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A Proposed Secured Health Monitoring System for the Elderly using Block chain Technology in Nigeria

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Abstract: ***A large number of connected smart objects and sensors, as well as the establishment of seamless data exchange between them, have been made possible by the Internet of Things (IoT) technology's recent rapid development. As a result, there is a high demand for platforms for data analysis and data storage, such as cloud computing and fog computing. IoT makes it possible to customize apps for older persons as well as for rapidly expanding markets that must modify their products to match the preferences of their customers. This study suggests a framework for a decision-support system and a protected health monitoring system using IoT data collected from senior residents' homes. The study intends to provide security to the users' data from the point of acquiring of the data to the relaying of the data to cloud and to the alert generation using blockchain technology. Further research should focus on key management and security, as well as the capability to easily replace lost or compromised keys.***

Keywords: Internet of Things (Iot); Blockchain; Cloud Computing, Health Monitoring, Behavioural Reasoning Theory (BRT)

1. INTRODUCTION

Internet of Things is a new technology that has emerged as a result of the recent proliferation of embedded systems and information and communication technology (ICT) (IoT). IoT makes it possible for physical items and people to communicate with data and virtual worlds. IoT is positioned to play a significant role in all facets of health management due to the quick development of IoT device deployment and growing need to make healthcare more affordable, customized, and proactive [1]. The Internet of Things (IoT) is gaining traction as a disruptive

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paradigm to offer new capabilities and services in a variety of industries, including smart cities, industry 4.0, smart energy, and connected cars [2]. One of the most well-liked technology innovations in healthcare right now is the Internet of Things (IoT), which is used for Ambient-Assisted Living (AAL), remote health monitoring, chronic illness management, senior care, and fitness programs [3].

The need for effective healthcare solutions, particularly for the elderly, is driven by aging populations and the rise in chronic illnesses worldwide. Concentrating on remote health monitoring systems powered by IoT technology is one technique that has attracted a lot of academic attention. In particular for patients with chronic illnesses and the elderly, this notion can help lessen the burden on hospital systems and healthcare personnel, lower healthcare expenditures, and enhance homecare [4]. Older adults can now receive real-time healthcare by sending information about their physical conditions to a medical facility via wireless sensor networks thanks to the development of a variety of smart wearable systems, which provide immediate feedback on vital signs like heart rate and blood pressure [5].

IoT usage and the advancement of wireless communication technologies enable for the real-time streaming of patient health status to caregivers [6]. Sensors, actuators, and smart textiles can be used to construct a smart wearable system that is backed by technologies like wireless sensor networks and electronic care surveillance devices for health assessment and decision assistance. The major functions of modern smart wearable devices are fall prevention, location tracking, body movement monitoring, and monitoring of vital indicators [5]. Additionally, a number of readily accessible sensors and portable devices may instantly monitor some human physiological parameters including blood pressure (BP), respiration rate (RR), and heart rate (HR) with a single touch. Although it is still in the early stages of development, businesses and industries have swiftly incorporated the potential of IoT into their current systems and seen gains in both user experiences and production [7].

All health and medical data are saved on the central server computer according to the usual centralized storage pattern. Each hospital department's computers have the ability to store, gather, and query health information. In this instance, a hacker attack on the main server compromises health data. In reality, figures show that the healthcare industry saw almost millions of patient records exposed in hundreds of breaches between 2010 and 2017 [8]. IoT technology integration in healthcare does present certain difficulties, including those related to data management, storage, and sharing between devices as well as security and privacy. Blockchain and cloud computing technologies are two potential responses to these problems [9].

Due to extra regulatory needs to secure patients' medical information, the healthcare sector has specific security and privacy requirements. With cloud storage and the use of mobile health devices, the exchange of records and data is becoming more common in the Internet age, but so is the possibility of hostile assaults and the chance of private information being compromised. The sharing and privacy of this information are issues when people visit several providers and access to health information via smart devices increases. Authentication, interoperability, data sharing, the transfer of medical information, and considerations for mobile health are the specific criteria that the healthcare sector must meet [10]. As a result, blockchain technology may be used by IoT and cloud providers to communicate data in a decentralized fashion that is both safe and private.

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As more people are eager to participate in healthcare decision-making, IoT technology is becoming more commonplace in the industry. Additionally, patients are more eager to personalize their treatment by acting more proactively. Smart gadgets and smart sensors that capture and deliver crucial health data to their doctor to remotely monitor chronic illnesses can help to personalize healthcare and treatment [11]. Smart watches, contact lenses, fitness bands, chips embedded in the skin, and wireless sensors are a few examples of IOT healthcare applications that help seniors make better health decisions. However, these wireless systems don't always give security the same kind of consideration that other, more sensitive systems, such databases and databanks, do. IoT systems are susceptible to several threats and vulnerabilities that might jeopardize security [12].

Symmetric key cryptography is the security approach used by a Cloud-Centric IoT-based healthcare system by [13] to secure and protect the patient's medical data. The user password is encrypted using a "private key" as the foundation of the security system. Despite the many advantages of symmetric encryption, there is one significant drawback: the difficulty of sending the keys needed to encrypt and decode data. These keys are susceptible to being intercepted by nefarious third parties when they are transmitted over an insecure connection. The security of any data encrypted with a specific symmetric key is jeopardized if an unauthorized user obtains that key. Since a result, the asymmetric cryptographic method can aid in resolving the trust issue in health data management [14], as only secured and decision-supporting data can be trusted. The asymmetric cryptographic technique used by the blockchain-based healthcare system effectively solves the authentication challenge. Two cryptographic keys, a public key and a private key, are stored on each node. Anyone who wishes to communicate encrypted material to the owner of the private key can receive the public key.

Data privacy and security issues for important stakeholders have unavoidably increased as the healthcare system becomes more complicated. Even though the vast majority of medical records have been converted to digital format, they are frequently scattered throughout many medical facilities around the world in storage towers. This has repercussions for the healthcare sector, which depends on organizations providing accurate and comprehensive information. It is claimed that blockchain technology can solve the problems with information exchange in the healthcare industry.

