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Design and Implementation of a Feasible Model for the IoT Based Ubiquitous Healthcare Monitoring System for Rural and Urban Areas

MOHAMMAD NURUZZAMAN BHUIYAN[1], MD MASUM BILLAH[2], FARZANA BHUIYAN[3], MD ASHIKUR RAHMAN BHUIYAN [4], NAZMUL HASAN[5], MD MAHBUBUR RAHMAN[6,*], MD SIPON MIAH[6,7,*], MOHAMMAD ALIBAKHSHIKENARI[7,*], FARHAD ARPANAEI[8], FRANCISCO FALCONE[9,10] and MINGBO NIU[11]

[1]Institute of Information Technology (IIT), Noakhali Science and Technology University, Bangladesh (e-mail: nuruzzaman.iit@nstu.edu.bd)
[2]Department of Computer Science, American International University Bangladesh, Dhaka, Bangladesh (e-mail: billah.masumcu@aiub.edu)
[3]Department of Computer Science, University of Chittagong, Chittagong, Bangladesh (e-mail: farzanabhuiyancse.cu@gmail.com)
[4]Department of Computer Science and Engineering, Dhaka University, Bangladesh (e-mail: ashik18710@gmail.com)
[5]Department of Computer Science and Engineering , Bangladesh University and Engineering and Technology, Bangladesh (e-mail: nazmul.buet17@gmail.com)
[6]Department of Information and Communication Technology, Islamic University, Kushtia, 7003, Bangladesh (e-mail: mrahman@ict.iu.ac.bd (Md Mahbubur Rahman), sipon@ict.iu.ac.bd (Md Sipon Miah))
[7]Department of Signal Theory and Communications, University Carlos III of Madrid, 28911, Leganes, Madrid, Spain (e-mail: mohammad.alibakhshikenari@uc3m.es)
[8]Department of Telematic Engineering, Universidad Carlos III de Madrid, 28911 Leganés, Madrid, Spain (e-mail: farhad.arpanaei@uc3m.es)
[9]Electric, Electronic and Communication Engineering Department, Public University of Navarre, 31006 Pamplona, Spain
[10]Institute of Smart Cities, Public University of Navarre, 31006 Pamplona, Spain
[11]School of Electronics and Control Engineering, Chang'an University, ShaanXi Province, 710064, China (e-mail: ivr.niu@chd.edu.cn)

Corresponding author: Md Mahbubur Rahman (e-mail:mrahman@ict.iu.ac.bd), Md Sipon Miah (e-mail:sipon@ict.iu.ac.bd),and Mohammad Alibakhshikenari (e-mail: mohammad.alibakhshikenari@uc3m.es).

ABSTRACT The Internet of Things (IoT) based real-time health monitoring system has contributed towards a brilliant human welfare both in urban and rural areas. Many of such solutions are not well applicable in developing countries like Bangladesh due to lack of uninterrupted communication system. In this paper, we present an IoT-based real-time health monitoring system that can measure, monitor and report people's health condition online and offline from anywhere. Our proposed IoT based solution is capable to transmit the sensitive health information to medical centres and caregivers in real time. The proposed system has been designed with Arduino UNO, Nodemcu, and GSM modules to measure body temperature, pulse rate, oxygen saturation, room temperature, and air quality in a smart home setting. The system can also provide the patient's historical health records. Our implementation was tested on some test cases which works excellent with accuracy. The proposed system has high potentiality for the rural and urban areas in developing countries.

INDEX TERMS IoT, Healthcare, Rural and Urban areas, Monitoring System, Architectures, Networks.

I. INTRODUCTION

In terms of technological advancement, humans are also becoming very concerned about their health. The last coronavirus has ruined the world economy and made the world leaders responsible for their own country's present healthcare facilities. Because of coronavirus, all health-related people face problems giving proper treatment to their patients. Even a vast number of health-related persons lost their lives in this COVID-19. At that time, many severe patients abstained from the hospital for infection anxiety and were deprived of their regular health checkups. Rural and urban areas patients face serious problems during the epidemic.

Our health monitoring system is designed to assist patient care, drive clinical performance, and lower costs. This integrated solution provides the hospital's IT environment to capture secure patient data and provide it literally to the hospital. So clinicians have access to the relevant, detailed information they need to make informed care decisions.

Most risk-based defense-in-depth security helps protect patients' privacy. Data integrity works right from the start and at every stage of patients to help customize and standardize monitoring solutions. Hospital protocol patient monitoring is a total solution designed around the challenges of data security. In the last decade, governance has been getting more attention for the quality of life. It works to develop technologies to promote healthcare participation in different areas. Our system explores the obtained topics and proposes cutting-edge solutions using a healthcare monitoring system—governance efficient based on public health services.

Our proposed system space has been a big boost as a cloud enables security and helps connect to real-time data and access performance data. The Internet of Things has allowed capturing data continuously; having access to the data will enable us to respond more quickly. We see tremendous opportunity for a growing portfolio of devices but potentially even more exciting is the chance to put data in the hands of our customer's intelligent equipment management device-derived data. We're positioned to potentially transform healthcare in partnership with users if we can provide clinical insights with some of the device insights and ultimately get to better patient outcomes.

Our healthcare monitoring is particularly significant because it's solving a critical and sensitive area of the real situation, as highlighted by the pandemic. The demonstration of previous research that has been done a few features. But we have solved more issues of the previous state of arts. The IoT based healthcare system has been considered the next technological revolution globally. The remote patient monitoring system allows patients to monitor from anywhere, like home, office, rural and urban areas [1]. The fundamental emerging objectives of this influential research are to design and execute a feasible model for the IoT based ubiquitous healthcare monitoring system for rural and urban areas. The proposed model can measure and display Blood pressure, Room temperature, Body temperature, oxygen saturation, heart rate, track the patient's location using different sensors, and transmit the data online and offline to mobile apps. So that patients can take the attention of doctors even if they live in rural and urban areas. Using our system, any registered patient can inform doctors about their physical conditions anytime. Apart from the personalized critical health, the developed system also provides an alert signal to the doctors and caregivers to identify the patient's critical health condition. Our developed system also provides the patient's previous statistical data and has an emergency button.

Our device-derived data on the patients is assistance with fleet management. Data allows us to maintain a large number of medical devices. The system is very user-friendly and reliable based on real-time monitoring.

The tested system will be fruitful for patients. When any patient feels his body temperature and the pulse rate are unnatural or any vital physiological sign is irregular, the system will immediately send an alert signal to the doctor and caregivers online and offline. The emergency button will help the patients to communicate with the doctors and caregivers. The developed system was tested on fifty human bodies in different rural and urban areas and obtained accurate results through the mobile application. The system is technologically rich but economical, reliable, user-friendly, and serves multiple purposes. The system worked successfully in each test case.

To achieve a high-quality health monitoring system through new technologies. Our system framework of a health monitoring system based on a mobile platform is designed to execute pervasive health monitoring.

The rest of the paper is organized as follows "Related Works" "Materials and methods" sections provide the major hardware components, system design, and the implementation details of the developed system. The "Experimental results analysis" section discusses the experimental results of the developed system, and finally, the "conclusion" section addresses the overview of the system and points to the future directions.

