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Smart healthcare in smart cities: wireless patient monitoring system using IoT

M. Poongodi[1] · Ashutosh Sharma[2] · Mounir Hamdi[1] · Ma Maode[3] · Naveen Chilamkurti[4]

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Abstract

Recently, the development of building a smart city has been inclined rapidly with the help of emerging technologies in 5G and internet of things (IoT). In addition with smart city, concepts of smart traffic systems and smart health are also being developed. Combining the above two, smart navigation system for ambulances is being coined. When critical patients are referred by an ambulance, there is a lot of time wastage in facilitation of information and the hospital is completely unaware of the patient's parameters who is arriving beforehand. Therefore, patient monitor and ambulance tracking system is an efficient system used to carry out a quick thirty-second diagnosis using heartbeat, temperature, breath rate sensors to record vital patient parameters required initially by the doctors to start any treatment and remotely transmit these parameters over wireless medium to the hospital even before the ambulance is deployed. The patient also gets an instant way to request an ambulance on touch of a button without having to call up the hospital and also instantly send a short message service (SMS) to an emergency contact giving both the hospital and contact necessary emergency details a lot earlier. This saves a lot of time, each second of which is important to the patient at life risk. The patient can keep a track of the ambulance's location, which gives them an idea of its arrival and can also get instant navigation toward the nearest hospital for themselves if need be. The device can be kept with the patient and also installed inside the ambulance. The device enables the use of IoT sensors and android applications for better user interaction and efficient information transmission. The model dictated here is potentially outperformed with easiness and in a better way toward smart healthcare monitoring services.

Keywords Internet of things · Smart healthcare · Smart city · Wireless patient monitoring

✉ Ashutosh Sharma
sharmaashutosh1326@gmail.com

Extended author information available on the last page of the article

1 Introduction

The integration of conventional urban infrastructures is considered as the foremost significant and can be possible by using the smart city concept and IoT technology [1]. The IoT technology utilizes the sensors for cities for the sake of social and economic development for the development of smart cities and its services. Therefore, a systematic control structure is highly in need of the cooperation between the sectors of public and private for the smart city infrastructure. Along with this involvement of information technology (IT) sector indeed made it highly effective with the concept of smart cities [2]. While we are mentioning smart cities concepts, then there are lot of definition that comes to the picture because the definition of smart cities is vague in nature and has not enough predefined definitions. The cities with the emergence of information and communication technology (ICT) for the investment on human capitals for their life enhancement using the education and also the quality lifestyle of the residents, wiser health aid organization, transparent and strategic governance, efficient mobilization, high sustainability, security for the residents and also high privacy on their personal are known as smart cities [3]. The necessity of smart cities also grabbed the attention from industries as well as academics too. It can be shown by looking at the investment scenarios of the companies like Siemens, Intel and IBM are expanding their investments wiser further in future [4].

Recently, it has been predicted that exponential growth can be possible and considered as boom for the urbanization. At the moment, the 50% of the human population around the globe reside in the city area [5]. It has also been predicted that in near future this number can be level up 70% through 2050. The utilization for the people on all aspects needs to be enhanced with 100% fulfilment and quality needs to be provided for the people residing is significant. The infrastructure of those cities should be equipped with ICT to guarantee the context-conscious information. So that, the people can be satisfied with the intake of resources available and also proper allocation by the governing bodies. The smart conversation devices via ICT are to guarantee the above-mentioned context-conscious information [6]. Various major cities are started the process of adapting the concept. There are four areas which are required to persist with the sustainability and determination by means of Amsterdam and those incorporates the mobilization, operation, and spacing in public and living style [7]. The smarter initiations are conducted in selected regions for improvising the metropolis. In the Amsterdam, they mainly focus on the ecosystem enhancement and detoxification by reducing the Co2 emissions, but the research additionally discovered some illustration that focused sides also [8]. At some circumstances, cities which chase the smartness consist of Toronto, Vienna, London, Paris, Copenhagen, New York, Barcelona and Hong Kong. The normal and large implementation of specific sensors within the smart cities gives supplement connections in the path of participatory, human beings-centric, in addition to resourceful sensing. As in keeping with the given context, a smart city turns into an enormous gadget of systems, which is required to provide the processed statistics to its local authorities and residents.

In most conditions, they can provide personalized data that allow them the usage of the on-request provider companies for managing cities and creating the drive for corrective acts [9]. In the detailed study of smart cities, the integration of various services on the same platform at the same time made it feasible to boost the development of smart cities concept [10]. The smart economy is influenced by the factors with the international market strategy and integration and ability of sustainable transformation, entrepreneurship and spirit toward the innovative solutions, the smart governance, transparency in the system of governance, individuals roles to be significant in public life and decisions, the quality public services and good quantity [11], smart living, health facilities, the cultural development, quality of basic needs (foods and shelter) and tourist attractiveness. The smart city concept is shown in Fig. 1 for the better understanding to the emergence of smart cities concept in various sectors [12]. Since systematic evidence is required to inform smart city stakeholders and researchers about state-of-the-art solutions. Also, for the smart living, the systematic review reported by the present article aimed to identify the most relevant applications with an impact in the provision of healthcare. Lot of efforts have been made already for the healthcare services in the support to the smart cities [13]. The concept of e-healthcare has

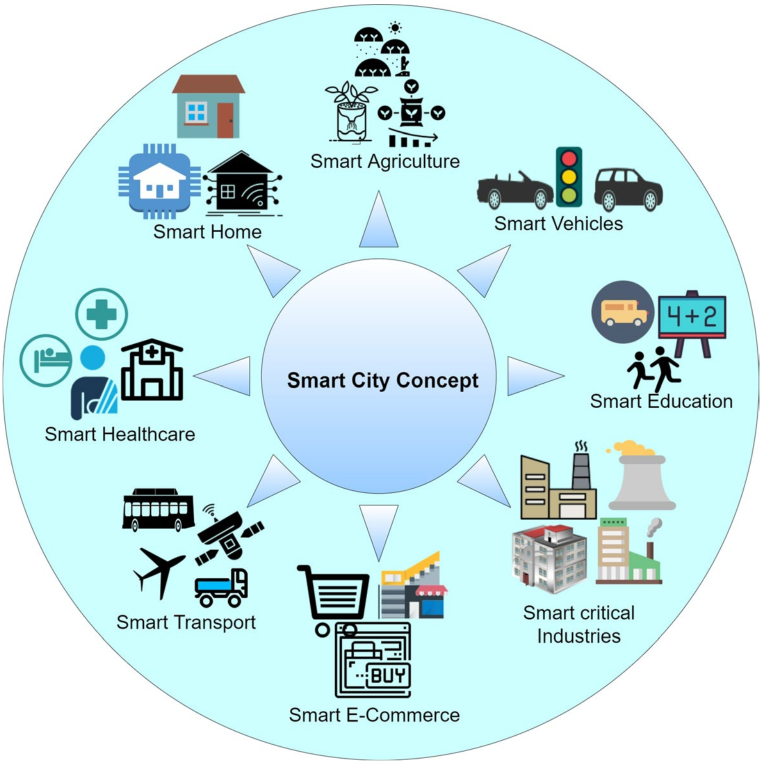


Fig. 1 Smart city concept

been exploited by the authors to provide the healthcare services over communication network. Also, the smart ambulance routing has been also proposed for strengthening the concept of smart healthcare services. The online patient monitoring, nurse scheduling, and blockchain-enabled security system for healthcare data have been also proposed to support the healthcare system in smart cities. The various data-driven machine learning and artificial intelligence (AI) approaches have been proposed to understand the need of healthcare and act of healthcare services for the critical patients [14]. Still lot of efforts and gaps are remaining to fulfill the support for the smart cities. Here, the authors have proposed the patient monitoring and ambulance tracking system for the quick diagnosis of health issues. In the next subsection, the contribution has been drawn to show the impact of proposed model for the smart healthcare services in the smart cities [15].

