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MScResearchProject
CloudComputing

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Blockchain and AWS Integration for Financial Transaction

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Abstract

Today blockchain represents an innovative breakthrough by creating secure digital transaction recording systems with immutable data storage capabilities. The distributed nature of blockchain architecture attracts finance institutions because they value data protection. As transaction numbers rise Blockchain technology becomes slower which creates performance obstacles. The proposed solution adopts both blockchain systems and Amazon Web Services (AWS) to build a comprehensive financial transaction management system which resolves current challenges. The integration of AWS with its high availability together with elasticity enhances blockchain capabilities through real-time monitoring and encryption features to establish seamless financial transaction processing across scalable systems. The proposed system implements three key features including robust data security during transmission alongside improved transaction speed and support for current financial network protocols. Through research this study presents an extensive solution which explains effective blockchain integration with AWS to meet financial institutions' escalating need for secure transaction processing solutions.

1 Introduction

Technology related to blockchain has now considered as a revolutionary invention with a significant amount of adoption as a secure way of storing record for digital transactions in different fields. It makes data unalterable, so once a transaction has taken place, the record cannot be changed, which makes for virtually no transparency and security. This aspect has made blockchain especially more attractive to industries like the financial industry where such information is very sensitive. However, there are certain disadvantages of the blockchain and the primary among them is that these are highly centralized, and thus the issue of scalability becomes a major problem. Due to the increase in the number of users in the blockchain and an increase in volume, the system is likely to slow down and call for more resource to perform validation and confirmation of the transaction. These challenges must be worrying for industries that need very high throughput such as banking and finance when considering blockchain. This is where other service providers such as the cloud computing services providers like Amazon, AWS comes in handy. AWS delivers high availability and elasticity attributes to blockchain systems where environments can self-provision to accommodate greater transaction loads. AWS also comes with features such as security that includes encryption, identity and access management and security monitoring for a blockchain system which secure and improves the performance of the system.

1.0.1 Motivation

The financial services industry is now one of the most rigorous in terms of actual

transactions processing. Banks and other financial institutions handle billions of transactions on a daily basis and the traffic is only set to rise with the adoption of mobile and internet banking, and other financial solutions. It is important for the financial institutions, the regulatory authorities and for the customers to make these transactions secure, easily track able, and are processed relatively less time. Still, the issues arise when the current systems, even the ones employing blockchain, try to manage the loads of transactions without any slowdowns or threats to their security. Blockchain's decentralized architecture is safe but each time a transaction occurs, it has to be approved by many nodes.

1.0.2 Goals

The aim of this project is therefore to prototype, build and deploy a blockchain based financial transaction management system that shall rely on AWS cloud services for improved scalability, security, and effectiveness. This system aims to: Ensure secure data transmission and storage: This security can be achieved through the distributed ledger of the blockchain whilst integrating the high-level encryption and security measures afforded by AWS. Achieve scalable transaction processing: Take advantage of Amazon

Web Services to guarantee that the system will be able to accommodate all transactions in form of loads, without having to degrade in performance. Enable efficient system monitoring and logging: This will entail incorporating real time monitoring and logging and real time reporting to show transaction status, system performance and any security threat. Facilitate seamless integration: Organize the system in such manner that it complements with other traditional financial service architectures to reduce the interference and to enhance compatibility.

1.0.1 Research Question

In what ways can blockchain technology supplement the AWS cloud services and what integrated cloud solution is the most suitable for the safe and efficient processing of financial transactions? The following research question defines the main problem investigated in this research, how to integrate blockchain's security characteristics with the AWS environment's adaptive and expansive nature to design a sound system. The answer to this question will help to determine the conditions of creating an integrated system, so that in the future an efficient and unique solution can be offered to the financial service industry's increasing needs.

2 Literature Review

2.0.1 Blockchain Technology Security and Integrity

Blockchain has reinvented the paradigm behind transaction security using the main attributes of decentralization and data immutability. In contrast to the fact that centralized systems keep authority over the data, controlling the process and making it difficult for others to alter it, blockchain decentralizes control in a network of nodes. All transactions in the network are validated by several nodes, through consensus algorithms, meaning that any alternative is almost a herculean task on the recorded transaction.

The work of Nakamoto (2008) on Bitcoin through the application of Blockchain set a revolution in the way of carrying out financial transactions where Blockchain guarantees the negotiations carrying out among peers avoiding the presence of third parties. Nakamoto's model by using a cryptographic solution for the protection of the transaction got rid of the intermediary between users and their capability to oversee and authenticate transactions as, for instance, banks and payment services. In original blockchain systems, the data enclosed in transactions are safeguarded by cryptographic algorithms that render it impossible to change the record: once a transaction is included in the blockchain and validated, it is set in stone. This feature is indispensable in the field of financial services because the availability and reliability of data on transactions that meet the requirements of identity and integrity are vital to combating fraud and unauthorized access.

Based on this, Swan (2015) provides additional information on how blockchain goes beyond just the realm of the cryptocurrencies. Humble explains how blockchain can protect the chain of a critical piece of data in various health care, supply chain, and especially in the financial sectors. The benefits of decentralization in blockchain include;

Blockchain acts as a system that has the ability of reducing different insecure aspects such as fraud, data breaches and unauthorized access among others. This is especially important for financial services, as it processes a considerable amount of the clients' personal and financial information and one data leak is critical. Blockchain provides a solution to these challenges given it is irreversible, cryptographically secure and its records of transactions can therefore not be manipulated.

2.0.2 Blockchain Limitations: Scalability and Performance Issues

However, like any other technology, implementation of blockchain technology has some drawbacks. Another key issue that it has to solve is the growth the company's capacity for processing more and more orders. Expansion in the size of blockchain networks poses a problem of scalability that may limit the efficiency of the networks' capabilities in processing transactions. Croman et al. (2016) provide the following major challenges in the context of blockchain, most notably those related to the transaction validation and confirmation process. For any new transaction to be added into a blockchain, it has to be approved by a set of nodes within the blockchain network.

Such mechanism is called consensus, which also helps to guarantee the stability of the network but leads to issues with the transaction throughput when the number of transactions does matter. As more nodes join the network and more transactions are created, the time it takes to complete a transaction is longer and the transaction fees can be higher, because there are only 6 TPS allowed on the blockchain. Thus, in their study, Croman et al. see scaling solutions like sharding, where network subdivisions into smaller portions referred to as shards help decrease the loads on individual nodes, and off-chain transactions, where all transactions are processed outside of a blockchain and only their summary is written into it.
Zheng et al. (2017) extend on this in showing that blockchain is not optimal for high traffic, high transaction throughput uses cases. That is why they are interested in the computational overhead from consensus mechanisms such as Proof of Work (PoW) that, although they provide network security, consume much time and resources. For instance, when determining the validity of the transactions, PoW demands that miners solve a difficult hash problem; a scenario that slows the network's performance with the increase in traffic. While other consensus algorithms like the Proof of Stake (PoS) which seek to bring about efficiency in term of computational resources the problem of scalability does not disappear for blockchain systems.

2.0.3 Cloud Computing: AWS and Blockchain Scalability through Cloud Integration

The biggest problem of the blockchain is the issue of the decentralized platform's scalability, especially with extremely high volumes of transactions. Blockchain is a decentralized structure, and every node on the network is involved in the validation and information recording processes, which can cause the rate of these processes to become gradually slower with the growth in the network size. Because of this limitation, research has turned to cloud computing as the solution and today companies such as Amazon Web Service, AWS provides a flexible infrastructure that counteracts Blockchain's performance issues. In their paper, Kushwaha et al., (2019) look at how blockchain can
Rong et al. (2017) also describe the advantages of cloud computing for blockchain, and this paper specifically covers how cloud solutions such as AWS increase both performance and capability, with specific attention paid to data handling. This can be a problem because the more that blockchain systems are adopted, the greater the volume of data that can be created and stored, to the extent that it may become unmanageable, for instance in the financial world where transaction records are created at a very fast rate. These trends towards greater data storage needs can be accommodated by AWS services like Amazon S3 that offers almost endless storage space for data as well as fast retrieval of stored information. Apart from storage, computing power is also available through EC2 instances from AWS and through GPU instances, for running more parallel transactions within a blockchain network.

2.0.4 Security and Monitoring via Cloud

Although blockchain technology is the decentralized ledgers and cryptography based, hence secure, using the cloud services such as AWS can open the new scope of security and monitoring. However, AWS has a line of security solutions that work in conjunction with blockchain thus providing a second line of security for data and transactions.

