How to Cite:
Abdullah, D. M., & Zeebaree, S. R. M. (2022). Comprehensive survey of IoT based arduino applications in healthcare monitoring. *International Journal of Health Sciences*, *6*(S3), 6871–6892. https://doi.org/10.53730/ijhs.v6nS3.7588

Comprehensive survey of IoT based arduino applications in healthcare monitoring

Dakhaz Mustafa Abdullah*
IT Dept., Technical College of Informatics-Akre, Duhok Polytechnic University, Duhok, Iraq

Subhi R. M. Zeebaree
Energy Eng. Dept., Technical College of Engineering, Duhok Polytechnic University, Duhok, Iraq

***Abstract*---**The Internet of Things (IoT) enables a range of applications in the area of information technology, one of which is linked and smart health care. A successful Monitoring patients' health state in real time through an IoT healthcare system is the goal, to avert critical patient scenarios, and to enhance patient quality of life via smart IoT settings. Additionally, healthcare expenses are reduced, and patient outcomes are improved. Edge devices (glucose monitors, ventilators, pacemakers) are common in IoT systems. etc.). We reviewed the essential methodologies and cutting-edge technology for remote patient monitoring in this paper, taking into consideration data privacy and security concerns. The primary emphasis of this study is on the many solutions suggested in healthcare for IoT in real-time remote patient monitoring, blockchain technology in healthcare, and data security.

***Keywords*---**IoT, Arduino, ESP32, ESP8266, healthcare sensors.

Introduction

The IoT offers a myriad of applications across a range of sectors, including smart healthcare, smart housing, smart commerce and marketing, smart wearables, smart waste management, and smart water, to name a few. The use of IoT in healthcare has created new opportunities for delivering high-quality healthcare to people globally, making it easier for anyone to contact and receive healthcare services at any time (Bhatia, Panda, & Nagpal, 2020; Muthu et al., 2020). The IoT exists as a result of the sensing and interaction capabilities of items connected through a wireless network(Qadri, Nauman, Zikria, Vasilakos, & Kim, 2020). Wireless technologies such as Bluetooth, RFID, NFC, and Wi-Fi allow smart devices to communicate with one another. This increases versatility and

Manuscript submitted: 27 March 2022, Manuscript revised: 18 April 2022, Accepted for publication: 9 May 2022

convenience of use for monitoring and communicating in a range of situations. The machines or protocols formed as a consequence of the IoT include embedded technology that allows them to communicate with one another(Isravel & Silas, 2020).

With IoT-enabled devices, a move from a reactive to a preventive healthcare system is possible, where sickness and disease are not only better treated but also prevented(Saha, Singh, & Saini, 2019). These IoT-connected devices offer a variety of application areas in which they are used for various health issues in order to develop better healthcare through the provision of instant support in a variety of forms. For instance, older patients will be able to live independently at home due to the integrated IoT devices, and both physicians and patients will have comprehensive access to medical information. Also, many smart devices and sensors are used in several cases to monitor patients(Onasanya, Lakkis, & Elshakankiri, 2019).

Different communication protocols, such as Bluetooth, have been used to monitor and share data between IoT devices (sensors, actuators, etc.), Wi-Fi, and so on(Jaiswal et al., 2018). Physiological data such as temperature, pressure rate, electrocardiograph (ECG), and electroencephalograph (EEG) may be collected by sensors implanted or worn on the human body in healthcare applications (EEG), glucose, pulse oximeter (SpO2), and so on from the patient’s body (Mohsen, Zekry, Abouelatta, & Youssef, 2020; Qamar, Abdelrehman, Elshafie, & Mohiuddin, 2018). Besides that, environmental data may also be captured, such as the temperature, the humidity, the date, and the time. These data aid in drawing accurate and insightful conclusions about the health status of individuals. The IoT system also relies heavily on data storage and accessibility since a vast volume of data is collected from a number of sources (sensors, mobile phones, e-mail, software, and applications). Doctors, carers, and other authorized individuals have access to the data from the aforementioned sensors. The ability to quickly diagnose patients and give medical assistance when required is made possible by the cloud/server exchange of this data. Efficient and safe transmission is ensured by the participation of the users, patients, and the communication module (Mamdiwar, Shakruwala, Chadha, Srinivasan, & Chang, 2021; Pradhan, Bhattacharyya, & Pal, 2021).

Arduino is a good way to enter the world of microcontrollers and is used in many IoT projects. Arduino is a hardware and software open-source electronics platform (Abdulwahid, 2019). LEDs and motors may be actuated by light sensors, buttons, or even a tweet, all of which can be inputs to an Arduino board. In order to provide instructions to the board's microcontroller, you must use the board's serial port. A programming language and development environment based on Wiring, respectively, are used to create Arduino projects (IDE) is a software application based on Processing (Jayashree, Pavithra, Monika, Charanya, & Priya, 2020; Lin, Lin, Yang, & Lin, 2017). We did this review based on Arduino due to its low cost and high efficiency, the availability of many sensors that are compatible with it, and because there is no complexity on it. The remainder of this document is structured as follows:: The II section presents IOT brief review, then IoT architecture. The III section is a brief look at IoT Arduino microcontrollers and Methodology. The IV section is the Literature review. Section V presents

Discussion and Recommendations, and we discuss and compare the Previous works and propose recommendations for future work. in the VI section conclusion

IoT: A brief review

The IoT is a relatively new connectedness technology disparate by use of actual physical items integrated technology capable of communicating with and sensing either their internal or exterior states environments(Chaudhari & Umamaheswari, 2018). Complementary technologies that make up the IoT include cloud computing, big data analytics, fog computing, smart sensors, RFID and communication technologies. A dynamic network architecture that may self-configure based on the concept of interoperability and standard communication protocols is known as the IoT. As a result of the IoT, anybody, everything may be linked to a network in real-time, regardless of location or time zone (Ahad, Tahir, & Yau, 2019). Along with the characteristics acquired from previous technologies, the IoT also inherits their problems and outstanding concerns. IoT research strives to improve the capabilities of distributed processing and storage. IoT centralized solutions waste time, network traffic management resources, compute, and power consumption resources (Bader, Ghazzai, Kadri, & Alouini, 2016; Dang, Piran, Han, Min, & Moon, 2019).

IoT architecture

The most well-known paradigm for IoT is the three-layer architecture. The IoT layers are distinguished by the functions they perform and the devices that operate within them. There are several viewpoints on the number of layers in IoT. However, the majority of research publications highlighted three primary levels in IoT(Hail, 2019; Pace et al., 2018). The IoT architecture is illustrated in Figure 1, which Perception, Networking, and Application layers are all part of the same system (Al Hinai & Singh, 2017).

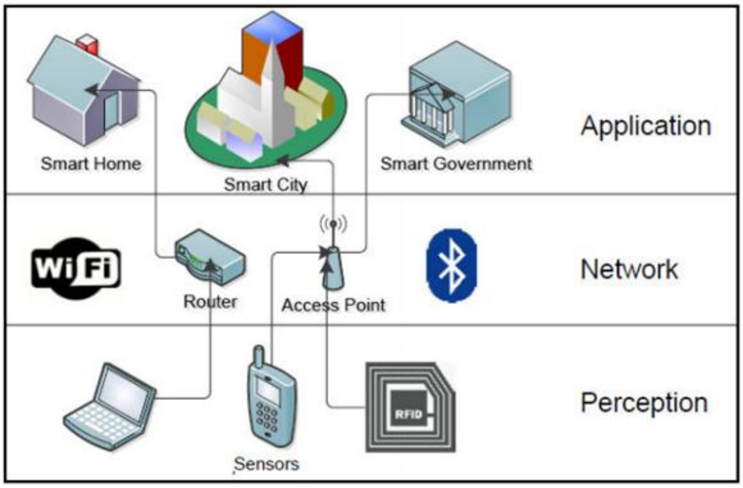

Figure 1. The three Layers of IoT architecture (Al Hinai & Singh, 2017).