Blockchain technology has become increasingly popular in recent years thanks to its many attractive features, including chronological and time-stamped data records, auditable and cryptographically sealed information blocks, consensus-based transactions, and policy-based access to help with data protection, fault-tolerant distributed ledger, and many more. Blockchain link parties directly without the need for middlemen; they are economical and distributed ledgers that improve information accessibility [15]. These characteristics make blockchain technology a profitable choice for the healthcare sector. Due to its intrinsic properties, blockchain can offer a suitable solution to privacy and security issues, making it a viable paradigm for fields where privacy and security are highly valued [16].

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The aim of this study is to propose a cloud-centric IoT based framework for health monitoring with blockchain capability.

A. Overview of internet of things

The name "Internet of Things" is a combination of two concepts: the first is "Internet," which is described as networks of networks that may link billions of people using common internet protocols [17]. IoT is also known as an open, vast network of intelligent devices that may self-organize, exchange information, data, and resources, and respond and act in response to circumstances and environmental changes [18].

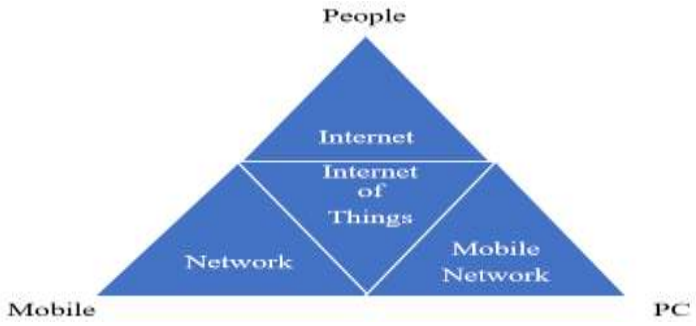


Fig. 1. Basics of Internet of Things

Source: Adopted from [19]

B. History of IoT

The Intert of Things (IoT) sector ushers in a new era of technology and communication where devices can converse, compute, and change data as needed. This communication situation has already been tried, but it wasn't well received. In 1999, Kevin Auston, the Executive Director of MIT's Auto-ID Labs, created the phrase "Internet of Things." Through the Auto-ID Centre in 2003, as well as in linked market analyses and its publications, the idea of IoT initially gained significant popularity [20]. When the idea of this type of communication first emerged, various businesses concentrated on it, tried to understand its significance, and started to pinpoint its function and related future aspects. Following this, these businesses began investing in the IoT sector at irregular but consistent intervals of time [21].

C. IoT architecture

IoT system technical standards and reference designs are still in need of completion and standardization [22]. Typical IoT communication topologies allow IoT devices to interact with one another independently in addition to connecting to the Internet, which serves as the network's infrastructure [23]. IoT architecture does not currently have a recommended standard, but [17] presents five architects or models created by academics, writers, and practitioners. An IoT system typically consists of three layers, though there may be slight variations in the architectural models: a physical perception layer that perceives the physical environment and human social life; a network layer that transforms and processes the data from the perceived environment; and an application layer that provides pervasive, context-aware intelligent services [24].

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The mixing of various hardware and software components in an IoT multilayer stack made up of three fundamental layers—the item or device layer, the connection layer, and the IoT cloud layer—is also described in [25]. [26] provide an explanation of each layer, indicating that the IoT is architecturally divided into three layers: the device layer, which is the foundation of the IoT and uses technologies like RFID, NFC, wireless sensor networks, and embedded intelligence; the connection layer, which is made up of gateways and the core network; and the application layer, which is made up of objects with sensors. The study of [27] notes that sensors collect, analyse, and measure data. IoT is made possible by the tethering of equipment and sensors. Furthermore, the secret to exploiting leveraged data is cloud-based apps.

Without cloud-based apps to analyse and send the data flowing from numerous sensors, the IoT cannot work. An IoT architecture model that was simplified was created using the findings of this research. View Figure 2. IoT development teams need to know the architecture in order to build and maintain the IoT, but academics and practitioners are more likely to be interested in IoT applications.

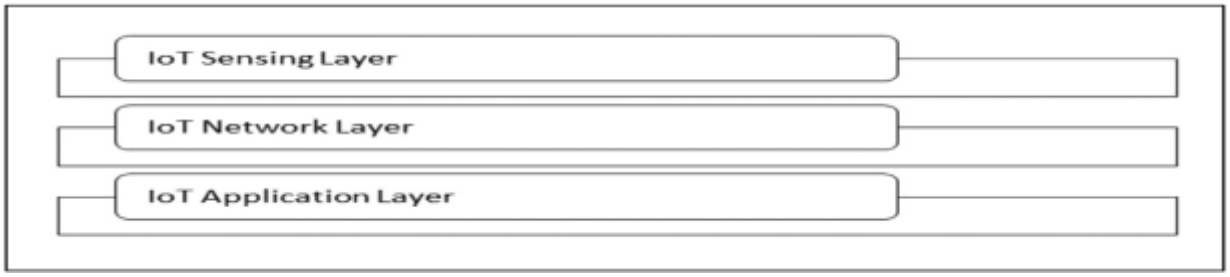


Fig. 1. IoT architectural model

Source: Adopted from [28]

D. **IoT applications**

IoT applications may be used in a wide range of contexts, from "big" company to personal. This idea is supported by [29], who claim that the IoT makes it possible to create a wide range of industry- and user-specific IoT applications. IoT apps enable device-to-device and human-to-device interactions in a reliable and resilient way, whilst devices and networks offer physical connectivity. The study of [30] divided IoT applications into four major categories: personal and social domain, healthcare, smart environments (home, workplace, and plant), and transportation and logistics. Manufacturing, retail trade, information services, banking, and insurance were ranked by [29] as the top four industries in terms of IoT value. The breadth of the relevance of IoT applications inside sections of their enterprises was shown by the findings of a survey involving 500 senior executives from across the world who were in charge of IoT activities [31].

