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Comparative Analysis of Healthcare Cost between M-DPS vs. DPS Architecture by Using Blockchain Technology

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Abstract: The potential for blockchain technology to transform healthcare systems globally is enormous. Blockchain technology has the potential to revolutionize healthcare by creating a decentralized, transparent, and secure platform that can tackle issues like data interoperability, supply chain management, and patient participation. Using blockchain technology, this article compares and contrasts the healthcare expenses of two architectures: The Modified Decentralized Patient System (MPS) and the Decentralized Patient System (DPS). The study examines the gas costs linked with transactions to assess the economic impact of implementing these designs in healthcare settings. The paper compares the M-DPS and DPS architectures and determines the gas costs associated with file uploads. Furthermore, the article compares the expenses of file uploads on blockchain networks that use IPFS (InterPlanetary File System) and those that do not. Results shed light on possible monetary gains and losses from using blockchain technology in healthcare data management systems.

Keywords: Blockchain, Healthcare, Cost, Patients, System, Management.

1. INTRODUCTION

The design and systems used have a significant impact on how efficient, accessible, and cost-effective healthcare services are in the always changing world of healthcare technology. A comparison of healthcare expenses between two different paradigms, namely Distributed Data Processing Systems (DPS) and Monolithic Data Processing Systems (M-DPS), with a focus on the latter's integration with blockchain technology, is the subject of this study. The need to

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maximize healthcare spending while improving patient outcomes and system efficiency is central to this approach.

As an example of a more traditional method, monolithic data processing systems (M-DPS) consolidate all data processing into one large framework. Structural limitations, such as scalability issues, vulnerability to single points of failure, and difficulties in meeting changing regulatory requirements, have long been linked to M-DPS designs. In addition to security risks, maintaining performance and compliance requires heavy investments in infrastructure, maintenance, and updates when data is concentrated in one location.

On the other hand, DPS signal a paradigm change towards decentralization by spreading data processing jobs across a network of linked nodes. Scalability, fault tolerance, and resilience are three areas where this decentralized design excels, which helps to reduce the likelihood of failure spots and makes the system more resilient overall. Distributed processing system (DPS) designs enable healthcare systems to easily scale and adapt to changing regulatory requirements and increasing data volumes by distributing computational tasks and data storage over numerous nodes.

By providing a fresh perspective on data management, integrity assurance, and transactional transparency, blockchain technology when integrated into DPS systems further enhances their revolutionary potential. Using cryptography, blockchain secures transaction data over a network of autonomous nodes, functioning as a distributed ledger. While reducing the likelihood of data manipulation, illegal access, and information asymmetry, blockchain technology has the potential to transform healthcare by improving data interchange, interoperability, and patient-centric care delivery. Adopting DPS architectures that are blockchain-enabled could have a plethora of cost benefits. Significant cost savings can be achieved by healthcare organizations by automating contractual agreements through smart contracts, reducing administrative operations, and reconciling different information. Further, regulatory compliance and auditability are both improved by blockchain transactions, which lessens the possibility of expensive fines, penalties, and legal challenges due to their transparent and auditable nature.

Tokenization, incentive models, and value-based care programs are a few more ways that blockchain-enabled DPS designs open up new avenues of income and ways to save costs. Cryptographic tokens allow for new forms of economic incentive and reward that can be used to improve health-related behaviors, healthcare outcomes, and resource allocation. The use of blockchain technology has several benefits, including the acceleration of clinical trials, research partnerships, and precision medicine programs; the improvement of treatment efficacy; and the shortening of drug development cycles, all of which contribute to cost savings. The implementation of blockchain technology in healthcare, however, is fraught with numerous obstacles and factors to think about. In order to make blockchain networks work well in healthcare ecosystems, we need to solve technical problems with scalability, throughput, and energy efficiency. We must be vigilant and adaptable as we navigate the complicated

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convergence of blockchain technology and healthcare policy, especially in light of regulatory uncertainty, data protection issues, and interoperability challenges.

Block Chain Technology in Healthcare

Healthcare is just one of several sectors that might be revolutionized by blockchain technology, which was first developed to support digital currencies like Bitcoin. Blockchain, at its heart, is a distributed ledger that securely and transparently records transactions across a network of interconnected nodes. It is also immutable. Blockchain technology has the potential to completely transform healthcare by enhancing data management, interoperability, security, and the delivery of patient-centered care.

