

Internet of Things (IoT) Based Health Monitoring & Facility System for Remote Homes

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How to cite this article:

Malik, I., & Ullah, A. (2024). Internet of Things (IoT) Based Health Monitoring & Facility System for Remote Homes. *Journal of Excellence in Social Sciences*, 3(1), 96-109.

Received: 20 August 2023 / Accepted: 27 December 2023 / Published online: 8 April 2024

Abstract

This research study explores IoT's potential in the healthcare sector. The proposed system comprises a series of smart devices connected to the patients, a data collection and transmission system, intelligent software for basic medical analysis, and a team of medical practitioners to handle complex scenarios. To test the efficacy of the proposed mechanism, the healthcare system was simulated using the ns-3 software, and a pilot project was conducted on a small scale, where the medical conditions of three to five patients were monitored, and a medical practitioner coordinated remotely. The pilot project results were encouraging, and the proposed IoT-based healthcare system demonstrated a significant reduction in the burden, improved efficiency and a better quality of life for patients. The proposed mechanism has the potential to revolutionize the healthcare sector and provide relief to the overburdened healthcare systems in developing countries. IoT in healthcare can help provide remote medical assistance to patients in remote areas, reduce hospital load, and enable doctors to monitor patients' health in real time. Furthermore, the proposed system could facilitate access to medical care for marginalized communities where access to healthcare is limited due to geographical or financial constraints. The system proposed in this study has the potential to significantly improve healthcare outcomes and alleviate the challenges faced by the healthcare sector in developing countries. The system has demonstrated its effectiveness in a pilot project, and its implementation could positively impact the healthcare system.

Keywords: Internet of Things, Healthcare Industry, Health facility, Remote Homes

1 Introduction

The Internet of Things (IoT) is a revolutionary mechanism that has been bringing magnificent changes in the lives of mankind for the past two decades. IoT refers to the network where several

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devices are connected, and these devices communicate in real-time, thus establishing a convoluted chain of reactions (Manogaran et al., [2018](#)). In an IoT-based system, sensors record and observe real-time data processed through algorithms. In case of necessary action, the system automatically generates and applies the necessary response (Blake, [2015](#)). Nowadays, advanced cloud computing, AI tools, and big data analytics mechanisms with databases are available, and they are even more simple in implementing sensors-based solutions to our current predicaments (Saif et al., [2020](#)). IoT has major applications in numerous fields, such as smart homes, smart meters, smart grids, smart security systems, smart health, etc.

IoT leverages smart devices and the internet to deliver solutions to industries, the medical field, government agencies, homes and institutions. Novel business models and security plans are not the results of successfully implementing these sensors-based connected networks (Abdulwahid, [2019](#)). With modern communication technologies like near-field communication and wireless sensor networks, IoT has gained widespread acceptance and application in various sectors such as auto trains, auto cars, payment-checking sensors and auto doors at malls (Kishor & Chakraborty, [2022](#)). Another concept of smart home systems has been realised due to the implementation of the internet and sensors to automate our homes and conserve energy through efficient utilization of units. Considering IoT implementation at the hospital, it will monitor different wards, trauma centres, the number of patients under treatment and awaiting treatment, etc. This will help revolutionize how patients are dealt with and how hospital services are run. The medical field can greatly benefit from implementing this sensor-based model, and building databases holding medical data files will help ease the diagnosis of patients (Rghioui & Oumnad, [2018](#)). Considering its scope in trade and industries in economics and finances, its achievements are many, to name a few. It has successfully thwarted many cyber-attacks and offers platitudes of protection and security layers. Due to internet data integrity, loss and theft are at risk. IoT can be upscaled and encrypted to protect databases, have appropriate data backups, and be redundant to nullify risks and safeguard against invasion (Sasubilli et al., [2020](#)).

1.1 Problem Statement

With the exponential population growth and recession in global economies, the economically underprivileged section of society has been facing difficulties in visiting hospitals for diagnoses and treatments (Malik et al., [2021](#)). During the COVID-19 pandemic, most of the patients were reluctant to visit the hospital and were relying on telemedicine or asking a friend who is a doctor. Changes in virus spread were high, and so was fear. Most people who catch the virus from hospitals and third-world countries have poor conditions at medical centres with poor sanitation and protective gear (Fernandez & Pallis, [2014](#)). Furthermore, in poor nations, the prevalence of quacks is high, and the use of syringes in remote villages with quacks in driving seats cannot be ruled out (Bhanushali et al., [2020](#)). To overcome this gap, the internet and sensors should be utilized in such a manner that simplifies medical procedures and medical checkups. Developers have made significant feats in building a great range of medical devices that are readily available in markets at cheap rates and help capture human health indicators. Moreover, cloud computing and big data analytics have played a vital role in business decisions. Similarly, these can be deployed at medical facilities to play their role in recording, maintaining, and giving insight into the medical trajectories of our population (Golpira et al., 2021). Therefore, authorities will have a clear picture of the population's health condition age-wise across different regions and can make decisions to allocate relevant health resources to other hospitals.