Perception Layer

The Perception Layer, which includes objects/devices and sensors, is also known as the Device Layer. It functions like a live organism's skin, using its five senses to recognize things, gather data, and provide information. Identity, node networking, and data sensing are functions performed by this layer, which include the identification of healthcare service providers, patient medical information, and equipment and waste information. This layer contains all of the data that may be detected in an IoT architecture (Maktoubian & Ansari, 2019; Navani, Jain, & Nehra, 2017; Soni & Kumar, 2019).

Network layer

Infrastructure for hospitals and the IoT are both built on this layer. Sending and analyzing data from the Perceptual Layer, this layer is known as the Transmission Layer. The network layer handles connectivity between devices, and it uses sensors and computers to communicate the gathered data across wired and wireless networks. The dependability of data transfer may also be used to provide connection-oriented services (Navani et al., 2017; Soni & Kumar, 2019).

Application Layer

also known as the Process layer. is the interface applications and their customers. It serves as a means of communication between them. It may be used for a wide range of systems purposes of the healthcare organization services. It also manages resource allocation and computing in data production, processing, screening, and selection. Through its filtering functionality, it can distinguish between spam, data that is damaging and data that is true. In order to carry out intelligent processing, it identifies, connects, and controls devices and objects using incoming data and control choices. (Al Hinai & Singh, 2017; Oryema, Kim, Li, & Park, 2017).

IoT microcontrollers

The IoT needs a strong, low-cost, and low-power IoT device solution in order to extend its applications. In addition to having a tiny form factor, an IoT device must be lightweight and small in order to a wide variety of potential uses. In order for an IoT device to function, it must have a microcontroller (C) and a wireless communication module (often Wi-Fi). IoT devices can already be built using a broad range of modules and microcontrollers on the market. Xbee, WhizFi, various Arduino boards, and so forth are included (K. J. Singh & Kapoor, 2017). Despite this, the vast majority of presently available gadgets are either prohibitively costly or disproportionately heavy and huge in size. In addition, there are only a few modules that are open-source and may be used for any purpose. IoT devices may benefit from two gadgets that are specifically built for this purpose the two devices are (ESP8266 & ESP32)(Mitrović, Đorđević, Veljković, & Danković, 2021).

ESP8266

The widely used ESP8266 microcontroller is mostly used to operate wirelessly networked home appliances, and the IoT is the usage of the phrase to refer to this kind of remote management (IoT). However, because of the cheap cost and the features listed in "Table 1," these microcontrollers may be used in combination with one another or a server (Abd Jalil, Mohamad, Anas, Kassim, & Suliman, 2021).

Table 1
Main characteristics of ESP8266 [30]

Parameter	Value
CPU	32 bit 80 MHz (160 MHz)
Wi-Fi protocols	802.11 b / g / n
Supply voltage	3.0-3.6V
Maximum current	220mA
Built-in flash memory	4 MB
Peripheral buses	UART / HSPI / I2C / I2S
Network protocols	IPv4, TCP / UDP / HTTP / FTP

In many cases, however, the most important considerations are things like power consumption and operational stability. Based on the example of a wireless network ESP8266s running together may be used for local positioning systems, controlling a fleet of autonomous aerial vehicles aircraft, robotics, or other applications.. Input voltage for the ESP8266 module is 3.3 V. 2 GPIO pins (GPIO 0, RST), VCC, and GND makes up the eight total pins on the board (Ground) (Srivastava, Bajaj, & Rana, 2018; Zinkevich, 2021).

ESP32

Microcontroller ESP32 is a strong SoC (System on Chip). TCP/IP, complete 802.11 b/g/n/e/i WLAN MAC, and Wi-Fi Direct are all supported by the ESP32 microcontroller's architecture. Using the The microcontroller and the distributed control function (DCF) protocol may perform Basic Service Set (BSS) STA and SoftAP functions. It also supports P2P group operations that are compatible with the current Wi-Fi P2P protocol. The board has a Bluetooth Low Energy module (BLE). It is a more sophisticated version of the 8266 chip, with two cores running at up to 240 MHz in various versions. Additionally, it has increased the number of PWM channels from 16 to 32, increased the number of GPIO pins from 17 to 36, and added 4MB of flash memory to the device (Babiuch, Foltýnek, & Smutný, 2019; Maier, Sharp, & Vagapov, 2017; Rai & Rehman, 2019).

Methodology

Many studies are being conducted to discover innovative, accurate, and efficient healthcare technology in which patients' health may be tracked in real time in regular life as well as during accidents and emergencies in order to boost the healthcare business. Although the IoT-DHS has had a significant influence on the healthcare business, numerous obstacles and unresolved concerns remain that must be addressed and solutions found (Onasanya & Elshakankiri, 2021). The healthcare industry is also considering a distributed fog-based access control architecture for patient data protection (Alagar, Alsaig, Ormandjiva, & Wan, 2018; Alnefaie, Cherif, & Alshehri, 2019; Birje & Hanji, 2020; Mani, Singh, & Nimmagadda, 2020; Siddartha & Ravikumar, 2019). Patients with cancer may also benefit from this treatment. The IoT-based cancer care system and analytics/cloud services (Onasanya & Elshakankiri, 2021). In the healthcare industry, blockchain technology is also making an impact by providing a platform for healthcare providers (doctors, nurses, etc.) and patients to benefit from efficient service and safe delivery of healthcare management. Blockchain is poised to revolutionize the healthcare industry because of its decentralized principles, although research on the topic is scarce. Researchers in academia and business have begun investigating healthcare-related blockchain applications based on already existent technologies. There are several proposals for a blockchain-based solution that would ensure the security of electronic medical records (EHR). Sensors, the IoT, diabetic illness monitoring, databases, smart contracts, and other computer resources are all part of the architecture. Thus, it may reshape health care in a way that empowers people to take charge of their own treatment (Saxena, Sharanya, & Ramaiah, 2019). It's still a worry that blockchain technology has distinct weaknesses and challenges to solve, such as mining incentives, mine assaults and key management (Abdellatif et al., 2020; Abou-Nassar et al., 2020; Aich, Chakraborty, Sain, Lee, & Kim, 2019; H. S. Chen, Jarrell, Carpenter, Cohen, & Huang, 2019; M. Chen et al., 2021; Fusco, Dicuonzo, Dell'Atti, & Tatullo, 2020; Ismail, Materwala, & Zeadally, 2019; Kassab et al., 2019; McGhin, Choo, Liu, & He, 2019; Premkumar & Srimathi, 2020; Quasim, Algarni, Radwan, & Alshmrani, 2020; Quasim, Radwan, Alshmrani, & Meraj, 2020; Ramani, Kumar, Bracken, Liyanage, & Ylianttila, 2018; A. P. Singh et al., 2020).

Literature review

Patients with epidemic illnesses need continual There is a lot of money that goes into monitoring their health, whether they're in the hospital or at home. These expenses may be reduced via the use of information and communication technology and artificial intelligence principles. By Al-Mutairi and others, (Al-Mutairi, Al-Aubidy, & Al-Halaiqa, 2021), Patients with pneumonia will be able to get real-time monitoring of their health through cellphones or other internet-connected devices. A real-time monitoring device was created to ensure that this system was operating properly. The setup of the monitoring device may be done wirelessly with the help of an encrypted connection.

