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MULTIDIMENSIONAL BLOCKCHAIN AND ITS ADVANTAGES

Abstract: *The multidimensional blockchain is a revolutionary evolution of traditional blockchain technology, offering a dynamic and efficient architecture for data storage and processing. This unique structure enhances scalability by distributing transaction loads across various chains, significantly improving processing speed and reducing latency. With these parallel chains, the risk of bottlenecks is minimized, allowing for much higher throughput and optimized data flow. Additionally, multidimensional blockchains offer stronger security by isolating data within specific chains, making it harder for malicious actors to access or tamper with the entire network. This architecture also helps reduce energy consumption by allowing resource allocation based on demand, unlike traditional blockchains that require high energy output for each transaction. Multidimensional blockchains can be customized to suit diverse business models, from finance and logistics to healthcare, adapting seamlessly to sector-specific needs. In summary, multidimensional blockchains present an adaptable, energy-efficient, and highly scalable solution that improves transaction speeds, security, and data management capabilities across industries.*

Key words*: Industry adaptability ,business models, cross-chain security, enhanced scalability, multidimensional blockchain, bandwidth, transaction optimization, energy efficiency.*

Introduction

At the present time, when cryptocurrency is almost the main factor and all digital achievements have a huge impact on the development, thanks to the development of decentralized systems. The advantage of decentralized systems has become almost the most important advantage to achieve consensus between various unreliable nodes in possible unsafe environments. But it should be borne in mind that at first the blockchain became more popular due to its use in cryptocurrency, but since then it has become a universal basis for building decentralized infrastructures, and not thanks to an application solution.

Despite its potential, broad adoption of blockchain technology faces notable obstacles, including unrestrained blockchain growth, inefficient consensus algorithms, and dependence on intermediaries for interoperability across systems. Developing robust distributed ledgers has largely focused on overcoming these limitations. «Proof of ownership» is almost one of the main mechanisms that is supported by checks with very strict mathematical checks, with the help of which another proof of work option is offered and it makes the requirements for calculations quite much easier. However, as data volume on network nodes continues to grow, this challenge remains critical. Predicting future growth remains challenging due to the nonlinear relationship between system characteristics and their popularity. For instance, in Figure 1, the graph displays the growth trend of the Bitcoin blockchain as of September 2024 [7].

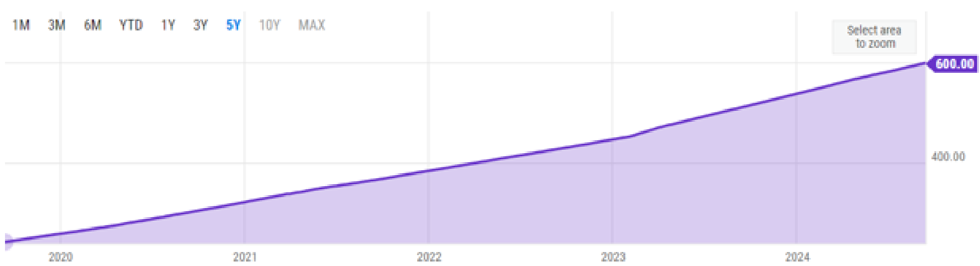

Figure 1 – Bitcoin blockchain volume growth chart for September 2024

The challenge of transferring value between fiat currencies and cryptocurrencies, as well as across various cryptocurrency networks, is usually managed through intermediaries or sidechains, which function mainly to bridge two separate systems [8].

In this study, an approach will be shown through which problems such as system availability and integrity can be solved, increasing confidentiality and through this approach, secure cross-system exchange will be maintained, connects individual systems and helps scalability.

Materials and methods

A multidimensional blockchain is a network where there are a lot of chains that are interconnected with each other and any additional chain in addition to the original one is already embedded in the existing blockchain.

At the same time, key information about its origin and main characteristics is recorded, and thanks to this approach to registration, a two-level structure of a distributed registry is created, and when a multidimensional blockchain works as a single registry and each of the blockchains works independently and exists as a separate registry The 2nd figure shows two modes of operation, both blocking and status, where each blockchain can be controlled independently, and with this, a unique ability is preserved in each.

