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EVALUATION OF RELIABLE SERVER SYSTEM USING QUEUING THEORY AND BLOCKCHAIN

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ABSTRACT

The Internet of Things (IoT) devices' communication is insecure and unreliable. There are several security dangers involved. Existing security systems are difficult to administer since they need more resources, which raises the system's total cost. IoT devices have inadequateassets and do not execute a lot of calculations. When services requested from IoT devices are not addressed by an effective security system, they may be malicious and have serious implications. The services' dependability is an essential feature of the IoT network. In this way, the blockchain presents a solution that is both safe and cost-effective. The performance of the model is measured based onthe Mining Time of Each Block, Waiting Time in Memory pool, System Throughput, Memory pool count, Number of Transactions per Block, and Number of Unconfirmed Transactions in the whole classification are compared to real data throughout the implementation process. The findings obtained from the suggested model were found to be in excellent agreement with real statistics.

Keywords: Blockchain, Queuing Theory, Reliable Server System, Mining Process, Internet Of Things.

I. INTRODUCTION

In today's networked world, server dependability is critical where every E-commerce is reliant on stable servers and networks linking those servers to customers for billions of dollars [1]. Likelihood that the system woul doffer proper outputs up to a particular time “t” is recognized as a reliability. Even when problems happen, availability characteristics enable the method to continue to operate [2]. The faulty element of a highly available system would be disabled, and the system would continue to operate at a reduced capacity [3]. When selecting a shared - hosting service or a committed web hosting service such as a server that wants to be sure of the amount of server dependability [4]. Large web hosting providers often have the greatest support professionals available, while smaller web hosting providers tend to place more focus on how effectively their servers are handled. A server's dependability may be affected by a variety of variables, including the operating system used, the number of websites hosted, and the number of resources available; in most cases, server downtime is caused by a lack of resources, not the operating system. Computer devices connected to the internet through a network are referred to as IoT. Data may be sent and exchanged between IoT devices and other networked devices. Examples include sensors, smart meters, smart lighting, smart air conditioning, and other devices.

The majority of IoT devices have limited resources and the edge servers provide the services requested by these devices. The edge servers, in turn, offer cloud service provider service codes [5-7]. These devices must be protected against unreliable and untrustworthy services. They need safe and dependable services from cloud servers and in a transparent computing environment, discuss security issues in IoT devices for interaction, trust is also a key aspect. It is critical to establish trust among service sources and IoT devices so that information may be shared advocated utilizing blockchain to provide a reliable service to IoT devices[8][9].

The IoT devices must be capable to determine if the services they are seeking are dependable and, if so, at what degree of dependability. The service provider's trust value may be used to determine the degree of dependability. Our main goal is to ensure that the cloud servers' services are reliable. When a service provider's trust value or rating is elevated, it indicates that a service provider is very trustworthy. The rating assessment shows reliability of the service inspired by the recommended model design, in which an IoT device may confirm the provided service codes by an edge server [10][11].They used the blockchain in order to keep informed cloud service provider service codes. Smart contracts may be triggered by IoT devices to authenticate service codes. In the same way, a blockchain is mentioned in this work. After using the services of genuine cloud servers, IoT devices might submit feedback to the service provider. The feedback is used to assign the ratings.

A blockchain is used to store smart contracts with an aid of a smart contract, the feedback is kept on a blockchain, every service is rated in this manner, and each rating has a certain value. Similarly, IoT devices may decide whether or not to run the programs given by service providers depending on their ratings. Blockchain technology has an ability to overcome privacy and security issues [12][13]. Blockchain is the decentralized peer-to-peer system with the whole nodes linked. A blockchain's transactions are transparent and immune to tampering. The distributed ledger stores all of the transactions in a blockchain network and distributed ledger maintains track of all of a network's transactions. A transaction cannot be modified after it has been entered into a ledger. On the network, the smart contract manages the transmission of digital money and resources. A smart contract is the short software that is activated when a certain event happens.

1.1. A framework of blockchain for reliable server system

A blockchain-assisted architecture for multi-user data exchange that is safe and dependable. A data owner may easily allow or revoke the authorization of various users to access the encrypted data store. Blockchain is a decentralized infrastructure as well as a distributed computation and management paradigm for data. It had previously been applied to effectively trade and record digital currencies like DASH and Bitcoin. Its decentralization, openness, non-tampering capabilities, and traceability had all been shown. The consensus layer, excitation layer, intelligent contract layer network layer, data layer, and application layer make up the blockchain architecture, as represented in Figure 1. Data layer creates data blocks, performs encryption methods, and adds a timestamp to the data blocks from top to bottom [14]. The network layer runs a block exchange network in the same way as a normal P2P network does, with no centralized node in order to control network and every node equal and linked using the flat model. Each node in the network can produce new data blocks, validate them, and trade them. The excitation layer, consensus layer, and the smart contract layer are the middle three levels that establish the operating protocols for data block packing and transmission. Various common application contexts and instances are defined by the application layer [15].Transaction data is kept in a block and transmitted to a complete system during the block creation process. The block is linked to the major chain once the whole network nodes have validated the information, and the blockchain grows.

