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Analysis Study of Cryptocurrency Blockchain Technologies to Revolutionize Degree Automation

Oumaima Ouadoud*[1,2], Ahmed Eddaoui[1], Tarik Chafiq[1], Brahim Elbhiri[2]

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Abstract: Cryptocurrencies have garnered significant attention in recent years due to their disruptive potential to revolutionize traditional systems and offer innovative solutions. Their incorporation into DApps has created distinctive opportunities across various sectors, including the education industry. Our study focuses on evaluating the key attributes of cryptocurrencies utilized in DApps for managing and verifying academic qualifications. The research methodology involves an in-depth analysis of several prominent cryptocurrencies widely used in decentralized education systems, among them, we find Ethereum, Solana, and Tron. Various factors are considered, including scalability, transaction speed, security, data storage, smart contract functionality, and community support.

The comparative analysis between the chosen cryptocurrencies reveals the distinct advantages and limitations of each cryptocurrency in the context of university degrees. The examination of scalability factors has brought to the forefront new cryptocurrencies like Polygon, EOS, and Stellar, showing promise in addressing the limitations of Ethereum.

The findings serve as a valuable reference for developers, educators, and policymakers seeking to implement secure and efficient DApps for managing academic qualifications.

Keywords: *Cryptocurrencies, Decentralized Applications, University Degrees, Comparative Study, Practicality, Scalability, Smart Contracts, and Security.*

1. Introduction

Cryptocurrencies have revolutionized the financial world by providing a decentralized and secure alternative to traditional monetary systems. Since the creation of Bitcoin in 2009, numerous cryptocurrencies have emerged, each with its characteristics, technologies, and objectives.

However, we have observed the integration of blockchain technology in various fields that require a high level of security, such as the educational domain, specifically in the management of university degrees/certificates. Several studies have been conducted using the Ethereum [ref to my first article] blockchain as a tool for managing digitally signed degree transactions for later verification.

Recently, Ethereum has presented vulnerabilities such as scalability and operational costs, prompting us to conduct a comparative study among existing cryptocurrencies to find a remedy to Ethereum's limitations. This comparative study aims to analyze and compare different cryptocurrencies, focusing on their fundamental characteristics, historical performance, and current trends. The objective is to provide an overall understanding of the strengths and weaknesses of each studied cryptocurrency, as well as the opportunities and challenges they face.

[1] *Faculty of science Ben m'sick, Hassan II University, Casablanca, Morocco*
[1] *Moroccan school of engineering sciences, Rabat, Morocco*
* *oumaima.ouadoud-etu@etu.univh2c.ma*

The study will involve studying the general and specific factors that determine the nature of cryptocurrencies to perform a comparison among them. The goal is to gain insights into the most suitable cryptocurrency in our study based on speed, security, and fee predictions, ultimately deducing the most compatible cryptocurrency.

- This paper mainly consists of several important sections:
- We begin with a general introduction to the document and its objectives.
- Then, we define the important concepts of the Blockchain
- We present the related works to this topic
- As a result, we present our contribution by proposing a comparison of scalability between the popular Blockchains.
- Finally, we contribute to a conclusion that is to reveal the result obtained to present the perspectives that will form the basis for our future publications.

2. Concepts

2.1 Blockchain and cryptocurrencies

Blockchain is a technology for storing and transmitting information that forms the foundation of many cryptocurrencies [1]. The blockchain enables the creation of a decentralized and immutable ledger where transactions can be verified and validated by a network of participants, without the need for a trusted third party. This allows for the creation of digital currency, or cryptocurrency that can be used for online transactions without intermediaries.

The most well-known cryptocurrencies that utilize blockchain technology include Bitcoin, Ethereum, Litecoin, Ripple, and Bitcoin Cash, among others. Each of these cryptocurrencies has its blockchain with specific characteristics and functionalities. For example, the Bitcoin blockchain is primarily used for financial transactions, while the Ethereum blockchain is used for creating decentralized applications.

Cryptocurrencies have gained popularity in recent years due to their security, transparency, and decentralization. However, there are also disadvantages such as price volatility, usability complexities, and regulatory issues.

2.2 Blockchain and DAPP

Decentralized Applications (DApps) are digital programs or applications that operate on computer nodes. These nodes utilize a distributed network rather than a single server.

