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Review Article

A Review of Wireless Systems for Monitoring and Diagnosing Patients in Emergency Telemedicine

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Abstract *- Recently, healthcare systems based on wireless technology have been concentrated. The basic conceptions related to the use of nanotechnology applications have been discussed. This study presented a system that combines ongoing collection in addition to an assessment of multiple vital signs, ongoing healthcare, as well as the cases of emergency and a cellular connection to a medical facility; a mobile-care unit had been presented, which introduces a healthcare-based on the wireless system which combining sensor, processor, and communication units in one chip that attached to the body of the patient. The proposed system was explained so that patients' mobility would be increased and that daily life would not be obstructed while being monitored. Additionally, the basic components of the system were also illustrated. This study also provided details about the hardware of the mobile-care unit and the different software designs.*

Keywords *- WLAN, Healthcare, Patients, Monitoring mobility.*

1. Introduction

In the past 10 years, remote medical systems have drawn more and more attention, which is why smart objects with physiological signal tracking for intentional care are a developing field. As a result, this study uses a system that incorporates ongoing collection and assessment of several vital signs, ongoing healthcare, and, in an emergency, a cellular link to a medical facility. In a typical situation, all collected raw data is transferred through the internet. The suggested system may constantly collect four distinct physiological signals, such as blood pressure, temperature, SpO2, and ECG, and send those signals to an efficient information processing system to detect aberrant pulses and investigate suspected chronic illnesses. Additionally, the suggested system enables medical practitioners to monitor real-time electrical impulses for remote treatment using an intuitive web-based interface. All physiological signals are instantly transmitted through cellular and online to a remote medical server as soon as an unforeseen occurrence happens or the need for a genuine vital sign show is confirmed. Moreover, data may be transferred through GPRS to a doctor's or family member's phone. A working prototype has already been put to use for this system. It will make access to high-quality healthcare much more affordable for society.

Recent advancements in recent developments in nanotechnology applications, WiFi and networking protocols, and ubiquitous computational capabilities, have made it conceivable to create a healthcare system in the previous ten years. The practice of using telecommunications technology for clinical conditions, therapy, and patient care is known as telemedicine [1]. Telemedicine aims to use contemporary wireless communications and information technology to deliver expert-based care to understaffed distant areas. Saving money is one of the advantages of telemedicine since it is less inexpensive to transmit information than humans. The aged population has been growing more quickly due to medical advancements in many nations, which has increased the need for primary care monitoring to guarantee that older people can live independent lives with the help of the Internet of Things [2]. Numerous physiological signals may be recorded from people while they go about their regular lives in their homes and may be used to detect early health status abnormalities or automatically summon paramedics in emergencies [3]. All research that has been done and is still being used in this field, namely for wireless connectivity of physiological indicators, may be divided into numerous categories. Sensors, data transmission methods, monitoring equipment, and digitization algorithms [4]. Therefore, these elements , as well as current findings, will be included in this section. Figure 1 illustrates the key elements of a modern telemedicine system, including signal-based data transport networks, processing components, sensors, and a medical care centre. Biological signal sensors are required to gather and transmit the physiological data (critical clinical signs) to the signal main processor using multiple sensors in one system with cost-effective, retain free movement, and use minimal operational power to minimise battery size and increase battery life [5, 6, and 7]. Through the use of a body network or personal area network, which may even be included in a user's clothing, a group of medical alert sensors may be able to interact with one another [9]. The processing device for each remote monitoring system's sensor layer is normally linked to the next stage at this point.

Signal gathering, analysis, and data formatting for transmission to the network layers. The baseband processor may assess the patient's condition and trends in those conditions. A PC, a smartphone, or an embedded system with a microprocessor, DSP processing, and FPGA are examples of processing units [10, 11, and 12]. In recent telemedicine investigations, several medical algorithms were created to aid in diagnostic testing and cardiovascular disease early detection [13, 14, and 31]; because a person's pulse indicates their level of health, pulse evaluation has long been a topic of investigation in the field of physiology [15]. Numerous studies have suggested monitoring that can assess different bio-signals, identify QRS, classify arrhythmias, and measure heart rate variability, among other functions [13, 14].

