Journal of Health Informatics in Africa

Smart Medical System for Trusted Lorawan Server

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Background and Purpose: Leading tech of LoRaWAN in Smart Medical System (SMS) measures the human health parameters with no laboratory diagnosis.
Methods: The system uses an ESP32 microcontroller and bio-sensors to examine the human physiological conditions based on environmental factors using low power components but provides a seamless experience with long-range communication modules (LoRa). Monitored data is centralized in a server that can be accessed securely from remote place.
Results: The main goal of this paper is to implement the patient's health records maintenance with end-to-end encrypted data using consensus algorithms. An Authorized person only accesses encrypted data with the private key through decentralization.
Conclusions: Simultaneously, the proposed system introduces an efficient method to get alert messages from the patient that enables sharing the predicted data in real-time to the caretaker and hospital doctor.

Keywords: Consensus Algorithm, Decentralized, Encrypted, LoRaWAN, SMS.

1 Introduction

In the past decade, various communication technologies have been exhausted and widely used in the universe. This paper introduces IoT with block-chain technology for confidential LoRaWAN servers in hospitals. The Internet of Things (IoT) is an emerging technology, which consists of numerous connections to communicate with each other. It ensures human life more comfortably and is widespread with various paradigms for numerous purposes. IoT facilitates many standard methods to adopt rejuvenation, and it serves many valid tenacities to keep it worth. Hence IoT is the main parameter in the healthcare system's advancement from face-to-face consultation to telemedicine and maintaining health records through Peer to Peer encrypted data. The IoT environment monitors the real-time basic health signs of patients, as present in the room condition. ESP32 Lora Sensor Nodes are used to examine real-time sensor readings wirelessly. A wearable device has various biomedical sensors such as temperature sensors, pulse rate sensors, and glucose-sensor to monitor body temperature, pulse rate, and blood sugar level. Moreover, this system predicts the local temperature and humidity level of the location in real-time to ensure the patient's situation concerning the room condition. The final data comes with digital and graphic visualization, is allowed to be accessed anywhere, from any device, including P.C. and smartphones. It restricts the menacing attacks from IoT and ensures a safe connection between the connected devices start from the beginning.

An analysis system provides excellent insight to bring patient self-assessment in a remote place. The proposed smart medical system circuit and authenticate patient health record function, mainly focused on monitoring the patient's health condition and process of the medical report in an efficient method. Secure transaction of health records to authenticate a person is cost-effective and improves the quality of healthcare or hospital sector. The rest of the paper is discussed as follows: Section 2 discusses this paper's related works. Section 3 presents proposed system design and workflow of the trusted LoRaWAN network using

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 J Health Inform Afr. 2025;12(1):65-73. DOI: 10.12856/JHIA-2025-v12-i1-548

block-chain. Section 4 has the results. Section 5 has the discussion about measurements of the data transaction performance. Finally, conclusion in Section 6.

2 Related Works

One of the rapidly developing assertive communication of the Internet of Things (IoT) connects several objects such as mobile or electronic devices, vehicles, and home appliances connected to the internet. It shares the stored data with the user in a remote place [1]. Evolving a wireless sensor to observe basic health parameters in real-time rate with an alarm indication for the abnormal patient [2], and that support remote healthcare monitoring system [3]. The estimation of blood glucose level is essential for a diabetic patient to avoid the critical stage [4]. A wearable body area network (WBAN) monitors the human body and surface conditions around the people, including temperature and humidity [5]. Recently, LoRa technology used in broad areas like research and industrial interests. It connects several wireless devices with low-cost power and long-range communication [6]. For encryption and data security, the LoRaWAN use three different security keys and transfer the data through wireless sensor [7]. A remote Healthcare Monitoring system is portable that detects the patient's current condition, conveys it to the medical staff or guardians in real-time with safe and secure [8] & [9]. To improve the healthcare sector, electronic health record system involves in secure data storage and transaction using block-chain technology [10], [11] & [12]. This method has a decentralized, data transparency and confidential features for data exchange verification at a particular time in network [13], [14], [15], [16] & [17].

3 Materials and Methods

The proposed system construct with the bio-medical sensor to detect the physiological human health and the LoRaWAN network server integrated with block-chain for privacy and more security data transaction.

