An Intelligent Internet of Medical Things based Smart Healthcare Monitoring Equipment for Patients

Mrs. Nagaveni R[1], Dr. Manish T I[2], B Nagaraju[3], Dr. Rakhi Kamra[4], Rama chaithanya Tanguturi[5], Dillip Narayan Sahu [6*]

[1]Assistant Professor, Department of Computer Science, Maharani Lakshmi Ammanni College For Women (Autonomous), Affiliated to Bangalore City University, Bangalore, Karnataka, India.

[2]Professor, Department of Computer Science and Engineering, SCMS School of Engineering and Technology, Kerala, India.

[3]Assistant Professor, Department of CSE(IoT), RVR&JC College of Engineering, Guntur, India.

[4]Assistant Professor, Department of Electrical and Electronics Engineering, Maharaja Surajmal Institute of Technology, New Delhi, Delhi, India.

[5]Professor, Computer Science and Engineering, PACE Institute of Technology And Sciences Ongole, Andhra Pradesh, India.

[6*]Assistant Professor, Department of MCA, Gangadhar Meher University, Odisha, India.

*Email: dillip1seminar@gmail.com

Abstract

In today's fast-paced world, a new technology paradigm known as the Internet of Things (IoT) is advancing every business. It allows for communication across the virtual and physical worlds, which will drastically alter how business is conducted in the near future. It paves the way for a plethora of novel, exciting prospects across all sectors of the economy and is stimulating creativity in every sphere of human activity. The Internet of Things (IoT) has had a profound impact on the delivery of healthcare services in recent years. Easy measurement of medical indicators by smart devices implanted in the body yields a massive quantity of individually identifiable medical data for each patient. There are a number of security risks associated with this data collection. It is challenging to implement a complicated data encryption method to improve security on IoT devices because of their limited resources. Existing cryptographic security techniques also have a significant computational cost, which must be reduced. However, these algorithms must be secure against a wide range of assaults, including differential attacks, linear attacks, algebraic attacks, and others. As a result of these assaults, there is a pressing need to design foolproof, highly effective, and relatively lightweight security algorithms for use in the healthcare IoT sector. Due to the inability of the doctor to assess the patient's vitals via video chat alone, this kind of telemedicine falls short. To get around this, there has to be a system in place with very precise sensors for monitoring the patient's vitals.

Keywords: Healthcare, IoTM, Patient's, Sensor, Connectivity and Medical parameters.

1. Introduction

The concept of telemedicine uses a variety of scientific fields, such as physiology, biomedical devices, and communications, to provide healthcare remotely. Telemedicine may be a useful substitute when medical resources are limited, such as when there are not enough physicians available or when there is a large population to serve. Despite the numerous benefits it provides, telemedicine has not yet realised its full potential due to the relatively expensive cost of the necessary equipment. Since the doctor may not be aware of the patient's physiological data while speaking with them over the phone or video chat, this kind of telemedicine is not particularly successful. A full system made up of a number of sensors must be set up in order to do this. This will provide the doctor a realistic replica of the patient's physiological state to deal with. A lightweight, low-cost telemedicine system is created using the most recent advancements in embedded systems and the Internet of Things[1]. Energy-efficient technology is used to power these sensors, which in no way affects their accuracy or reliability. The data gathered by the sensors is analysed and displayed using sophisticated algorithms that are created in a number of different computer languages. The system's own graphical user interface is utilised to track and show the parameters as they are being tracked in real time. In contrast to past medical devices, the newly developed technology requires extremely minimal user training. The created device has the ability to precisely measure a wide range of physiological signs. The package also contains information on the amount of oxygen in the blood, skin temperature, heart rate, an electrocardiogram showing the heart's pulse rate, and non-invasive blood pressure calculated from pulse transit time. Telemedicine is the practise of providing medical care to patients who are located far away using different electronic communication and computer technology. Telemedicine applications that have been shown to be efficient uses of the resources that are now available include teleconsultation, tele-education, telepathology, teleradiology, and telecardiology [2]. The store and forward method and real-time implementation are the two primary ways that telemedicine may be used. Patients' information may be retained in either an electronic or paper format under the store and forward method. The material is then transmitted to the medical expert for examination using a range of various techniques. The second method entails the expert analysing the patient's medical history while remotely monitoring the treatment. The telemedicine data includes a wide range of information, such as patient reports, personal information, medical histories, and clinical data. Given the growing global population and declining healthcare budget, widespread use of telemedicine is imperative. Standard medical tools must be used to diagnose and treat the patients. Many hospitals and clinics lack the requisite health monitoring equipment due to an ever-growing patient load. Traditional systems need a lot of time and labour to operate and maintain. For instance, getting a temperature measurement with a conventional mercury thermometer may take three to five minutes. The time spent checking a patient's vital signs, like as their pulse and blood pressure, might be better used to treat the patient. The majority of clinics and hospitals still lack the equipment essential to quickly and properly assess patients' vital signs[3]. More individuals can get this kind of treatment faster because to low-cost telemedicine technologies. In the bigger nations, the distance between the medical centre and the patients is a significant issue. Since it is challenging to establish health care facilities with specialised personnel in every small village with 500 or fewer residents, the majority of these institutions are found in metropolitan and semi-urban regions. The subjects claim that travelling to metropolitan centres for standard medical treatment is challenging for them. Less time is spent on the road as a result of the development of telemedicine and improvements in high-speed connectivity[4]. Doctors on medical missions to remote places may also benefit from the data storage capacities of telemedicine technology. An efficient non-invasive method to research and analyse the status of the cardiovascular system is the ECG. Figure.1 illustrates that it has a rhythmic pattern when the cardiovascular system is operating normally. Any departure from the pattern in the ECG is a sign of cardiovascular system problems. Any departure from the pattern in the ECG is a sign of cardiovascular system problems. Electrodes may be applied to the skin to acquire the signal, and the location of the electrodes must be modified depending on the number of electrodes being utilised. For instance, Einthoven's triangle is followed by the fundamental three-electrode ECG. The size of the heart chambers, arrhythmia, and myocardial infarction are among the diseases of the heart that the ECG may identify. The electrical activity of pacemakers inserted into the circulatory system is monitored via electrocardiography.