A study conducted by [32] evaluated three things in a research on IoT applications: what people search for on Google, what people tweet about, and what people post on LinkedIn. The top 10 application category rankings followed. According to this report, the top three categories are "smart home," "wearables," and "smart city." The study of [33] classified the top 10 IoT application areas after verifying 640 genuine enterprise-IoT projects. On the list of actual IoT project areas, connected industry, smart cities, and smart energy were at the top. Despite being

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a young technology, the IoT has a wide range of applications and has a substantial influence on a sizable portion of society. This is supported by [25], which shows that the IoT technologies' domains of use are as varied as they are numerous, touching almost every aspect of daily life.

E. IoT in healthcare

IoT healthcare solutions are appealing in this new environment because they allow clinical healthcare to be personalized, resulting in not just considerable cost savings but also better results because to increased responsiveness, customisation, and efficient use of aggregated data. IoT healthcare can speed up the diagnosis of medical conditions [34], deliver effective, high-quality treatment, and lower the cost of hospitalization [35] and likelihood of readmission for the same medical problem [36: 37]. Connected IoT healthcare enables people to track their own development and provide clinicians ongoing input, increasing patient engagement and happiness. The introduction of IoT in healthcare also creates new opportunities for enhancing doctors' current standard diagnostic methods by allowing for rich longitudinal data collecting from many sources. In particular, data analytics can automatically identify physiological abnormalities for additional inquiry, and visualization tools can highlight important patterns without taxing doctors' cognitive resources or obstructing their interactions with patients in the clinic [38].

In order to satisfy the demands of healthcare follow-up connected to the enormous growth in the senior population and provide e-health services, Health Monitoring Systems is a fantastic option. Medical treatments that were previously exclusively offered in hospitals can now be provided at home thanks to this approach. The gathering and analysis of patient-related data through wearable sensors is a key component of these services. This unprocessed data is insufficient for e-health services and may be misinterpreted by health monitoring systems. By analysing the observed patient's Activities of Daily Living, we may evaluate the context, increase our knowledge of the subject, and interpret the patient more accurately [19]. Health professionals can now deliver quicker, more effective, and better healthcare services, which improves the patient experience. This is made possible by the integration of IoT and cloud computing into the healthcare industry. Better healthcare services, a better patient experience, and fewer paperwork for healthcare personnel are all benefits of this.

Health monitoring may be used to create Internet of Things (IoT) healthcare apps that offer clinical decision assistance to patients in an efficient manner. Clinical participation will be reduced via change prediction and decision support. Patients can receive feedback such as suggestions for medication, a healthy diet, and exercise without the involvement of a doctor [4].

F. IoT and cloud computing for healthcare

The only ways that doctors and patients could communicate before the Internet of Things and cloud computing periods were in-person visits, phone calls, and texts. Doctors were unable to remotely check on their patients' health in order to administer prompt therapy. But recently, IoT and cloud computing-based healthcare systems have opened up the possibility of real-time applications in the healthcare industry, unleashed the full potential of IoT and cloud computing in the healthcare, and assisted doctors in providing top-notch medical treatment [9]. Because

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patient and doctor communications have become more accessible and effective, IoT and cloud computing have enhanced patient participation and satisfaction. Additionally, remote monitoring shortens hospital stays and prevents readmissions. These new technologies consequently have a big influence on lowering healthcare costs and raising patient outcomes. By fostering the development of a new range of IoT-connected medical equipment and enhancing patient engagement in healthcare systems, IoT and cloud computing technologies are enhancing the healthcare sector. Applications for IoT and cloud computing in healthcare are being created at an increasing rate to benefit patients, families, doctors, hospitals, and insurance providers [9].

The cloud computing paradigm has emerged as one of the most popular subjects in information technology in recent years. By offering consumers on-demand computing resources (such as storage, services, networks, servers, apps, and hardware), it provides advantages in terms of scalability, mobility, and security. Research by [39] indicates that cloud computing has lately become the foundation of IoT healthcare systems. The capacity to share information amongst medical staff, carers, and patients in a more structured and organized manner, hence reducing the likelihood of lost medical data, is another significant benefit of cloud computing [40]. As a result, the development of technologies like IoT and Cloud Computing has helped healthcare services and applications [41]. Because of this, healthcare organizations are depending on the adoption of IoT and Cloud computing to improve the way elderly patients and staff/health care professionals receive healthcare services [42]. These technologies have the ability to assist the medical services offered for the elderly's best health management in a comfortable setting that improves quality of life.

I. Blockchain Technology

A blockchain is an immutable, traceable distributed ledger, also known as database, of transactions [43]. There are three main blockchain designs: public, which is not controlled by any one entity and is open source, allowing any actor to participate without restriction, private, which is permission-based and accessible only by authorized actors, and finally hybrid, which offers flexibility and the option to designate specific data subsets to be available publicly or privately [44]. Bitcoin, which Satoshi Nakamoto introduced in 2008 [45], was supported by the first blockchain. Although a thorough technical description is outside the scope of this paper, it is important to note that the system was designed as a shared, distributed ledger that uses encryption and is independent of a central authority that validates transactions [45]. By establishing a system where two strangers may transfer value to one other without prior established trust in a secure, irrefutable fashion, this idea effectively eliminates middlemen. According to the research, this technique might be used to safeguard healthcare data more effectively while facilitating system interoperability [46]. According to the literature, blockchain is a suitable option when there are several stakeholders, there is a lack of confidence, and accurate and accountable tracking is needed [15].

Enhancing data sharing, EMR administration, and access control are at the forefront of this technology's application in healthcare, according to recent systematic literature reviews by [15] and [47]. With Guardtime being used to administer the EMRs for more than 1 million residents, Estonia, for instance, was the first nation to utilize blockchain technology on a national scale [15; 48; 49]. Each individual has the option to grant or deny permission for their

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healthcare records to be accessed and utilized by third parties thanks to blockchain technology [50].