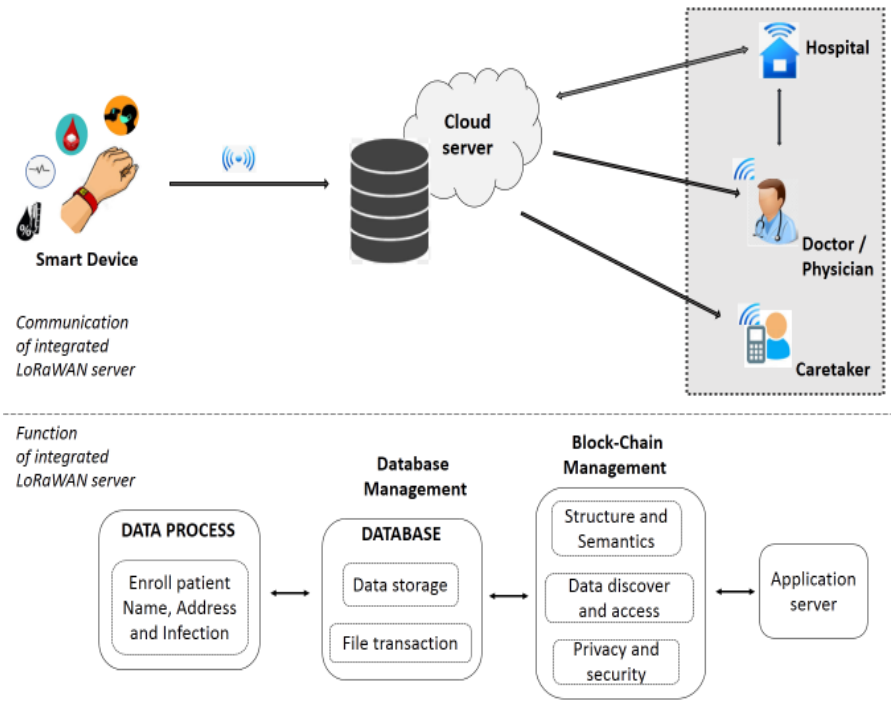

Figure 1. System architecture

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3.1 User - Server Communication Interface

The user interface system module could be patient, caretaker, doctor, physician, nurse, hospital, etc. The smart medical device consists with bio-sensor equipment to monitor the human health condition which depend upon the environment parameter. In an emergency period, the smart device helps to determine the patient body health before undertaking treatment. ESP32 encloses a pulse and temperature sensor to examine the human condition body level and send it to the webserver through the Wi-Fi /internet /Bluetooth. MAX30100 Pulse Oximeter sensor is integrated pulse oximetry and heart-rate monitor sensor kit. The sensor emits the infra-red light used to measure oxygen levels in the blood. As a result of having more blood, the oxygenated blood increases when the heart pumps the blood, whereas the heart relaxes, the volume of oxygenated blood decreases. The time interval between the increase and decrease of oxygenated blood or the counts were taken to move to another phase determines the pulse rate. In general, oxygenated blood absorbs more I.R. rays and passes red light, while deoxygenated blood absorbs red light and passes more I.R. rays. The variation of sugar level in blood signifies as diabetic and that monitor using the analyzing system. In wireless communication, the data are sent to the internet and served in the IoT cloud server to reach the user. Receiving sensor information infer the environment that can affect the actuators to move accordingly. The actuators control the receiving signal into physical system. The data stored in a buffer can read via I2C. DHT11 is a low-cost digital temperature and humidity sensor that uses a capacitive humidity monitor and thermistor, respectively. It detects the environment contamination level, and that illustrate in Fig.3. It is relatively easy to integrate and predicts results more accurately. Monitor the room temperature and humidity level in a continuous manner. These sensors are integrated with a single PCB board to achieve examination, similar to the laboratory workings easily.

In the transmitting node, hold an accelerometer and gyroscope that measure the static acceleration. Whenever the patients need any help, fingers' movement works as an input to the microcontroller and different processes. The microcontroller maps the 0 – 5 voltage into 0 – 1023 analog values and is more sensitive. Even a slight movement can change the values, and thus the sensitivity is reduced. Receiving data information and alerts are stored in data storage such as name, address, and patient health information. These messages maintained and delivered to the user for corresponding request. The data table ensures the statistics of human health and corresponding alert messages to the health senses level. A health monitoring system evaluates and tracks from remote area in real-time approach.

