1. INTRODUCTION

1.1 Introduction to the Seminar Title

A blockchain, by design and definition, is a particular type of database. It is constructed as a to-read-only-once database. This means that blockchain databases are designed to be only-ever-created, and not edited or deleted. Data stored in a blockchain decentralized ledger (computer file asset) is a transactional type of data that requires space of 1 kB or less, and no one is able to access it as long as the owner holds the private keys.

Blockchain has the potential to substantially impact the health care industry as a whole and payers, providers and patients with respect to drug traceability, clinical trials and research, and data management. Blockchain technology has the potential to address the interoperability challenges currently present in health IT systems and to be the technical standard that enables individuals, health care providers, health care entities and medical researchers to securely share electronic health data.

Blockchain has many applications in healthcare and can improve mobile health applications, monitoring devices, sharing and storing of electronic medical records, clinical trial data, and insurance information storage. Any blockchain for health care would need to be public and would also need to include technological solutions for three key elements: scalability, access security and data privacy.

1.2 Description of the Seminar Concept

Blockchain technology has come out as a key technology recently in the digital revolution of the healthcare sector and several research studies have identified blockchain potential for the healthcare ecosystem. It is constructed as a to-read-only-once database. This means that blockchain databases are designed to be only-ever-created, and not edited or deleted. Blockchain is a distributed ledger technology that is managed by different peers on a peer-to-peer network. This technology operates without any central administrator or centralized data storage management. Data is widely spread across several nodes and the quality of data is maintained by replication and encryption Data stored in a blockchain decentralized ledger (computer file asset) is a transactional type of data that requires space of 1 kB or less, and no one is able to access it as long as the owner holds the private keys. Also, a single version of data is copied on every node of the blockchain. This reduces the volume of transactions that occur between information systems, thus reducing the burden on the healthcare ecosystem

Blockchain has the potential to substantially impact the health care industry as a whole and payers, providers and patients with respect to drug traceability, clinical trials and research, and data management. It is a very exciting time for health care and information technology. Due to improvements in genetic research and the advancement of precision medicine, health care is witnessing an innovative approach to disease prevention and treatment that incorporates an individual patient's genetic makeup, lifestyle and environment. Simultaneously, IT advancement has produced large databases of health information, provided tools to track health data and engaged individuals more in their own health care.

Blockchain provides us with a tremendous opportunity to overcome challenges that exist in the healthcare industry today, including interoperability, security, integrity, traceability and universal access.

Some of the healthcare challenges
- Interoperability
- Security and Integrity

- Universal Access

- Cost of Maintenance

Fig. 1.2 (a) Blockchain in Healthcare

Blockchain technology has the potential to address the interoperability challenges currently present in health IT systems and to be the technical standard that enables individuals, health care providers, health care entities and medical researchers to securely share electronic health data. Information and Communication Technologies (ICTs) and blockchain are key enabling technologies for the decentralization and digitalization of healthcare institutions and provides modern and digitalized healthcare ecosystem to patients as well as service providers. Blockchain applications for healthcare data management create utilities for patient, doctors and healthcare institutes in the directions of patient record access and control, claims and payments management, management of medical IoT security and research data verification and exchange for financial auditing and transparency. In these applications, real-time updates to an encrypted, decentralized blockchain ledger are done to understand, monitor, and control medical information. This also facilitates the healthcare institutions to restrict the unauthorized person to access sensitive information.

What is a Blockchain?

Blockchain is a peer-to-peer (P2P) distributed ledger technology for a new generation of applications that establishes transparency and trust. Blockchain is a decentralized P2P architecture with nodes consisting of network participants.

How blockchain works?

The idea is relatively simple. When a customer wants to perform a transaction, they use specialized software to communicate this to a ledger. In contrast to traditional ledgers, however, the record of transactions in a blockchain is distributed across a large number of servers, each of which is able to verify their records against each other.

How Blockchain works

Someone requests a **transaction.**

The requested transaction is broadcast to a **P2P** network consisting of computers known as nodes.

The network of nodes **validates** the transaction and the user's status using known algorithms.