Inviting suggestions on how blockchain technology may be used into US healthcare, the CDC in America has also started to investigate how distributed ledgers can assist PH practitioners in responding more promptly to crises [51; 52]. However, there hasn't been much study done to yet on possible obstacles to blockchain adoption in the healthcare industry. According to some study, the difficulties with implementation are related to scalability, cyberattacks, and excessive energy use [53; 54]. Additionally, it has been acknowledged that while the initial costs of using blockchain technology are high, they may be reduced over time [55].

J. The need for blockchain in healthcare

Blockchain is characterized as a growing body of information, commonly referred to as blocks that are connected through cryptography in a way that prevents alterations [56] and encourages security and transparency. Through the removal of expenses and privacy problems, improving coverage and quality, and enabling user provision of healthcare, technology can help to enhance health service delivery and quality of care support [57]. Every area of information and communications technology (ICT) has been impacted by blockchain technology, and usage has increased significantly in recent years. Healthcare is one of the industries where blockchain is thought to have a lot of promise [58].

The management of data that might profit from the capacity to link disparate systems and improve the accuracy of EHRs should be the focus of efforts to reform healthcare. Access control, data sharing, and monitoring an audit trail of medical activities are all possible with the use of blockchain technology. It can also be used to support medicine prescriptions and supply chain management, pregnancy and any risk data management, as well as access control. Provider credentials, medical billing, contracts, medical record interchange, clinical trials, and anti-counterfeiting medications are all sectors of healthcare that stand to gain from blockchain technology. One advantage of adopting blockchain, which is based on peer-to-peer networks, is that it updates in real-time, eliminating the need for middlemen and their expenses [59]. Blockchain provides a transparent environment where both patients and healthcare providers may access records easily and without further expenses because it is resistant to alterations [59; 60]. By lowering the likelihood of lost records and mistakes, it also improves system security [61].

The provision of healthcare services is evolving to support a patient-centric philosophy. Since people will have authority over their medical information, blockchain-based healthcare solutions might improve the security and dependability of patient data. These technologies could also aid in the consolidation of patient data, facilitating the sharing of medical records between various healthcare facilities. In the healthcare industry, it is crucial to store patients' medical information [62]. Due to their extreme sensitivity, these data make for a lucrative target for online assaults. Consequently, it is crucial to protect any critical data. Control of data is another issue, which should ideally be handled by the patient. Therefore, obtaining and exchanging patient health data is another use case that can profit from cutting-edge contemporary technology. Blockchain technology offers a variety of access control strategies and is very resistant to assaults and failures. Blockchain therefore offers a solid platform for healthcare data [62].

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The healthcare sector is described as a conventional one that is resistive to novel techniques and extremely inflexible to measure owing to the realities of change. Healthcare-related issues, such as privacy, treatment quality, and information security, have gained attention in recent years on a global scale. Blockchain technologies are being recognized more and more as a solution to solve current problems with information dissemination. It could enhance the provision of immediate healthcare services and support for excellent treatment, for instance [10]. Civilian health records have an inherent difficulty with data sharing and access in addition to a security issue. Sharing medical records can be challenging at times since an individual's complete data can be kept in many different places. In the same way that healthcare practitioners do not have access to the most recent patient data if the records are kept elsewhere, patients do not have a unified picture of these dispersed records [63].

Blockchain technology can protect clinical trial results, health information, and regulatory compliance. Blockchain technology is utilized to show how smart contracts might facilitate real-time patient monitoring and medical treatments [64]. Such systems guarantee record security while enabling Health Insurance Portability and Accountability Act (HIPAA)-compliant access for patients and medical providers. By encoding data in a block, the blockchain's security is accomplished utilizing cryptographic keys, a distributed network, and a network servicing protocol. Once information (such as a transaction request) has been verified, meta-data is stored in a block and cannot be deleted without the networks and the record's creators' knowledge and consent. A block does not alter when it is included in a chain of other blocks.

H. Empirical Review

Many researchers concentrate their efforts in this field of study. A people-centric sensing paradigm for the aged and handicapped was presented by [65]. The methodology's goal is to offer a service-oriented emergency response in the event that the patient's state is aberrant. To reduce vulnerabilities in a healthcare setting based on the Internet of Things, [40] presented an intelligent collaborative security architecture in 2015. 74 They also looked at developments in IoT healthcare technology. Additionally, a focus is placed on examining the most advanced network architecture/platform, applications, and commercial advances for IoT-based healthcare solutions. A Smart Hospital System (SHS) was proposed by [66] in 2015 employing technology improvements, primarily RFID, WSN, and smart phones. Through an architecture of IPv6 through low-power wireless personal area networks, these technologies communicate with one another.

Healthcare Industrial IoT, a real-time health monitoring system, was presented in [67]. (HealthIoT). This approach has a lot of promise for analysing patient healthcare data to disprove causes of mortality. The medical devices and sensors used in this IoT framework for healthcare are used to gather patient data. Additionally, this framework incorporates security practices like watermarking and signal augmentation to prevent identity theft and clinical mistakes made by medical personnel.

The integration recommendations for remote health monitoring in medical practice have been given by [68]. In IoT infrastructure, cell phones have been employed as concentrators, while clouds or cloudlets have been used for data aggregation. It is also understood that employing clouds for data processing would be more effective than combining

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cloudlets and wearable sensors for data collection. Using these sensors, authors conducted a two- to three-day period of continuous physiological monitoring and gathered key physiological information to update the pertinent health database.

Study of [69] described a new technology known as a body sensor network that is built on improvements in IoT medical devices (BSN). Using various tiny-powder and lightweight sensor networks, the patient may be observed inside this framework. Additionally, this architecture took into account the security needs for constructing BSN-healthcare systems. In 2015, [70] explored the history of IoT and its use from the standpoint of healthcare. The authors developed an IoT for u-healthcare ideological framework.