Jebane et al. (Jebane, Anusuya, Suganya, & Meena) Arduino, sensors, and an ESP 8266 wireless module were used to create an IoT-based patient health monitoring and analysis system. ThingSpeak's IoT platform and API have been utilized for data storage and retrieval. To store and retrieve open-source ThingSpeak is a free IoT application and an API. Measurement of the pulse rate, body temperature, blood pressure, and communication with the patient's family members and doctors are all possible with this current system. The current technology is reliant on sensors connected to the user's body and the surrounding environment. The patient just has to be a few meters away from the sensors for this kind of contactless health monitoring.

Yakub et al. have created a Smart Healthcare Tracker using the IoT as a healthcare solution (Yakub et al., 2021). EMG sensor, accelerometer, gyroscope and heart rate/pulse oximeter are linked to ESP 32 with NodeMCU interface to investigate patients' health conditions for arm and leg strength by delivering the data to carers or doctors. The system is made up of these components. The goal of the study was to get a consistent and accurate reading for each of the aspects of arms and legs strength analysis and sleep disruption analysis. Apps such as BLYNK may be used to present the analysis results to caregivers and clinicians at any time and from any location. Sune et al. (Sune, Meshram, & Balbudhe, 2021) presented a health monitoring system based on the IoT. In addition to monitoring body temperature and pulse rate, the system also monitored ambient humidity and temperature using sensors presented on a mobile application. A wireless connection is used to transmit these sensor readings to a medical server. These data are then received on a personal smartphone with an IoT platform by an authorized individual. From these data, the doctor is able to make a diagnosis of the patient's illness and health status. This healthcare monitoring system used NodeMCU, Arduino, and sensors. If the parameters go abnormal, this system sends an alert message to the doctors, or it makes a buzzer sound.

Sakphrom et al. (Sakphrom et al. 2021) addressed a low-cost Wireless Body Sensor Network (WBSN) with three sensors: heart rate (HR), blood pressure (BP), and body temperature (BT) were provided, as well as an IoT platform, for the monitoring of vital signs. In order to store and manage the patient's vital signs data in a data center, the patient wears a wristwatch with an OLED display that processes and displays the data. Using a set of criteria developed by professionals, the data may be examined and alerted to medical personnel when aberrant signals are received from the sensors. Lakshmi et al. (Lakshmi, Ghonge, & Obaid, 2021) indicated that the patients may now be monitored remotely using cloud-based IoT healthcare sensors. Wi-Fi units in the cloud may monitor patient physical characteristics such as heartbeat and breathing, excessive temperature, and stress. Pharmaceutical companies will analyze medical data gathered by these professionals in order to develop more effective treatments. The video option might be implemented in the future for face-to-face consultations between physicians and patients. Powered by the Raspberry Pi, the design has Wi-Fi and Bluetooth connectivity. Except that, sadly, it's a reasonable amount. There's no ADC on the Arduino nano; hence the serial port is considered the best way to communicate with sensors. As a result of this application, the Raspberry Pi may show information on a screen and send data back to a server. A server receives data from the Raspberry Pi and sends it to a smartphone linked to the server.

Chintala et al. (Chintala, Akhilesh, Ganesh, & Ravideep, 2020) create a wireless sensor network for m-health care monitoring. Aberrant and unexpected circumstances may be detected by monitoring physiological markers and other symptoms using particular wearable sensors. The primary goal is to create a monitoring system that can measure the patient's pulse, temperature, and humidity. To quickly verify the Heartbeat, this work gives an easy-to-use framework. The devices are used as props in the photoshoots. Arduino's ADC is given a simple signal to denote the completion of a task. In this case, basic voltages are being replaced with sophisticated ones, and the Arduino's EEPROM will hold the computerized attributes. The Wi-Fi module automatically updates the cloud server based on the values stored in EEPROM. Using the Things Speak to site, anybody may access that data and see it in an Android or iOS application from that server.

Rathod et al. (Rathod, Kharat, & Bansode) IoT-based, machine-driven remote health monitoring system was projected by giving alarm warning and recommended medicine name and dosage presented in connection with a notice. In order to improve the health of a patient, this technique makes use of a wide range of sensors, including temperature and heart rate oxygen sensors. The ARM controller is attached to each sensor, and the ESP8266 Wi-Fi module is linked to the controller. An LCD digital display, an alphanumeric display, and a Wi-Fi connection are all used to monitor the patient's health and communicate the data to an Android app through the web-server (wireless sensing node). IoT mostly based on the android app is used to send an alert to the patient in the event of any sudden changes in the patient's heart rate or vital signs.

Rahimoon et al. (Rahimoon, Abdullah, & Taib, 2020) recommended Using a CT-UNO controller, data is collected in real-time. Temperature readings from the LM-35 and MLX-90614 sensors are sent to the internet site via an ESP-wifi shield. The S1 and S2 sensors are wirelessly linked to the platform, which monitors and displays their real-time data. It is now possible to see the impact of environmental factors like humidity, barometer, blood pressure, and heart rate on temperature data. The data show that the average temperature difference between S2 and S1 is around 150C. While monitoring one's temperature on a regular basis helps protect individuals from developing fever, hypothermia, or hyperthermia, it is not without risk.

Rathy et al. have presented an IoT-based health monitoring and diagnostic system (HMDS) utilizing LabVIEW.(Rathy, Sivasankar, & Fadhil, 2020) Monitored the patient's health status. The patient's medical data, such as heart rate, pulse, blood pressure, temperature, and step count, are gathered using a variety of wearable sensors. LCD screens will show information about the patient's health. The LMU and RMU front panels may show the same information through the gateway. LabVIEW and myRIO were used to examine the Wi-Fi sensor data obtained by LMU. Patients' medical records will be available to specialists, carers, and diagnostic systems through LMU and RMU. Remote system monitoring was developed by D'Aloia et al. (D'Aloia et al. 2020) to provide a consistent and secure method of monitoring equipment and collecting vital performance data. The development of a remote and real-time environmental parameter monitoring module in interior locations is shown in this design. The system comprises a microprocessor, sensors, a GSM/GPRS module, and a single LED for device malfunction reporting. The microservice concept is used to describe the module architecture.

Fig 2. Device proposed (D'Aloia et al., 2020)

Parkhomenko et al. have presented a system for remote monitoring of hospital patients' cardiovascular data (Parkhomenko, Presaizen, Gladkova, Tulenkov, & Kalinina, 2019). The first prototype of the software-hardware complex for HR monitoring has been built. The Mesh network and various access points were utilized in the project to connect to the network. With the WeMOS D1 Mini and the Freeboard.io IoT service as the foundation, it's possible to save and see data on a patient's condition while in the hospital. The characteristics of the research subject were considered during the investigation of gadget features and data transmission methods. A list of algorithms for coordinating remote heart rate monitoring is provided here.

Mankar et al. propose an IoT-based remote monitoring system for hypertension patients. (Mankar, Gawande, & Thakare). Body sensors like blood pressure, temperature, pulse oximeter, breath sensor, and air quality sensor may be used to monitor a patient's health in a holistic manner. Microcontroller controller ESP 32 coupled to the IoT is used to monitor the patient's temperature, heart rate and blood oxygen concentration (IoT). The main parts of the system are a bio-signal sensor and a microprocessor. Using a bio-signal sensor, data is transferred to a server that processes it. In the event of an emergency, the caregiver and doctor are notified by short message service so that they can provide appropriate assistance.

