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SONBlock: Blockchain based EHR Management with Comparative Analysis of Ethereum and Hyperledger Fabric

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Abstract: Health related data for any patient is very sensitive. The traditional approach to maintain such data is to maintain the records in physical format. With digital explosions these records are now being maintained digitally through Electronic Health Records (EHRs). These records are stored and maintained on the central server storage. Such centralized storage approach challenges privacy, unauthorized access and the availability of health data. Blockchain technology is one of the solutions to provide secured access with preservation of the privacy of EHR. A brief literature survey has been carried out in this research to indicate the benefits of the usage of blockchain technology in the healthcare domain. In this research Secured Optimized Network using Blockchain (SONBlock) is proposed for EHR management system with secured approach. The study also proposed EHR partitioning as off-chain and on-chain. The identity attributes of the patient are stored in blockchain ledger as on-chain data. Other health data is stored on the distributed storage i.e. InterPlanetary File System (IPFS) as off-chain. There are different blockchain platforms which can be used in healthcare systems. SONBlock is implemented using Ethereum and Hyperledger Fabric. The research has compared the Ethereum and Hyperledger Fabric using the metrics i.e. global availability, smart contract flexibility, decentralization, cost, scalability, latency, throughput, and tokenomics. The brief comparative analysis indicates that Ethereum usage is significant to achieve the metrics i.e. global availability, smart contract flexibility, decentralization, and tokenomics. Hyperledger Fabric usage has shown good impact for the cost, scalability, latency, and throughput.

Keywords: Healthcare, EHR, Blockchain, Privacy, Ethereum, Hyperledger Fabric

I. INTRODUCTION

One essential technology that industrialized nations are implementing to enhance the health system and provide better care is the centralized Electronic Health Record (EHR) system. The EHR is defined by the Health Information Management System Society (HIMSS) as a longitudinal electronic record of a patient's medical information collected during visits in any place where healthcare is provided with the aim of enhancing patient care [1]. Demographic information about the patient, progress notes, issues, lab and radiological data, etc., may also be included in the information [2].

EHRs for patients are systematized and collected into a single database to create a centralized EHR. The World Health Organization (WHO) has warned about the COVID-19 viral disease [3] and suggested countries worldwide to implement several measures. These actions have shown to be somewhat successful in containing the outbreak. There appear to be a few gaps in the achievement of ideal global health systems and security, notwithstanding these efforts. The foundation for delivering healthcare has evolved nationally due to the growing impact of digitization on the health system.

The traditional paper method of storing and retrieving medical records has since been superseded by EHRs. The next phase in reducing costs is centralized EHRs, decreased prescription mistakes and overall health care system optimization. One of the most important applications of centralized EHRs is the early identification of symptoms as a means of preventing the onset of new illnesses and ailments. An investigation from Wuhan, China, established the relevance of this revelation. About 89% of patients were diagnosed with the illness and admitted to the hospital in 5 days. Early discovery, in fewer than five days, would have made a big difference in stopping the virus's early spread. Sadly, not enough improvements were made to the EHR system to deal with this problem.

The overall usefulness of EHRs will increase with the implementation of a centralized system. This will help identify patients who are symptomatic early and reduce the likelihood that future outbreaks would be fatal. The centralized EHR system demonstrates its importance in identifying and collecting persons who are at a higher risk of contracting an outbreak, such as those residing in locations with high concentrations of illness. With the cooperation of the Centralized EHRs and

Health Officials and other related officials, movement of people could be monitored and managed to prevent the disease from spreading widely. Online communication between the authorities, other officials, states and countries ensured prevention of spread of disease. Centralized databases will have huge amounts of data, which can be analyzed to detect unusual patterns. Such patterns will be helpful for strategies to manage the overall course of the disease. Subtle information (like how genetic variations affect a drug's response, the effectiveness of different herbal remedies, the impact of surrounding factors on medicine dosage, etc.) will

therefore be found, making it possible to quickly identify evidence-based treatment options for pandemic conditions and put them into practice to lower death rates and enhance quality of life.

1.1 Centralized EHR system

Research on how countries with centralized EHR systems detected and distributed surveillance of people at risk using efficient analytics stored in the database is few. This makes use of all patient information, such as underlying medical problems, risk ratings, and reported symptoms. The smooth transfer of data from community pharmacies and primary health clinics to hospitals guarantees the potential for better tracking and monitoring; the system provides an integrated, unified, and coordinated network of health services, the availability of which has been essential in managing the pandemic; and this data helps in the precise prediction of patients who are more likely to get the infection. Important elements of this process include emerging artificial intelligence, data modeling, and information technology.

1.1.1 Shortcomings of centralized EHR system

Centralized EHR system is having few shortcomings as mentioned below [4]

- **Price:** At the initial stage an EHR system needs setup. It may incur expenses and may need continued annual maintenance expenses.
- **The learning curve:** Healthcare organizations may have skilled staff, but they might not be technically comfortable. That's why they need training to be comfortable with the healthcare systems. The training duration may disturb the daily routine work resulting in low productivity.
- **Problems with technology:** There might be any technical issues in the EHR management system. Such issues might have an impact on the patient's safety.
- **Harmony:** There are multiple gadgets or devices nowadays. No device might be compatible with proposed EHR systems of that respective healthcare system.
- **Data security and privacy:** EHR data is very sensitive. Centralized systems are honeypots for hackers. There are high chances of hacking and data breaches in such HER systems. Such intruder activities hamper the patient's privacy.
- **Data accuracy:** There might be many visits of patients to healthcare organizations. To ensure the data accuracy, data needs to be updated for every visit.
- **Misconduct liability:** Most of the time, only specific data from the whole EHR is required. In such cases, healthcare stakeholders must use only required data from EHR. In such cases, the healthcare should be accountable if he uses the whole EHR.
- **Resistance:** Few healthcare stakeholders have habitual and comfortable physical medical records. They might not be interested in completely switching to electronic health records.
- **User friendly:** EHR systems may not be easy to use for the healthcare stakeholders.
- **Conversion to EHR:** The data stored in the traditional approach might be in the physical form. Every health data is in a different format as well. So, it's very difficult to convert every medical record in EHR.
- **EHR access:** In EHR management systems, every healthcare stakeholder may not have access to the EHR. Such limited access to the EHR might hinder the care for the patients.
- **Single Point of Failure (SPoF):** As the EHR management system is centralized there might not be access to the system in the case of server failure. Centralized storage is also prone to attacks on data.
- **Bottleneck:** As there is only one server / node to access the EHR, there are high chances of bottlenecking of the times.
- **Privacy concerns:** Centralized storage is also prone to attacks on data, raising concerns of the patient's privacy.
- **Continuous investment:** Centralized systems need to be scalable and updated with the latest software and hardware. It requires continuous funding.