Additionally, new developments in communication and network technology enable the creation of a wireless medicine system that provides patients an efficient way to access healthcare services. Genuine mode, in which client information is accessible at the website ends quickly upon capture, and retail mode, which entails obtaining the information in the future, are the two operational modes that may be used with telemedicine systems. The vital indicators are sent using both methods via networked computers and cell phone networks, cable TV networks, phone lines networks, or to the server [16, 17, 18, and 19].

To improve the doctor's mobility, a mobile phone line using the global system for mobile (GSM) connection was used to connect the server. [20]. Hung and Zhang designed a tele-monitoring system based on the wireless protocol specification (WAP) [21]. Doctors may read the real-time on WAP smartphones in store-and-forward mode, using WAP handsets as mobile communication terminals [22]. The patient's mobility increases far less under such techniques than the doctor's. The sensor unit in some earlier telemedicine platforms was made comprised of an ECG data collecting circuit, an A/D converter, and a storage unit, as shown in Figure1. The patient had extremely limited mobility thanks to this gadget, which had an inside wireless transmitter for transferring the data obtained to an internet PC [18, 21]. A PC was attached to a Mobile phone to send real-time ECG data from a moving paramedic [23, 31]. Using the Global app for smart communication, Rasid & Wood presented a mobile remote monitoring system that transmits the information gathered to a BT mobile phone before sending it to the server (general packet radio communications) , employing a Bluetooth-enabled processing unit to connect to a network. An alternative method was used by Ingénieur et al., who sent the real-time EEG data that was being analyzed using a mobile phone. These patterns improve the patient's range of motion [24, 25].