A framework for the human vital sign monitoring system was established by [71] in 2015. From a distance, the device measures the body temperature and pulse rate. Additionally, in the event of anomalies in health measures, an IoT enabled network infrastructure and computational processor are employed to create emergency alerts. Using context motion tracking, [72] created an emergency scenario monitoring system for patients with chronic diseases in 2015. The system uses contextual information to diagnose the patient's present condition and then uses patient life patterns to offer the necessary information. To identify and stop the spread of the chikungunya virus, [73] created a fog-assisted cloud-based healthcare system in 2017. By combining proximity data and temporal network analysis at the cloud layer, the status of the chikungunya virus outbreak is ascertained.

They mention a few instances of the use of blockchain technology in healthcare in their assessment by [48]. These include the MedRec project, which was developed to make the management of permissions, authorization, and data sharing between healthcare entities easier, and the Guard time company, which runs a blockchain-based healthcare platform for the validation of patients' identities for Estonian citizens. Similar to this, [15] lists a number of "notable" instances of blockchain technology businesses in the healthcare industry. These businesses are categorized under three main healthcare use cases: the dentistry sector, patient-centred medical records, and prescription medication fraud detection. This assessment is also comparable to the one by [49], in which he lists some instances of blockchain-based enterprises and applications in the fields of managing public health, conducting medical research, and combating medication fraud in the pharmaceutical sector.

The primary advantages of blockchain over conventional databases for healthcare applications are published by [74] on their end. They go on to describe how these advantages might be used to develop healthcare data ledgers, boost clinical research, and streamline insurance claim procedures. In their study, [75] also discusses the current and future uses of blockchain in a variety of medical disciplines, including legal medicine, health data analytics, biomedical research, electronic medical records, meaningful use, and the payment of medical services, among others.

They provided a high-level system architecture in the research of [1] to illustrate the integration of HIoT into clinical healthcare. Data acquisition and sensing technologies will profit from future VLSI technologies that require less battery power for their operation, according to research on HIoT clinical applications. Meanwhile, communication standards will continue to advance to provide higher communication throughput with lower power consumption requirements. The study's framework is shown in Fig. 3.

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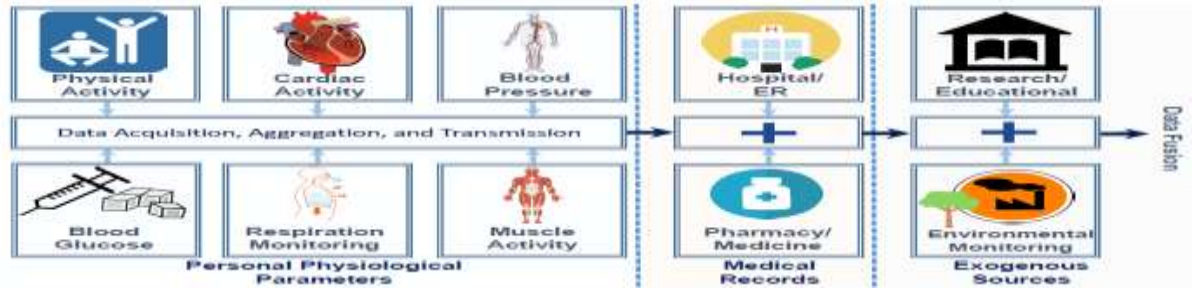


Fig. 3. High-level system architecture illustrating HIoT integration into clinical healthcare
Source: Adopted from [1]

Another research by [4] put out an IoT Tiered Architecture (IoTTA) as a means of producing real-time clinical feedback from sensor data. According to the study's findings, the next wave of IoT applications for healthcare should concentrate on self-care, data mining, and machine learning. The study's architecture is shown in Fig. 4.



Fig. 4. IoT Tiered Architecture (IoTTA) for transforming clinical feedback
Source: Adopted from [4]

An IoT-based approach for pain evaluation and treatment was suggested in a research by [76]. The study's findings demonstrate how IoT-enabled solutions may increase pain assessment accuracy while also achieving high levels of usability and compliance. They learn that the IoT mind-set has led to the adoption of technologies that enable the IoT in isolation rather than in combination, and that further implementations and study are required to assure the viability and acceptability of suggested solutions. The study's suggested framework is shown in Fig. 5.

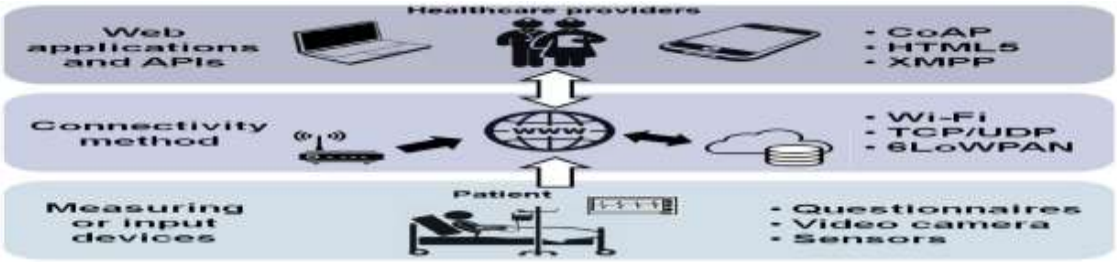


Fig. 5. IoT-based system for pain assessment and management
Source: Adopted from [76]

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IoT healthcare solutions give healthcare applications the capacity to fully exploit the IoT backbone and handle different communication protocols for smart devices, according to a research on internet of things and cloud computing for healthcare by [9]. Figure 6 depicts the study's conceptual structure.

