper.” Patient Helper requires location access and Internet access to be functioning properly. If at any moment, a patient is in inconvenience, Patient Helper can easily help that person achieve treatment. When the person clicks on the Button in Fig. 5.11, FIND MY LOCATION, the application requests for the last known location of the patient or requests for the location update. In the next step, the person should click on GET HELP as soon as their location is successfully updated which they can see on the screen. In Fig. 5.12, the description of the location is shown in Latitude and Longitude. When GET HELP is pressed, the information is passed to thingspeak.com [36], using the RESTFUL API provided by the thingspeak.com. In Thingspeak, the location of the patients is saved in a database, which is then sent to another application named FINDMYPATIENT for further purposes.

Showing the location of the patients is imperative for this project. Hence, achieving it in an easier way seemed to be by an application. Likewise, this application is developed for Android operating system for experimental purpose and named, FINDMYPATIENT. Initially, the data were fetched from an API which is sent by thingspeak.com. The API sends the file in JSON Array. A JSON Array is similar to JavaScript [42]. The JSON Array consists of four types of data which are being sent: longitude, latitude, the data type, and the date of the entry. At the same time, the Google Map API is called, for displaying the map. When the map has all the data of the markers, the map animates to display all markers of different colors zoomed in the Google Map in Fig. 5.12. For displaying the location of the patient, the orange marker was used; for displaying neighbor’s location, the yellow marker was used; for displaying pharmacy’s location blue marker was used, for displaying hospital green marker was used; and for displaying ambulance red marker was used. The

| Table 5.2 Work flow diagram for mobile application |
|-----------------------------------------------|
| Emergency initiate by a patient               |
| Data uploaded to the Thingspeak               |
| Neighbor app sets alarm for nearest emergency call |
| Neighbor would go to the person for giving treatment |
| For better treatment neighbor would ask for help from pharmacy |
| For better treatment neighbor would ask for help from ambulance |

Figure 5.10 shows the first application developed for the patient’s convenience, namely “Patient Helper.” Patient Helper requires location access and Internet access to be functioning properly. If at any moment, a patient is in inconvenience, Patient Helper can easily help that person achieve treatment. When the person clicks on the Button in Fig. 5.11, FIND MY LOCATION, the application requests for the last known location of the patient or requests for the location update. In the next step, the person should click on GET HELP as soon as their location is successfully updated which they can see on the screen. In Fig. 5.12, the description of the location is shown in Latitude and Longitude. When GET HELP is pressed, the information is passed to thingspeak.com [36], using the RESTFUL API provided by the thingspeak.com. In Thingspeak, the location of the patients is saved in a database, which is then sent to another application named FINDMYPATIENT for further purposes.

Showing the location of the patients is imperative for this project. Hence, achieving it in an easier way seemed to be by an application. Likewise, this application is developed for Android operating system for experimental purpose and named, FINDMYPATIENT. Initially, the data were fetched from an API which is sent by thingspeak.com. The API sends the file in JSON Array. A JSON Array is similar to JavaScript [42]. The JSON Array consists of four types of data which are being sent: longitude, latitude, the data type, and the date of the entry. At the same time, the Google Map API is called, for displaying the map. When the map has all the data of the markers, the map animates to display all markers of different colors zoomed in the Google Map in Fig. 5.12. For displaying the location of the patient, the orange marker was used; for displaying neighbor’s location, the yellow marker was used; for displaying pharmacy’s location blue marker was used, for displaying hospital green marker was used; and for displaying ambulance red marker was used. The
user is given the ability to zoom in any interesting location to see more details around his point of interest in Fig. 5.13. Moreover, if he/she clicks on the marker, the option to see the direction and the time it will take to reach his interested location using Google Map Services are given (Fig. 5.14).

Moreover, this mobile application is also going to be used by ambulance service so that they can get the news instantly. In addition, the researcher suggests the pharmacy to use web application to get the information. A web application is suitable for pharmacy as they are not moving.