Rittenhouse and Ransome (2017) give detailed information about AWS covers and focuses on the encryption service of AWS. AWS now supports secure access to your data through encrypting the actual data and the data that is in transit so that if intercepted financial information is to be intercepted it will be very difficult to be understood. This is more relevant especially to the blockchain financial applications because the data need to be protected and also be accurate. AWS reinforces the security of blockchain networks by encrypting information at the process of information storage and during their transferring between nodes. Rittenhouse and Ransome also point IAM services in AWS for regulating who can use the data and resources within the cloud.

Other than the encryption, AWS has a continuous monitoring solution and logging for monitoring the health and security of blockchain systems. amazon CloudWatch AWS cloud trail offers the notifications of the network activities, so an administrator can identify and counter threats as they occur. All these monitoring tools are good in the sense that they alert an administrator of surprising behavior like tried security invasions or inefficiencies.

Bhojwani et al. (2020) extends the previously discussed phase to learn how AWS security measures can complement blockchain systems by adding another layer of security for data in transit and storage. They assert that AWS has solved this problem through the use of cleartext encryption, access controls, and more real-time security monitoring to cut the risk of cyber-attacks especially when handling borrower's money in the financial institutions.

2.0.5 Blockchain in Financial Service: Blockchain Adoption in the Financial Sector

There exists significant literature on the subject of blockchain implementation in the financial sector. Gupta (2018) examines how the banking sectors are using blockchain in enhancing the efficiency, security and transparency of transactions. Citing examples from banks as well as fintech firms, which use blockchain to effect faster settlement and mitigate fraud, the study adds a voice to the push for increased adoption of the technology within the financial services industry.

Another important paper by Tapscott and Tapscott (2016) discusses the change that the blockchain can bring to the financial industry. According to the authors, blockchain as a technology has the capability of bringing a complete overhaul in the financial services, due to factors such as the elimination of the middlemen, extension of drastic reduction of costs, and a cut down of the transaction time. It brought to light the positive aspects of using blockchain regarding security to development but also noted that blockchain needs to be scaled, which AWS provided.

2.0.6 Regulatory and Compliance Considerations

As mentioned earlier, the target sector, the financial services sector, is already heavily regulated; therefore, the implementation of blockchain must follow regulatory requirements. Zohar (2015) explains that blockchain's structure will spell changes in regulatory compliance by understanding how the distributed ledger could enhance AML and KYC functions in the FinServ industry. As discussed in these compliance frameworks and tools sections, AWS can help financial institutions to meet the requirements while using blockchain.

In their recent paper, Auer and Claessens (2020) focus on the impacts of using blockchain technology and cloud computing adopted by companies and regulation. They elaborate where, based on the principles of blockchain technology such as traceability and transparency, it can satisfy the strict regulations of financial institutions but stress that cloud capability is important for building up a proper large-scale system.

2.0.7 Combining Blockchain and AWS for Financial Transactions Performance Optimization and Transaction Throughput

The integration of blockchain architecture and the Amazon Web Services could improve the system efficiency and TPS immensely. Wu¨st and Gervais (2018) talk of how cloud resources could be used to feed the blockchain systems since their transaction flow capacity is proportional to the size. From their work, they found that with AWS's elastic cloud structure, blockchain-based financial transactions can avoid problems of bottleneck occurrence due to utilization of elastic resources.

Kaur and Gera (2020) explain the possible enhancements upon the use of blockchain with cloud vendors, including Amazon Web Services. The paper proves that against other typical BaaS providers, AWS can perform computation parallel computing tasks, thereby accelerating the process of transaction validation thus minimizing the common latency of blockchain systems.

2.0.1 Monitoring and Logging for Security and Efficiency

Logging and monitoring are major elements that should be integrated in the process of securing and controlling such systems as financial transaction ones. Sharma et al (2019) also stress the need to monitor blockchain based systems and, according to the authors, AWS contains a full range of monitoring tools that can increase the visibility of blockchain networks. Their work shows how the monitoring services of AWS can be incorporated in blockchain applications to identify irregularities, how efficiency of the applications can be maintained and how compliance with the set security standards can be checked in real-time.

This is further extended by Dinh et al. (2017) to discuss the use of basic logging mechanism provided by AWS to facilitate blockchain transaction auditing. This is particularly useful for financial institution is where the audited transaction is pertinent in the provision of the regulatory compliance.

2.0.2 Future Research Directions

Although, there has been advances on how blockchain can be implemented on cloud computing, Zhang and Jacobsen (2019) posited that more work has to be done to efficiently incorporate blockchain in cloud for some areas such as high-frequency trading and cross-border settlements in finance. They suggest that more work should be done to understand how blockchain's consensus mechanisms can best be integrated into cloud offerings such as AWS specifically for high-priority use cases in finance.
In a similar vein, Atlam Wills, (2019) proposed that further investigations should be carried out on the integration of block chain and cloud technologies in such a way that while block chain is used for maintenance of the critical transaction information, cloud could handle others for optimum utilization and reduction in the cost implications.

Summary of the literature review papers:

Through decentralization and cryptography, blockchain technology allows for secure and tamper-proof transactions, which can be particularly useful for financial services. As blockchain networks expand, they struggle with drawbacks such as delayed transactions and scalability problems tied to consensus methods. The integration of blockchain with AWS comes with answers to these because there is a large-scale infrastructure, enough storage, and processing power provided by AWS that is capable of working efficiently even during peak transaction hours. AWS also protects the blockchain act by using encryption along with access controls with real-time monitoring for detecting and preventing threats via CloudWatch. This pairing not only enhances transaction speed but also boosts security and regulatory compliance, making it the perfect fit for the financial sector.

3 Methodology

Tools and Technologies
In this project, numerous tools and technologies are utilized to plan and develop the blockchain financial transaction system associated with AWS services. They help the system to be scalable, secure, and receive efficient management of the transactions that it performs. Below are the primary tools and technologies used:

3.1 AWS EC2 (Elastic Compute Cloud):

AWS EC2 has the ability to supply the required processing needed to manage the blockchain network. EC2 instances are used in this project where Hyperledger Fabric nodes will be deployed and run on. These can be resized depending on the requirement of the network making the overall blockchain system capable of handling large numbers of financial transactions. For this project, a t2.large instance was chosen, which has 2 vCPU and 8GiB of RAM, so initially using more affordable and optimal for tests. If needed, the instance size can also be increased if the workload on the system increases as the system grows in terms of size.

3.2 AWS S3 (Simple Storage Service):

AWS S3 is employed for secure storage and scalabilities of logs and transaction data associated with the proposed blockchain network. As blockchain systems create massive transactions and logs, S3 brings the best value in terms of keeping the data at a minimum cost. The use of S3 allows for all logs generated from system activity, and transactions to details, performance evaluations to be safely stored as backup in S3 Since S3 is extremely secure, it supports encryption at rest, as well as automated versioning to ensure data integrity.

3.3 AWS RDS (Relational Database Service):

AWS RDS is used for storing metadata that cover transactions on the block chain and users' profiles, transactions, and nodes information. In this project, Amazon RDS with PostgreSQL was selected since it has improved stability, adaptability and integration with blockchain frameworks. Storing, querying and retrieving of the metadata using RDS is made effective due to AWS high availability in addition to security measures such as encryption and automated backup.

3.4 Hyperledger Fabric:

Hyperledger Fabric is a permissioned Blockchain platform selected for this project, due to its capability in the deployment of private and secure networks particularly relevant to the financial service industry. It enables formation of private channels for transaction thus the ability to contain sensitive financial information between participants. It is also vital to note that through this modularity, the Hyperledger Fabric has a capability of being configured for certain business requirements for instance developing over custom consensus mechanisms or smart contracts.

3.5 Docker, Go, and Node.js:

Before running the Hyperledger Fabric on AWS EC2 a tool known as Docker is utilized when it comes to the creation of blockchain containers. This enables the deployment of blockchain nodes in various environments hence making it easier to achieve a coherent and substantial outcome. Go is used for writing smart contracts which in Hyperledger Fabric, they refer to as chain code to facilitate the execution of the transaction. Node.js is used to create the web front end and client GUI's that interface with the blockchain network. These tools collectively offer a stable and low latency environment in which to build and run the Blockchain framework.

