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# Real-Time Robust Remote Server Room Monitoring System

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**ABSTRACT**

**Remote monitoring systems have become very popular with the development of IoT technology. Remote monitoring and tracking systems, which have become widespread in many areas, are frequently used in areas such as smart home features, health, environment security, monitoring of ambient values, vehicle tracking, etc. The widespread use of this usage has brought security vulnerabilities that need to be worked on. The emerging blockchain technology brings very powerful solutions in this regard. In this study, a system where a server room can be remotely monitored is studied. The values to be monitored are parameters such as temperature, pressure, humidity, flood, fire, network control of different parts of the server room. A new purpose-specific electronic circuit board was designed to read the data collected from the environment. The values read by the board are sent to the server side. The records are kept in the blockchain structure prepared here. The performance metrics of the prepared blockchain structure are measured and the overall performance of the system is discussed.**

Keywords **– Blockchain, data security, IoT, IoT security, Remote Monitoring Syste**

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## I. INTRODUCTION

IoT (Internet of Things) technology is a network and communication infrastructure that enables objects (objects) to exchange data by connecting with each other and the internet. This technology enables various objects (sensors, devices, equipment, vehicles, etc.) to share information and interact by connecting to the internet [1]. IoT technology is of great importance for remote monitoring and tracking systems.

IoT technology is used in data collection and data analysis processes in terms of remote monitoring and tracking systems. IoT technology makes it possible to collect environmental data (temperature, humidity, pressure, etc.) and other user or event data (location, movement, vibration, etc.) through sensors. This data is sent to remote monitoring and tracking systems and analysed and converted into meaningful information. In this way, information about the status of objects or the development of events can be obtained in real time. In addition, it is critical in remote control and management mechanisms [2]. For example, operations such as switching a device on and off, changing its settings or controlling alarm systems can be performed remotely. This facilitates the management of a remotely accessed system and increases operational efficiency. It provides convenience in monitoring the instantaneous situations occurring in the developed system and configuring warning systems. For example, an automatic alarm can be issued when a security camera detects movement or when a sensor exceeds a certain temperature threshold. In this way, rapid intervention is possible and important situations are immediately recognised. IoT is very useful in ensuring efficiency and cost savings. IoT-based remote monitoring and tracking systems provide efficiency in business processes and reduce costs. For example, production equipment of an industrial plant can be remotely monitored to detect malfunctions in advance and optimise maintenance scheduling. This reduces unexpected downtime, increases productivity and lowers operating costs. With features such as real-time data exchange, remote control, alarm notifications and data analyses via the Internet of Things, these systems meet security, monitoring and management needs in many areas [3].

Remote monitoring systems are technological systems that enable remote monitoring of a place or event. Typically, these systems have elements like cameras, sensors, and communication technologies. Systems for remote monitoring have a wide range of applications and can be utilized in many different contexts. One of the most popular applications used for security purposes is remote monitoring. Using cameras and motion detectors, one may keep an eye on the building's or location's security. These devices can be utilized to find theft, an assault, or other dangerous situations. It can also be used to monitor traffic flow and spot issues like traffic jams. Additionally, it can be used to track the whereabouts of public transportation vehicles and improve the administration of transportation networks [4]. It can be used to keep track of the condition of industrial facility equipment and find problems. This gives business owners the chance to keep an eye on production processes and boost productivity. It can be used to keep an eye on and safeguard natural resources. For instance, it can be used to assess environmental consequences and keep track of changes in water resources, woods, or animal regions. It is significant in the healthcare industry as well. For instance, it can be used to care for elderly or chronic patients who are housebound while also remotely monitoring their vital signs [5] [6]. In home automation, remote monitoring systems are also employed. Smart thermostats, lighting systems, and security cameras can all be monitored and controlled remotely by homeowners [7] [8]. These are but a few application cases for remote monitoring systems. More applications might appear as a result of technological advancement, and these systems might expand even further.