Blockchain and DApps (Distributed Applications) are two closely related concepts. DApps are applications that utilize the blockchain to store and transfer data, thereby offering a decentralized and transparent solution.

Specifically, DApps are applications that run on a blockchain, enabling them to be decentralized and autonomous. Unlike traditional applications that run on centralized servers, DApps are distributed across a network of nodes, with each node participating in transaction processing and verification[2].

In 2019, the estimated size of the DApps market was over $10 billion[3]. With the current growth rate, the market is projected to reach $368.25 billion by 2027. The DApps market growth projection is progressing at 56.1%.

DApps can be used in various domains, including financial services, social networks, gaming, and online marketplaces.

DApps are often seen as the next level of application development, as they offer numerous advantages over centralized applications. Some of the key benefits include security, transparency, resilience, and autonomy. However, like any emerging technology, there are still challenges to overcome, such as complexity, interoperability, and user adoption.

Currently, the most widely used blockchain in DApps is Ethereum[4]. Its public blockchain is specifically designed to support the development of decentralized applications. Its smart contract technology enables developers to create complex and customized DApps such as decentralized exchanges, games, voting systems, and more.

Ethereum is also popular because it offers a high level of security and reliability through its proof-of-work consensus[5]. Additionally, it has a large community of developers and users, as well as a constantly expanding DApp ecosystem.

However, there are also other Blockchains used in DApps, such as EOS, TRON, Cardano, Binance Smart Chain, etc. These Blockchains offer different functionalities and advantages, and the choice of blockchain will depend on the specific needs of each DApp project[6].

3. Related Works

Ethereum stands as the leading cryptocurrency for decentralized applications (DApps), pioneering smart contract implementation[7]. Developers employ the Solidity language to code these contracts on Ethereum, forming the foundation of DApps. While Ethereum dominates, other DApp-utilized cryptocurrencies include EOS, TRON, Cardano, and Binance Coin, each with unique traits.

In the educational realm, Ethereum is one of the most popular Blockchains for the creation and management of digital university degrees[8]. Blockchain platforms like BlockCert[9] and Learning Machine[10] have emerged to validate degrees on Bitcoin and Ethereum Blockchains. BlockCert employs Bitcoin to record degree proofs, validated via online tools. Learning Machine contrasts by utilizing Ethereum for the same purpose.

The use of blockchain technology for degree management can offer several advantages, including:

- Authenticity: The blockchain securely stores information that cannot be modified or deleted. This means that university degrees stored on the Ethereum blockchain are authentic and cannot be falsified.
- Accessibility: University degrees stored on the Ethereum blockchain can be easily accessed at any time, from anywhere in the world. Students can share their digital degrees with potential employers, higher education institutions, and other stakeholders.
- Transparency: The Ethereum blockchain is transparent and allows users to track the history of degrees from issuance to verification. This enables employers and higher education institutions to verify the authenticity of university degrees more easily and quickly.
- Efficiency: University degrees stored on the Ethereum blockchain can be verified within minutes, unlike traditional methods that can take weeks. This can help speed up the recruitment process for employers and improve student satisfaction.

However, it is important to note that the use of blockchain for the management of digital university degrees can also present challenges, such as the need to ensure the privacy of student information, protection against security attacks, and the implementation of strict security standards to ensure the authenticity and integrity of digital degrees.

Indeed, while Ethereum is widely adopted for the management of digital university degrees, it is essential to consider the potential constraints and challenges inherent in this blockchain to ensure the security, confidentiality, and efficiency of degree management.

Among these constraints, transaction fees [11]are on the rise. The implementation of the Proof of Work consensus mechanism requires high computational power, leading to significant energy consumption [12], substantial costs, and variable confirmation times for transactions [13]. Several minutes, or even longer, may elapse before a transaction is confirmed and added to a block. These transaction processing delays can extend, resulting in a noticeable increase in transaction fees. This situation can become problematic for financial applications requiring real-time operations.

Another major challenge in Ethereum's scalability is the ability to handle a large number of transactions [14], its throughput, transaction time, latency, and security can be put to the test when numerous users attempt simultaneous transactions. This scalability limitation can impede the smooth flow of operations.