3.6 AWS CloudWatch:

We use CloudWatch for monitoring system performance and for logging purposes as well as for analysis of the general health of the specific blockchain system. Using alarms and dashboard in CloudWatch, administrators can monitor different problems, for example, resource usage and attempts to access them by unauthorized users. CloudWatch also includes other performance indicators such as CPU and memory occupancy, and network

delays, to maintain that a blockchain system is not only responsive to various loads of transactions but also efficient.

3.7 Experimental Setup

AWS infrastructure, blockchain nodes are created, installed and tested to make sure that the system is adequately secured to conduct financial transactions in large volumes. The subsequent sections will explain precisely what has been done to build the environment.

3.8 EC2 Setup:

The first experiment is to set up the environment where a Hyperledger Fabric blockchain node will be located on an EC2 instance. An EC2 instance t2.large was used for initial testing because of its flexibility in processing power and main memory to support the major components of the system such as transaction processing and validation. The EC2 instance is configured with the following steps:

- Operating System: The base operating systems of the instance is Ubuntu 20.04 because it is compatible with Docker, Go, and Node.js.
- Security Groups: Custom AMI with or without specific security groups are developed to manage instance's network access. These security groups only allow some selected IP address and some selected port like port 7050 for hyper ledger, port 22 for SSH and port 443 for https to avoid any instance get hacked from outside.
- IAM Roles: IAM roles are set up for the permission for the EC2 instance, for example, to write logs into an S3 bucket or manage metadata in an RDS.

3.9 Blockchain Configuration:

For this project Hyperledger Fabric is chosen as the blockchain framework because Hyperledger fabric is suitable for permissioned network especially for the financial application where privacy and confidentiality are key factor. The blockchain configuration includes the following steps: Network Setup: Hyperledger fabric is used to develop a permissioned blockchain network, where every connected organization has its peer node. It is useful for structuring so that only participants who are allowed can join it and engage with the rest of the nodes.

3.10 Security Configuration:

Security concerns have particularly valuable in blockchain based systems due to the nature of information transferred in the chain most importantly financial information. The following security measures are implemented in the AWS environment:

- Encryption: Laws related to data encryption are compiled to by enforcing encryption of data such as data which is at rest is encrypted by AWS Key Management Service (KMS) and data in-transit is encrypted with the help of SSL/TLS encryption. Blockchain nodes, client applications, AWS RDS and S3, use standard encryption mechanisms for communication over the network.
- IAM Policies: There is rigid IAM policies implemented to regulate access to AWS operational resources. Only the admin and other specific roles are permitted to perform

tasks such as creating an EC2 instance, accessing logs in the S3 bucket, or changing some information in the blockchain tables in RDS.

- Network Security: The blockchain infrastructure is secluded from the public internet as the Virtual Private Cloud (VPC) is configured. This means that only the permitted traffic will be allowed to access the blockchain nodes thus close out the threats.
- Security Audits: AWS CloudTrail is an audit service that logs API calls made within the AWS infrastructure so that detailed action history is kept regarding user, services, or applications. This way, if there is any sort of violation of security and or any unauthorized actions, it can be flagged and dealt with immediately.

4 Architecture

Understandings on Architecture Diagram

The depiction in the diagram gives the reader a clear perspective of how the financial transaction system on the block chain applies sundry services of AWS for expansion, protection, and control. Below is a step-by-step breakdown of the architecture as illustrated:

4.1 User Interaction

The User starts a transaction involving elements of finance through a Front-end application that connects with the BLE through API Gateway. The user request is forwarded to the blockchain system for more processing taking place in the AWS cloud exclusively.

4.2 API Gateway

The AWS API Gateway handles incoming transaction requests coming from the users. This helps to offer a secure and massive endpoint via which such requests can be received and processed. The URL Path is generated by the API Gateway leading the user request to the correct services to access the blockchain network securely with proper authentication.

- Role in Architecture: The API Gateway will make sure that the requests that are processed are properly authenticated and authorized before the information passes through the blockchain network to be processed. It has the role of a manager, being responsible for the admission to blockchain system.

4.3 Blockchain Processing through Amazon EC2 Instances

The EC2 Instances are just like what they are the compute infrastructure on which the blockchain nodes reside that execute the blockchain application and its transactions. After a user initiates a transaction, the API Gateway forwards the request to these instances, and these do the blockchain work, such as validating and processing the given transaction through the Hyperledger Fabric platform.

• Role in Architecture: EC2 instances: These are part of AWS and are responsible for the running the blockchain network and for executing smart contract solutions, data validation and consensus across the network.

4.4 Blockchain Network

The Blockchain Network, shown in the diagram is the central system of the process and it efficiently performs the transaction processing. The blockchain nodes residing on the EC2 approve and authenticate the transactions through the Smart Contracts set earlier. The blockchain guarantees that the transactions entered are made timelessly unchangeable on the distributed ledger.

4.5 Storage (AWS S3 and RDS)

1. AWS S3: A blockchain node records transactions in the form of transaction logs which is then stored in S3. These logs contain performance information, transaction histories as well as debugging information and are therefore used for audit and analysis.

• Role in Architecture: S3 is responsible for storing block chain logs and backup of other critical information at a larger and flexible manner with great durability and availability. 2. AWS RDS: Transaction information including user identity, time of transaction, and other information regarding the parsed transactions is saved in RDS, Relational Database Service. This metadata is important for the indexing and searching of the information about the transactions but as it can be understood is not kept on the blockchain for reasons of efficiency of the blockchain.

• Role in Architecture: Off chain data enhances the ability of Decentralized systems to provide additional contextual information which is stored outside of the block chain which is what RDS is used for.

4.6 Monitoring (AWS CloudWatch)

AWS CloudWatch is used for the monitoring of the system performance, collecting logs and values. CloudWatch gathers metrics for all parts, the EC2 instances, API gateway, blockchain nodes as well. It gives information about system status and it warns administrators when things are not as they should be in the system.

• Role in Architecture: The CloudWatch services alert CloudWatch continuously on the status of the blockchain and knows if the system is running well. This enables the identification of problems with regards to resource consumption as well as network and system problems.

4.7 Architecture Diagram

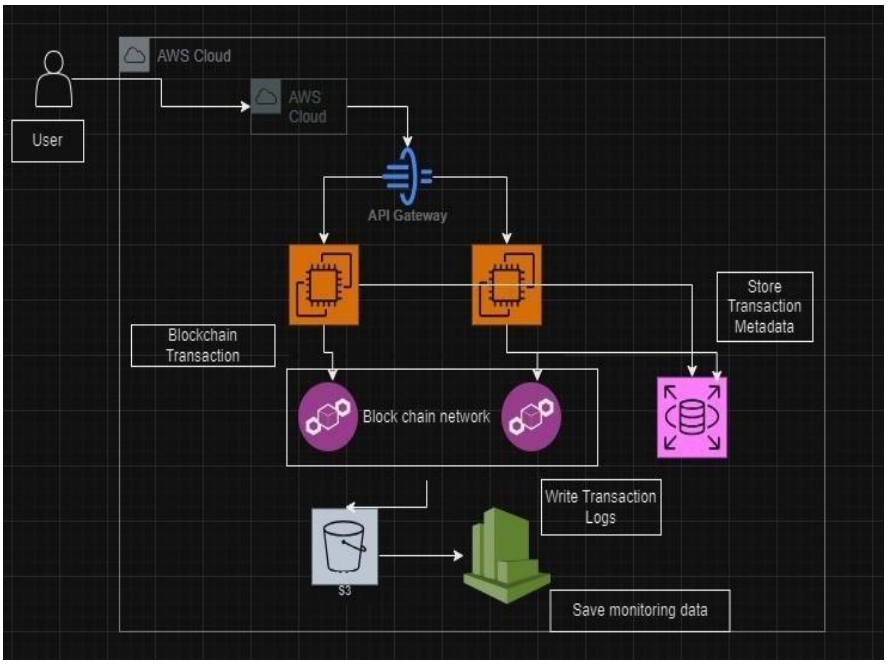

Figure 1: Architecture Diagram

4.8 Transaction Flow

The transaction flow, as represented in the above diagram, follows a well-defined path: • User Initiation: A user performs the transaction through the front-end application; API Gateway transmits this request.

- Transaction Processing: The API Gateway refers the transaction request to the EC2 instances in the blockchain network where the transaction takes place and is checked for validity.
- Metadata and Logging: At this point, we create logs and store them in S3 buckets while the other off-chain metadata related to the current transaction and its time are kept within the RDS.
- Monitoring: While running, CloudWatch gathers performance data and logs and monitors whether the system is functioning properly and if any problems occurred. Such a flow makes sure user transactions are well dealt with by the system, with monitoring in real-time and account logging in case of audits and troubleshooting.