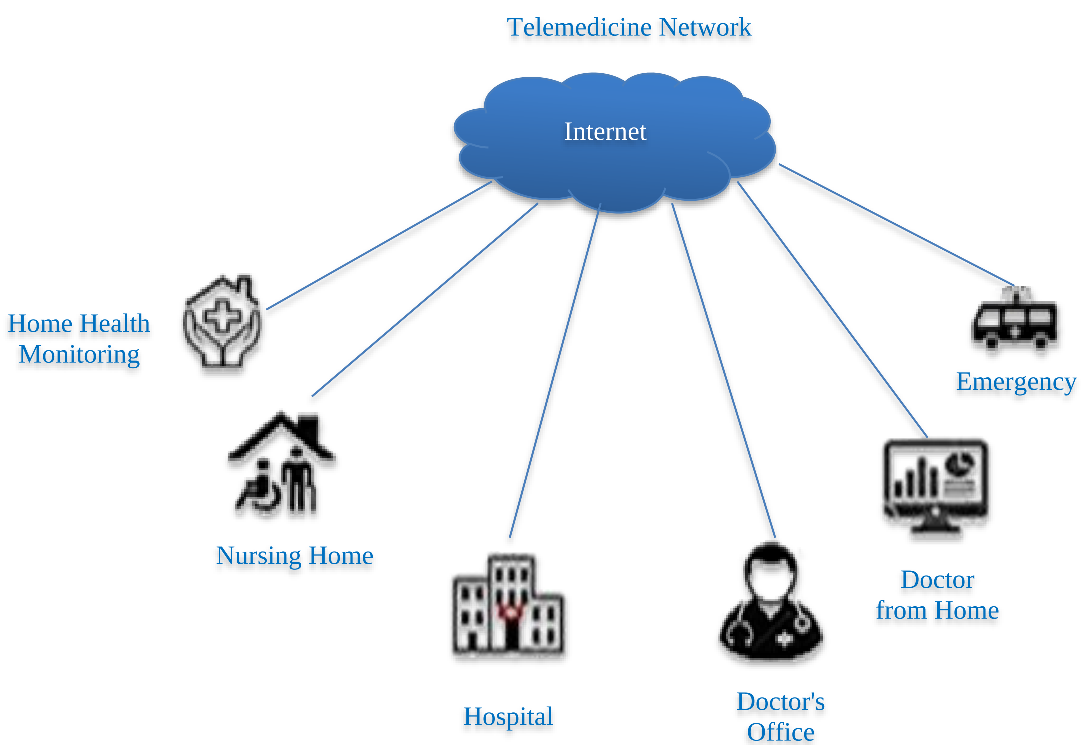

Fig. 1 Main components of the telemedicine system

The ECG analysis can be carried out elsewhere, for instance, at the backend, not where the ECG is received. There is actually a loss of productivity because routine ECGs are also transmitted through the GSM/GPRS network. This entails a substantial expense. Lin et al. remote patient monitors the system. WLAN and PDA technologies are used to send real-time patient vitals to a remote central control unit [26]. The technique relies on a tiny piece of transportable ECG recording hardware that wirelessly sends sensor readings to a mobile telephone [27]. If any anomalies are found in one of the measurement data's component parts, the data is analyzed on the smartphone and sent to a server. However, due to the processing unit limits of the mobile phone, the system productivity was seldom ever operated at an ideal state [28, 29]. A delay in data transmission might impact its interpretation and measurement. In line with the healthcare system's mentioned components, all systems built may be divided into a number of various subcategories. Aspects: signal processing techniques, monitoring/processing equipment, data communication technology, sensor type, and sensor connection type. Table 1 lists several telemedicine studies from recent decades, along with the topics each research focused on. This study presents a mobile-care unit, a wireless healthcare system that combines sensors, processors, and communication units into a single chip attached to the patient's body, as shown in Table 1. The patient's mobility will increase as a result, and active everyday life won't be hampered while being monitored. Only anomalous readings are broadcast to reduce the cost of utilising the GPRS network; consequently, the recommended system operates in real-time and store-and-forward modes.

Table 1. A mobile-care unit, a wireless healthcare system

The Citation Number	Sensors For Biosignal	GSM/GPRS Communication Technology	Communication Technology Internet	Medical Formula	Comments
3	SPO2, TEMP., RESP., HR	●			Create a working prototype of a wireless GSM and GPS-based telemedicine system.
6	Electrocardiogram, HR, SPO2, TEMP., and REPS		●		High-quality, flexible components for receiving signals are built and put together into a belt.
4	Weight, exercise level, and blood pressure	●	●		Android application for using and keeping track of Bluetooth-enabled sensors.
5	Temp, BP, and HR	●	●		VLSI and FPGA are used in the design of devices to minimize power consumption.
9	ECG, BP, HR TEMP., PPG		●	●	Smart wearable vest with a small RF transmission range that derives BP and HR from an ECG.
29	BP, ECG, HR, and TEMP	●	●		Technology, a method for locating patients, a transmission mechanism that uses little energy, and video streaming.
14	ECG		●	●	The PDA and GPS implement the QRS detection technique and variation in heart rate extraction.
13	ECG		●	●	GPS, a real-time R wave detection technique, and a real-time ECG classification system.
22	ECG, HR, SPO2, TEMP., RESP.				Using the RS232 interface, vital signals are obtained from the monitor and sent over the internet.
15	Pulse signal		●	●	Analyzing data intelligently to detect irregular pulses and investigate probable chronic conditions.
23	ECG, BP, and TEMP HR.		●	●	Commercial monitors are used to collect bio-signals and to compress ECG signals using the Huffman algorithm, GSM, GPRS, POTS, or satellites.

The care unit logs patients' vital signs and transmits them to a server through the internet in store-and-forward mode. The care unit immediately sends any detected abnormal heartbeat to the server through the GPRS network when the doctor expresses worry about it. If required, the doctor from the server side might contact the patient through SMS. Compared to previous research, Recent developments in a combination of telemedicine (remote patient management) and wireless systems have resulted in integrated monitoring systems offering various capabilities, but 3 main limitations continue to persist in the existing solutions. Earlier mobile systems were limited in either their form factor or power despite having basic vital sign tracking [3, 4]. The system designed for a standalone wearable chip overcomes the mobility-power tradeoffs characteristic of prior designs, such as the chest-worn sensor arrays and smartphone-powered architectures [9, 11]. research gap, although previous works have addressed separate contributions (such as sensor fusion and cloud-based analysis), there is no integrated answer that solves the mobility, affordability, and reliability trilemma [9, 30, and 31].

