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SECURING BIG DATA OF E-COMMERCE BUSINESSES USING LAYER-2 SCALING TECHNOLOGY

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ABSTRACT
The core areas of blockchain technology and cloud computing creating a more secure and convenient storage space for E-commerce businesses to store large set of data is addressed in this paper. Data requires protection. One of the key security enhancements in this integration is data encryption that allow authorized access only. Cloud computing with the utilization of blockchain technology enhances data security and privacy preventing data breaches. Blockchain provides immutability, means that once data is recorded, it cannot be altered or deleted. But huge datasets arise data scalability issues. There are a few ways to reconcile them and one such way is utilizing LAYER-2 scaling solutions.

KEYWORDS
Blockchain, Cloud Storage, Decentralization, Layer-2 Scaling, ZK rollups

INTRODUCTION
E-Commerce businesses ought to store huge customer datasets. But blockchain technology is slow when it deals with large number of transactions and consumes high energy for its operations. The sheer volume of data presents a significant challenge for management within a blockchain-cloud environment. As the amount of data increases, the number of nodes required in the blockchain also increases, leading to slower performance and higher energy consumption. The major problem is addressing the scalability of data management, processing, and synchronization.

LITERATURE REVIEW
Blockchain and Cloud Computing technologies continue to grab widespread attention and high demand in market, hence several researchers have focused on their functionalities and their possible benefits and limitations. However, limited research has been conducted on the integration of both technologies together and its practical implications. Based on the research, blockchain technology has been consistent in ensuring data security and privacy. This way, it becomes almost impossible to steal or manipulate the data. It is found that cloud computing ensures data scalability and it is considered as one of the most efficient methods to store data while also optimizing memory usage [1]. The most significant feature of blockchain includes robust security and shared record-keeping methodology which helps cloud security by reducing the risk of data leaks ensuring the data accuracy and thus allows clear tracking. But it is difficult to promise that integrating blockchain technology with cloud computing helps handle big data such as E-commerce datasets, using less energy, and getting different systems to work together. [2].
Blockchain facilitates interoperability. It strengthens data security by using cryptographic hashes to encrypt and protect data ensuring its integrity. Furthermore, blockchain's smart contracts automate and enforce Service Level Agreements (SLAs). SLAs is a platform which builds trust and promote transparency among cloud users and providers. While challenges related to scalability and interoperability remains constant [3].
Cloud storage is convenient, but it is not always completely secure. Using blockchain, access and manipulation of the is strictly controlled and it makes sure only authorized people can see sensitive information. It is easy to track where data came from and what happened to it. Researchers are looking

at ways to use blockchain for things like sharing data securely and creating decentralized storage systems. While there are still some technical hurdles to overcome [4]. The exploration of the literature reviews discusses the individual benefits of blockchain-cloud environment but the gaps remain in addressing the data scalability challenges.

METHODOLOGY

LAYER-2 scaling refers to techniques designed to enhance the scalability and efficiency of blockchain networks by handling transactions off the main blockchain (Layer-1) while still relying on its security. LAYER-2 scaling is the most efficient way to solve the scalability problem.

Sidechains – LAYER-2 scaling creates sidechains without disturbing the main blockchain. These sidechains work independently in the blockchains which handles the transactions separately over the main block.

State Channels – State Channels help in off-chain transactions without interrupting the main block. It acts as a shortcut where other blocks in the blockchain does not know about the interactions made with the essential block required by the user.

Plasma Frameworks – The roots or the child of the main blocks are created by the parent blockchain. The operations are done in the child block and the child block periodically sends its transactions to the main block improving the scalability and speed of processing.

IMPLEMENATION

Utilizing ZK-Rollups for LAYER-2 Scaling is one way to alleviate the scalability limitations of blockchain to treat the most challenging part of the blockchain trilemma through a LAYER-2 scaling mechanism like Zero-Knowledge Rollups (ZK-Rollups). This significantly improves transaction throughout and lowers cost while improving efficiency on blockchain networks.

ZK-Rollups are a LAYER-2 solution batching multiple transactions together and executing them off-chain before posting a single proof to the on-chain. This significantly reduces the computation requirement on the main chain while maintaining transactions as secure and verifiable.

Step 1: ZK-Rollup Architecture: A ZK-Rollup system is made of off-Chain transactions processing. The data is proved to be valid through creating a cryptographic proof using ZK-SNARK/ ZK-STARK after which the proof is posted to a Layer 1 smart contract which checks its validity.

Step 2: The smart contract is deployed on the main blockchain to accept deposits from users and keep the Merkle root of the rollup state. The ZK-proofs are then verified and withdrawals are processed with valid proofs.

Step 3: Transactions are initiated by users and temporarily stored in an off-chain aggregator. A prover node then processes batches of transactions and verifies the validity of writing, generating a cryptographic proof. It then submits the proof to the on-chain smart contract for the verification process.

Step 4: Though all transactions are verified through math proofs, there is a decentralized entity validating transactions, meaning it is secure. Moreover, there may be fraud-proof mechanisms built in to deal with false proofs.