5 Implementation

5.1 EC2 Dashboard Overview:

The EC2 dashboard shows available instances and the capability to launch new instances, which will be used to handle blockchain blockchain transactions.

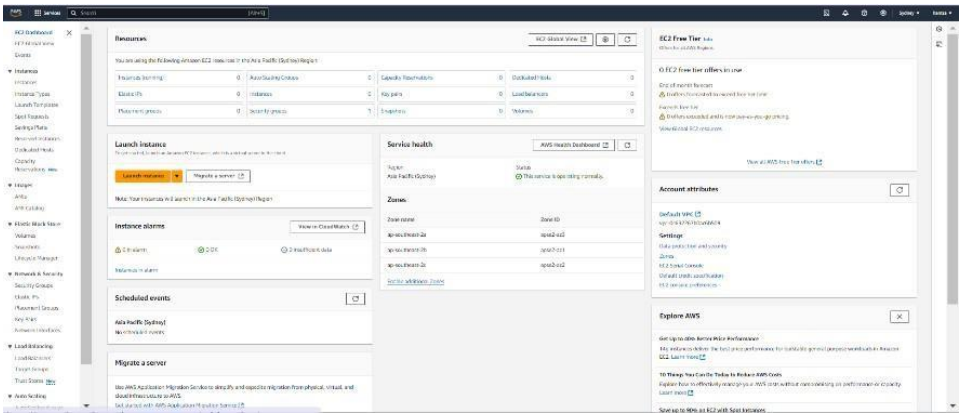

Figure 2: EC2 Dashboard

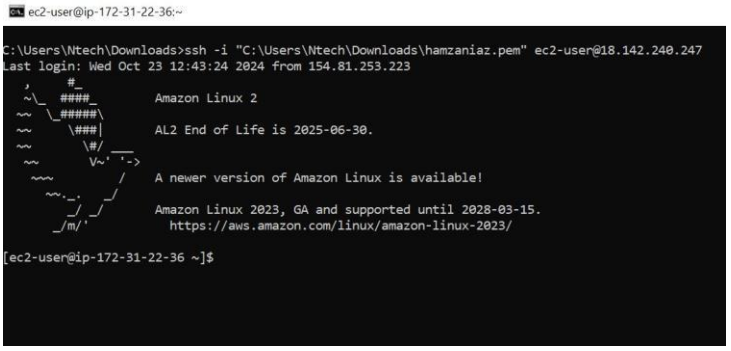

Figure 3: EC2 Connection

5.2 Setting up BlockchainBlockchain on AWS

AWS currently offers a scalable and highly available option known as Amazon Managed Blockchain, Blockchain, through which users can create blockchain blockchain networks. This service helps popular blockchain frameworks, Hyperledger Fabric and Ethereum, with which users have the freedom to select a framework that is suitable for their use case.

5.3 Setting Up the EC2 Instance for BlockchainBlockchain Node

The first step in forming the blockchain system is creating an EC2 instance for the blocchain node. The blockchain node is the heart of a given blockchain network, as it is responsible for processing transactions, running the consensus algorithms, and communicating between peers of the network.

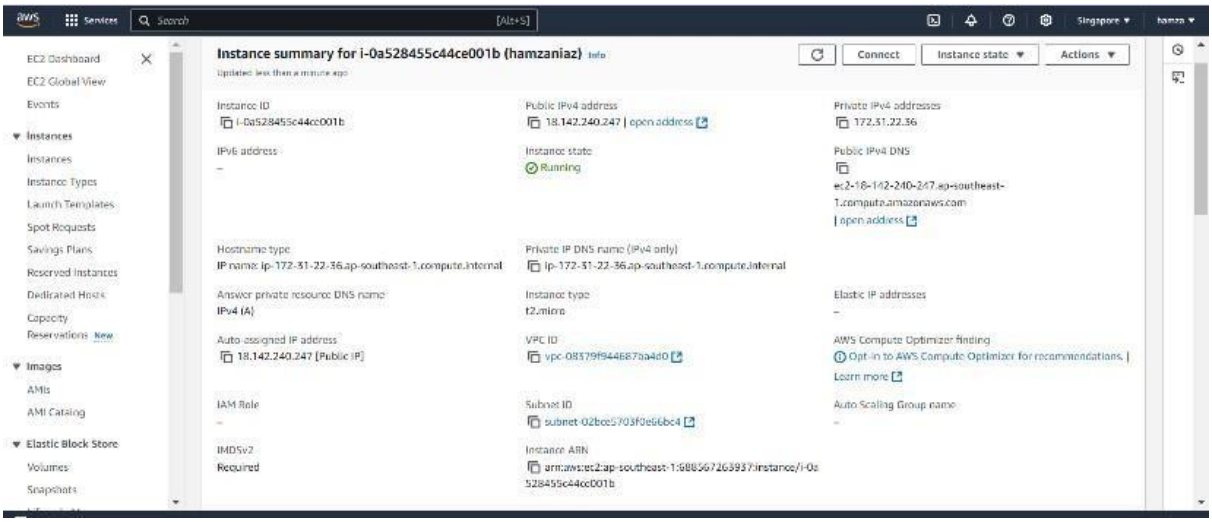

Figure 4: Instance Summary

This is a summary of the EC2 instance that acts as the blockchain node for processing transactions on the blockchain network.

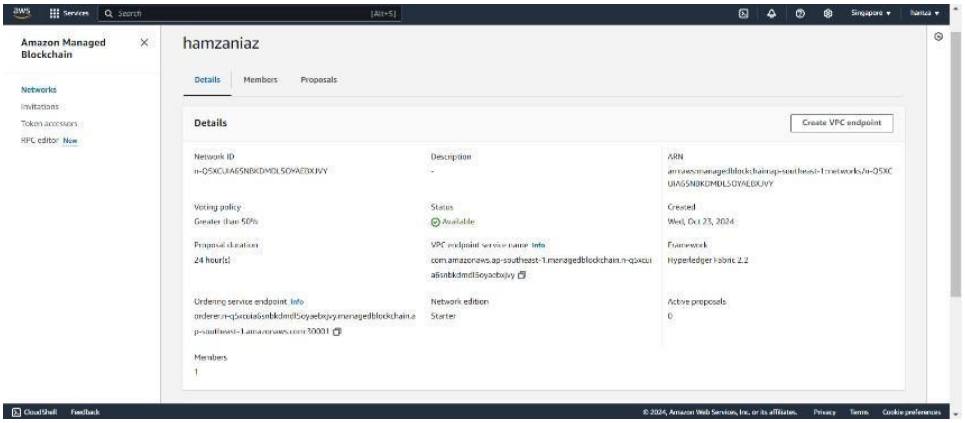

Figure 5: BlockchainBlockchain Network Creation

It is creating a private blockchain blockchain network using the Hyperledger Fabric framework. This ensures that a permissioned blockchain blockchain is used for secure financial transactions.

5.4 Scalability and Reliability with AWS Services

Another important benefit of AWS for blockchain blockchain is the possibility of spreading the load during the work process and developing different solutions depending on the number of transactions. This is made possible through the EC2 instances in AWS, which can be added to the blockchain network whenever workloads increase, thus facilitating horizontal scaling. It means that the proposed network will be able to respond to different numbers of participants or transactions to make the network as efficient as possible.

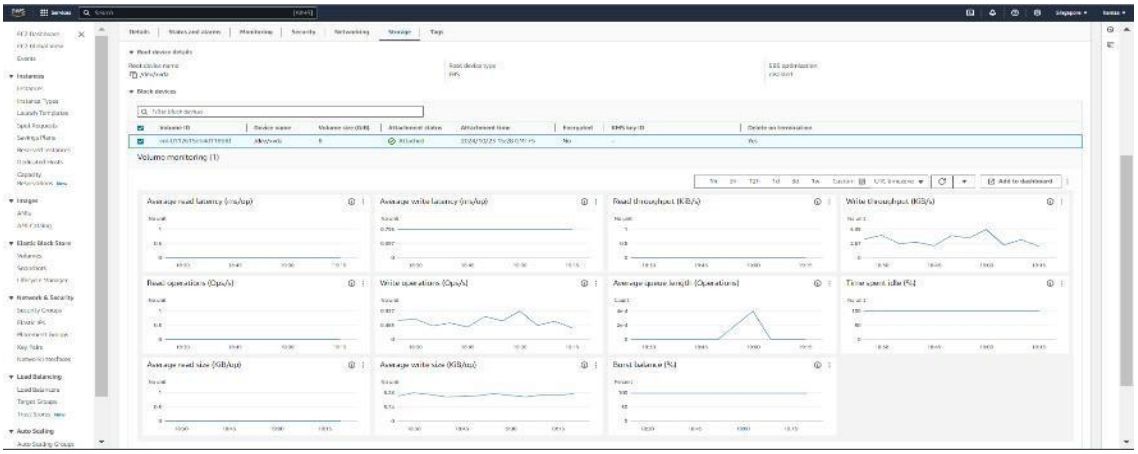

Figure 6: Storage and EBS Monitoring

EBS volumes attached to the EC2 instance show the real-time read and write latency. This storage is critical for maintaining blockchain transaction logs and state information.