1.2 Scope and Significance of this Study

The following are key scopes that this study signifies.

- This research study will contribute towards technology utilization to improve the life and lifestyle of people in general.

- During the pandemic, most people were clueless, and most of them rushed to hospitals for non-related symptoms. This overburdened the fragile healthcare infrastructure, which was also short on medical practitioners.
- It will accrue benefits at both ends. Patients will become self-aware, and Hospitals/Doctors will be less stressed.

1.3 Objectives

This research study aims to develop a simulated implementation of a remotely controlled IoT-based healthcare system. Following are the key aims and objectives of this paper.

- Patients will be able to consult physicians remotely without visiting hospitals.
- Physicians can check reports on their devices and advise patients.
- The financial burden of patients and hospitals will be reduced.
- Data will be recorded through sensors and saved in a centralised cloud-based setup.
- In case of a fundamental problem which has been treated before, the machine learning algorithm will generate advice without the involvement of a physician.
- In case of a complicated problem, problems will be escalated to physicians.
- If necessary, patients will be advised to visit hospitals.

2 Literature Review

The Internet of Things (IoT) has been a fascinating research area, and various studies have been conducted in this domain. One such study conducted an extensive literature review and analysed IoT's implementation in different industrial sectors (Malik et al., [2021](#)). The authors concluded that IoT has applications in almost every field, including automotive industries, embedded devices, environment monitoring, agriculture, construction, smart grid, and healthcare. Each year, new advancements are reported across different spheres of life. We are in constant touch with IoT-based solutions and use them seamlessly daily. Similarly, Golpîra et al. ([2021](#)) conducted a literature review and proposed a comprehensive framework for integrating IoT in various logistics enterprises. Transportation improvement can significantly benefit the supply chain and reduce not only CO2 emissions but also conserve fuel and cost. Not only does our environment benefit, but so does business across the globe. Another study examined the implementation of IoT systems, highlighted the challenges that threaten any IoT system, and provided potential solutions (Pushpa & Riyaz, [2018](#)). These threats are not limited to cyber-attacks; intellectual thefts are also on the rise. To guard against such misuse, researchers have developed significant checks in the form of data encryption, data redundancy, firewalls, and digital signatures. As we move towards the digital world, threats will be there, but security enhancement is a regular feature, and updates are patched regularly to various applications in use (Singh et al., [2022](#)). Choi et al. (2021) also presented a framework for developing smart homes through an integrated IoT-based system. The healthcare sector has also been discussed in research studies, with Chunara et al. ([2021](#)) examining the status of telemedicine in providing healthcare accessibility to marginalised communities. The study encouraged the incorporation of telemedicine to increase healthcare reachability. Saghaian et al. ([2022](#)) analysed the factors leading to the closure of private-sector hospitals due to financial hardships in the developed world. Another research study focused on the viability and usefulness of electronic health records for improved learning and accelerated research development (Chen et al., [2021](#)). Digital health records last longer than paper records and can be stored for ages. Digital information does not age compared to written information, and digital data can be used to plot charts to deliver a more vivid graphical context.

Farhin et al. ([2021](#)) proposed a multilayer security system through Bayesian inference-based trust management with the digitally signed blockchain network to improve data protection mechanisms on the Internet of Healthcare things. Furthermore, since IoT employs the internet as

communication media, it is open to intercept and necessary coding of data streams with authentication checks and helps protect against unauthorised access. Additionally, Khan et al. (2022) have proposed a health monitoring system that addresses the dilapidated health infrastructure of Bangladesh and caters to patients during the COVID-19 pandemic. Their proposal was modelled using hardware such as Arduino, an oxygen meter, and a temperature sensor.

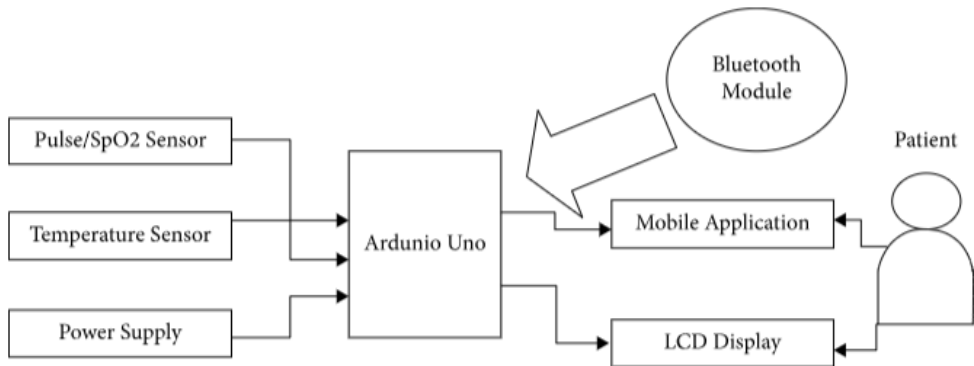


Figure 1: Block Diagram (Khan et al., 2022)

Another similar research was performed by Wu et al. (2023) in which, again, pandemic-exposed health emergency response shortcomings were highlighted and addressed by using wearable health monitoring devices that can help quarantine patients of virus affected to have their health concerns diagnosed and addressed using IoT applications.