Furthermore, Ethereum faces difficulties in terms of scalability when it comes to adding new features or updating existing smart contracts [15]. These processes can prove complex and require significant development efforts. Programming errors or poor smart contract management can lead to security vulnerabilities and substantial financial losses [5], thereby limiting the flexibility of the blockchain. Once a smart contract is deployed on Ethereum, it becomes challenging to modify [16] because it is considered "self-executing." Errors or vulnerabilities can be exploited without recourse, complicating the maintenance and improvement of smart contracts as user needs evolve (see Figure 1).

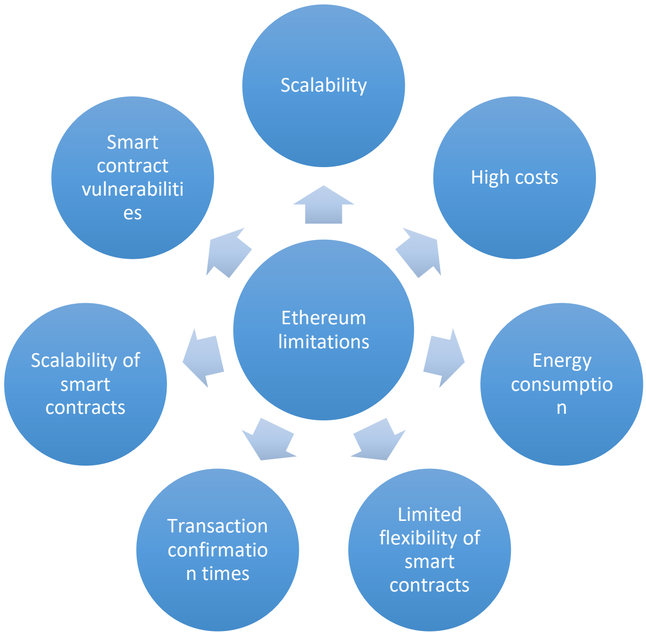


Fig 1: Limitations and Challenges of Ethereum

These challenges highlight the areas of compatibility and reliability of the Ethereum Blockchain in the education sector.

While Ethereum is a popular solution for managing digital university degrees, it is important to consider the limitations and potential challenges of the blockchain to ensure the security, privacy, and efficiency of degree management.

4. Contribution

To address the limitations of the Ethereum Blockchain and improve the performance of decentralized applications that manage university diplomas, we propose a comparative study focusing on the most popular Blockchains used in DApps.

There are existing studies that compare cryptocurrencies[17] to predict the best fit among today's major cryptocurrencies to compete with the traditional monetary system. In our study, we will also rely on a comparative analysis based on broader and more detailed criteria to predict the most suitable cryptocurrency for digitizing university diplomas.

To achieve this, we propose conducting a major study that will focus on extracting the cryptocurrencies valid for our study, as well as the possible features for making this comparison.

Depending on the results obtained, we will be able to deduce the Blockchain best suited to our case.

4.1. Extraction of crypto-currencies used in DAPPs

There are several cryptocurrencies used in the creation of decentralized applications. To extract the most popular cryptocurrencies used in the most popular applications, we have based ourselves on the platforms: state of the DApps [18] + DApp radar[19]:

4.2. Factors and requirements for choosing a crypto-currency

A recent study[17] aimed to determine the most suitable cryptocurrency, among the top five by market capitalization in July 2020, as a future payment currency compared to Bitcoin. The evaluation was based on five benchmark factors: speed, activity, decentralization, users, and community. The findings indicated that Ethereum might be more suitable as a future payment currency than Bitcoin. Additionally, Ethereum was identified as the most prevalent cryptocurrency in the educational sector, particularly in the management of digital diplomas.

To address the limitations of the Ethereum blockchain and identify a more suitable blockchain for our specific case, we propose conducting a more comprehensive comparative study focusing on both general and specific factors.General factors

For our study, and based on the work we've been working on, it's important to take several factors into account and compare them.