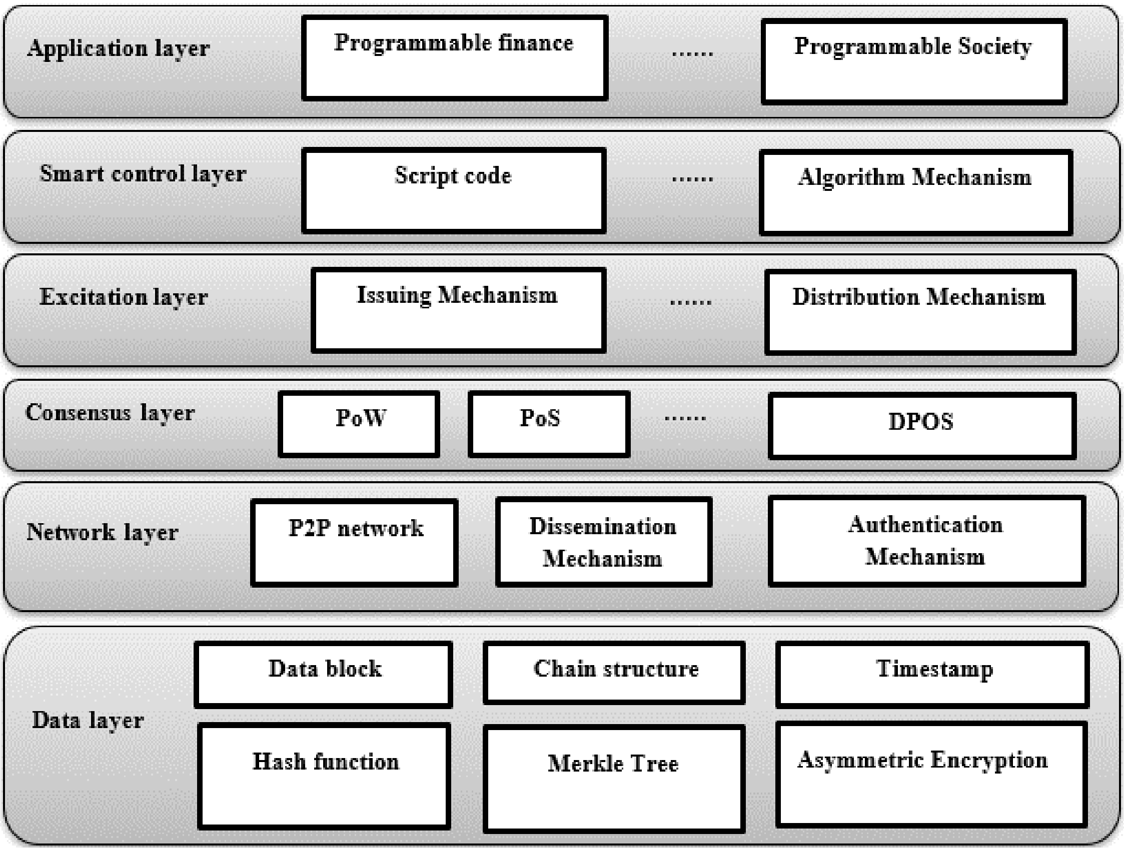

Figure 1: The framework of blockchain [15].

1.2. Queuing theory

Queue theory is a branch of mathematics that has received a lot of attention in recent years. Queuing theory has functions in a mathematical model [16], computer applications [17], linear statistical inference [18], and engineering systems. The field of healthcare is where some of the most recent queuing theory research is being conducted. Various functions of queuing theory to improve the health care procedure. To improve the efficiency of communications operations, the authors use a variety of queues and queue networks in their article. Srivastava et al. [19] give in-depth research on utilization of the queuing theory in conjunction with a big data technology for data analysis optimization. Some academics have been applying queuing theory to optimize the Internet of Things network in recent years. Choi et al. propose an M|M|1 queue system in which the repository (server) is active while one caris moving [20]. The energy distribution and dynamic user scheduling issue arecreated by Zhui et al. as the stochastic optimization problem to decreasean overall network's total energy consumption while keeping all users' long-term rate needs in mind [21]. Chekired et al. suggest a hierarchical fog server deployment across several tiers at the network service layer in their paper. They show that the suggested hierarchical fog computing architecture is more efficient than the flat design [22] using probabilistic analysis models.

The memory pool of the blockchain is modeled using the M/M/1 paradigm. The arrivals are Poisson-Spread in this model, and the service time is exponentially supplied, even though there is only one serving station. The M/M/c model is applied to replicate the mining pool, which has more than one server. Across real life, miners collaborate in large networks to solve a single block problem. In our concept, a single block of Transactions is solved by numerous miners.

1.3. Blockchain Queueing System

Construct a novel blockchain queue based on a real-world blockchain background, where block creation and blockchain construction processes are defined as 2phases of batch services. When modeling a blockchain with a queueing system, it's vital to analyze the mining administration, which is linked to the consensus system, to build up the service process. Take transaction confirmation time, which is the sum of blockchain building periods and block generation, and that service time is split into 2phases: the first is caused by mining procedures, and the second is caused by network delay. A newly created block is verified during the block-generation stage by solving a computationally difficult issue using a cryptographic hash algorithm, which is known as mining; miners are a group of nodes that compete to discover the solution. The winner will get a reward consisting of specified values and fees from the block's transactions, as well as the right to add the new block to a blockchain. A block contains a directory of transactions as well as information such as the current block's timestamp, the recent block's timestamp, and a nonce field provided by the mining winner. As a consequence, the blockchain-building, and block generation processes, the 2phases of services are clearly understood by looking at the genuine background of blockchains, such as Bitcoin networks by Nakamoto [23], Bhaskar and Chuen [24], and blockchain by Zheng et al. [25], and Dinh et al. [26]. The mining operations are utilized to set up a two phases of services: block generation and blockchain-building processes, as illustrated in Figure 1, such that ablockchain system is represented as the Markovian batch service queue with the two separate assistance phases.

