Design smart hospital system based on cloud computing

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ABSTRACT

Smart healthcare is a program that provides services to patients and healthcare assistants at any time, it is used smartly with cloud computing. A smart mobile device can collect data from a wide range of receiving sets (Wi-Fi and cloud), underwired sensors, the internet of things (IoT). It permits doctors to monitor and diagnose patients with small embedded devices that are unobtrusive, wireless, lightweight, and capable of detecting, interpreting and communicating physiological signs easily in a timely manner without the need for a doctor present. This paper develops integrated smart records and reports and is shared via the cloud. A variety of small devices have been used that detect the object to be sensed and then tell the person monitoring the patient's condition, for example, body and room temperature, oxygen percentage, heart rate). This data is sent to the server via the Internet. To store details and monitor the patient through it. In the event that any error occurs in any of this data, such as a decrease or increase in the normal value, a signal will be sent via Telegram to the phone of the individual monitoring the patient's condition to alert and to take necessary action.

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1. INTRODUCTION

The National Institute of Standards and Technology offers cloud computing and defines it as a model for making omnipresent and relevant access to a public pool of computing training tools on-demand over the internet (for instance, storage networks, servers, applications, and services). Cloud computing is becoming increasingly popular in distributed computing environments where it can be efficiently delivered and released with no administration work or communication with service providers [1]. The use of cloud environments for storage and data processing is becoming more popular. The term "cloud computing" refers to accessible on-demand computer services through which users can be provided with computer infrastructure, applications, and business processes as a service wherever and whenever they need them, as shown in Figure 1 [2].

The long-held hope of computing as instrument for the emergence of cloud computing has become real with cloud computing can be equated with electricity and gas supply, so consumers are paid only on the basis of the use of the resources and services that have been given in a predictable monthly subscription. Everything has been rolled up; thus, one only pays for what he uses [3]. Many studies have indicated that cloud computing has a bright future in healthcare, and have proposed various frameworks to improve healthcare services. Platforms, software, and infrastructure are all available through cloud computing [4]. In terms of accessing shared computer resources. Wireless body area network (WBAN) systems are currently utilizing cloud computing technology. Power, storage, scalability, administration, and processing limitations may all be overcome. This combination of WBAN systems with CC technology (S-CI) aids the area of healthcare through real-time patient surveillance and early illness treatment as a sensor-cloud infrastructure. Wireless body area networks (WBANs) are notable for their creation and deployment in order to improve the quality of health care [5].

Managing the odd circumstances of chronically ill patients’ pervasive healthcare intensive care offers rich contextual information. In addition to improving the quality of life of elderly and chronically unkind people [6], continuous nursing and medical service response also help these people and parents by delivering high-quality programming services for their babies and infants who are completely paralyzed, quality healthcare is paramount [7]. It is likely as a result of the decrease in information knowledge. Several scientists have mentioned various skills in this manner. Cloud computing delivers more of the internet in terms of technologies, platforms, and infrastructure in sectors uses in the military, weather prediction, transportation, healthcare, and environmental monitoring, among others. It's possible to connect it to the sensor system [8].

People's attitudes towards technology have shifted all across the world. There's no need to sit in your workplace to do your business or everyday duties. Many characteristics, such as efficiency, dependability, and simplicity, are based on simpler lives. Easy internet access Users may switch to a variety of places to enforce the requirement to safeguard user data from unwanted disclosure, particularly via non-secure wireless networks [9]. All of these mobile device features and their integration into our lives are driving the transition to greener and smarter cities. Another new skill is cloud storage, which allows Links to save information whenever and wherever they choose see Figure 2 [10]. Then it can be used to maximize efficiency, increase output, and minimize cost and complexity in various organizations or by individuals. NIST describes cloud computing as "a pattern for providing access to a common pool of configurable computing resources to the omnipresent, easy, on-demand network (for instance, services networks, storage, servers, and applications) which, with minimal effort in management or contact with provision providers, can be easily provisioned and released [11].

However, in this mobile cloud computing (MCC) model, some requests require the production of this knowledge in real-time, such as applications for wellbeing, where data analysis and the retrieval of the correct decisions can make a difference between death and life of patients [12]. The cloudlets are placed close to the hospital and cover an area that has been approved by those who will have access to and monitor patient data as a whole. In addition, there is a large amount of patient data being generated in this model, and it is important to analyze it. Figure 2, Demonstrates cloud mobile computing for big data applications in healthcare. Over the last decade, well-being has grown in popularity. Table 1 lists several healthcare system improvements.