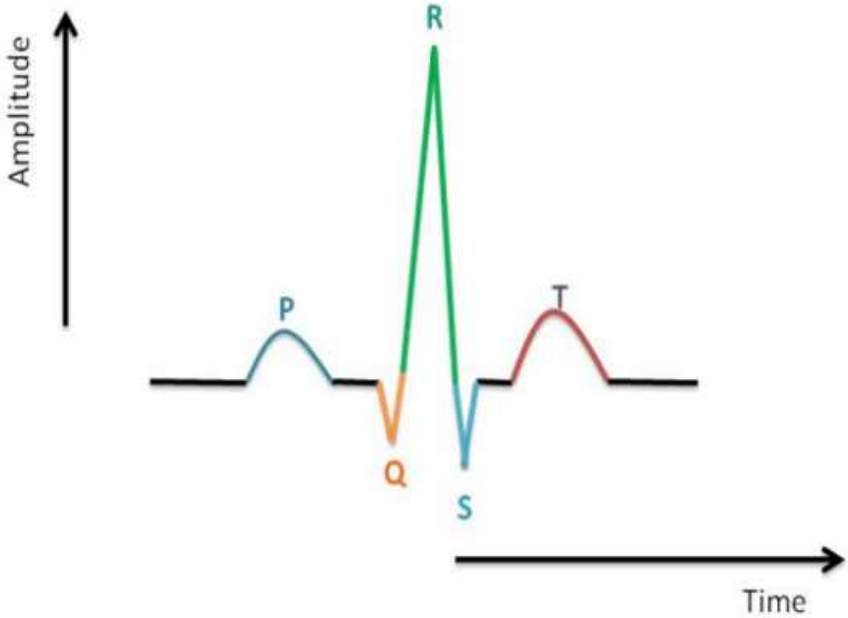

Figure.1: ECG cycle of a heart

2. Literature Survey

The technique of examining, monitoring, and treating a patient when a doctor is not physically present at the patient's bedside is known as telemedicine. The three main components of telemedicine services are picture capture, storage and analysis, and transmission to a distant site. By securely connecting physicians and patients, telemedicine might help low- and middle-income nations close the healthcare gap[5]. For getting accurate measurements of vital indicators like heart rate, blood pressure, and oxygen levels, telemedicine significantly depends on sophisticated sensors. To process the data, a central computer receives the readings from these sensors. In order to measure many health indicators concurrently, it is essential to merge the sensors and CPU into a single device[6]. Real-time healthcare data must be made accessible in order for hospitals and physicians to respond appropriately based on such data. The Internet of Things is essential for getting healthcare information to the right people.

Ganapathy discussed the medical system in India, pointing out that it differs between urban and rural regions. Due to their rural residence, almost 700 million Indians lack access to quality healthcare. The 80% of Indians who are medical professionals are only accessible to only 20% of the country's population. The author offered a solution for improving healthcare quality in rural areas by virtually bringing urban doctors there. Video conferencing, which also makes it feasible for international teleconsultation, enables medical practitioners to conduct e-home visits[7]. The telemedicine approach enables the doctor, from any location, to virtually visit the patient and monitor them. This cuts down on the amount of time it takes a doctor or patient to go from a rural to an urban area. As part of the telemedicine system, images are taken, examined, and presented. The virtual visit of a medical practitioner to the intensive care unit (ICU) considerably enhances remote medical therapy. Thanks to a technique created by Görset et al., patients in remote places now have access to mobile telemedicine. It could be challenging to provide enough medical care facilities in heavily populated and industrialised countries. Patients in these countries' rural regions often experience early mortality because of the lack of access to high-quality healthcare. In order to remotely monitor a person's health indicators and transmit that information to the proper authorities for action, a system must be developed and made available at all times[8]. This study installs a system made up of certain sensors to monitor the health parameters, all of which are incorporated in a distributed network architecture, to help the medical care system in a remote location. The system includes a teleservice centre that employs data analysis to provide remote assistance to persons in need. The system's layout saves time and money since patients won't need to go elsewhere to get the services they need. Modern technology is now available to medical care units in remote areas due to the quick development of the communications and data collection infrastructure. With the aid of this system, a variety of ailments may be treated more successfully due to the integration and connectivity of multiple sensors[9]. The main elements of this system are a heart rate monitor, blood pressure gauge, scale, and electrocardiogram (ECG). A Data Acquisition Unit (DAU) transmits sensor data to a smartphone. Segato and Masella's study revealed a number of factors that are essential for the establishment of telemedicine programmes. The authors' study of telemedicine provided understandings into the processes that keep telehealth programmes operating efficiently. Three Italian telemedicine programmes were the subject of a six-year, in-depth investigation by the authors[10]. Between 2008 and 2010, the Italian Ministry of Health's database was utilised to check the availability of telemedicine services there. It is helpful for recognising the various telemedicine service use cases as well as the fundamental factors that must be taken into account when efficiently creating such services[11]. According to the study, telemedicine services' organisational and financial soundness are important determinants. Understanding medicine and giving patients the right amount of care might improve the stability of the company and the respect among employees. One example of how patients' needs might be satisfied as a result of technical improvements that aid improve organisational stability is the availability of a nurse at all times. To increase financial stability, a number of solutions—including hospital management and policymakers have been found.

3. Role of IoTM in Healthcare

The creation of compact, transportable, and user-friendly electronic equipment to capture the physiological data is made possible by advancements in embedded systems. Commonly speaking, embedded systems are computerised systems where hardware and software collaborate to complete a task. The development of embedded systems has accelerated with the introduction of microcontrollers. Microcontrollers/microprocessors, sensors, and actuators are ubiquitous due to the adaptability that their presence provides. As IoT technology advances, millions of embedded devices are networked to provide users a broad range of beneficial new capabilities[12]. Things or "smart objects" in the Internet of Things (IoT) may interact with one another, the environment, and other things. Figure 2 shows a typical illustration of an IoT ecosystem. The architecture of the internet of embedded things is supported by embedded systems and their internet connection, as shown in Figure 3. Devices with specialised functions known as embedded systems are constructed around a microcontroller or microprocessor and a number of sensors and actuators. The sensors provide the microcontroller with an input of an electrical signal that represents the physical parameters[13]. The data has to be processed and stored in memory by microcontrollers. The actuators are powered by the processed data using microcontrollers. It is also possible to send data and control signals to distant devices by connecting to the IoT. An integrated circuit known as a microprocessor is capable of carrying out various arithmetic, logic, and control operations quickly. An integrated circuit called a microcontroller has a CPU, memory, and programmable peripherals. Due to its built-in random access memory and programme memory, embedded engineers often prefer microcontroller devices. Microcontrollers are made by a large number of businesses, including Intel, Advanced Micro Devices, National Semiconductor, Microchip, Texas Instruments, and Silicon Labs[14]. Modern microcontrollers are evolving into SoCs (Systems-on-chip) as more and more components, such as co-processors, wireless fidelity modules, and graphics processors, are combined onto a single chip.