The security aspect of IoT-based remote tracking and monitoring devices is crucial. Since these systems transport a lot of sensitive data and information through the communication network, they may be susceptible to security flaws. IoT devices are used by remote monitoring and tracking systems to gather and transmit massive volumes of data. Sensitive information, such as pictures from surveillance cameras or production statistics from industrial sensors, may be included in this data. Data security is therefore crucial in these systems [9]. Access controls, secure communication methods, and data encryption should all be implemented. IoT-based systems must also take precautions to guarantee device security. It is recommended to adopt techniques like robust authentication mechanisms, current software updates, and device protection against physical access. Devices must also be secured against unauthorized access and be impervious to harmful attacks [10]. IoT devices often have a network connection and use it for data communication. The security of IoT-based remote monitoring and tracking systems depends heavily on network security. It is important to take precautions including secure network configuration, firewall installation, network monitoring, and the application of security protocols. Encrypting network traffic is essential for securing it from unauthorized access. The provision of user security by IoT-based devices is equally crucial. Access to these systems requires safe user identification via authentication procedures. Strong password policies, multi-factor authentication, and user authorization systems should all be used as security precautions.

Blockchain, or blockchain as it is commonly known, works as a distributed and transparent ledger technology. This technology allows data to be recorded in a secure and unalterable way [11]. For these reasons, Blockchain technology can play an important role for IoT security. The use of Blockchain in areas such as data integrity, authentication, data sharing, distributed security and event monitoring can improve the security of IoT systems and provide a reliable environment [12].

In this study, a new purpose-specific circuit board has been developed for remote monitoring of a server room and monitoring of critical parameters. Software suitable for the developed circuit board has been implemented and implemented in real life. In order to protect the mission of the whole system and the confidentiality and security principles required, the system data is kept in a blockchain structure specially prepared for the monitoring system. The contributions of the study to the literature are listed below.

- A new circuit board has been designed for monitoring the critical values of the server room.
- The capabilities of the development board include a warning and alarm system configured against critical thresholds of environment variables.
- All operations performed on the system, read values, control points and user processes are carried out on the blockchain.
- The software on the card developed for the system room can be updated remotely. This capability provides the system with uninterrupted monitoring feature.

In the second part of the study, studies related to this subject area in the literature are included. In the third section, the developed card will be explained in detail, schematic connections and pcb drawings are shown. In the fourth section, the findings and blockchain structure of the whole system are explained. In the fifth section, the conclusion of the study and future goals are stated.

## II. RELATED WORKS

Remote monitoring systems are of critical importance in the field of health. Many researchers have developed systems for different purposes for the patients they want to follow. In the system developed by Küçüköner and Yavuz, the motion sensor circuit near the patient informs the relevant persons or institutions by sending an emergency message via mobile phone if the patient remains motionless for a certain period of time within a specified time interval, thus aiming to minimise the time to intervene in the patient [13]. Kuzu et al. worked on a remote monitoring system to provide continuous monitoring of vital data such as blood pressure, blood oxygen percentage and body temperature and to establish communication between the relevant healthcare team and the patient and patient relatives [14]. Yilmaz et al. carried out a study on remote patient monitoring using wireless body sensors. In the study, data such as ECG, SPO2, weight, sugar, blood pressure are received from the patient. IEEE 802.15.6 protocol was preferred as the communication protocol [15]. Taşlı and Yıldırım propose a microservice based patient monitoring system using edge cloud technology infrastructure. With the proposed system, critically ill patients can be monitored and emergency situations that may occur in the patient can be evaluated in a hierarchical manner. The unique aspect of the proposed system is that the system uses a microservice software architecture that uses a circuit breaker mechanism and can control all microservices with a container infrastructure. Thanks to these features, significant improvements in system load and response delay have been achieved [16].