This paper is distributed into 4 sections, the 1st section contains the brief introduction of the paper, and 2nd section contains the related work of various authors. The 3rd section contains the research methodology and implementation results, and the final section contains the conclusion.

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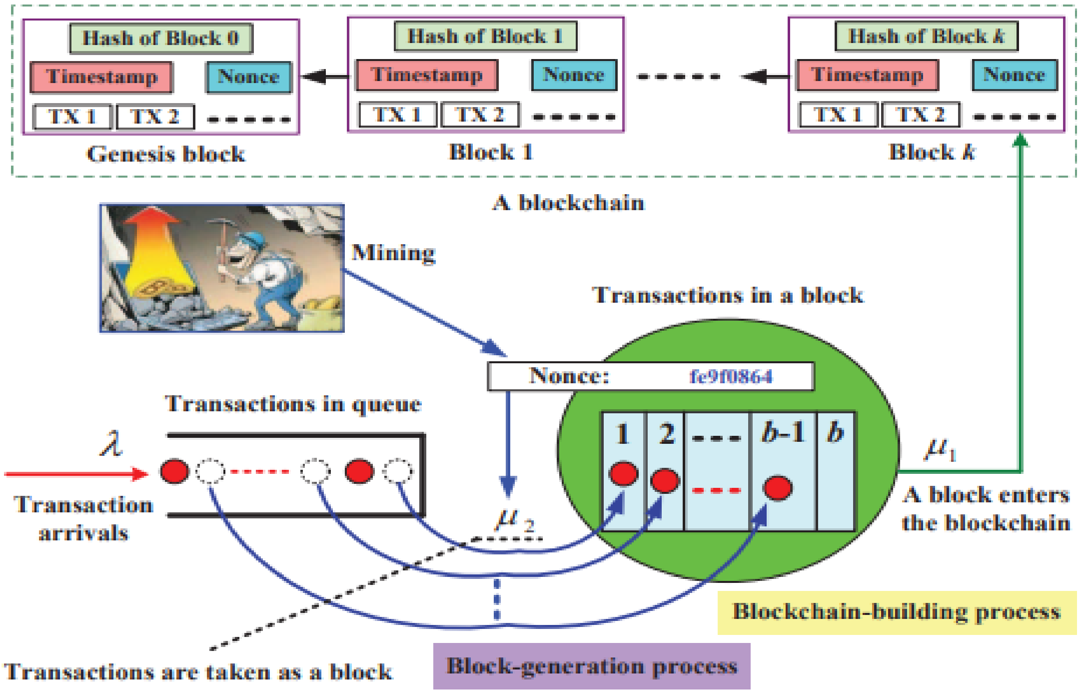

Figure 2: Queueing system using blockchain [26]

II. REVIEW OF LITERATURE

There is various work given by the different authors which are given below:

Veselyet al. [27]stated that the Bitcoin network is built on a shared public ledger established as the blockchain. The blockchain is a record of all transactions that have taken place. They are permitted to figure out how much they have left in their Bitcoin wallets. New transactions may be verified and ensured they belong to the person who paid for them. The blockchain's integrity and chronological order are safeguarded via cryptography. A transaction is a value allocation among two Bitcoin wallets that are logged on the blockchain. The private key of a Bitcoin wallet is used to sign transactions and prove mathematically that they derived from the wallet's owner. The signature also prevents the transaction from being tampered with after it has been issued.

Vladyko et al. [28]stated that blockchain technology is rapidly evolving because of its capability and decentralization to provide secure, frictionless, and trustworthy information transfer and storage. An essential consideration when using blockchain technology is to examine how these technical processes affect network characteristics in order to forecast traffic behavior and assure needed value indicators including stability of public transmission network parts. Researchers should consider different methods for modeling complex systems, for example using a model system to study the network and its components, since full-scale research is time-taking and not practical.

Lianet al. [29] stated that blockchain has had a subversive impact on the flowering of all businesses, notably in the financial sector, due to its traits of tampering, trustlessness, and decentralization. The usage of blockchain technology in the business industry must be investigated. The financial industry is heavily influenced by stock, and the sequence of stock and blockchain is developing more popular. Several researchers have concentrated on forecasting stock value, but they have not adequately studied the interaction of time, value, and acquisition. Meanwhile, the Markov chain is utilized to discover the optimal solution for a resource scheduling model based on queuing. The technique suggested in the paper has the potential to dramatically improve system efficiency while also laying the groundwork for future scientific study on the securities industry's healthy and sustainable expansion.