II. BLOCKCHAIN'S IMPORTANCE

Validation and verification of the transactions, consensus, immutability, and distributed network are the core components of the blockchain technology. These characteristics can be used in healthcare organizations for EHR management system. Blockchain will be very useful for the validation of the healthcare stakeholders, securing medical records, and preserving the privacy of the patients. Using the smart contract, patients can own their medical records, and they will be able to grant or reject access to any healthcare stakeholders [4] [5] [6] [7] [8].

Usage of blockchain technology will provide the following benefits.

- **Patient-centric:** Patients may take control of their health data with blockchain technology, granting or removing access to it whenever they choose.
- **Security:** Health data can be made more private and secure with the use of blockchain.
- **Transparency:** As blockchain tracks each and every activity through the maintained and shared ledger, it promotes transparency among the healthcare stakeholders.
- **Smart contracts:** To cut expenses and ensure transaction legitimacy, smart contracts and blockchain can be utilized together.
- **Micropayments:** Value-based models that reward patients for adhering to their doctors' orders can be made possible by blockchain.

• **Immutable transactions:** Transactions on the blockchain cannot be modified or changed in any manner.

2.1. Blockchain's Significance and Advantages for the Healthcare Industry

• **Data security:** With the help of blockchain characteristics like encryption and smart contracts patient data will be secured. Inaccurately altering patient data might make it difficult for physicians and hospitals to diagnose a condition or issue with a patient. A hack of more than 176 million patient records occurred between 2009 and 2017.
• **Medical Drugs Supply Chain Management:** Hospitals do not manufacture pharmaceuticals or medicines. Depending on each nation's demands, these medications are further delivered. What would happen if someone tampered with the medications when they were being transported across the nation? Therefore, the medical supply chain needs to be transparent to importers and exporters and impenetrable to tampering. This issue is mitigated by blockchain because of its advantages like tamper-proof, decentralized, and transparent properties [9].
• **Single Longitudinal Patient Records:** Every kind of patient record will be added to the blockchain ledger since it is a chain of blocks. Machine learning and artificial intelligence can be used to forecast the disease depending on the patient's next visit by analyzing records such as lab test results, treatment costs, and disease history [10].
• **Supply chain optimization:** Ensuring the genuine origin of medical supplies is a major difficulty in the healthcare industry in order to guarantee the authenticity of pharmaceuticals. The food products can be tracked from the point of manufacture to each point in the supply chain, using blockchain technology [11]. This makes the products that can be purchased fully visible and transparent. This can help businesses better anticipate demand, optimize supply, and boost consumer confidence all while utilizing artificial intelligence.
• **Drug Traceability:** The most dependable, secure method for tracking each drug back to its source is blockchain technology. Each block of data with medication-related information will have a hash value associated with it [12].
• **Payments with Cryptocurrencies:** Blockchain enables the payment of medical services with bitcoin. Two examples of blockchain-based technologies that make use of blockchain's benefits are Aveon Health and Micropayment [13]. Aveon Health takes advantage of Bitcoin's benefits. Every action the patient takes in relation to the treatment reexamination will be documented in detail by the micropayment model.
• **Decentralized medical record storage:** Versioned file data can be stored in decentralized storage using interplanetary file system (IPFS). To make sure that every file version is the same, the filesystem generates a single hash called the base configured IED description. Website data can be accessed by users using the hash that the IPFS returns, but blockchain files remain immutable.
• **Modernize medical supply chain management:** Blockchain is a great tool for organizing and tracking the flow of medicine supplies because of its security, dependability, and decentralized storage. It contributes to the development of a reliable vendor network that improves patient safety. Blockchain unifies all the procedures, including manufacturing, packing, shipping, and distribution.
• **Enhances EHR systems:** Digital health records developed and maintained by various medical facilities comprise electronic health data. Blockchain solves issues with sharing ownership of the records across all parties involved, accessibility, and interoperability.
• **Better clinical trial recruitment:** A blockchain based on Ethereum has been developed by researchers to replicate the recruiting procedure [14]. The resultant blockchain-based solution preserves trial participants' privacy while enabling access to trial data by all academics.

2.2. How blockchain will be useful for EHR management

Using blockchain technology, blockchain-based EHR develops a new EHR system. The objective is to build an effective, transparent, and safe system. A blockchain-based EHR's ability to securely communicate data amongst numerous healthcare providers is one of its main benefits.

EHRs could benefit from blockchain technology in a number of ways, including:

• **Privacy:** The decentralized ledger technology of blockchain can aid in preventing unwanted access to medical records.
• **Information exchange:** Patients may be able to control the sharing and access of their data using blockchain technology.
• **Storage of data:** Instead of keeping health data on a single server, blockchain allows information to be distributed over numerous PCs worldwide.
• **Transparency of data:** Blockchain technology can enhance the openness of health data exchanges.
• **Accuracy of data:** Blockchain technology can assist in locating mistakes and risky circumstances in the medical industry.
• **Access for patients:** Patients may be able to view their medical records centrally using blockchain technology [15].
• **Health of the public:** By exchanging de-identified patient data, blockchain can assist public health authorities in identifying trends and hazards.
• **Smart Contracts:** Ethereum and other blockchain systems provide smart contracts, which are self-executing contracts with autonomous enforcement capabilities.

However, there are a few obstacles to blockchain technology's adoption in the medical field, such as:

• **Trust:** A lack of knowledge about blockchain technology and practical regulations may cause patients and physicians to lose trust in one another.
• **Efficiency:** EHRs built on blockchain technology could be needed to solve efficiency problems.
• **Carbon footprint:** Blockchain-based EHRs might use a lot of energy and have an adverse effect on the environment.

III. LITERATURE SURVEY

This careful study evaluates the difficulties associated with the adoption of EHRs, carrying out a comprehensive analysis of tools and resources available to the healthcare industry. It examines the complex process of converting paper-based records to digital formats and highlights the necessity of effective mechanisms. The study examines adoption hurdles for EHRs critically and provides insights on areas that need improvement and targeted attention. Usage of blockchain improvises healthcare data management [16]. As per the Healthcare 4.0 blockchain can be integrated with other latest technologies. Integration of blockchain technology with Internet of Medical Things (IoMT) can improvise the EHR management. Such integration may improvise health data security [17]. Access levels can be provided using the chaincode / smart contact in blockchain based system [18]. Data integrity is maintained through such access mechanisms. The study in [19] detailed blockchain topologies involvement in improvising the data security and secrecy.