For instance, Wired interfaces are used by systems such as [18], losing mobility. Utilizes WLAN/PDA combos but does not provide for emergency prioritization [26]. Commercial wearables (e.g., [4, 9]) ignore clinical-grade diagnostics focusing on fitness monitoring. This work contribution (presents) a wearable telemedicine system that addresses these gaps with A singular sensor-processor-communication chip for continuous, unobtrusive monitoring (Section 2). Adaptive data transmission: Routine vitals are done using an internet running at lower power; emergencies are done via prioritized GSM/GPRS (Section 3). Anomaly detection on the edge via optimized algorithms on a 32-bit MCU reduces cloud dependency (Section 4). Section 5 shows the validation of this system on real-world cardiac and SpO2 datasets, where it achieves 15% lower power consumption and 40% cost reduction than state-of-the-art solutions while maintaining diagnostic accuracy [3, 26].

2. System Design

The proposed system, which uses physiological sensors, sensor fusion, embedded devices, wireless communication, and internet technologies, is described in depth in this section. The suggested system's architecture is shown in Figure 2. A description of the network infrastructure is provided in Section 3, and the specifics of the system's functioning are described .

3. Architecture of a System

This study's objective is to develop and deploy a facility with intelligent data processing based on integrated physiological sensors, Wireless technology and the internet are utilized for patient diagnostics, vital sign monitoring, and at-home care. The suggested system's architecture is shown in Figure 2. It mostly consists of the following elements.

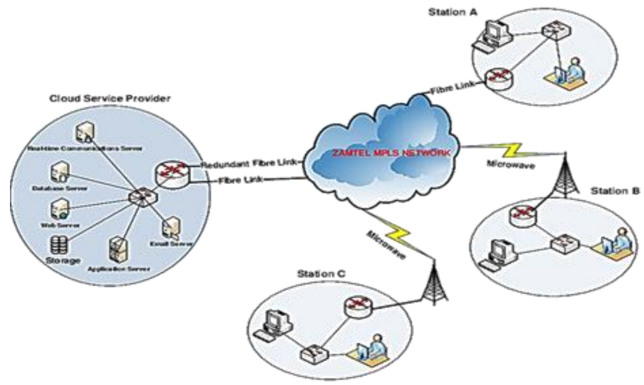

Fig. 2 The suggested system's architecture

1. Without disrupting the patient's everyday activities, a transportable treatment unit might be attached to the human chest to gather regular or actual vital sign data. The data is then transmitted to the cloud host via wireless connection using either the web in retail mode for normal cases or wireless connections in real-world systems for abnormal cases once a smart data analysis algorithm has been implemented to identify aberrant pulses. It is also possible to manually control real-time patient data transfer. The user can send the management unit his current vital indicators if he feels uneasy for guidance or a check-up. By doing this, the cost of utilising the nationwide system is reduced since only strange signals are sent. The mobile care unit's expanded cryptographically secure flash memory can be used to save the raw data for potential long-term storage and forward mode.
2. The remote server: It uses an application programmed to display the biological signal to the medical staff for diagnosis and records the obtained vitals in a database of human physiology. Additionally, it allows caretakers and doctors to access vital signs remotely through a web-based interface and monitor the data on their mobile devices. After reviewing the vital sign data, the doctor might give the user a response MMS message . In addition to medical advice, a set of control signals to the smartphone for resending the vital sign data for the abnormal case may be included in the message. Additionally, a distant server might notify a family member in an unusual circumstance and contact an ambulance to take the patient to the closest hospital.
3. Pervasive devices: These include mobile phones, laptops, and Personal Digital Assistants (PDAs). Family members and medical professionals may obtain a wealth of information about the patients at any time and anywhere by using these terminal devices and system components (2.2). The planned emergency telemedicine system's system components for patient tracking and diagnosis are described in depth in this section.

Mobile-Care Unit, the mobile-care unit in the developed framework, was made lightweight and transportable, making it simple to operate and requiring little effort from patients. Three modules make up the majority of the mobile care unit. These are primarily the data transmission module, the data control and control algorithm (MCU), and the acquisition module for vital sign signals. As a result, it may gather important bio-signals such as a three-lead ECG, heart rate, blood pressure, and SpO2, two essential indicators. Additionally, if the patient's health is serious, it may monitor the patient's status and medical condition trends and create an emergency alert. In order to determine the patient's position for emergency assistance, it should also offer a wireless connection and be interoperable with global positioning information systems. This demonstrates a mobile medical unit's block diagram, also a transportable care unit, and contains a local storage system for information that is used to save raw data and signal processing results.