Step 5: Withdrawal of assets is possible by making a request, which the rollup contract validates before reintroducing money to the Layer-1 blockchain.

RESULTS AND FINDINGS:

- **LAYER-2 Scaling:** Improved transaction capacity by offloading processing from the main blockchain.
    a. **ZK Rollups**: Efficiently reduces the amount of data to be stored on-chain, thus enhancing scalability.

Implementation using Fuzzy Inference System for LAYER-2 Scaling

A Fuzzy Inference System (FIS) is designed and implemented to address scalability challenges in LAYER-2 scaling solutions, specifically ZK Rollups. The primary focus is to predict scalability based on key performance indicators as follows.

Input Parameters

a) Transaction Volume
   Membership Function: Gaussian Membership Function- Low, Medium, High
b) Validity Check
   Membership Function: Gaussian Membership Function- Low, Medium, High

Output Parameter

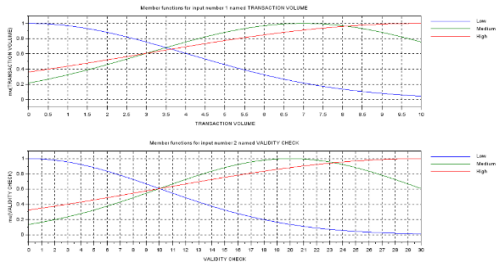
a) Scalability Index
   Membership Function: Triangular Membership Function- Low, Medium, High

This fuzzy logic system effectively maps the relationship between transaction volume, validity check, and scalability, aiding in optimizing the performance of ZK Rollups for blockchain scalability.

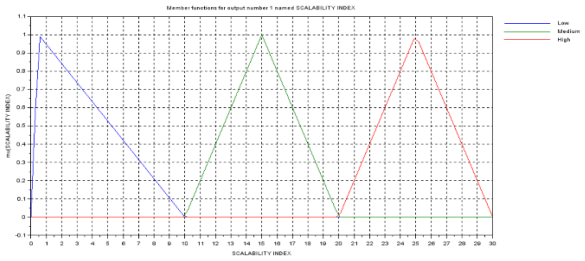
The following rules define the relationship between inputs and the scalability output:

1. If Transaction Volume is Low AND Validity Check is Low, THEN Scalability is Low.
2. If Transaction Volume is Low AND Validity Check is Medium, THEN Scalability is Low.
3. If Transaction Volume is Low AND Validity Check is High, THEN Scalability is Medium.
4.If Transaction Volume is Medium AND Validity Check is Low, THEN Scalability is Low.
5. If Transaction Volume is Medium AND Validity Check is Medium, THEN Scalability is Medium.
6. If Transaction Volume is Medium AND Validity Check is High, THEN Scalability is High.
7. If Transaction Volume is High AND Validity Check is Low, THEN Scalability is Medium.
8. If Transaction Volume is High AND Validity Check is Medium, THEN Scalability is High.
9. If Transaction Volume is High AND Validity Check is High, THEN Scalability is High.

The Graph (1A) and (1B) represents the Input graph and Output graph respectively.

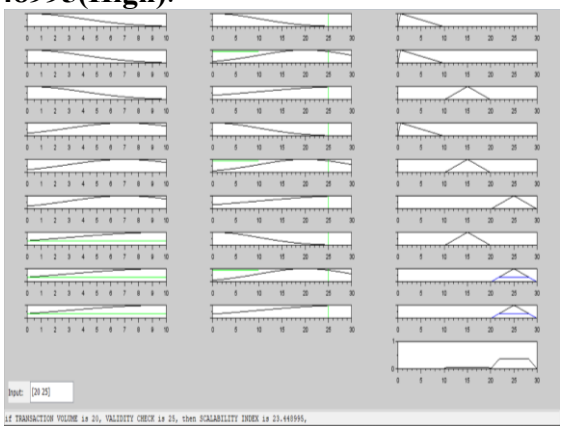


GRAPH-1A



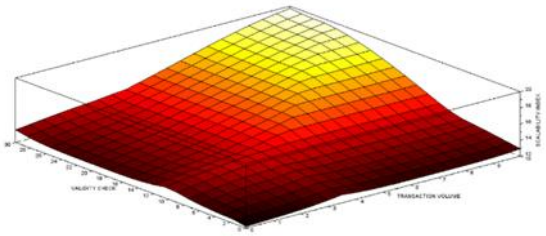
GRAPH-1B

In graph (2A) Volume is set to **20(Medium)** and Validity Check ois set to **25(High)**, resulting in a Scalability Index of **23.448995(High)**.



GRAPH-2A

The following graph (3A) illustrates the Surface Graph, where the X-axis represents **Transaction Volume (20)**, the Y-axis represents **Validity Check (25)**, and the Z-axis represents the corresponding **Scalability Index**.



GRAPH-3A

CONCLUSION

The above implementation helps in inferring that using LAYER-2 scaling with ZK rollups can reduce data scalability issues while also ensuring security of large sets of data belonging to E-commerce businesses.

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