A verified transaction can involve **cryptocurrency, contracts, records, or other information.**

Once verified, the transaction is combined with other transactions **to create a new block of data for the ledger.**

The new block is then **added to the existing blockchain**, in a way that us permanent and unalterable.
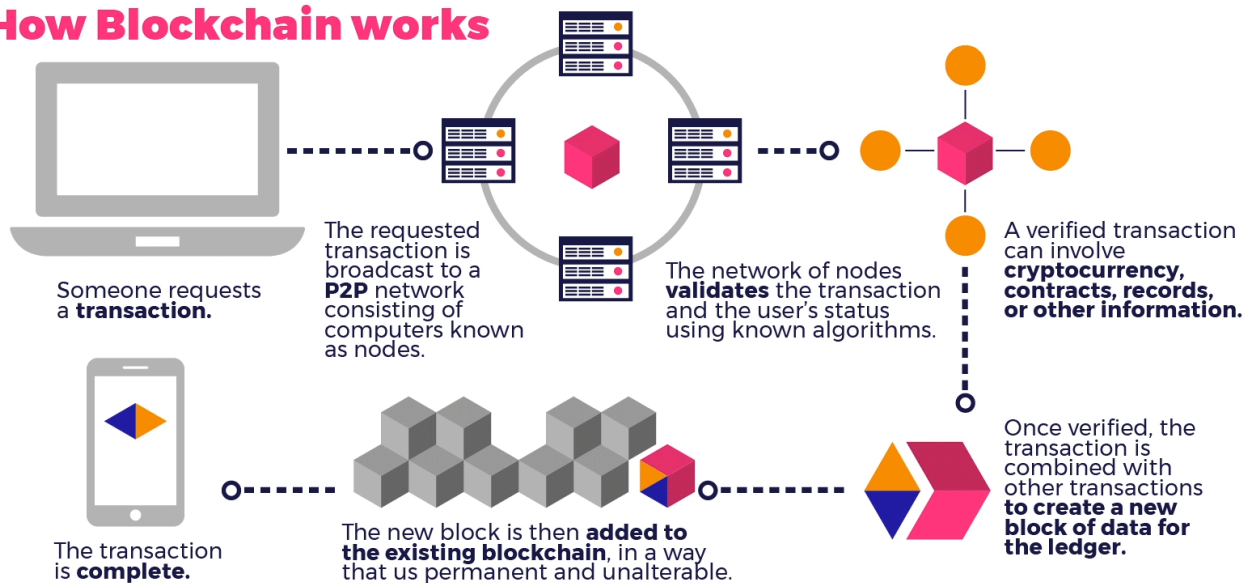
The transaction is **complete.**

Fig. 1.2 (b) Blockchain working

1.3 Applications of the concept

- **Securing Patient Identification Information:**

Currently, all the health information about patients are being recorded in Databases controlled by individual organizations or group of organizations. It is not being shared with other organizations due to security issues and chance of the data being modified or tampered with. But having a single trusted source of information for health details will be a great boon to patients and healthcare organizations alike. Blockchains can be used to save this data, which can be accessed by all the organizations, allowing doctors to see the prescriptions for a patient by other practitioners. Blockchain prevents data corruption using hashes and the block chain can be design to be viewed only with a pass key.