Spirkinaet al. [30] stated that because of its decentralization and capacity to establish a secure, comprehensive swap and storage of data, blockchain technology is presently being actively explored. This technique is now being applied in a range of industries. Simultaneously, the task of evaluating the influence of this technology on network features in order to forecast network traffic behavior and guarantee the essential service quality indicators, among the constancy of a state of the communication system elements throughout an operation of distributed registry technology, arises. But examining and assessing the impact of technology in the full-scale test is time-consuming task that cannot constantly be completed; so, the authors suggest examining strategies for modeling these systems and, as a backup, employing any logic system.

Fan et al. [31]stated that it is widely believed that blockchain technology can revolutionize a variety of industries. It is critical to evaluate the usefulness of new blockchain platforms as they arise in a range of situations and applications. As a result of this investigation, the authors have categorized blockchain performance assessment into 2 key types: analytical modeling and empirical analysis. The empirical research analyses have several methods for evaluating blockchain technology, involving experimental analysis, monitoring, benchmarking, and computer simulations. Analytical modeling is used to examine stochastic models to evaluate the implementation of different blockchain consensus processes. To improve the performance of blockchain systems, the author compares and contrasts several assessment methods.

Ricciet al. [32] stated that the rising interest in crypto currencies, as well as the time it takes to complete transactions, is one of the issues preventing the widespread implementation of systems like Bitcoin. Bitcoin transactions are normally completed in a short amount of time (minutes), although they are still substantially greater than traditional credit card transactions. The author presents a structure that combines ML with the queueing theory model in order to determine which transactions would be verified and define the time it takes for authorized transactions to be confirmed. The suggested queueing theory model takes into consideration aspects like block activity time and transaction meantime. The model is parameterized for transactions that are approved within minutes.

Memonet al. [33]stated that blockchains have gotten plenty of attention from academics, engineers, & institutions in modern times, and their implementation has begun to revitalize a lot of applications, including e-finance, e-healthcare, smart homes, the IoT, social security, logistics, and so on. The majority of studies on blockchains concentrate on their technical implementation, with minimal emphasis paid to the examination of theoretical elements of the structure; nevertheless, present work is confined to modeling the mining process primarily. The queuing theory-centered model for comprehending the operational and abstract features of a blockchain is provided. The author verify the suggested model by performing simulations for two months of transactions using the real data of two major crypto currencies, Bitcoin and Ethereum.

Raheelet al. [34]stated that for research groups and companies, combining blockchain with the IoT to create a safe, reliable, and resilient transmission platform is now of significant interest. However, determining the proper role of blockchain in existing IoT contexts with minimum implications is difficult. The authors of the paper advocate a dual fog-IoT architecture centered on blockchain, including3design filters for incoming applications at the entrance stage: Real-Time, Non-Real-Time, and Delay Tolerant Blockchain applications. The fog layer is divided into two clusters by the Dual Fog-IoT: Fog Cloud Cluster and Fog Mining Cluster. The suggested Dual Fog-IoT architecture is contrasted with the present IoT design, which is centered on centralized datacenters. The suggested paradigm, in addition to the inherent benefits of blockchain, reduces system loss rate and offloads the cloud datacenter with little changes to the current IoT ecosystem.

Liet al. [35]stated that the benefits of blockchain, which extend from crypto currencies to financial services, the IoT, the sharing economy, reputation systems, and public and social services, include decentralization, consistency, auditability, persistency, availability, anonymity, and accountability. Blockchain is the kind of a distributed ledger technology that employs a decentralized, trustworthy record of perfectly ordered transactions. It isn't only a side effect of Bitcoin money systems. Basic theory, such as mathematical models for mining management and consensus mechanisms, as well as performance analysis and optimization of blockchain systems, is becoming more relevant, according to the blockchain literature.

Kawaseet al. [36] stated that the commonly known confirmation of a user-issued transaction takes longer than a standard block-generation period of 10 minutes in Bitcoin. The author provides queueing model with the batch service and broad input to better detect stochastic character of a transaction confirmation process. Furthermore, the author believes that transaction inter-arrival durations are identically distributed, independent and understands a common allocation in queueing model, and that queued transactions are

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executed in batches. A matrix analytic approach is applied to estimate the mean transaction-confirmation time and steady-state distribution, and the system state is defined as the number of transactions in queue shortly before the transaction arrives. Table 1 illustrates the summary of the above work.

Table 1: Summary of Related Work

S.no.	Author	Year	Outcomes
1.	Vesely et al. [27]	2021	The blockchain's integrity and chronological order are safeguarded via cryptography. A transaction is a value allocation among two Bitcoin wallets that are logged on the blockchain.
2.	Vladyko et al. [28]	2021	Blockchain technology is to examine how these technical processes affect network characteristics in order to forecast traffic behavior and assure needed value indicators including stability of public transmission network parts.
3.	Lian et al. [29]	2020	The technique hasthe potential to dramatically improve system efficiency while also laying the groundwork for future scientific study on the securities industry's healthy and sustainable expansion.
4.	Spirkina et al. [30]	2020	The task of evaluating the influence of this technology on network features in order to forecast network traffic behavior and guarantee the essential service quality indicators.
5.	Fan et al. [31]	2020	To improve the performance of blockchain systems, the author compares and contrasts several assessment methods.
6.	Ricci et al. [32]	2019	The model is parameterized for transactions that are approved within minutes.
7.	Memon et al. [33]	2019	Performing simulations for two months of transactions using the real data of two major crypto currencies, Bitcoin and Ethereum.
8.	Raheel et al. [34]	2019	Reduces system loss rate and offloads the cloud datacenter with little changes to the current IoT ecosystem.
9.	Li et al. [35]	2018	Blockchain is the kind of distributed ledger technology that employs a decentralized, trustworthy record of perfectly ordered transactions. It isn't only a side effect of Bitcoin money systems.
10.	Kawase et al. [36]	2018	A matrix analytic approach is applied to estimate the mean transaction-confirmation time and steady-state distribution, and the system state is described as the number of transactions in queue shortly before a transaction arrives.