II. RELATED WORKS

IoT will reduce the healthcare cost, time, and diagnostic testing procedures [2]. Some Intelligent IoT related applications are smart health, home, city, parking , agriculture and industry [3-8]. Modern patient healthcare management system is an excellent IoT facility, which links with sensors and networks. For health monitoring, the connected components are used on devices. The sensors then send the information to the smartphones using different processing modules like Arduino Uno and Nodemcu. It is a straightforward, energy-efficient, scalable, interoperable, cost-effective, and time-consuming way of tracking and optimizing healthcare problems.

The two most significant syndromes of human health are heart rate and body temperature. Heart rate is commonly known as pulse rate in most cases. Based on the blood flow volume, the doctor used to calculate pulse rate. Doctors advise their patients to keep their "heart rate 60 beats per minute and 100 beats per minute" if they are healthy. The average heart rate is roughly "70beats per minute" for males, and "75 beats per minute for females" [11]. The average body temperature depends on a few factors, such as a person's age, gender, job responsibilities, and eating habits.

Doctors and Engineers have been trying to merge their knowledge for years. The dominant approach in this sector is to implement IoT with a Healthcare management system. Following all those dedicated works, we proposed a system that provides total support for patients and Doctors. Our proposed approach is a mobile, online-based, offline emergency SMS calling supported real-time monitoring application. We tried to make the system automated. Our future plan is to gather this vital data from the patients (with permission) and analyze the data with professionals using NLP to provide some valuable decisions.

Generally , a thermometer which is accessible in the market [12] can provide both analog and digital reading with a very low cost. The emerging IoT-based health monitoring systems have impressively supported the healthcare sector [13]. The rising industrial IoT-based devices have taken a remarkable footstep from healthcare research. The reviewed research based article " IoT-based smart health monitoring system for COVID-19 patients". [14]. The authors used pulse rate, body temperature, and Spo2 only for COVID-19 patients. Without an IoT environment, the system can not measure the patient's vital syndrome [15]. In [16], the authors proposed a model to allow a set of Emergency Contact Persons (ECP) to provide a person's medical information where the Break-Glass key is used as an alternate key. The authors ran his lightweight model in several simulations test to their proposed system.

In [17], using the C-band sensing, the authors propose automatic monitoring ketoacidosis of a non-invasive breathing monitoring system for diabetic patients. The testing result was an excellent outcome. C-band sensing is one of the upcoming features of 5G internet that is recommended by many countries, which will undoubtedly be widespread soon.

In [18], the authors inaugurated an S-band frequency-directed monitoring system for dementia patients to automatically monitor three wandering patterns: random, pacing, and lapping. The patients wandering patterns are trained in a controlled indoor environment to machine learning model, which achieves 90% accurate output. The system will use as a baseline of similar works in the future. In [19], the authors mention in case of emergencies; patients can save their lives using the GSM module functionalities. The communication protocols collect patient data from the GSM module. The sensors received the data and sent it to the doctor.

"A lung function monitoring system for asthma patients" was proposed in [20], where body temperature, pulse rate, Spo2 and CO2 were not measured. Cloud computing structured hardware prototypes using Arduino Uno were produced where real-world testing data is not involved [21]. Mobile application-based heart rate monitoring systems were developed and there is no investigation analysis report [22]."A detailed Research on Human Health Monitoring System Based on the Internet of Things" where acquired data with the sensors but no specific measured in this system [23].

In [24], The device is beneficial mainly for elderly, infectious, chronic patients in rural and urban areas. Worldwide, 5% of deaths occurred for chronic obstructive pulmonary diseases (COPD) and asthma in 2005. A blockchain-based security system has been proposed for the Internet of Things (IoT) health monitoring system in [25]. The clustering algorithm should construct the best group phrases for all users [26].

III. MATERIALS AND METHODS

A. OVERALL SYSTEM OVERVIEW

The primary purpose of the proposed system is 24/7 continuous and uninterrupted monitoring of all the most significant health and room condition parameters of a patient with or without wi-fi. The system also provides an improved and automated alarming process that works with or without internet connectivity and can track the patient's location in case of emergencies. The patient is also allowed to press an emergency alert button to send notifications on troubles. The patient himself, guardians, and the doctors will simultaneously supervise the patient's health details in our system. Again, as the system can store previous health records of a patient, the doctors or

caregivers will be able to access them when required, which will assist in taking essential decisions about the patient.

The system integrates several technologies but mainly consists of two components, a hardware device carried by the patient and a mobile application to display the patient's real-time and prior health records. The patient carrying the device can move freely under constant monitoring.

The sensors associated with the device collect the patient's body and environmental parameters and pass them to the processing unit. Here, we have considered the most valuable health parameters for most common health problems: patient's body temperature, heart rate or pulse rate, oxygen saturation or SpO2 level, ECG, respiration rate, room temperature, room humidity, and CO2 gas level. The processed health records are then displayed on the device as well as periodically transmitted to a cloud server using wifi or cellular internet from the processing unit.

The server stores the data in a patient database and sends it to the mobile application. Both the device and the mobile application can detect irregular health records and show alarming notifications that include the patient's location. The device can also send an emergency alert via SMS or call with or without the internet. A block diagram is presented in Figure 1 as a guide to visualize the overall process of the system. The block diagram shows the fundamental process of the system that is the data flow from the patient's body or environment to the end-user who will be monitoring the health records.

B. MAJOR HARDWARE COMPONENTS

Since a wearable hardware device is the supreme element of the proposed system, several sensors, modules, and gadgets are mandatory to develop it. The required hardware components, quantity, and cost are listed in Table 2, which reveals that the device's total cost becomes 5080 BDT or

Refe- -rences	Real-Time Monitoring	Major Hardware Components	Emer- -gency Alert	SMS Alert	Mobile Apps	Monito- -ring with Wifi	Monito- -ring with Mobile data	Cost
Our System	Yes	Aurdino Uno, NodeMCU, GSM Module, Wifi Module, Temperature sensor, Pulse sensor, Pulse sensor, ECG, Room Temperature sensor, Air Quality Sensor	Yes	Yes	Yes	Yes	Yes	Cost Effective
[2]	Yes	Wi-Fi module, Bluetooth, RFID, ECG, blood pressure	Yes	Yes	No	Yes	Yes	Low Cost
[27]	Yes	Heart rate sensor, Bluetooth, microcontroller, electrode pads, display	No	No	No	Yes	No	Costly
[28]	Yes	Arduino Uno, temperature sensor, heart rate sensor, body position sensor, Wi-Fi module	No	No	No	Yes	No	High-Cost
[29]	Yes	Raspberry pi, Lo-Ra module, temperature, sensor, humidity sensor, pulse sensor, WSN,WDM,UV, CO2 sensor	No	No	No	Yes	No	Costly
[30]	Yes	ECG, pulse sensor, temperature, camera, environmental sensor, Bluetooth, ZigBee, RFID	No	No	No	Yes	No	High-Cost
[31]	Yes	Measure blood pressure, temperature, camera, environmental sensor & temperature	No	No	No	Yes	No	Low-Cost

TABLE 1. Improvements of the proposed system with respect to similar IoT-based systems

$59 US dollars. The significant hardware components used to implement the system are elaborated in this section.

1) Arduino Uno

Arduino Uno is a low-cost, reliable, easy-to-use open-source IoT board based on the ATmega328P microcontroller. It is used as the main controller board in our system as it meets all our requirements. The major components of an Arduino board are a USB type B connector, a power port, six analog pins, 14 digital pins, an ATmega3288P microcontroller, a UART, a reset button, a voltage regulator, and a crystal oscillator. It has a 32KB-flash memory and a 2KB-RAM. It commonly takes 7V to 12V as input voltage and operates at a voltage of 5V. Arduino Uno is programmable using the Arduino IDE that supports C or C++ programming languages. Arduino Uno is a vital hardware component in our system as it plays a prominent role in connecting all other sensors and modules.