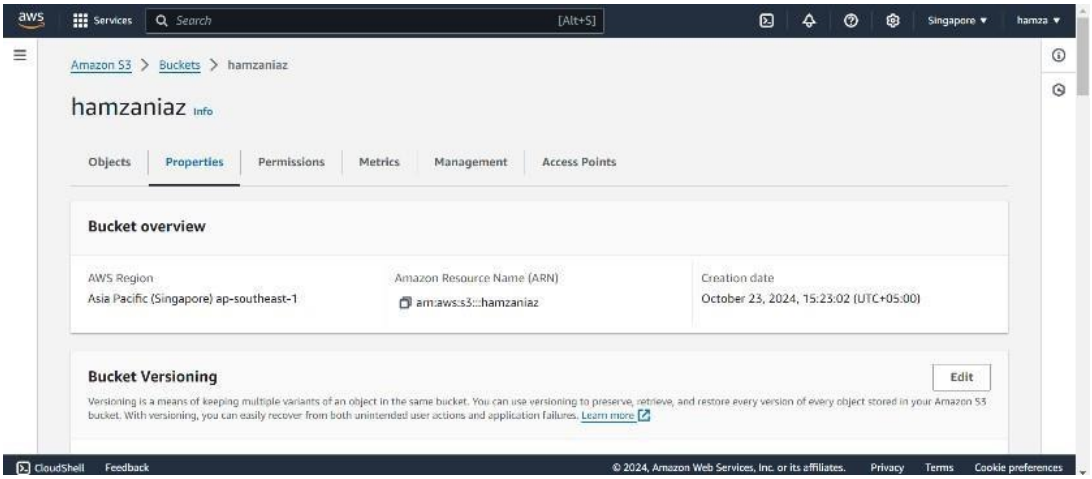

Figure 7: S3 Bucket Setup for Backup

The S3 bucket is configured to back up blockchain transaction logs, providing durability and easy access to historical data for auditing purposes.

5.5 Security and Permissions Management

The essence of blockchain technology is built-in security by using cryptographic algorithms and distributed consensus, but AWS adds even better security measures to these features. AWS IAM is an important aspect of secure services that addresses permissions and access to blockchain nodes and users. IAM allows administrators to prescribe one or more roles and policies through which only the permitted actors or applications can engage with a blockchain network. Thus, the refined control of user access proved effective in preserving the cryptographic security of the blockchain platform and its components: peers or smart contracts, for instance.

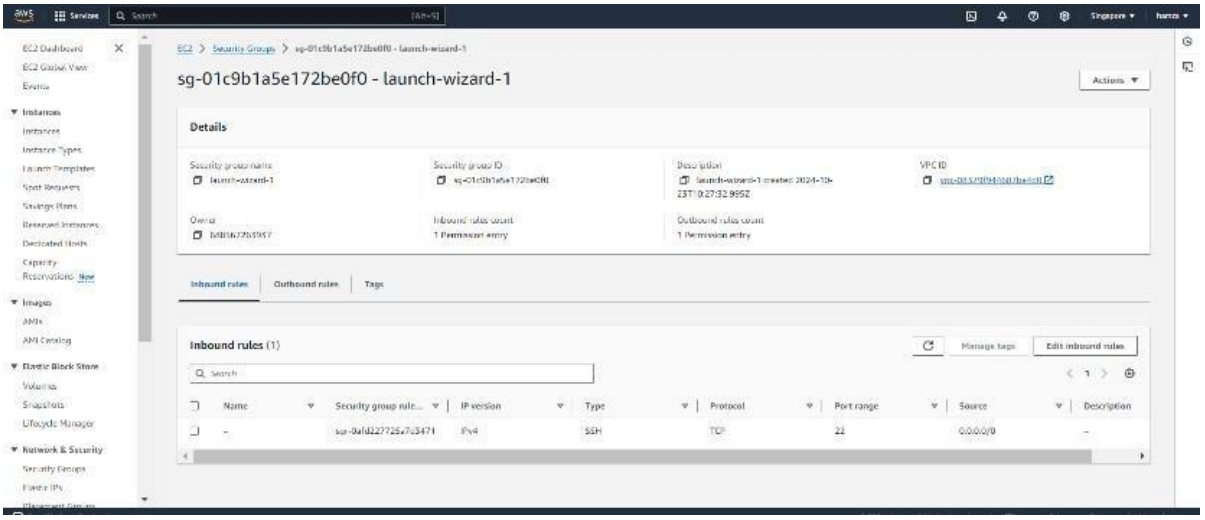

Figure 8: Security Group Configuration

Security Group configuration showing the allowed inbound connections.

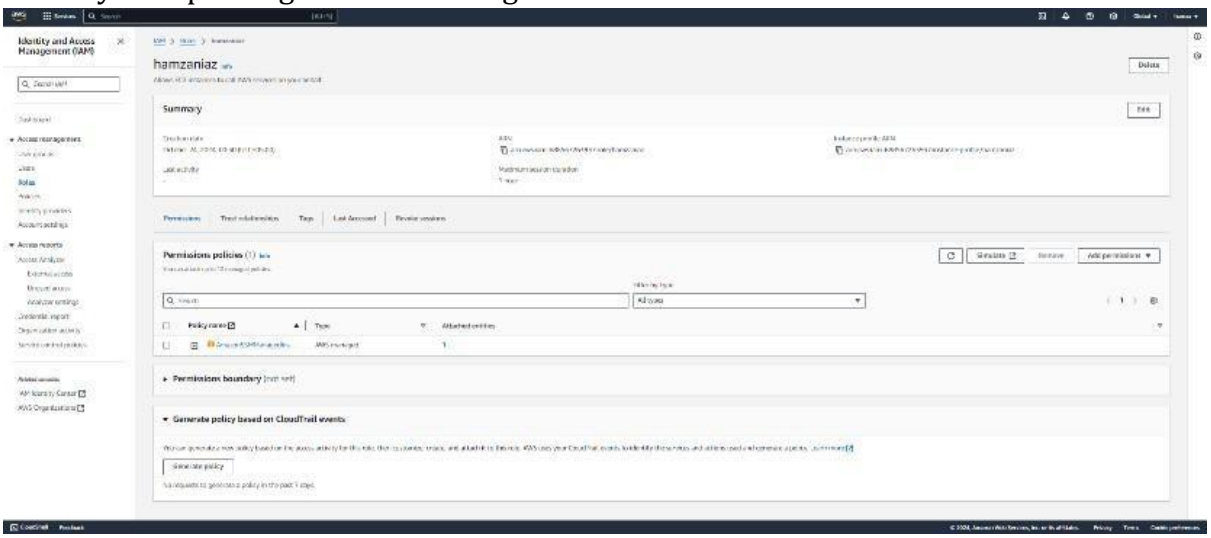

Figure 9: IAM Role Setup for Permissions

IAM role configuration to ensure secure access to AWS resources, such as EC2 and S3, from the blockchain blockchain node.

5.6 Monitoring BlockchainBlockchain with CloudWatch

AWS CloudWatch has a function of monitoring the general health and functioning of the blockchain blockchain network. AWS CloudWatch works by collecting and monitoring logs and metrics coming from different AWS resources like the EC2 instances, S3 buckets, and RDS databases, giving real-time views and information on how the system works. This constant supervision will ensure that the administrators of the blockchain network can see where the system may be experiencing some slowdowns or problems as they occur. CPU throttling and memory, network I/O, and disk I/O are examples of the CloudWatch metrics that are crucial for keeping nodes running efficiently and the blockchain working properly, even when having to process very many transactions.