Blockchain's ability to keep an incorruptible, decentralized and transparent log of all patient data makes it a technology rife for security applications. Additionally, while blockchain is transparent it is also private, concealing the identity of any individual with complex and secure codes that can protect the sensitivity of medical data. The decentralized nature of the technology also allows patients, doctors and healthcare providers to share the same information quickly and safely.
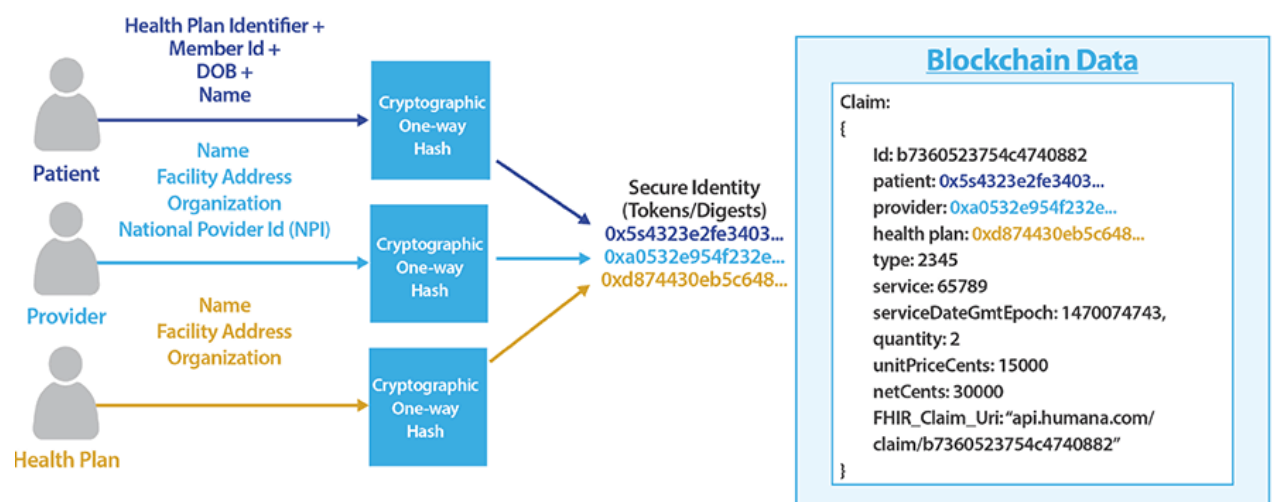

Fig. 1.3 (a) Blockchain data hashing

- **Maintaining longitudinal patient history:**

Blockchain can be used as a generic tool to keep data securely in a distributed, encrypted ledger along with controlling the resources who can access this ledger. Rather than having one central administrator that acts as a guard the health data, there's one shared ledger which is spread across a network of synchronized, similar databases visible to anybody with access. This helps in preserving the patient health records securely and the same will be accessible even if a few of the systems in the data-network are unavailable.

Health information or medical records of patients are stored in individual systems or with a data aggregator who is consolidating health information at patient level. Drawback of this practice is that patient does not have any say to whom his/her information is shared. Which makes it difficult for both healthcare provider and insurance company to accurately maintain and assess the medical history of patients.

Blockchain technology offers an attractive opportunity to get rid of this "extra link". It is designed perfectly to take on all three most important roles of the traditional patient data: registration of transactions, identity verification and sharing.
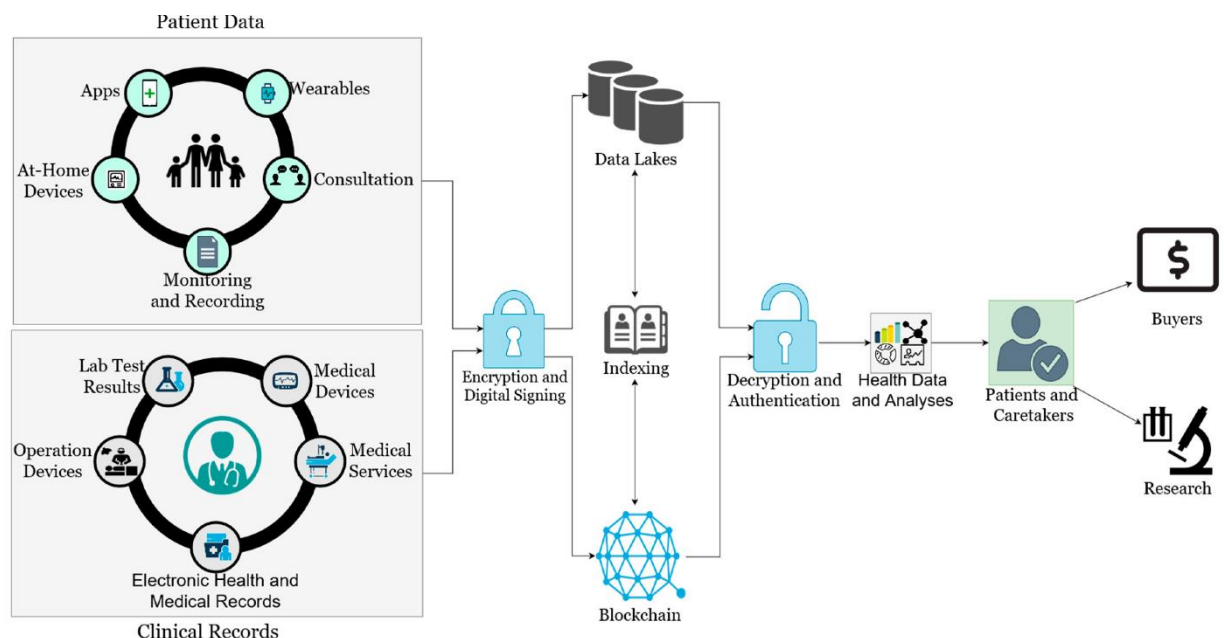