Aziz et al. have developed an automated method (Aziz, Sharmin, & Ahammad, 2019) so that the vital signs may be kept track of from afar. The planned system is broken down into three key sections. As a starting point, sensors will be used to monitor the patient's vital signs. A NodeMCU-based cloud storage service is then used to store and analyse the observed data; this data is then made available for remote viewing. The relevant authorities (relatives/doctors) may use this information to monitor a patient's health metrics remotely. As a wearable device that can be utilized anywhere, the suggested system serves as a data logger for archiving patient data in the cloud. The doctor has access to all the recorded data to keep track of the patient's past records. When an abnormality is detected, an alert message will be sent and a recommendation based on the patient's present condition.

patient health tracking system presented by Akshaya et al (Akshaya, Anil, Paulson, Abraham, & Vandana, 2019) that uses heartbeat and temperature sensors to track patient's health and uses the Internet to give alerts in case of any issues. A GPS is provided in the system to track the person's location. A GSM module is incorporated in the system to send SMS alerts to doctors and also location information to an ambulance in case of emergency. An Arduino board is used to keep tabs on the sensors, GSM, and GPS modules' states, as well as send out notifications as necessary. The system immediately warns the user when a patient's pulse or body temperature suddenly changes, and it also provides information on the patient's heartbeat and temperature over the Internet.

Mehmood et al (Mehmood, Mehmood, & Song, 2019) proposed a system based on web application and android in which physicians may prescribe medications to patients using a stylus pen and an android app, while those who are involved in the process, including as patients, front desk staff, and pharmacists, and administrators connect to the system through their internet connectivity. The suggested system combines the IoT and cloud computing technologies via the use of Arduino and E-Health sensors. The registered IoT devices are utilized by users, which helps healthcare stakeholders by simplifying and improving the system's efficiency, usability, and error-prone nature. Saeed et al (Saeed et al.) Workers in restricted spaces might benefit from an IoT-based health monitoring system. Microcontroller sensors, such as the LM35 for monitoring body temperature, heart rate, blood pressure, and an LPG gas sensor are all included in the system's design. A GPS module connects all of the above sensors, allowing the data to be sent to a smartphone app. In order to evaluate the suggested sensors, a simulation was run using competitive commercial measurements as a standard. Simulated results revealed a reasonable level of accuracy for the sensors compared to the benchmark.

Chakole et al. (Chakole, Giripunje, Dhak, & Sawarkar) For continuous cardiac monitoring, a cloud-based physiological signal monitoring system was proposed ECG sensor module, a digital temperature sensor, ultra-low power MSP432 microcontroller, and IoT module make up the system. The digital thermometer DS18B20 is used in the system to get the user's body temperature, and no additional ADC hardware is required. In order to monitor the heart rate, a three-lead ECG sensor module AD8232 is used. An ultra-low-power high-speed cortex core MSP432P401R processor/controller processes the temperature value and the ECG signal obtained from the corresponding sensors. The ESP 8266 Node MCU transmits the temperature and ECG signals to the cloud, and there is a comparison and analysis of the signals at both the sending and receiving ends.

Marin and Jabber (Marin & Jabber, 2018) The wireless sensor network is the basis for the healthcare monitoring system that is being suggested. Patient temperature and heart rate are shown in real time on the device. GSM node application for Android using Android Studio, the main program in Visual Studio (using C# programming) and LabVIEW for the graphical user interface (using C# programming) (to support processing, monitoring and alerting in case of a critical situation) are all part of the system proposed here. The graphical user interface shows the ECG signal (GUI). The temperature is also shown on the GUI. Sensors collect the patient's vital signs from their body. Vital signs are relayed to a professional doctor in the event of an emergency.

Gogate and Bakal (Gogate & Bakal, 2018) proposed a prototype of a monitoring system for healthcare employing a WSN is given in a three-tier design to continually monitor various bodily parameters of the patient. Node MCU ESP8266 wireless connection is used to send recorded signals to the server from various biosensors available for heart rate, oxygen level, and temperature are all measured. ThingSpeak, an IoT program, provides physicians and caregivers with access to data stored on distant servers. Smartphone notifications may be used to notify carers in the event of an emergency. Cardiac patients may benefit from the system, and it can also be used to care for infants and the elderly at home and in hospitals.

Discussion and Recommendations

This paper has reviewed more than 70 papers related to the healthcare sector, such as distributed healthcare systems, distributed fog, healthcare systems for cancer and diabetes disease patients, and blockchain technology in healthcare. Then this paper focuses on healthcare monitoring depending on an Arduino microcontroller with sensors in addition to the platform (website) for presenting data. All researchers in Previous works focus on how much data that collected from sensors to present to the doctor. In this case, there are some points that will be a kind of complicated for the user (patient/doctor). So there are several points they should work on in the future, such as; all proposed systems being unable to add new sensors. They should write new code to add a new sensor. They do not build a special platform to present data that support multi-user profiles that let the doctor watch their patients and write their feedback on profiles each time they receive a new record. Some of them built a simple website to present one patient's data only, which is not supported for multi-patient users. At the same time, some researchers used an IoT platform that may be off or paid for services in one day. Also, the system cannot access the Internet if the Wi-Fi point is changed or if the Wi-Fi password has been changed. Because the Wi-Fi name and password stored in micro controller while coding the system.

Table 2
Comparison of previous work

Ref.	Sensors	Health Focus	Platform
Al-Mutairi et al (Al-Mutairi et al., 2021)	body temperature, heart rate, Oxygen saturation (SPO2), (ECG)	Epidemic Diseases Patients	Local webserver
Jebane et al(Jebane et al.)	body temperature, blood pressure	monitor chronically ill patients	Thing Speak IoT & API
Yakub et al (Yakub et al., 2021)	heart rate/pulse oximeter, gyroscope,	Brain Injury is known as neurotrauma	Blynk

	accelerometer, EMG sensor		
Sune et al (Sune et al., 2021)	Pulse oximeter, body temperature & humidity	human health tracking	Blynk
Sakphrom et al (Sakphrom et al., 2021)	body temperature, blood pressure, heart rate	monitoring vital signs	Things Board
Lakshmi et al (Lakshmi et al., 2021)	ECG, SPO2, Body Temperature	Patient physical parameters	Thing Speak
Chintala et al (Chintala et al., 2020)	Heartbeat, Temperature, and Humidity	Monitoring of Human Being	Thing speak
Rathod et al (Rathod et al.)	heartbeat oxygen level and Temperature	trace the patient's health	android app
Rahimoon et al (Rahimoon et al., 2020)	temperature sensors	body temperature measurement	Local webserver
Rathy et al (Rathy et al., 2020)	blood pressure, heart rate, pulse, temperature, and step count	monitoring the health condition of the patient	LabVIEW
Parkhomenko et al (Parkhomenko et al., 2019)	Pulse Sensor	cardio data monitoring	Freeboard.io
Mankar et al (Mankar et al.)	Temperature sensor, Blood pressure sensor, Breath Sensor, Pulse oximeter sensor, Air Quality Sensor	hypertensive patients	ubidots
Aziz et al (Aziz et al., 2019)	ECG, Body Temperature, heartbeat	monitor the health parameters	Firebase
Akshaya et al (Akshaya et al., 2019)	Body temperature, heartbeat	health tracking	Thing speak
Mehmood et al (Mehmood et al., 2019)	ECG, blood glucose, blood pressure, heartbeat	monitor the health parameters	android & web application
Saeed et al (Saeed et al.)	Blood pressure, heartbeat rate, Temperature, Gas sensor,	health tracking, confined spaces	Blynk
Chakole et al (Chakole et al.)	ECG, Temperature, Heart Rate	monitor physiological parameters	Thing Speak
Marin and Jabber	Body temperature,	monitor	LabVIEW

(Marin & Jabber, 2018)	electrocardiogram (ECG) and blood oxygen saturation	chronically ill patients	
Gogate and Bakal (Gogate & Bakal, 2018)	heart rate, body temperature and oxygen level	Cardiovascular diseases	Thing speak

Discussion and Comparison of the previous works

In the previous section, it can be observed that IoTH has been used in various fields. Such as the protection of electronic health care records, it can be noted that blockchain technology has been used to securely manage health care. On the other hand, there are some disadvantages to this technology, which need to find appropriate solutions, such as the cost of mining, key management, and mining attacks(Abdellatif et al., 2020; Abou-Nassar et al., 2020; Aich et al., 2019; H. S. Chen et al., 2019; M. Chen et al., 2021; Fusco et al., 2020; Ismail et al., 2019; Kassab et al., 2019; McGhin et al., 2019; Premkumar & Srimathi, 2020; Quasim, Algarni, et al., 2020; Quasim, Radwan, et al., 2020; Ramani et al., 2018; A. P. Singh et al., 2020). It can also be seen that IoTH has played an important role in the field of distributed healthcare systems and distributed fog technology(Onasanya & Elshakankiri, 2021). As well as in health care systems for patients with cancer and diabetes(Saxena et al., 2019).