1.1 Contribution

The contribution of the proposed system model can be quantified into following points:

- Patient monitor and ambulance tracking system is an efficient system model used to carry out a quick two-dimensional (2D) diagnosis, the usage of heartbeat, temperature, breath charge sensors. The data from these sensors are used to record important patient parameters to start any treatment and transmit the data over wireless medium so that patient can get the healthcare slot earlier than the ambulance is deployed.
- The affected person additionally gets an immediate manner to request an ambulance on touch of a button without having to name up the health centre and additionally instantly send a SMS to an emergency touch giving each the health centre and contact necessary emergency details a lot earlier.
- The affected person can hold a tune of the ambulance's place, which gives them an idea of its arrival, and can also get instantaneous navigation closer to the nearest hospital for themselves if want be. The device may be stored with the patient and also installed in the ambulance.
- The tool enables the use of IoT sensors and android programs for better user interaction and efficient information transmission.

In the next subsection, the flow of the paper has been discussed for the better understanding.

1.2 Organization

The rest of the paper is organized as follows: In the second section, an exhaustive literature is discussed. A proposed system model is discussed to firm the base for the patient monitoring and ambulance tracking system in the third section. In the fourth section, the working of the component used in the design model is discussed.

A detailed implementation and results are dictated in the fifth section. A conclusion is drawn in the last section.

2 Literature review

In the literature, smart health can be categorized as a subset of e-health, given s-health is on the subject of the ICT infrastructure of the diagnosed smart city [12]. Nevertheless, there is a difference between s-health and m-health; for instance, in s-health there is a possibility that the diagnosed fundamental conversation won't be cell or not [16]. In reality, for almost all of cases it could encompass mounted fixed sensors as discussed below:

- *Case 1*Classical health is explained as general activity associated with health, which suggests a doctor that visits patients with the required traditional tools, which don't essentially ICT.
- *Case 2*E-Health involves utilization of databases and electronic health records (EHRs) that assist in saving or storing sufferer medical facts [17].
- *Case 3*M-Health is the case when affected person is in a position to check their prescriptions from their personal cellular gadgets for guaranteed adherence to the medications. This m-health explained as a subset of E-Health, given it uses medical gadgets for accessing medical-related figures.
- *Case 4*S-Health is used where the affected person gets information or facts from an interactive pole of statistics for checking the degree of dust, pollen, plus pollution that individual has allergy. The records further help sufferers in preventing the areas that would show to be dangerous for his or her health conditions. The pole of facts enables in providing the patient with statistics about the satisfactory course or course that they could fancy attain a resort area and about the closest pharmacies from where he can buy antihistamine pills [18].
- *Case 5*M-Health amplified with s-Health which can be explained with a cyclist who's sporting a band or bracelet that has in-built acceleration meters and accident is that the main monitoring capability of the device. The frame sensor network will help in detecting the autumn of the character and can send an notification to the town infrastructure. Once the system receives notification, the traffic instances are being evaluated, and an ambulance is dispatched using the pleasant selected course [17]. Additionally, it's miles possible to switch the town traffic lighting during a dynamic manner to scale back the time spent before the ambulance arrives at the scene [18, 19].

In case of a medical emergency, a manual call has to be made to the hospital for emergency care. This call constitutes the critical information like address or location, nature of medical problem and a valid contact that will be available until ambulance arrives. After being received by the ambulance, once the patient finally reaches hospital, the doctor allotted has to record parameters like breath rate, heartbeat, etc., to proceed with any further treatment.

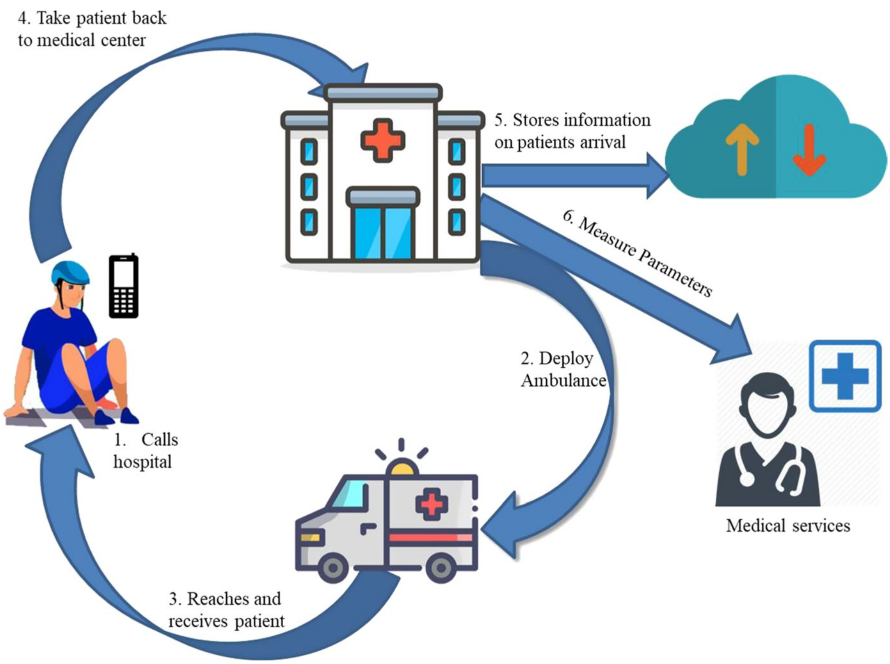


Fig. 2 Existing model

The existing system as shown in Fig. 2 has various drawbacks such as a lot of time wastage, lack of any kind of effective information transmission beforehand, lack of information transmission equipment in ambulance, unnecessary delays. Usually in case of an emergency, it's either the helpline number we rely on or the individual hospital services, and both of them consume a lot of time and also causing delays [20].

3 Problem statement and system model

The current method to call an ambulance and admit the patient is very time-consuming, and there is lack of transfer of any kind of vital information to the hospital beforehand. During emergency every second counts, lack of access to proper emergency care could be a difference between life and death. When seriously ill patients are transported by ambulance, the hospital is completely unaware of the vital patient parameters needed by the doctor before starting any further treatment, until the patient arrives [16].

The methodologies are sometimes useful for the prediction; logistic regression is a predictive regression model in which the dependent variables are categorical (For ex, event of success or failure). It used maximum likelihood estimation to formulate the probabilities in which logistic regression will take on a particular class, with an iterative algorithm [21]. The decentralized autonomous organization (DAO) endeavours for creating a wholly sustainable, tidy community development throughout the world and at the same time enhances the monetary situation of all folks connected officially with the company in some capability together with the households [22]. The technology of the linear SVM can be reused or retransformed using the prediction of any two given observations rather than the observations themselves [23] when the patients are unable to keep a track of requested ambulance. Each second of this time is affecting the patient in need of treatment as soon as possible [24].

