

Research Article

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Exploring the Capabilities of Crypto-Based Blockchains Polygon, EOS, and Stellar vs. Ethereum to Revolutionize Degree Automation in Education

Oumaima Ouadoud , Tarik Chafiq , Ahmed Eddaoui

Abstract

Background/purpose. This research was conducted to address the growing need for more secure, transparent, and efficient solutions for the issuance and management of university degrees. The main purpose of the study is to evaluate which Blockchains are best suited for this application, aiming to enhance the reliability and speed of degree-related transactions.

Materials/methods. The study is based on a comparative evaluation of several leading Blockchains (Ethereum, Polygon, Cardano, Stellar, and EOS), using criteria such as scalability, security, ease of implementation, transaction speed, and associated costs.

Results. The results show that Stellar is the best-suited Blockchain for managing degrees, due to its very low transaction fees and high speed. EOS ranks second, offering low fees but requiring more complex resource management. Ethereum has higher transaction costs, while Polygon and Cardano offer a balanced mix of cost and performance.

Conclusion. The main conclusion of the study is that Stellar is the most appropriate option for university degree management. However, the final choice should be based on the specific needs of each institution.

1. Introduction

The essential role of university diplomas and certificates is to ensure the validity of a study process to obtain proof of knowledge of a certain discipline. From their birth in the twentieth century, their handling was done according to a manual method based on the trust of the university, yet this method of validation is limited to a trusted third party, hence the birth of new studies that allow the automatic management of university certificates and diplomas without recourse to a trusted third party with the help of Blockchain technology (Cekerevac & Cekerevac, 2022) to obtain a sustainable degree, better secured, and valued against other countries.

In the rapidly evolving landscape of Blockchain technology, the innovation potential extends far beyond the realm of cryptocurrencies. One promising application is the issuance and management of academic credentials using Blockchain technology (Averin et al., 2020). This paradigm shift in the way educational achievements are verified and stored has the potential to streamline the process, increase security (Li et al., 2020), and enhance academic qualifications (Andoni et al., 2019).

To explore this new technology, several leading Blockchain platforms have emerged as contenders in the race to revolutionize the creation and management of university degrees (Oumaima et al., 2023).

Among the most widely used Blockchains in this field are Ethereum (Wu, 2019), Bitcoin (via solutions such as "Blockcerts" (Capece et al., 2020)), Hyperledger Fabric (Perboli et al., 2018), and Algorand. Ethereum, due to its widespread adoption and the power of its smart contracts (Liang & Xu, 2021), is one of the most popular platforms for issuing digital degrees.

However, it is not alone in taking this route. Several platforms have emerged as potential alternatives, each with unique features and capabilities. For example, MIT uses the "Blockcerts" solution (Yeh et al., n.d.), initially developed in partnership with Learning Machine and based on Bitcoin and Ethereum, to issue verifiable degrees (Turkanovi, 2018). Similarly, Hyperledger Fabric (Duy, 2022), supported by the Linux Foundation, is preferred by some universities for its authorization features, which enable better control over access to sensitive data (Juričić et al., 2019).

However, several limitations persist. First, scalability remains a major issue, particularly on public blockchains such as Ethereum (Mondal & Goswami, 2024), where transaction fees can become prohibitive during periods of high congestion. Second, data privacy is another concern: although blockchains guarantee data integrity (Chafiq et al., 2024), their immutable and often public nature can pose compliance issues with the General Data Protection Regulation (GDPR) in Europe ("Opposites Attract: Reconciling GDPR and Blockchain - European Commission," 2018).

The fundamental objective of this study is to conduct an in-depth transaction test on several major Blockchains, with a focus on evaluating their performance, security, and scalability. Our approach is based on the digitization of university diplomas and certificates.

This comparative study looks at the practical aspects of using other Blockchains as alternatives to Ethereum for the creation and management of university degrees. We examine the strengths and weaknesses of each platform in terms of scalability, cost-effectiveness, security, and ease of implementation. At the end of this exploration, readers will have a better understanding of which Blockchain platform offers the most promising solution for the future of university degree management.