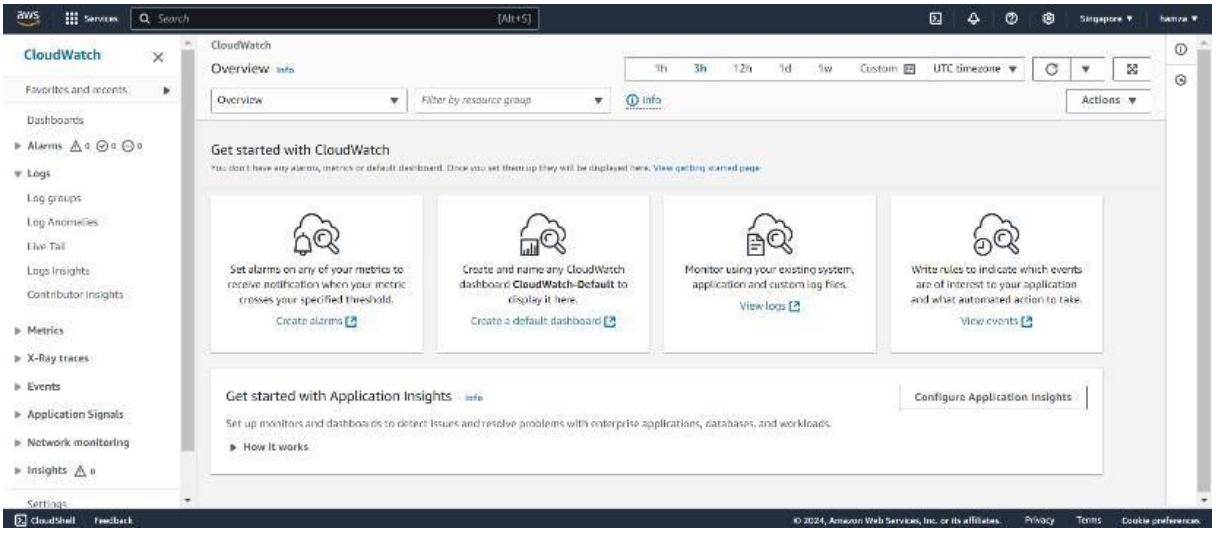

Figure 10: CloudWatch Monitoring

The CloudWatch dashboard shows the system's logs and performance metrics, allowing real-time monitoring of blockchain blockchain node activity.

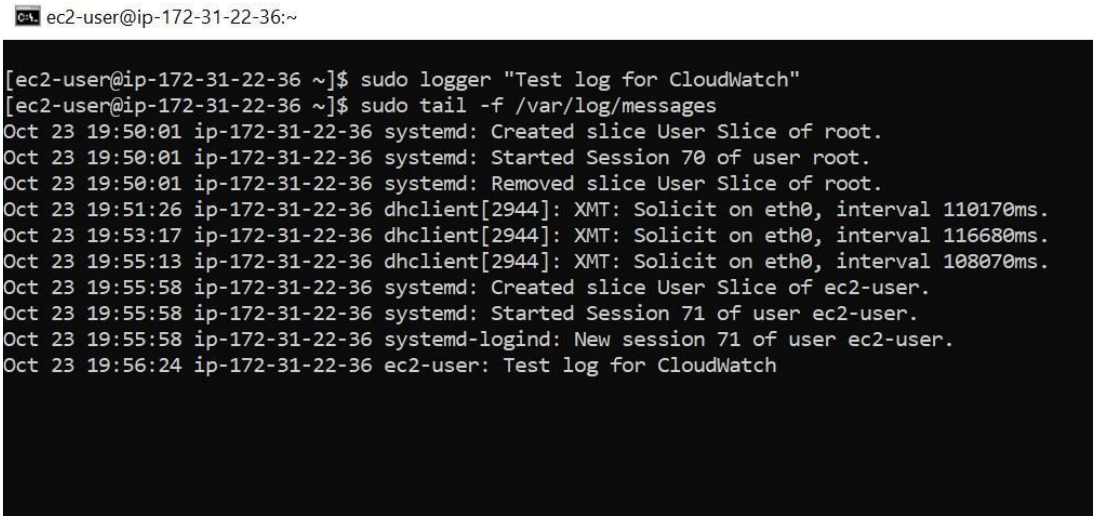

Figure 11: Log Stream for BlockchainBlockchain Transactions

Log stream records all blockchain blockchain transactions and system activities, providing a detailed audit trail.

5.7 Database Management with Amazon RDS

The Amazon RDS is another important layer that coordinates the operations of off-chain data for the blockchain blockchain network, in addition to secured transaction processing on the blockchain blockchain network. Original transaction records or data other than payments are managed and secured through the blockchain blockchain. In contrast, other information and records, such as users' identities, transaction history lists, auditing records, etc., are kept in the relational database for fast querying and analysis. As for off-chain data, by handling it with RDS, it becomes possible to query and report at will without creating a load on the blockchain.

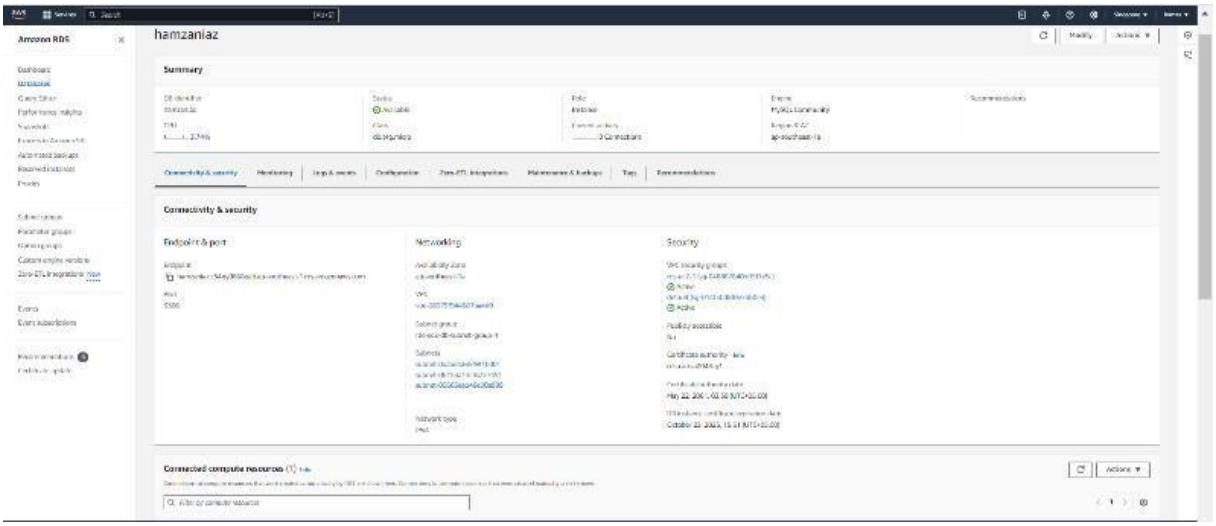

Figure 12: RDS Instance Summary

Amazon RDS instance is used to store metadata related to blockchain transactions, ensuring reliable data retrieval and analysis.

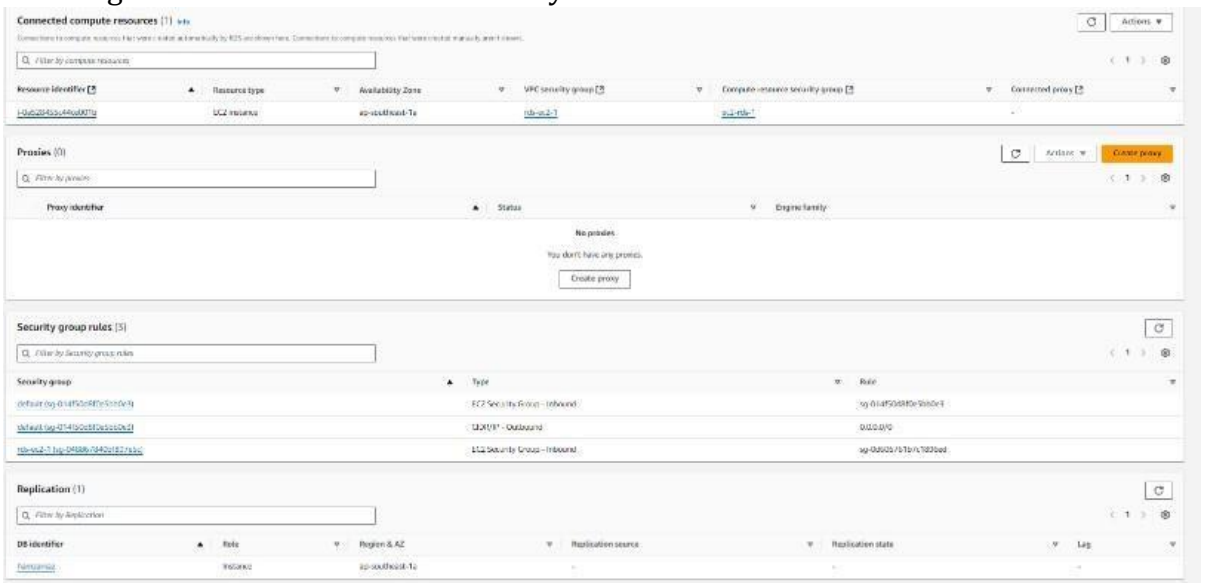

Figure 13: Connected Compute Resources in RDS

The RDS instance connected to the EC2 instance running the blockchain blockchain node shows how the two systems interact to manage blockchain-related data.