Fig. 1.3 (b) Blockchain patient data history

- **Securing Billing:**

The Financial Sector of the Healthcare industry has much to gain from blockchain technology. Secure transaction of bills and process of claims can be established using blockchains, while tracking this information in case there is a need to backtrack. It has proved its potency in this sector through Bitcoins, Ethereum etc.

Blockchain is the greatest innovation in this modern business world for making payment gateway more secure to the users. For an online transaction, a blockchain wallet app stores private and public keys. The wallet interacts with multiple Blockchains to validate an online payment, allowing users to buy or sell one or several cryptocurrencies.
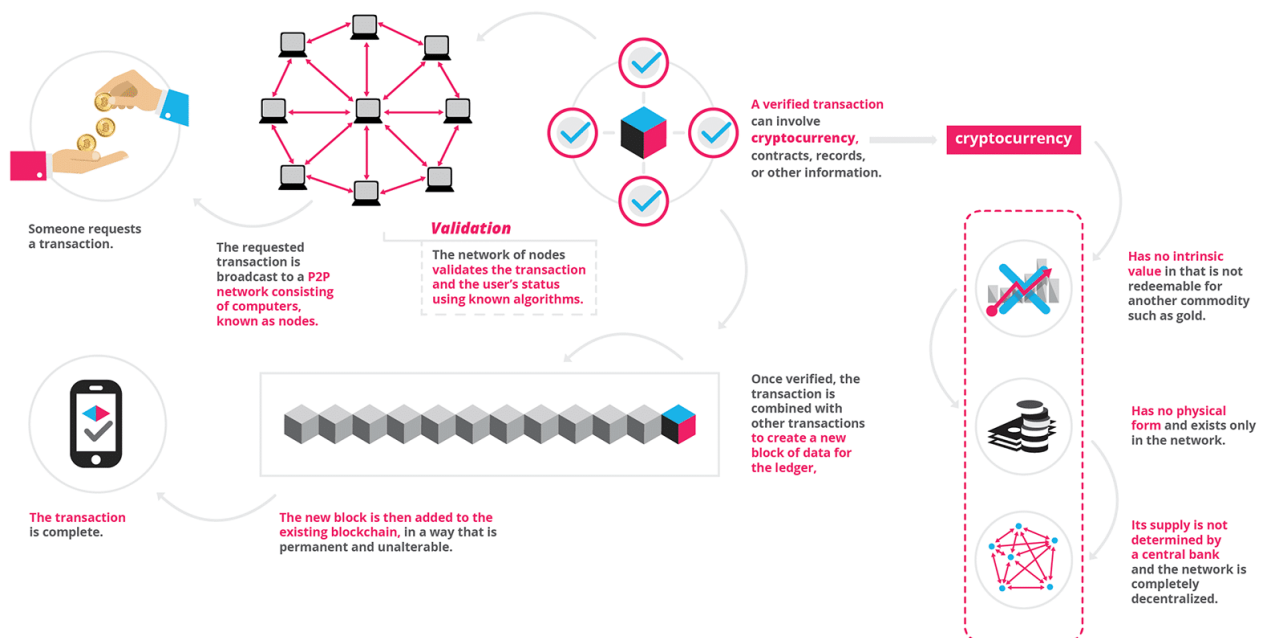
Fig. 1.3 (c) Secure billing

It is important to understand the concept of public and private keys that are on Blockchain for online payment. The public key is shared with anyone while the private key is kept secret. These keys work in a very similar way to the concept of lock and key: the lock (private key) and the keys (public key). It does not matter how many people have the keys, they can only be useful if they are used to open the correct block, that is, the private key is correctly matched with the public key. when the private and public keys used in a

transaction match, users can see the value of their digital assets (Bitcoins, ICO tokens, etc.) in their wallets.