After the treatment, all the information regarding treatment would be uploaded to the server for future reference.
This information is significant to analyze the patient’s health. If enough information is gathered, then an AI system can be implemented by training and using machine learning algorithms.

### 5.7 System Evaluation

International Telecommunication Union has divided 5G communication into ultra-reliable and low latency communication (URLLC), massive machine-type communication (mMTC), and enhanced mobile broadband (eMBB). To understand the
The diversified communication system ITU has introduced these various systems. mMTC is a new type of service to assist the access of a large number of machine-type devices where mMTC-based services, for example, sensing, monitoring, tagging, and metering are included for high connection density and better energy efficiency. IoT devices are in part of mMTC where latency is not an important factor [43].

This system is considered to be a random network [44, 45]. Every point on the system (e.g., patient, neighbor, pharmacy, and ambulance) is situated on different locations on the system. All the random points are used by mMTC devices. For the purpose of this research, these random points are generated using the device described in device description (Sect. 5.5.1).
In Fig. 5.15, the location of the simulated position is shown. Plotting longitude and latitude of the patient, neighbor, pharmacy, ambulance, and base station (BS) is there. Only pharmacy and BS position would be fixed in place every time. Other than pharmacy and BS, location of everything changes. Thus it becomes a random wireless network. This IoT network works the same as a 5G wireless network system. Connectivity between all these would be analyzed in this section. It is necessary to evaluate the performance of this network in a random situation.

From Fig. 5.15 it is easily understandable that there are a lot of mMTC devices working simultaneously. When mMTC device of the patient is communicated with BS, another mMTC device creates interference. This interference signal can be described as [44–46]:

**Fig. 5.13** Displaying all the partaker zoomed in FindMyPatient
Where $p_i$ is the transmission power from mMTC device of the patient and $h_i$ is the channel gain from the intended patient’s device to BS. The distance between the intended patient’s device to BS is denoted by $d_i$. And $n$ denotes pathloss exponent in wireless environment.

Outage probability is a significant feature to assess the 5G network. The outage probability of BS (uplink scenario) or mMTC devices (downlink scenario) can be represented as [44]:

$$I_o = \sum_{d_i \in \cap \cup d_e} p_i h_i d_i^{-n}$$  \hspace{1cm} (5.1)
Where $SIR_o$ is signal-to-interference ratio represented as $SIR_o = \frac{p_o}{I_o}$. $p_o$ Represents signal power of intended mMTC device (uplink scenario) and BS (downlink scenario). $I_o$ is the interfering power from adjacent mMTC devices where intended mMTC device is not included. $\theta$ denotes intended SIR threshold. Signal does not recover when $SIR_o$ is lower than target SIR threshold. For the simulation of outage probability, we consider that all transmit powers of mMTC or BS are same (i.e., $p_o = p_1 = p_2 = \ldots = p$) [44].

BS is the main station which would be responsible to maintain the connection between mMTC stations. This research has proposed a mobile application along with an online database. This online database is user-friendly and all mMTC devices are connected everywhere with different level of capability, 5G has always maintained security to secure the sheer volume of data across a diverse set of platforms. An algorithm would be responsible for controlling the connection between mMTC devices.

As shown in Fig. 5.16, we see that the outage probability has a notable outcome on the SIR threshold ($\theta$). Here pathloss exponent is considered 4 ($n = 4$). As $\theta$ increases, the outage probability of BS increases, and this implies that low $\theta$ is better. For $\theta = 0$ dBm, the outage probability is 0.2329 which is an acceptable level for uplink communication.

Figure 5.17 shows the outage probability for the downlink scenario of various mMTC devices’ consideration of $n = 4$. mMTC device of an ambulance is lower outage probability than mMTC device of neighbor and pharmacy. Because the
distance of mMTC device of ambulance and BS is lower than other mMTC devices shown in Fig. 5.15, there is a line of sight communication between mMTC device of ambulance and BS. For $\theta = 0$ dBm, the outage probability of ambulance, neighbor, and pharmacy is 0.01314, 0.1026, and 0.1223, respectively.