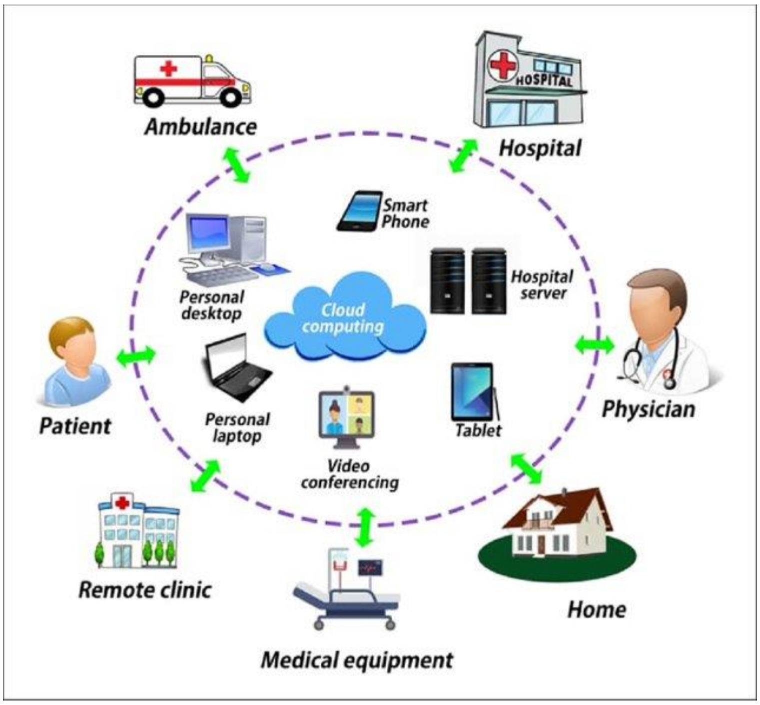

Figure 1. Cloud computing system

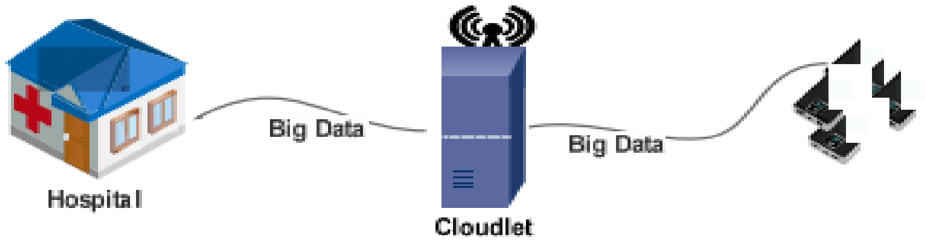

Figure 2. Mobile cloud computing (MCC) big data healthcare [11]

Table 1. Summary of related work

Authors	References	Device used	Observation
S. K. Dash, S. Mohapatra2 and P. K. Pattnaik	[13]	networks of wireless sensors (WSN)	Studied some common Sensor Network applications that use Cloud computing as a backbone It is new to bring several WSNs organized for different purposes under one top and see them as a single virtual WSN entity using cloud computing architecture.
B. Xua, L. Xua, H. Caib, L. Jiangb, Y. Luob and Y.Gub	[14]	Cloud-MHMS	The Cloud-MHMS system has four function modules that help with healthcare data management and application: multitenant data storage, data annotation, data examination, and clinical decision support. The Cloud-MHMS m-Health monitoring process.
L. Tawalbeh1, R. Mehmood3, E. Benkhlifa, and H. Song.	[15]	technology for big data and mobile cloud computing	This study discusses the importance of mobile cloud computing and big data analytics in enabling networked healthcare.
F. Alharbi, A. Atkins, C. Stanier, H. A. Al-Buti	[16]	strategy map and the KPIs	Based on a balanced scorecard approach, the goal of this study is to demonstrate the strategic value of cloud computing adoption to healthcare organizations.
S Lakshmanachari, C. Srihari, A. Sudhakar, P. Nalajala	[17]	Cloud of IoT and sensors	created an Android-based mobile data acquisition (DAQ) solution that gathers individualized health data, analyzes, and displays it on smart devices with the option of sending it to the datacenter for additional processing.
A. Abatal, H. Khallouki and M. Bahaj	[18]	semantic web with cloud computing	Using the cloud and the semantic web together, a semantic smart networked healthcare system makes it possible to view, transmit, and share medical records and reports.
N. A. Kumar, S. Suresh	[19]	Internet of things (IoT), machine learning, and hybrid clouds (ML)	The entire procedure would be considerably more effective and straightforward if a smart hospital information management system used hybrid cloud, IoT, machine learning, and patient and doctor unique IDs.
S. Chenthara, K. Ahmed, H. Wang, and F. Whittaker	[20]	electronic health records (EHRs)	As part of qualitative data analysis, this section conducts categorical research connected to EHR security and privacy preservation studies, making it easier to compare and analyze the core of the work.
C. He, X. Jin, Z. Zhao, T. Xiang	[21]	cloud computing	Suggest a network module attached to existing systems that are connected within the hospitals as a method to ease this construction HIS.
B. Ç. Uslu, E. Okay	[22]	Internet of Things (IoT)	IoT technology also makes it possible to increase Quality of Service (QoS). The flow of information between patients, physicians, and the manufacturers of pharmaceuticals and biomedical supplies is constant.