It is always risky when you make payments online through bank using ATM pin and password as it carries a threat of hacking confidential data by hackers. However, due to blockchain wallet app development, online payments have become secured and there is no chance to hack data when two parties make an online transaction.
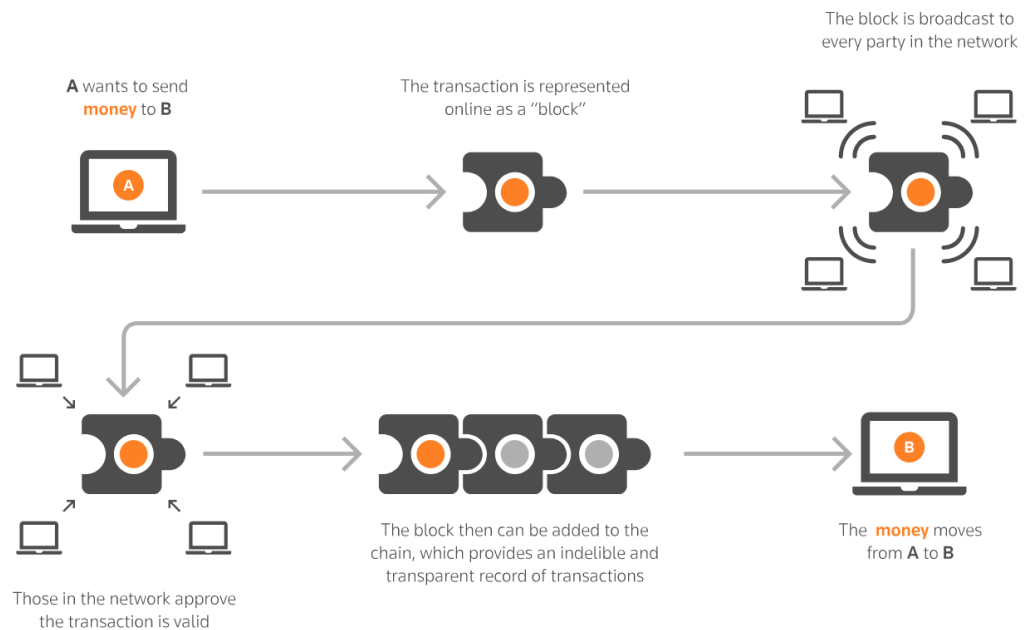

Fig. 1.3 (d) Peer tot Peer transaction

- **Supply Chain Management:**

SCM is designed to streamline the entire delivery processes from ordering to supply. SCM is a challenging prospect in healthcare; with scattered ordering settings of medical supplies, drugs and critical resources, there is inherit risk of compromising the supply chain process that might directly impact patients' safety.