Fig. 5.16 Outage probability versus SIR threshold ($\theta$) for uplink connection

Fig. 5.17 Outage probability versus SIR threshold ($\theta$) for downlink connection
5.8 Conclusion and Future Work

Despite the poor doctor to patient ratio and below standard medical service, Bangladesh is a developing country with a huge potential. With the rapid growth of technology and innovation, a system can be implemented which can mitigate the medical services and poor doctor to patient ratio. In this chapter, a research has been done deeply by combining IoT, GSM, and mobile application. Moreover, a real-time database is introduced which will be connected with the IoT device, and mobile application thus will update and provide information about location of the patient, pharmacy, ambulance, and hospital. From the simulation results, it can be concluded that the performance will be lower in highly populated areas, having high numbers of patient, pharmacy, ambulance, and hospital. In the future, this system would be upgraded for better performance. The database would include artificial intelligence and automation. This inclusion would make the system swift and help IoT to make its own decision. Also, there is a plan to use a body sensor to detect problems more quickly and properly.

Acknowledgments

This research was funded by the ICT Division, Ministry of Posts, Telecommunications and IT, Government of the People’s Republic of Bangladesh. Also this research has published a conference paper in ICSIMA in 2018. All the authors have contributed equally.

References

1. Who.int. (2018). WHO, Bangladesh. [online] Available at: http://www.who.int/workforceal- liance/countries/bgd/en/. Accessed 10 Oct 2018.
2. Mahmud, S., & Mahmud, S. Health workforce in Bangladesh | The Opinion Pages. The opinion pages (2019). [Online]. Available: https://opinion.bdnews24.com/2013/03/24/health-workforce-inbangladesh/#targetText=While%20the%20suggested%20ratio%20is%20ratio%20in%20Bangladesh%20only%200.4. Accessed 19 Oct 2019.
3. Number of connected devices worldwide 2012–2025, Statista. [online] Available at: https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide. Accessed 30 June 2018.
4. 5 ways Canada’s physician workforce is changing. Global news (2019). [Online]. Available: https://globalnews.ca/news/1552175/5-ways-canadas-physicianworkforce-is-changing/. Accessed: 08 Nov 2019.
5. Alvarez, R. (2002) The promise of e-Health – A Canadian perspective. eHealth International, Vol. 1(1). Available: https://doi.org/10.1186/1476-3591-1-4. Accessed 08 Nov 2019.
6. Showcase of Success: e-Health solutions are changing health care in Canada | Canada Health Infoway. Infoway-inforoute.ca (2019). [Online]. Available: https://www.infowayinforoute.ca/en/209-what-we-do/digital-health-and-you/stories/579showcase-of-success-ehealth-solutions-are-changing-health-care-in-canada. Accessed 08 Nov 2019.
7. Indexmundi.com. (2018). Bangladesh Age structure – Demographics. [online] Available at: https://www.indexmundi.com/bangladesh/age_structure.html. Accessed 10 Oct 2018.
8. Healthcare Services for All: The Bangladesh Story. (2019). [online] Available at: http://cri.org.bd/2014/10/02/healthcare-services-for-all-the-bangladesh-story/. Accessed 27 Mar 2019.
9. Malamas, V., Dasaklis, T., Kotzanikolaou, P., Burmester, M., & Katsikas, S. (2019). A forensics-by-design management framework for medical devices based on blockchain. In World congress on services (SERVICES) 2019 IEEE (Vol. 2642-939X, pp. 35-40).