The medical information, stored at the cloud infrastructure, which is vulnerable to the security issues, can be stored in two or more servers, so that the probability attacker can attack all the servers that are less, and that hosts this information which is encrypted with bastion algorithm [25]. The patients can also have suggestive methods with the user credibility depending on a number of factors based on the purchase and review history of the user in question. All the ratings actually provided are normalized using these factors, which is then used by the recommendation algorithm [26].

3.1 Motivation

The system is designed and developed with an aim to monitor patients in homes, hospitals, or old age homes remotely while transmitting that information timely and over wireless medium to the medical centre in case of a medical emergency. There is a need to save time in case medical emergencies and the hospital should receive patient information before the patient arrives in order to proceed straight with treatment. There are various needs the user deserves to get such as patients with critical symptoms. For example, in old age shelter homes need to be monitored effectively, the user should be able to notify emergency contact instantly, the user should be able to deploy ambulance request instantly and also get to track the arrival of the deployed ambulance, the user should get instant navigation details to the nearest medical centre. The existing system has various drawbacks such as a lot of time wastage, lack of any kind of effective information transmission beforehand, lack of information transmission equipment in ambulance, unnecessary delays, etc. Therefore, a better system should be proposed in order to overcome these issues when a medical emergency arises.

3.2 Proposed system

In this paper, a new cost-effective communication system has been proposed to improve the speed of diagnosis and save time by transmitting medical data from the ambulance or the patient in need to the emergency medical centre efficiently as shown in Fig. 3. The IoT devices are useful to monitor patient parameters remotely [27]. The patient details can transmit over wireless medium to the hospital or medical centre even before the ambulance is deployed with an improvement in the existing system. The patient can also keep a track of ambulance and allow user to notify an emergency contact with location details and parameters via SMS [28]. An instant navigation service is also provided to the nearest hospital or medical centre and

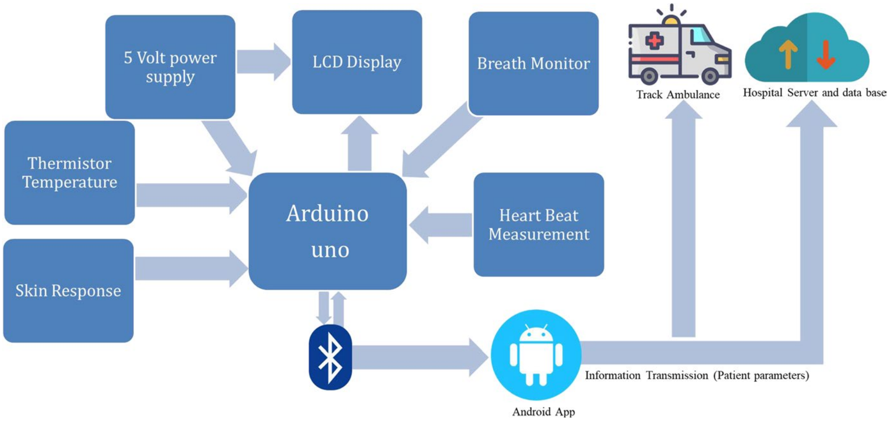


Fig. 3 Workflow of proposed system

geodecode latitude and longitude details into proper readable address [29]. The proposed system is an efficient system with smart intelligent environment that enables to carry out a quick thirty-second diagnosis using heartbeat, temperature, breath rate, and skin-type sensors to record vital patient parameters required initially by the doctors to start any treatment and transmit these parameters to the hospital even before the ambulance is deployed. The patient also gets an instant way to request an ambulance on touch of a button without having to call up the hospital and also instantly send a SMS to an emergency contact giving both the hospital and contact necessary emergency details a lot earlier. The patient can keep a track of the

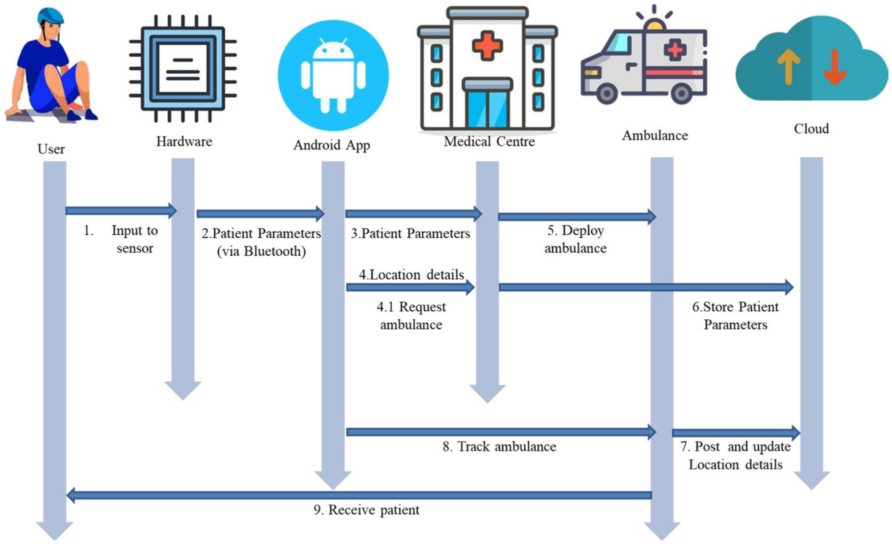


Fig. 4 Sequence diagram

ambulance's location, which gives them an idea of its arrival and can also get instant navigation and details towards the nearest hospital for themselves if need to be as shown in Fig. 4. The device can be kept with the patient and also installed inside the ambulance [27]. The device enables the use of IoT sensors and android applications for better user interaction and efficient information transmission.

3.3 System plan

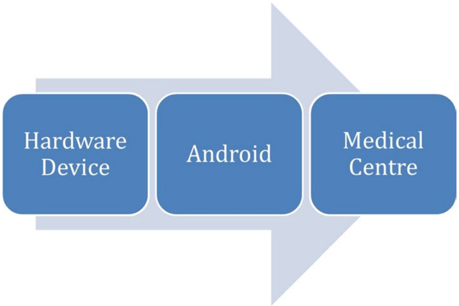
3.3.1 Task specification

- *Task 1* For temperature measurement, a thermistor base circuit has been used. In skin response module, body resistance can be checked by two metallic probes. In pulse monitors system, a pulse oximetry system has been used, and in breath monitor system one turbine and dynamo base module is used. The output of all these sensors has been displayed on the liquid crystal diode (LCD) display.
- *Task 2* In order to transmit recorded parameters from the hardware to android, a medium is required and therefore a HC05 Bluetooth module has been used to pair android device with the hardware and facilitate exchange of any information.
- *Task 3* The smart system has been created for the medical centre to receive the vital patient parameters along with the patient's location details. This helps the hospital to maintain an organized record of patients along with their details and also to deploy an ambulance to a specific patient location. This system has been created a receiving end(front end) on Visual Studio.
- *Task 4* To create android applications for interactive user interface and to provide various services in case of an emergency, a quick thirty-second diagnosis test has been formulated. In this test, patient body parameters are measured using hardware-wearable sensors. After these parameters are sent to the medical centre along with the patient location details to get an access with emergency facilities like requesting an ambulance, notify an emergency contact with parameters and location details, allow the user to track the arrival of ambulance and to provide instant navigation details towards the nearest medical centre.

Patient parameters measured using wearable sensors are used to transfer the data to android device via Bluetooth. Once data have been received to the android, these parameters are transmitted to the medical centre along with the patient's current location details.