Table 1 shows the main points for comparing the investigations mentioned in the paragraph (Literature review). Where it can be seen that researchers relied on Internet platforms that are ready to display the data, and we previously mentioned that these platforms have drawbacks, their characteristics may be limited or they may be paid services, or the service may stop one day. Therefore, we do not recommend the implementation of such systems in reality (it may work only in the initial experiments). We note that (Jebane et al.),(Lakshmi et al., 2021),(Chintala et al., 2020),(Akshaya et al., 2019),(Chakole et al.)and (Gogate & Bakal, 2018) rely on the (Thingspeak) platform, while (Rathy et al., 2020) and (Marin & Jabber, 2018) use(labview), and there are other platforms such as (Blynk) that were used by (Yakub et al., 2021),(Sune et al., 2021)and(Saeed et al.).Where the (freeboard) platform was used by (Parkhomenko et al., 2019) &(Aziz et al., 2019). Sensors also have an important role in these systems, as they help to know the patient's status. They are available in several types: temperature, blood pressure measurements, heart rate, blood oxygen levels, ECG, etc., as shown in Table No. 1. In the following paragraph, we extracted several recommendations for future research to enhance healthcare monitoring systems based on Arduino. Figure 3 represents a statistics chart for used sensors in previous works. Figure 4 represents the statistics and a statistics chart for used platforms by depended on previous works. Figure.5 represents the Statistics Chart for the Health-Focus field depending by Previous Works.

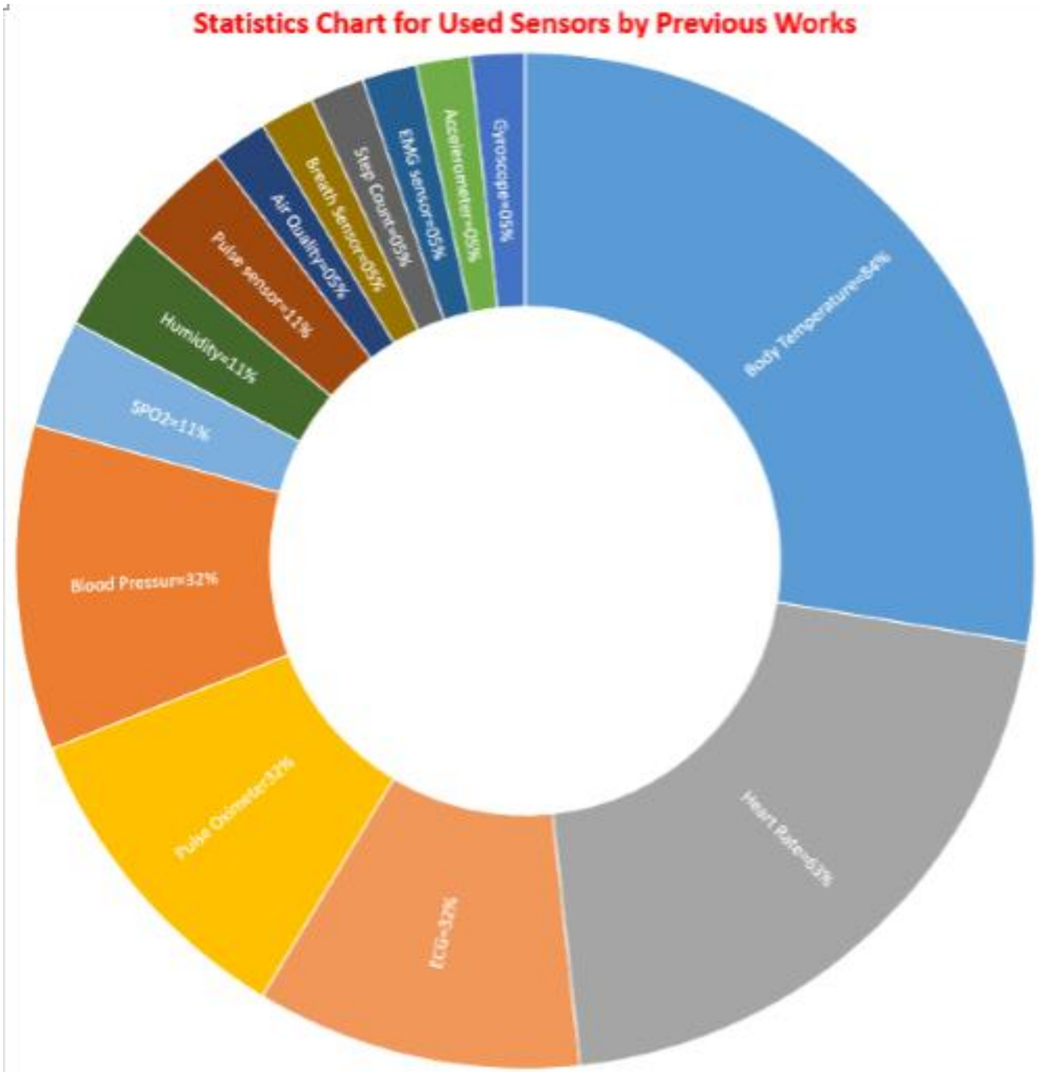

Fig 3. Statistics Chart for Used Sensors by Previous Works.