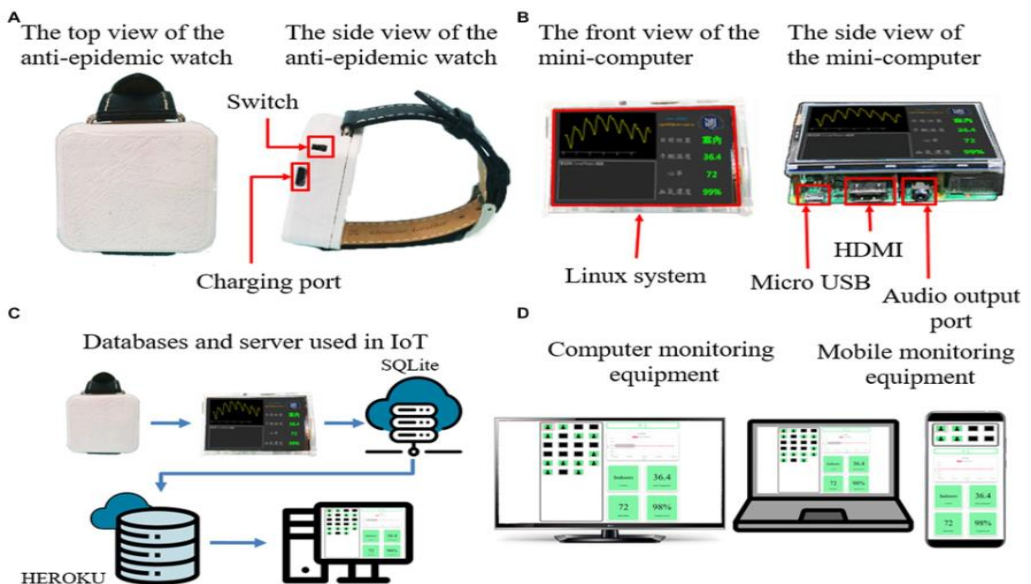


Figure 2: IoT-based wearable health monitoring device and system (Wu et al., 2023)

There is continuous development in medical engineering. With each passing day, either new equipment is developed or the previous one is improved. All these medical tools must incorporate data storing and sharing mechanisms. Since these are deployed and used only at hospitals, they can greatly contribute to the cause of IoT applications by communicating their data to a central database and processing unit. This will give a glimpse of health trends that are dealt with by the

hospital. It will provide a clear picture of which type of patients are getting treatment, i.e., whether they were healthy, underwent unnecessary tests, or were diagnosed with defects. This will go a long way in rationalising hospital medical tests and will migrate patients to use this checkup model (Al-Turjman et al., [2020](#)). The convolution of this system will deliver unprecedented results and patient satisfaction. Wait times can be reduced to the bare minimum, and the quality of diagnosis will become unparalleled (Maksimovic et al., [2020](#)). Some researchers have worked with telemedicine and succeeded during the recent pandemic, but a medical database was not conceived then. The proposed model aimfully overcomes some of the deficits in previous related works by having appropriate data storing elements and using big data analytics insightful deductions (Jagadeeswari et al., [2018](#)). TV programs showed different online sessions with doctors with varying degrees of patient interest in approaching this facility. Some may avoid it due to shyness, which can be addressed by implementing this model (Yuehong et al., [2016](#)). However, there still needs to be a research gap regarding IoT's implementation in healthcare, which this study aims to fill. Sifting through the internet, one can find various medical-related work in various geographical areas, but IoT-based intelligent systems are a rarity. Some work in USA-leading hospitals has been carried out that is limited to those hospital areas only (Kumar, [2015](#)). Major works in Europe are focused only on smart environments and transportation. This means there is a vacuum in this field that needs to be filled with sound methodology to help scientists build reliable structures that will improve the region's overall health. In poor nations, health is a luxury and expensive to maintain (Shah et al., [2018](#)). The trickle-down effect of this model will help these nations to overcome their deficiencies. Moreover, the proposed framework contains seven prime health indicators of the human body: blood pressure, blood glucose, heart rate, temperature, oximeter, step counters, and calorie consumption. These parameters are vitals and tell a complete picture of the optimal functioning of the human body. Some researchers have worked with telemedicine, which achieved success during the pandemic, but the medical database was not conceived at that time (Birje & Hanji, [2020](#)). The proposed model aimfully overcomes some of the deficits in previous related works by having appropriate data storing elements and using insightful deductions from big data analytics.