2) Node MCU ESP8266

Node MCU ESP8266 is a low-cost, widely used, open-source development board and firmware built around an SoC ESP8266. It merges functionalities like a Wifi access point and a microcontroller. The board has 16 GPIO pins and a UART(TX, RX pins). Node MCU takes 7V to 12V s input and operates at 3.3V voltage. It has a 4MB-flash memory and a 64KB-SRAM. The node MCU ESP8266 plays a crucial role in our developed system because it enables the wifi capability of our system. As long as the wifi is available, the measured sensor data are sent to the server through the ESP8266. The board also performs as the system's processing unit as it maintains two-way serial communication with

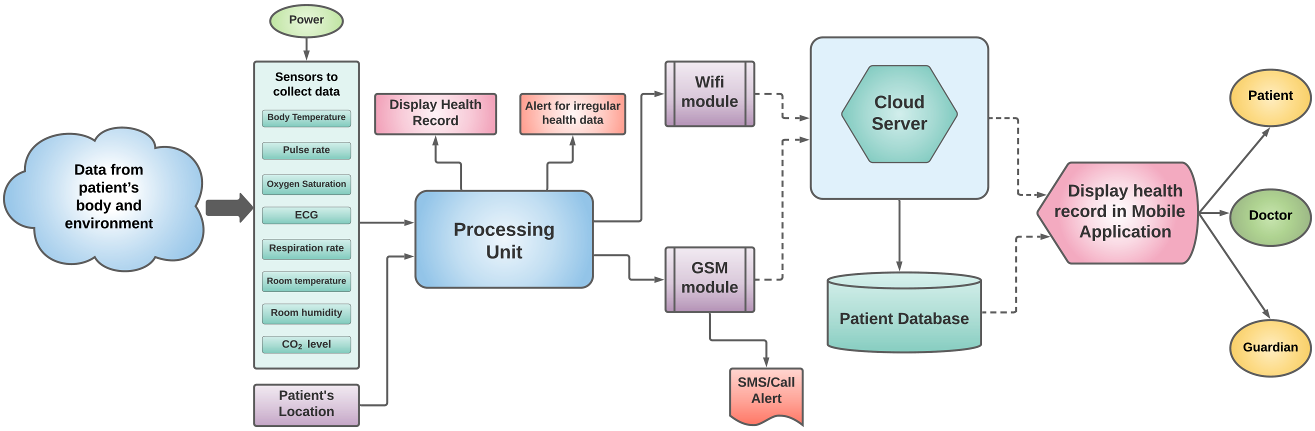

FIGURE 1. Block diagram of the system

Serial	Item description	Quantity	Price BDT
1	Ardunio Uno	1	450
2	NodeMcu	1	490
3	GSM Sim900A module	1	1400
4	Temperature sensor DS18B20	1	270
5	Pulse Sensors MAX30100	1	400
6	ECG Sensor AD8232	1	985
7	Room Temperature and Humidity Sensors DHT11	1	350
8	Air Quality Sensor MQ135	1	200
9	LCD Display	1	205
10	Battery Adapter	1	100
11	Switch	1	10
12	Buzzer	1	20
13	Wire set	2	200
	Total		5080

TABLE 2. List of the major Hardware components, quantity and cost of the product

the Arduino Uno.

3) GSM Module SIM900A

GSM SIM900A is a compact, reliable, and complete dual-band module for GSM/GPRS communication using a mobile sim card. It automatically searches and works on EGSM 900MHz and DCS 1800MHz frequency bands that allow users to send/receive cellular calls and SMS, connect to the internet, and track locations. The module has 68 pins and requires a power input between 3.4V to 4.5V to operate. The primary functional interfaces of the module are power, antenna, SIM card, UART, LCD, audio, and GPIO/keypad. Different supported AT commands are required to interact with the GSM/GPRS cellular network. The SIM900A module is a prominent constituent of our developed system and makes our system more sophisticated. The module sends the health data to the cloud server when the wifi is unavailable. It also sends the SMS/call alert on emergencies tracing the patient's location. But when the wifi is available and there is no emergency, the module stays in sleep mode to reduce power consumption.

4) Body Temperature Sensor DS18B20

DS18B20 is a small-sized, widely used digital temperature sensor that uses a one-wire protocol to measure the range -55°C to +125°C and provide a digital output. It needs only one pin of the controller board to sense the temperature. A pull-up resistor of 4.7 Ohm with a power supply of 3V to 5V is necessary for wiring the sensor ideally. The accuracy of this simple sensor is ±0.5°C which makes it more reliable. So we have utilized this sensor to precisely measure the patient's body temperature.

5) Pulse Sensor MAX30100

MAX30100 is a particular electro-optical sensor capable of measuring heart rate and oxygen saturation, utilizing the wavelengths of lights from two LEDs, one red and another infrared. The infrared light is enough for measuring pulse, but both LEDs are required to find the pulse oximetry. The operating voltage of the sensor should be between 1.8V to 3.3V, and the input current is only 20mA. The sensor has five pins and uses an I2C protocol to communicate with the controller. We have used this sensor to measure the pulse rate and the SpO2 of a patient. The pulse rate is nothing but the heart rate, and the SpO2 denotes the amount of oxygenated hemoglobin in the blood.

6) ECG Sensor AD8232

AD8232 ECG sensor is a small chip that amplifies, extracts, and filters biopotential signals to provide an analog output utilized to calculate the electrical movement of the human heart. An Electrocardiogram of the heart helps to analyze various health parameters. The sensor AD8232 has six pins: 3.3V, GND, LO+, LO-, OUTPUT, and SDN. It operates at voltage 2V to 3.5V and has a low current supply of just 170µA. The complete setup of the ECG sensor includes the main IC chip and tree electrodes that will be placed in the patient's skin. The board has three pins: RA, LA, and RL, to connect the electrodes.

7) Room Temperature and Humidity Sensor DHT11

DHT11 is a commonly used, low-cost digital sensor that consists of a capacitive element to sense relative humidity and a thermistor to measure room temperature. The main three components of the sensor are a resistive type humidity sensor, an NTC(negative temperature coefficient) thermistor to measure temperature, and an 8-bit microcontroller to process the measured values in series. It has three pins and uses a single DATA pin to communicate with the controller. The sensor operates at a voltage from 3V to 5V and a maximum of 2.5mA current. The temperature measuring range of the DHT11 is 0°C to 50°C with +-2 degrees accuracy, and the scope for measuring humidity is 20% to 80% with a 5% accuracy. We have used the sensor in our system to monitor the patient's room condition.

8) Air Quality Sensor MQ135

MQ-135 is a gas sensor that can detect harmful gases and smoke to monitor indoor air conditions. The sensor can detect gases like CO2, ammonia, sulfur, benzene, nicotine, etc. Its detection range is 10-1000ppm. The sensor has four pins: +Vcc, GND, A0 analog pin, and D0 digital pin. The gases are measured in ppm by TTL's analog pin and operate on 5V. We have used this sensor in our system to measure CO2 gas levels to monitor the air quality of a patient's surrounding environment.