In the proposed system, patient parameters like pulse rate, temperature measurement, breath measurement and skin response have been displayed all the parameters of patient on an LCD display as shown in Figs. 5, 6 and 7 as Data Flow Diagram 0 and Data Flow Diagram 1(DFD 0 and DFD 1). The proposed system has been categorized into three applications to facilitate efficient information flow such as health monitor, ambulance tracker and ambulance uploader. The Health Monitor application transmits patient parameters along with the patient's location details to

Fig. 5 DFD Level=0



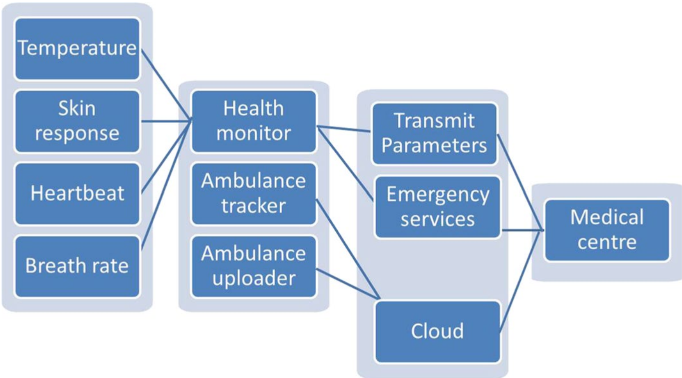


Fig. 6 DFD Level=1

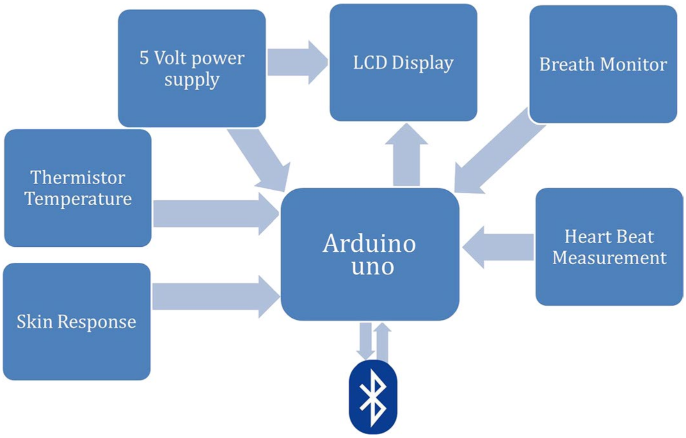


Fig. 7 Hardware architecture

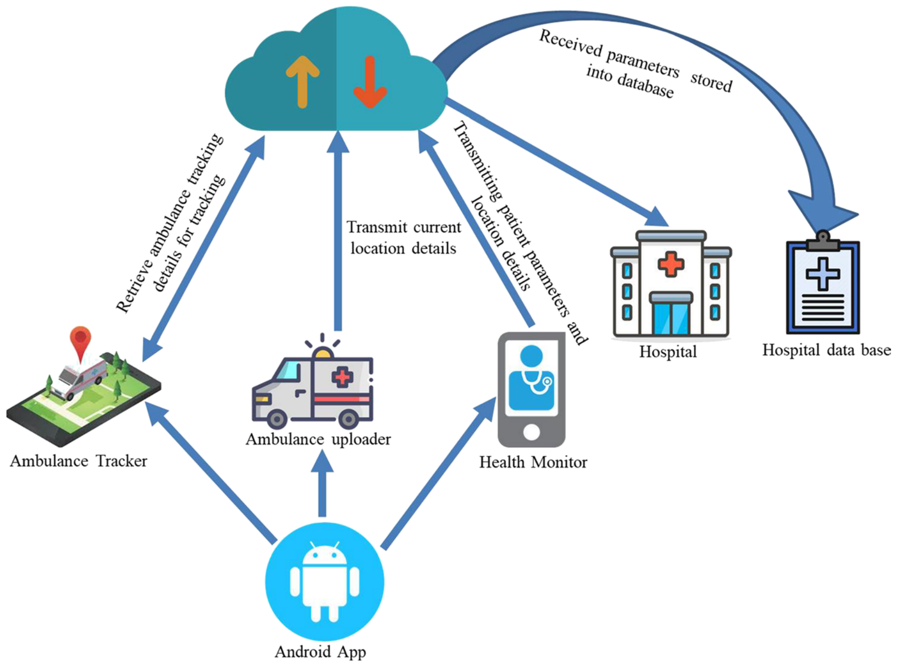
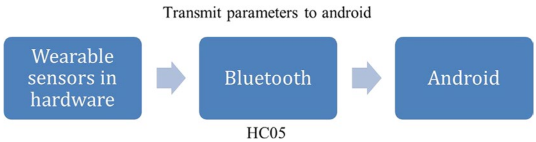


Fig. 8 Software architecture

Fig. 9 Bluetooth for data transmission



the medical centre. It also provides facilities like requesting an ambulance, notifying an emergency contact and also providing instant navigation details to the nearest medical centre. The ambulance uploader keeps posting its updated location to the cloud and is used by the ambulance to share location details. The ambulance tracker is used by the user to track the arrival of the deployed ambulance as shown in Figs. 8, 9 and 10.

4 System design

4.1 Power supply

The Arduino Uno can be powered via the USB connection or with an external power supply. The battery terminal can be inserted in the ground (GND) and input voltage (VIN) pin headers of the power connector. The power pins are as follows:

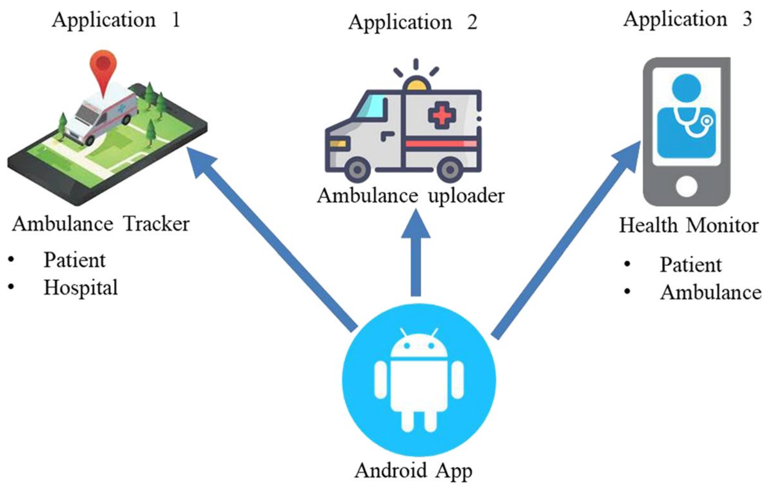


Fig. 10 Android applications

VIN: The input voltage to the Arduino board when it's using an external power source 5V. The regulated power supply is used to power the microcontroller and other components on the board. This can come either from VIN via an on-board regulator or supplied by USB or another regulated 5V supply.

3V3: A 3.3 volt supply is generated by the on-board regulator where maximum current draw is 50 mA.

GND: Ground pins.

4.2 Skin response

In skin response module, the body resistance has been checked using two metallic probes, which vary according to the blood pressure. The output of the probes is connected to the analogue input of Arduino same as a thermistor to monitor the variations. The change of body resistance has been converted into voltage change, which is measured by Arduino module and then displayed on the LCD. Here, the model has been used 2-line and 16-character display module. In every LCD display, there is a small factory-fitted microcontroller. The LCD module has been connected Arduino directly in parallel, which means data will transfer from Arduino to LCD by number of wires. In every LCD, there are 8 data lines for input.