In the implementation of EHR management there may be lot of issues. Issues may be related to the data complexities and patient related information. Blockchain based systems may be useful to address such issues. Such issues including efficiency and interoperability can be addressed with EHR deployment techniques as discussed in [5].

The study in [20] provides the comprehensive analysis of the possible advantages and difficulties of applying blockchain to EHR management. The analysis in this paper helps to analyze how blockchain technology can be used to transform the traditional approach to the blockchain based approach for health data management.

The framework proposed in [21] details the decentralized healthcare system approach. Smart contracts are used for securing health data in healthcare systems. The healthcare system may deploy different blockchain platforms. Healthcare systems should facilitate seamless exchange of EHRs irrespective of underlying blockchain platforms. The study in [6] conducts a thorough survey on interoperability in various levels of the healthcare sector. in the management of EHRs and suggests a blockchain-based framework to overcome current issues. Detailed analysis on existing interoperable solutions is done in the study. Interoperability issues for the seamless exchange of EHRs are addressed in [22]. The research in [22] also highlighted important aspects of standardization. Such standardization helps to improve interoperability issues across healthcare institutes. There is a need for research to focus on interoperability standards.

Adoption of blockchain technology to manage conversion of physical data into electronic is a challenge [23]. It also requires safe administration of the system [24]. Along with the proper administration the privacy issues to safeguard the health data are also required. The study in [25] [33] focuses on the provision of privacy in the healthcare domain. Apart from the preservation of the privacy of EHR there are also another potential hazards to the system. To protect the health data from such hazards, strong security counter measures should be planned which should also address the interoperability issues [26] [27] [28] [30]. The detailed approaches of EHR management systems using blockchain technology are briefed in Table 1.

Table 1: Research work done on blockchain based EHR Management

Paper	Blockchain Platform Used	Implementation Details	Advantages	Limitations
[16]	Not specified	Enhanced data security, robustness in healthcare data management	Improved data security, resilience	Lack of specific blockchain platform details
[17]	Integrates with IoMT	Strengthening data security in EHR	Forward-looking perspective, potential of blockchain-IoMT integration	Limited information on specific implementation
[18]	Permission-based system with chaincode	Secure EHR sharing system	Improved data integrity, access control	Emphasis on permission-based model
[19]	Ethereum (permissionless) and Hyperledger (permissioned)	Privacy and security preservation	Enhanced confidentiality, data protection	Trade-offs between permissionless and permissioned blockchains not extensively discussed
[5]	Not specified	Framework for interoperable EHR	Improved interoperability, system efficiency	Limited details on specific blockchain platform and implementation
[20]	Not specified	Overall benefits and challenges	Potential transformative role of blockchain in healthcare	Lack of specific implementation details
[21]	Smart contract-based decentralized system	Application of smart contracts for security	Enhanced security, automation in healthcare data management	Focus on decentralized systems and smart contracts
[6]	Proposes a blockchain-based framework	Addressing interoperability challenges	Insights into hurdles, survey of existing solutions	Emphasis on achieving complete interoperability
[22]	Advocates for standardized approaches	Improving interoperability in sharing EHR	Importance of standardization for efficient data exchange	Focus on standardized approaches

Paper	Blockchain Platform Used	Implementation Details	Advantages	Limitations
[23]	Not specified	Benefits and challenges of blockchain in EHR	Potential advantages and challenges	Lack of specific blockchain platform and implementation details
[24]	Not specified	Strategies for overcoming barriers	Practical strategies for electronic record-keeping	Limited details on specific blockchain platform and implementation
[25]	Not specified	Strategies and technologies for privacy	Enhanced security measures for healthcare data	Comprehensive exploration of security techniques
[26]	Not specified	Challenges and opportunities	Insights into digitalization of healthcare records	Lack of specific implementation details
[27]	Advocates standardized approaches	Improving interoperability in sharing EHR	Importance of standardization for efficient data exchange	Emphasis on achieving complete interoperability
[28]	Implementation of smart contracts	Enhancing security and automation	Application of smart contracts for securing healthcare data	Focus on decentralized systems and smart contracts
[29]	Advocates for standardized approaches	Challenges in sharing EHR	Importance of standardization for efficient data exchange	Focus on standardized approaches
[30]	Not specified	Applications of blockchain in EHR security	Insights into blockchain applications in healthcare	Lack of specific blockchain platform and implementation details
[31]	Emphasizes blockchain for decentralized data control	Shifting control to individual patients	Enhanced data ownership and privacy	Focus on patient-centric approach
[32]	Not specified	Categorizes potential areas of exploration	Future research directions in blockchain-based EHR systems	Lack of specific implementation details

IV. PROPOSED APPROACH

A novel approach to EHR management using blockchain involves the creation of a blockchain network specifically designed for healthcare as shown in Fig.1. This network would include all relevant stakeholders, such as healthcare providers, patients, insurers, and regulatory bodies, ensuring a comprehensive and collaborative approach to patient care. Smart contracts would be utilized to automate access controls, ensuring that only authorized individuals can access and update patient records. These contracts can also facilitate automated billing processes, streamlining administrative tasks and reducing the likelihood of errors.