Remote monitoring and tracking systems, which are widely used in the field of health, are also very popular in different fields. In their study, Batmaz and Çelik present a web-based remote monitoring system in which the location of an individual with an Android-based smartphone can be monitored with the data obtained from the GPS sensor and the body activities such as falling, walking, etc. with the data obtained from the accelerometer sensor [17]. An IoT-based remote greenhouse monitoring system was developed by Baysal et al. In this study, a low-cost Raspberry Pi single board computer and esp8266 wi-fi modules were used to create an Internet of Things-based system. Thanks to the system's development, measurements of the greenhouse's indoor and exterior temperature and humidity, soil moisture, air quality, and light levels made by wireless sensors are recorded and visualized remotely. The user may be notified via email and short message service (SMS) if the values obtained from the sensors are greater than the lower and higher limit values set by the user [18]. In this study, a weather station installed on the roof of Kocaeli University Uzunçiftlik Nuh Çimento Vocational High School is considered for the purposes of monitoring meteorological data, determining the potential of the region in terms of solar and wind energy with real data, and collecting meteorological data to be used in weather or alternative energy systems prediction algorithms. With the weather station built, a 32-bit Arduino Due microcontroller was used to gather regional data on global radiation, wind speed, wind direction, temperature, and humidity, which was then stored in the SD memory module. In addition, the data were transferred to the ThingSpeak cloud environment via the ESP8266 WiFi module and the system was transformed into an Internet of Things application [19]. A remote car tracking system was created by Fuad and Drieberg by fusing a GSM modem with a Google Map. Short Message Service (SMS) coordinates are received by the GSM modem at the control center, which updates the master database. The website then makes use of this data to display the position of the vehicle using the Google Maps app. As long as there is an internet connection, the user can access a website that has been created to assist in tracking and viewing the location of the vehicles [20]. An embedded system created and built for vehicle tracking based on an android app was introduced by Mustafa et al. The system's main contribution is to reduce the amount of data sent from the embedded system in the vehicle to the cloud server by only using the GPS data necessary for vehicle tracking and to decrease the volume of HTTP requests sent to the cloud server by interpreting the information transmission based on the movement of vehicles. The embedded system, which is put in the vehicle, the cloud/server part, which has a database of every movement made by each car, and the monitoring section, which is the main user interface to monitor the vehicle, are the three components that make up this system [21]. Researchers frequently use blockchain for data security [22]. Blockchain is also a popular method in different monitoring systems. For example, in a study investigating the techniques to guarantee the health of antibodies, a model supporting the immunisation inventory network using the blockchain network was planned. In the proposed method, it has been useful to control antibody exchange and track unique immunisations with real credit exchanges where information guarantees protection and security [23].

## III. Proposed Model and Results

In this section, the circuit board developed, the blockchain structure created and the findings obtained will be explained under separate headings.

3.1. Developed Circuit Board

In this study, a secure remote monitoring and tracking system for a server room is proposed. In the proposed system, the temperature values of the anteroom section, the back section of the server panels, the server room environment and the UPS room in the server room are measured. In addition, movement actions in the server vestibule, fire status with sensors behind the server, pressure and humidity values of the server room environment are monitored. In addition, network utilization, generator utilization and water fault conditions can be monitored in real time.