4.3 Pulse monitor system

In pulse monitor system, a pulse oximetry system has been used where one probe is connected with patient finger to monitor the pulse by flow of blood. In this probe, there is one sharp LED and photo-diode circuit. With the help of this senor and one very sensitive amplifier, the sensor signal has been converted into small pulse, which is similar as the heartbeat pulse. In the Arduino section, these pulses have been counted in particular time period and displayed on LCD. Here, a LM324 operational amplifier (OpAmp) circuit has been used with infrared photo-diode circuit.

4.4 Breath monitoring system

In breath monitor system, a turbine and dynamo-based module has been used where a blow pipe is used with patient. When air enters in the pipe, the turbine rotates and moves the dynamo, which converts mechanical movement into electrical voltage. This voltage is connected to the Arduino module for measurement after amplification. Also, this blow pipe can be connected to the mouth or nose of the patient. The output of this sensor is then displayed on the LCD along with other parameters.

4.5 Temperature monitor

Temperature measurement has been measured via thermistor base circuit where thermistors changes its resistance according to the body temperature. The output of the thermistor is connected to the Arduino module analogue pin. In every Arduino, there is analogue-to-digital converter circuit to convert analogue signal to digital. Simple circuit before Arduino converts thermistor resistance into small voltage. This change of voltage is connected to the analogue pin of Arduino. The whole details have been measured and monitored the change of voltage and display on the LCD. In the programming part, voltage level has been converted to LCD values and compare these values with the preset values for alarm output.

4.6 Interfacing Bluetooth for data transmission

Initially, the only requirement of the module had been raised to handle the wireless portion of the protocol by converting the raw Bluetooth data to a 2.4-GHz wave, which allow to deal with digital bits. In order for the hardware to transmit the measured patient parameters using wearable sensors, it requires a wired or wireless medium. Here, a wireless Bluetooth medium has been used to transmit recorded parameters from the hardware device to android and transferred data serially to the mobile application. To accomplish this, HC05 Bluetooth module is used. The first stage will be to make an activity and to select the paired Bluetooth device and then create another activity to transmit information from Arduino to Android. HC05 works on 2.4 GHz frequency and transfers the data serially to nearby Bluetooth device after pairing. Once android device is paired with the hardware, it simply connects and starts diagnosis.

4.7 Android applications

The proposed model in this paper was to create an android applications in order to receive data from the hardware device via Bluetooth and then further transmit that data to the medical centre along with patient details to provide emergency services like requesting an ambulance, notifying emergency contact, getting instant navigation details to the nearest medical centre.

- *Monitor Patients* The android application helps the user to undergo a quick measurement of parameters using proposed modelled wearable devices. Patient's latitude and longitude details have been recorded along with the diagnosis details. These details then communicated with server using https:// Uniform Resource Locator (URL). The parameters that have been transmitted through android are in JavaScript Object Notation (JSON) format and must undergo to JSON parsing first to get the access for them. The application allows the patient to request an ambulance with just a click of a button, which notifies an emergency contact via SMS containing medical parameters along with patient details. It also provides instant navigation to nearest hospital or medical centre.
- *Ambulance Uploader* This application is used to upload the ambulance current location parameters at a frequent time intervals with patient and medical centre for the tracking purpose and whereabouts. The ambulance starts updating its location using a cloud on a frequent time interval for the user to track and stops updating once the patient has arrived in the ambulance.
- *Ambulance Tracker* This application retrieves the uploaded ambulance location parameters from the cloud in order to help the patient and the medical centre to track the deployed ambulance's arrival.
- *Https:// URL Connection* There is a need to transmit data using the android app to the web server/internet to communication the information; therefore, https:// URL Connection has been used. A new connection has been formulated to transmit the parameters with the stream, and then, the transmitted data need to be read from the stream. Since the parameters transmitted are in JSON format, they need to be parsed using JSON parser in order to get accessed. Once the parameters are successfully accessed, the stream is closed followed by the connection to be closed.
- *JSON Parsing* JSON is an independent data exchange format, which is the best alternative for Extensible Markup Language (XML). The patient parameters to be transmitted using https:// URL connection are in JSON format and can be accessed using JSON parsing.
- *Ambulance Tracking* Android allows us to integrate Google maps in designed application. Anyone can customize the map and route according to the demand. The tracking of the deployed ambulance is done using android Applications (APIs). Location client object (LCO) has been used to create the current location and connect it via command methods like location services using connect() method as well as call its get last location() method. These methods return the most recent location in the form of location objects with latitude and longitude coordinates. To have location-based functionality in your activity, you will have to implement two interfaces:

  GooglePlayServicesClient.ConnectionCallbacks

  GooglePlayServicesClient.OnConnectionFailedListener
- *Medical centre* A website with a front end for the medical centre has been designed to receive the important patient parameters and location details to

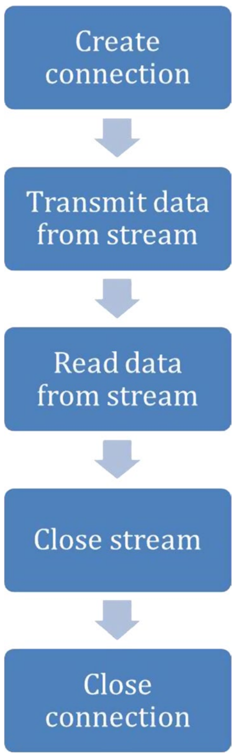
deploy an ambulance as per user request. The received patient parameters are stored in a database for the medical centre to maintain a record. To design a front end and web pages, Visual Studio software has been used. Here, overall four web pages have been designed to maintain user variables as shown in Figs. 11, 12 and 13.

4.8 Connectivity design hardware and software

For temperature measurement, thermistor-based circuit has been used. In skin response module, the body resistance has been checked using two metallic probes, whereas in pulse monitor system, pulse oximetry system has been used. In breath monitor system, one turbine- and dynamo-based module has been used. The output of all these modules with parameters has been displayed on LCD.

- *Bluetooth* In order to transmit recorded parameters from the hardware to android, HC05 Bluetooth module has been used in android device to pair with the hardware and facilitate exchange of any information.