The management and interoperability of data is one of the most important uses of blockchain technology in healthcare. There is a lack of interoperability and smooth data interchange since healthcare systems are frequently compartmentalized and patient data is spread out over many databases and platforms. One possible option is blockchain technology, which can store, share, and access healthcare data in a decentralized and secure manner. Electronic health records (EHRs) enabled by blockchain technology allow patients to have complete authority over their medical records, allowing healthcare professionals appropriate access while protecting the confidentiality and security of their information. Through blockchain-based networks, several healthcare stakeholders can improve care coordination and enable real-time data exchange, including hospitals, clinics, pharmacies, and insurance firms.

Additionally, healthcare organizations can benefit from blockchain technology's improved data security and privacy. Cyberattacks, data breaches, and unauthorized access are security threats that traditional centralized databases face, putting sensitive patient information at risk. Blockchain technology reduces the dangers of data tampering and illegal access by decentralizing data storage and utilizing cryptographic techniques. This assures that data remains intact, immutable, and transparent. Furthermore, patients may choose who can access their medical records and under what conditions thanks to blockchain-based access controls, which enable granular permission settings. This helps to preserve privacy and confidentiality.
Supply chain management and the identification of counterfeit drugs are two more important areas where blockchain technology is being used in the healthcare industry. Falsified medications, thievery, and inefficiency abound in the complicated and disjointed pharmaceutical supply chain that spans the world. Thanks to the unchangeable ledger that blockchain technology records every transaction on, pharmaceutical products can be tracked from production to distribution to consumption. By being open and honest about where drugs come from, we can make sure they are genuine and stop illegal substances from getting into the supply chain. In addition, smart contracts built on the blockchain may automate and enforce compliance with regulations, which is great for quality and safety. To further promote healthy behaviors and improve patient outcomes, blockchain technology also makes it easier to apply incentive mechanisms and value-based care models. Tokenization and digital incentives provide new financial incentives and reward systems for healthcare stakeholders to promote preventative care, medication adherence, and healthy lifestyle choices. By maintaining healthy habits like exercising regularly, taking their medications as prescribed, and taking part in

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wellness programs, patients can accumulate prizes or tokens that can be used for savings on healthcare goods and services.

Several obstacles stand in the way of blockchain technology's broad use in healthcare, although its enormous potential. For blockchain networks to be easily integrated into current healthcare infrastructures, several technical challenges must be resolved. These include issues with scalability, interoperability, and energy consumption. Compliance with data protection rules and regulations also necessitates thoughtful evaluation of privacy concerns, legal frameworks, and regulatory uncertainty. The only way to overcome these obstacles and realize blockchain technology's promise of transforming healthcare delivery, enhancing patient outcomes, and creating a more equitable and efficient healthcare ecosystem is through cross-disciplinary collaboration and industry-wide standards.

Overview of M-DPS and DPS Architectures

There are two competing paradigms in the field of information technology: distributed processing systems (DPS) and monolithic data processing systems (M-DPS). Both have their own set of pros and cons. M-DPS, or centralized architectures, stick to the tried-and-true method of consolidating data processing duties into one large framework. Data in M-DPS designs is often housed on a single server or mainframe and handled all in one central location. Due to its familiarity, simplicity, and ease of management, this centralized approach has historically been prevalent in several industries, including healthcare, finance, and manufacturing. The scalability, flexibility, and fault tolerance of M-DPS designs are their inherent limits. It may become necessary to invest in expensive infrastructure upgrades, maintenance, and scalability improvements if M-DPS frameworks fail to handle increasing data volumes and computational workloads. Furthermore, security holes and threats are introduced when data is concentrated in one place; as an example, a single point of failure can cause complete system disruptions, damage data integrity, and make sensitive information vulnerable to cyberattacks or illegal access. In spite of all these problems, M-DPS designs are still used in some places, especially in older systems where switching to a new design would be too expensive or impossible.

The opposite is true with Distributed Data Processing Systems (DPS), which use a decentralized paradigm to spread out data processing across a network of linked nodes. Distributed processing systems (DPS) enable a distributed and fault-tolerant method of processing data by breaking down computational tasks and data storage into its component parts and then distributing them across numerous nodes or servers. Compared to centralized models, this decentralized one has better scalability, robustness, and adaptability, among other benefits. Digital proof of concept (DPS) architectures are able to improve resource efficiency, reduce the risks of single points of failure, and expand to meet increasing needs since data storage and computational resources are distributed throughout a network of joined nodes. Furthermore, DPS frameworks are more agile and flexible because they can easily adjust to changing requirements, workloads, and resource demands. Because the failure of a single node or component does not usually affect the entire system functionality, DPS designs provide

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resilience and dependability from a fault tolerance perspective, guaranteeing data availability and uninterrupted operation.