C. SYSTEM DESIGN

Our proposed system space has been a big boost as a cloud enables security and helps connect to real-time data and access performance data. The Internet of Things has allowed capturing data continuously; having access to the data will enable us to respond more quickly. We see tremendous opportunity for a growing portfolio of devices but potentially even more exciting is the chance to put data in the hands of our customer's intelligent equipment management is a device-derived data. We're positioned to potentially transform healthcare in partnership with users if we can clinical insights with some of the device insights and ultimately get to better patient outcomes.

As the fundamental idea of the proposed system is 24/7 continuous online monitoring of patients' health and room environment, the system architecture and functionality has diverged mainly into three modules: 1) Sensing and data processing module 2) Data storage module 3) Interaction module. In fact, the sensing and data processing module represents the device carried by the patient. The data storage module indicates the cloud server. And the interaction module denotes the mobile application. Figure III-C illustrates the overall system architecture of the developed system.

- Sensing and data processing module: Figure III-C exhibits that the sensor and data processing module comprises sensors to collect data from the patient's body and room environment by converting physical and physiological phenomena into analog or digital signals. The ESP8266 WIFI module or GSM module SIM900A sends the collected data to the cloud server; the LCD showcases the health record; the buzzer and the emergency button participate in the emergency alert system. Thus, this module recurrently senses the health and environment parameters, processes the data, and transmits it to the cloud server.
- Data storage module: This module is accountable for acquiring and accumulating the collected data. The system utilizes a real-time database and a cloud firestore of the Google Firebase cloud server. The real-time database receives the data sent from the hardware device and stores it as a current health record. It is updated every 7-8 seconds to find a new health record which allows the patient to be monitored in real-time. But The frequency of measurement on the device is based on the intervals. Considering the situation parameters: date and time, the distinct health records of every hour are stored in the cloud firestore labeled as the patient database in figure 7.
- Interaction module: This module is a mobile application that fetches the health records from the cloud server and displays them to authenticated users. New users can sign up as patients, guardians, or doctors and log in to interact with the system and access a patient's real-time and prior health records.

The flow chart of the complete system is demonstrated in Figure 3, which identifies the essential steps of the process in chronological order. The workflow of all three system modules and their interrelation are displayed in the flowchart. The sensing and data processing module recurrently extracts sensor data, processes, and displays it, and checks for irregularities. If the system finds any irregular health data, the buzzer is activated to alert the patient, SMS/call alert is sent with the patient's location through the GSM module. Then the system checks the internet connectivity, and if WIFI is available, the health record is sent to the cloud via the ESP8266 WIFI module of the node MCU. If WIFI is not available, the data is sent through the GSM SIM900A module. The data storage module then collects, processes, and stores the health records periodically until the stop command is given. The health records are then transmitted to the interaction module and accessed by only authenticated users. Any user needs to verify every session of interaction with the mobile application.

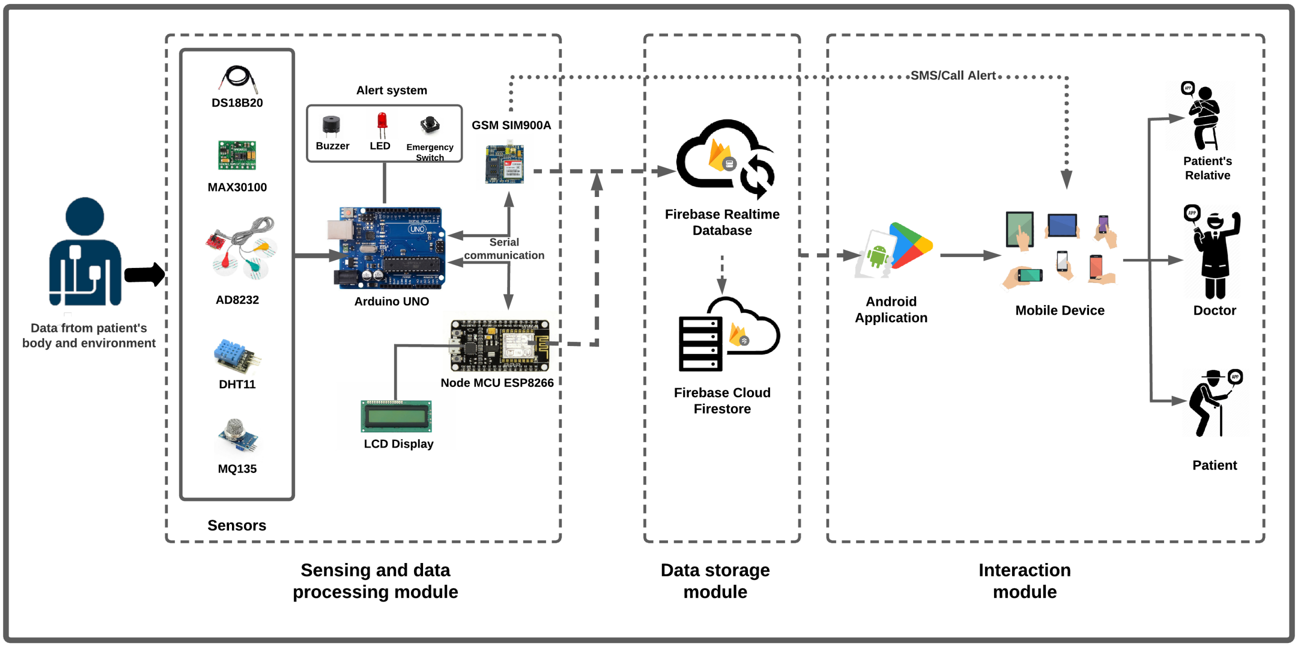

FIGURE 2. System Architecture

D. IMPLEMENTATION DETAILS

As the entire function of the proposed system is systematized utilizing a hardware device and an application interface, the implementation phase can be categorized into hardware implementation and software implementation.

1) Hardware Implementation

The hardware implementation represents the implementation of the sensing and data processing module stated in the "System Design" section, which is a vital component of the system. The module measures the sensor data, processes it, and sends it to the cloud server. So, this multifunctional device requires various hardware gadgets to be assembled. The implementation of the hardware device is achieved by connecting the required hardware components according to the system design and programming the microcontroller of the IoT board utilized. The circuit diagram of the developed system is illustrated in Figure 12, which indicates the pin configuration between the sensors, Arduino, node MCU, GSM module, LCD, LED, buzzer, and other essential electrical circuit elements. The "Proteus Design Suite" software is utilized to design the circuit diagram.

We have taken an Arduino Uno as the main controller board for the system. A 9V rechargeable Li-po battery is used to power up the Arduino. Another controller board node MCU ESP8266 is merged with the Arduino to enable the WIFI capability and increase the number of analog pins and digital pins. Two-way serial communication is achieved by connecting the RX and TX pins of node MCU to PB4(12) and PB5(13) pins of the Arduino. The software serial library for Arduino is used to define PB4 as TX pin and PB5 as RX pin to allow the serial communication between node MCU and Arduino.