Fig. 11 HTTP URL connection



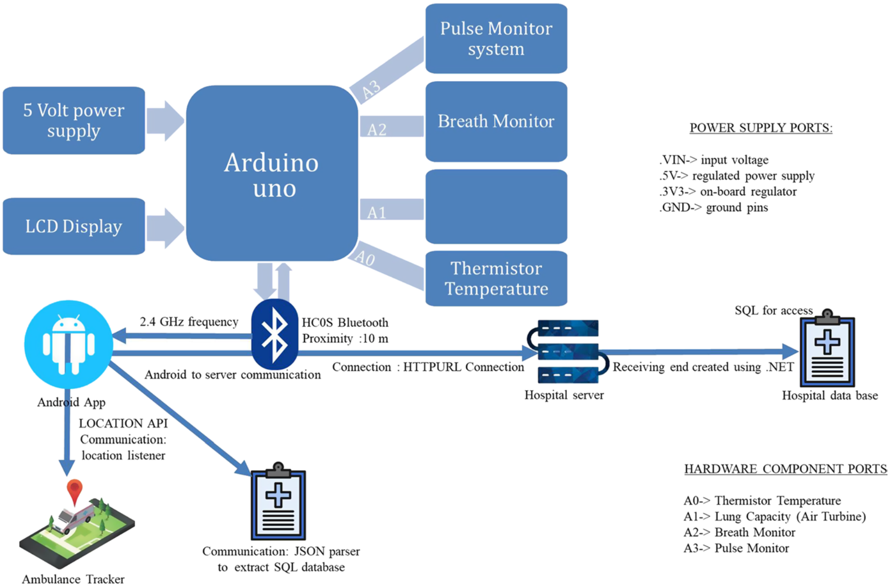


Fig. 12 User–server communication

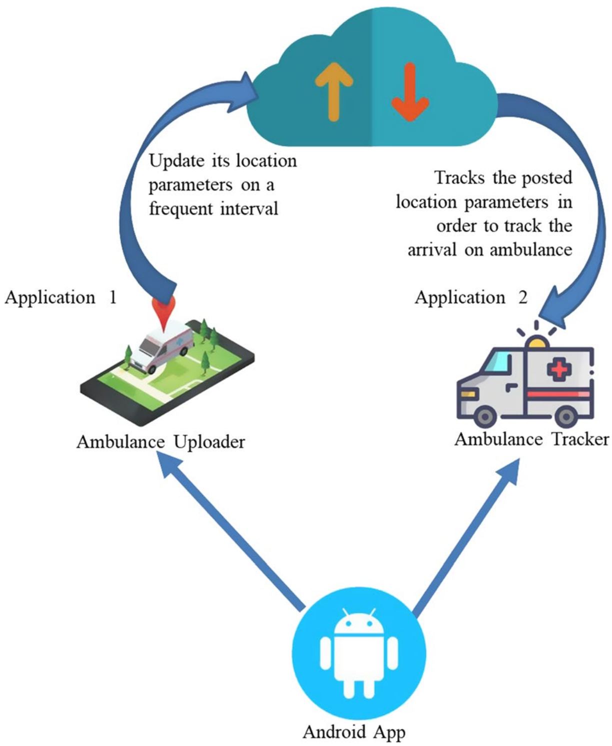


Fig. 13 Ambulance tracking

- *Software* To create android applications for interactive user interface, various emergency services and application have been designed for our system architecture to function efficiently. The android application gives the access to the patient to undergo a quick thirty-second diagnosis where patient's body parameters are measured using proposed modelled hardware-wearable sensors. All these parameters are sent to the medical centre along with the patient location details, which are used to provide the patient with emergency facilities like requesting an ambulance, notifying an emergency contact with parameters and location details, allowing the user to track the arrival of ambulance and providing instant navigation details towards the nearest medical centre. Also, there is a need to create a website for the medical centre to receive the vital patient parameters along with the patient's location details. This helps the hospital to maintain an organized record of patients along with their details and also to deploy an ambulance to a

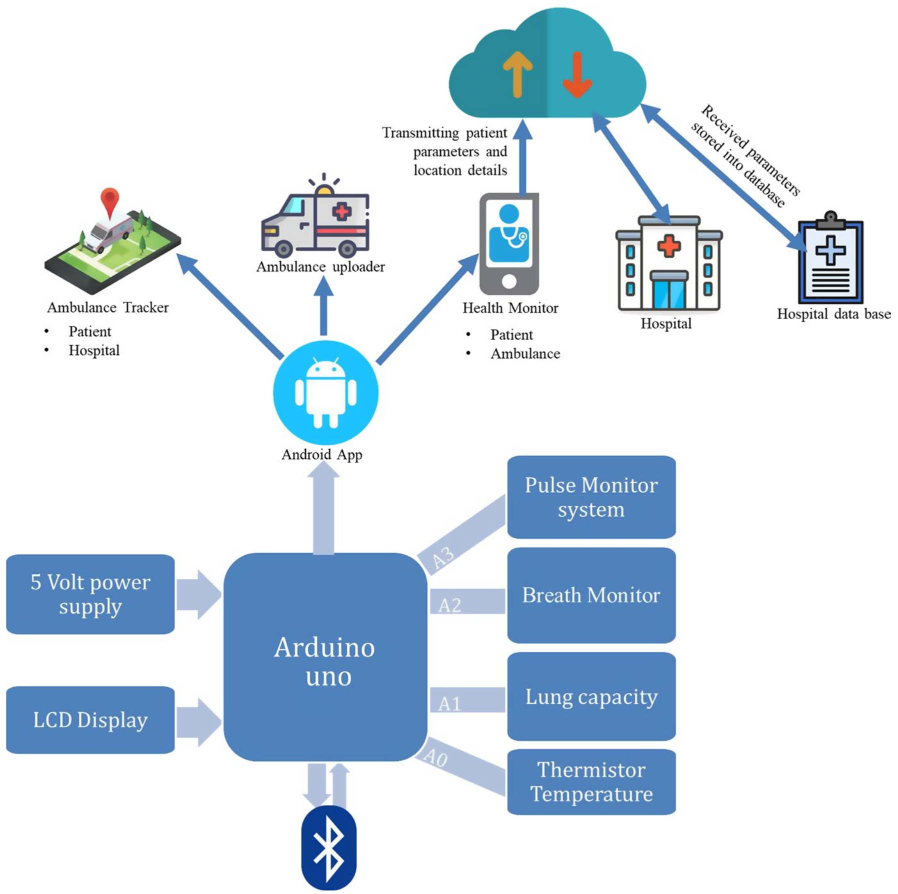


Fig. 14 Connectivity design

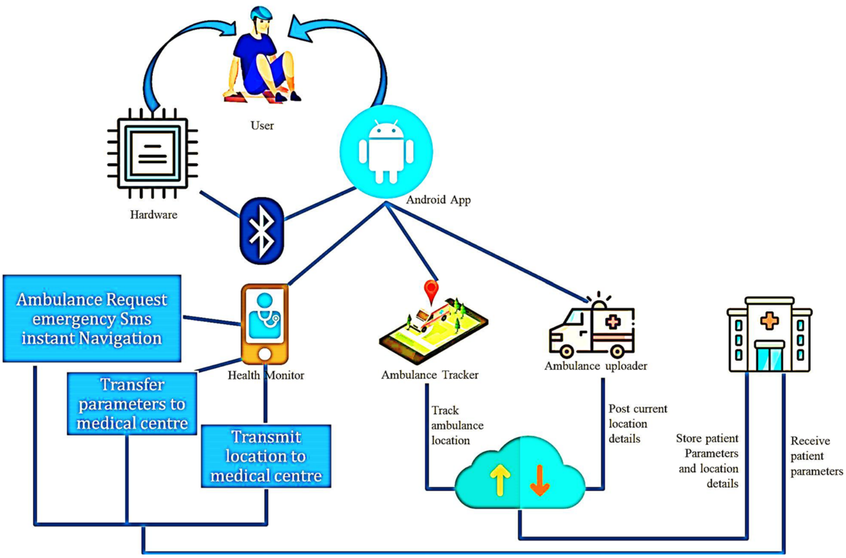


Fig. 15 Entity relationship diagram

specific patient location. This receiving end(front end) has been created on Visual Studio as shown in Figs. 14 and 15.