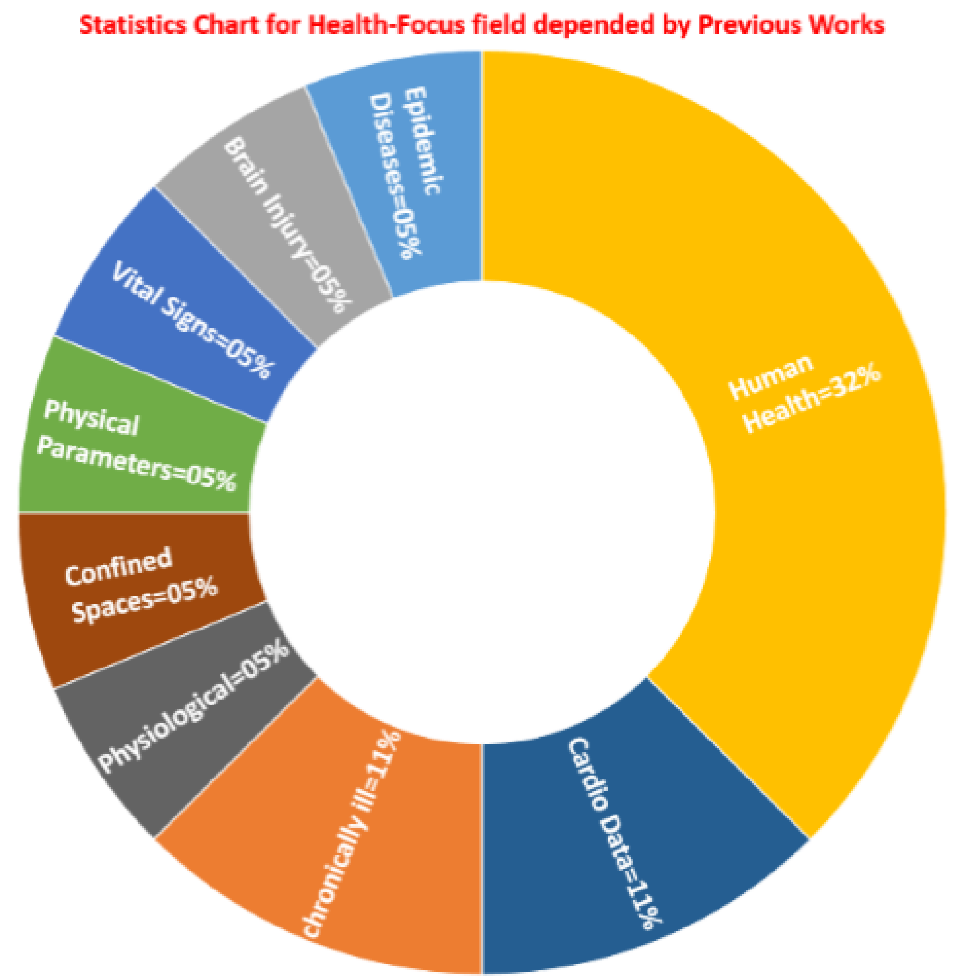

Fig 4. Statistics Chart for Health-Focus field depended by Previous Works.

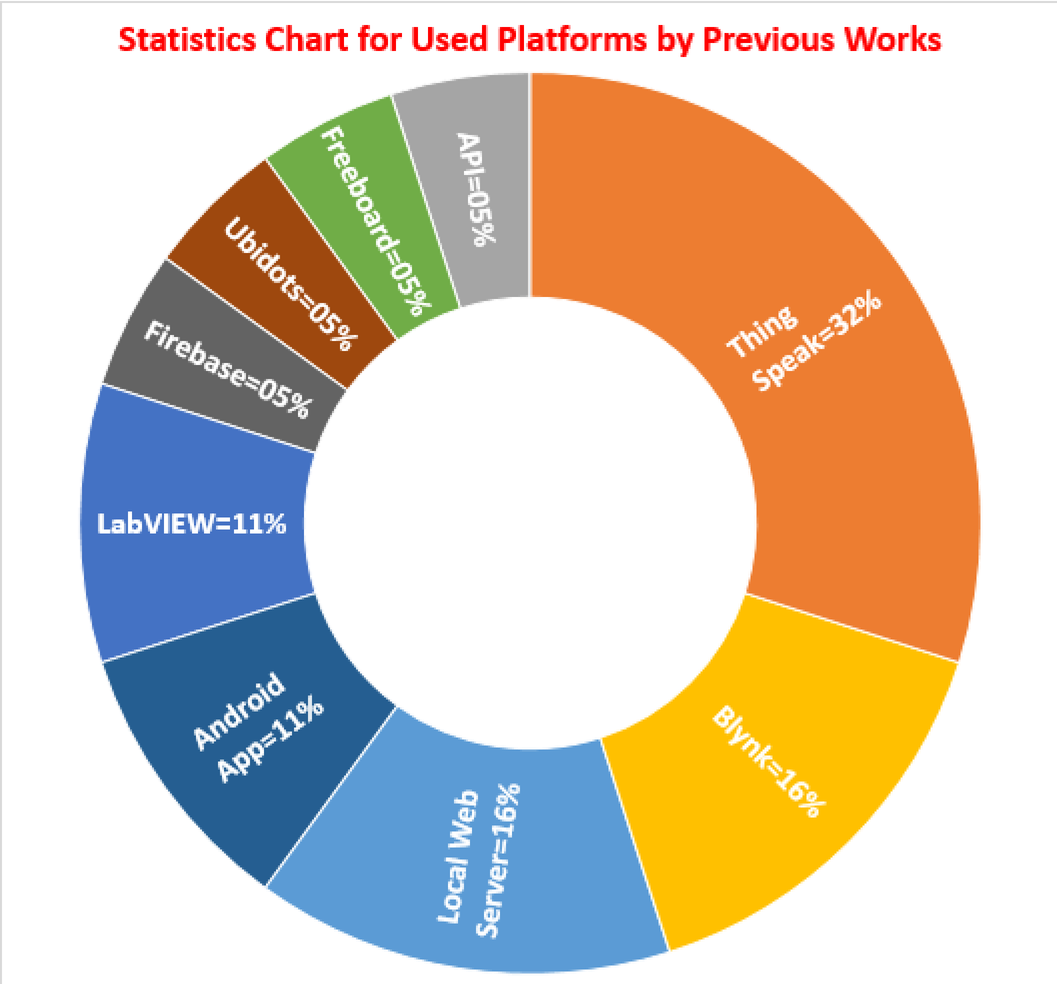

Fig 5. Statistics Chart for used Platforms by depended by Previous Works

Recommendations

In the future and with the comprehensive development in the field of the IoT in health care, we recommend the following.

- The ability of the system to add other additional sensors without creating a new system or reprogramming the system again.
- The possibility of changing the Wi-Fi name and password without referring to the system programming, because in the mentioned systems, the Wi-Fi name and password are stored in advance by the system programmer, and in the case that the name of the hotspot or the password is changed, the system will not be able to connect to the Internet.
- build special platforms that support the healthcare requirements of more than one patient, where each patient has his own profile in which his data is stored according to the time and date, with the possibility of adding a

filter so that the doctor can compare the patient's health status between two time periods with the possibility of adding the doctor's feedback.

Conclusion

IoT is widely employed in the present day. Due to the complexity of today's lifestyle, individuals are attempting to simplify their life via the use of technology. Health is a critical aspect of our lives. The IoT links numerous intelligent items to the Internet in order to control them. The IoT may be used to monitor the progress of a patient over time. Monitoring a patient's activities in real time, mobility, and other physiological movements might provide health-related metrics. Abnormal activities inside the patient could then be identified. Wearable technology may collect this data to monitor patients' blood pressure, temperature, and heart rate are all examples of vital indicators, and activity. The bulk of this study focuses on the many healthcare IoT solutions presented for real-time remote patient monitoring, blockchain technology, and data security.

References

Abd Jalil, A. M., Mohamad, R., Anas, N. M., Kassim, M., & Suliman, S. I. (2021). Implementation of vehicle ventilation system using NodeMCU ESP8266 for remote monitoring. Bulletin of Electrical Engineering and Informatics, 10(1), 327-336.

Abdellatif, A. A., Al-Marridi, A. Z., Mohamed, A., Erbad, A., Chiasserini, C. F., & Refaey, A. (2020). ssHealth: toward secure, blockchain-enabled healthcare systems. IEEE Network, 34(4), 312-319.

Abdulwahid, A. H. (2019). Modern application of Internet of Things in healthcare system. Int. J. Eng. Res. Technol., 12(4), 494-499.

Abou-Nassar, E. M., Iliyasu, A. M., El-Kafrawy, P. M., Song, O.-Y., Bashir, A. K., & Abd El-Latif, A. A. (2020). DITrust chain: towards blockchain-based trust models for sustainable healthcare IoT systems. IEEE Access, 8, 111223-111238.

Ahad, A., Tahir, M., & Yau, K.-L. A. (2019). 5G-based smart healthcare network: architecture, taxonomy, challenges and future research directions. IEEE Access, 7, 100747-100762.