A fixed baud rate is specified to maintain the data transmission rate between the Arduino and node MCU. So, both the Arduino and the node MCU ESP8266 function as the system's processing unit. A GSM/GPRS module SIM900A is connected, allowing Arduino to connect to the internet, make calls, and send and receive SMS using the cellular connectivity. The module also features a GPS chipset that enables location tracking. The TX and RX pins of SIM900A are connected to pins PD0(RX) and PD1(TX) of the Arduino to establish communication. A 3.7V Li-po battery is dedicated to the GSM module as it needs a proper voltage supply to function ideally. The Vcc and GND pins of all the sensors are connected to the Vcc and GND of the Arduino. The DQ pin of body temperature sensor DS18B20 and the Data pin of the room temperature sensor DHT11 is connected to PD2 and PD3 digital pins of the Arduino. For the Pulse sensor module MAX30100, the SCL and SDA pins are linked to PC5(A5) and PC4(A4) pins of the Arduino. In the case of ECG sensor AD8232, the OUTPUT, LO-, and LO+ pins are mapped to PC1(A1), PB3(11), and PB2(10) of the Arduino. The analog pin A0 of the air quality sensor MQ-135 is joined to PC0(A0) of the Arduino. An LED and a buzzer are connected to PD7 and PD6 pins of the Arduino. An LCD is configured with the node MCU in 4-bit mode. Then we have added some resistors where required and connected all the grounds to complete the entire circuit. After completing the circuit, the Arduino Uno, and the node MCU are connected to the computer with USB, and the required C++ code is uploaded utilizing the Arduino

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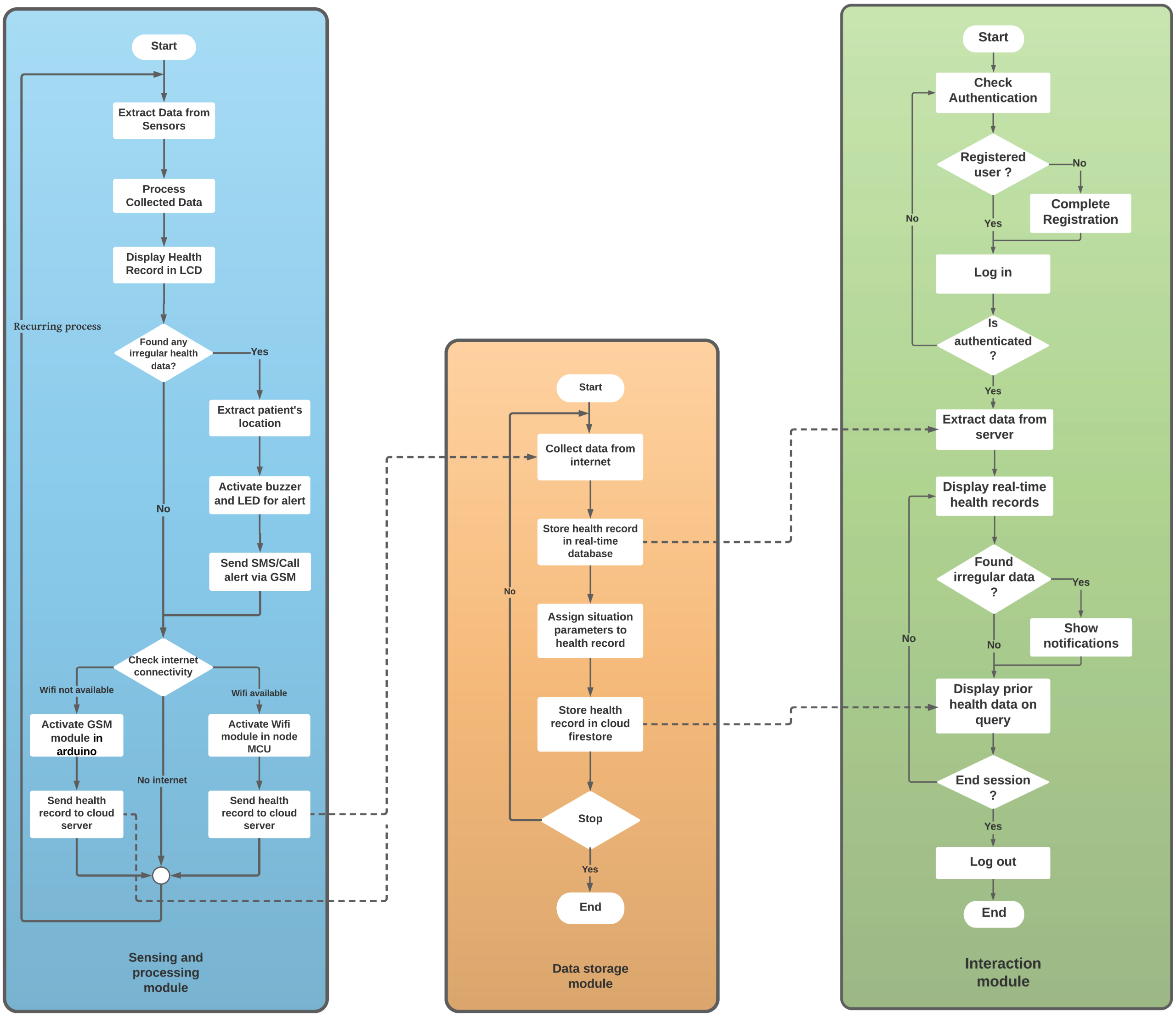


FIGURE 3. Flowchart of the complete system

IDE. The full functioning user prototype is displayed in Figure 13, where the system is tested with a user. The figure shows that when the sensors are connected to the patient's body, the real-time health record is depicted both in the LCD and the mobile application.

2) Software Implementation

The software implementation denotes the implementation of the Data storage module and the Interaction module stated in the "System Design" section. The two modules are accountable for storing the health data in the cloud server and displaying it in the mobile application. The implementation of the data storage module is obtained by utilizing the Firebase cloud platform by Google. It is a Backend-as-a-Service (Baas) platform that provides developers with NoSQL databases, tools, and backend features for creating mobile and web applications. Firebase offers databases of two categories:

1) Firebase Realtime Database that lets users store and sync data in real-time
2) Firebase Cloud Fire store enables users to store, sync, and query data at a large scale. We have utilized databases of both types in our developed system. Databases used in the system are demonstrated in Figures 6 and 5.

The health data sent from the hardware device to the firebase cloud server are firstly stored in the real-time database shown in 6.

This database is updated every 7-8 seconds to discover a new health record in real-time. Every hour, one health record is stored in the firestore database shown in Figure