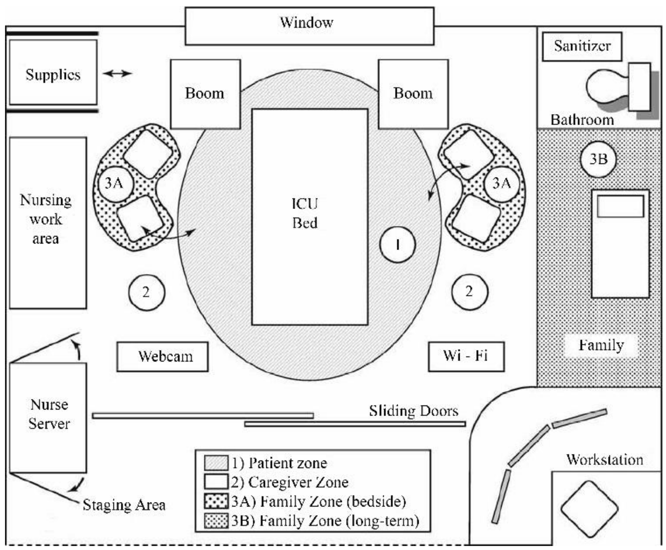

Fig. 3 Local storage system for information

1. The vital sign signal acquisition module. Sending vital signs to the processing node for ADC, analysis, and abnormality detection is the module responsible for gathering vital signs. The collection unit for vital sign signals has been selected as the e-health sensors shield V2.0. This module has the ability to continuously gather physiological signs such as the ECG, SpO2, skin temperature, and blood pressure, as shown in Figure 3. All vital sign measurements will be non-invasive. Non-invasive vital sign measurements clearly have an advantage over their intrusive counterparts due to their ease of use and lack of risks. ECG sensors, the brain signals of the heart, are tracked over time by an ECG, which is a vibrational signal. The electric shock between two body regions is measured by a special conditioning circuit to form the ECG. In the anticipated mobile-care unit, the electrolyte interface ECG signals are converted with a gain of 300 and filtering with cut-off rates of 0.5 Hz for the good success filter and 100 Hz for the low-pass filter. The typical maximum ECG signal is 1mV; however, crisp morphological reproduction and heart rate monitoring need a 300-fold signal amplification. A split amp with a gain of 20 avoids noise from dominating the ECG signals by combining an amplifier circuit (Analog AD8625) with a gain of 15 and an instruments amplifier (INA321EA) with a CMRR of 100 dB. The Signals are restricted in frequency between 0.5 and 100 Hz, utilizing second-order amplification after the early stages. High-pass and low-pass filters are made by Butterworth. A consumer 50 Hz notched filter removes the electrical interference from the ECG signal to prevent the loss of the 50 Hz portion of the data. The ECG signal is subsequently sent to the analogue input of the processing unit for digitization and analysis. Figure 4 displays a block diagram of the gear used to acquire ECG data. Temperature gauge: the average body temperature of a healthy person is about 37 ° Centigrade; in hot surroundings or during physical activity, this temperature may briefly or slightly rise; with extreme effort, it may even dramatically rise. For medical purposes, the capability to measure body temperature is essential. The reason for this is that certain diseases are characterized by changes in body temperature. A clinician can evaluate the efficacy of therapy after beginning it, much like how air temperature can be used to monitor the development of various conditions. Before sending the signal to the processing unit, the signal must be adjusted and amplified; Figure 5 (a) shows the industry Cmos technology temperature sensor chosen and connected to the circuit for signal conditioning(b). Measurement of heart rate and plasma oxygenation (SpO2): The SpO2 or pulse blood oxygenation, a test of oxygen levels in the plasma, is coupled to the heartbeat as blood is pushed from the brain to other parts of the body. There will be a