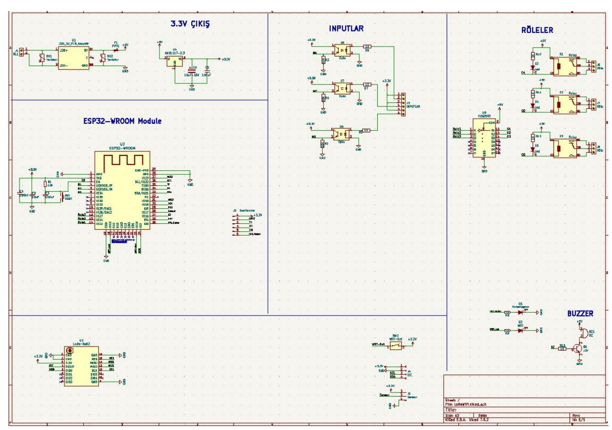


**Fig. 1** Schematic drawing of the developed board

The developed electronic card provides 220 volt input and 3.3 volt output. ESP32 system onchip module is used as microcontroller. The connection of the device to the internet is realized with the wifi connection on the device. On the system, 4 pins were used as digital inputs. The temperature measurements of the server back, vestibule, UPS room were measured via the dallas18b20 temperature sensor that communicates via OneWire protocol. Server room ambient temperature, humidity and pressure values were measured via the BME280 sensor using I2C communication. There is a buzzer on the system that gives an alarm in case of anomalies (fire, high temperature, flood).

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The development of the board was carried out with the open source KiCAD design and development program. Figure 2 shows the printed circuit drawing of the board.

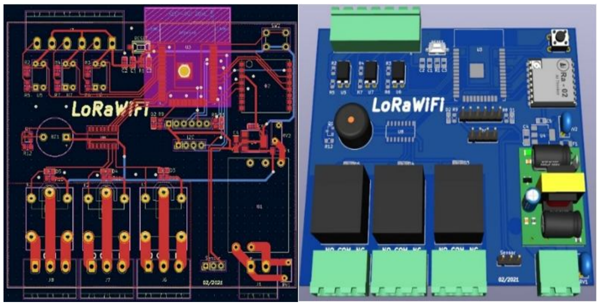

**Fig. 2** Printed circuit and 3D view drawing of the developed board

After the device is switched on, it performs the connection process by checking the wifi connection. Then it controls the sensors connected to it and starts to work. The device sends the measured parameters (temperature humidity pressure) to the server at certain intervals. In case of anomaly detection on the server side, a notification is sent to the authorised persons via the mobile application. In addition, the card itself sends similar warnings via e-mail via SNTP protocol. The interface where the developed system is monitored is shown in Figure 3.

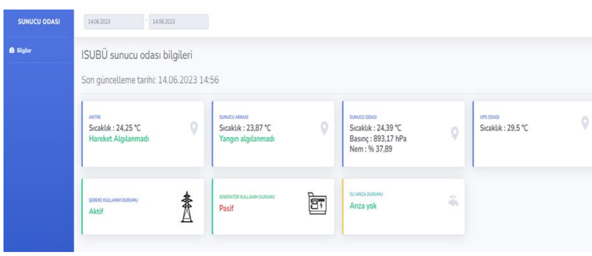

**Fig. 3** Developed system tracking interface

The money spent for the creation of the hardware part of the remote monitoring and tracking system is given in Table 1 as a cost analysis.

Table 1: Cost analysis of the developed card

| Component Name | Number | Price |
|---|---|---|
| Esp32 MCU | 1 | 8$ |
| Bme280 Sensor | 1 | 7$ |
| DALLAS 18b20 Sensor | 3 | 3$ |
| Motion Sensor | 1 | 2$ |
| Fire Sensor | 1 | 4$ |
| Water Flow Sensor | 1 | 4$ |
| Electronic Component & PCB Printing | 1 | 2$ |
| Total | 9 | 30$ |

The hardware shown in TABLE 1 was prepared with the data obtained from international e-commerce pages at current retail prices on 15.06.2023. The hardware cost of the whole system is 30$. This value seems to be quite advantageous considering the capabilities of the system in question.