III. BACKGROUND STUDY

Researchers, engineers, and institutions have been paying close attention to blockchains, and their implementation has begun to revitalize a wide range of applications, including e-finance, e-healthcare, smart homes, the IoT, social security, logistics, and so on. The majority of studies on blockchains concentrate on their

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technical implementation, with minimal emphasis paid to the examination of theoretical elements of the system; nevertheless, present work is confined to modeling the mining process primarily. The queuing theory-established model for comprehending the operational and the theoretical features of the blockchain is provided in this research. The author verify the suggested model by performing simulations for two months of transactions using the real data of two major crypto currencies, Ethereum and Bitcoin. Blockchains are still understudied concerning theoretical modeling in the study [33].

IV. PROBLEM FORMULATION

The number of Internet apps that are availability-critical is rapidly rising. The Internet Engineering Task Force (IETF) has established Reliable Server Pooling (RSerPool) as a new benchmark for the common server redundancy and the session failover architecture to facilitate creation and operation of such applications. The need of the hour in a dependable server system is to provide an authenticated and secure system with service availability. The suggested work is based on a study of the server system, which is prone to failures and repairs. The study is carried out by permitting the assessment of the steady-state server system. Because the server accumulates a large quantity of data, adequate tracking for each module must be maintained. When the module is correctly monitored, there should be a single system that keeps track of the data and analyses the module's performance in comparison to the steady-state. Because it is a fundamental necessity to monitor the modules in the server using reliable queuing theory, the suggested technique uses queuing theory to examine the system's performance. After the tracking is completed, blockchain technology is utilized to maintain track of the mining pool's records and to identify any anomalous modules or behavior that might disrupt the server's stable state.

V. RESEARCH METHODOLOGY

In the proposed methodology the steady-state of the server is examined using the queuing theory and the blockchain. Initially, the working behavior of the module is tracked using the queuing theory. After that, the module status and performance are recorded with the help of blockchain blocks. After this ,if the module failure occurs then the mining pool gets the module information, performs distributed mining and finally, the blockchain network receives the outcomes reassemble them for a working state. And if no module failures found keep up with the iterations as in regular working. The overall of working is explained in Figure 3 and steps are described below:

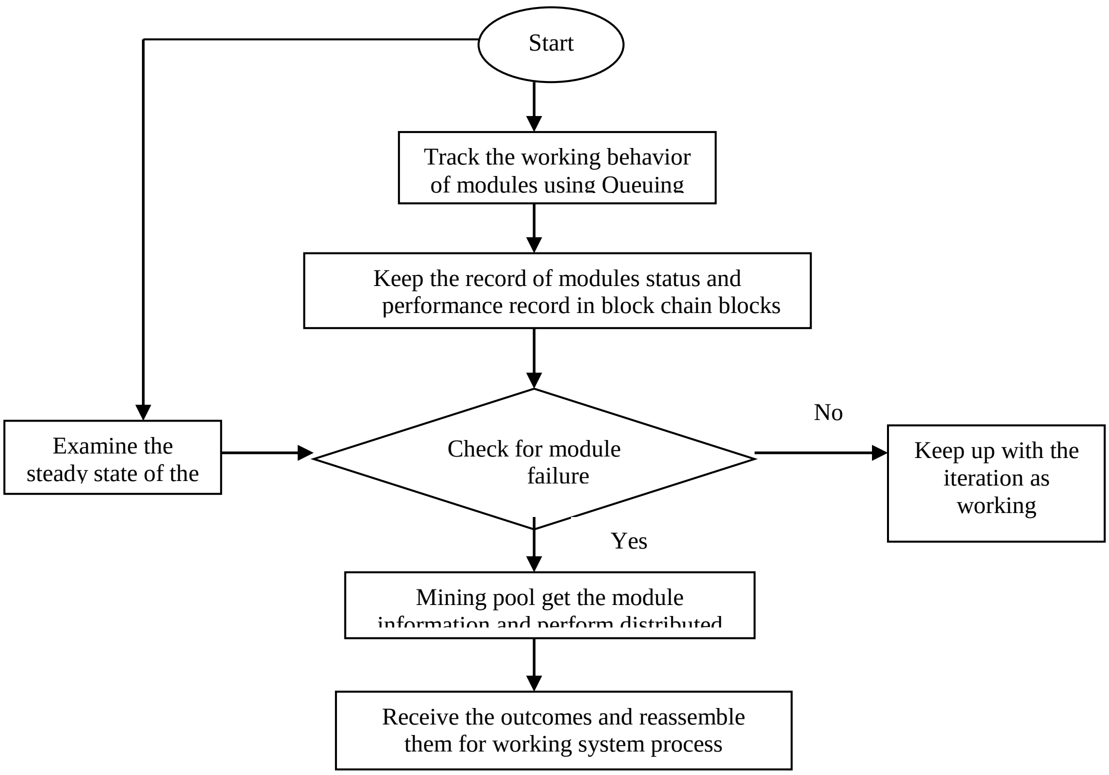

Figure 3: Proposed Methodology

Step 1: Initially the steady-state of the system is examined by the queuing theory and the blockchain. To comprehend the functional and theoretical elements of the blockchain, a queuing theory-based model is developed.