Among the general criteria that will help us evaluate the various cryptocurrencies selected:

- Speed: refers to how quickly transactions can be confirmed and processed on the network. High speed means that transactions can be executed quickly, which is essential to encourage the adoption and practical use of cryptocurrencies.
- Activity: Activity in the context of cryptocurrencies refers to the volume and intensity of transactions carried out on a specific network. It can be measured in terms of the number of daily transactions, trading volume, or participation in cryptocurrency-related activities, such as mining or participation in proof-of-stake networks.
- Decentralization: the fundamental principle of cryptocurrencies, referring to the distribution of control and decision-making across a decentralized network rather than to a single central authority. This means that no central entity owns or controls the cryptocurrency, and transactions are verified and recorded by network participants, often through decentralized consensus.
- Community: The cryptocurrency community is made up of individuals and groups who are interested in, use, or support a specific cryptocurrency or the field of cryptocurrencies in general. It can include developers, miners, traders, investors, regular users, and other stakeholders who contribute to the cryptocurrency ecosystem through discussions, collaborations, knowledge sharing, and other forms of engagement.
- Market capitalization: this measures the total value of cryptocurrency in circulation. It is an indicator of the cryptocurrency's size and popularity.

It's important to note that market capitalization can vary considerably depending on the cryptocurrency's price and number in circulation, which are subject to frequent fluctuations.

The following table (Table 1) provides general information on our cryptocurrencies: (information as of March 2023)

Table 1: general factors of chosen cryptocurrencies

Cryptocurrency	Main features	Community and adoption: Number of people using it (In millions) *	Market capitalization: How many currencies are in circulation (Billion dollars)	dollar value
Cardano	Development and execution of smart contracts and decentralized applications (DApps).	3. 536	9.129	0.26097
Polkadot	Decentralized blockchain platform.	3	5.456	4.39

	Development of decentralized applications (DApps).			
Polygon (MATIC)	Ethereum scaling platform	2.6	14.8	1.91
BNB	the native token of the Binance exchange platform	70	174.5	1102.21
Cronos Chain[1]	Interoperable with Ethereum and part of the Cosmos ecosystem	0.3		
Fantom blockchain	Offers advanced potential for Ethereum Compatible smart contracts On a very low cost	0.11	14.6	2.03
Flow Blockchain	Among the first successful NFTs launched on Ethereum	0.0007	6.9	49.15
TRON		1.8	7.1	0.0083
Neo (NEO)	-Peer-to-peer smart contracts -Chinese government support	N/A	5.2	69.91
Solana	Addresses traditional issues that exist on the Bitcoin and Ethereum Blockchains.	N/A	169.8	338.71
Stellar (XLM)	Popular for regulating payments between companies or individuals	7.2	14.9	0.1054
Ethereum (ETH)	-Peer-to-peer smart contracts	1.4	41.2	4323.92
EOS[2]	Enables the development, hosting, and execution of decentralized applications -Access to smart contract functionalities	5.7	6.3	6.66

Please bear in mind that these figures are subject to change due to market fluctuations.

According to the available statistics, pinpointing the precise number of cryptocurrency users remains challenging, primarily because there exists no centralized registry of users [20].

Measuring the size of a cryptocurrency's community entails considering various indicators, encompassing the number of wallets, transaction volume, the count of network nodes, and the utilization of public data like active addresses. The quantity of active Bitcoin wallets worldwide, while in the millions, should be interpreted with caution since some users may possess multiple wallets, rendering it an imperfect reflection of the total user count. Another metric is the daily transaction volume of Bitcoin, which serves as a barometer of the cryptocurrency's popularity; higher transaction volumes indicate increased user activity. Additionally, the number of nodes supporting the Bitcoin blockchain is a factor in estimating community size, although it does not encompass users who abstain from hosting nodes. However, due to the decentralized and anonymous nature of cryptocurrencies, providing an exact numerical representation of their communities remains a challenge. Nevertheless, estimating user numbers becomes feasible by utilizing public data such as active addresses, as is the approach we will employ in this case, relying on the data source https://blockchair.com/fr [21].

[1] Cronos Chain is a relatively new project, and data on CRON's market capitalization and dollar value can be hard to find.
[2] Developed by identifying the shortcomings of the Ethereum network in terms of scalability, transaction speed and cost, spam and limited computing power.

4.2.1. Particular factors

Choosing the ideal cryptocurrency for a decentralized application involves a careful evaluation of essential factors. First and foremost, the cryptocurrency must align with the specific goals and functionality requirements of the application. It should also be built on a technology that complements the application's needs and capabilities. Scalability is another critical consideration, ensuring that the chosen cryptocurrency can effectively handle a growing number of transactions as the application expands. Security is paramount, and the cryptocurrency should offer robust protection for users and their assets. Furthermore, opting for a cryptocurrency with an active development team that regularly releases updates is crucial to maintaining the technology's quality and reliability. Lastly, fairness and transparency play a vital role, with the chosen cryptocurrency ideally not being controlled by a single entity, ensuring equitable access and governance for all users. In sum, a comprehensive assessment of these factors is essential to make an informed choice for a decentralized application.