2. SMART HEALTH CARE

Patient physiological data is monitored, drug administration records are monitored, and patients and doctors are observed within a hospital using sensor networks, which are also available for use in health care and are often used. Figure 3 shows the smart health care system architecture; two key players communicate with the system; once the doctor or healthcare assistant is identified, the patient information can be consulted and patient health directories can also be generated, on the other hand, the patient is allowed to create analytics, share medical directories, and connect with the patient after logging into the system. The main goal of this study is to reduce force by incorporating the concept of home mechanization into the board architecture. Home mechanization is a word that refers to the use of specific computerization techniques in homes to improve comfort and accommodation.

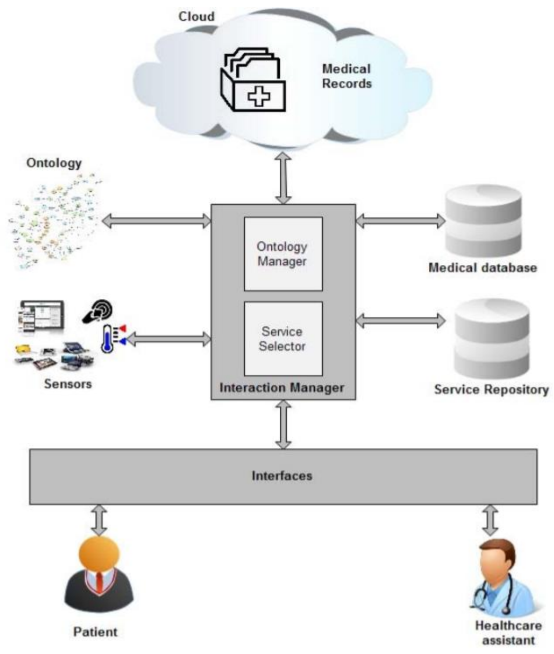

Figure 3. Architecture of a device

3. SENSOR SYSTEM

They are also utilized in a variety of industrial and civilian applications, such as environmental and habitat monitoring, machine health monitoring, and monitoring of industrial processes. Each node in the Network of Sensors comes equipped with a radio transceiver, a tiny microprocessor, and an energy source, usually a battery, or other wireless communication device. The sensor's node size might be anything from a shoebox to a single grain of dust. Depending on the scale of the sensor network and the complexity needed from each sensor node, the cost of a sensor node can range from hundreds of dollars to a few cents. In intelligent hospitals, the atmosphere for the expansion of autonomous sensors is favorable. Temperature, sound, vibration, friction, motion, and pollutants, among other physical or environmental elements, are geographically dispersed to track in a cooperative way. Military applications such as battlefield monitoring have accelerated the development of wireless sensor networks [23].

Sensor nodes, size, and cost restrictions emerge from the subsequent resource limits caused by resources, memory, computing speed, and bandwidth. A processer network composed of a large number of sensor nodes is a sensor network [24]. There are densely distributed sensor nodes. They deploy randomly and have co-operative capabilities within the phenomenon. These strategies are typically small and cheap. To produce and deploy them in large numbers, their memory, energy, bandwidth, and computer speed resources are strictly restricted. Pressure, accelerometer, heat, microphone, camera, and sensors, are different. These sensors consist of their elements: sensing, processing, and communicating and monitoring situations at various locations, such as temperature, damp, movement of vehicles, lightning conditions, pressure, etc. Detection, interaction, and computing (including hardware, software, and algorithms) from three different research areas are required to develop sensor networks thus, combined and distinct developments have guided research in sensor networks in each of these fields [25]. The interior layout of the cloud server is depicted in Figure 4. A database server, an HTTPS server, a MQTT server, and a Socket real-time communication server make up the four parts of the cloud server [26].

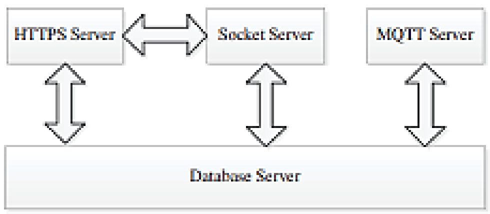

Figure 4. Internal structure of a cloud server

MQTT server: message transmission A smart device notifies the home gateway when its state changes, and the home gateway publishes the information to the cloud's MQTT server with a designated topic. The cloud's MQTT server then sends the message to all control terminals that have subscribed to the topic [27].