Step 2: In this step blockchain blocks are used to keep the record of the module's status and performance .A block is made up of a list of some or all of the most recent Bitcoin transactions that haven't been recorded in any earlier blocks. As a consequence, a block resembles a page in a ledger or book of records. When a block in the blockchain is 'completed,' it creates a place for the next block in the chain to be created.

Step 3: After storing the performance output of the module in blocks there is a check for module failure. If there is no failure occurs, then keep up with the iteration as working.

Step 5: The mining pool is a collection of the miners; Mining Network = "[A, B, C, D, E], where A = [a1, a2, a3, a4, a5, a6, a7, a8, a9, a10, a11, a12, a13, a14, a15, a16, a17, a18, a19, a20, a21, a22, a23", The M/M/c model is used in order to simulate the mining pool. Finally, mining pool gets the module information and performs distributed mining then reassemble them for the working system process.

VI. IMPLEMENTATION AND RESULTS

This section of the paper contains implementation done using the proposed methodology and based on the proposed methodology implementation results are described.

4.1 Tools Used

For implementation work, MATLAB is used for and its description is given below in detail:

4.2 MATLAB

MATLAB is a scientific computer system with an interactive programming environment. For data analysis, problem-solving, experimentation, and algorithm creation, MATLAB is widely utilized in many technical domains. MATLAB-based discipline-specific software, arranged into libraries of functions called toolboxes, is also frequently used. MATLAB is widely used in technical education as the foundation for computational laboratory work; more than 1000 textbooks utilize MATLAB as a teaching tool. MathWorks, based in Natick, Massachusetts, produces MATLAB. Following are the results implemented to support the proposed work.

Result 1:

Figure 4 depicts the number of transactions per block under Bitcoin's ideal theoretical assumptions, where the number of transactions per block must not go beyond 1 MB and there are 2100 Tx/blocks. However, the pattern indicates that the system turns stable and gives 2100 for the balance of the created blocks after the initial block with 1400 transactions. I computed the number of blocks using the algorithm below [37]:

$$\beta_n = \frac{T}{\beta_t} (1)$$

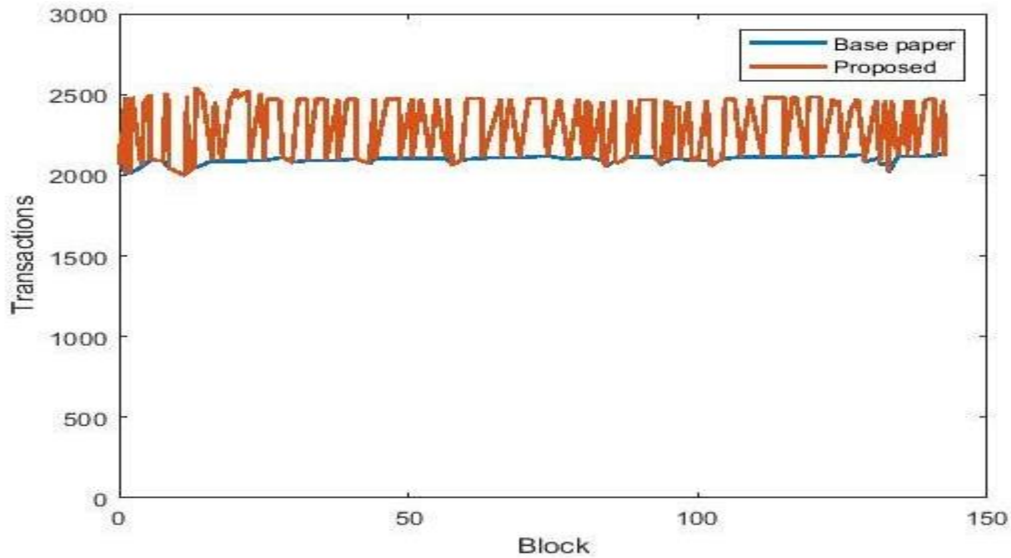

Figure 4: Number of Transactions per block

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Where β_n is the number of blocks, T is the total time and β_t is block-mining time.