Figure.2: Internet of Things

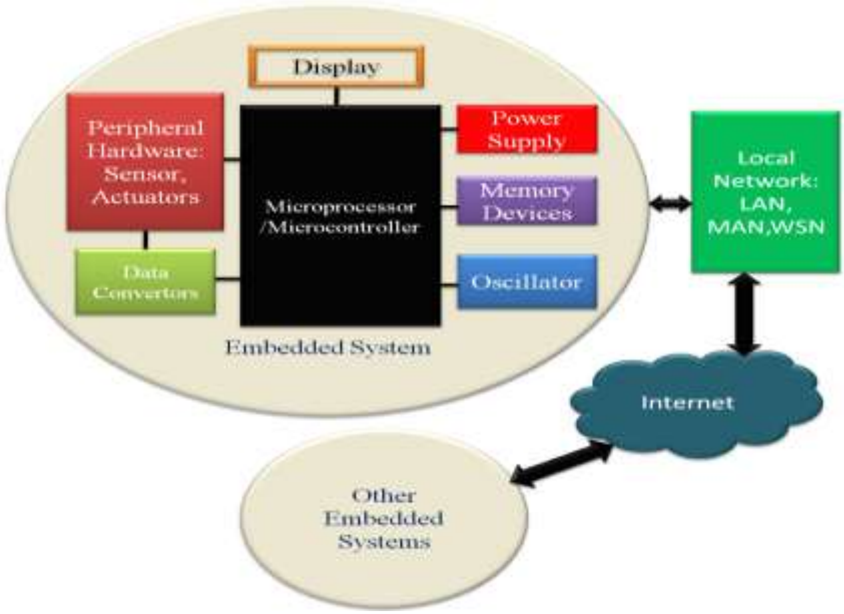

Figure.3: An Overview of Embedded Internet of Things Architecture

Sensors allow for the detection of physical values and their conversion into electrical impulses. Nowadays, when almost everyone has at least one electronic gadget, sensors are an integral part of everyday life. In order to capture a range of data, sensors are often placed close to embedded systems' input[15]. The characteristics of the information they offer, the materials used in their construction, the guiding principles and metrics by which they are assessed, and other elements have led to the development of several distinct types of sensors. Electrical signals must be changed by transducers known as actuators in order to control and move the systems that are linked to it. For instance, in an electronic sphygmomanometer, the actuator fills and empties the air cuff in response to a signal from the microprocessor of the device. Stepper motors may be used in robotics to move limbs, and actuators linked to the Internet of Things can be utilised in household appliances to switch on and off water pumps[16]. Not all transducers in embedded systems are able to communicate digital information directly since some lack data converters. The analogue data from the sensors may be linked to the analogue to digital data converter incorporated inside the processing unit. Noise immunity may be increased by immediately digitising data after acquisition, ideally using an external ADC if the distance between the sensor and controller is great.

Figure.4: Medical Sensors

Sensors are a crucial part of smart objects since context awareness is a key component of the Internet of Things. To get information from the outside world, every IoT application needs at least one sensor. Dreaming of a linked world is impossible without sensor technology. IoT sensors are compact, use less energy, and are less costly. Despite being battery-powered, they are simple to deploy on any surface. To measure various physical properties, there are several sensors on the market. Numerous wearables with built-in sensors are used to monitor a patient's medical conditions, including blood pressure, heart rate, pulse, body temperature, blood sugar levels, and breathing rate. Some examples of wearables include smart watches, monitoring patches, wristbands, and smart fabrics. They are connected to smartphones via certain unique capabilities. In Figure.4, a selection of medical sensors are shown.

However, certain actuators can only function with analogue signals since they don't have built-in data converters[17]. Microcontrollers only output digital signals, therefore actuators must be interfaced with digital to analogue signal converters. It is standard practise to link microcontrollers to external memory devices in order to improve their overall performance since the internal memories of the majority of these chips have poor capacity[18]. An embedded system's operating system must be stored in a bootable read-only memory (ROM) in order to execute complicated programmes. On read-only memory devices like CD-ROMs, hard drives, flash drives, and solid-state drives, the embedded devices are booted and their data is stored non-volatilly. Another way to increase RAM and hence speed up processing is by connecting the external RAM modules. small-outline, single-inline, and dual-inline When it comes to dynamic synchronous RAM modules, dual-inline packages are an option. Power is necessary for every embedded system to function. Different sources of power have been used, such as standard AC power, DC batteries, and wireless energy transmission. Electronic devices without batteries may use mechanical, thermal, magnetic, radiative, or biological energy, according to research[19]. A regulated power supply circuit is used by the majority of embedded systems to accommodate both alternating current (AC) and direct current (DC) power sources. It's crucial for embedded system designers to keep in mind that not all devices have the same power needs. Level shifting circuits are utilised to provide the power that the device's different components need. It takes precise clock pulses to keep the CPU operating in sync with the rest of the system. The oscillator circuit is one of the factors that affects an embedded system's speed. The clock pulses should be produced at the microcontroller's maximum achievable frequency to achieve peak performance[20]. The clock signals may be produced using a passive component oscillator, an integrated circuit oscillator, or a piezoelectric oscillator circuit. Piezoelectric oscillators are well suited for usage in embedded processing units because they can generate exact time intervals at very high frequencies. Clock circuitry is required in addition to the microcontroller so that everything can run in unison. Microcontrollers often share their clock with other parts, such as the real-time clock and random access memory. An external oscillator must be linked into each device when a microcontroller lacks a way to divide up clock signals.

4. Applications

The widespread use of integrated embedded systems linked to the internet of things has been facilitated by fast processing, remote object access, and the ability to do numerous tasks at

once. Among the various fields that may profit from integrated system applications are agriculture, meteorology, medical, home appliances, industries, education, and the military.
Installing Internet of Things (IoT)-enabled integrated systems with different sensors and actuators in agricultural regions may reduce the burden of farmers[21]. Monitoring factors like soil moisture and salinity, spotting rain, and operating equipment like irrigation pumps are often used in agriculture. The appropriateness of the water for agriculture may be improved by integrating more devices that measure water variables including pH, salinity, and contaminated particles.

Figure.5: Applications of Internet of Things

The potential of IoT is to enhance quality of life. Home automation, environmental protection, smart cities, smart education, smart agriculture, and smart healthcare are a few of the potential IoT uses. Figure 5 displays several IoT application possibilities.
The study of meteorology employs a variety of tools to gauge the physical and chemical characteristics of the atmosphere. In order to aid in atmospheric analysis, embedded systems that monitor variables including temperature, humidity, barometric pressure, wind speed and direction, carbon monoxide, atmospheric ozone, and carbon dioxide all function in concert. Weather and air quality forecasts are more accurate as a result of improved IoT system integration and wireless sensor networks.
Integral Internet of Things (IoT) gadgets are extensively employed in this fourth industrial revolution. As the fifth industrial revolution draws near, businesses are purchasing more embedded IoT devices to speed up production and marketing[22]. The development of industrial systems has advanced quickly, along with other technologies like AI and VR. The significance of IoT embedded systems is being confirmed by a large number of industries, including those involved in autonomous cars, online marketing, and remote-controlled 3D printers.
The development of the human race requires education. Online educational tools are helping to support the conventional chalk-and-talk teaching technique. Blended learning creates a rich learning environment by fusing conventional classroom teaching with online resources.

Students now have access to expensive and far-flung laboratory facilities thanks to integrated IoT devices. Without the need for physical travel, knowledge exchange between distant students and instructors is made feasible. IoT-based solutions are enhancing classroom learning by gathering data in real-time, reducing administrative processes, and enhancing safety precautions.

In many areas of medical practise, from diagnosis to treatment to patient progress tracking, the use of electronic equipment has become essential. Only a few of the many embedded systems being used in the diagnostic process include temperature monitoring, endoscopy, heart rate measurement, blood testing, electrocardiography, electromyography, and other electrophysiological tests. Embedded systems are necessary for the manufacture and installation of implantable devices. Real-time monitoring of anaesthetic effects during surgery, such as variations in blood pressure and oxygen saturation, is made possible by embedded equipment linked to patients. Patients' vital signs are tracked during the postoperative surveillance stage in order to detect any unfavourable physiological responses to the surgery.

A patient who is experiencing a medical emergency or has just had surgery must have numerous medical indicators closely monitored. One of the most exciting uses of the Internet of Things is in the field of healthcare, where patients may be monitored remotely or in a hospital setting using smart sensors. A patient's health state is continually monitored online using smart sensors. IoT devices are used to offer real-time monitoring of health conditions such as real-time electrocardiograms (ECG), glucose levels, blood pressure (BP), temperature monitoring, automated wheelchair access, medication reminders, and automatic ambulance calling facilities. Other IoT applications in healthcare include telemedicine, medical monitoring for the aged or incapacitated, electronic recordkeeping, and health information exchanges for remote support. Figure.6 shows the IoT application situation in the healthcare industry.