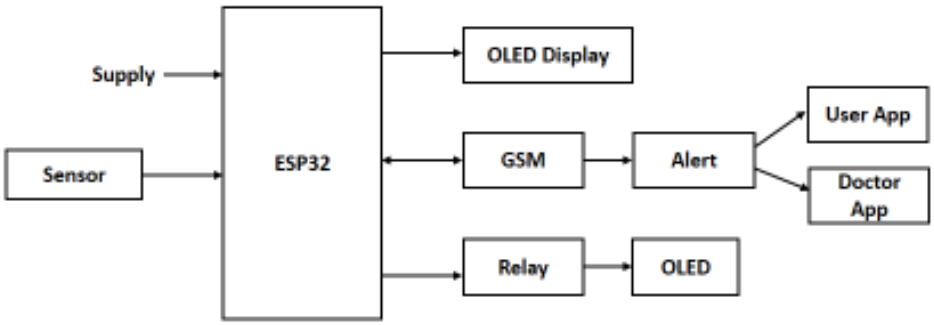

Figure 2. Server sends an alert to mobile app

LoRa Radio sends a signal through a server or mobile application designed dedicatedly to such an application. As an alternative, for immediate output response, OLED is connected and can be viewed quickly. The I.P. address display on the OLED and the data can be monitor after accessing it in the browser. The advantage of using LoRaWAN is that the system cannot be broken or interrupted by any external agency unless the battery goes down, thus providing a stable connection between the transmitter and receiver. The alarm is set in the device to alert their time of treatment and consume food and medicine. Sudden changes in the human body increase the illness; in that situation, this analyzing system examines the temperature and body condition to proceed for the next stage of treatment. Furthermore, this device sends a message with no delay and operates in a remote place with full security.

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Table 1. – Data variation's an alert's

No.	Sensor Name	Monitoring Rate	Data Range	Alert Message
1	MAX30100 Pulse oximetry	Pulse rate	>100 beats	Take rest to reduce your stress.
2	MAX30100 temperature sensor	Body temperature	>36 ℃	Remind to drink more water and take a rest
3	DHT11	Temperature and humidity	>50 and above 70%	Avoid working and take rest

Table 1 shows a variation of collected information and the alert message for corresponding data. The human health rate fluctuations notify the user in the form of an alert message. The message variation guides the user to treat the patient properly and the regular analyzing indicates improvement of health. An alert transfer to mobile app (caretaker, physician and Doctor) and access the medical data from storage.

3.2 Trusted LoRaWAN Network Server Function

The smart medical system is another potential application to collect the patient health records. In medical environment, the LoRaWAN server provides secure transaction in private organization network. In this paper, the LoRaWAN technology integrated with block-chain method to improve more secure transaction. It is open, trusted, decentralized and tamper-proof network. To reduce the communication traffic, the consensus algorithm implemented to encrypt the data information before updating the block-chain ledger which stores hash data. Each block-chain has transaction function of packaging, hashing, verifying, block creation and storing block-chain, etc. The following transaction Functions are given below to ensure the privacy and data authentication. Such as,

- Hashing – A unique ID to identify the block.
- Asymmetric cryptography – public/ private key establishment and secure data transaction
- Digital signature – the digital signature of the generating a node
- End to End encryption – the data transaction between Smart device to users without hacking at a specific time.

The PoA algorithm implement to ensure privacy and authenticate data transaction. The PoA is a combination of proof of work and proof of stake algorithm which provides more secure transaction against hackers or attack types.

Algorithm for Security

Input: m smart devices and n number of users participating in the network

Output: block chain- data for m smart devices

For SD_x, U_y,CS_r MN_ido

Register all assigned values {SD_x, U_y,CS_r}

Generate the secret key

Prepare block BLK_p from SD_x receiveddata

Call mining method for block addition using the algorithm with MN_q

If other MN_q performs adding of BLK_p then

Add BLK_p in block-chain

Else

Abort addition of BLK_p in block-chain

End if Prepare block BLK_p from SD_x receiveddata then

Call mining method for block addition using the algorithm with MN_q

If other MN_q performs adding of BLK_p then

Add BLK_p in block-chain

Else

Abort addition of BLK_p in block-chain

End if

End for

Table 2. Abbreviation used in proposed algorithm

Abbreviation	Meaning
SD_x	x^{th} position of Smart Device
U_y,	y^{th} User
BLK_p	p^{th}Block in block-chain
MN_q	q^{th}Miner Node
CS_r	r^{th} Cloud Server