4. THE AFFAIRS CLOUD IN MEDICAL

The cloud computing paradigm provides a new solution to address the aforementioned issues. There has been some research conducted. Dealings recently outlined the MIA (Medical) issues in an attempt to apply the cloud approach in medical matters. A new cloud-based computing paradigm for cancer imaging research is discussed and proposed by scientists and physicians. Although it does not specifically address hospital issues, it does discuss the challenges of processing medical data and a thorough examination of cloud computing's potential [28]. In addition, the cloud technique allows for the collecting of patient data. It can automate the entire process, from bedside data collecting through medical staff information sharing and remote access. This paper explains how cloud computing can be used in hospital settings and points to future developments in HIS [29], [30]. The relevant words commonly used in sensor networks are as shown in:

a. Sensor: A transducer is a device that turns a physical event like heat, light, sound, or motion into an electrical or another signal that can be manipulated by other devices.
b. Sensor node: A sensor network's base unit, equipped with a processor, memory, wireless modem, and power supply.
c. Network topology: A graph with nodes representing sensor nodes and edges representing communication linkages.
d. Routing: Determining a network path from a source node to its destination.
e. Resource: Sensors, communication lines, processors, memory, and node energy are all resources.
f. Data storage: Support for sensor network applications at runtime. Storage might be local to the data-generating node, distributed over a network, or anchored at a few place.

5. THE PROPOSED METHOD

The healthcare system is under strain all around the world due to rising costs, an increasing load of chronic diseases, an aging population, and a shrinking number of healthcare workers. This complicated scenario has a significant influence on how health care facilities are organized and delivered. A smart hospital is one that employs streamlined and automated operations that are based on an ICT ecosystem of interconnected properties, namely the internet of things (IoT), which can be utilized to solve this problem, improve existing patient care programs, and bring new capabilities. As a result, what makes a hospital smart is the availability and usage of meaningfully connected systems and gadgets that contribute to overall smartness. While outdated systems may be an important element of intelligent end-to-end processes, this training will focus on new technology, notably IoT components. A noteworthy one is the wireless medical service that may deliver clinical health care from a distance. As people get older, their health deteriorates, and because the disability rate in the elderly is low, they are less likely to visit a hospital. The far-off medical facilities That could be specifically controlled and nursing-diagnosed diagnosis controlled to offer the immediate debate by means of a result. Body Temperature Natural body temperatures vary from 36.5 to 37.5 degrees depending on oldness, gender, illness, exertion, reproductive status, etc. Health monitors are mounted in clinics with major illnesses to facilitate the diagnosis of anomalies in body temperature. Heartbeat Level: The human pulse rate is calculated in bpm (calculated in contractions or beats). As seen above, the physical need for oxygen is due to the amount of contraction, that varies sensors are installed to screen the pulses rate during the different physical operations carried out during the day, the oxygen saturation level the word oxygen saturation in medicine refers to the sum of hemoglobin oxygen-saturated. Patients with extreme anemia, typically suffer from diminished arterial saturation of oxygen is less than 90 percent with SaO2.

In this work, the monitor of heart rate, despite elderly physiological signals, body and ocean temperature, and blood oxygen percentage, can be obtained to determine the elderly health status via the remote service. The used sensors are MAX30100 and MLX90614 as shown in Figure 5.

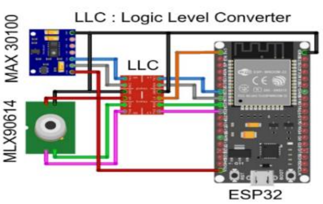

Figure 5. Architecture proposed method

The Component are used in this paper:

a. Temperature sensor MLX90614: it measures the body's patient temperature and room.
b. MAX30100: it gives signal processing to detect pulse oximetry and heart rate.
c. Microprocessor ESP32: A functionality MCU for a wide range of applications with integrated Wi-Fi and Bluetooth networking.
d. Logic level converter: The converter at the bi-directional logic level from spark fun is a small device that safely reduces 5V signals to 3.3V AND at the same time steps up 3.3V to 5V.
e. Router: A system for networking that forwards data packets between computer networks, routers perform traffic-directing functions on the internet and the data is transmitted over the network.
f. Server of Cloud: A virtual computer to supply heath sensed patient information and store health data, this data is also processed through some extensions. The Figure 6 Show the flow chart of the proposed system.

The proposed method offered into five steps:

a. The first step is patient feedback, when attached to the body of a patient, smart objects begin to feel the physiological limitations they are assigned to accomplish as patients breathe their daily life in an unobtrusive technique.
b. Smart items are the second stage. Smart items are responsible for sensing and sending to cloud storage at this level, allowing high volumes of sensitive patient information to be gathered, processed and stored. This system stores the data collected from the sensor nodes and allows the wireless internet connection of official users accessible.
c. The third step is the combination of data, which is forwarded to the specific cloud after the data is collected, depending on the arrangement model chosen by the healthcare institution.
d. Fourth step Cloud storage, patient health records (heartbeat, blood oxygen, body and room temperature) are stored in the cloud implementation form defined by the health agency where the information for this work will be accessible and stored on the server.
e. The fifth stage is to track performance data, usually having minimal access to health records for patients, family associates and care staff; while, on the other hand, clinicians have full contact with health records. They are also allowed to type notes, prescriptions and compose statements on the various health states of the patient. To clarify the work more, block diagram explains it.as show in Figure 7.