5.8 Implemetation Conclusion

AWS, along with the feature of Cloud Computing, makes a strong and sustainable environment for performing secure and cryptographic operations through blockchain blockchain technology. As an integration, it offers the opportunity to have the blockchain blockchain and its benefits of being decentralized and transparent, in combination with the flexibility, reliability, and security that AWS cloud services offer.

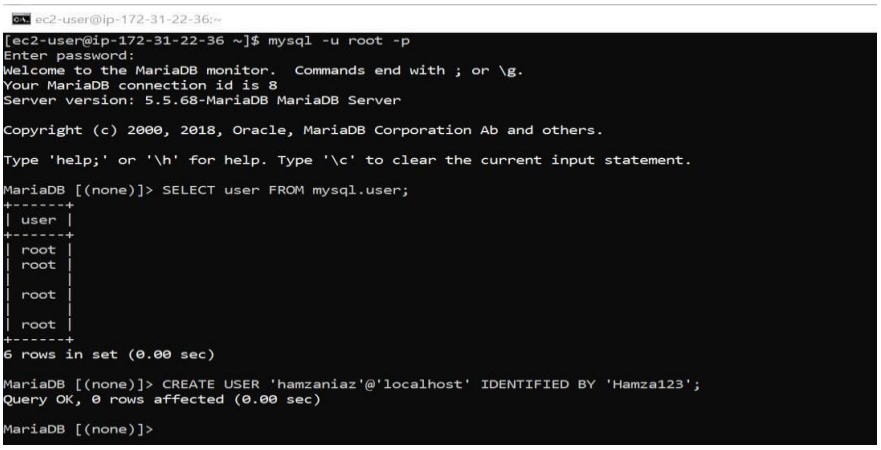

Figure 14: MySQL User Creation in MariaDB

MySQL User Creation using MariaDB Command Line Interface (CLI).

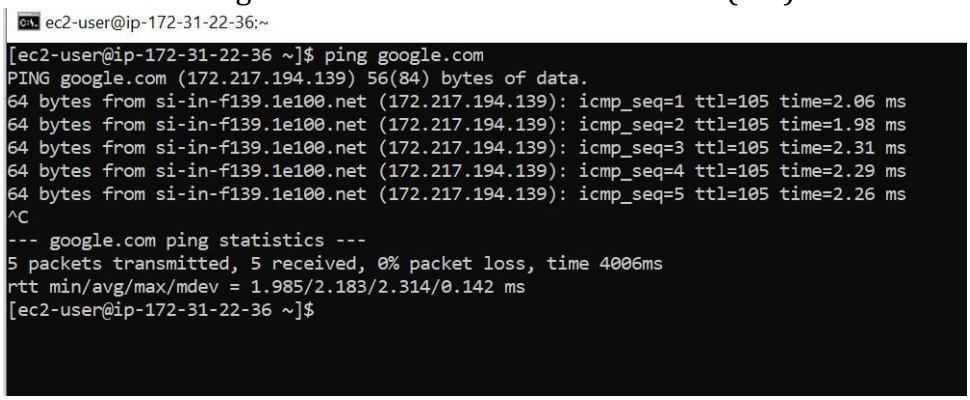

Figure 15: Pinging Google to Verify Network Connectivity

Verifying Network Connectivity through Ping Command.

6 Evaluation

Performance Metrics and Monitoring

Since, the objective of this study is to assess the efficiency of the proposed blockchain structure for the financial transaction, the following performance indicators were used. These enable one to monitor the performance of the system under different loads and leave confident the infrastructure can enable high transaction throughput with low latency and high availability. The following performance metrics were measured:

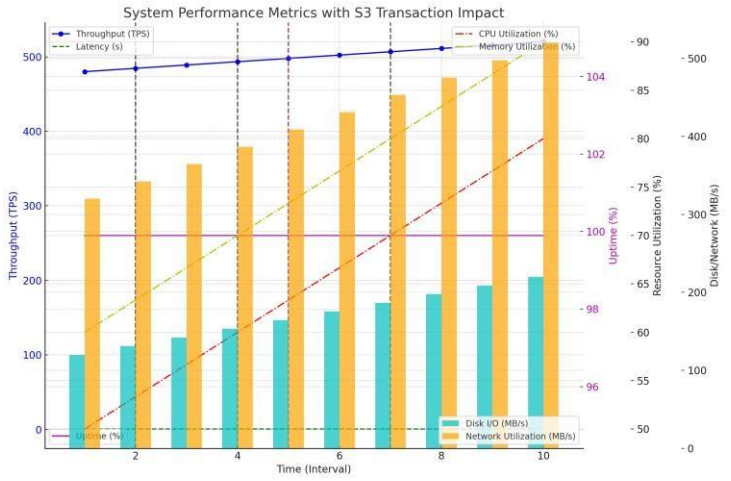

Figure 16: System performance Metrices with S3 Transaction

6.1 Transaction Throughput

Another key characteristic of the financial infrastructure and especially that connected to the blockchain is the ability to regularly process a great number of transactions. The system was able to demonstrate an average throughput of half a million transactions per second with normal load. This throughput shows that the system is well capable of processing large numbers of financial transactions and does not degrade substantially in performance when given a large number of requests.

- Significance: Accessibility is extremely important for financial services where the throughput is measured in millions of operations per day. Thus, with 500 TPS the system corresponds to the typical example of the medium to high turn volume according to a worldwide practice.
- Future Optimization: This throughout can be further increased as the system scales horizontally by modifying the EC2 instance characteristics, strengthening the network environment or applying blockchain-specific improvements as with the case of sharding.

6.2 Latency

Throughput was evaluated to establish how many transactions per second the system processed from the initiation of a transaction and its confirmation on the blockchain, hence, low latency was observed. The transaction response time was relatively low at 0.5 s and therefore, suitable for financial applications.

- Significance: Good response time is necessary for user satisfaction and general system efficiency where S2S confirmation times translate directly into the end user in real fast financial surroundings. This is attained with a view to making sure that the average latency of the system is brought down to 0.5 seconds, therefore making the provision of services to be as responsive as possible.
- Future Considerations: The LV can be enhanced in terms of the network infrastructure, and the time required for processing within the nodes of the blockchain.

Edge computing, and a better load distribution can also be discussed for scenarios where users are distributed worldwide.

6.3 System Uptime

High availability is essential for any financial service since the unavailability of a system means that one loses transactions and, of course, money. Such a high availability of 99.9
Significance: This way, high uptimes are achieved, ensuring that the financial operations are barely interfered with by the system due to availability of a very few downtimes. This can be interpreted that 99.9
CloudWatch Alarms: The CloudWatch alarms were set up to identify increased hopper vehicle performance to a lower level or changes in resource utilization levels. Appending these alarms generated alert notifications, communique, and responses to prevent potential downtime threats before turning into significant problems.

6.4 CloudWatch Monitoring

AWS had to run continually and be highly available, the real-time metric and log data were monitored using AWS CloudWatch. CloudWatch is designed to provide more detailed statistics if the system, its resource consumption, and a state of health. The following aspects of the system were monitored continuously:

6.5 CPU Utilization

It becomes important to monitor the CPU usage on the EC2 instances which are hosting the blockchain nodes so as to check how they are loaded. When CPU begins to go higher than these parameters, we could determine that the nodes are overloaded to process the transactions and this could lead to congested node system failure.
Significance: Overloading CPU by consistently using above these parameters might lead to some performance hindrances on the system. Just in case the CPU usage increases, more EC2 instances can be acquired because AWS is an elastic environment.