4.2.2. Scalability of cryptocurrencies

The scalability of cryptocurrencies refers to their ability to efficiently and optimally handle an increase in the number of users, transactions, and workloads on their network. In other words, a cryptocurrency is scalable if it can accommodate significant growth without compromising its performance, security, and integrity.

To ensure better scalability, one study has identified three main axes [20] that present the key elements. We will apply these axes to our selection of cryptocurrencies to determine which is best suited to our study, taking these criteria into account.

Table 2: scalability axes

Areas for scalability	Problems	Solution
Throughput (number of transactions per second)	The throughput of transactions in Blockchain remains relatively low when compared to the transaction volumes handled by traditional methods.	• Augmenting block size • Diminishing transaction size • Decreasing the volume of transactions processed by nodes • Minimizing the time interval between blocks
Storage	Every node is required to process and store all data, spanning from the entire transaction details to the original block.	• Examine methods for storing data on blockchain nodes with restricted resources. • Explore the utilization of external resources for secondary data storage.
Networking	• Every node forwards all transactions. • A transaction is transmitted twice to all nodes: once upon its generation and again when a block containing the transaction is retrieved. • This process significantly drains network resources. • It leads to longer block propagation times.	• Implementing streamlined data transmission methods, • Minimizing the volume of data disseminated across the blockchain network.

Scalability is a crucial aspect of the development and large-scale adoption of cryptocurrencies. A scalable cryptocurrency can handle a significant increase in transaction volume without causing network congestion, slowdowns, or high fees. This enables a smooth user experience, fast transaction times, and reduced costs [20].

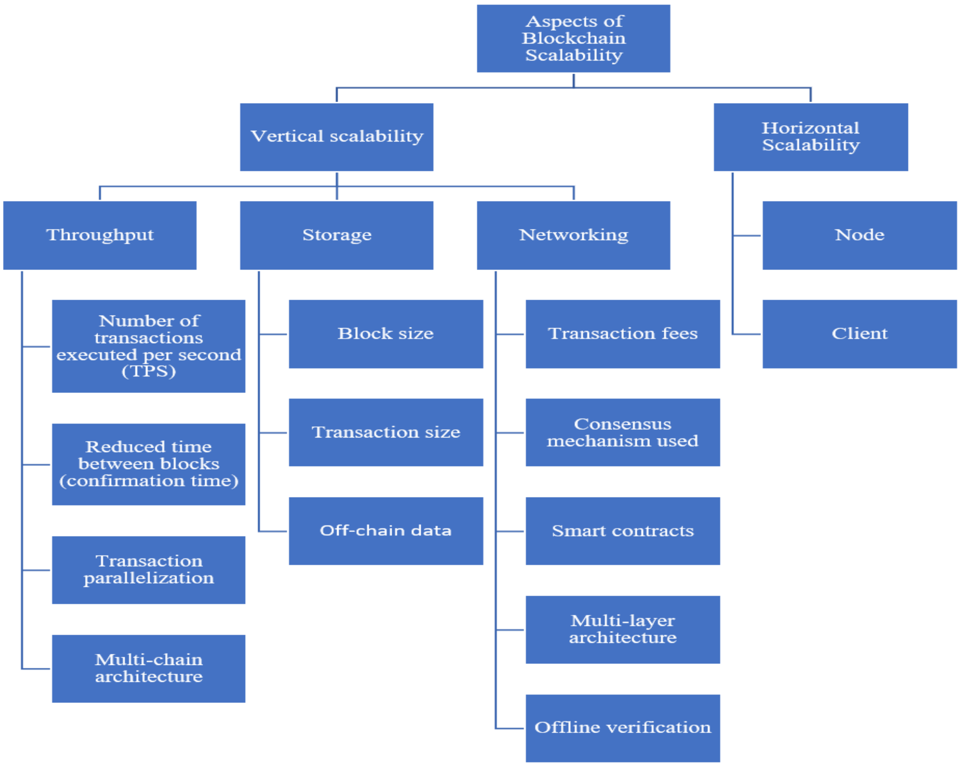


Fig 2: Scalability properties on the axes of Throughput/Storage and Networking

In our study, we've applied scalability aspects to cryptocurrencies, detailing key axes for comparison, as shown in Figure 2:

1. Offline Verification: Confirming blockchain transactions without an internet connection via digital signatures and hash checks.
2. Block Size: Storage in MB occupied by a blockchain block, including headers, transactions, and more.
3. Transaction Fees: Payments for transaction processing, varying with network demand.
4. Off-Chain Data: Data stored externally, like atomic swaps for decentralized asset exchange.
5. Multi-Layer Architecture: Functional layers in a blockchain system, e.g., Lightning Network.
6. Multi-Chain Architecture: Interconnected Blockchains with distinct rules.
7. Sidechain: A linked separate blockchain for specific transactions.
8. Transaction Parallelization: Simultaneous transaction execution for efficiency.
9. Smart Contracts: Self-executing code automating and verifying contracts.
10. Transactions per Second (TPS): Measures blockchain speed.
11. Consensus Mechanisms: Protocols ensuring transaction validation.
12. Confirmation Time: Time for transactions to become irreversible.

Consensus mechanisms offer a diverse range of approaches to orchestrate transaction validation within blockchain networks. Proof of Stake (PoS) introduces a validator selection based on cryptocurrency holdings, promoting increased energy efficiency compared to Proof of Work (PoW). PoS Plasma, an iteration of PoS, explores scalability by introducing secondary chains (plasma) linked to a main PoS chain. The Proof of Authority (PoA) approach ensures validation by authorized entities, ideal for consortia where trust prevails among participating nodes. The Flexible Delegated Proof of Stake (FDLP) model innovates by allowing token holders to vote for delegates, providing flexibility in their selection. Proof of Elapsed Time (PoE), designed by Intel, relies on participants waiting for a random time to solve a cryptographic problem, aiming for increased fairness in terms of energy consumption. Delegated Proof of Stake (DPoS) involves token holders in voting for delegates, constituting a form of delegated PoS, focused on efficiency improvement. Neo VM, used by the Neo platform, employs its consensus mechanism, dBFT, and Neo VM to execute smart contracts. The Stellar Consensus Protocol (SCP), adopted by the Stellar blockchain, is characterized by speed and energy efficiency, relying on a network of reliable nodes. Finally, Proof of Work (PoW), Bitcoin's original mechanism, requires miners to solve complex mathematical problems for block addition, despite its considerable energy consumption. The choice between these mechanisms depends on specific criteria such as security, scalability, decentralization, and energy efficiency, according to the unique requirements of each project. Each algorithm has its advantages and disadvantages, necessitating a careful evaluation to align with the specific needs of the envisioned project.

For this reason, we will apply these factors to compare the cryptocurrencies we have identified.

Table 3 presents the scalability of the cryptocurrencies studied to determine the most appropriate blockchain for our case. To enhance the digitalization of university diplomas while addressing the sensitivity of the data and the heightened security requirements, it is imperative to select a Blockchain solution that aligns with these criteria. While Ethereum was among the initial Blockchains utilized for such purposes, it has exhibited certain limitations at the operational level.

We've created a model connecting these points to scalability aspects.

Consequently, our objective involves conducting a comparative analysis among these cryptocurrencies to determine the most appropriate Blockchain for our specific scenario. This analysis will be presented in Table 3, outlining the incorporation of scalability considerations into the chosen cryptocurrencies based on established research. Throughout this process, we encountered several obstacles in gathering information, attributable to its scarcity, which stems from the pioneering nature of this field.

Table 3: Application of scalability properties of selected cryptocurrencies

Properties of scalability / Cryptocurrency	**Offline verification**	**Off-chain data Exp: atomic swaps**	**Multi-layer architecture**	**Multi-chains architecture**	**Sidechain[3]**	**Transaction parallelization**	**Smart contract**	**Number of transactions per second[4]**	**Number of confirmations required (by miners)**	**Transaction confirmation time (in min)**
Cardano	Yes	Yes	Yes	Yes	No	Yes	Yes	5	15	10
Polkadot	Yes	Yes	Yes	Yes	Yes	Yes	Yes	1000	N/A	0
Polygon (MATIC)[21]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	65 000	250	5
BNB [22]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Between 5 000 et 10 000	5	10
Cronos Chain [23]	Yes	Yes	Yes	Yes	Yes	No	Yes	N/A	N/A	N/A
Fantom blockchain[24]	Yes	Yes	Yes	Yes	Yes: With Fantom Opera technology	No	Yes	2	Low	Almost instantaneous
Flow Blockchain [25]	Yes	Yes	Yes	Yes	No	Yes	Yes	4 500	1	Almost instantaneous
TRON [26]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	30	1

[3] Run their customized blockchains as an internal value system for a large number of users, while maintaining a close connection with the BSC.
[4] The number of transactions does not depend on the number of miners, but rather on the block size and the interval between blocks.

