Interoperability and Integration of e-Health Systems with Blockchain

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Abstract— **Globally the use of electronic health systems in recent years has made significant impact in countries. E-health has significantly impacted on the operations in the hospital environment. Designing and implementation of e-health systems can increase the productivity and value of the medical industry. But the implementation of e-health systems comes with different challenges and complications such as different hospital administration, poor regulation, and lack of software designed and developed that communicates with other software. As a consequence, e-health systems implemented are not able to share medical data and therefore, are not in a position to meet the needs of transformation in healthcare system delivery. The e-health records lack interoperability, security and privacy, the data quality is low and lacks the component of auditability. Going forward, because of the issue of health data sharing, hospital efficiency enhancement, all the independent systems will need to be able to communicate with each other. The study therefore proposes and design a health system that is integrated and interoperable using block chain availing the much needed security and privacy of medical records.**

Keywords— e-health, Interoperability, Integration, API, Blockchain

I. INTRODUCTION

Across all the countries worldwide, all facets of industry are in agreement that the use of new technologies increases the provision of service delivery and increase competitiveness. The use of newer technology is no exception in the health care provision. The use of digital technology can change how the health delivery system is implemented and also how the health delivery systems are operated on a day to day basis. The use of new technologies in the health sector is defined as e-Health. e-Health is defined as "the combined use of electronic communication and information technology in the health sector". In today's world, e-Health is "the means of ensuring that the right health information is provided to the right person at the right place and time in a secure, electronic form for the purpose of optimizing the quality and efficiency of health care delivery". The following are ways of effective use of ICT in the health sector;

1 During treatment, the use of computers can help control efficient use of resources by implementing the use of newer and electronic patient systems to on patient diagnosis,

2 Treatment can be given to a patient at minimum price as and when alternative methods of reaching out to patients in remote areas or not near the hospital are provided such as Telemedicine,

3 Disease Monitoring Systems that avail critical information to enable strategic decision making at the right time and for the right people basing on information provided.[1].

The quick adoption of new technology like computerization in the medical field has enabled the creation and storage of enormous volumes of electronic records about patients. Such developments pose serious demands for medical records to be given adequate security of data while at rest, motion & when in use. The growth of technologies such as blockchain as a accountable and transparent instrument to keep and dispense information is creating a means for novel possibilities of solving serious data privacy, security, and integrity issues in healthcare. The use of blockchain has generated substantial responses from business and also from scholars in recent times. [2][3].

A blockchain is a peer-to-peer digital ledger of transactions that may be publicly or privately distributed to all users (and therefore is said to be decentralized and distributed). Blockchain technology uses cryptography and a consensus mechanism to authenticate transactions, which guarantees the legitimacy of a transaction, prevents double-spending, and allows for high-value transactions in a trustless environment. A blockchain offers transparency and eradicates the need for intermediaries or third-party administrators. Blockchain technology allows any form of data to be stored in a consistent and verifiable manner.

Blockchain is emerging, though it is altering the way some industries operated and has become an interesting new concept for many organisations, even in this foundational phase. The use of blockchain technology has some vital benefits which includes the following [4],[5],[6].

TABLE 1: Advantages of Blockchain

	Advantages	Detail
1.	**Transparency**	The details of each activity are stored permanently and can be available to all the users in the network permanently. Every user in the network is aware of any activity hence there is.
2.	**Business Continuity**	The continuous uptime of services is a vital feature for any business. The lack of a weak sole failure point ensures that the network is always up.
3.	**Disintermediation**	Technology procedures and features can substitute mediators, improving productivity, and dropping the issues of costs that are there when business and individuals interact due to decreased trust.
4.	**Trust**	Blockchain provides the formation of a

| 5. | **Smart Contracts** | dependable file amongst parties that are untrusted. The rules and regulations of blockchain provides for the enforcement of trust and easy for validation and verification. |
| | | This is software that is programmed to automatically accelerate, validate, and implement the business logic's conciliation or performance. These execute automatically without any go between. |

II. BACKGROUND

If health authorities must strive to provide speedy and efficient healthcare delivery services to her citizens, then computer based health information systems are required to achieve this dream. Unfortunately, software systems built for the healthcare domain do not possess the ability to talk to each other or exchange information meaningful with other software products within the domain. A significant barrier, therefore, to the introduction of e-health systems is the lack of interoperability; most e-health systems do not interact well with other applications[7].