3 Methodology

NS3 is an open-source simulator on open-source operating systems such as Ubuntu. The simulator requires various packages to be installed for its operationalisation. It runs on C++, so it is unnecessary to learn another language to operate it. It has many libraries, but external libraries can also be used. It has a graphical interface, and at the same time, users can use external graphical animations with little modifications to the command line. Considering these advantages of NS-3 and familiarity with the C++ program, it is used to perform this research experiment. The experiment involves sensors, a CPU, and a database. These nodes can be easily created with already available libraries and modified in name, working to achieve a communication model of the healthcare industry. Pre-existing mesh and star topologies have been combined to obtain the topology for this research implementation. Coding is easy to modify, and help from the internet was also taken to develop an algorithm to validate this model of health facilities for remote homes. A node represents the human person and is remote to the CPU and medical database. Sensor nodes are in the vicinity of human nodes and record physical metrics of human vitals.

A simplified version of the proposed model has been developed and implemented in the NS-3 simulator, which embodies the following key features.

- A set of customer end devices that monitor physiological features such as temperature, pulse rate, sugar level, oxygen level, blood pressure, etc.
- These devices communicate this data to centralized processing units, which then compare these values with the medical database library and detect anomalies, if any.
- In case of anomalies, the patient profile is highlighted, and the patient is informed through

text message, email or mobile app for prescription and remedial measures.

- The concerned physician is alerted, and system-generated remedial measures are communicated to the patient, with or without the physician's approval, depending on the severity of the issue.
- In case of minor health problems such as flu or headache, etc., the CPU generates a sufficient predefined response.
- In case of severity, the physician must submit a response to the end user. It can be a prescription or a further medical procedure, depending upon the patient's exact condition, as highlighted by sensors.
- In addition to sensor data, patients can share feedback in their profile for medical advice or to explain their current position.

The sensors can be available on smartphones, purchased and placed at home, or in other appropriate locations. Whenever a patient comes into contact with sensors to record values, the sensors send these values to the CPU via Wi-Fi. The CPU will then generate a remedial response by looking up the database.

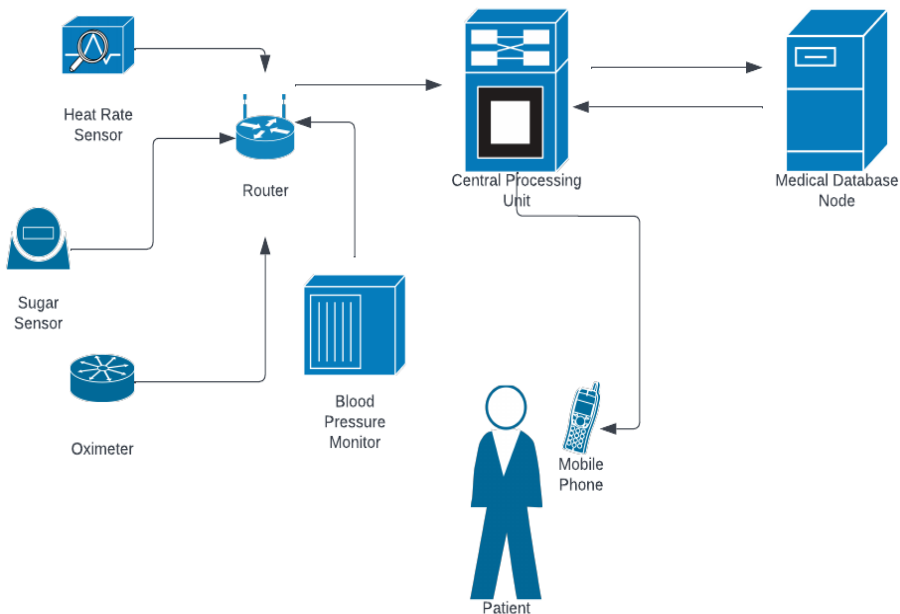


Figure 3: Implementation Setup

The NS-3 is easy to use and is an adequate tool for the undertaken simulation. The simulator consists of its vast libraries of C++ codes that are modified to implement this scheme of work. To run NS-3, ubuntu needs to be installed on a high-end computer. Necessary updates and libraries must be installed to enable the simulator to run without errors. Netanim can also be used when required packages are installed to make it function and show an animation of the proposed model. Both OS can run simultaneously, so there is no need to remove Windows and install the open-source OS as NS-3 does not run on Windows. Due to this experiment's lack of practical health records, only a simple library is created with predefined medical data to implement alert signals from sensors to CPU and from CPU to database for a lookup table and then generate an appropriate patient response.

Starting with the coding on the NS-3 flow diagram (figure 3.2), logic is developed to be translated into code. Since a huge number of sensors are available in the market to simplify the procedure

and show concrete results, there are four sensors to record values and send data to the centralized processing unit. This processing unit then compares these values with a medical database and stores them there. Comparison is done on a range rather than a fixed value. Based on medical comparison, the processing unit decides. The decision follows the nature of the illness depending on the patient's vitals as recorded by the sensor. If vitals are normal, the patient is healthy, and no prescription is required. The patient is informed accordingly. A prescription is sent to the patient based on the medical database record if there is a minor variation from the standard vitals values. Prescriptions for each condition are predefined in the database gathered from medical institutions and doctors. Only multinational medicines that are prescribed are of solid quality. This medical database stores each registered patient's medical history and all the personal information such as BMI, age, marital status, family medical issues, genetic issues, etc. This database follows the big data analytics model to ensure accurate analysis. The larger the data sample, the more precise the outcome will be. Suppose the sensors record poor values of health parameters. In that case, the processing unit immediately informs the doctor of the patient's medical condition, who then prescribes or advises the patient to visit the hospital, depending on the severity. This process eliminated the need for no to less medical needs of a patient and only requested critical or acutely ill patients. Hence, a third of the traffic is diverted to the hospital, and the system handles two-thirds.