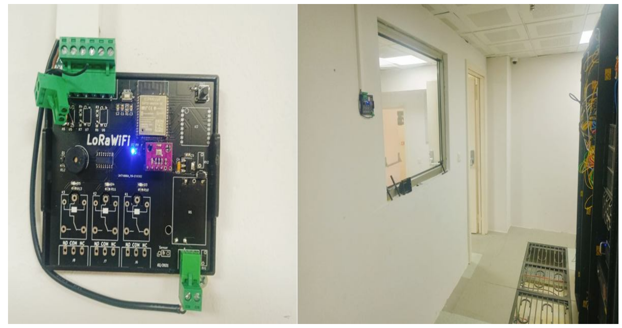

**Fig. 4** View of the developed circuit from the server room

3.2. Constructed Blockchain Structure

In this study, a basic blockchain structure has been prepared to securely store the records of the data obtained from the server room and to securely store the records of the users' access to the system. Python language was preferred while preparing the block chain structure. Figure 5 shows the definition and basic function of the Block class.

```python
# Blok class
class Block:
    def __init__(self, index, timestamp, data[], previous_hash):
        self.index = index
        self.timestamp = timestamp
        self.data[] = temp1,temp2,temp3,temp4, humidty, press, elect_netw_stat, jener, flooding,fire
        self.previous_hash = previous_hash
        self.hash = self.calculate_hash()

    def calculate_hash(self):
        sha = hashlib.sha256()
        sha.update(str(self.index).encode('utf-8') +
                   str(self.timestamp).encode('utf-8') +
                   str(self.data[]).encode('utf-8') +
                   str(self.previous_hash).encode('utf-8'))
        return sha.hexdigest()
```

**Fig. 5** Block class definition and its basic function

Figure 6 shows the definition and basic function of the Blockchain class. In the Blockchain class, firstly, the genesis block is controlled, and if it has not been created yet, it is created. In addition, block addition operations are also carried out.

```python
# Blockchain Class
class Blockchain:
    def __init__(self):
        self.chain = [self.create_genesis_block()]

    def create_genesis_block(self):
        return Block(0, datetime.datetime.now(), "Genesis Block", "0")

    def get_latest_block(self):
        return self.chain[-1]

    def add_block(self, new_block):
        new_block.previous_hash = self.get_latest_block().hash
        new_block.hash = new_block.calculate_hash()
        self.chain.append(new_block)
```

**Fig. 6** Definition and basic function of the blockchain class

SHA256 was preferred as the core algorithm. The decentralisation feature of the blockchain was not implemented since the system's recording mechanism was not built on a ready-made infrastructure such as Hyperledger Fabric. Since no complex transaction is performed on the chain, it is concluded that there is no need for a smart contract. It was decided to evaluate this detail in the objectives of the future study.

3.3. Findings
Transaction speed, transaction verification time, network latency, resource utilisation parameters were measured to measure the performance of the blockchain.

The transaction speed of the blockchain is the number of transactions performed per unit time. This metric is important for evaluating the total transaction capacity and performance of the blockchain network. Transaction speed is expressed as transactions per second (TPS - Transactions Per Second) or transactions per block (BPS - Transactions Per Block). The verification time of a transaction in the blockchain refers to the time it takes for the transaction to be included in a block in the blockchain and confirmed by the network. This is the time it takes for the transaction to be added to the blockchain after it is sent. Network latency refers to the time it takes for a transaction to be transmitted to and confirmed by other nodes on the blockchain network. Lower network latency means faster transaction transmission and validation. Resource utilisation shows the share of RAM and CPU consumed.

In Figure 7, the error rates at different TPS values are measured with 10 different threads running simultaneously for a fixed period of 20 seconds. In these measurements, the TPS value varies between 20-1000. In the light of the findings, it is seen that the blockchain successfully manages requests from 10 different threads with small-valued error rates up to 400 TPS values. As the TPS value increases above 400, it is seen that the error values start to increase linearly. In this sense, it can be said that the upper limit of the performance of the proposed blockchain system is 400 TPS value.