Aich, S., Chakraborty, S., Sain, M., Lee, H.-i., & Kim, H.-C. (2019). A review on benefits of IoT integrated blockchain based supply chain management implementations across different sectors with case study. Paper presented at the 2019 21st international conference on advanced communication technology (ICACT).

Akshaya, S., Anil, G., Paulson, R., Abraham, R. J., & Vandana, P. (2019). IoT based Health Monitoring System. International Journal of Research in Engineering, Science and Management, 2, 230-232.

Al-Mutairi, A., Al-Aubidy, K., & Al-Halaiqa, F. (2021). IoT-based real-time monitoring system for epidemic diseases patients: Design and evaluation.

Al Hinai, S., & Singh, A. V. (2017). Internet of things: Architecture, security challenges and solutions. Paper presented at the 2017 International Conference on Infocom Technologies and Unmanned Systems (Trends and Future Directions)(ICTUS).

Alagar, V., Alsaig, A., Ormandjiva, O., & Wan, K. (2018). Context-based security and privacy for healthcare IoT. Paper presented at the 2018 IEEE International Conference on Smart Internet of Things (SmartIoT).

Alnefaie, S., Cherif, A., & Alshehri, S. (2019). Towards a distributed access control model for IoT in healthcare. Paper presented at the 2019 2nd International Conference on Computer Applications & Information Security (ICCAIS).

Aziz, H. B., Sharmin, S., & Ahammad, T. (2019). Cloud based remote healthcare monitoring system using IoT. Paper presented at the 2019 International Conference on Sustainable Technologies for Industry 4.0 (STI).

Babiuch, M., Foltýnek, P., & Smutný, P. (2019). Using the ESP32 microcontroller for data processing. Paper presented at the 2019 20th International Carpathian Control Conference (ICCC).

Bader, A., Ghazzai, H., Kadri, A., & Alouini, M.-S. (2016). Front-end intelligence for large-scale application-oriented internet-of-things. IEEE Access, 4, 3257-3272.

Bhatia, H., Panda, S. N., & Nagpal, D. (2020). Internet of Things and its Applications in Healthcare-A Survey. Paper presented at the 2020 8th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions)(ICRITO).

Birje, M. N., & Hanji, S. S. (2020). Internet of things based distributed healthcare systems: a review. Journal of Data, Information and Management, 2(3), 149-165.

Chakole, S. R., Giripunje, V., Dhak, B., & Sawarkar, M. IOT Based Healthcare System For Signal Monitoring Using Cloud Technology. International Journal of Engineering Applied Sciences and Technology, 4(2), 206-211.

Chaudhari, D. A., & Umamaheswari, E. (2018). Survey on data management for healthcare using Internet of things. Paper presented at the 2018 Fourth International Conference on Computing Communication Control and Automation (ICCUBEA).

Chen, H. S., Jarrell, J. T., Carpenter, K. A., Cohen, D. S., & Huang, X. (2019). Blockchain in healthcare: a patient-centered model. Biomedical journal of scientific & technical research, 20(3), 15017.

Chen, M., Malook, T., Rehman, A. U., Muhammad, Y., Alshehri, M. D., Akbar, A., . . . Khan, M. A. (2021). Blockchain-enabled healthcare system for detection of diabetes. Journal of Information Security and Applications, 58, 102771.

Chintala, R. R., Akhilesh, C., Ganesh, N., & Ravideep, T. (2020). Wireless sensor network for m-healthcare monitoring of human being. International Journal, 8(5).

D'Aloia, M., Longo, A., Guadagno, G., Pulpito, M., Fornarelli, P., Laera, P. N., . . . Rizzi, M. (2020). Low Cost IoT Sensor System for Real-time Remote Monitoring. Paper presented at the 2020 IEEE International Workshop on Metrology for Industry 4.0 & IoT.

Dang, L. M., Piran, M., Han, D., Min, K., & Moon, H. (2019). A survey on Internet of things and cloud computing for healthcare. Electronics, 8(7), 768.

Fusco, A., Dicuonzo, G., Dell'Atti, V., & Tatullo, M. (2020). Blockchain in healthcare: Insights on COVID-19. International Journal of Environmental Research and Public Health, 17(19), 7167.

Gogate, U., & Bakal, J. (2018). Healthcare monitoring system based on wireless sensor network for cardiac patients. Biomedical & Pharmacology Journal, 11(3), 1681.

Hail, M. A. (2019). Iot-ndn: An iot architecture via named data netwoking (ndn). Paper presented at the 2019 IEEE International Conference on Industry 4.0, Artificial Intelligence, and Communications Technology (IAICT).

Ismail, L., Materwala, H., & Zeadally, S. (2019). Lightweight blockchain for healthcare. IEEE Access, 7, 149935-149951.

Isravel, D. P., & Silas, S. (2020). A comprehensive review on the emerging IoT-cloud based technologies for smart healthcare. Paper presented at the 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS).

Jaiswal, K., Sobhanayak, S., Turuk, A. K., Bibhudatta, S. L., Mohanta, B. K., & Jena, D. (2018). An IoT-cloud based smart healthcare monitoring system using container based virtual environment in edge device. Paper presented at the 2018 International Conference on Emerging Trends and Innovations In Engineering And Technological Research (ICETIETR).

Jayashree, N., Pavithra, B., Monika, S., Charanya, R., & Priya, M. (2020). Arduino Based Iot Device for Septuagenarian Fall Detection. Paper presented at the 2020 International Conference on Emerging Trends in Information Technology and Engineering (ic-ETITE).

Jebane, P., Anusuya, P., Suganya, M., & Meena, S. IOT BASED HEALTH MONITORING AND ANALYSING SYSTEM USING THINGSPEAK CLOUD & ARDUINO.

Kassab, M., DeFranco, J., Malas, T., Laplante, P., Destefanis, G., & Neto, V. V. G. (2019). Exploring research in blockchain for healthcare and a roadmap for the future. IEEE Transactions on Emerging Topics in Computing, 9(4), 1835-1852.

Lakshmi, G. J., Ghonge, M., & Obaid, A. J. (2021). Cloud based iot smart healthcare system for remote patient monitoring. EAI Endorsed Transactions on Pervasive Health and Technology, e4.

Lin, Y.-W., Lin, Y.-B., Yang, M.-T., & Lin, J.-H. (2017). ArduTalk: An Arduino network application development platform based on IoTtalk. IEEE Systems Journal, 13(1), 468-476.

Maier, A., Sharp, A., & Vagapov, Y. (2017). Comparative analysis and practical implementation of the ESP32 microcontroller module for the Internet of things. Paper presented at the 2017 Internet Technologies and Applications (ITA).

Maktoubian, J., & Ansari, K. (2019). An IoT architecture for preventive maintenance of medical devices in healthcare organizations. Health and Technology, 9(3), 233-243.

Mamdiwar, S. D., Shakruwala, Z., Chadha, U., Srinivasan, K., & Chang, C.-Y. (2021). Recent advances on IoT-assisted wearable sensor systems for healthcare monitoring. Biosensors, 11(10), 372.

Mani, N., Singh, A., & Nimmagadda, S. L. (2020). An IoT guided healthcare monitoring system for managing real-time notifications by fog computing services. Procedia Computer Science, 167, 850-859.

Mankar, K., Gawande, P., & Thakare, A. P. Design Remote Healthcare Monitoring System for Hypertensive Patient Based On IOT.

Marin, I., & Jabber, Z. A. (2018). Wireless Sensors Network based on Real-time Healthcare Monitoring. Paper presented at the 2018 International Symposium on Fundamentals of Electrical Engineering (ISFEE).