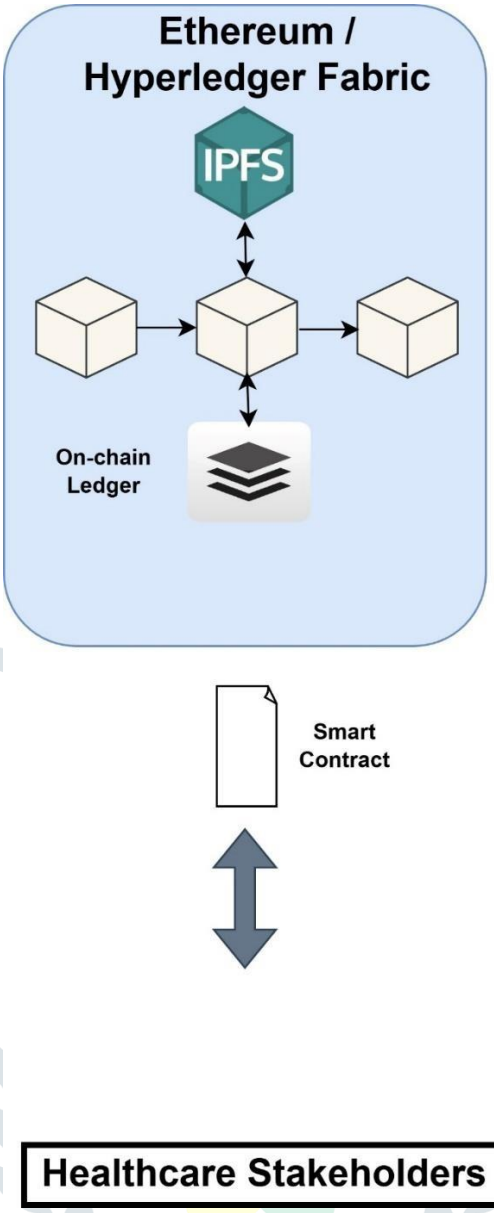

Fig 1. Proposed Architecture

The use of decentralized identifiers (DIDs) and verifiable credentials in combination with blockchain ensures secure and privacy-preserving patient identification. Patients have control over their own data, granting or revoking access as needed, thus addressing privacy concerns associated with traditional EHR systems. If all the health information is stored on the blockchain, it will be very costly with respect to the requirement of the gas as well as the high latency for the data retrieval. That's why we have proposed the EHR partitioning as on-chain and off-chain. On the on-chain only patient identity attributes will be stored and remaining health information will be stored in off-chain databases. IPFS is used in this research for the off-chain database. Anyone with a copy of the decentralized ledger can view them since they are stored there. Every time an On- chain transaction takes place, the blockchain network is updated. On-chain transactions can proceed quickly when there is little transaction volume. The agreed-upon, verified contract, complete with all required details, is represented by the smart contract. Its logic draws implications for any situation that might occur under a contract.

This novel approach leverages blockchain's transparency to improve the auditability of healthcare processes, enabling regulatory bodies to ensure compliance with standards and regulations. The implementation of a user-friendly interface would facilitate the adoption of this blockchain-based EHR system among healthcare professionals and patients. Blockchain platform can be public or private, it depends on the need. The proposed approach is implemented using the public blockchain as well as private blockchain. The comparison between these platforms is done in this paper. Ethereum is used as a public blockchain and Hyperledger fabric is used as private blockchain.

A Turing-complete programming language is integrated into the Ethereum [34] blockchain network, which may be used to create a variety of decentralized applications, or Dapps. The "ether" coin is what powers the Ethereum network. Ethereum is a decentralized, open-source public blockchain in which anybody can join. All parties benefit from the transparency and immutability this offers. Ethereum uses smart contracts to impose rules on their own. This may contribute to maintaining trust across various healthcare professionals. Because Ethereum is a public network, a huge number of validators provide high-level security. However, since all data is accessible to the public unless it is encrypted, privacy may be a problem. Layer 2 scaling (such as Polygon) and the switch to Ethereum 2.0 are two attempts to address Ethereum's scalability problems. Ethereum transactions are subject to variable gas prices. For frequent transactions in an EHR system, this can be a problem. Ethereum could be useful if your system needs a

visible, public ledger with low participant trust. However, it might also require privacy features like encrypted data or zero-knowledge proofs. IPFS (Interplanetary File System) [35] is essentially a file system that functions similarly to BitTorrent [36], allowing to store files and track versions across time. It is similar to Git in that it keeps track of data over a distributed network. After the storage on the on the IFPS, stored data is identified by the CID i.e. unique value. Using this unique value data on the IPFS is mapped with the data stored on the on-chain blockchain ledger. Hyperledger Fabric is intended to be a permissioned blockchain, which limits membership to those who are permitted [37]. Because of this, it is more appropriate for healthcare settings where access control and privacy are crucial. Fine-grained access control is supported by Fabric, giving various healthcare stakeholders such as patients, physicians, and insurers tailored access to particular data sets.
Hyperledger Fabric can manage a high volume of transactions with fewer worries about performance bottlenecks and is more scalable for private use cases. There aren't any transaction costs because the network is permissioned. Hyperledger Fabric's components can be customized, allowing you to incorporate membership services, consensus processes, and smart contracts to meet requirements unique to the healthcare industry.

V. Experimentation & Results

Depending on your needs and priorities, Ethereum and Hyperledger Fabric each have unique benefits when it comes to EHR administration. The medical dataset was used in the experimentation which was administered ten times for both blockchain platforms. As per that the comparisons are done depending on following factors:

a) Global availability

The phrase "global availability" describes how easily accessible the blockchain network is on a worldwide scale in terms of adoption, usage, and engagement. It involves having simple access to the network regardless of one's location or the laws in effect.
Assessment of Global Availability:

- **Network Nodes Across Geographies:** The dispersion of nodes throughout the world to guarantee the resilience and availability of the network.
- **Public vs. Private Access:** Anyone with internet access can access public blockchains from anywhere. Blockchains that are private or have permissions may have limited access, which lowers availability.
- **Adoption and Usage:** The global count of enterprises, developers, and users that make use of the platform.

Ethereum is a public blockchain with thousands of nodes worldwide, Ethereum is accessible to everyone and extensively used by consumers, developers, and companies. As shown in Fig. 2 the global availability score is 9 out of 10. Fabric has a lower global availability because it is frequently used in permissioned networks (private). Typically, only particular participants within a consortium are allowed access. That's why the global availability score is 5.6 as shown in Fig. 2.

b) Smart contract flexibility

The term "smart contract flexibility" describes the blockchain platform's capacity to facilitate the creation and implementation of intricate smart contracts. It covers the range of tools offered, the programming languages that are supported, and the platform's capacity to manage complex decentralized applications (dApps).

Flexibility of Smart Contract Measurement:

- **Programming Language Support:** Flexibility in developing smart contracts is enhanced by a greater selection of supported programming languages.
- **Customizability:** The capacity to alter smart contracts in accordance with corporate rules.
- **dApp Ecosystem:** Quantity and intricacy of decentralized apps developed on the platform.