differential in the quantity of light absorbed where the heart pumps and relaxes in the human body. When hemoglobin is oxygenated, more infrared light wavelengths are absorbed , and less red light waves pass through. On the other hand, for hemoglobin that has reduced oxygenation, more infrared light may get through while more red lights are absorbed. Because of haemoglobin's unique interaction using red and infrared light waves, oxygen saturation may be measured without the need for invasive treatments. Oxygen saturation is a rapid and precise alternative to invasive methods for measuring oxygen saturation. A customized sensor, seen in Figure 6, was chosen and filled with infrared (940 nm) LEDs. The sensor being utilized also offers heart rate in addition to blood oxygen saturation. Through the acquisition module, the SpO2/HR sensor's output is sent to the processing unit. The suggested system's specifications for several physiological metrics are presented.

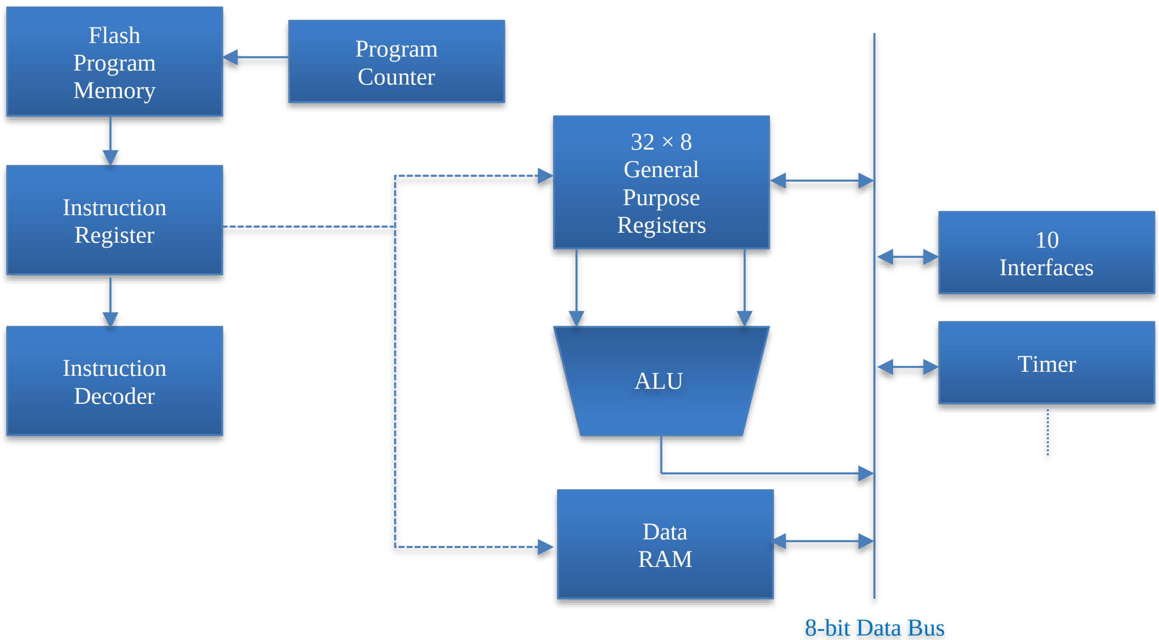

Fig. 4 Architecture of microcontroller

2. The module for data control and processing in the medical care unit's brain centre is the data control and processing module. This module's primary role may be broken down into two parts: the first is an designed algorithm to synchronise, regulate, and uphold the precise operation and communication of every other module. The proposed algorithm digitizes and analyses the vital sign signals obtained in the second section to assess whether or not each signal's levels are above the predetermined limit. If any one of these readings or all of them—exceeds their respective critical values, a trigger alarm is issued. After processing, all data is sent to the communication layer. A microcontroller, which was chosen to check particular parameters, makes up the majority of this module. To adapt to a huge quantity of data acquisition and processing, a micro control unit (MCU) with significant processing and control capabilities is required. Additionally, this module has more extension interfaces and a high level of system integration. The microcontroller with 8 bits, PIC18F458, is the one chosen for the medical care unit. It contains built-in peripherals and input-output hardware, enabling it to connect more or less directly with real-world objects like sensors. Many times, modern microcontrollers only require minimal external circuitry. The PIC microcontrollers are among the most widely available. A microcontroller has been specifically created for monitoring and/or controlling tasks and comes with all the necessary parts to work on its own. As a result, in addition to the processor, it also has general-purpose I/O pins; SPI, I2C, CAN, ADC, and UASRT interface controllers; RAM, ROM, and EEPROM memory units; and one or more timers. Figure 4 depicts the MCU's architecture. Following is a list of the MCU's primary responsibilities in the suggested system. (1) It gets signals from vital sign sensors and digitizes them. (2) It regulates how each linked module functions. (3) It uses a variety of processing methods and algorithms to process the signals that have been received. (4) It connects to the web computer and uses several communication channels to transmit the original data and analysis results. (5) It saves raw data and analytical findings to flash memory.