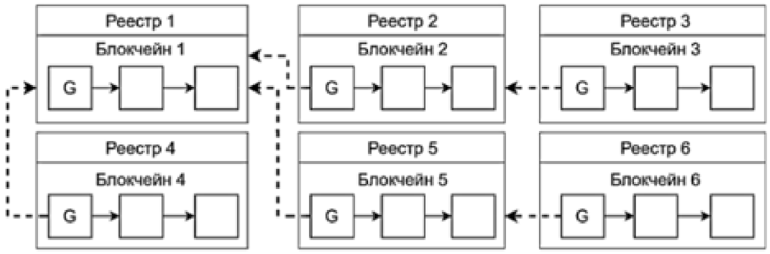

Figure 2 – Multidimensional Blockchain Structure

In the blockchain system, blocks are classified into categories, each of which defines specific fields and methods. Unlike side chains, whose users are often unaware of blocked assets, multidimensional blockchains treat each new genesis block as a unique entry inside an existing blockchain. This approach to registration ensures the independence of the new blockchain and eliminates the need for additional functions.

The state mode, which is based on the Ethereum architecture, is a more complex system. Its main advantage is that transactions are verified exclusively by the last block using the concept of "virtual states". In addition, this mode supports Turing smart contracts, which increases the level of interactivity. Each blockchain in a multidimensional network independently manages changes in its states, and the entire system is synchronized based on the largest common divisor of all transition intervals between chains.

One of the unique features is the hierarchical addressing system, which creates a base for structured application development. This system, similar to the file system, guarantees secure transfers of funds and organizes the network logically. Addressing can be carried out in two main formats:

1. Absolute Addressing - Refers back to the first genesis block.
2. Relative Addressing - Applicable within the current blockchain.

Addresses, recorded as numbers or hash sums, vary based on the blockchain's mode. In block mode, child blockchains are referenced by block numbers and hash sums, with the latter offering efficient referencing.

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Using the example of a block with the address 0xaabbcc08 operating in the status mode (see Fig. 3), it is shown how such addressing is implemented. The multidimensional blockchain offers several advantages over traditional blockchains:

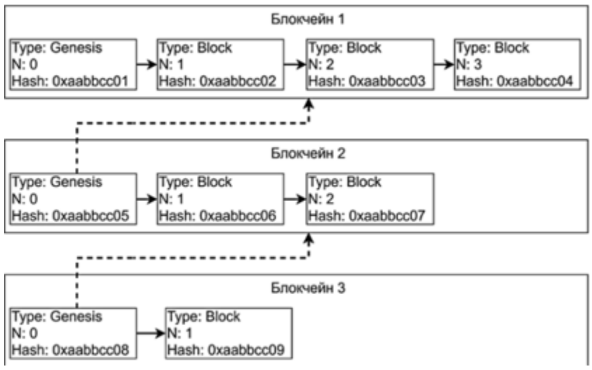

Figure 3 – An example of addressing in a multidimensional blockchain in the state machine mode

Results and discussion

The multidimensional blockchain has a number of advantages due to its unique architecture and basic principles of operation. His work is based on decentralized peer-to-peer networks and various consensus algorithms such as Proof-of-Work, Proof-of-Stake and Byzantine. Together, these mechanisms form a stable and decentralized system. Special protocols support secure data exchange between systems, recording transactions in external registries and ensuring the integrity and stability of distributed records.

The transition from the traditional blockchain model to a multidimensional one allows efficient use of memory for each node of the network. The size of the database in a multidimensional registry is influenced by factors such as the block size and the time required to form a block with a certain number of transactions. The main parameters in this system are:

- t – time
- v is the frequency of transaction generation by a separate account;
- NA – number of accounts;
- LV – the volume of the registry;
- T0 – the period of transaction generation by the entire system;
- T is the period for generating transactions by a separate account;
- •NL – number of registries;
- v0 – the frequency of transaction generation by the entire system;

The structure of multidimensional blockchains excludes the possibility of simultaneous adjustment of these parameters in order not to violate agreed protocols. For example, if the main registry is divided into N smaller sub-registers, the percentage of accounts allocated to each of them can be calculated as follows:

$$p_i = \frac{N_{A(i)}}{N_A}$$

No additional accounts are created, so the sum of all allocations is 1:

$$\sum_i p_i = 1.$$

The transaction generation frequency is the number of transactions generated per unit of time. For the source registry, it is defined as follows:

$$v = \frac{N_A}{T} \Longrightarrow v_o = N_a v$$

The total transaction generation period for the system is expressed as:

$$T_0 = \frac{1}{v_0} = \frac{T}{N_A}$$

The registry volume can then be determined by:

$$LV = \left\lfloor \frac{St}{T_0} \right\rfloor$$

As the number of accounts registered in the new sub-registry decreases, the volume of transactions decreases accordingly:

$$N_{A(i)} = p_i N_A$$

Therefore, as the transaction volume decreases, the realization time of the transaction increases:

$$T_i = \frac{T_0}{p_i}, v_i = p_i v_0$$

and the registry volume of each separate registry follows the equation:

$$LV_i = \left\lceil \frac{S_i t}{T_i} \right\rceil = \lceil P_i LV_0 \rceil$$

The average registry volume across the multidimensional blockchain structure is then:

$$LV = \frac{1}{N_L} \sum LV_i = \frac{1}{N_L} \sum p_i LV_0$$

This division reduces the average volume of information held in each sub-registry by approximately NL times, minimizing the storage requirements across nodes. Reducing the size of the blocks. If the block generation frequency is fixed, the block size is defined as follows:

$$S = s \cdot NTX = s \cdot N_A \cdot v \cdot T_s$$

Reducing the number of accounts reduces the volume of transactions and, consequently, the block size:

$$S_i = s \cdot N_{A(i)} \cdot v \cdot T_s = p_i S$$

Hence, the registry volume for each sub-registry is given by:

$$LV_i = \left\lfloor \frac{S_i T}{T_i} \right\rfloor = \lfloor p_i LV_0 \rfloor$$

and the average registry volume can be expressed as:

$$LV = \frac{1}{N_L} \sum_i LV_i = \frac{1}{N_L} \sum_i p_i LV_0$$

Reducing the block size and extending the transaction generation period can similarly reduce the amount of information stored on each node in a multidimensional blockchain system.

This relationship is illustrated in Figure 4, where the amount of data stored by nodes diminishes as the number of child registries increases. Concurrently, each individual node's data volume follows a linear growth pattern. With well-timed registry creation, the average data storage requirement per node can remain fairly stable.

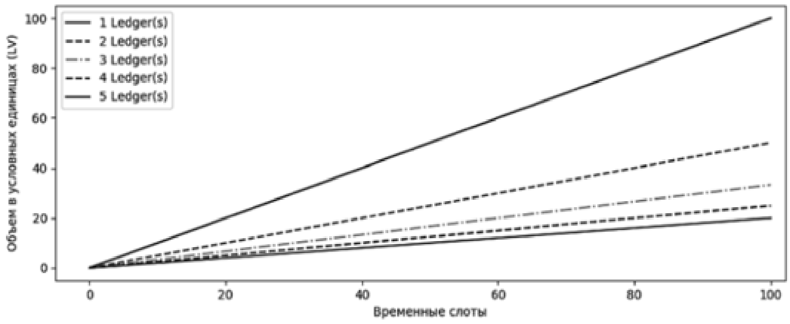

Figure 4 – The amount of information stored by nodes of a multidimensional blockchain

Figure 5 provides additional context, showing how the registry volume grows more gradually as the number of child registries rises. By sequentially adding registries, the data burden on each node is effectively reduced.

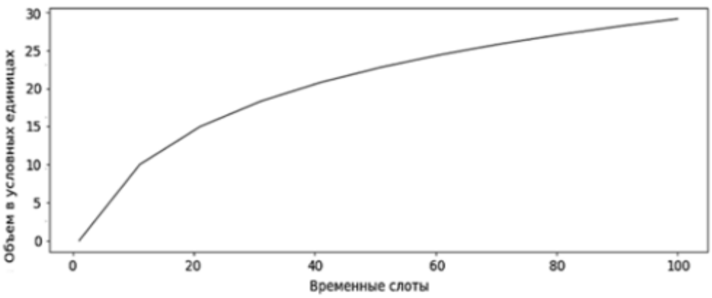

Figure 5 – The amount of information with a consistent increase in the number of registries

As multidimensional blockchain systems evolve by gradually generating nested chains, an important optimization challenge arises: determining both the optimal timing for registry division and the ideal count of nested blockchains. Notably, this model does not currently account for potential increases in the number of accounts and transactions, which would impact calculations. Including these factors could provide a more accurate, realistic assessment.

Calculations suggest that, with balanced distribution across nested blockchains, the average load on each node decreases by approximately NL times. Thus, even with limited resources and a steady rise in transaction numbers, the system load can remain relatively constant over time.

In essence, a multidimensional blockchain model offers promising scalability and efficiency benefits for distributed registries. However, continued research and refinement are essential to fully optimize these potential advantages.

Conclusion

In conclusion, the multidimensional blockchain represents a significant improvement on traditional blockchain technology, offering a flexible and scalable architecture for data storage and processing. Due to the multidimensional structure consisting of parallel chains, it provides higher throughput and reduces the likelihood of bottlenecks, which improves overall performance and reduces system delays. The unique separation of chains also strengthens security by making it difficult for intruders to access the network, and the energy consumption of the system is reduced due to the rational allocation of resources. The potential of the multidimensional blockchain to adapt to different business models and applications makes it a universal solution for a variety of industries such as finance, logistics and healthcare. Taken together, these advantages indicate that a multidimensional blockchain can become the basis for more efficient and secure decentralized systems in the future.