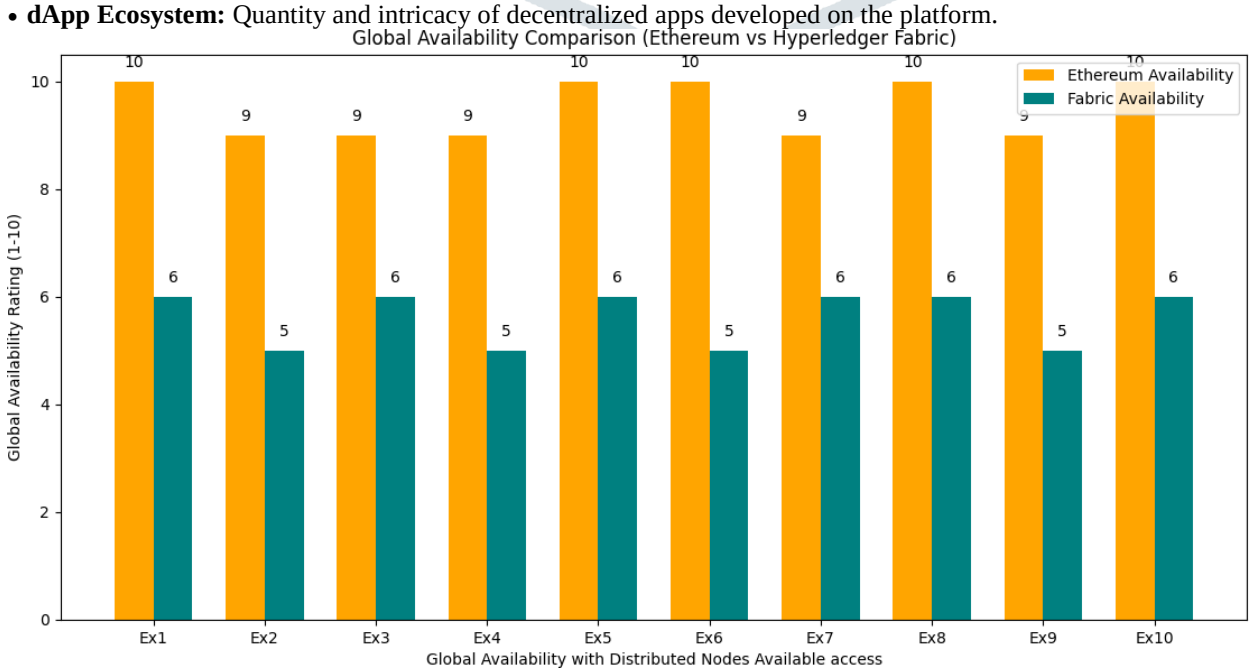

Fig. 2. Global availability comparison between Ethereum & Hyperledger Fabric

• **Frameworks and Tools:** The availability of libraries, frameworks, and development tools to make the deployment of smart contracts easier.

Ethereum is a very flexible platform for developing smart contracts since it supports Vyper, Solidity, and a number of third-party tools like Hardhat, Remix, and Truffle. That's why the Score of smart contract flexibility for Ethereum is 9 out of 10 as shown in Fig. 3. Go, Java, and Node.js are examples of general-purpose languages used to write chaincode for Hyperledger. Although it is adaptable for private smart contracts, its main application is in enterprise environments with restricted support for dApps. So, smart contract flexibility for the Hyperledger Fabric is 6-7 as shown in Fig. 3.

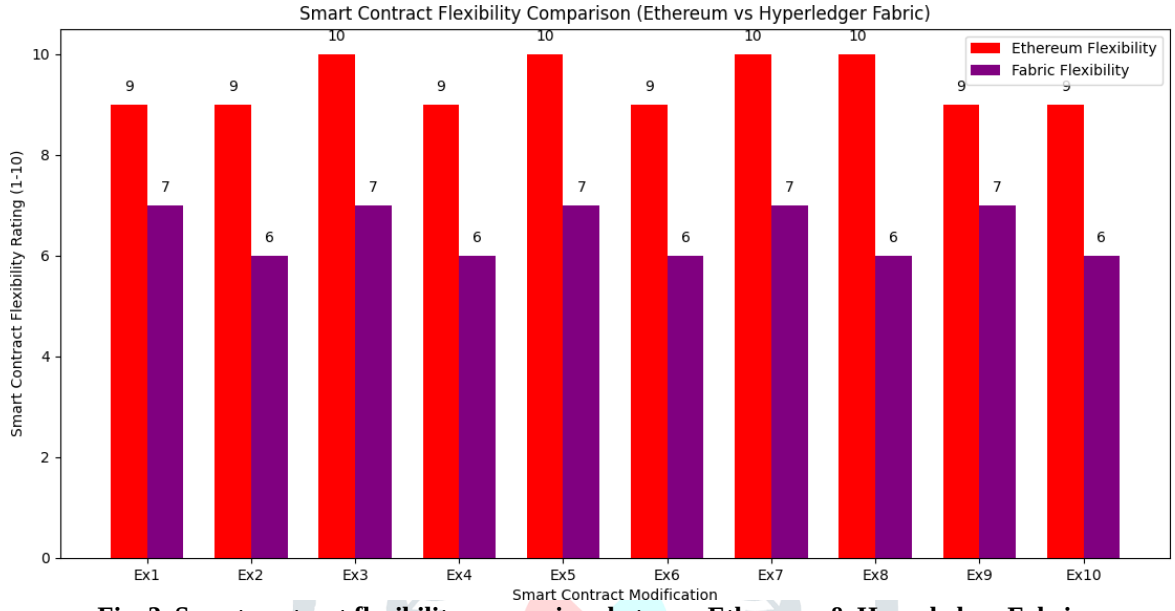

Fig. 3. Smart contract flexibility comparison between Ethereum & Hyperledger Fabric

c) Decentralization

The degree to which a blockchain network is dispersed among several nodes without depending on a central authority is referred to as decentralization. The following metrics can be used to gauge it.

Measure Decentralization

Node Distribution: The quantity and geographic distribution of the network's active nodes. Greater decentralization is indicated by more nodes spread over more regions.
Diversity of Validators: The range of entities in charge of validators and miners. The network is less decentralized if a single entity or a small number of entities control a large number of validators.
Stake Distribution: The concentration of stakes among validators in Proof-of-Stake (PoS) networks, such as Ethereum, may be a sign of centralization. Higher decentralization is indicated by more evenly distributed stakes.

Ethereum is a decentralized platform that features hundreds of nodes spread throughout the world for its validators. The stake distribution in PoS is rather even scoring 9 out of 10 as shown in Fig. 4. Hyperledger Fabric is less decentralized, and fewer entities control the nodes because Fabric networks are frequently permissioned and managed by a consortium scoring 4-5 as shown in Fig. 4.