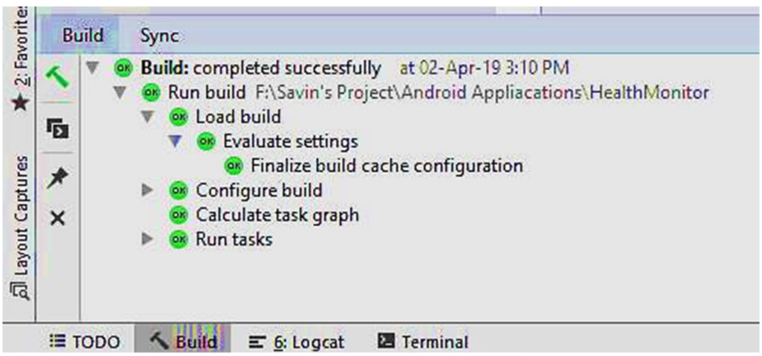


Fig. 16 Compilation of health monitor application

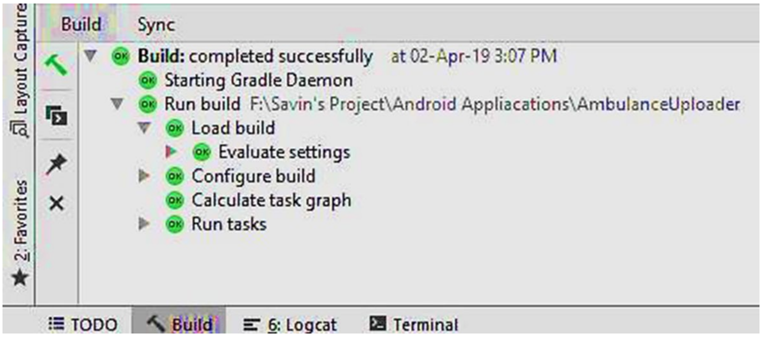


Fig. 17 Compilation of ambulance uploader application

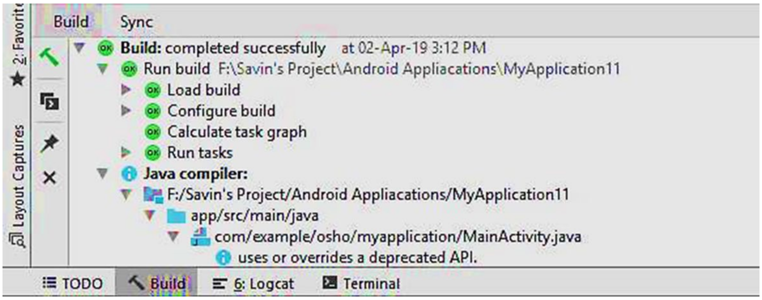


Fig. 18 Compilation of ambulance tracker application

5 System implementation, testing and result discussion

To design an application for the proposed application model, Arduino IDE connect, Arduino board, Arduino Uno, Arduino Mega, Duemilanove and Arduino Nano have been used as shown in Figs. 16, 17 and 18. All these modules automatically draw power from either the universal serial bus (USB) connection to the computer or an external power supply. Also, the drivers for the Arduino Uno or Arduino Mega 2560 with Windows 7, Vista, or XP need to be installed. In the very first step for the system implementation, plugin and wait for Windows to begin its driver installation process. After a few moments, the process will fail, despite its best efforts. Then, click on the start menu and open up the control panel to navigate to system and security. In the next step, click on system and once the system window is up, open the device manager. In the next step, look under ports (COM & Line Print Terminal (LPT)) an open port named "Arduino UNO (COMxx)" has been shown. If there is no COM & LPT section, then look under "Other Devices" for "Unknown Device". After this, right click on the "Arduino UNO (COMxx)" port and choose the "Update Driver Software" option. Next, choose the "Browse My Computer for Driver Software" option and finally navigate to and select the driver file named "arduino.inf", located in the "Drivers" folder of the Arduino software download (not the "Future Technology Devices International (FTDI) USB Drivers" sub-directory). If there is an old version of the Integrated Development Environment (IDE) (1.0.3 or older), choose the Uno driver file named "Arduino UNO.inf". Windows will finish up the driver installation from there to launch the Arduino application and then open the code saved from its location and run it.

Download the latest version of android studio along with required jdk bundles. Set path variables for android studio and start installation. Upon installation, run a basic code to check for any updates. If any update notifications pop up, allow the update. This is necessary to run the bundles in the heavier applications without any faults. Once updates are successfully installed, open the coded apk files for the applications. Three new windows would be required for this. One window per application. Once the apk files have opened and Gradle has been synced successfully to move into the next step. Now, it has requested to build/compile each coded application in order to see whether errors still persist in the code. Without errors, the build for health monitor application should look like this.

Once all the three applications have built successfully, export the built project application files to the android device of requested choice. Open android device and Bluetooth settings to run the application. Once Bluetooth devices are visible, turn on and connect and pair android to the Bluetooth module in the proposed modelled hardware device as shown in Figs. 19 and 20.

Once Bluetooth connection is established between android and hardware, the application can be started as shown in Figs. 21 and 22. Open health monitor application, log in and start diagnosis, request ambulance, notify emergency contact, get instant navigation to the nearest medical centre. Open ambulance up-loader application and start uploading the location details on the cloud. Open