The algorithm explains the function of authenticate transaction in network. The proposed algorithm possesses patient medical records (Name, address, disease, etc.) that are to define the functions to insert, update and delete accounts. Consider the m number of smart device and n number of users are participating in the proposed network. Register the assign the values (SDx, Uy, CSr) for smart devices, user and cloud server. Performing a mutual authentication and generating a secret key among the register values. After a key generation the block is prepared to store a secure information from the smart devices. Request the mining procedure to add block using the proof of Activity (PoA) protocol with other miner nodes. The other miner node sends a request to add block, and it verifies the block signature successfully to perform the block-addition function. Nevertheless, it performs to abort the block in block-chain and it repeats the function.

4 Results

The system makes it more reliable to the users, guardians, or physicians. The smart device monitors the temperature level, blood glucose, and pulse rate measures and represented in a graphical view with quick access to digital text. It is ultimately showing accurate results tested and transfer the medical report to authenticate user through trusted network.

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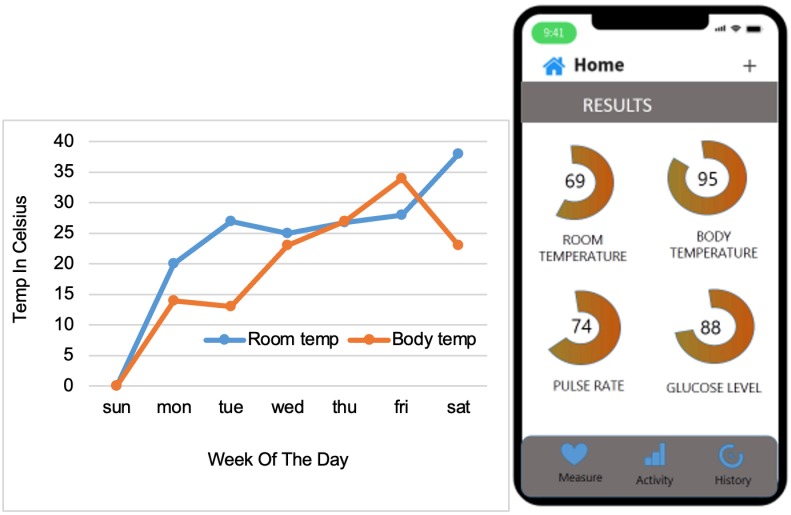

(a) (b)

Figure 3. (a) Monitoring the room temperature and human body temperature, (b) Health Monitoring Dashboard.

Fig.3 (a) & (b) illustrates the graphical representation of the room temperature and the human body temperature. A significant factor, health condition depends upon the environment climate. The output of the temperature plot in Celsius displays its temperature level of the human body and its surrounding environment. The room temperature and relative humidity change the body temperature, affecting the pulse level and other health parameters. The variation of the glucose level also monitored for an average person and diabetics. The glucose level in the blood is always high for diabetics than the typical person. The pulse rate and glucose level are sequential high for the people with diabetes; they test and verify their body condition using this system. The monitoring system is helpful for the person to maintain their health condition.

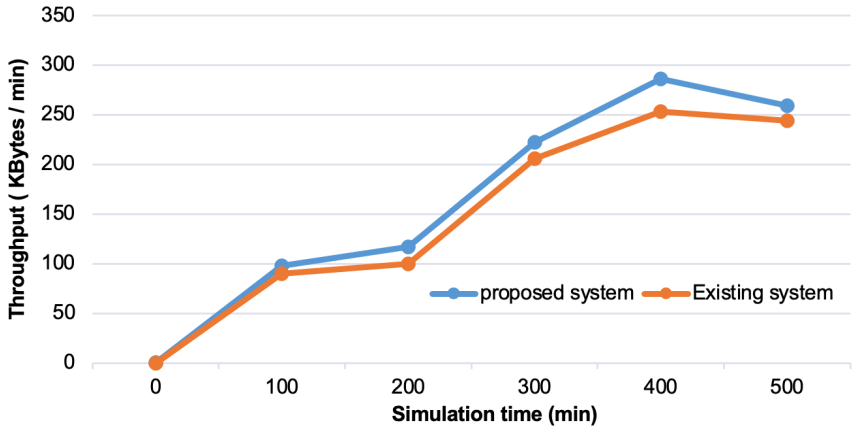

Figure 4. Throughput Vs Simulation time

The Fig.4 graph represents the throughput performance for proposed and existing system. The throughput has been measured, and it denotes as KB/min unit. The medical report delivers to authenticate user from the smart device which used to monitor the physical condition. Increasing throughput value indicates the improvement of secure transaction with low traffic rate.