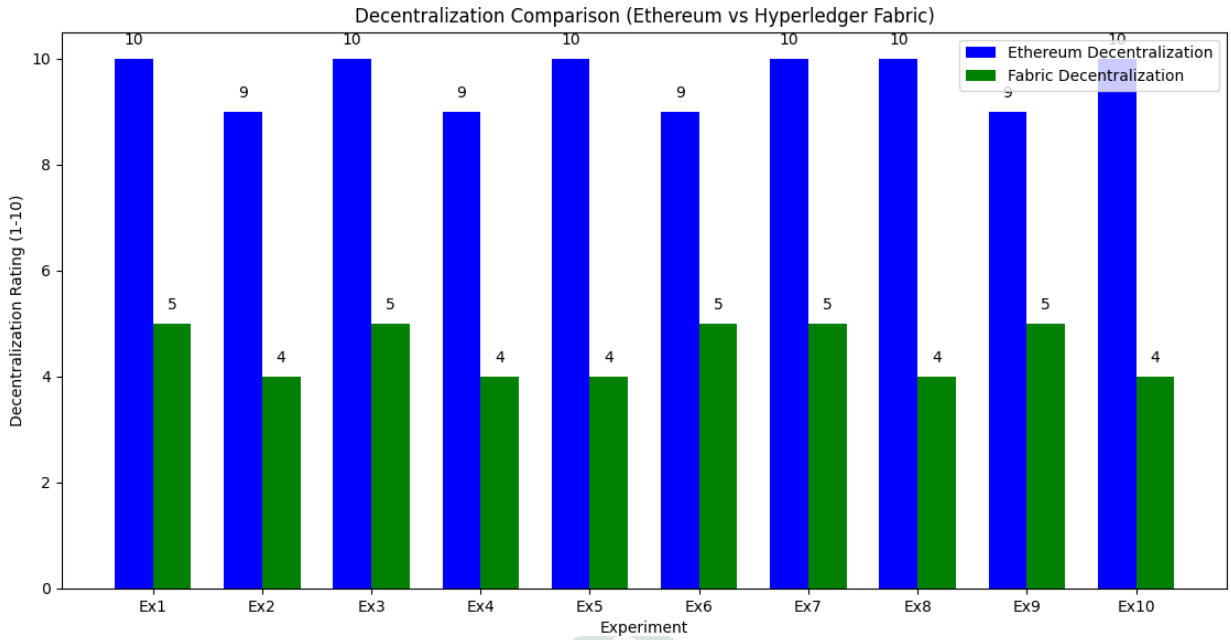

Fig. 4. Decentralization comparison between Ethereum & Hyperledger Fabric

d) Cost

In Ethereum, depending on network activity, gas fees are applied to transactions on Ethereum. This can get expensive with regular transactions like EHR management. Costs can be decreased by using Layer 2 solutions, such as Polygon, and gas optimization techniques. On average storage cost required for the Ethereum is 5-8 as shown in Fig. 5. In Hyperledger Fabric, transaction fees are absent because it is a permissioned blockchain. Hosting and infrastructure management account for the majority of the cost, which is predictable and may be optimized depending on consumption. So, the storage cost in Hyperledger Fabric is very low i.e. 0.04 – 0.06 as shown in Fig. 5.

e) Scalability

Ethereum's scalability in the past has been a problem because of expensive gas prices and network congestion. By adding shard chains and PoS, Layer 2 systems (like Polygon) and Ethereum 2.0 seek to improve this. But still if we compare the scalability issue between the main net of Ethereum with Hyperledger Fabric then Hyperledger fabric is more scalable than the Ethereum. Fabric, a permissioned blockchain, is easily scalable through modifications to consensus protocols and node settings. It can manage a lot of users and transactions by making the network infrastructure more efficient. It can be observed from Fig. 6. that Hyperledger Fabric is more scalable than Ethereum.