Another factor that has accelerated the spread of DPS frameworks across different areas is the advent of distributed computing technologies like cloud, edge, and microservices architectures. The ability to leverage distributed computing capabilities without the burden of managing underlying infrastructure is made possible by cloud computing platforms, such as Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS) offerings. These platforms offer scalable and on-demand access to computational resources. Also, edge computing architectures bring processing power to the very periphery of a network, paving the way for low-latency interactions, distributed decision-making, and real-time data processing. Distributed development, scalability, and agility are made possible by microservices designs, which break down monolithic applications into separate deployable services.

2. REVIEWS OF RELATED WORK

Prasad, Sanjana & RajendraPrasad, Deepashree. (2024) a healthcare data manager's duties include collecting, organizing, processing, storing, and eventually erasing any data that is no longer needed. Processing and managing the lifespan of health data is a part of it. Data stored via blockchain technology is transparent and secure, making it impossible to change or tamper with. The advantages of blockchain technology over more conventional security frameworks include more privacy and control, better data interoperability, increased resilience to data breaches and fraud, immutable and auditable records, trust and security via consensus, and decentralization. The paper delves into the significance of healthcare data management, the function of conventional security frameworks, the utilization of blockchain technology in healthcare, the benefits of blockchain technology compared to conventional security frameworks, the various applications of blockchain technology, as well as the obstacles and constraints associated with blockchain technology as it pertains to healthcare data management. Shah, Rujuta & Rajagopal, Sridaran. (2022) a healthcare data manager's duties include collecting, organizing, processing, storing, and eventually erasing any data that is no longer needed. Processing and managing the lifespan of health data is a part of it. Data stored via blockchain technology is transparent and secure, making it impossible to change or tamper with. The advantages of blockchain technology over more conventional security frameworks include more privacy and control, better data interoperability, increased resilience to data breaches and fraud, immutable and auditable records, trust and security via consensus, and decentralization. The paper delves into the significance of healthcare data management, the function of conventional security frameworks, the utilization of blockchain technology in healthcare, the benefits of blockchain technology compared to conventional security frameworks, the various applications of blockchain technology, as well as the obstacles and constraints associated with blockchain technology as it pertains to healthcare data management. Saha, Arijit et al., (2019) when compared to other industries, healthcare has seen the greatest increase in both revenue and data. Security has become an urgent need due to the widespread use of electronic health data. There has been a push to deploy blockchain technology to bolster the security of this vital data. Researchers thus devised a solution using blockchain technology

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for use in healthcare, which would prevent data leaking and tampering. This technique has the potential to provide dependability by preserving data. Additionally, storage-related issues may be eliminated by combining this technology with cloud computing, since the cloud offers a reliable platform for data storage and management. When it comes to cloud security, the blockchain can fix that, too. It is true that many medical data difficulties may be resolved by storing and exchanging medical data on a Blockchain-based cloud. Presenting the current state-of-the-art on blockchain-based medical healthcare system is the major purpose of this study. In addition to providing a comparison analysis among the published works, we have clearly addressed many works in the same topic.

Agbo, Cc et al., (2019) Research on expanding blockchain's uses to non-financial use cases has been underway since its introduction via Bitcoin. One sector that blockchain is anticipated to significantly influence is healthcare. Researchers and practitioners in the field of health informatics are constantly challenged to stay up with the high pace of research in this subject, which is relatively young yet expanding at a rapid rate. A comprehensive analysis of current studies investigating blockchain technology's potential medical applications is detailed in this article. The research methodology follows the PRISMA guidelines and is based on a systematic mapping study process. It involves searching four scientific databases with a well-designed search protocol to find, extract, and analyze all relevant publications. According to the study, many studies have suggested various uses for blockchain technology in healthcare; however, there is a dearth of research and sufficient prototypes to evaluate the viability of these uses.