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МНОГОМЕРНЫЙ БЛОКЧЕЙН И ЕГО ПРЕИМУЩЕСТВА

Многомерный блокчейн – это революционное развитие традиционной технологии блокчейн, предлагающее динамичную и эффективную архитектуру для хранения и обработки данных. Эта уникальная структура повышает масштабируемость за счет распределения транзакционной нагрузки по различным цепочкам, значительно повышая скорость обработки и сокращая время ожидания. Благодаря таким параллельным цепочкам риск возникновения узких мест сводится к минимуму, что позволяет значительно повысить пропускную способность и оптимизировать поток данных. Кроме того, многомерные блокчейны обеспечивают более высокий уровень безопасности, изолируя данные в определенных цепочках, что затрудняет злоумышленникам доступ ко всей сети или вмешательство в нее. Эта архитектура также помогает снизить энергопотребление, позволяя распределять ресурсы в зависимости от спроса, в отличие от традиционных блокчейнов, которые требуют высокой энергоемкости для каждой транзакции. Многомерные блокчейны могут быть адаптированы к различным бизнес-моделям, от финансов и логистики до здравоохранения, и легко адаптироваться к отраслям.

Ключевые слова: *многомерный блокчейн, параллельные цепочки, масштабируемость, безопасность данных, пропускная способность, оптимизация транзакций, энергоэффективность, бизнес-модели.*

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КӨП ӨЛШЕМДІ БЛОКЧЕЙН ЖӘНЕ ОНЫҢ АРТЫҚШЫЛЫҚТАРЫ

Көп өлшемді блокчейн-деректерді сақтау және өңдеу үшін жаңа архитектураны ұсынатын дәстүрлі блокчейннің жетілдірілген нұсқасы. Бір өлшемді блокчейндерден айырмашылығы, көп өлшемді блокчейн бірнеше параллель тізбектерді құруға және басқаруға мүмкіндік береді, олардың әрқайсысы дербес жұмыс істей алады немесе ортақ желідегі басқа тізбектермен өзара әрекеттесе алады. Бұл стандартты блокчейндерге тән кедергілерді жою арқылы транзакциялардың ауқымдылығын, қауіпсіздігін және жылдамдығын арттырады. Көпөлшемді блокчейннің артықшылықтары жоғары өткізу қабілеттілігін, оңтайландырылған деректерді басқаруды, қуатты тұтынуды азайтуды және әртүрлі бизнес үлгілері мен талаптарына бейімделу мүмкіндігін қамтиды.

Түйін сөздер: *көп өлшемді блокчейн, параллель тізбектер, масштабтау, деректер қауіпсіздігі, өткізу қабілеттілігі, транзакцияны оңтайландыру, энергия тиімділігі, бизнес модельдері.*

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SOIL YIELD FORECASTING

Abstract: *This research project serves as a comprehensive meta-analysis in the field of agricultural science, specifically focusing on the prediction of crop yields. This endeavor involves collating and synthesizing findings from a variety of studies and articles that have explored different methodologies and models for forecasting agricultural outputs. The objective of this comprehensive review is to identify trends, methodologies, and key factors that consistently influence crop yield predictions across different studies.*

It synthesizes methodologies from various studies, emphasizing machine learning (ML) techniques like Support Vector Machines (SVM), Random Forest (RF), and Convolutional Neural Networks (CNN). These studies integrate high-resolution satellite imagery with environmental indices such as NDVI, EVI, and LAI. Soil chemical properties (pH, nutrients) and satellite-derived data were used to enhance the prediction of crop yields for diverse crops. The findings highlight the comparative effectiveness of different models in handling the spatial and temporal variability of both above-ground and below-ground data, improving prediction accuracy under varying environmental and soil conditions.

Through this theoretical analysis, the research underscores the potential of advanced analytical models to transform agricultural monitoring and prediction, providing critical insights that can aid in the optimization of agricultural policies and resource management.

Key words: *Crop Yield Prediction, Satellite Imagery, Machine Learning, Convolutional Neural Networks (CNN), Vegetation Indices, Soil Chemical Properties.*

Introduction

Accurate crop yield prediction is essential for enhancing agricultural productivity and ensuring food security. Advances in technology have significantly improved these predictions, helping manage environmental risks and optimize resources.

Traditional methods of yield prediction, relying on historical data and simple empirical models, often struggle to capture the complexity of modern agricultural ecosystems. Factors like unpredictable weather, soil variability, and crop management practices add challenges that these models cannot address. The integration of high-resolution satellite imagery and vegetation indices