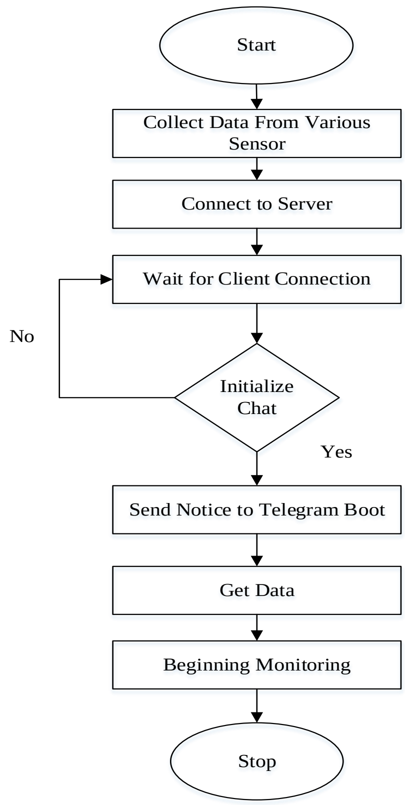

Figure 6. Flow chart declare steps proposed method

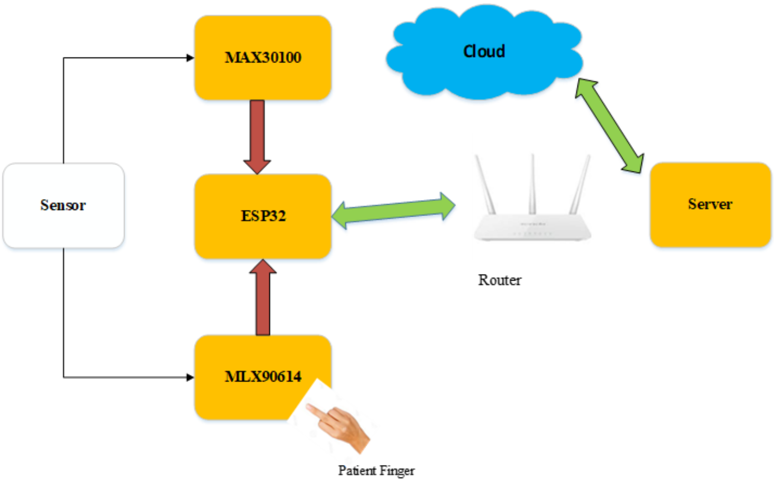

Figure 7. Shows block diagram for planned way

6. RESULTS

This paper has demonstrated fundamental features and criteria that direct the provision of smart healthcare services by current healthcare institutions. The conventional healthcare system used worldwide by healthcare institutions is evolving into a modern integrated and expanded smart healthcare system capable of solving the undeniably complicated current healthcare situation. The healthcare system project was implemented using C++ language, and IOT used MQTT. The web application is intended for observers, whether a family member or nursing staff. This improves efficiency, service quality, patient care delivery quality, and physician satisfaction when employing telemedicine services. We pointed out that the use of telemedicine services in clinical settings is contingent on physician and patient satisfaction. Making use of the service the research adds to empirical knowledge by identifying critical predictors. Impacting physician satisfaction with telemedicine services. When the system starts working, first a message or notification comes on the phone of the person or medical staff through the telegram bot “Hey, I'm working now" or as shown in the Figure 8. If the observer who monitors the patient's condition does not receive any message or notification, this means that he has not connected to the Internet, or the server may be offline.

Figure 8. Shows the start-up of the project

After connecting to the Internet, the system interface opens, which is divided into four sections that contain the data to be measured or monitored through which it enables or helps the doctor in diagnosing the patient's condition, and these data are: human temperature, room temperature, blood oxygen level, and heart rate; as shown in Figure 9.