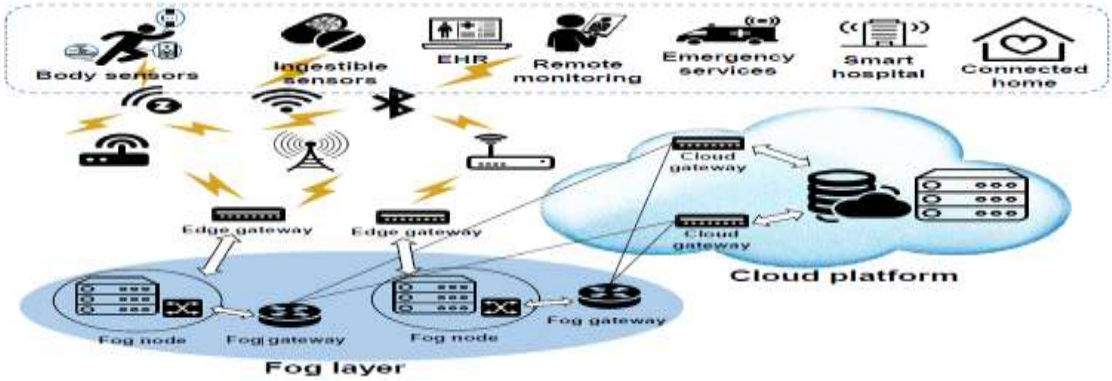


Fig. 6. IoT and cloud computing-based healthcare system

Source: Adopted from [9].

They suggested a fog IoT cloud-based health monitoring system in the study [19]. The study's findings demonstrate that patient data privacy and data anonymization are honoured during all communications across the sensor, fog, and cloud layers. Their technique makes it possible for medical professionals to monitor elderly or alone patients' health conditions and behavioural changes. Additionally, the technology offers a way to track patients' rehabilitation and recovery processes. A local gateway for storing data locally and fast, a wireless sensor network, and a Lambda cloud architecture make up their Fog-IoT design. Figure 7 illustrates the study's conceptual structure.

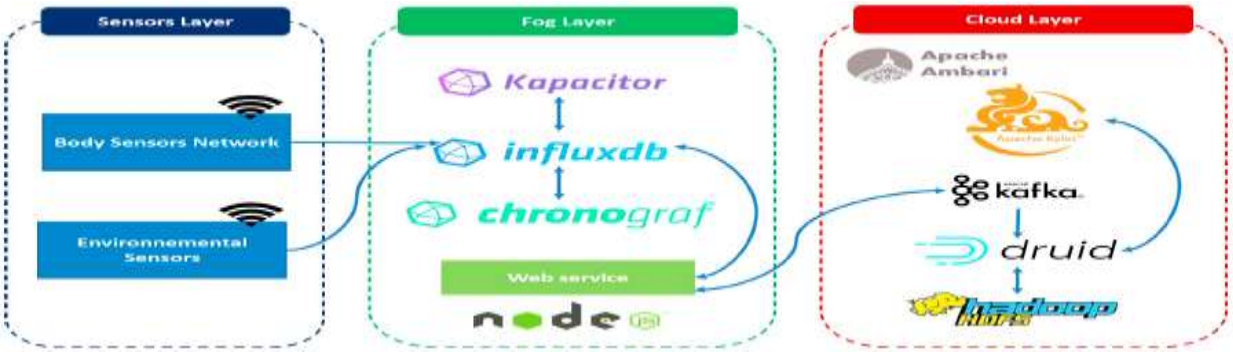


Fig. 7. Fog IoT cloud-based health monitoring system

Source: Adopted [19]

Table 1: Related IoT Based Healthcare Frameworks

S/No	Author(s)	Method Used	Outcome	Recommendation

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1	[1]	Data analytics and inference algorithms	VLSI technologies that require less battery power for operation will be advantageous for data acquisition and sensing. Advances in communication standards will allow for higher communication throughput while reducing the power requirements placed on sensing networks, according to researchers at Texas A&M University's Energy Institute (EAT).	1.limited public datasets are available for training ML algorithms and HCOs rely on their individual databases 2.Large datasets that are required to train sophisticated algorithms (such as ones that use Deep Learning) are not freely available.
2	[4]	1.CIoud computing 2. Machine learning 3.Classification and regression algorithms 4. Bluetooth, RFID, NFC, UWB 5. Wearable devices (sensors)	The review's findings indicate that the next wave of IoT applications for healthcare should concentrate on self-care, data mining, and machine learning.	Future work will focus on data collection and analysis for the development of the falls detection and prevention system based on IoTTA approach
3	[76]	1.Search strategy 2.Identification and selection of relevant studies	IoT-enabled solutions aid in achieving high levels of usability and compliance while also enhancing the precision of pain assessment.	Further development of this field depends on effective collaboration between engineers and healthcare providers.
4	[9]	1.Algorithm 2.Smart phone 3. RFID	The framework enables healthcare applications to fully take use of the Internet of Things and cloud computing. The framework also offers protocols to facilitate the transmission of unprocessed medical signals from a variety of sensors and intelligent devices to a	Future work will focus on data collection and analysis for the development of the falls detection and prevention system based on IoTTA approach.

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			network of fog nodes for communication and dissemination.	
5	[19]	Using of physiological and environmental signals allowing to provide contextual information in terms of Daily Living Activities.	The privacy of patient data and data anonymization are upheld during all communications between the sensor, fog, and cloud layers.	In future, the complete traceability of data patient treatment must again be implemented.

Source: Generated by researcher, 2022.

2. METHODS

The approaches appropriate for the investigation are presented in this section. A Behavioral Reasoning Theory (BRT) methodology and an optimized blockchain model for IoT-based healthcare applications were explored in the study on wearables based on the internet of things for geriatric healthcare.