Blockchain is particularly key monitoring technology for tapping into the whole process of drugs and medical products movement. Since all transactions are recorded onto the ledger, and every node in the blockchain maintains a record of the transaction, it is easy to verify the origin of the drug, the vendor and the distributor instantly.
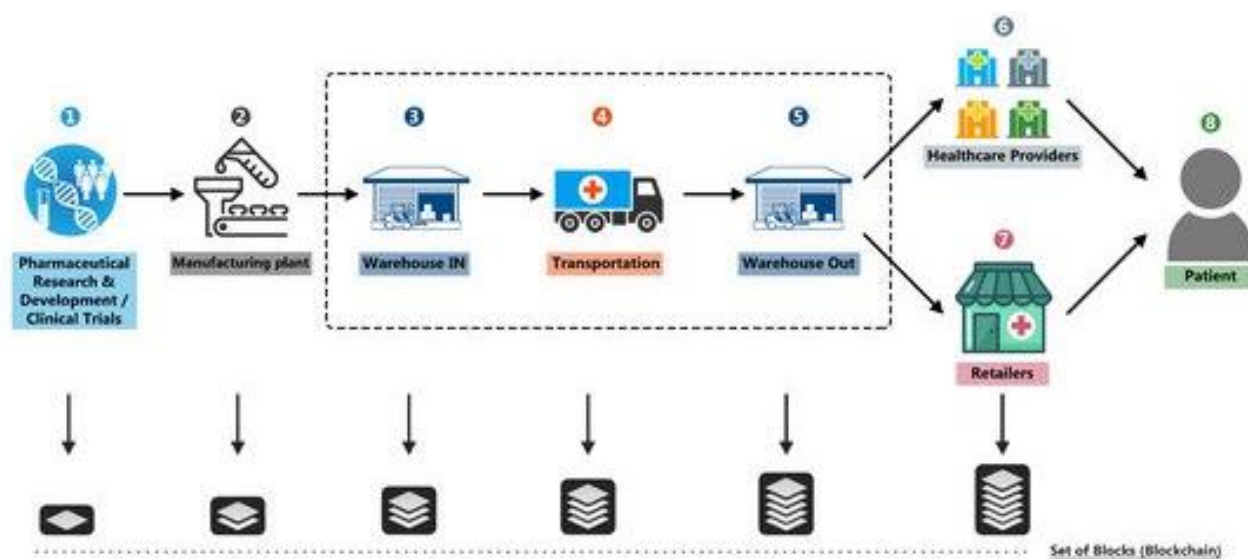
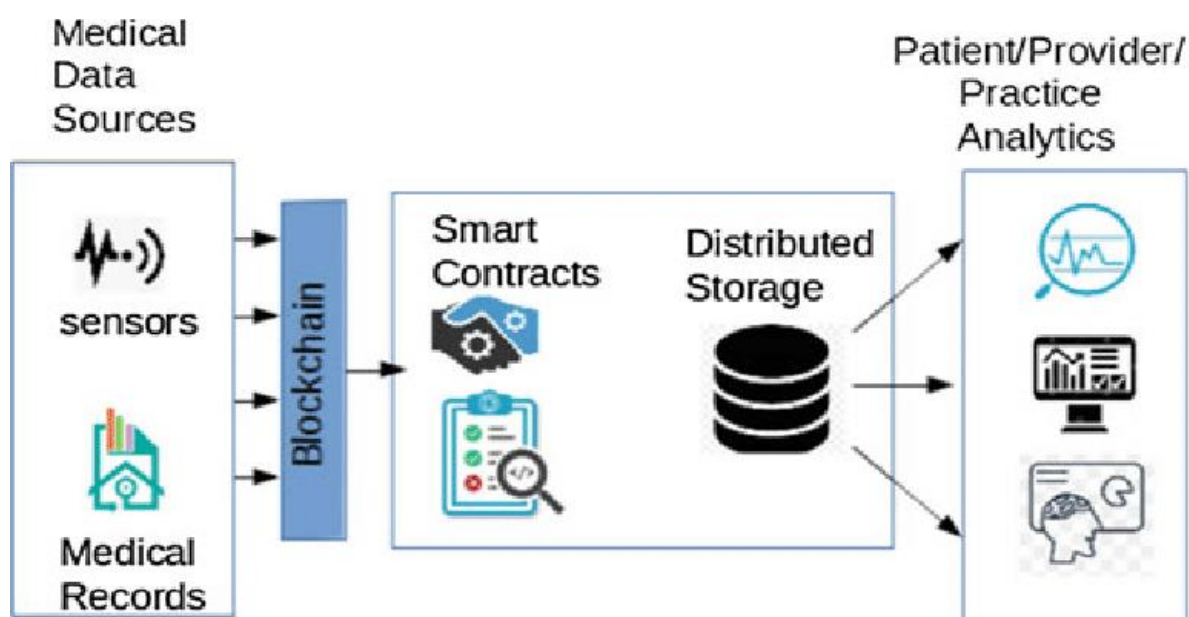Fig. 1.3 (e) Blockchain SCM

1.4 Architecture Diagram

Fig 1.4 (a) Blockchain architecture in healthcare

2. LITERATURE REVIEW

2.1 Literature Survey

[1] *A Survey of System Architecture Requirements for Health Care-Based Wireless Sensor Networks-* Emeka E. Egbogah and Abraham O. Fapojuwo, Sensors 2011, ISSN 1424-8220, 11, pp. 4875-4898, May, 2011

The review of the state-of-the-art in wireless sensor network research is done and the gaps between the existing technologies and the needs of a Health Care Wireless Sensor Network (HCWSN), with special emphasis on reliable communication is highlighted.