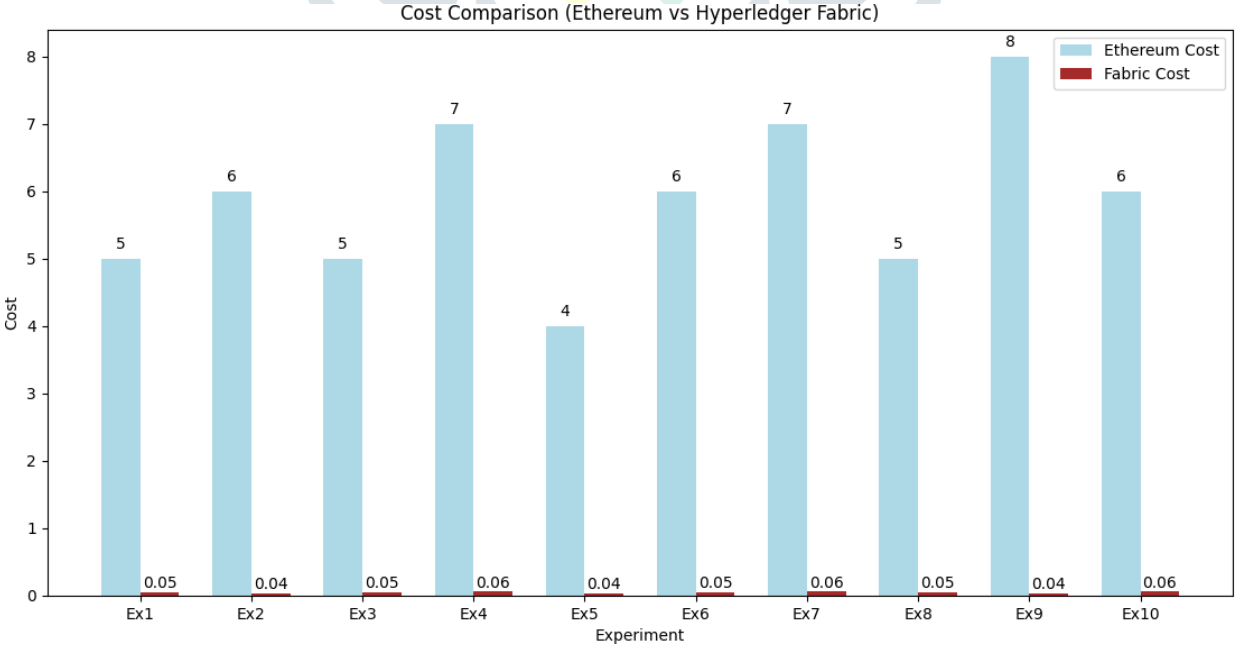

Fig. 5. Cost comparison between Ethereum & Hyperledger Fabric

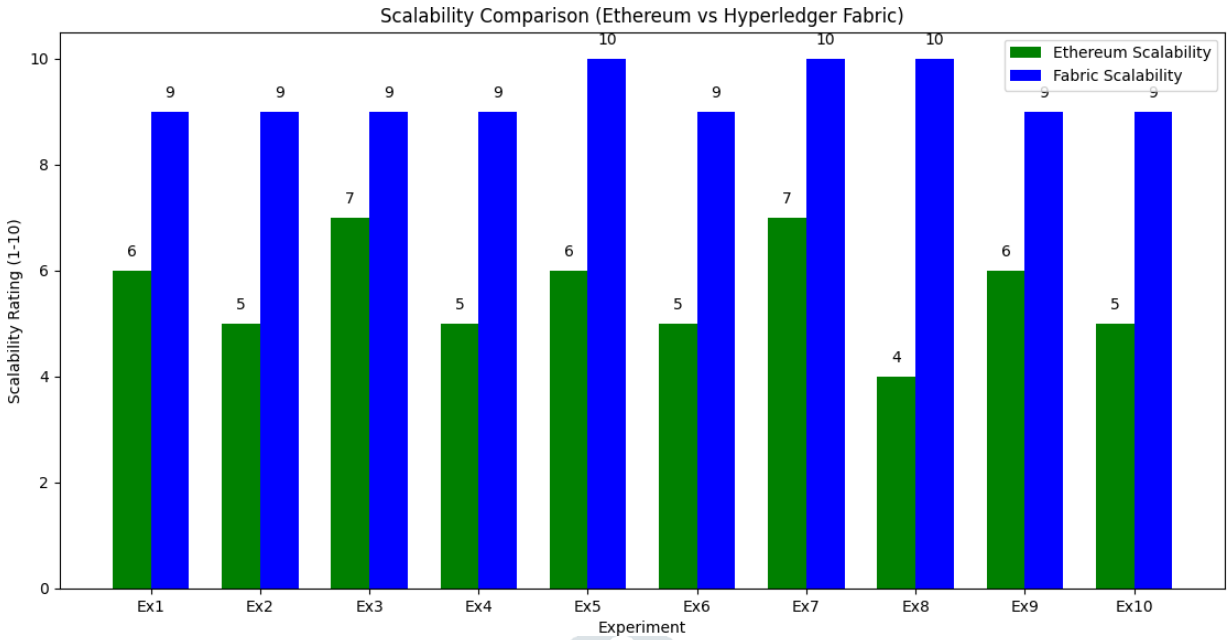

Fig. 6. Scalability comparison between Ethereum & Hyperledger Fabric

f)Latency

The amount of time needed to complete a deal or come to an agreement is termed as latency. In Ethereum, depending on network congestion and gas prices, transaction finality might take anywhere from 15 seconds to several minutes as shown in Fig. 7. Hyperledger Fabric runs in a permissioned environment with speedier consensus techniques like Raft or Kafka, meaning that transactions are typically completed in milliseconds to a few seconds as shown in Fig. 7.

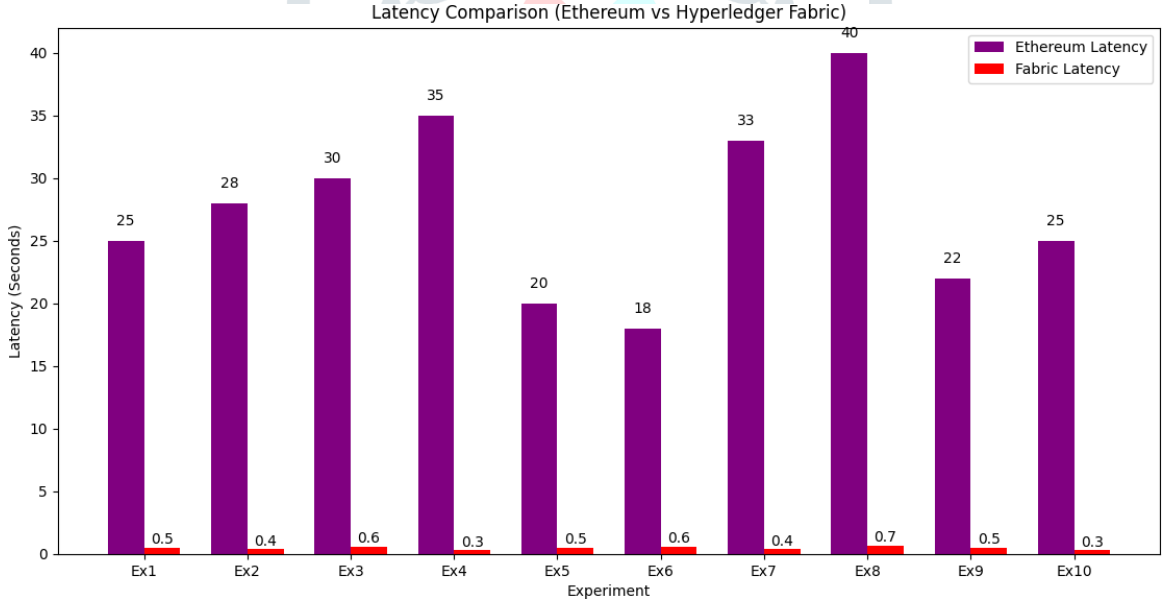

Fig. 7. Latency comparison between Ethereum & Hyperledger Fabric

g) Throughput

Throughput counts how many transactions in a second the blockchain can handle. Previously, the fundamental layer (Layer 1) of Ethereum could only handle 10–30 TPS; however, Layer 2 solutions, such as Polygon, can greatly increase throughput. Hyperledger Fabric is made to function in a private network with regulated nodes and can manage thousands of TPS. and enhanced consensus-building techniques. Fig. 8 indicates that the throughput of Hyperledger Fabric is higher, i.e. approximately 300 than that of Ethereum i.e. approximately 15.