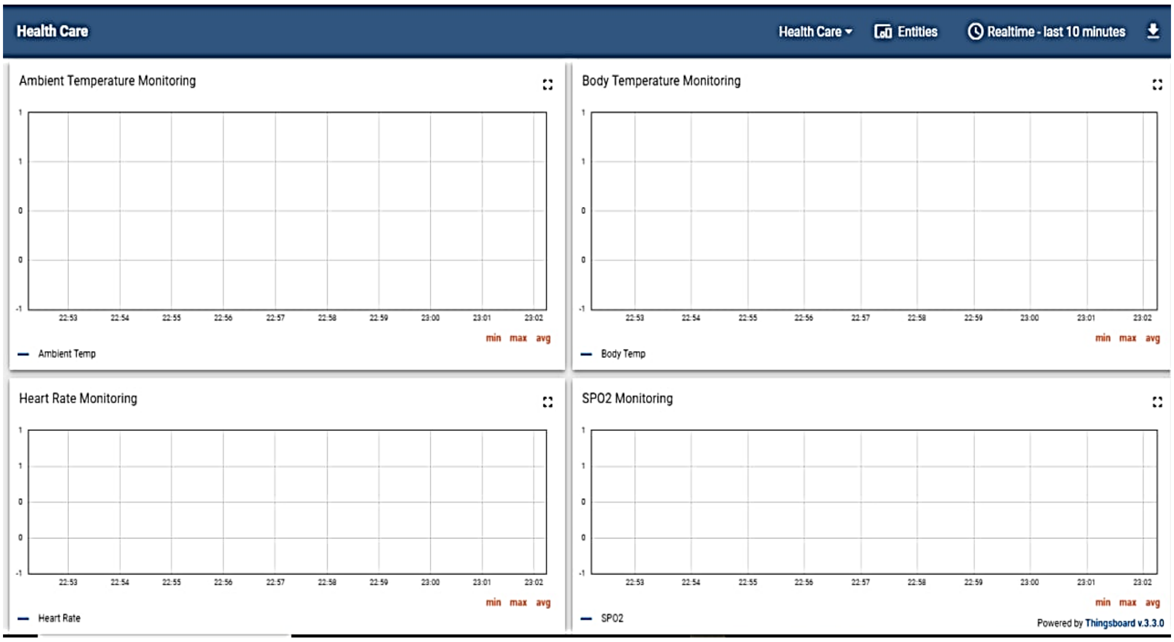

Figure 8. explain interface that contains the data to be monitored

The system begins to sense when a patient's finger is placed on the temperature sensor, and then begins to measure their temperature and the temperature of their location together on the same sensor used; As shown in Figure 9, the graph explains, a person's maximum body temperature is 47 degrees Celsius, the minimum is 11.3 degrees Celsius, and the average is 21.18. Send to A cloud server, is a virtual computer that provides and stores health sensitive data for patients, in addition to processing it through some plug-ins.

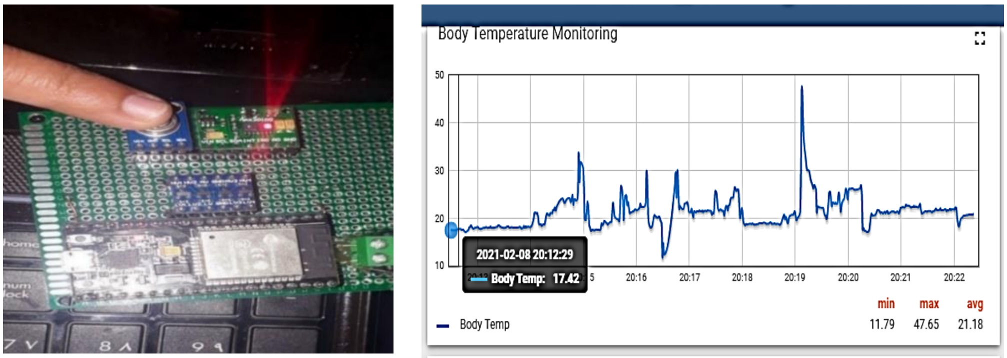

Figure 9. Experimental results show starts to run and clarify the measuring of body temperature

The interface of the system, which is divided into four sections, as in Figure 10, the first section shows the temperature of the place where the patient is. The above. 25.27^0. Min value is 23.33^0 and average value 24.24^0. The second section shows that the maximum body temperature is 26.55^0, the minimum is 19.09^0 and the average is 23.11^0. The third section is clear to monitor the heart rate max. It is 82.38 beat, the minimum is 0 beat and the mean is 43 beat. The last branch is as shown in the figure showing the percentage of SPO2 in the blood with a minimum is 0, a maximum is 116 and a mean of 58. All numbers mean that the patient's condition is normal.

Figure 10. Experimrntal result that show measure location temperature 25°, body temperature is 26°, heart rate is 82 beat and ratio of oxygen in blood is 116 respectively

When the oxygen percentage is less than the normal limit, which is less than 85, an alert message will be sent to the person who monitors the patient's condition, whether the monitoring is in the same place, such as the home, hospital or clinic, or the monitoring is remotely anywhere in the world. A warning message will be sent to the nurse To take the necessary action and give the appropriate treatment as shown in Figure 11.