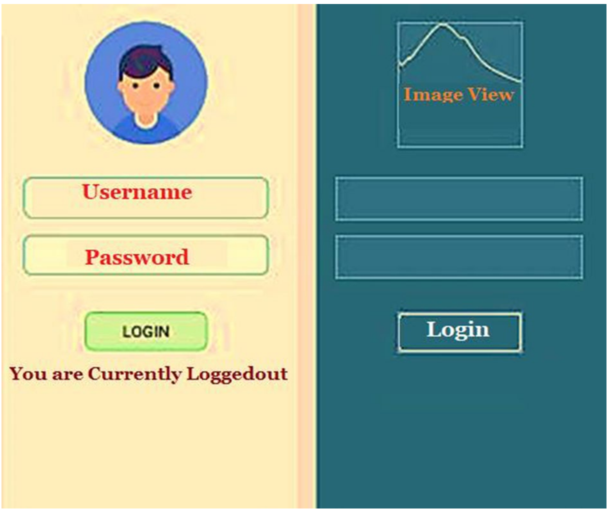


Fig. 19 Login screen

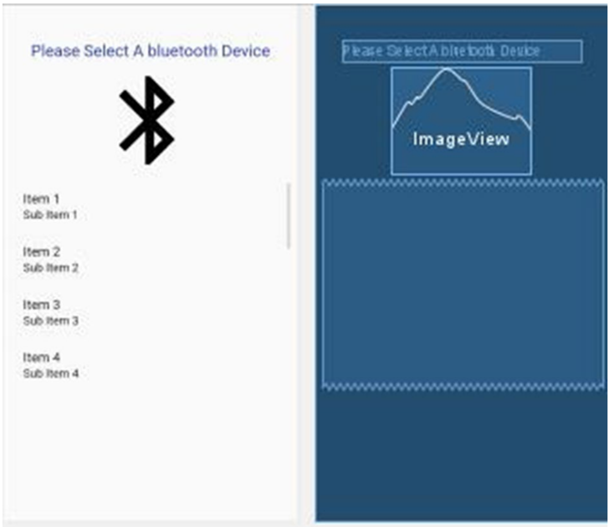


Fig. 20 Bluetooth pairing screen

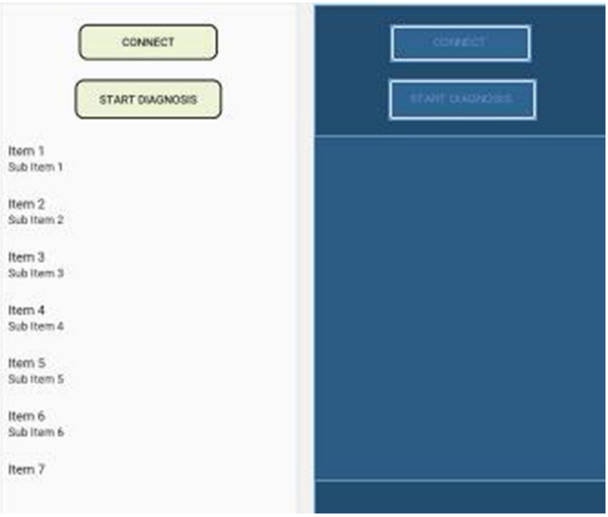


Fig. 21 Diagnosis screen

ambulance tracker application and start retrieving the location details posted by ambulance up-loader as shown in Figs. 23 and 24.

Once the system is implemented, it is the time for it to undergo the testing phase. Testing is the process of evaluating a system or its component(s) with the intent to find whether it satisfies the specified requirements or not as shown in Tables 1 and 2. Testing is done to identify faults/mistakes/errors/bugs, etc. In

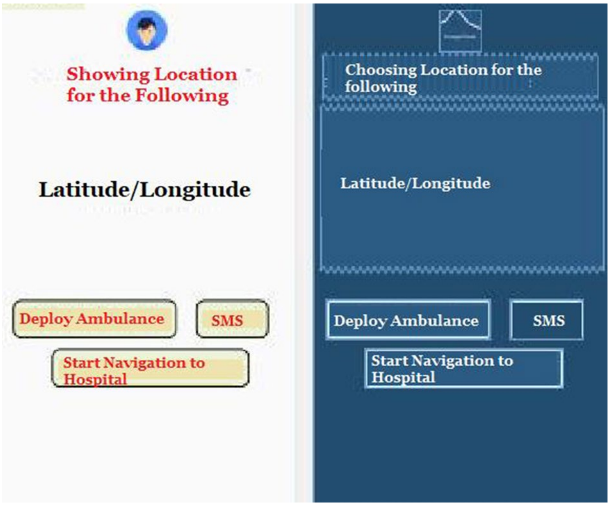


Fig. 22 Emergency service screen

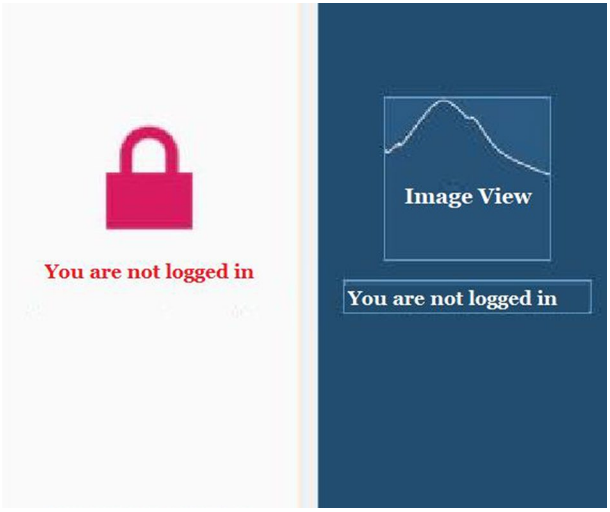


Fig. 23 Unlogged screen

the proposed system, there are various combinations of components communicating with each other using both hardware and software. Therefore, various test cases have been produced to ensure proper integration testing.

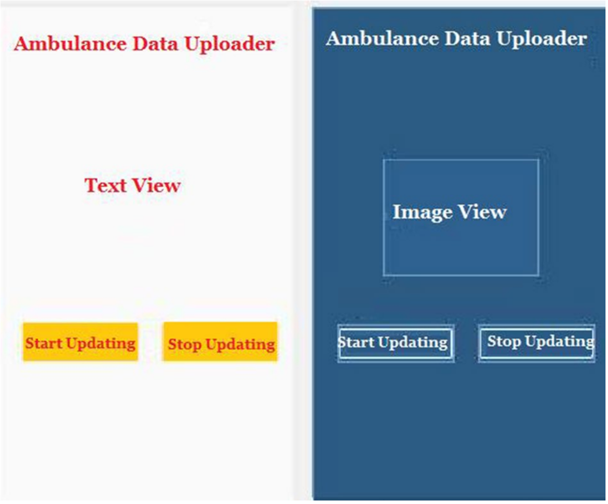


Fig. 24 Ambulance updated main screen

Table 1 Software test cases

Input	Expected output	Actual output	Pass/Fail
Username: True Password: False	Does not record log	Does not record log	Pass
Username: False Password: True	Does not record log	Does not record log	Pass
Username: abcde Password: True	Does not record log	Does not record log	Pass
Session in progress	Stay logged in	Stay logged in	Pass
Defined username and password	Log in successfully	Log in successfully	Pass

Table 2 Hardware component test cases

Input	Expected output	Actual output	Pass/Fail
Pulse monitor sensor	Calibrate(LED blink) and Print on LCD	Calibrate(LED blink) and Print on LCD	Pass
Skin response sensor	Calibrate(LED blink) and Print on LCD	Calibrate(LED blink) and Print on LCD	Pass
Temperature monitor	Calibrate(LED blink) and Print on LCD	Calibrate(LED blink) and Print on LCD	Pass
Breath rate sensor	Calibrate(LED blink) and Print on LCD	Calibrate(LED blink) and Print on LCD	Pass
LCD Display	Print sensor measured values	Calibrate(LED blink) and Print on LCD	Pass

6 Conclusion

Due to advent growth in technology, the healthcare is a hot area to implement the technology to proper care. Therefore, in this paper patient health parameters remote monitoring using android and IoT devises have been discussed and implemented. The proposed application can deliver vital patient parameters to the hospital even before the patient arrives or before ambulance is deployed. The proposed system saves all the time wasted in the existing system as well as the proposed system can be with the patient to monitor at any time. The proposed system application is also installed in the ambulance to transmit emergency information on time to the medical centre, which allows the patient to keep a track of ambulance. The proposed system model and designed application allow the patient to send an emergency message to an emergency contact, which consist of medical and location details. This system also provides navigation to the nearest hospital to the user on just a click of a button. In future, this application can be further extended with security mechanism to secure the health data.

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Authors and Affiliations

M. Poongodi[1] · Ashutosh Sharma[2] · Mounir Hamdi[1] · Ma Maode[3] · Naveen Chilamkurti[4]

M. Poongodi
dr.m.poongodi@gmail.com

Mounir Hamdi
mhamdi@hbku.edu.qa

Ma Maode
emdma@ntu.edu.sg

Naveen Chilamkurti
n.chilamkurti@latrobe.edu.au

1 College of science and Engineering, Hamad Bin Khalifa University, Doha, Qatar

2 Institute of Computer Technology and Information Security, Southern Federal University, Rostov-on-Don, Russia

3 School of Electrical and Electronics Engineering, Nanyang Technological University, Singapore, Singapore

4 Computer Science and Computer Engineering, La Trobe University, Melbourne, Australia