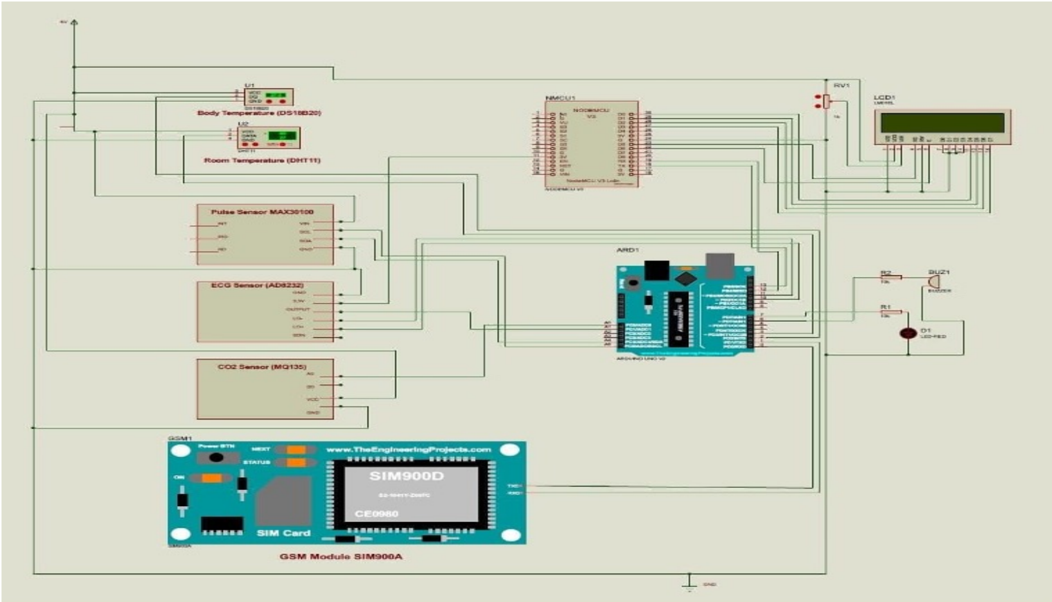


FIGURE 4. Circuit diagram of the system

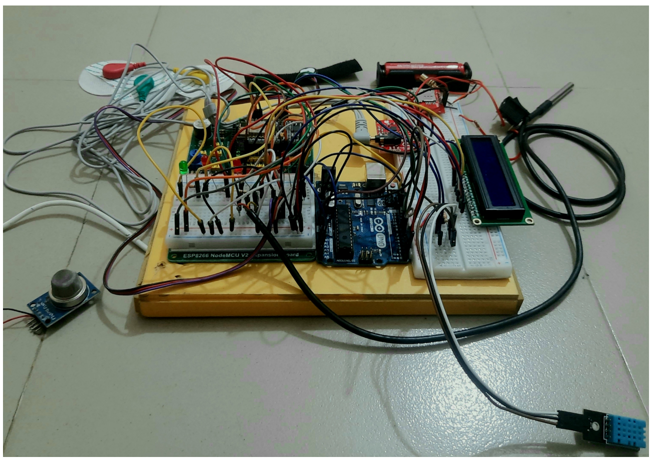


FIGURE 5. Prototype of the system

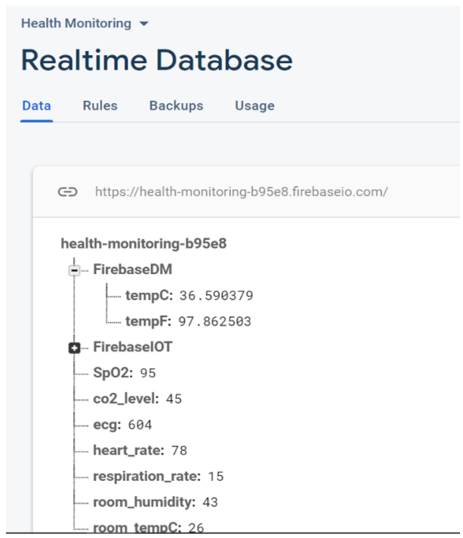


FIGURE 6. Firebase Realtime database of the System

15 to keep the patient's history. The interaction module that is the mobile application is developed in Android Studio, which is the official IDE for Google's Android operating system. It is a stable IDE powered by IntelliJ IDEA specially built for accelerating mobile application development. We have utilized Google Firebase as the backend server and Java as the programming language for implementing the mobile application. The significant interfaces of the mobile app named "HSMART" are pictured in Figures 16, 17, and 18.

Figures 16(a) and 16(b), respectively, show the mobile application's login and sign-up interfaces. Registered users can log in with their username and password, whereas fresh users need to sign-up to provide their username, email, and password before logging in. After logging in to the mobile application, users will find an interface shown in Figure 17(a), displaying real-time health data of the patient carrying the sensing device. The users are offered an option to select all or activate/halt specific sensors, and the app will display the health data accordingly. The interface is depicted in Figure 17(b). The users can also find an interface for the patient's history exhibited in Figure 18, which displays health records of each hour of a day.

E. EXPERIMENT RESULTS ANALYSIS

The data collected from remote patient sensors and IoT platforms have been suggested for optimal efficiency of the systems and accuracy of data processing. Human sensor data in the IoT platform is sent to the server with the Internet. We

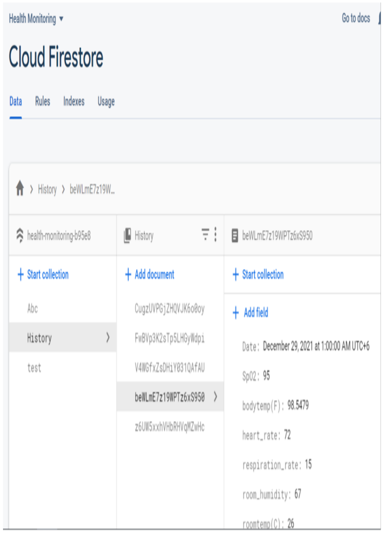
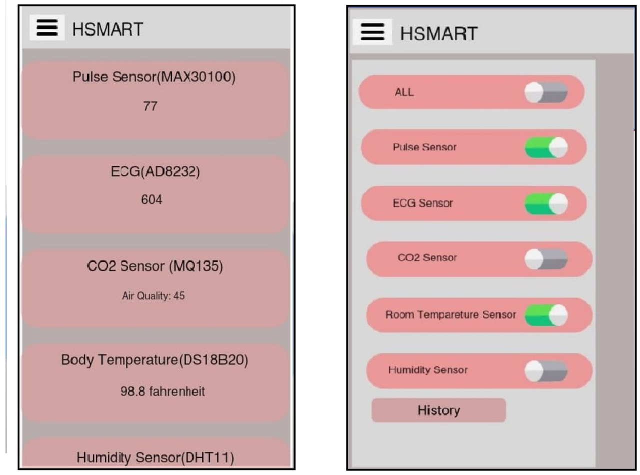
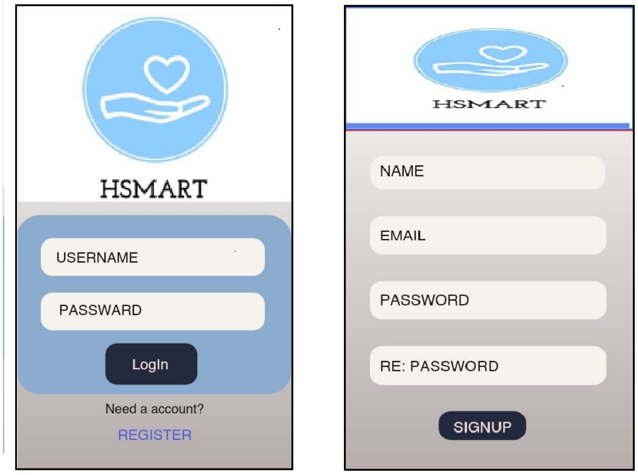


FIGURE 7. Cloud Firestore database of the system



(a) (b)

FIGURE 9. (a) Displaying health data
(b) Menu to select specific sensors



(a) (b)

FIGURE 8. (a) Login interface of the mobile application
(b)Signup interface of the mobile application

FIGURE 10. Patient's health history interface

have chosen numerous data but here represents the 10 patient's of sample data. We have collected numerous datasets including continuous measurements from different people for conducting statistical data analysis to investigate the accuracy and reliability of our proposed system with respect to the actual measurements of people's health conditions. But we have represented only 10 different people in their dataset.

It allows remote data on server-based and facilitates the collaboration of any authorized person, including external specialists. It is also appropriate for mobile devices for health applications. We have created an effective healthcare service that provides numerous opportunities. We can observe a vital benchmark to specify the required requirements during emergency conditions. There are different patient sensor data associated with IoT devices. Data received from the sensor is distributed on a second basis—IoT servers are connected to patients' data received from sensor devices 24/7.