Internet of things (IoT) based wearables for elderly healthcare: a behavioural reasoning theory (BRT) approach

The adoption of IoT-based wearables is being studied using BRT theory, which broadens the scope of the literature on innovation dissemination. The adoption of healthcare technology has been the subject of extensive past study [77]. The "reasons for" and "reasons against" adoption are not offered in a unified framework, though. The application of BRT to IoT-based wearables is extended in this one-of-a-kind study, which emphasizes the context-specific factors that affect senior citizens' cognitive processing of innovation adoption in a developing nation like India. The elderly have a long-standing practice of seeing physicians for medical health checks; they find it challenging to employ IoT-based wearables; and they also worry that anybody with internet access may access their healthcare data in the cloud. IoT-based healthcare wearables are "results against" adoption because to the user barrier, conventional barrier, and risk barrier. According to the perspective of older persons, ease, relative benefit, iniquitousness, and compatibility are the main "reasons for" adoption of IoT wearables. According to research, IoT-based wearables make it easier for seniors to monitor their health condition since they save them the time and hassle of making routine clinic visits [78].

Optimized blockchain model for IoT based healthcare applications

They presented a unique blockchain paradigm that is tailored for IoT devices in the work of [79]. They cited the example of remote patient monitoring to demonstrate their point (RPM). RPM allows a medical facility to interact with the patient outside of the typical clinical setting

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(in the home as an example). Wearable Internet of Things (IoT) devices are worn by patients, and they may provide data to medical professionals about a patient's blood sugar level, blood pressure, breathing pattern, and other things. In their proposal, they attempt to install a lightweight blockchain while retaining the fundamental privacy and security advantages of blockchain technology. In their simplistic approach, they do away with the idea of Proof of Work (PoW). As a result, the distributed feature of the model is what the proposed framework's security and privacy rely on. The Blockchain Network, Cloud Storage, Healthcare Providers, Smart Contracts, and Patients using Healthcare Wearable IoT Devices make up the five main components of their platform. They separated their blockchain into clusters using an overlay network to reduce network cost and latency. They employ clusters rather than a single blockchain, where each cluster is a collection of nodes with one node acting as the Cluster Head [79].

3. RESULTS AND DISCUSSION

Three phases make up the conceptual structure of the IoT-based m-Health Monitoring system. Users' health information is gathered in phase 1 through sensors and medical equipment. Using a gateway or local processing unit, the obtained data is sent to the cloud subsystem (LPU). In phase 2, the medical diagnosis system uses the medical measures to inform a cognitive choice about an individual's health. In phase 3, a warning regarding people's health is sent to the parents or guardians. Additionally, if an emergency occurs, a warning is sent to the local hospital to manage the medical problem.

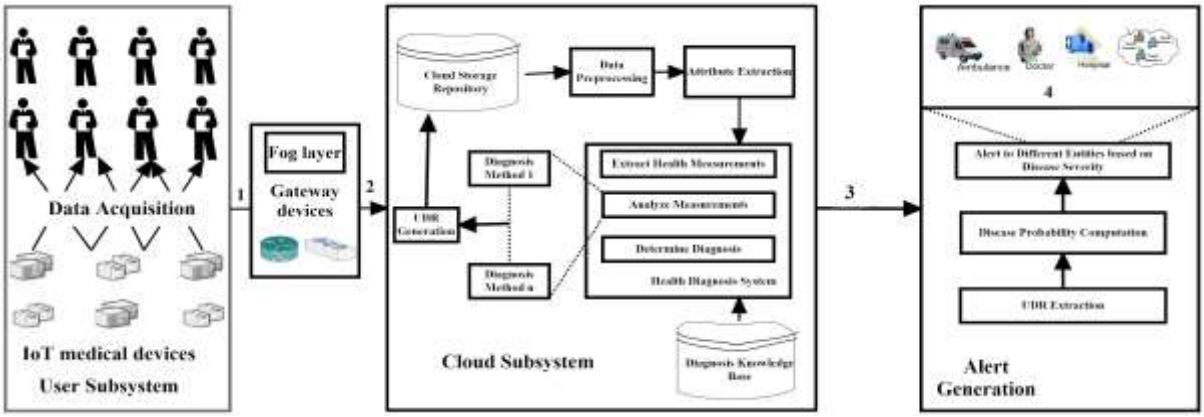


Fig. 8. A framework for IoT based m-health disease diagnosing system

Source: Adopted from [13]

They use symmetric key cryptography and a role-based access mechanism as the foundation of their Cloud-Centric IoT (CCIoT) security system (RBAM). The security method of their suggested system is based on encrypting the user password with a "private key" provided by a reliable third party (TTP). Furthermore, TTP is a body that carries out the security procedure in the system we offer. Additionally, it only grants access to authorized individuals that have registered with CCIoT. Following the authentication stage, authorisation is dependent on each

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user's role. Given that the owner of the data has the authority to place restrictions on a number of accessible partners and provide them varying levels of authorisation,