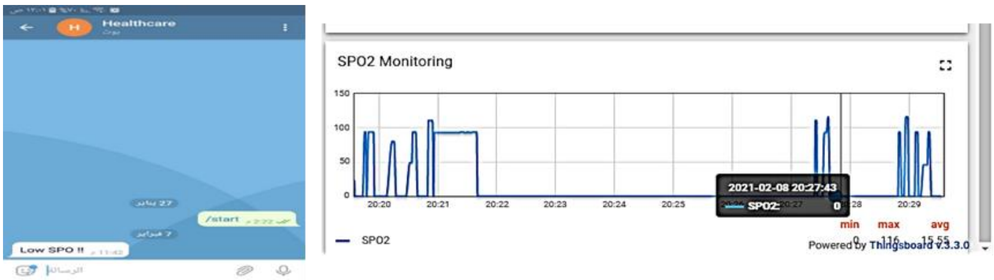

Figure 11. Offer the abnormal case for ratio oxygen

Nowadays, the customary process in the medical healthcare systems is to track the patient's vital readings such as: blood pressure, temperature, and heart rate. These readings are considered as an indicator for the criticalness of the patient. Accordingly, the IoT technology helped so much in recording these readings without interfering in the patient's daily activities. These IoT devices could be small in size and thus could be implemented in the smart phones. Therefore, they can help in remote monitoring and easily accessing the patient, thus improving the healthcare, time, and treatment managements. Moreover, the information collected by the IoT devices are easily transferred to the cloud computing mainly for storage. Analysis and interpretation of these information could also be done at the cloud. smart hospital system, minimize all difficult requirements which suffering doctors and patients and increase the quality of patient's care.

7. CONCLUSION

By reviewing the observed results, smart devices are able to obtain the various measurements that a person needs, and from these important data that must be under control is the patient's temperature if it rises or falls, and this also depends on the temperature of the environment in which he lives. The temperature of the place must be measured. To take the necessary action to keep the patient from pain, one of the important information that must be monitored is the number of heartbeats and the rate of oxygen in the blood. Below 85, the oxygen sensor will alert the user to inform him about patient damage by cloud computing using servers to store and monitor data.

REFERENCES

[1] S. K. Dash, S. Mohapatra, and P. K. Pattnaik, "A survey on applications of wireless sensor network using cloud computing," *International Journal of Computer Science & Emerging Technologies*, vol. 1, no. 4, pp. 2044–6004, 2010.

[2] J. Kissi, B. Dai, C. S. K. Dogbe, J. Banahene, and O. Ernest, "Predictive factors of physicians' satisfaction with telemedicine services acceptance," *Health Informatics J.*, vol. 26, no. 3, pp. 1866–1880, 2020, doi: 10.1177/1460458219892162.

[3] L. A. Tawalbeh, R. Mehmood, E. Benkhlifa, and H. Song, "Mobile cloud computing model and big data analysis for healthcare applications," *IEEE Access*, vol. 4, pp. 6171–6180, 2016, doi: 10.1109/ACCESS.2016.2613278.

[4] M. Opazo Basaez, S. Ghulam, D. Arias Aranda, and V. Stantchev, "Smart healthcare services: a patient oriented cloud computing solution," in *The 3-rd International Business Servitization Conference, Proceedings of*, 2014, vol. 71.

[5] I. Masood, Y. Wang, A. Daud, N. R. Aljohani, and H. Dawood, "Towards smart healthcare: Patient data privacy and security in sensor-cloud infrastructure," *Wirel. Commun. Mob. Comput.*, vol. 2018, pp. 21–24, 2018, doi: 10.1155/2018/2143897.

[6] Y.-Y. Ou, P.-Y. Shih, Y.-H. Chin, T.-W. Kuan, J.-F. Wang, and S.-H. Shih, "Framework of Ubiquitous Healthcare System Based on Cloud Computing for Elderly Living," in *2013 Asia-Pacific Signal and Information Processing Association Annual Summit and Conference*, 2013, pp. 1-4, doi: 10.1109/APSIPA.2013.6694298.

[7] N. A. Kumar and S. Suresh, "A Proposal of smart hospital management using hybrid Cloud, IoT, ML, and AI," in *2019 International Conference on Communication and Electronics Systems (ICCES)*, 2019, pp. 1082-1085, doi: 10.1109/ICCES45898.2019.9002098.

[8] A. Alamri, W. S. Ansari, M. M. Hassan, M. S. Hossain, A. Alelaiwi, and M. A. Hossain, "A survey on sensor-cloud: Architecture, applications, and approaches," *Int. J. Distrib. Sens. Networks*, vol. 2013, 2013, doi: 10.1155/2013/917923.

[9] A. I. Tahirkheli *et al.*, "A survey on modern cloud computing security over smart city networks: Threats, vulnerabilities, consequences, countermeasures and challenges," *Electron.*, vol. 10, no. 15, 2021, doi: 10.3390/electronics10151811.

[10] H. Alemdar and C. Ersoy, "Wireless sensor networks for healthcare: A survey," *Comput. Networks*, vol. 54, no. 15, pp. 2688–2710, 2010, doi: 10.1016/j.comnet.2010.05.003.

[11] Y. Ma, Y. Wang, J. Yang, Y. Miao, and W. Li, "Big health application system based on health internet of things and big data," *IEEE Access*, vol. 5, pp. 7885–7897, 2017, doi: 10.1109/ACCESS.2016.2638449.

[12] J. Lalithavani, R. Senthil Ganesh, S. A. Sivakumar, and B. Maruthi Shankar, "Cloud server based smart home automation and power management," *Materials Today: Proceedings*, Dec. 2020, doi: 10.1016/j.matpr.2020.10.646.