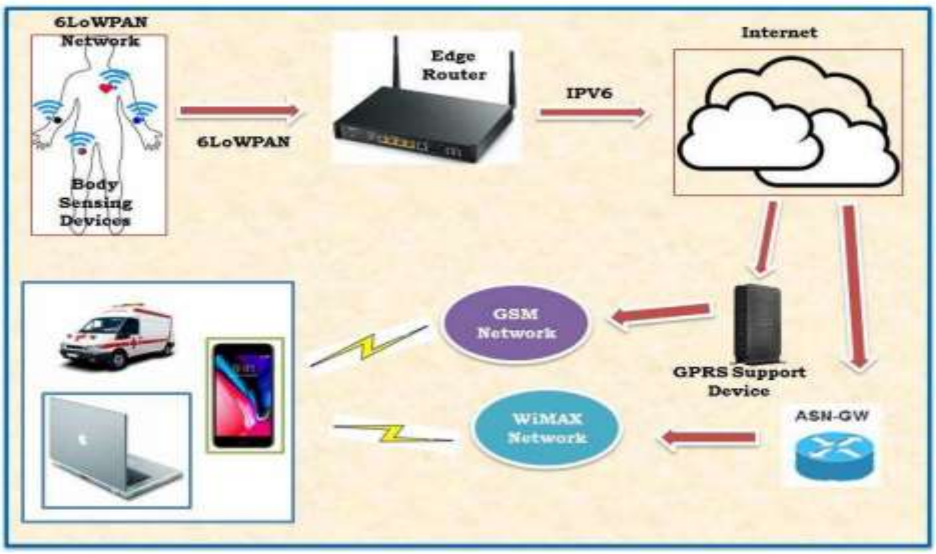

Figure.6: Application Scenario of IoT in Healthcare

Telehealth applications mix telecom and medical software to benefit from current advancements in both industries. Telemedicine uses integrated embedded communication systems with diagnostic capabilities to convey patient information over a variety of communication channels. Healthcare and telecom integration is still a relatively recent practise. A range of various sorts of high-tech devices will need to be mass developed in order to fully realise the promise of telemedicine.

5. IoT Enabled Medical Devices

An Internet of Things-based health monitoring system may be used to improve the delivery of medical services to low-income and rural communities, according to research by Rohokale et al. Only a few of the health indicators that can be recognised by contemporary sensors and sent to people who are concerned include haemoglobin (HB), blood sugar (BS), blood pressure (BP), and abnormal cell proliferation. The high mortality rate, especially in rural areas, is largely a result of the general lack of education. The key to reducing this frequency is understanding how to utilise current technologies to quickly convey health information to medical specialists. According to the World Health Organisation and the United Nations Children's Fund, more effective prenatal care might reduce the number of maternal mortality. A patient and doctor may effortlessly communicate information thanks to IoT technology. The possibility that a patient may be rescued rises with the usage of Internet of Things (IoT) connected devices since crucial health data may be sent to a hospital at an early stage. The Internet of Things (IoT) technology may also be helpful for maintaining patient records and enhancing the treatment of health issues. The significance of the Internet of Things in the healthcare industry is summed up by Lu and Liu. The structure of the Internet of Things (IoT), how its features are carried out, and how it fits into the telemedicine infrastructure are all described by the writers. A number of protocols may be used by sensors to communicate with other IoT devices in the Internet of Things. The perceptual, sensor network, and application layers make up the three tiers of the Internet of Things' architecture. Vital signs and other health indicators are tracked by a number of sensors in the perceptive layer. Sensors establish a network at the sensors layer and connect to the internet to distribute the gathered data. The proven technology of the IoT is used in real-world applications at the application layer. In the IoT-based telemedicine system, each patient is given a unique ID, and those IDs are connected to sensors that gather information on the patient's vital signs. Sensor data is sent through a gateway to the host database management system. The IoT medical unit process requires the identification of patients, doctors, prescriptions, medical equipment, and ailments. All of these things may have immediate effects if the Internet of Things is integrated with the medical equipment. In an IoT system that gathers data from the patient, radio frequency identification (RFID) may be used to identify patients from a distance. In their study, Wu et al. constructed a system using wearable sensor nodes that capture solar energy. After that, an autonomous wireless body area network (WBAN) is put into place to enable Bluetooth low energy connection sharing of the observed data. The study highlights the value of IoT in healthcare and the ways in which state-of-the-art technology may improve healthcare facilities. Numerous sensors are connected to the individual in order to monitor vitals including heart rate and core temperature. On a web-based programme created for usage with smartphones, the sensor data is shown together with an identification of a human body fall. Solar energy harvesting technologies enable wearable sensors to operate for extended periods of time. A solar energy harvester, a sensor node with Bluetooth connectivity, and a smartphone-friendly web application make up the system's three main parts. Any wearable sensor system must have a microcontroller (MCU) for the sensors to connect to. The system uses a Bluetooth low energy (BLE) module (HM-10) to send sensor data to a smartphone running a customised web app. Sensors may become more convenient to operate and connect in subsequent system revisions. If the sensor node is designed to integrate with other sensors to monitor other health metrics and if it is worn on a smart cap or smart T-shirt, the solar panel may be exposed to more sunlight. A wristband device that can track movement and heart rate was created by Zhang et al. The device may use IoT technology to continuously record and communicate data on a person's vital indicators, such as heart rate, blood pressure, and oxygen saturation levels. The technology was developed to accurately and easily measure the parameters. A mobile phone's Bluetooth module makes wireless communication possible. Wireless communication has become an essential part of the healthcare system's infrastructure thanks to the Internet of Things (IoT). The intended system's sensors collect data, which is then sent to the central controlling system for processing. The controlling system then uses cloud server technology to broadcast the executed data through a TCP connection. A TCP control programme is used by the cloud server to collect data from the sensors and store it in a database for later use. The suggested system allows access to the patient's information through an app on a mobile device, and historical data is also shown. A doctor may view several patients at once and talk with them in real time using web technology and a personal computer.