We use patient datasets associated with IoT devices connected to the sensors. Different data from IoT devices and servers connected to patients store data obtained from IoT devices in real-time.Table 3 shows the suggested dataset in the method. Ten people are examined, and their health situation is assessed regarding various requirements at different day duration. That is not a significant standard to specify required conditions during severe movements or sports. In accordance with the proposed model discussed, our results were obtained from the simulation. Obtained results are compared with expected outcomes. This section discusses the accuracy of the proposed algorithm in various conditions of the patient's body. The proposed model has 95% accuracy in responding and transmitting information in 85-90% of cases. The sensor's high accuracy sends and receives information from sensors to the doctor or server to use IoT technology.

$$Accuracy_j = \frac{\sum_{i=1}^{n} TP(i) + \sum_{i=1}^{n} TN(i)}{\sum_{i=1}^{n} TP(i) + FN(i) + FP(i) + TN(i)}$$

$$Sensitivity_j = \frac{\sum_{i=1}^{n} TP(i)}{\sum_{i=1}^{n} TP(i) + FP(i)}$$

$$Specificity_j = \frac{\sum_{i=1}^{n} TN(i)}{\sum_{i=1}^{n} FP(i) + TN(i)}$$

FIGURE 11. Different Error percentage based on actual and observed data of human body

TP (True Positive) indicated that patients in a normal health condition are identified as expected. TN (True Negative) demonstrates that patients have a common health condition but are identified as emergencies. FP (False Positive) showed patients in emergency conditions and identified as expected. FN (False Negative) pointed patients in emergency conditions and identified them as critical. N indicates the number of samples, and i is between 1 and n. We compare the results to the accuracy of the different states of the patient's data. We consider the various sensor data in our simulation and compare the obtained results.

IV. CONCLUSION

Our system collects and shares data among each other for the distribution of different healthcare applications and services. The purpose of remote healthcare monitoring systems would be much more accessible.The system is technologically rich but economical, reliable, user friendly and serves multiple purposes. Remote healthcare monitoring systems include intelligent sensors and devices that can operate continuously online and offline emergency monitoring. Certain limitations and relevant factors complicate its continuous improvement such studies provide considerable opportunities to resolve the identified challenges. Usability is always a significant functionality consideration to improve continuous monitoring. The accuracy and reliability mechanisms must be assured over everyday utilization. Authentication of the network is one of the essential aspects for ensuring the structure of remote healthcare monitoring systems.After proper manufacturing, the system has high potentiality for rural and urban areas in developing countries.

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Patients No	Act Temature	Observed Temature	Error (%)	Actual Heartbeat	Observed Heartbeat	Error (%)	Act Oxygen	Observed Oxygen	Error (%)	Act Pulse	Observed Pulse	Error (%)	Actual Respiration	Observed Respiration	Error (%)
1	37	38	2.70	72	70	2.70	93	94	1.80	93	92	1.80	14	16	2.70
2	35	34	2.70	136	139	3.10	94	92	2.70	91	90	1.80	15	16	1.80
3	36	37	2.70	68	70	2.70	90	94	4.08	75	77	2.70	15	11	2.70
4	37	39	4.08	55	57	2.70	95	95	0.0	62	64	3.80	15	15	0.0
5	35	34	2.80	117	120	3.10	94	92	2.70	87	86	1.80	12	14	2.70
6	32	30	2.90	112	114	2.70	94	93	1.80	89	91	2.70	15	12	3.70
7	35	37	4.90	82	80	2.70	90	92	2.70	92	93	1.80	17	18	1.80
8	30	28	2.70	54	53	1.80	92	94	2.70	93	91	2.70	12	12	0.0
9	31	30	1.80	112	110	2.70	95	95	0.0	92	89	3.80	10	13	3.80
10	35	36	1.50	74	75	1.80	96	94	2.70	93	91	2.70	9	10	1.80

TABLE 3. Actual and observed dataset for the error assessment

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MOHAMMAD NURUZZAMAN BHUIYAN received the M.Sc. degree from the Department of Computer Science and Engineering, Jahangirnagar University, Dhaka, Bangladesh, in 2014. He is currently working as an Assistant Professor with the Institute of Information Technology, Noakhali Science and Technology University, Noakhali, Bangladesh, where he is the Founder-Director. His research interests are the Internet of Things, blockchain technology, network security, and big data analysis.

MD MASUM BILLAH Md Masum Billah received the M.Sc. degree in computer engineering from the University of Duisburg-Essen, Duisburg, Germany, in 2018 and a B.Sc. degree (Hons.) in computer science and engineering from the University of Chittagong, Chittagong, Bangladesh, in 2009.

He is currently working as a Lecturer with American International University–Bangladesh, Dhaka, Bangladesh, where he has been serving since 2019. He already has outstanding publications in machine learning and data mining and IoT. His research engagement concentrates on IoT, machine learning, deep learning, and eHealth. IoT with their combination of several dimensionalities. Simplification and their interpretation, distribution (computer cluster architecture), and their high-performance computing aspects.

FARZANA BHUIYAN received M.Sc(Engg.) and B.Sc. (Engg.) degree in computer science and engineering from the University of Chittagong, Chittagong, Bangladesh. Her research interest is in IoT, Data Science, and Machine Learning, Machine Learning -Driven Textual Classification.

MD ASHIKUR RAHMAN BHUIYAN is studying at the University of Dhaka in Computer Science and Engineering. His research interest is in IoT, Data Science, and Machine Learning.

NAZMUL HASAN is studying at the Bangladesh University of Engineering and Technology in Computer Science and Engineering. His research interest is in IoT, Data Science, and Machine Learning.

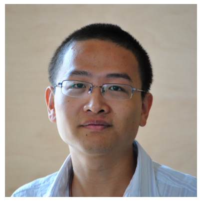
DR. MD MAHBUBUR RAHMAN currently works as Grade-I professor in the Department of Information and Communication Technology (ICT), Islamic University, Kushtia-7003, Bangladesh. Originally from Bangladesh, Dr. Md Mahbubur Rahman studied Physics with major in Solid State at Rajshahi University, where he graduated with a M.Sc. (Dept. Physics) in 1984. In 1997, he acquired his Ph.D. from the Department of Computer Science and Engineering, Rajshahi University, Bangladesh. Between 2000 and 2020 he worked in various administrative and academic sector of Islamic University, Bangladesh. Now, he is appointed as a Pro-Vice-Chancellor of Islamic University, Kushtia-7003, Bangladesh. He supervised a lot of PhD, Mphil and MSc research students. His research interests include Communication, Deep Learning, Image Processing, cognitive radio networks, and the Internet of Things.

DR. MD. SIPON MIAH received his B.Sc., M.Sc., and Ph.D. in Information and Communication Technology from the Islamic University, Shantidanga-Dulalpur, Kushtia,-7003, Bangladesh, in 2006, 2007, and 2016, respectively. In 2021, Sipon received his structured Ph.D. in Computer Science from National University of Ireland Galway (NUIG), Galway, Ireland. Since 2010, he has been with the Department of Information and Communication Technology, in the Islamic University, Shantidanga-Dulalpur, Kushtia-,7003, Bangladesh. Sipon is currently an Associate Professor in the same department and a Postdoctoral Fellow in the department of Signal Theory and Communications, University Carlos III of Madrid (UC3M), Leganes, Madrid, Spain. In 2016, Sipon was awarded the prestigious Hardiman Scholarship at NUIG. In 2021, Sipon was awarded the prestigious 30 Postdoctoral Fellowship at UC3M. His research interests include spectrum sensing, throughput, energy harvesting, MU-MIMO-based cognitive radio networks, Internet of things with machine learning, and massive MIMO-based cognitive radio networks.