[13] C. R. Panigrahi, J. L. Sarkar, B. Pati, R. Buyya, P. Mohapatra, and A. Majumder, "Mobile cloud computing and wireless sensor networks: a review, integration architecture, and future directions," *IET Networks*, vol. 10, no. 4, pp. 141–161, 2021, doi: 10.1049/ntw2.12013.

[14] F. Alharbi, A. Atkins, C. Stanier, and H. A. Al-Buti, "Strategic value of cloud computing in healthcare organisations using the balanced scorecard approach: a case study from a Saudi Hospital," *Procedia Computer Science*, vol. 98, pp. 332–339, 2016, doi: 10.1016/j.procs.2016.09.050.

[15] S. Lakshmanachari, C. Srihari, A. Sudhakar, and P. Nalajala, "Design and Implementation of Cloud based Patient Health Care Monitoring Systems using IoT," in *2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS)*, pp. 3713-3717, 2017, doi: 10.1109/ICECDS.2017.8390157.

[16] B. Xu, L. Xu, H. Cai, L. Jiang, Y. Luo, and Y. Gu, "The design of an m-Health monitoring system based on a cloud computing platform," *Enterprise Information Systems*, vol. 11, no. 1, pp. 17–36, Jan. 2017, doi: 10.1080/17517575.2015.1053416.

[17] Z. Liu and J. Pu, "Analysis and research on intelligent manufacturing medical product design and intelligent hospital system dynamics based on machine learning under big data," *Enterprise Information Systems*, vol. 16, no. 2, pp. 193–207, Feb. 2022, doi: 10.1080/17517575.2019.1701713.

[18] S. Chenthara, K. Ahmed, H. Wang, and F. Whittaker, "Security and privacy-preserving challenges of e-health solutions in cloud computing," *IEEE Access*, vol. 7, pp. 74361–74382, 2019, doi: 10.1109/ACCESS.2019.2919982.

[19] C. He, X. Jin, Z.g Zhao, T. Xiang," A Cloud Computing Solution for Hospital Information System", *nternational Conference on Intelligent Computing and Intelligent Systems, 978-1-4244-6585,* IEEE *2010* .

[20] B. Ç. Uslu, E. Okay, and E. Dursun, "Analysis of factors affecting IoT-based smart hospital design," *Journal of Cloud Computing*, vol. 9, no. 1, 2020, doi: 10.1186/s13677-020-00215-5.

[21] S. Cao *et al*., "Cloud computing-based medical health monitoring IoT system design," *Mobile Information Systems*, vol. 2021, pp. 1–12, Jul. 2021, doi: 10.1155/2021/8278612.

[22] J. Lalithavani, R. Senthil Ganesh, S. A. Sivakumar, and B. Maruthi Shankar, "Cloud server based smart home automation and power management," *Materials Today: Proceedings*, 2020, doi: 10.1016/j.matpr.2020.10.646.

[23] D. Rizk, H. Hosny, and E.-S. El-Horbaty, "SMART hospital management systems based on internet of things: challenges, intelligent solutions and functional requirements," *International Journal of Intelligent Computing and Information Sciences*, vol. 22, no. 1, pp. 32–43, 2022.

[24] A. Tiwari, P. Ballal, and F. L. Lewis, "Energy-efficient wireless sensor network design and implementation for condition-based maintenance," *ACM Transactions on Sensor Networks*, vol. 3, no. 1, 2007, doi: 10.1145/1210699.1210670.

[25] K. Romer and M. Friedemann, "The design space of wireless sensor networks," *IEEE Wireless Communications*, vol. 11, no. 5005, pp. 54–61, 2004.

[26] Y. Li, "Design of Smart Home Cloud Server," in *Proceedings of 2018 IEEE International Conference of Safety Produce Informatization, IICSPI 2018*, Dec. 2019, pp. 200–203, doi: 10.1109/IICSPI.2018.8690355.

[27] G.-M. Sung, Y.-S. Shen, J.-H. Hsieh, and Y.-K. Chiu, "Internet of Things–based smart home system using a virtualized cloud server and mobile phone app," *International Journal of Distributed Sensor Networks*, vol. 15, no. 9, p. 155014771987935, Sep. 2019, doi: 10.1177/1550147719879354.

[28] K. Sohraby, D. Minoli, and T. Znati, "Basic wireless sensor technology," in *Wireless Sensor Networks*, Hoboken, NJ, USA: John Wiley & Sons, Inc., 2007, pp. 75–92.

[29] F. Gherardi and L. Aquiloni, "Sexual Selection in Crayfish: A Review," in *New Frontiers in Crustacean Biology,* vol. 15, BRILL, 2011, pp. 213–223.

[30] K. Haseeb, Z. Jan, F. A. Alzahrani, and G. Jeon, "A Secure Mobile Wireless Sensor Networks based Protocol for Smart Data Gathering with Cloud," *Computers & Electrical Engineering*, vol. 97, Jan. 2022, doi: 10.1016/j.compeleceng.2021.107584.

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