6. Healthcare Monitoring device

The development of embedded systems significantly depends on the thoughtful selection of hardware elements like CPUs and sensors. It is anticipated that the gadget would use little power and respond quickly. The Advanced Virtual Reduced-instruction-set computer architecture is controlled by an AMD processor and an AVR controller. The sensors are connected to the AVR controller via signal conditioning circuitry, which then collects data. Data from the microcontroller is analysed and displayed using AMD's CPU. Figure 2 displays a functional block diagram of the system built for the purposes of this study. The five main parts of the system are computing, sensing, displaying, storage, and the Internet of Things. One of the two blocks that makes up the processing unit is comprised of the AMD processor and the AVR controller. The controller is the part in charge of gathering information from the sensors and sending it on to the CPU. Because it enables the processing of data from the microcontroller, the display of that data in the local unit, and a connection to the internet of things, an AMD processor with an integrated graphics processing unit is used. The operating system-running CPU makes a large range of practical applications available since it can cooperate with a wide range of peripheral devices. The sensor block consists of four interconnected sensors: pulmonary function (PPG), electrocardiogram (ECG), temperature, and oxygen saturation (SpO2). A contact-based human body temperature sensor made by MAXIM is used for the measurements, and the sensor is factory calibrated before use. The reflecting kind of SpO2 sensor that was employed in this investigation was created with low-noise circuitry in order to produce a greater signal-to-noise ratio. Two light-emitting diodes (LEDs) and a photo-detector (diode) are employed as measuring instruments to determine the quantity of oxygen saturation. A single integrated circuit with inbuilt analogue to digital converters is used to collect data from the photoplethysmograph (PPG) and the electrocardiogram (ECG) for cuff-free blood pressure monitoring. The participant is requested to touch the tip of their finger to a sensor in order to record a PPG signal after having three electrodes placed on them to record an electrocardiogram (ECG). The display is a high-definition multimedia interface (HDMI) monitor with a built-in digital camera input. The HDMI display, which may be of a variety of sizes, can be linked to the display interface without any updates to the software or hardware being necessary. Through the use of a digital camera, the position of the patient may be seen and recorded. The system is connected to a capacitive touch screen display device that has a screen size of 7 inches. The adapter for wireless communication in the gadget that connects to the internet of things. One of the USB ports on the SoC, which serves as the connection point, is used to insert the wireless adapter into the system. An integrated multi-media card (eMMC) and a DDR4 memory module make up the memory block. The AMD central processor unit (CPU) is connected to an operating system and a memory module with 32 gigabytes of storage. The installation of an 8GB DDR4 RAM module, which can be accessible via the computer's motherboard, has increased the performance of the device. While patients are being joined up for continuous monitoring, a wireless mouse and keyboard allows access to the system. The patients are not in any way bothered by the access being offered. The AVR controller is interfaced with a reflection-type sensor, MAX30102, for noninvasively measuring the saturation percentage of oxygen (SpO2) in human blood. A thin, chemically resistant glass layer covers the 14-pin optical sensor. The sensor is protected from skin, perspiration, and dust particles by the glass cover, ensuring a reliable and top-notch performance. With the optoelectrical embedded circuitry on the small integrated chip, the sensor offers several fascinating properties. According to Figure. 7, the MAX30102 is divided into five sections: optical, analogue, digital, control, and communication.

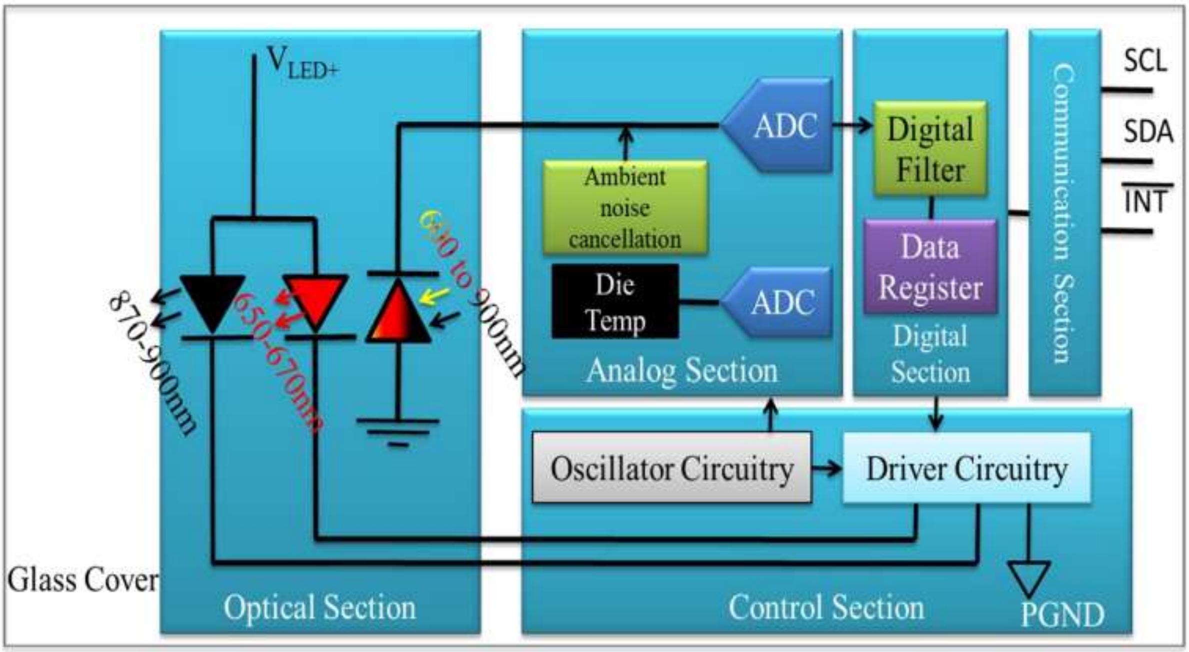

Figure.7: Block diagram of SpO2 Sensor

One of the most frequent diagnostic techniques is taking a patient's temperature, which is often carried out with a mercury-filled glass thermometer. The information gathered by temperature sensors, which utilise a range of sensing methods, is kept in electronic memory. The smart temperature sensor MAX30205 is used in this investigation to capture precise surface-level measurements of the skin. The immediate calibration of the high-resolution temperature sensor to degrees Celsius ensures precision. The sensor only requires 2.7–3.3 V and 600 A of electricity to operate. Since your sensor will only require 1.65 A while idle, you may further improve its power economy by switching to shutdown after each reading. The four blocks that make up the sensor are the interfacing block, register block, logic block, and temperature measurement block, as illustrated in Figure 8. The temperature measurement block is composed of an analog-to-digital converter, a logic circuit, a reference voltage circuit, and a temperature sensor circuit. The temperature sensor circuit, which monitors the ambient temperature, provides an analogue output to the ADC. The temperature derived from an analogue input is stored in the sigma-delta type ADC using 16 bits of digital space. The built-in reference voltage circuit provides a constant voltage that the analog-to-digital converter (ADC) utilises as a point of reference. The logic block causes the over-temperature shutdown output pin (OS pin) to emit an alarm when the temperature exceeds the setpoints. A digital comparator in the logic block compares the current temperature to the minimum and maximum threshold temperatures. The four registers that may be accessed through the register pointer located within the register block are the lower threshold temperature (THYST), over temperature (TOS), configuration, and temperature registers. The lowest and highest temperatures at which the sensor may operate without triggering the operating system are specified by the lower threshold and over-temperature registers. The temperature register stores the 16-bit temperature data from the ADC. The interface block houses the register pointer that the microcontroller uses to connect with the sensor. The serial logic circuit of the interface block, which controls the I2C protocol, is paired with an address decoding circuit, which determines the address of the MAX30205 on the I2C bus.