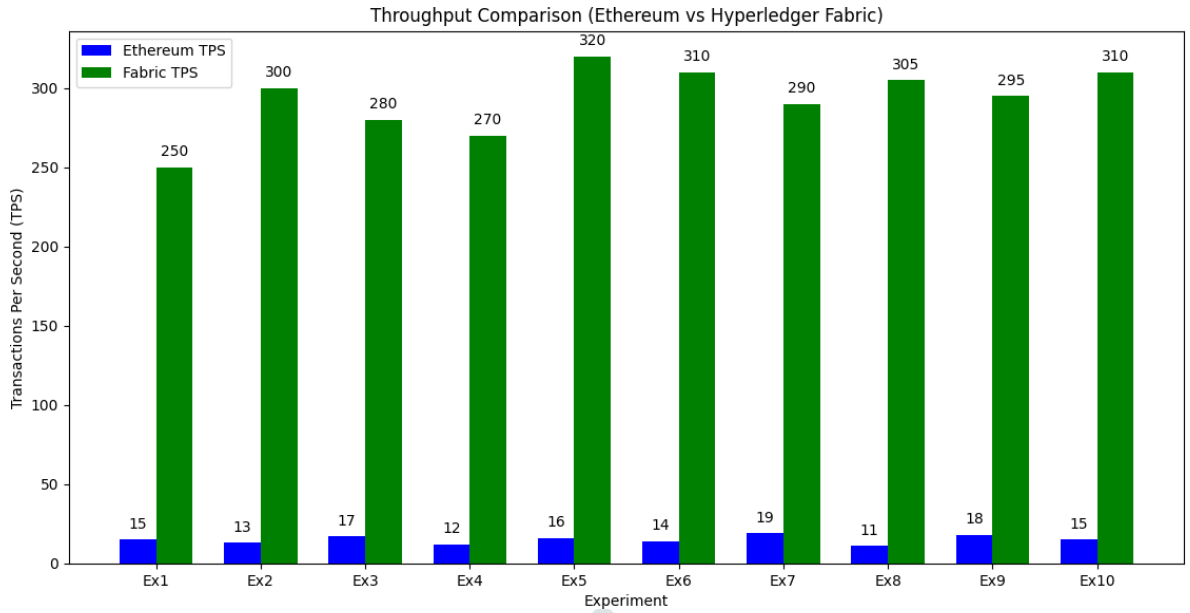

Fig. 8. Throughput comparison between Ethereum & Hyperledger Fabric

h) Tokenomics

The term "tokenomics" describes the blockchain platform's economic model. includes the creation, distribution, usage, and motivation of tokens (cryptocurrencies). Tokenomics are essential to public blockchains because they support the network's viability and provide incentives for users.

The following metrics may be used to calculate Tokenomics

Token Utility: The token's value in the ecosystem (such as for staking, governance, transaction fees, etc.).
Incentives for Validators: Payments made to miners and validators in exchange for preserving the network.
Supply Mechanism: Token creation and distribution methods, including inflation/deflation models (e.g., continuous minting or capped supply).
Market Adoption: How widely the token is used, accepted, and traded across various platforms and sectors.

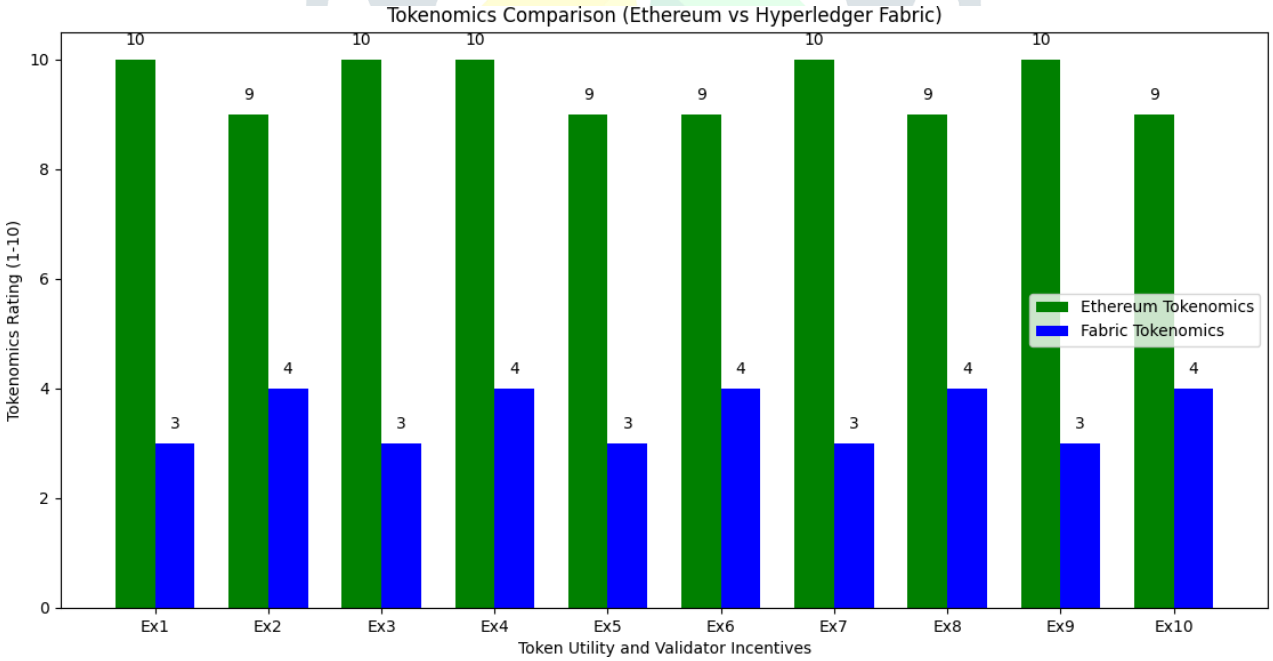

Fig. 9. Tokenomics comparison between Ethereum & Hyperledger Fabric

The native token of Ethereum, ETH, is extensively utilized for staking (PoS), transaction fees, and collateral in decentralized finance (DeFi). Because of its widespread adoption and deflationary mechanism (EIP-1559), its tokenomics are robust, scoring 9 out of 10 approximately as shown in Fig. 9. Unlike public blockchains, tokens on Hyperledger Fabric are usually used in a permissioned manner. In fabric networks, tokenomics usually doesn't apply or just play a minor part. That's why it can be scored as 3 - 4 as shown in Fig. 9.

VI. CONCLUSION

Any patient's health information is extremely sensitive. Keeping the records in a tangible format is the conventional method of preserving such data. The central server storage is where these EHR documents are kept up to date. The availability of health data, privacy, and illegal access are all threatened by this centralized storage strategy. One way to offer secure access while maintaining EHR privacy is using blockchain technology. This study conducted a brief literature review to highlight the advantages of using blockchain technology in the healthcare industry. For an EHR management system with a secure approach, the Secured Optimized Network using Blockchain (SONBlock) is suggested in this study. EHR partitioning as on-chain and off-chain was also suggested by the study. The blockchain ledger stores the patient's identification attributes on-chain. The InterPlanetary File System (IPFS) is where the remaining health data is kept off- chain. Healthcare systems can make use of a variety of blockchain technologies. Hyperledger Fabric and Ethereum are used in the implementation of SONBlock. Using parameters like as worldwide availability, smart contract flexibility, decentralization, cost, scalability, latency, throughput, and tokenomics, the study has compared Ethereum to Hyperledger Fabric. According to the succinct comparative analysis in the research, Ethereum usage is important for achieving the parameters of decentralization, tokenomics, smart contract flexibility, and worldwide availability. The use of Hyperledger Fabric has demonstrated positive effects on throughput, latency, scalability, and cost.

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