3. RESEARCH METHODOLOGY

The study compares healthcare costs using the M-DPS (Modified Distributed Processing System) and the traditional DPS (Distributed Processing System) architecture. It looks at the effects of using block chain technology, specifically looking at the gas costs related to data uploads. Improvements in healthcare data management efficiency and scalability are the goals of the M-DPS architecture, which is an expansion of the current DPS framework. On order to grasp the monetary implications, we painstakingly calculated the gas costs endured during file uploads on both platforms. This involves comparing the costs of using non-IPFS block chain networks with those of using the Inter Planetary File System (IPFS) block chain network in great detail. According to the results, while both designs have their uses, the M-DPS framework might be more economical since it streamlines data transfers and cuts down on block chain interface overhead. For healthcare companies looking to improve data accessibility and integrity while decreasing prices, M-DPS might be a good solution since it uses IPFS's decentralized structure to possibly reduce healthcare data administration costs. This in-depth analysis shows how block chain technology is changing healthcare systems and how important it is to compare costs while developing new technologies.

4. RESULT AND DISCUSSION

Here the cost of publishing and validating blockchain transactions is underlined. To compare prices, we employ a tabular data representation. Using the table, we can calculate the cost (in

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USD) of file maintenance on the blockchain network as a function of file size (in bytes/ Megabytes).
The costs associated with storing files on the blockchain are displayed in table 1 below, which is presented in USD.

Table 1: Cost Incurred to Preserve Files on Block chain

File size (in bytes)	DPSArchitecture (in USD)	Data Prov Architecture(in USD)	CBDMArchitecture (in USD)	Modified DPS Architecture (in USD)
10	0.1	0.25	0.29	0.09
20	0.2	0.31	0.37	0.11
40-50	0.3	0.40	0.46	0.14
50-80	0.4	0.52	0.55	0.15
80-100	0.5	0.70	0.73	0.16

The cost to preserve the files in four distinct architectures has been computed based on the file size that the user supplied, as shown in table 1. Figure 1 below provides a visual depiction of these numbers for easier comprehension. According to the data shown above, the cost of uploading the file varies with its size. According to the numbers, M-DPS is far more cost-effective than the existing file-uploading and -archiving infrastructures. As the file size increases, users can save a significant amount of money by saving it in a modified DPS architecture.
You can see the huge difference in the costs of uploading files to IPFS and non-IPFS networks in table 2.

Table 2: Fee Charged for Uploading File in Non-IPFS vs. IPFS Network

File size(in MB)	Cost (in USD) inNon-IPFS DPSNetwork	Data Prov architecture(in USD)	CBDM Architecture(in USD)	Cost (in USD)inIPFSM-DPSNetwork
0-1	~0.175	~0.25	0.30	NA
1-10	0.4	0.625	0.90	NA
10-50	1.3	2.25	3.15	NA

Table 2 compares the two types of networks—IPFS and non-IPFS—based on the file sizes and upload costs that user's experience. Costs associated with file uploads for four distinct architectural types are shown in the bar chart above. The figure clearly shows that out of the four architectures, only one (the M-DPS architecture) uses the IPFS network. The other three do not use IPFS in any way. Users on the IPFS network do not pay to upload files, however users on other networks pay according on the size of the file. The data and comparisons presented above make it clear that, in comparison to the current architectures, M-DPS architecture aids in drastically lowering the uploading and storage costs. Since M-DPS design makes use of IPFS technology, which allocates block space on an as-needed basis, a significant amount of storage space is also conserved.

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5. CONCLUSION

Finally, the economic ramifications of implementing M-DPS and DPS architectures utilising blockchain technology in hospital contexts are illuminated by our comparative study of healthcare expenditures. Our research shows that there are clear variations in the economic performance of M-DPS and DPS architectures, despite the fact that both have the ability to save money as compared to conventional centralized systems. With its improvements and alterations, M-DPS architecture outperforms DPS design in terms of transaction gas cost efficiency. In addition, we show how blockchain technology affects healthcare expenses, specifically when it comes to file uploads on the InterPlanetary File System (IPFS) and non-IPFS blockchain networks. When calculating potential expenses, it is critical to take into account the particular blockchain architecture and protocols, as shown in the results. The significance of thoroughly analyzing the financial implications of implementing blockchain technology into healthcare data management systems is shown by our research. Economic feasibility and cost-effectiveness are crucial factors for decision-makers to consider when evaluating blockchain technology, despite its promising applications in healthcare data security, interoperability, and transparency. We need more studies and real-world applications to confirm our findings and find out what else factors into the financial feasibility of healthcare systems that use blockchain technology. More effective, less expensive, and long-term healthcare solutions are possible if we take on these problems and use blockchain technology to its fullest potential.

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