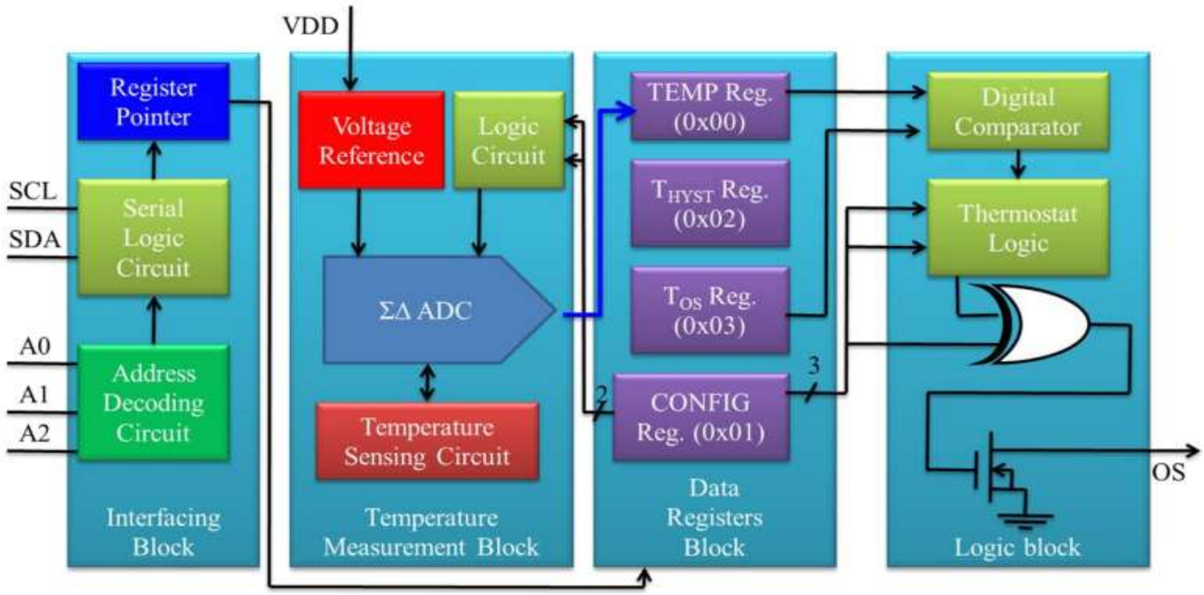

Figure.8: Block diagram of temperature sensor

7. Results and Discussion

Temperature, pulse rate, saturation of the blood (SpO2), heart rate, respiration rate, as well as systolic and diastolic blood pressure, are among the data that can be tracked using the system that has been developed. These are only a few examples of the data that may be tracked. The technology also offers graphic representations of the PPG and ECG signals. The technology that permits remote access to the videographic data related to patients makes teleconferencing feasible. Delivered to the GITAM Institute of Medical Science and Research (GIMSR) hospital in Visakhapatnam, the newly created system will allow for data comparison with existing systems. The four hospital departments from which the information is taken are the emergency room, the critical care unit, the operating room, and the regular ward. Standard rooms and outpatient spaces feature plenty of windows, whereas the acute care unit and operation room have air conditioning. Eighty adult patients with a mean age of 37.12 (SD) years are assessed, and their vital signs are recorded using the hospital's standard protocols and tools. The patients vary in age from 18 to 79. One sample is taken from each patient as part of the procedure, which is used to measure outpatient data. In the remaining portions, the gadget collects data from each subject for a full half-hour. The portable system is first put to use in the outpatient ward of the GIMSR, where it is very simple to measure a wide range of patient data. The outpatient ward uses both the designed system and the hospital's current systems to compile the data of 24 patients. A mercury thermometer, an infrared thermometer, a commercial pulse oximeter, a stethoscope, and a mercury sphygmomanometer are all common tools used in the outpatient ward to measure temperature, heart rate, and blood pressure, respectively. By putting a finger on the pulse nerve and noting the number of breaths you take in a minute, you may estimate your heart rate and respiration rate with the help of medical professionals. The graphs of various patient parameters gathered from the outpatient ward are shown in Figures 9–12.