3. Components of the processor unit's software. The MCU is in charge of managing and supervising all aspects of the mobile care unit. Figure 5 displays the process for the mobile care unit. In C, software has been developed to replicate an MCU and its components, where the following ideas serve as its foundation. (1) The component for initializing sensors and modules is in charge of turning on, initializing, and setting up the medical care unit. (2) Component for perceiving vital signs: it obtains vital sign data from sensor nodes. (3) Signals of life processing element: It carries out data translation and processing as well as patient diagnosis by assessing the patient's health.
4. Component for information transmission: This component facilitates data sharing between the server and the mobile medical unit.
5. The information-receiving element assists the node in taking instructions or requests from the server.
6. Exceptions notification portion: as soon as unusual sensing data is found, it sends to the server and sets off the alarm.

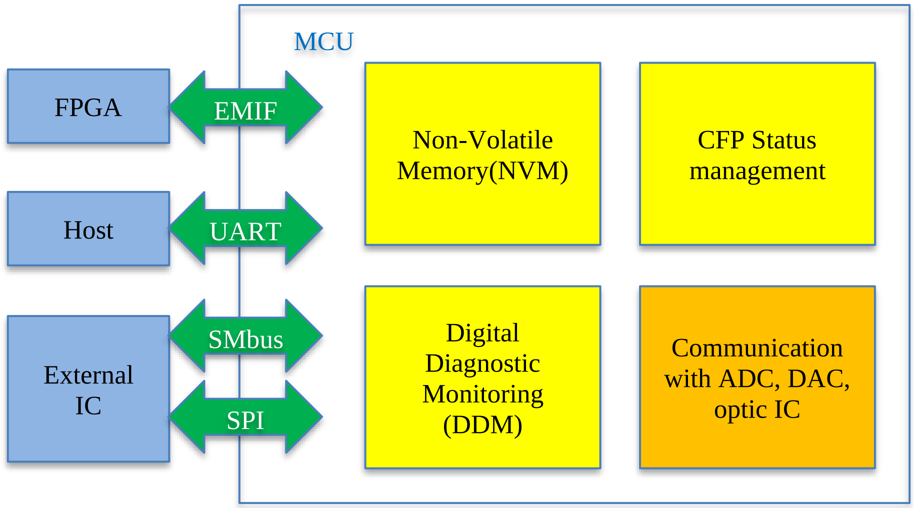

Fig. 5 The MCU is in charge of managing and supervising all aspects

4. System Presentation Level

The front end enables the permitted user to work with the supplied patient data using application software created in the C# computer language. The interface design mostly complies with the following fundamental and practical requirements.

1) Access controls are continuously deployed based on the authorized user information recorded containing the database.
2) Patient records and private data about patients are included.
3) It displays the patients' vital signs and establishes thresholds for every measured parameter.
4) In abnormal circumstances, it notifies healthcare professionals.
5) It includes new clients, fresh advice, and medication prescriptions.
6) It displays all patients' previous medical histories, including illnesses, previous operations, clinical results, previous medications, allergies, and pictures.
7) By patient ID or patient name, you can search for all currently registered patients.
8) While taking measures, notations (patient experience) are displayed.
9) It transmits communications that provide patient instructions and prescriptions for medications.
10) Sensor data will automatically refresh at certain intervals to keep the display current. Screenshots of the developed software.