[2] *Exploring Research in Blockchain for Healthcare and a Roadmap for the Future*, M. H. Kassab, J. DeFranco, T. Malas, P. Laplante, g. destefanis and V. V. Graciano Neto, TETC.2019.2936881, ISSN: 2168-6750, 10.11.09

Healthcare is a data-intensive domain, once a considerable volume of data is daily to monitoring patients, managing clinical research, producing medical records, and processing medical insurance claims. While the focus of applications of blockchain in practice has been to build distributed ledgers involving virtual tokens, the impetus of this emerging technology has now extended to the medical domain.

[3] *Blockchain Utilization in Healthcare,* T. Kumar, V. Ramani, I. Ahmad, A. Braeken, E. Harjula and M. Ylianttila, HealthCom.2018.8531136, ISBN:978-1-5386-4294-8, 2018, pp. 1-7, doi: 10.11.09

Blockchain is so far well-known for its potential applications in financial and banking sectors. However, blockchain as a decentralized and distributed technology can be utilized as a powerful tool for immense daily life applications. Healthcare is one of the prominent applications area among others where blockchain is supposed to make a strong impact. It is generating wide range of opportunities and possibilities in current healthcare systems.

[4] *Blockchain in Healthcare: A Patient-Centered Model,* Hannah S Chen, Juliet T Jarrell, Kristy A Carpenter, David S Cohen, and Xudong Huang, PMCID: PMC6764776 NIHMSID: NIHMS1046136
PMID: 31565696, 2019 Aug 8

Blockchain has many applications in healthcare, and can improve mobile health applications, monitoring devices, sharing and storing of electronic medical records, clinical trial data, and insurance information storage. Research about blockchain and healthcare is currently limited, but blockchain is on the brink of transforming the healthcare system; through its decentralized principles, blockchain can improve accessibility and security of patient information, and can therefore overturn the healthcare hierarchy and build a new system in which patients manage their own care.

[5] *Blockchain and Healthcare: Opportunities and Prospects for the EHR*, Guendalina Capece and Francesco Lorenzi, Sustainability 2020, 12, 9693.

Health protection has always been a primary concern for mankind. Despite its important social role, current systems for managing the health records are slow, complicated, sometimes expensive and exposed to human errors and misunderstandings. In the health sector, the Medicalchain project seems to have the potential to become a new standard for managing health records using blockchain technology as a platform.

2.2 Summary of the literature survey

The article presents several promising use cases for applying blockchain technology in health care, especially related to interoperability, claims adjudication, supply chain and longitudinal patient care records. The most important takeaway to keep in mind is that blockchain, while progressing quickly, is still very much an emerging technology.

The remaining security and privacy issues in current healthcare systems need to be addressed in order for patients to have more confidence in the medical professional and their respective clinics. One major area that needs to be focused on is EMR management. Digitalizing medical records has eased their storage and sharing. However, there remain issues around

unauthorized access and disclosure, the centralized system that can be seen as a single point of attack, and patient medical information fragmentation in the event that multiple healthcare professionals are visited.

In order to address these concerns, researchers are turning towards blockchains, a technology that was introduced when Bitcoin first came to light. Blockchain maximizes security and accessibility, the technology can be used in many different areas of the healthcare system, such as for storing and sharing medical records and insurance information both in healthcare venues and in mobile applications and remote monitoring systems, and for clinical trials. Research about blockchain's applications to healthcare is currently limited, but more research becomes available every day. Blockchain is one of the most active areas of software research currently, and it can change the hierarchy of healthcare by returning authority over medical records and health data to the patient. This transfer of authority may lead to an overall shift toward patient-centered care; the blockchain movement for patients is just beginning.