10. Tariq, T., Amir Latif, R. M., Farhan, M., Abbas, A., & Ijaz, F. (2019) A smart heart beat analytics system using wearable device. In Communication computing and digital systems (C-CODE), 2019 2nd international conference on (pp. 137–142).
11. Bisio, A. D., Lavagetto, F., & Sciarrone, A. (2017). Enabling IoT for in-home rehabilitation: accelerometer signals classification methods for activity and movement recognition. IEEE Internet of Things Journal, 4(1), 135–146.
12. Karvonen, H., Matilainen, A., & Niemelä, V. (2019). Remote activity monitoring using indirect sensing approach in assisted living scenario. In Medical information and communication technology (ISMICT), 2019 13th international symposium on (pp. 1–6).
13. Al-Taee, M. A., Al-Nuaimy, W., Muhsin, Z. J., & Al-Ataby, A. (2017). Robot assistant in management of diabetes in children based on the Internet of things. IEEE Internet of Things Journal, 4(2), 437–445.
14. Gramata, N. B., Monje, J. C. N., & Oppus, C. M. (2019). Development and implementation of an IoT platform. In Multimedia and communication technology (ISMAC), 2019 international symposium on (pp. 1–5).
15. Meng, Y., Huang, Z., Shen, G., & Ke, C. (2020). SDN-Based Security Enforcement Framework for Data Sharing Systems of Smart Healthcare. Network and Service Management IEEE Transactions on, 17(1), 308–318.
16. Al-Shayea, T. K., Batalla, J. M., Mavromoustakis, C. X., & Mastorakis, G. (2019). Embedded dynamic modification for efficient watermarking using different medical inputs in IoT. In Computer aided modeling and design of communication links and networks (CAMAD), 2019 IEEE 24th international workshop on (pp. 1–6).
17. Ashmawy, M. N., Khairy, A. M., Hamdy, M. W., El-Shazly, A., El-Rashidy, K., Salah, M., Mansour, Z., & Khattab, A. (2019). SmartAmb: An integrated platform for ambulance routing and patient monitoring. In Microelectronics (ICM), 2019 31st international conference on (pp. 330–333).
18. Farahani, B., Firouzi, F., Chang, V., Badaroglu, M., Constant, N., & Mankodiya, K. (2018). Towards fog-driven IoT e-health: promises and challenges of IoT in medicine and health care. Future Generation Computer Systems, 78(2), 659–676.
19. Hossain, F. M., Naeem, M. A., & Gutierrez, J. (2017). A crowd sourced framework for neighbour assisted medical emergency system. In Proceedings of international telecommunication networks and applications conference.
20. Jiang, Y., Xiao, W., Wang, R., & Barnawi, A. (2020). Smart urban living: Enabling emotion-guided interaction with next generation sensing fabric. Access IEEE, 8, 28395–28402.
21. Punj, R., & Kumar, R. (2019). Technological aspects of WBANs for health monitoring: A comprehensive review. Wireless Networks, 25, 1125.
22. Mishra, S. S., & Rasool, A. (2019). IoT health care monitoring and tracking: A survey. In 2019 3rd international conference on trends in electronics and informatics (ICOEI), Tirunelveli (pp. 1052–1057).
23. Ali, M., Lee, S., & Kang, B. (2017). An IoT-based CBL methodology to create realworld clinical cases for medical education. In Proceedings of international conference on information and communication technology convergence (ICTC).
24. Albahri, S., et al. (2019). Based multiple heterogeneous wearable sensors: A smart real-time health monitoringstructured for hospitals distributor. In IEEE access (Vol. 7, pp. 37269–37323).
25. Tamgno, J. K., Diallo, N. R., & Lishou, C. (2018). IoT-based medical control system. In 2018 20th international conference on advanced communication technology (ICACT), Chuncheon-si Gangwon-do (pp. 399–404).
26. Murali, D., Rao, D. R., Rao, S. R., & Ananda, M. (2018). Pulse oximetry and IOT based cardiac monitoring integrated alert system. In 2018 international conference on advances in computing, communications and informatics (ICACCI), Bangalore (pp. 2237–2243).