5. Web Level

The web tier enables many users, including doctors, nurses, and medical facilities, to communicate with the server via a web interface. Through the internet, a remote online user will have continuous and real-time access to patients' vital signs. The HTTP protocol via a TCP/IP connection is used by the web user to interact with the web components. The user is provided with the material and information via an internet browser and a webpage created with Microsoft Visual Studio 2010. The created webpage offers the built application's most basic features in the presentation layer previously mentioned. The units for monitoring with the use of pervasive devices like laptops, PDAs, and cell phones, as well as the web layer in the remote server, are intended to enable distant users to obtain a wealth of information on the healthcare receiver whenever and whenever they want.

In this study, it is suggested that a wireless telemedicine system be built and executed. This technology sends all physiologic vital signs to a remote medical server for long-term monitoring through mobile networks in a crisis and the net in a non-emergency. Due to the fact that only uncommon circumstances will be relayed over the cellular network, the cost of using the GSM/GPRS network is reduced. A consumer web-based interface is also provided by the recommended system for healthcare providers to observe real-time vitals for remote therapy. Compared to the earlier systems listed in the introduction, the proposed system includes a sensing unit, a processing unit, and a transceiver [18–28] and a customised sensor seen in Figure 6 was chosen and filled with infrared (940 nm) LEDs. The sensor being utilised also offers heart rate and blood oxygen saturation. Through the acquisition module, the SpO2/HR sensor's output is sent to the processing unit. The suggested system's specifications for several physiological metrics are presented.

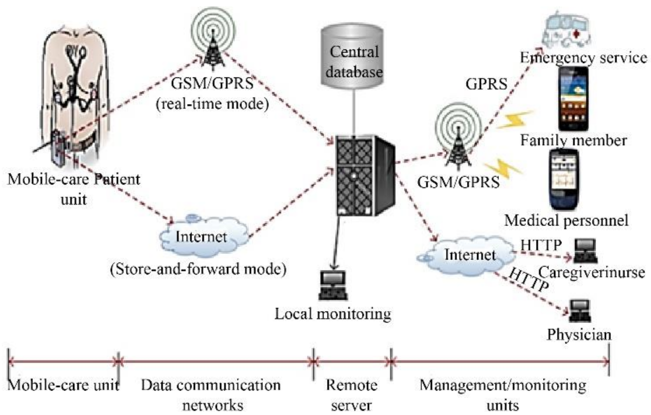

Fig. 6 GSM/GPRS network

The suggested method has the capability of continually tracking patients' critical health states rather than using discrete readings. For instance, patient monitoring software for android-based mobile phones enables doctors to track the health of. With the user-friendly interface, monitor the patient's condition (UI). This tool also provides alerts, recalls, and emergency alerts for critical parameters to aid physicians in making snap decisions in emergencies. In many countries, 3G mobile networks, such as the UMTS, are already operational and established. They provide capacity for data connections up to a maximum of 2 Mbps (usually tens of kbps) [29]. As a result, it will be feasible to provide extra information, including continuous 12-lead ECGs, to monitor cardiac patients from the moving ambulance. The present emergence of new technologies, including video telephony utilizing wireless networks, is another advancement that can help in interactions between a healthcare professional. In addition, it improves the healthcare living facilities using Remote Health Monitoring (RHM) and the Internet of Medical Things (IoMT); it provides alerts, recalls, and emergency alerts for critical parameters to aid physicians in making snap decisions in emergencies [30].

6. Conclusion

Wireless telemedicine systems which had been studied, ensure sending all physiologic vital signs to a remote medical server for long-term monitoring depending on mobile networks in a crisis and the net in a non-emergency by comparing with the previous systems had been mentioned in the literature review, the proposed system includes a sensing unit, a processing unit, and a transceiver. By a single chip that is affixed to the person's blood, he could be able to do day-to-day activities while being monitored. In this way, patients who have critical health states can be tracked continually, and this is better than depending on the discrete readings. This system could work for three situations: link based on time, Emergency connection, and connectivity in order for (Event awareness). The basic components of this system were also presented by detailed surveys to explain the efficiency of these techniques in the healthcare field.

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