3. TECHNICAL SIGNIFICANCE

3.1 Details of the unresolved domain chosen

Blockchain applied to the health sector can offer new and effective opportunities to improve several activities associated with the prevention and control of pathologies and, therefore, better clinical risk management in the context of a pandemic emergency such as the current one. Blockchain provides us with a tremendous opportunity to overcome challenges that exist in the healthcare industry today, including interoperability, security, integrity, traceability and universal access. The key to the interest in this technology lies in its ability to move from a system of centralized data logging to a distributed system that ensures no alteration of the information and the maintenance of privacy.

In the past years, blockchain-based projects have become a hot topic. It would be a mistake to think that we are dealing with a technology of immediate application or that changes can be implemented easily because the blockchain is a very novel and complex technology. We are rather in an initial exploratory period. The blockchain is not the solution that will fix everything that is wrong with today's management of health records. However, it does offer some possibilities for improving the system we have today, and that is the reason why it is so interesting and challenging to explore.

Blockchain technology could transform the healthcare industry's IT infrastructure from centralized, isolated, and small-scale systems to distributed, decentralized and worldwide systems, which could dramatically improve the quality of care provided and eliminate costly administrative inefficiencies.

3.2 Tools and Technologies

Tools used:
- Ethereum
- VScode

Ethhereum:

Ethereum is a decentralized, open-source blockchain featuring smart contract functionality. Ether (ETH) is the native cryptocurrency of the platform. It is the second-largest cryptocurrency by market capitalization, after Bitcoin. Ethereum is the most actively used blockchain. Enterprise Ethereum offers interoperability with smart contracts and applications that can revolutionize the industry. It facilitates safe data protection, approval control, medical tools, and product monitoring, among other blockchain use cases.

VsCode:

Visual Studio Code is a free source-code editor made by Microsoft for Windows, Linux and macOS. Features include support for debugging, syntax highlighting, intelligent code completion, snippets, code refactoring, and embedded Git. Users can change the theme, keyboard shortcuts, preferences, and install extensions that add additional functionality.

Technology used:
- Python
- Solidity

Solidity:

Solidity is a contract-oriented, high-level language for implementing smart contracts. It was influenced by C++, Python and JavaScript and is designed to target the Ethereum Virtual Machine (EVM). Solidity is statically typed, supports inheritance, libraries and complex user-defined types among other features.

Solidity is a new programming language native to Ethereum, the second largest cryptocurrency by market capitalization, initially released in 2015. Ethereum is not only a cryptocurrency capable of storing value or making payments, but a fully-fledged platform for creating what's known as a smart contract.

Python:

Python is an interpreted, high-level and general-purpose programming language used worldwide. Python's design philosophy emphasizes code readability with its notable use of significant whitespace. Its language constructs and object-oriented approach aim to help programmers write clear, logical code for small and large-scale projects.

Python is dynamically typed and garbage-collected. It supports multiple programming paradigms, including structured (particularly, procedural), object-oriented and functional programming. Python is often described as a "batteries included" language due to its comprehensive standard library.

3.3 Conclusion

The remaining security and privacy issues in current healthcare systems need to be addressed in order for patients to have more confidence in the medical professional and their respective clinics. One major area that needs to be focused on is EMR management. Digitalizing medical records has eased their storage and sharing. However, there remain issues around unauthorized access and disclosure, the centralized system that can be seen as a single point of attack, and patient medical information fragmentation in the event that multiple healthcare professionals are visited.

On a blockchain, it is cheap to verify the integrity of an individual transaction. A single piece of information can be audited in real time; moreover, its integrity is available to any participant in the network. As a result, costless verification can be economically implemented. For example, healthcare accounting information that can be built up with integrity from the simplest

units of transactions has previously constituted a time consuming and costly audit. Now, with block-chains, this process can run continuously in the background in compliance with regulations.

Blockchain maximizes security and accessibility, the technology can be used in many different areas of the healthcare system, such as for storing and sharing medical records and insurance information both in healthcare venues and in mobile applications and remote monitoring systems, and for clinical trials. Research about blockchain's applications to healthcare is currently limited, but more research becomes available every day. Blockchain is one of the most active areas of software research currently, and it can change the hierarchy of healthcare by returning authority over medical records and health data to the patient. This transfer of authority may lead to an overall shift toward patient-centered care; the blockchain movement for patients is just beginning.

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