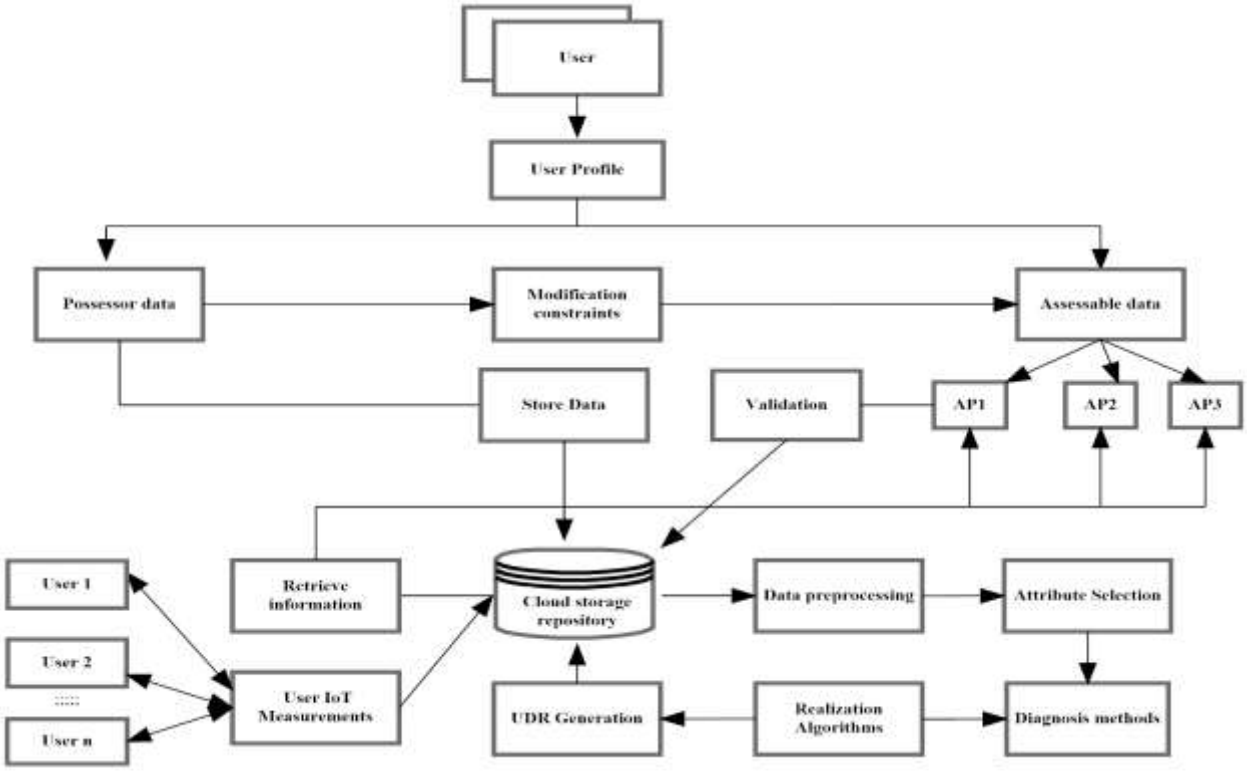


Fig. 9: Flow diagram of Cloud-Centric IoT (CCIoT) diagnosis security system

Source: Adopted from [13]

This study aims to improve the security already offered to users' data from the point of data acquisition to the point of data relay to the cloud and to the production of alerts utilizing blockchain technology. As a result, this project will employ asymmetric key cryptography in conjunction with blockchain technology. Blockchain technology will be used to safeguard the sharing of medical records since medical records are sensitive data and are thus subject to attack. Security has been a big worry in the IoT because hackers or attackers may simply access the data. Blockchain includes a number of capabilities built-in, including distributed ledgers, decentralized storage, authentication, security, and immutability. It has progressed past hype to find actual use cases in industries like healthcare. Therefore, this study would adapt the framework for IoT based m-health of [13].

Fig. 10 is the proposed conceptual framework for the elderly health monitoring system and alert generation to the elderly caretakers or guardians.

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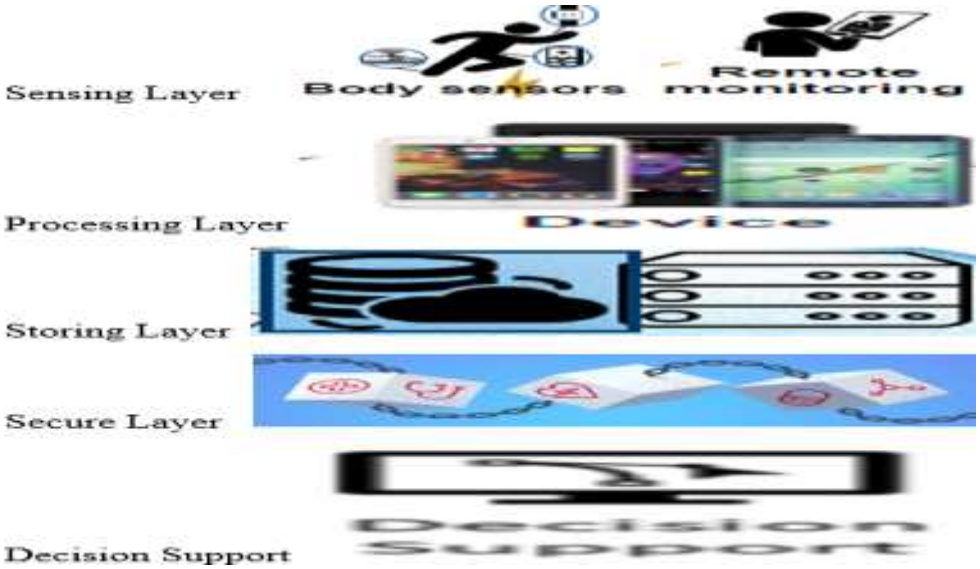


Fig. 10: Proposed conceptual framework

4. CONCLUSION

All around the world, the percentage of the population that is older is considerably rising. For elderly people who want to keep their independence, health monitoring systems in smart settings aim to replace conventional healthcare solutions by lowering the financial expenditures and reducing the danger of hospitalization in healthcare facilities (nursing homes or hospitals). The elderly make up a significant portion of our society and require particular care. To guarantee that the transition that IoT and cloud computing bring to the healthcare business is smooth, government, organizations, and research groups from all over the world are closely collaborating. In this work, we proposed a cloud-centric IoT based framework for health monitoring with blockchain capability. Then, we also propose a decision support level encryption for cloud-centric IoT based framework for health monitoring.

Recommendation

IoT and Blockchain are still relatively new technologies in the healthcare industry, and new applications are continually being developed and investigated. The suggestions for the research are listed below:

1. Scalability of healthcare afforded by blockchain requires research. Scalability is a significant problem since the healthcare sector is expanding, especially as our population ages. As more users or patients join the system, it will become increasingly more difficult to operate blockchain-enabled services.
2. Key management, security, and the capability to quickly replace lost or compromised keys should all be the subject of further study.
3. Identity verification needs to be a major area of research as well. However, in an emergency, what are fall-back plans or emergency protocols that may be utilized to provide a doctor access to the information without authorization? Many trials focused on having the patient be able to authorize access to patient records beforehand.

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Dedication
I dedicated this paper to my late mom (Maryam Bint Halima). May her soul find eternal rest, amen.

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