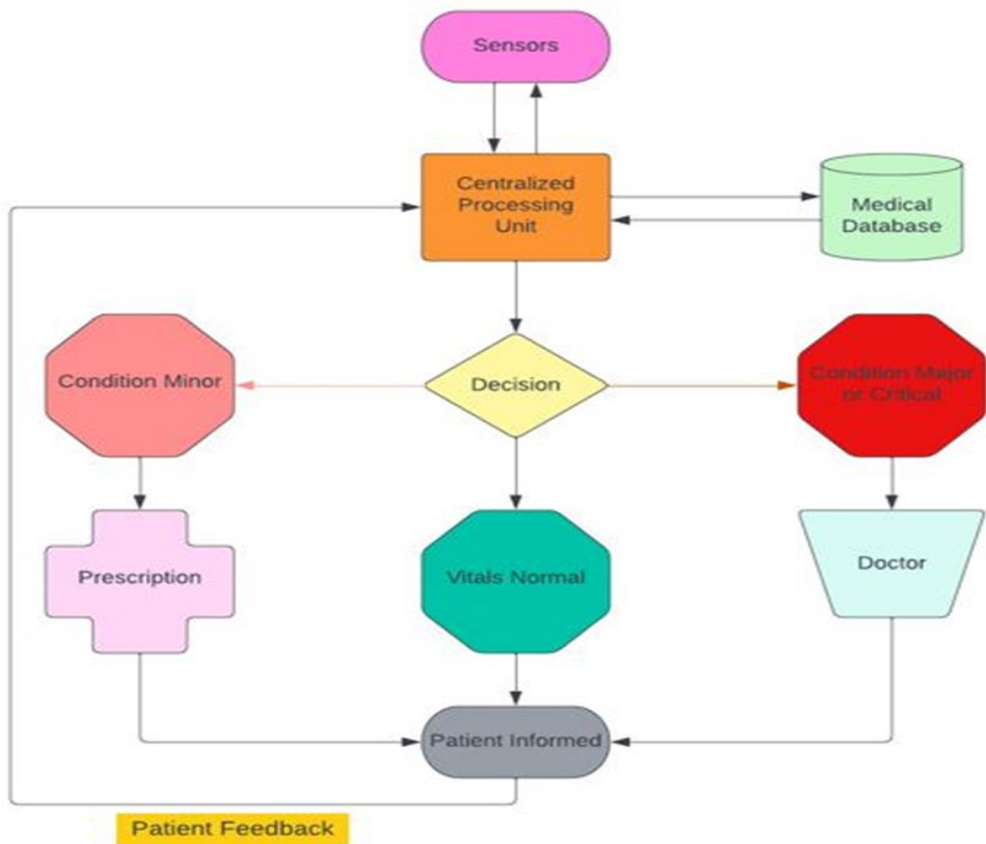


Figure 3: Flowchart

From the flowchart, the whole process is simplified for understanding and experimentation. This graphical representation makes it easier for the reader to grasp the method of remote health

facilities. As can be seen in the chart, the sensors, which are devices connected to human beings, record values of health parameters and turn those values into electrical signals. The Central Processing Unit collects these signals via internet connectivity. Most users now have internet connections and use fixed landlines or data services for mobile communication. The CPU then compares this signal information with the existing database scenarios. Against these scenarios, the CPU decides based on variations in values from sensors to those in the data silo. Only three outputs exist: the condition is expected, the condition is significant or critical, and the condition is minor. In each case, the patient is informed except in major or critical shortcomings of health in which the doctor is alerted and delivers a prescription or calls the patient to the hospital for further treatment or insights.