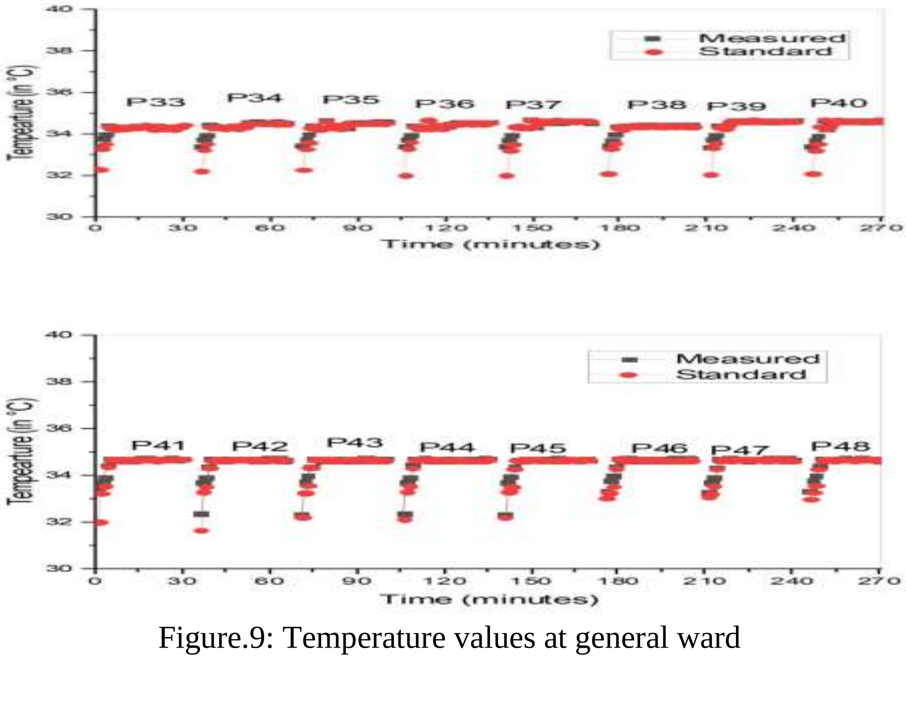

Figure.9: Temperature values at general ward

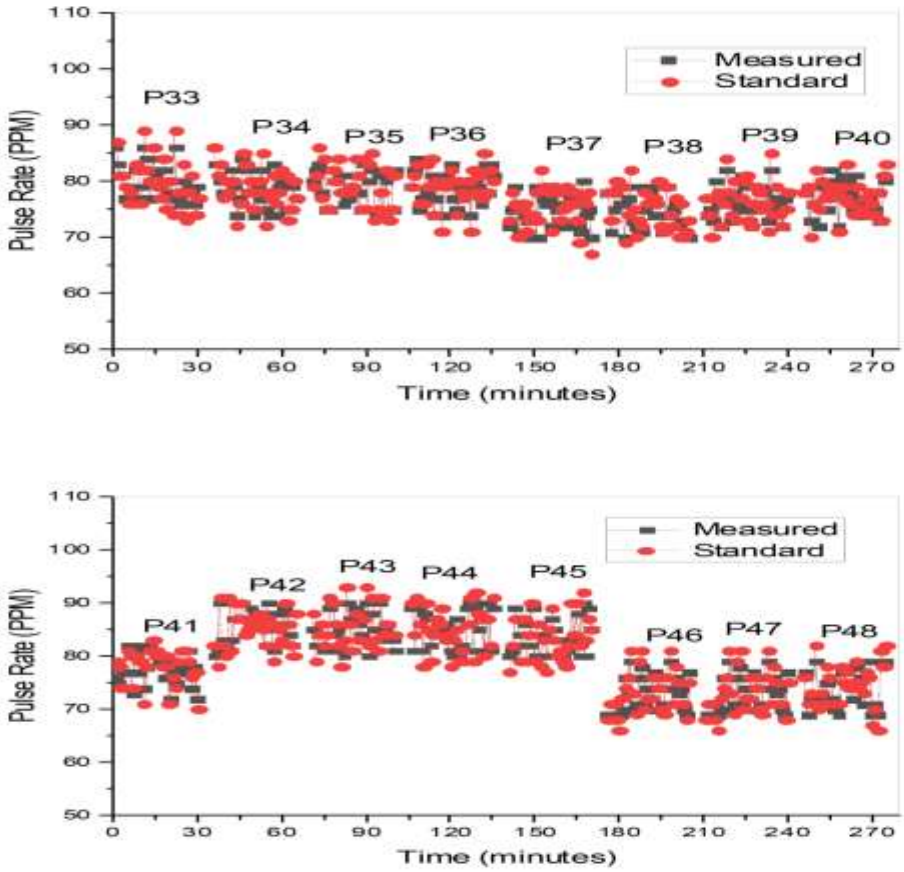

Figure.10: Pulse rate values at general ward

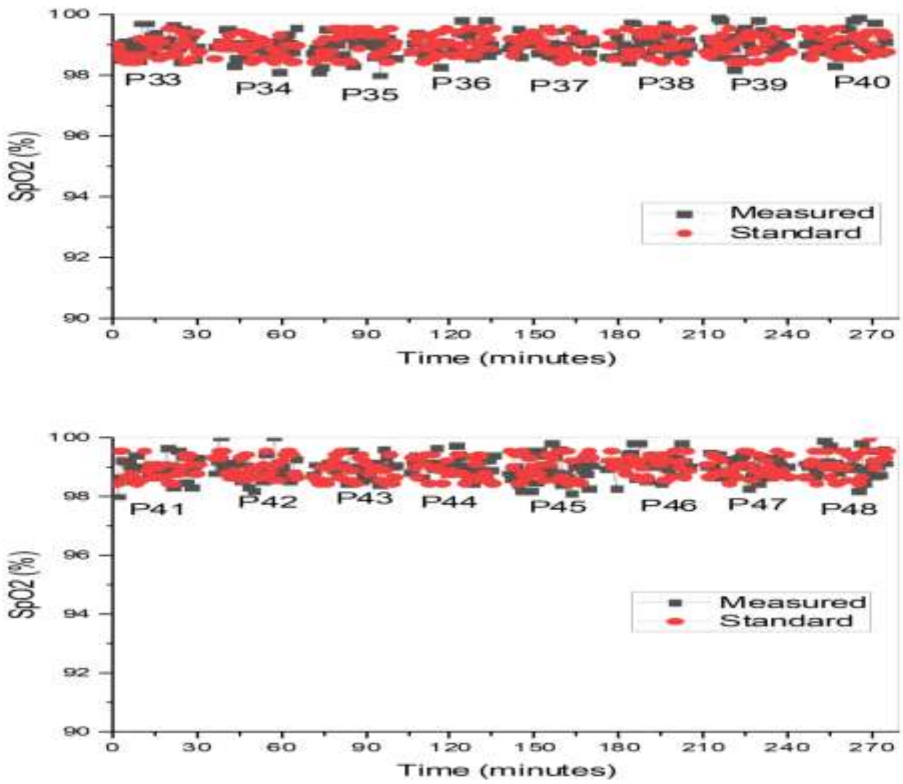

Figure.11: SpO2 values at general ward

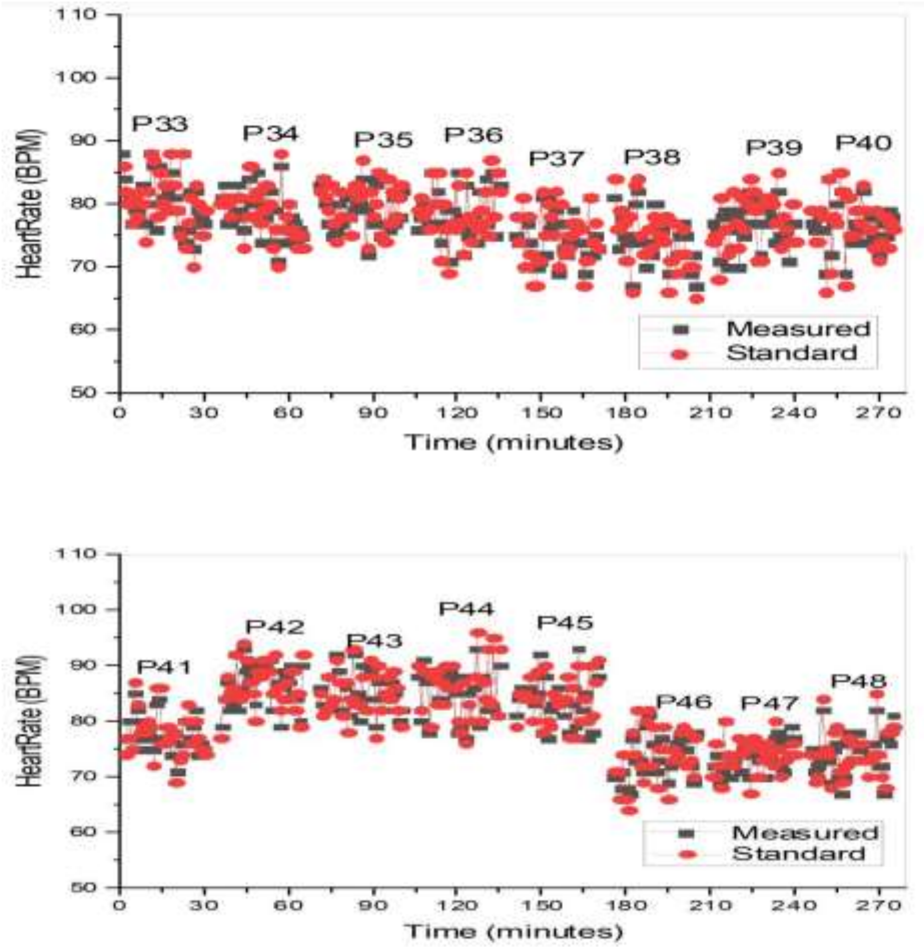

Figure.12: Heart rate values at general ward

The patients in the outpatient ward have a typical temperature variance of 0.8 degrees Celsius, bringing the average temperature to 35.45 degrees Celsius. The average pulse rate of the patients is 79 beats per minute (PPM), while the standard deviation of their pulse rates is 10.21 beats per minute (BPM). The results from the patients' pulse oximeters show that their average SpO2 is 97.57% on average, with a standard deviation of 2. The heart rate's standard deviation was 10.76 beats per minute (BPM), which is identical to the pulse rate. The average heartbeat per minute (BPM) was measured at 78.58. The patients' standard deviation was 2.7 RPM, and their average breathing rate was 15.4 breaths per minute (RPM). The device measured the systolic blood pressure of the patients, which had an average of 120.5 mm Hg and a standard deviation of 2.5 mm Hg. At the outpatient clinic, the average diastolic blood pressure reading is 78.41 mm Hg, with a standard variation of 2.5 mm Hg.