DR. MOHAMMAD ALIBAKHSHIKENARI (Member, IEEE) was born in Mazandaran, Iran, in February 1988. He received the Ph.D. degree (Hons.) with European Label in electronics engineering from the University of Rome "Tor Vergata", Italy, in February 2020. He was a Ph.D. Visiting Researcher with the Chalmers University of Technology, Sweden, in 2018. His training during the Ph.D. included a research stage in the Swedish company Gap Waves AB. He is currently with the Department of Signal Theory and Communications, Universidad Carlos III de Madrid (uc3m), Spain, as a Principal Investigator of the CONEX-Plus Talent Training Program and Marie Sklodowska-Curie Actions. He is also a lecturer of the "electromagnetic fields" and "electromagnetic laboratory" in the department. For academic year 2021/2022, he received the "Teaching Excellent Acknowledgement" certificate for the course of electromagnetic fields from Vice-rector of studies of uc3m. His research interests include electromagnetic systems, antennas and wave-propagations, metamaterials and metasurfaces, synthetic aperture radars (SAR), multiple-input multiple output (MIMO) systems, RFID tag antennas, substrate integrated waveguides (SIWs), impedance matching circuits, microwave components, millimeter-waves and terahertz integrated circuits, gap waveguide technology, beamforming matrix, and reconfigurable intelligent surfaces (RIS). The above research lines have produced more than 200 publications on international journals, presentations within international conferences, and book chapters with a total number of the citations more than 3100 and H-index of 40. He was a recipient of the three years research grant funded by Universidad Carlos III de Madrid and the European Union's Horizon 2020 Research and Innovation Program under the Marie Sklodowska-Curie Grant 801538 started in July 2021, the two years research grant funded by the University of Rome "Tor Vergata" started in November 2019, the three years Ph.D. Scholarship funded by the University of Rome "Tor Vergata" started in November 2016, and the two Young Engineer Awards of the 47th and 48th European Microwave Conference held in Nuremberg, Germany, in 2017, and in Madrid, Spain, in 2018, respectively. His research article entitled "High-Gain Metasurface in Polyimide On-Chip Antenna Based on CRLH-TL for Sub Terahertz Integrated Circuits" published in Scientific Reports was awarded as the Best Month Paper at the University of Bradford, UK, in April 2020. He is serving as an Associate Editor for IET Journal of Engineering and International Journal of Antennas and Propagation. He also acts as a referee in several highly reputed journals and international conferences.

DR. FARHAD ARPANAEI is a Marie Skłodowska-Curie (MSCA) Postdoctoral Fellow with University Carlos III of Madrid (UC3M) in Leganes, Madrid. His current research focuses on Machine Learning applications in Space Division Multiplexing (SDM) scenarios for optical fiber communications and networking. He received his M.Sc. and Ph.D., both in Electrical Engineering with a major in Telecommunication Systems from South and Central Tehran Azad University, Tehran, Iran, with the highest distinction in 2010 and 2019, respectively. Since 2010, he worked as a lecturer and researcher involved in Iranian industrial companies and universities, and from 2013 to 2021 worked as an Expert of Establishment and Delivery Optical Transmission Services in Telecommunication Infrastructure Company (TIC)-Ministry of ICT based in Tehran, Iran. His research topic's main interest concentrates on the cross-layer design of Transmission Software-Defined Networks (TSDNs) by considering the concepts of Optimization and Machin learning methods. Farhad regularly acts as a reviewer in several highly ranked IEEE and Optical Society of America (OSA) journals of his fields of expertise (e.g., JLT, JOCN, and TOC). He is a member of IEEE and OSA.

PROF. FRANCISCO FALCONE (M'05, SM'09) received the degree in telecommunication engineering and the Ph.D. degree in communication engineering from the Universidad Pública de Navarra (UPNA), Spain, in 1999 and 2005, respectively. From February 1999 to April 2000, he was the Microwave Commissioning Engineer at Siemens-Italtel, deploying microwave access systems. From May 2000 to December 2008, he was a Radio Access Engineer at Telefónica Móviles, performing radio network planning and optimization tasks in mobile network deployment. In January 2009, as a co-founding member, he has been the Director of Tafco Metawireless, a spin-off company from UPNA, until May 2009. In parallel, he is an Assistant Lecturer with the Electrical and Electronic Engineering Department, UPNA, from February 2003 to May 2009. In June 2009, he becomes an Associate Professor with the EE Department, being the Department Head, from January 2012 to July 2018. From January 2018 to May 2018, he was a Visiting Professor with the Kuwait College of Science and Technology, Kuwait. He is also affiliated with the Institute for Smart Cities (ISC), UPNA, which hosts around 140 researchers. He is currently acting as the Head of the ICT Section. His research interests are related to computational electromagnetics applied to the analysis of complex electromagnetic scenarios, with a focus on the analysis, design, and implementation of heterogeneous wireless networks to enable context-aware environments. He has over 500 contributions in indexed international journals, book chapters, and conference contributions. He has been awarded the CST 2003 and CST 2005 Best Paper Award, the Ph.D. Award from the Colegio Oficial de Ingenieros de Telecomunicación (COIT), in 2006, the Doctoral Award UPNA, 2010, 1st Juan Gomez Peñalver Research Award from the Royal Academy of Engineering of Spain, in 2010, the XII Talgo Innovation Award 2012, the IEEE 2014 Best Paper Award, 2014, the ECSA-3 Best Paper Award, 2016, and the ECSA-4 Best Paper Award, 2017.



DR. MINGBO NIU received a BEng in Electronic Engineering from Northwestern Polytechnical University, China, and an MSc (Eng.) (first-class) in Communication and Information Systems from the same university. Prior to his Ph.D., Dr. Niu worked at a State Key Laboratory on underwater information and signal processing. He received his Ph.D. in Electrical and Computer Engineering from the University of British Columbia, Canada. From 2008 to 2012, he was a research assistant at Optical Wireless Communications Laboratory and Integrated Optics Laboratory where he contributed to the development of ultra-high-speed optical data transmission links. Dr. Niu held a postdoctoral fellowship at Queen's University, Canada for two years. He also worked for Public Works at Calian Tech. Ltd., where he contributed to highly efficient statistical evaluation models of MIMO compressive sensing projects. He is currently professor in the department of Automation, School of Electronics and Control Engineering, Chang'an University, ShaanXi Province, 710064, China. Dr. Niu has co-authored more than thirty Institute of Electrical and Electronics Engineers (IEEE) and Optical Society of America (OSA) papers and supervised numerous student projects. Currently, he serves as a Lead Guest Editor for Wireless Communications and Mobile Computing and an Academic Editor for IntechOpen. He is a member of the Internet of Things (IoT) Committee at the China Institute of Communications (CIC). Dr. Niu received numerous scholarships during his undergraduate and graduate studies, including a Chinese Government Award, two University of British Columbia University Graduate Fellowships (UGFs), and a Huawei Tech. Ltd. Special Fellowship. His current research and teaching interests include the Internet of Vehicles (IoV), vehicle-to-road (V2R) infrastructure, cooperative microgrids, massive multiple input, multiple outputs (MIMO), image signal processing, low-carbon smart cities, energy harvesting, and electronic circuit theory. Dr. Niu is a licensed professional engineer in British Columbia.