3.1 Implementation

The implementation is carried out on a simulator. The simulator selected is NS-3 due to its ease of use and relies on C++ programming. A laptop is used to install necessary software and an open-source operating system. It is essential to keep a backup before proceeding. This simulator was developed for educational and research purposes. Four sensors were selected for implementation on the simulator: an oximeter, sugar level monitor, heart rate monitor and blood pressure monitor. In NS-3, four network nodes embody these sensors. The nodes are created using its internal library. The libraries for the node are modified to incorporate the sensors. The programming is C++-based and easy to perform. The nodes are Wi-Fi enabled to allow data communication. Nodes act as actuators that record physical parameters, turn them into electrical pulses and send them over. The average range values of these parameters are recorded in the database node in NS-3. Star Topology is used for sensor nodes to interact with human nodes. The basic code available with the NS-3 library is used. The necessary configuration of nodes is done, as well as the assignment of IP addresses. It is pertinent to mention that data rates are also needed to configure nodes in NS-3. The database node has predefined values for each health parameter discussed above. These were added manually to verify this mechanism of application of IoT mode. Databases are memory elements connected with entities that send data and entities that work on those data. These are also called memory buffers that hold data values. The central processing unit is programmed to receive values from these sensors against a single patient and compare them with average range values in the database using if-else logic. The CPU is the decision maker. It has been programmed to do so. Each node sends a pulse to the CPU, and the CPU has a buffer memory that holds that value. This node library has been modified to enable this method. Since four sensors are used, the CPU holds data from these four nodes. The CPU then compares these signals in data with a database and selects responses according to the algorithm. The result thus obtained is then communicated to the patient. The available library/code of wireless sensor node communication inside NS-3 has been modified to implement the architecture mentioned in the diagram below. The code has been inserted with the if-else logic C++ algorithm for each node, and return values have been replaced with statements.

In addition to modifications, several packages were included in the simulator to enable the program function as per the Open System Interconnect (OSI) model. Theoretically, the OSI is a seven-layer architecture, but there are five layers in practice. Nodes exist on a physical layer; each layer communicates via the interface. These communication layers are essential to consider while executing the program to avoid errors, as slight mistakes can result in the abortion of the run process. The data communication is handled by TCP instead of UDP for packet security checks. As in UDP mode, data packets can be lost, whereas in TCP, lost packets are resent. It is essential in medical correspondence that every packet of information is recovered. After completing the data communication formalities of the program, it can then only be shaped into the proposed idea.

After setting up the program in the simulator, the appropriate logic of if else has to be implemented. Basic C++ software is used to prepare the code for this. Code preparation follows pre-set

statements from four elements: the CPU and the Database. The simulator runs on C++ code but does not specify code problems; therefore, C++ software helped develop the code. C++ is object-oriented programming, and, in the current case, it is the perfect programming tool to help verify educational research. After considerable trials, a basic if-else logic was obtained and implemented with planted variations.

First, ‘if-else’ logic is implemented when values are typical for if logic and abnormal for else logic. A healthy response is returned to the patient for if logic, and for else logic, the process moves on to the second ‘if-else’ logic, where deviations from the normal range are considered. For variations within $\pm 15\%$ from the normal range, then the process moves to the following ‘if-else’ logic; otherwise, else logic is followed in which the doctor is alert to provide a remedial response. Under the following ‘if-else’ logic for variations within $\pm 15\%$, a remedial reaction is generated when above 15% variations are found than normal values under if logic, and under else logic, a remedial response is communicated for below normal range. In both cases, the patient responded with a remedial response. This $\pm 15\%$ threshold is implemented for the sake of experimentation. In practice, a medical practitioner will feed the required appropriate values just as the laboratory report holds, patient values are against a range of expected values for doctors to check. The same ranges can be fed into this model for realistic results. The flowchart of the Algorithm is shown in Figure 4.1 for ease of understanding.