8. Conclusion

Telehealth is necessary due to inadequate medical facilities and pandemics such as the COVID-19 outbreak. The system under development aims to provide a comprehensive environment for telemedicine applications with multiple peripherals. The measurements are collected in various hospital environments with varying ambient temperatures. The acquired results are consistent with the hospital's standard protocols for measuring various physiological parameters. The increasing demand for telemedicine is a consequence of the growing population and the unequal distribution of medical services. Traditional techniques for monitoring and disseminating physiological data are onerous because they are not automated and require trained personnel to operate. The successful deployment of telemedicine applications requires Internet of Things-based solutions that include physiological monitoring systems. For telemedicine to be effective, patient information must be recorded and transmitted to a medical expert located in a different location using Internet of Things (IoT)-based devices that are connected to a large number of sensors. The newly devised system can accept physiological data from patients in the operating room, general ward, intensive care unit, and outpatient ward. Compared to ISO-standard techniques for the measurement of a variety of physiological parameters, the system's precision is quite high. The blood pressure is measured with an accuracy of 5 mm Hg, the respiration rate of the patients is monitored with an accuracy of 3 PPM, and the SpO2 readings are determined with an accuracy of 3%. The accuracy of the temperature sensor is 0.1 degrees Celsius. A user-friendly, cost-effective to develop and market device could be used by the general public to regularly monitor physiological indicators and deployed in primary healthcare facilities in rural and suburban areas to capture patient data. A specialist physician in urban areas can receive measured data in real-time in order to provide advice, and can access historical data as needed.

References

1. L. Balakrishnan and Krishnaveni, "An Internet of Things(IoT) Based Intelligent Framework for Healthcare – A Survey," *2021 3rd International Conference on Signal Processing and Communication (ICPSC)*, Coimbatore, India, 2021, pp. 243-251, doi: 10.1109/ICSPC51351.2021.9451739.
2. C. S. Kruse, R. Goswamy, Y. Raval and S. Marawi, "Challenges and Opportunities of Big Data in Health Care: A Systematic Review Corresponding Author", vol. 4, pp. 1-12, 2016.
3. Blumenthal, I., 1992. Should we ban the mercury thermometer? Discussion paper, Journal of the Royal Society of Medicine, Vol. 85, 553-555.
4. M. H. Miraz, M. Ali, P. S. Excell and R. Picking, "A Review on Internet of Things (loT) Internet of Everything (IoE) and Internet of Nano Things (IoNT)", pp. 219-224.
5. K. Lin, C. Li, D. Tian, A. Ghoneim, M. S. Hossain and S. U. Amin, "Artificial-Intelligence-Based Data Analytics for Cognitive Communication in Heterogeneous Wireless Networks", *IEEE Wirel. Commun.*, vol. 26, no. June, pp. 83-89, 2019.
6. Dinesh, C. S., 2015. India still struggles with rural doctor shortages, The Lancet, Vol. 386(10011). DOI:https://doi.org/10.1016/S0140-6736(15)01231-3
7. L. Liu, Z. Chang, S. Member, X. Guo, S. Mao and S. Member, "Multi-objective Optimization for Computation Offloading in Fog Computing", vol. 5, no. 1, pp. 283-294, 2018.
8. Francis B. B., Robert LeBlanc, A., Nasmith, J. B., Palisaitis, D., Dubé, B., & Nadeau, R. 1997. Continuous ST-segment monitoring during coronary angioplasty using orthogonal ECG leads. Journal of Electrocardiology, 30(3), 175–187. doi:10.1016/s0022-0736(97)80002-7.
9. G. Aceto, V. Persico and A. Pescapé, "Journal of Network and Computer Applications The role of Information and Communication Technologies in healthcare: taxonomies perspectives and challenges", *J. Netw. Comput. Appl.*, vol. 107, no. February, pp. 125-154, 2018.
10. M. Pham, Y. Mengistu, H. Do and W. Sheng, "Delivering home healthcare through a Cloud-based Smart Home Environment (CoSHE)", vol. 81, pp. 129-140, 2018.
11. Iyengar K. P, V.K. Jain,R. Vaishya, 2020. Medical doctors in India are on strike: a moral and national conundrum Postgraduate Medical Journal Published Online First: 24 November 2020. doi: 10.1136/postgradmedj-2020-139325
12. Klaus MD, Fassbender, MD. Clotilde Balucani, MD. Silke Walter, et al, 2013. Streamlining of prehospital stroke management: the golden hour, The Lancet, Vol. 12 (6), pp. 585-596. DOI:https://doi.org/10.1016/S1474-4422(13)70100-5

13. Koo-Young, C., Walsh, T. J., Massie, E., 1965. Wolff-Parkinson-White syndrome, American Heart Journal, Vol. 69 (1), pp 116-133. https://doi.org/10.1016/0002- 8703(65)90224-3.
14. Kwok, C. S., Rashid, M., Beynon, R., Barker, D., Patwala, A., Morley-Davies, A., et al, 2016. Prolonged PR interval, first-degree heart block and adverse cardiovascular outcomes: a systematic review and meta-analysis. Heart, 102(9), 672–680. doi:10.1136/heartjnl-2015-308956
15. Meijer, G. C. M., Wang, G., Heidary, A., 2018. Smart temperature sensors and temperature sensor systems, Smart Sensors and MEMs, 57–85. doi:10.1016/b978-0- 08-102055-5.00003-6
16. Ojo, M. O., Giordano, S., Procissi, G., Seitanidis, I. N., 2018. A Review of Low-End, Middle-End, and High-End IoT Devices, IEEE Access, 6, 70528–70554. doi:10.1109/access.2018.2879615.
17. Scott Kruse C, Karem P, Shifflett K, Vegi L, Ravi K, Brooks M. Evaluating barriers to adopting telemedicine worldwide: A systematic review. Journal of Telemedicine and Telecare. Vol. 24(1) 2018 pp. 4-12. doi:10.1177/1357633X16674087
18. N. Mathur et al., "A Practical Design and Implementation of a Low Cost Platform for Remote Monitoring of Lower Limb Health of Amputees in the Developing World", *IEEE Access*, vol. 4, pp. 7440-7451, 2016.
19. Sridhar, V., Girish, K., Badrinarayan, M. Analysis of crowdsourced data for estimating data speeds across service areas of India. TelecommunSyst 76, 579–594 (2021). https://doi.org/10.1007/s11235-020-00736-z
20. Vaidya, N. S., Rughani, P. H., 2020. A forensic study of Tor usage on the Raspberry Pi platform using open source tools. Computer Fraud & Security, 2020(6), 13–19. doi:10.1016/s1361-3723(20)30064-6
21. N. K. Jha, "Smart healthcare," *2018 IEEE International Conference on Consumer Electronics (ICCE)*, Las Vegas, NV, USA, 2018, pp. 1-1, doi: 10.1109/ICCE.2018.8326054.
22. O. Al-Mahmud, K. Khan, R. Roy and F. Mashuque Alamgir, "Internet of Things (IoT) Based Smart Health Care Medical Box for Elderly People," *2020 International Conference for Emerging Technology (INCET)*, Belgaum, India, 2020, pp. 1-6, doi: 10.1109/INCET49848.2020.9153994.