Result 2:

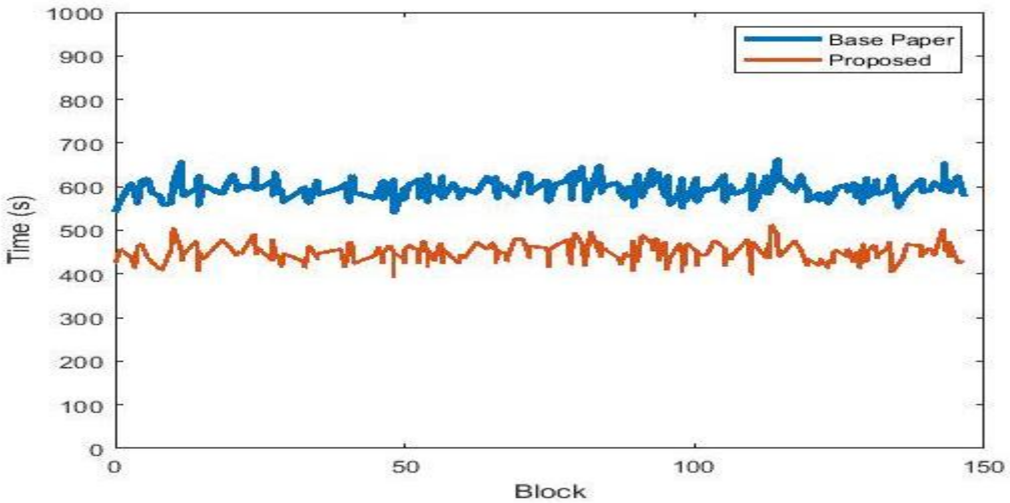

Figure 5: Mining Time of Each Block

Figure 5 depicts the mining time for each block; a miner should find a block in around 10 minutes (or 600s). However, in real life, this time constraint cannot be obeyed perfectly; mining durations vary, and each block has a varied difficulty level.

Result 3:

When comparing Bitcoin to Visa and other payment systems, Figure 6 illustrates the average number of transactions per second. The number of confirmed transactions per second per block, or system throughput, is the generally assessed metric. The average number of confirmed transactions per second per block, or the time it takes to mine a transaction effectively, is shown in this graph.

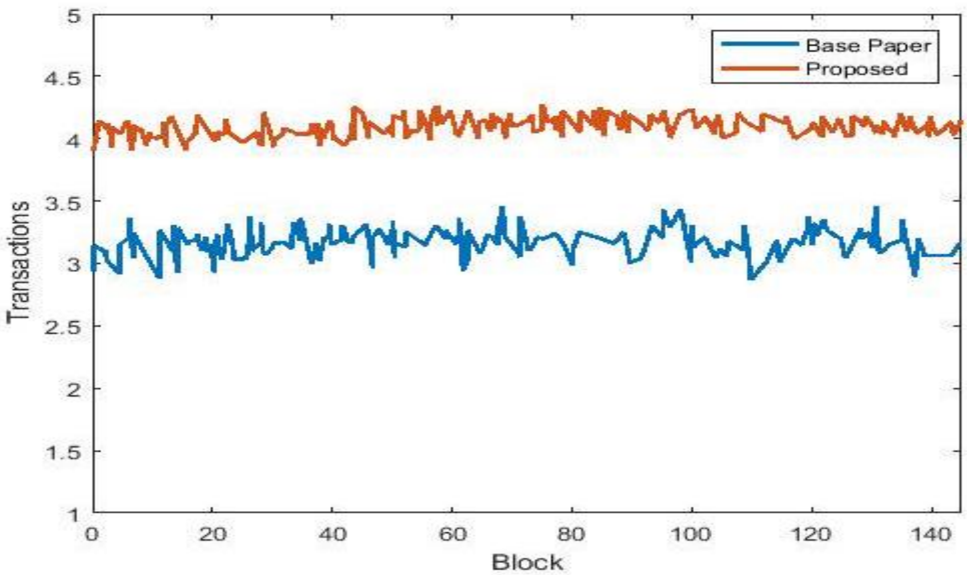

Figure 6: Average Number of Transactions Per second

Result 4:

The number of arrivals to the system is a bit greater than those examined at the mining station, as seen in Figure 7. If the number of transactions comes to the system, the transactions will begin to accumulate in the Memory pool at some time.

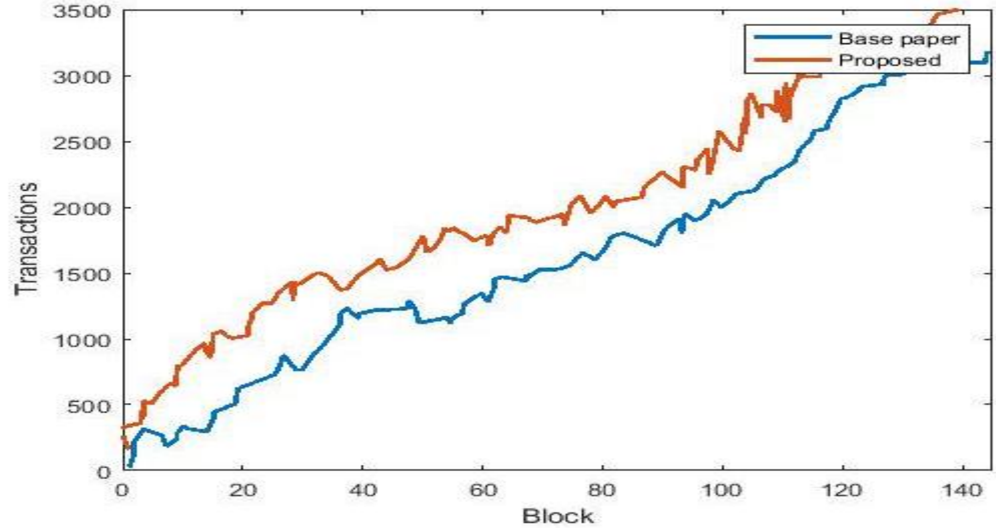

Figure 7: Memory pool count

Result 5:

Figure 8 depicts the memory pool waiting time. Each transaction entering the Bitcoin system must wait a certain amount of time before being picked through every miner. And when the memory count rises, the time it takes for a miner to choose transactions climbs as well.