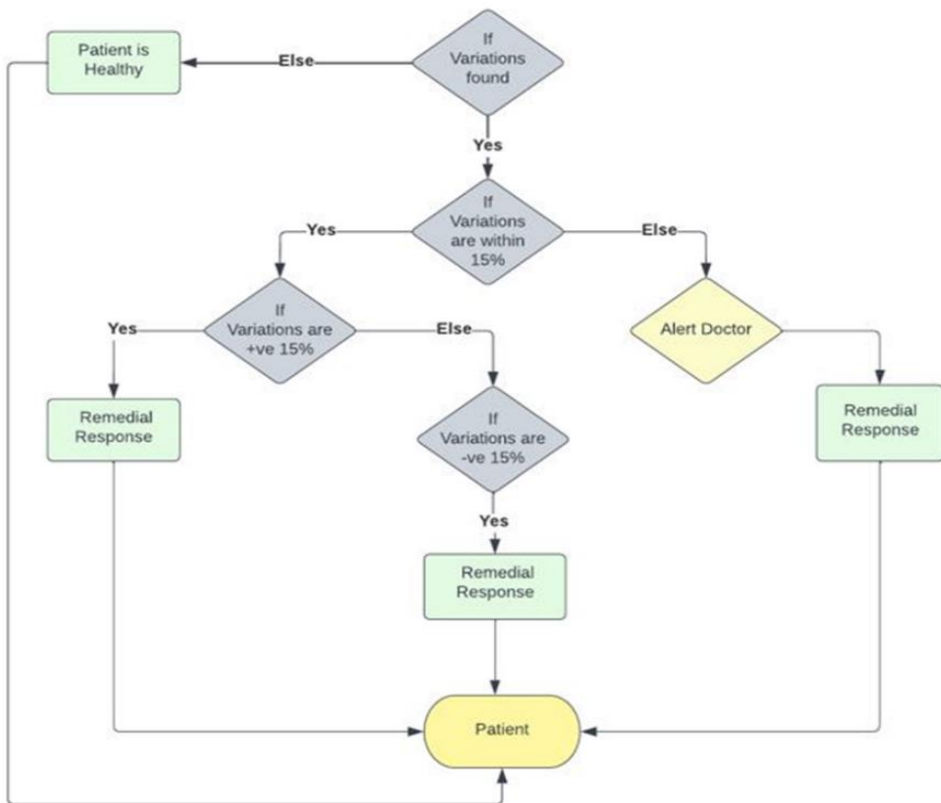


Figure 4: Algorithm

This code can be further upscaled to accommodate more sensors. Since numerous health-related monitoring devices are available at hospitals and markets that can help create a clearer picture of overall human health, the same can be implemented here by adding them to the program. In

practice, the more checkup devices, the better the system. This experimentation was carried out with four nodes; 7 nodes were proposed for the best results. As elaborated above, using seven sensors for critical health parameters will clearly show a patient's overall health condition. It is not just the system; doctors can also provide better responses when more parameters are in front of them. In practical scenarios, multiple health recorders can better judge a remote patient as more devices can help with accurate diagnosis. Due to rapid advancements in medical engineering, newer devices are entering the market, and soon, many monitoring instruments will become available that can be tied to the system and upscale its performance and reliability.

It is further mentioned here that the algorithm developed was for experimentation and was unsuitable for commercial purposes. A pilot project needs to be carried out in a particular hospital to establish for commercial purposes. During the initial stages, there will be complications and resistance. However, when benefits become apparent and weigh far more than what is at stake, they can be replicated nationwide, and their success can be donated to poor nations.

4 Results

4.1 Case 1

In the first case, the sugar level monitor recorded values from the human body and converted them into signals like an actual sensor. Then, IoT sent this collected data from the sugar level monitor to the CPU over the internet. The database is fed with a range of sugar levels and their prescriptions. These are manually written to implement the proposed idea. The level sent to the CPU by the glucose monitor is below 15% of the normal range. The CPU has used if-else logic compared with the database and returned the prescription for this illness category correctly predefined as "sugar intake required". In reality, the statement is replaced by doctor advice that can include a change of diet and an increase of meal intake from 3 to 5 times a day, depending on the scenario. Even medication or further diagnostic analysis depends on the severity of the patient's condition.

4.2 Case 2

In the second case, a blood pressure monitor was used. The blood pressure sensor records BP values from the human body and converts them into information signals. These signals were then transmitted to the central processing unit for decision-making. The database node in NS-3 has blood pressure values of 120/80mmHg, which is normal, and a range of non-normal values is also inserted into it. The sensor was programmed to send a BP value 10% above the normal to the CPU node. The CPU communicated with the database node and compared using if-else logic. The CPU then made the decision based on logic and selected the correct response from the database: "to reduce salt intake in diet". In real-life scenarios, appropriate remedial measures will be prescribed to the patient.

4.3 Case 3

In the third case, a heart rate sensor is used to record the value of the heartbeat. The normal range was fed into the database along with abnormal values. The sensor recorded physical values and was made to send data to the CPU beyond a 15% variation. The CPU compared this value with the database and, utilising the "if else" algorithm, selected the appropriate response by alerting the Doctor. Her doctor was shown as a node, which generated a remedial response to "visit hospital urgently". Furthermore, this logic can be further improved to dispatch ambulances if required by patients due to lack of transportation. Or a complete medical-fitted ambulance that addresses patient needs there and then. These advanced medical responses require more governmental funding for the healthcare sector.

4.4 Case 4

In the fourth case, an oximeter is used, and this sensor records values and converts them into information signals. It then sends average values to the processing unit as programmed over the wireless communication medium. The CPU checked this value with the data node and returned a “patient is healthy” response using the logic developed. Oxygen, being an important parameter, can reflect much on hemoglobin condition. The body needs oxygen to break down food and release energy. This energy then makes the body function normally.

This concluded the experimentation, and it verified this method and research. The logic was also tested, and the algorithm implementation was successful. In the above cases, this research has checked the mechanism of remedial response individually for each sensor. The same can be easily implemented for all sensors collectively, but for the sake of understanding, the procedure was kept simple to let readers grasp the underlying idea. In a collective setup, simultaneous values of each sensor are compared with the normal range, and the response is generated just like a complete checkup at a clinic where multiple tests are performed. Then, a remedy is provided for those abnormal tests. This model further confirmed the wireless communication, i.e. IoT implementation of the health facility for remote homes, which is the main focus of this research to provide medical facilities to distant homes and families. The data rates in the implementation setup also verified that low internet speeds are sufficient to execute this model and do not need super high internet speeds. Most remote sites lack fibre optical communications for high bandwidth. Simple 3G bandwidth is enough for the devices to send signals to the CPU.