The result is that for many physicians, even if they have begun using an e-health system, the data is fed to an e-health application that is not designed to "speak" to a hospital, laboratory or other external group. The technology in most doctors' offices cannot send or receive clinical information, such as the laboratory and radiology results and medication lists critical to patient care[8]. In a nutshell, nearly all of the e-health systems in use today are little more than database management programs that help generate patient data entry (forms) and produce reports. And none of these applications have the capacity to scale up to fully, multi-functional prototypes or to be commercially viable in terms of complete interoperability in a large-scale distributed environment.

III. LITERATURE REVIEW

e-Health

e-health is an developing area where different fields such as medical informatics, community wellbeing and business, referring to health services and data dissemination to clients or improved through the use of the web and interrelated technologies. E-Health is a promise for an interconnected, universal thinking, designed to enhance the provision of heath related issues in the country, across the country and worldwide by using newer and modern technologies. [9].

Benefits of –health systems

Researchers have observed the benefits of e-health systems by considering clinical, organizational, and societal outcomes. Clinical outcomes include improvements in the quality of care, a drop in medical errors, and other improvements in patient-level measures that describe the appropriateness of care. Organizational outcomes, on the other hand, have included such items as financial and operational performance, as well as satisfaction among patients and clinicians who use e-health systems. Lastly, societal outcomes include being better able to conduct research and achieving improved population health[10].

The goals of e-health include the desire to increase efficiency in health care, improve quality of care, increase commitment to evidence-based medicine, empowerment of patients and

consumers, and the development of new relationships between patients and health professionals[11]. From a global viewpoint, e-health can be used to distribute health information as well as to ensure that the most current evidence is used to improve people's health[12].

Application Programming Interface in healthcare.

Application programming interfaces permit the communication of systems and data transfers among two or more systems that might not be the same. APIs are capable of sending, retrieving data that can be used in the updating of records or files or deliver shared which might be compiled to be used in the creation of reports. A medical facility may capture information about their patient into a system that works with assurance organizations and closely and automatically define the patient's cover for a precise operation or prescription. This is made possible through the use of API[13]. APIs ensures that the digital e-health record data is available to the accurate internal and external users while keeping it safe against outside threats and malware.

Medical facilities are using APIs to dispense important data to their customers such as patients; to interact more logically with like-minded providers, services of support to patients, assurance organizations, health funders, and regulatory agencies and ministries relating to health; and to make use of their information in newer ways. Application Programming Interfaces (APIs) enables medication institutions to do all these activities while stimulating inventive designers to design and create new medical related applications that will enhance existing services, and perform with added efficiency. Healthcare APIs that control patient-side software generates different methods for institutions to contact and link with those patients through the new technologies such as social media apps the web and cell phones. Through the design and implementation of APIs that are internal, medical facilities can give their staff members and related institutions new tools that rationalize procedures and give patients an advanced worth of care while being attended to. The implementation of fruitful API policies are a must because in the current setup which changes rapidly, where quicker availability to information is of paramount importance and the need to make decisions and experiments separate life or death[14].

Web based technology

The quick embracing of the web technologies in the medical sector has allowed patients to require their health information that they can use to share with their loved ones across the internet in groups that provide support and also potentially share the information with their medical providers. Studies carried out indicate that doctor patient interaction which is effective is important for a patients' satisfaction, adherence to treatment and at the end of the day, positive health results[15][16]. The use of emails, or web based technology in digitally patient-centered communication, has the possibility to improve doctor-patient communications and connections by providing asynchronous, self-documenting communication of patient questions and doctors instructions. Studies held [17] indicate that those who are not feeling too well must obtain healthcare whenever they need it and in

many forms, not just direct visits, but also access to medical attention should be provided over the web, by phone, and by other forms that are possible such as social media.

In 2019, [18] published a research paper on the applications of biomedical and healthcare whose foundation was blockchain. This study mainly deliberates on the old-style of blockchain which used features of bitcoin & its design. The paper describes some features of blockchain for health record administration, processing of insurance claims, biomedical research, and health data ledger. In addition, the authors did not manage to expound the technical aspects on how information would be centrally distributed amongst the interested party in the transaction process.

In a similar study, [19] gets into details on some use cases for applying blockchain technology in healthcare. The areas of application were mainly about the connection of two or more systems for the purposes of sharing data and the records for patients with all the details, and also the distribution of medical supplies from suppliers to the hospital and also the distribution of the same in the hospital facility. The major limitation of this review is the shortage of availability of many areas of applications for blockchain, and lacks the follow-up on tracking new or fresh medical applications that use blockchain.

In another related work, [20] took a study of blockchain in medical field, comprising health assurance such as medical aid, electronic health records, the supply of drugs from hospitals and drug supply, research in the area of biomedical, processes involved in the procurement of goods and services and lastly medical education. Like similar studies carried out before, the researchers did not manage to take a dipper look into so important blockchain-based healthcare applications, such as the automatic validation and approving of contracts, record distribution, interoperability and sake keeping of data in the cloud.