Neo (NEO) [27]	Yes	Yes	Yes	Yes	No	No	Yes	2000	20	1
Solana [28]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10000	1 000	N/A
Stellar (1LM) [29]	Yes	Yes	Yes	Yes	No	Yes	Yes	50000	N/A	Almost instantaneous
Ethereum (ETH) [30]	Yes	Yes	Yes	No	Yes	No	Yes	1000	10	N/A
EOS [31]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100000	40	14

We embark on a comprehensive comparison of various blockchain consensus mechanisms, each playing a pivotal role in shaping the dynamics of decentralized networks. From Proof of Work (PoW) to Proof of Stake (PoS), Stellar Consensus Protocol (SCP), Delegated Proof of Stake (DPoS), and other innovative models like Flexible Delegated Proof of Stake (FDLP) and Proof of History (PoH), the landscape is rich and diverse. This exploration encompasses an examination of their security, decentralization, energy efficiency, and transaction speed, shedding light on the unique strengths and considerations associated with each mechanism.

Understanding these consensus mechanisms is integral to the broader consideration of choosing the most optimal cryptocurrency for our study. The intricacies of security, the degree of decentralization, energy efficiency, and transaction speed become pivotal factors in the nuanced decision-making process (see Table 4 & Table 5).

Table 4: Comparative Analysis of Blockchain Consensus Mechanism

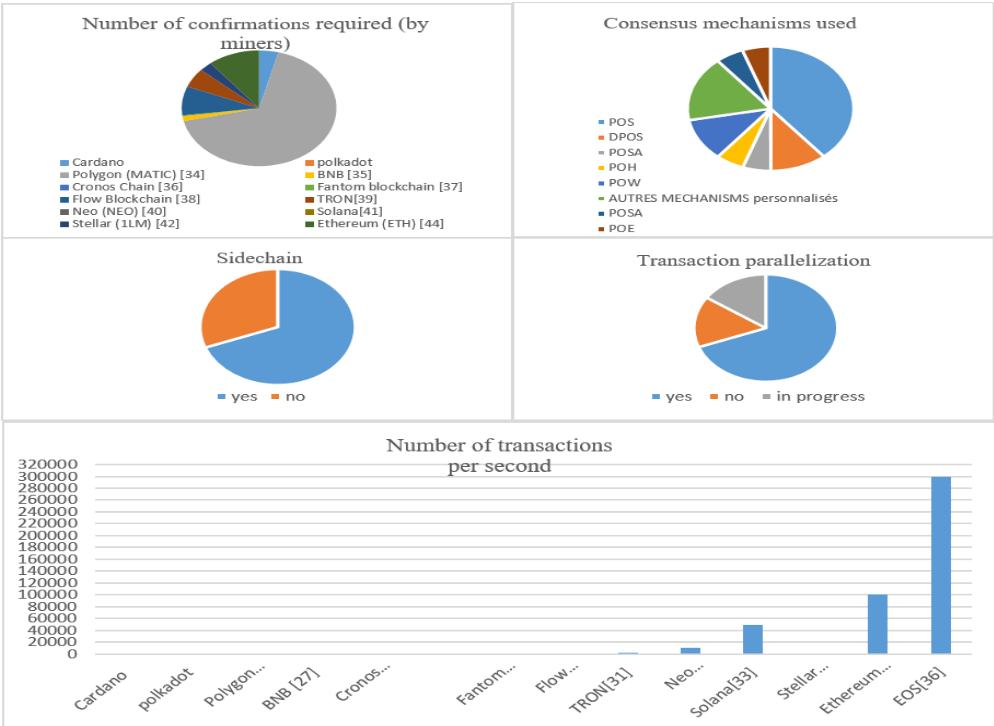
	PoW	PoS	PoS Plasma	DPoS	PoA	PoE	PoH	Neo	SCP	FDLP
Energy efficiency	10	1	3	4	2	8	9	7	6	5
Decentralization	1	2	4	5	7	8	10	9	3	6
Transaction speed	10	6	4	1	2	9	5	8	3	7
Security	1	2	4	5	7	8	10	9	3	6