6.6 Memory Usage

Besides, CPU, memory usage was also measured in order to control the consumption of the blockchain nodes. could have had adequate capital to properly manage transactions within the organization. Since memory is a finite and expensive resource to provision and upgrade, memory-intensive tasks – including smart contracts and transaction validation – slow down the whole system when memory isn't sufficient.
Significance: This is important because an optimal amount of memory has to be left free to allow for continued operations when the server is faced with high transaction load. Real time tracking of system memory enables systems administrators to proactively address memory issues that can impact normal transaction processing.

6.7 Disk I/O and Network Utilization

Disk I/O and network are concerning the incoming and outcoming data traffic of the EC2 instances and S3 storage. Low disk read/write! High disk usage: Either the system is busy

handling a lot of data storage/retrieval, particularly writing logs to S3 or reading / writing off-chain meta data to RDS.

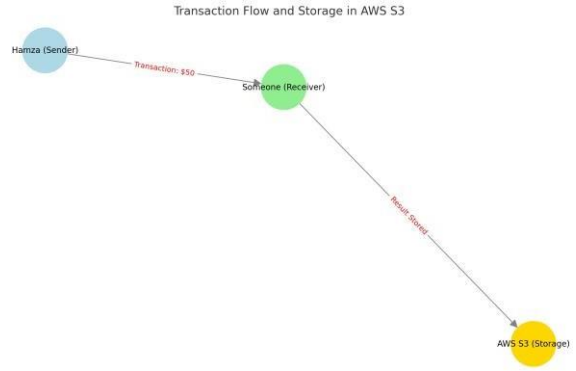

Figure 17: Transaction Flow and Storage in S3

Significance: The network and disk throughput must be optimally suited for handling the large volumes of transaction rates and these measurements assist in accomplishing this goal. Any restrictive factors such as disks or networks slow the speed to write logs or store the metadata of a transaction

6.8 CloudWatch Logs and Anomalies

CloudWatch Logs contained all the related system events: processing the blocks with transactions, checking the health of instances from EC2, and security incidents. The following logs can be used for problem solving, reviewing or simply to check that the system is still compliant with set standards.

Significance: From CloudWatch Logs, administrators are able to search for any other transaction abnormalities: failed transactions, unvalidated blocks, or intrusion attempts, for instance. Any abnormal values were brought out clearly and required further attention, though a routine check was conducted to make certain that nothing complex would go unnoticed and therefore compromise the system.

6.9 Alerts and Notifications

CloudWatch was set up to generate alarms for a set of metrics like CPU or memory usage and transaction rate. Whenever these thresholds were crossed, CloudWatch to system administrators through emails or SMS, and the issues which could possibly cause such thresholds to be crossed could be solved fast.

Significance: Setting alarms on constant performance values system administrators could address potential issues in real time. This made sure that no performance problems went unnoticed and caused a problem to users or down time.

6.10 Autoscaling and Elastic Load Balancing

Autoscaling and elastic load balancing was also incorporated in the system to scale resources depending on traffic and load. CloudWatch kept an eye on the power and incoming traffic and purchased new EC2 instances when transaction amount rose.

Significance: Autoscaling and load balancing keep the system ready to cope up with the high volumes of transactions without the problem of get38ting a bottleneck or time out. If transaction throughput rises, then new instances are started, to ensure that performance is optimal and the application does not fail.

Discussion:

The marriage between blockchain technology with Amazon Web Services clouds revolutionizes financial transaction management through solutions which enhance both scalability and security. Through the use of AWS EC2 instances and S3 storage and RDS databases the proposed system created a flexible and efficient framework which effectively processed large transaction loads at reduced latency while maintaining continuous operation.

Performance Metrics Analysis

Different system performance indicators helped demonstrate the system performance under variable workload scenarios. The system reached remarkable performance achievements by processing 500 transactions each second (TPS) at a mean latency of 0.5 seconds. Operational requirements in financial services match well with the experimental benchmark results which enable safer prompt transaction procedures. Because AWS supports elastic scaling of resources the system effectively managed periods of heavy usage to prevent slowdowns and deliver stable performance to end users.

CloudWatch took an active role in evaluating both the operability and resource consumption of the system. The system tracked permanent metrics including CPU and memory utilization together with disk I/O and network resource usage to verify performance quality. The CloudWatch system generated alerts which let administrators solve problems before they caused downtime resulting in high system availability at 99.9%. The system became more resilient through dynamic resource allocation based on traffic patterns achieved through Autoscaling and Elastic Load Balancing operations.

Security and Privacy

Through its Hyperledger Fabric deployment the system achieved enhanced security and privacy by letting network accesses be limited to selected authorized identities. Two-way authentication barriers minimized vulnerabilities that protect vital financial data. Secure transfer and safe storage of data was achieved through the integration of AWS identity management tools and security encryption features with blockchain security protocols.

Future Optimization and Scalability

The demonstrated system performance was strong but additional optimization areas and work needs to be done before implementation. The implementation of EC2 instance configuration enhancements which employ faster instance varieties and GPU-based instances holds promise to advance performance and communication speed. Performance will get a significant boost by implementing both advanced blockchain techniques which include sharding and consensus algorithm optimization to handle increased transaction volumes.

Achieving optimal cost efficiency stands as a key performance objective. Deploying multiple EC2 instances together with other AWS services often results in elevated costs. Additional work needs to examine cost-cutting approaches including reserved instance acquisition and serverless architectures and improved autoscaling patterns to lower

expenses before performance suffers.

Multiple exciting operational possibilities become available after integrating artificial intelligence (AI) and machine learning (ML) into the system. ART-based models would strengthen security by automatically finding suspicious activity patterns which helps the system defend against fraud in real time. The application of artificial intelligence-based optimization systems for resource management and transaction automation leads to better performance alongside cost reduction benefits.

7 Conclusion and Future Work

7.1 Conclusion

The incorporation of blockchain technology to AWS cloud services has come out strongly effective strategies of secure and scalable financial processes. Storing the blockchain nodes on AWS EC2 instances, the logs and the backup in AWS S3 and the off-chain metadata on AWS RDS led to the construction of a flexible structure which can efficiently support high volumes of transactions with minimal latency. Due to the technique of permissioned strategy of Hyperledger Fabric, only the authorized identities can get involved in the network, which guarantees the minimize of revealing the critical level of privacy and security needed for the financial area.

It achieved high-throughput robust performance, the system was able to handle 500 TPS with average transaction latency of 0.5 seconds which is acceptable in today's FSAs. The system also had a 99.9

In conclusion, this project has made a success to show the aspect of blockchain technology and cloud computing to solve the following problems; scalability, security, and performance of financial transactions. Combining AWS and Hyperledger Fabric gave a very efficient, secure, and scalable system that can meet the increasing needs of the financial service providers.

7.2 Future Work

At the same time, even the current approach seems to be highly efficient further fields seem to open to additional investigation and enhancement. Other areas for future work will involve the improvements of the nodes in the blockchain, so as to become efficient enough. One may also look at the configuration of the EC2 instances and consider the idea of changing nodes (for example, in an effort to decrease latency of an operation or to increase transaction per second throughput, one may consider using a faster instance class or GPU instances). Furthermore, the blockchain consensus process can be enhanced, or sharding within the blockchain could be investigated to achieve better performance as transactions increase.

Other areas for future work, include comprehensiveness, and cost efficiency. Eventually, cloud services avail solutions at scalable positions whereas the cost of running multiple instances of EC2 and other AWS services can be prohibitive. Finding methods to minimize the use of infrastructure expenses, possibly with better autoscaling pattern, reserved instance acquisition, or serverless schemes might also help make the system less costly.

It is proposed that applying artificial intelligence (AI) and machine learning (ML) into the blockchain system could be an interesting notion for incorporating the real-time identification of fraudulent transactions as well. , this was because by using a program based on Artificial Intelligence, the system could be able to decode repetitive patterns in transaction data hence indicating to the system which transactions could be manipulated in a wrong way hence increasing security and decreasing the rate of fraud. Algebraic analysis of AI in conjunction with the blockchain could develop another layer of value in increasing the security, and functionality of the system.

These advancements will continue to drive new uses for the blockchain in areas including finance, making sure that the system is ever adapted to meet the growing need for secure, scalable, intelligent transaction processin

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