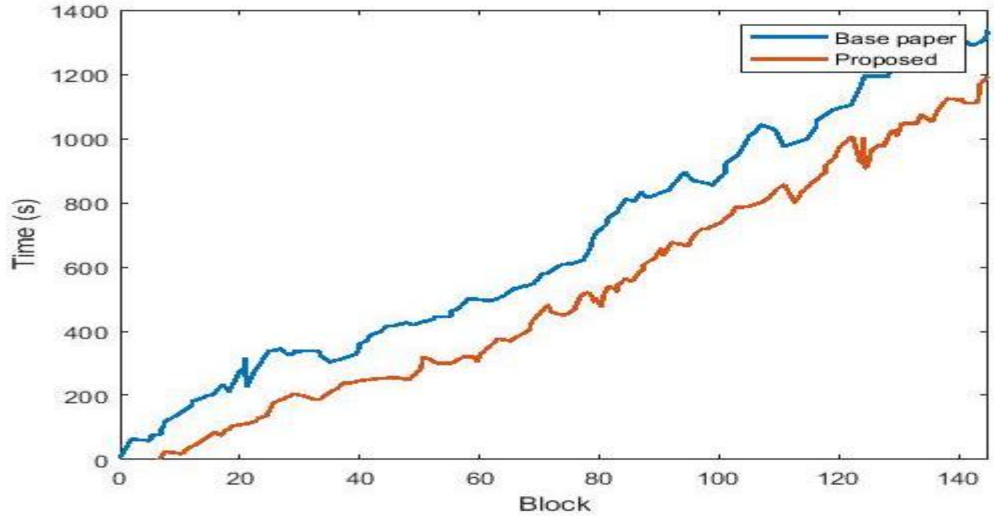

Figure 8: Waiting Time in Memorypool

Result 6:

The amount of unconfirmed transactions in the complete system is shown in Figure 9. The number of transactions arriving per day is volatile; at one point, there might be a huge number of transactions flowing into the network, but the number of arrivals the next moment could be lower than usual. As a result, user transaction requests are not stable, and system capacity and processing time are constrained, requiring the system to react in a certain and specified manner.

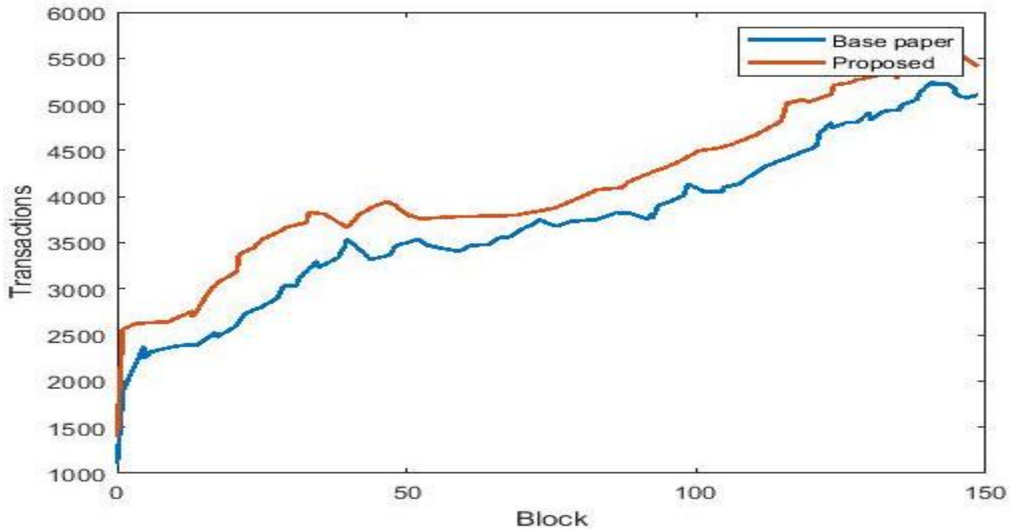

Figure 9: Number of Unconfirmed Transactions in the entire system

VII. CONCLUSION

As blockchain has grown in popularity, its performance issues (such as poor throughput and excessive latency) have become increasingly essential. Many changes have been suggested to address these concerns, ranging from system-level optimization to more effective consent techniques. Though, in order to show their performance benefits, such blockchain alterations must be assessed in a meaningful way. The suggested architecture is built using a set of fork-join for batch creation, a Memory Pool of one M/M/1 queue, and a Mining Pool of one M/M/c queue. The proposed model is a modest but effective way to expose a variety of important indices, including memory-pool count, the mining time of all block system transactions/throughput per second, the number of transactions per block memory-pool waiting time, and the number of unconfirmed transactions in the complete network. Resolving these issues and evaluating multiple blockchain systems in large-scale and real-time contexts are two future research priorities.

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