27. Ahad, M. T., & Yau, K. A. (2019). 5G-based smart healthcare network: Architecture, taxonomy, challenges and future research directions. In IEEE access (Vol. 7, pp. 100747–100762).
28. Yoshikawa, K., Takizawa, M., Nakamura, A., & Kuroda, M. (2019). Empirical study of medical IoT for patients with intractable diseases at home. In Proceedings of IEEE 2019 ITU Kaleidoscope: ICT for health: Networks, standards and innovation (ITU K).
29. Lu, S., Wang, A., Jing, S., Shan, T., Zhang, X., Guo, Y., & Liu, Y. (2019). A study on service-oriented smart medical systems combined with key algorithms in the IoT environment. In China communication (pp. 235–249).
30. Page, F., & Correspondent, S. (2019). Bangladesh 2nd largest economy in South Asia. The Daily Star. [Online]. Available: https://www.thedailystar.net/bangladesh/bangladesh-ranked-41st-largest-economy-in-2019-all-over-the-world-study-1684078. Accessed 29 Mar 2019.
31. Zaman, M. A. U., Yesmin, R., Hasan, S. S., Sadi, S. H., & Sabuj, S. R. (2018). Crowdsourcing medical emergency system using internet of things in Bangladesh perspective. In Proceedings of IEEE 5th international conference on smart instrumentation, measurement and application (ICSIMA 2018).
32. SparkFun. (2018). ProMini. [online] Available at: https://cdn.spark-fun.com/datasheets/Dev/Arduino/Boards/ProMini16MHzv1.pdf. Accessed 10 Oct 2018.
33. Simcom. (2018). sim808. [online] Available at: http://www.simcomm2m.com/En/module/detail.aspx?id=137. Accessed 10 Oct 2018.
34. Cdn-shop.adafruit.com. (2018). [online] Available: https://cdn-shop.adafruit.com/datasheets/SIM808_Hardware+Design_V1.00.pdf. Accessed 10 Oct 2018.
35. Mouser.com. (2018). [online] Available: https://www.mouser.com/ds/2/3/APAE1575R1340ABDD6-T-217962.pdf. Accessed 12 Oct 2018.
36. IoT Analytics – ThingSpeak Internet of Things. Thingspeak.com (2019). [Online]. Available: https://thingspeak.com/. Accessed 30 Mar 2019.
37. Overview – Google Earth. Google Earth. [Online]. Available: https://www.google.com/earth/. Accessed 02 Apr 2019.
38. Yesmin, R., & Hasan, S. S. (2018). Crowdsourcing medical emergency system using Internet of things in Bangladesh perspective. B. Sc thesis, BRAC University.
39. Download Android Studio and SDK tools. Android Developers (2019). [Online]. Available: https://developer.android.com/studio. Accessed 02 Apr 2019.
40. IntelliJ IDEA: The Java IDE for Professional Developers by JetBrains JetBrains (2019). [Online]. Available: https://www.jetbrains.com/idea/. Accessed 02 Apr 2019.
41. Play.google.com. (2019). [Online]. Available: https://play.google.com/store?hl=en. Accessed 02 Apr 2019.
42. JSON Arrays. W3schools.com. (2019). [Online]. Available: https://www.w3schools.com/js/js_json_arrays.asp. Accessed 02 Apr 2019.
43. Ji, H., Park, S., Yeo, J., Kim, Y., Lee, J., & Shim, B. (2018). Ultra-reliable and low-latency communications in 5G downlink: Physical layer aspects. IEEE Wireless Communications, 25(3), 124–130.
44. Sabuj, S. R., & Hamamura, M. (2015). Energy efficiency analysis of cognitive radio network using stochastic geometry. In Proceedings of IEEE conference on standards for communications and networking (CSCN).
45. Sabuj, S. R., & Hamamura, M. (2018). Two-slope path-loss design of energy harvesting in random cognitive radio networks. Computer Networks, 142, 128–141.
46. Khan, M., Rahman, M. T., & Sabuj, S. R. (2018). A transmit antenna selection technique in random cognitive radio network. In Proceedings of TENCON 2018.