Table 5: Application of consensus mechanisms of selected cryptocurrencies

Consensus mechanisms / Cryptocurrency	PoW	PoS	PoS Plasma	DPoS	PoSA	PoE	PoH	Neo	SCP	FDLP	PoW
Cardano		X									
Polkadot		X									
Polygon (MATIC)			X								
BNB					X						
Cronos Chain		X									
Fantom blockchain										X	
Flow Blockchain		X				X					
TRON				X							
Neo (NEO)											

Solana				X	
Stellar (1LM)					X
Ethereum (ETH)	X	X			
EOS			X		

Fig 3: interpretation of results



The provided illustration (see Figure 3) presents a visual depiction of the collected data. Upon analyzing these graphs, it becomes evident that the Ethereum blockchain is presently incorporating various scalability measures. These include the adoption of a multi-chain architecture and the implementation of transaction parallelization. Additionally, the latter approach along with the sidechain principle has been integrated into the majority of recent blockchain developments.

In terms of blockchain confirmation rates, the data reveals that Polygon leads the pack. The three leading cryptocurrencies in terms of transactions per second are EOS, Ether, and Polygon.

Furthermore, the prevailing consensus mechanism across the analyzed data points is Proof of Work (POW).

5. Discussion

Scalability criteria play a crucial role in the world of cryptocurrencies as they define a Blockchain's ability to efficiently handle a high volume of transactions while adapting to increasing adoption. Scalability represents one of the major concerns for cryptocurrency projects because it directly influences transaction processing speed, transaction costs, security, and overall user experience.

Transaction processing speed is essential to ensure that users can conduct transactions quickly and seamlessly. If a blockchain cannot scale to accommodate a large number of transactions, it leads to delays, queues, and a subpar user experience. Moreover, high transaction costs can discourage users from participating in the network.

Security is another significant concern. A blockchain must be able to withstand potential attacks, and poor scalability can weaken its security by making the network more vulnerable to attacks.

Lastly, the overall user experience is crucial for the success of a cryptocurrency. If users have to wait a long time for their transactions to be confirmed or if they have to pay excessive transaction fees, it can discourage their use of the cryptocurrency.

According to the findings of the conducted study, applying these criteria has revealed the emergence of new cryptocurrencies that have the potential to address the limitations of Ethereum. Among these, notable cryptocurrencies include Polygon, EOS, and Stellar. These three cryptocurrencies not only offer fundamental features for managing university degrees but also provide solutions for reducing transaction fees and the number of required confirmations. This aims to alleviate the constraints currently faced by Ethereum and pave the way for new applications and broader adoption of blockchain technology. By investing in scalability solutions, these cryptocurrencies seek to significantly enhance the efficiency and user-friendliness of their networks, thus offering promising alternatives for the future of the cryptocurrency sector.

6. Conclusion and Future Work

In light of this study, it is evident that scalability is a major concern in the cryptocurrency field, directly influencing transaction speed, associated costs, security, and overall user experience. The analysis of scalability criteria has highlighted the emergence of new cryptocurrencies such as Polygon, EOS, and Stellar, which appear promising in overcoming Ethereum's limitations.

In summary, cryptocurrency industry stakeholders must continue investing in scalability solutions to meet user and technological demands, fostering enhanced network performance and broader blockchain technology adoption. Ongoing research and development are vital for sustained ecosystem growth and viability. The future holds promise as scalability improvements continue, potentially leading to innovative solutions that address current challenges and expand Blockchain's applications, including decentralized payments and asset tokenization. Collaboration and sustained investment in research and development remain crucial for harnessing Blockchain's full potential.

Author contributions

Ouadoud Oumaima: Science and Technology in Intelligent Systems and Networks. **Eddaoui Ahmed:** Computer science specialist. **Chafiq Tarik:** Research field of geomatics such as Geographical Information Systems (GIS) analyses and Spatial Data Infrastructures (SDI). **Brahim ELBHIRI:** WSN, IoT-IIoT, mobile network, Smart Grid, embedded systems

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