In another study, [21] deliberated on many healthcare applications that are blockchain based that includes the detection of fraud, research in the area of neuroscience, clinical research, and Electronic Health Records. Blockchain helps in the detection of fraud through enabling the sharing of information in real-time and updating the ledger upon the agreement of all parties. This will not only prevent frauds but also lower the overall costs and time taken for the process too.

In a related work [22] provided a review on medical business specifications required to secure patients medical data using the concept of blockchain. The study by [22] explained limited applications for healthcare such as OmniPHR (this offers a united, important and current idea for those requiring medical attention)[23], MedRec (a combination of a social need with a technological enabler as it gives priority to patient agency giving a clear and available sight of treatment episodes)[24], Pervasive Social Network (PSN allows patients to get medical attention anytime, anywhere and thereby increasing the quality of care for patients) [25] and Healthcare Data Gateway (enables those who are being

attended to in hospitals and clinics to patient to possess, regulate and give rights to their health data in an easy and secure manner that does not infringe the issues of privacy, which delivers a prospective manner of improving the intelligence of systems being used in health facilities securely and privately)[26].

In addition, [26] proposes the Healthcare Data Gateway (HGD), a blockchain-based app architecture that allows patients to easily and securely own, control and share data without the fear of invading their privacy. However, this medical data cannot be modified or deleted by anyone, including the patient himself. Due to the variety of health data, it was suggested to use a simple and unified Indicator-Centric Scheme (ICS) to organize all types of patient data. He also pointed out that Secure MultiParty Computing (MPC) could be a solution that allows untrusted third parties to perform patient data calculations without compromising privacy

The healthcare industry is being transformed by blockchain technology. Mediators may become outdated in the future. Companies who are sluggish to adapt may be at a disadvantage versus those that use technology to reduce costs and improve productivity. In 2018,[27], a London-based financial services firm, published "A Prescription for Blockchain and Healthcare: Reinvent or Be Reinvented," a research. According to the report, 49 percent of 74 global healthcare companies are developing, piloting, or implementing blockchain projects, putting blockchain projects into action.

Use cases of implementing blockchain in the medical fraternity are widely available. [28] recognized several possible blockchain areas of implementation: tracking prescriptions given to patients to enable checking of overdoses and tracking to detect opioid overdose, the sharing of data to include the provision of medical services through the telephone together with the usual ways of face to face consultation, distribution of specific diseases like cancer with medical aid providers through the use of patient-authentication process, a person's digital identity management for improved file identification, personal health records for accessing and controlling complete health history and health insurance claim adjudication automation to reduce the occurrence of fraud and errors.

IV. RESEARCH GAP

Integration is defined as the action or manner of joining two or several systems so that they communicate and work in unison to achieve a common objective [29].

In general integration provides benefits such as optimizing business procedures, reduction in operating expenses and holdups, take advantage of newer technology and savings on the costs of the cloud, make it possible for old systems instead of making expensive substitutions, tap into invention by allowing the formation of newer assets that are in digital form, make improved decisions with richer insight into an integrated business, build a business that can adapt quickly to changing conditions and integrating the enterprise[30].

All the authors presented do not take into account the issue of patient privacy, security, authentication, and information asymmetry. There is need to design a system that is fully integrated provide a solution to the above mentioned issues. Integrated health systems play a key function in ensuring that information is the same and in the same format across all the platforms and providing a gateway of disseminating information in different departments in an organization and with other organizations that they deal with. The following are instances where integrated health systems are used in today's world:

- Medical results
- Medical material, summaries and records (these are details written by the doctor during observation and consultation such as release summaries, transfers)
- Treatment history
- Vaccination, Disease Surveillance and citizens' health data
- Digital Prescription
- Emergency Responder material e.g. Ambulance Personnel

Use of Block chain technology for electronic records is suggested to be looked at in greater detail as it seems to offer solutions to current problems.

V. AREAS FOR FUTURE WORK

[31] suggests that blockchain's application in healthcare may benefit from exploring a deeper integration of the technology with business processes for improved functionality[32]. For example, future researchers may focus on the further integration of edge computing, Artificial Intelligence (AI) and Machine Learning (ML) with blockchain-based healthcare ecosystems to create enhanced predictive analytics models for personalized patient care and diagnostics. Further, research may target service enhancement in the healthcare sector by increased integration of IoT-based sensors to improve service and data accessibility, remote monitoring, and emergency services.

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