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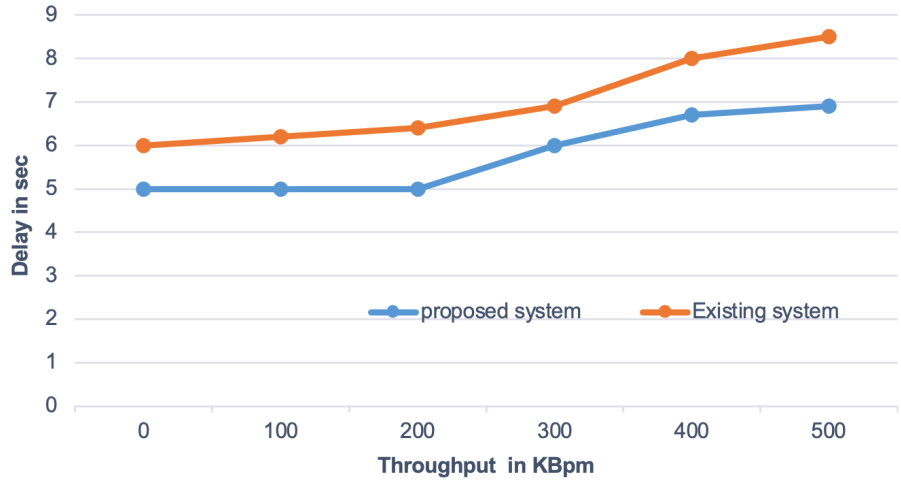

Figure 5. Transaction Delay for comparison work

The Fig.5 graph represents the delay that states the difference between two actions. The minimum delay improves the data transaction speed in a specific time. Hence, compute the transaction size before the calculation of throughput and delay parameters.

5 Discussions

The smart medical system delivers a data through the network at a particular time without delay. The network gathers the information from smart device and validates the cryptographic mechanism. The hash performs to create the unique ID to validate the secret key and provide secure transaction. The stored data in database (block) can be view, verify, add and delete records. The calculation of data collection has major parameters they are follows,

5.1 Transaction size and time

The transaction time refer as time duration between the two operations (appending and deleting) in the block-chain network. The calculation for the transaction time is given below,

$$\text{Time} = \text{Max}\ (t_x) - \text{Min}\ (t_y)$$

The ratio of blocks size to transaction per block provides the size of a transaction. The transaction size of each block can be calculated as follows,

$$\text{Transaction per block} = \text{No. of transaction per min} / \text{No. of blocks per min}$$

$$\text{Transaction size} = \text{blocks size} / \text{transaction per block}$$

Transaction per block is obtained by dividing number of transactions per minute with number of blocks per minute. The measurement of transaction size is 0.18KB approximately for better performance.

5.2 Throughput performance and delay

The amount of data transfers from one block to another block in a block-chain network within a particular time is known as throughput. Increasing of the throughput value improves the performance level in the network. Delay refers as the transaction time between the deployment and completion time in a block. The low value of delay increases the transaction speed in the network.

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6 Conclusion

This paper introduces the smart medical system to monitor the human health and describes the secure data transaction in the integrated LoRaWAN network. The LoRa gateway communicate the data between user and server. The health report can be view, update by authenticate user in real-time using the consensus algorithm. This system is more trusted using emerging block-chain technology through generating a secret key. The health report includes the patient details, and it helps to identify the patient ID for consultation at a time. The transaction size is also evaluated to improve the throughput performance and reduce the transaction delay in a block-chain network. The proposed system also helps us in pandemic season like COVID-19 for under treatment. Moreover, the medical report transfers in a concurrent session for consultation and treatment. The database ensure privacy than the existing system to provide quality transaction performance. It improves the highly efficient data transaction with low traffic in a real-time manner.

Acknowledgment

No acknowledgment.

Statement on Conflicts of Interest

The author(s) have not declared any conflict of interest.

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