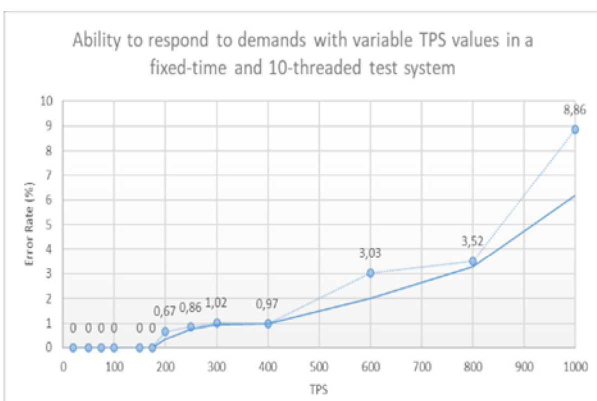


**Fig. 7** Ability of the system to respond to demands with TPS values

It is envisaged to evaluate the temporal performance of the system by measuring the error rates during its active operation. For this reason, in Figure 8, the number of requests generated according to TPS values ranging between 20-1000 were combined and the average completion time of the blockchain process was measured. With the findings obtained, the average delay time experienced in the blockchain system until the TPS value reaches 400 varies between 0.112 seconds and 0.312 seconds. Although this latency is considered acceptable for a blockchain system with strong verification and logging processes, it is observed that as the TPS value exceeds 400, the average latency suddenly reaches 2.915 and gradually increases.

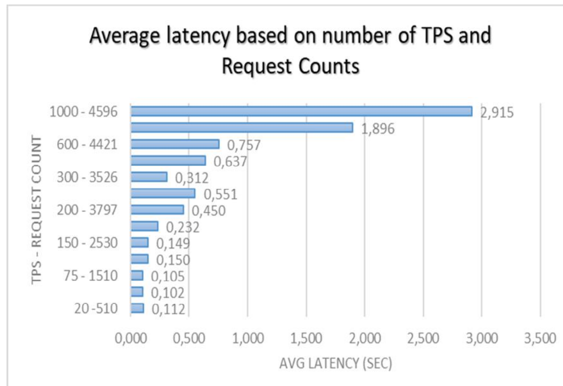


**Fig. 8** Average latency according to TPS and Number of Requests

To complete the performance evaluation of the proposed blockchain structure, it was deemed necessary to determine how it utilises computer resources during its operation. The measurements were performed on a computer equipped with Intel i5 CPU and 16 GB RAM. Therefore, in Figure 9, the CPU and RAM resource utilisation rates of the computer during the execution of blockchain operations are measured and graphed.

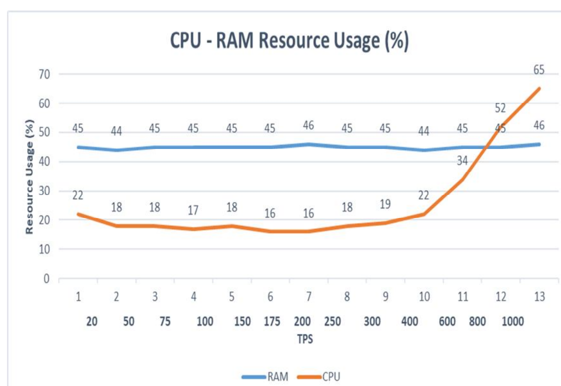


**Fig 9.** CPU - RAM Resource Usage (%)

In the measurement, it was aimed to measure the upper limits of the system by increasing the amount of work demanded per unit time (TPS value). In the findings obtained, it was interpreted that the RAM capacity did not show a significant change and therefore remained constant. It was found that the processor power remained at similar values until 400 tps and increased linearly after 600 tps. These findings show that the optimal upper limit of the system in terms of hardware is 400 TPS as shown in Figure 7 and Figure 8.

## IV. CONCLUSION

This study includes the development of a new purpose-specific circuit board for remote monitoring of critical areas such as server rooms and real-time monitoring of critical parameters, preparation of software and measurement of performance metrics. Due to the importance of the entire system, the system data is kept in a blockchain structure specially prepared for the monitoring system in order to protect privacy and security principles. The performance metrics and resource utilization of the prepared blockchain structure have been meticulously measured. The results obtained have satisfactory values. In future studies, it is planned to add smart contracts to the prepared block chain structure and to realize data flows through contracts. In addition to this, a serious reform of the blockchain infrastructure is aimed to achieve decentralization in data storage. It is thought that the current development targets will improve blockchain performance.

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