This method can greatly reduce the influx of non-serious patients; sometimes, a remedy can be provided via mobile health units. Only serious patients needing otherwise unavailable facilities, and neither can be managed at home, will be required to visit hospitals. Furthermore, disabled and disabled people now don’t need to get themselves in a lot of trouble by visiting distant centres of health for them is now this facility and, in their remote homes, can avail of the services of a specialist. Researchers can further improve this system in the medical domain and benefit babies and newborns. Because health complications are not limited to any particular age group, and all shortcomings exist along with age segmentation.

The resilience of this model can be further improved with redundancy models of data centres and nodes. Not only at patient premises but hospital information silos can be made duplicates and stored at secure places not in the exact location. The primary health database can operate in controller configuration, and the redundant node will operate in slave mode. This can help against incidents of destruction or cyberattacks. Suppose the controller node shuts down for any reason. In that case, the enslaved person will come online and act as the master unit, providing the same service, ensuring seamless communication without the patient feeling anything different or devoid of service. Telecom Industries widely operate these models of data redundancy and keep mobile communication systems online 24/7.

The trailing figure 5.1 depicts wireless body project developed at NS3 simulation [27]. It gives the basic idea of remote catering for hospital services. It uses IoT in its mechanism to achieve the goal of a healthy life. Fitness offered remotely is now the focus of multiple research centres across different educational institutions and governmental bodies. This research method has taken the process to an advanced stage with complete packaging to address shortcomings of previous and prevalent trends in healthcare IoT models. IoT is at the centre of implementation in all these proposed schemes, and its importance cannot be overstated. Just as important, it is more prone to risks and attacks. Due to the involvement of electronics and coding, constant security firewalls and firmware updates are needed to protect against advanced virus and malware attacks. The results have verified the process and enabled further data protection and reliability research through redundancy. Additional studies in this field can help achieve robotic surgeries just as robotic machines are involved in fabricating silicon chips.

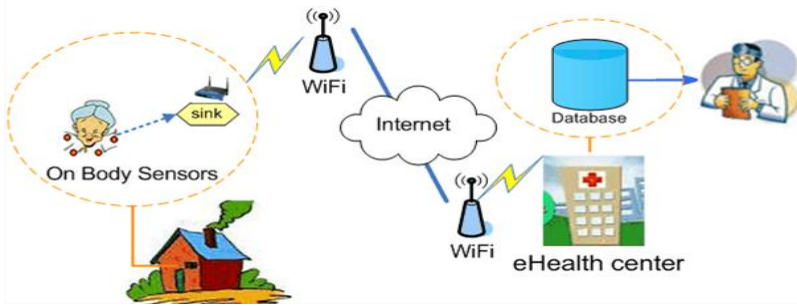


Figure 5: IoT Application Illustration [27]

5 Conclusions

Healthcare is one of the most disadvantaged sectors in the developing world, resulting in severe human suffering due to its inefficacy, lack of resources and governmental funding. To address this issue, this research study proposes an IoT-based framework that will enable remote monitoring and treatment of patients. The proposed framework aims to reduce the burden on the healthcare sector by improving efficiency and reducing costs and waste of resources. The proposed framework includes remote devices for monitoring, a data management system, intelligent software, and a group of remotely operating medical practitioners. These remote devices will generate and transmit the data, enabling the doctors to handle the patient remotely in case of issues. The IoT-based framework allows patients to receive high-quality medical attention from remote locations. This approach relieves the burden of finances from governments. Similarly, it also helps patients minimise health expenses and ensure some savings from it.

The study and its implementation have demonstrated its potential to commercialise the remote health monitoring facility. The advantages are numerous, and the limitations are minor. This research methodology and implementation have shown that a practical model can be prepared for a small hospital, and its success can be replicated nationwide. A model has been developed, and now investors/governmental agencies need to commercialise this project to benefit the general public. This simulation has laid the foundation for work to be started in the practical domain. Further researchers and engineers can also be taken on board to implement it in the practical domain. The results mentioned above are simplistic views of what can be done.

Further, many patients and doctors can be shielded from any outbreaks in future. Since remote delivery of human health will negate physical communication, protecting both the sick and the sick caretaker. So, not only in typical infectious diseases, it can benefit the masses, but also in viral outbreaks. It can provide a necessary barrier between different segments of interaction from home to hospital that can block the spread of the virus.

6 Future Work

However, this study is limited to a simulated demonstration, and the sample size may be increased for further research. Additionally, the proposed model does not consider the need to protect the patients' data. Future studies should incorporate data encryption tools to ensure that the machine learning algorithm can recognise and retain the history of individual patients. In contrast, personal profiles are encrypted and dealt with anonymously for data analysis, reporting, and demonstration purposes. Overall, this research study provides valuable insight into the potential benefits of IoT in healthcare. The proposed framework has the potential to transform the healthcare sector by improving accessibility to medical attention and reducing the burden on healthcare systems, especially in underdeveloped areas. This study's findings are significant for healthcare professionals, policymakers, and researchers in healthcare and IoT.

This research further opened doors for investigating data encryptions and database redundancy to make it more reliable and more complex to hack. These measures will build public confidence and make the system more robust and resilient.

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