McGhin, T., Choo, K.-K. R., Liu, C. Z., & He, D. (2019). Blockchain in healthcare applications: Research challenges and opportunities. Journal of Network and Computer Applications, 135, 62-75.

Mehmood, A., Mehmood, F., & Song, W.-C. (2019). Cloud based E-Prescription management system for healthcare services using IoT devices. Paper presented at the 2019 International Conference on Information and Communication Technology Convergence (ICTC).

Mitrović, N., Đorđević, M., Veljković, S., & Danković, D. (2021). Testing the efficiency of Wi-Fi data transmission in ESP-based IoT systems. Paper presented at the E-business technologies conference proceedings.

Mohsen, S., Zekry, A., Abouelatta, M., & Youssef, K. (2020). A self-powered wearable sensor node for IoT healthcare applications. Paper presented at the 2020 8th International Japan-Africa Conference on Electronics, Communications, and Computations (JAC-ECC).

Muthu, B., Sivaparthipan, C., Manogaran, G., Sundarasekar, R., Kadry, S., Shanthini, A., & Dasel, A. (2020). IOT based wearable sensor for diseases prediction and symptom analysis in healthcare sector. Peer-to-peer networking and applications, 13(6), 2123-2134.

Navani, D., Jain, S., & Nehra, M. S. (2017). The Internet of Things (IoT): A study of architectural elements. Paper presented at the 2017 13th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS).

Onasanya, A., & Elshakankiri, M. (2021). Smart integrated IoT healthcare system for cancer care. Wireless Networks, 27(6), 4297-4312.

Onasanya, A., Lakkis, S., & Elshakankiri, M. (2019). Implementing IoT/WSN based smart Saskatchewan healthcare system. Wireless Networks, 25(7), 3999-4020.

Oryema, B., Kim, H.-S., Li, W., & Park, J. T. (2017). Design and implementation of an interoperable messaging system for IoT healthcare services. Paper presented at the 2017 14th IEEE annual consumer communications & networking conference (CCNC).

Pace, P., Aloi, G., Gravina, R., Caliciuri, G., Fortino, G., & Liotta, A. (2018). An edge-based architecture to support efficient applications for healthcare industry 4.0. IEEE Transactions on Industrial Informatics, 15(1), 481-489.

Parkhomenko, A., Presaizen, Y., Gladkova, O., Tulenkov, A., & Kalinina, M. (2019). Remote Monitoring of the Hospital Cardiac Patients Heart Rate. Paper presented at the 2019 10th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS).

Pradhan, B., Bhattacharyya, S., & Pal, K. (2021). IoT-based applications in healthcare devices. Journal of healthcare engineering, 2021.

Premkumar, A., & Srimathi, C. (2020). Application of blockchain and iot towards pharmaceutical industry. Paper presented at the 2020 6th International Conference on Advanced Computing and Communication Systems (ICACCS).

Qadri, Y. A., Nauman, A., Zikria, Y. B., Vasilakos, A. V., & Kim, S. W. (2020). The future of healthcare internet of things: a survey of emerging technologies. IEEE Communications Surveys & Tutorials, 22(2), 1121-1167.

Qamar, S., Abdelrehman, A. M., Elshafie, H. E., & Mohiuddin, K. (2018). Sensor-based IoT industrial healthcare systems. Int. J. Sci. Eng. Sci, 11(2), 29-34.

Quasim, M. T., Algarni, F., Radwan, A. A. E., & Alshmrani, G. M. M. (2020). A blockchain based secured healthcare framework. Paper presented at the 2020 International Conference on Computational Performance Evaluation (ComPE).

Quasim, M. T., Radwan, A. A. E., Alshmrani, G. M. M., & Meraj, M. (2020). A blockchain framework for secure electronic health records in healthcare industry. Paper presented at the 2020 International Conference on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE).

Rahimoon, A. A., Abdullah, M. N., & Taib, I. (2020). Design of a contactless body temperature measurement system using Arduino. Indonesian Journal of Electrical Engineering and Computer Science, 19(3), 1251-1258.

Rai, P., & Rehman, M. (2019). ESP32 based smart surveillance system. Paper presented at the 2019 2nd International Conference on Computing, Mathematics and Engineering Technologies (iCoMET).

Ramani, V., Kumar, T., Bracken, A., Liyanage, M., & Ylianttila, M. (2018). Secure and efficient data accessibility in blockchain based healthcare systems. Paper presented at the 2018 IEEE Global Communications Conference (GLOBECOM).

Rathod, M. A. M., Kharat, G., & Bansode, R. IOT BASED PATIENT MONITORING SYSTEM.

Rathy, G., Sivasankar, P., & Fadhil, T. Z. (2020). An efficient IoT based biomedical health monitoring and diagnosing system using myRIO. Telkomnika, 18(6), 3050-3057.

Saeed, H., Mazin, M., Ibrahim, H., Hamzah, A., Qasim, H., Gore, A., & Hamza, M. IoT health monitoring system for preventing and controlling risk in confined space using microcontrollers.

Saha, G., Singh, R., & Saini, S. (2019). A Survey Paper on the impact of" Internet of Things" in Healthcare. Paper presented at the 2019 3rd international conference on electronics, communication and aerospace technology (ICECA).

Sakphrom, S., Limpiti, T., Funsian, K., Chandhaket, S., Haiges, R., & Thinsurat, K. (2021). Intelligent Medical System with Low-Cost Wearable Monitoring Devices to Measure Basic Vital Signals of Admitted Patients. Micromachines, 12(8), 918.

Saxena, A., Sharanya, M., & Ramaiah, N. S. (2019). IoT Based Acetone Level Monitoring Using Non-Invasive Method for Diabetic Patients. Available at SSRN 3358127.

Siddartha, B., & Ravikumar, G. (2019). Analysis of masking techniques to find out security and other efficiency issues in healthcare domain. Paper presented at the 2019 Third International conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)(I-SMAC).

Singh, A. P., Pradhan, N. R., Luhach, A. K., Agnihotri, S., Jhanjhi, N. Z., Verma, S., . . . Roy, D. S. (2020). A novel patient-centric architectural framework for blockchain-enabled healthcare applications. IEEE Transactions on Industrial Informatics, 17(8), 5779-5789.

Singh, K. J., & Kapoor, D. S. (2017). Create your own Internet of things: A survey of IoT platforms. IEEE Consumer Electronics Magazine, 6(2), 57-68.

Soni, R., & Kumar, G. (2019). A review on blockchain urgency in the Internet of things in healthcare. Paper presented at the 2019 International Conference on Intelligent Sustainable Systems (ICISS).

Srivastava, P., Bajaj, M., & Rana, A. S. (2018). Overview of ESP8266 Wi-Fi module based smart irrigation system using IOT. Paper presented at the 2018 Fourth International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics (AEEICB).

Sune, D., Meshram, M. K. S., & Balbudhe, P. (2021). Internet of Things (IoT) Based Smart Health Monitoring System–A Case Study. International Journal of Computational and Electronics Aspects in Engineering, 2(3).

Yogesh Hole et al 2019 J. Phys.: Conf. Ser. 1362 012121

Yakub, F., Rahman, M. A. A., Bahri, A. H. S., Syamir, M. A., Azizan, M. A., Kaidi, H. M., . . . Abdullah, H. (2021). Development of Smart Healthcare Tracker through Internet of Things. Paper presented at the 2021 IEEE National Biomedical Engineering Conference (NBEC).

Zinkevich, A. V. (2021). ESP8266 Microcontroller Application in Wireless Synchronization Tasks. Paper presented at the 2021 International Conference on Industrial Engineering, Applications and Manufacturing (ICIEAM).