The motivation behind this study stems from the specific needs and requirements of our use case. Blockchains vary significantly in their transaction processing capabilities, consensus models, security mechanisms, and associated costs. To select the optimal Blockchain for our application, it is

essential to conduct a rigorous comparative evaluation. This study aims to answer several key questions:

- Which blockchain offers the highest transaction throughput to support fast and large-scale issuance of academic diplomas and certificates?
- Which blockchain ensures strong security for storing and protecting sensitive student records and credentials?
- Which blockchain provides the scalability needed to meet the growing demands of digital credentialing in education?
- Which blockchain uses a consensus model that best suits the trust and transparency requirements of academic institutions?
- Which blockchain is the most cost-effective for issuing, storing, and verifying educational credentials?

Ultimately, this study aims to provide empirical data and relevant information to guide the selection of the most appropriate Blockchain for our use case, taking into account performance, security, scalability, consensus, and cost criteria.

2. Literature Review

The adoption of Blockchain technologies in a range of sectors has attracted increasing attention in recent years (Chafiq et al., 2024; Kuliha & Verma, 2024), especially in the registration of university degrees. Blockchains, with their decentralized and immutable characteristics, offer a powerful solution for ensuring the authenticity and traceability of diplomas, reducing fraud, and simplifying verification processes for employers and educational institutions (Sidhu, 2017).

The principal benefits of using Blockchain for diploma registration include transparency, security (Wang, 2024), and efficiency (Tapscott & Tapscott, n.d.). The transactions on a Blockchain are immutable, meaning that once a diploma is registered, it cannot be altered or falsified (Mougayar, 2016). In addition, the transparency of the Blockchain enables any authorized third party to verify the authenticity of a diploma quickly and reliably (Buterin, 2014). Automated, decentralized processes reduce the administrative costs and time involved in verifying diplomas (Graf et al., 2021).

Several Blockchains are being explored for their potential in this area, including Ethereum, Polygon, Cardano, Stellar, and EOS. Ethereum is one of the most popular Blockchain platforms for decentralized applications. Its ability to execute complex smart contracts makes it a viable option for degree registration, although its transaction costs can be prohibitive in times of congestion (Chauhan et al., 2018). Polygon, a scaling solution for Ethereum (Kargin et al., 2018), offers fast transactions at significantly lower costs, which can be advantageous for high-volume applications. Cardano stands out for its focus on security and scalability, with low and predictable transaction costs (Johnson, 2021). Its proof-of-stake (PoS) architecture promises enhanced security.

Although its ecosystem is still under development compared to Ethereum, Stellar offers extremely fast transactions at very low cost, thanks to its fixed fee-per-transaction model. This Blockchain is particularly suited to financial transactions and micropayments (Lokhava et al., 2019), but its use for complex applications may be limited vis-à-vis the use of smart contracts (Mokdad & Hewahi, 2020). EOS is known for its fast transactions and unique business model based on resource consumption (CPU, NET, and RAM). Although this model introduces some complexity, it allows for free transactions for end-users once resources have been acquired (Elrom, 2019).

Several initiatives and projects have explored the use of Blockchains for diploma registration. For example, the University of Nicosia in Cyprus has been using the Bitcoin Blockchain to record its

students' diplomas since 2014 (Overview < Media Lab Research Theme: Decentralized Society — MIT Media Lab, n.d.). Similarly, the MIT Media Lab has developed a blockchain-based certification system to issue verifiable diplomas online (Zyskind et al., 2015).

Despite the benefits, several challenges need to be overcome for widespread adoption. Technical complexity, initial implementation costs, and the need for interoperable standardization between different Blockchains are major obstacles ("Opposites Attract: Reconciling GDPR and Blockchain - European Commission," 2018). In addition, data privacy and regulatory issues need to be carefully addressed (Christidis & Devetsikiotis, 2016).

In this study, we analyze the costs and characteristics of transactions on different Blockchains, including Ethereum, Polygon, Cardano, Stellar, and EOS, to determine which is most suitable for recording university degrees. We evaluate transaction costs, execution time, and the impact of speed on the choice of Blockchains. However, the final choice of Blockchains depends on the specific needs of each institution and the interoperability solutions available to maximize the efficiency and security of these systems.

3. Methodology

3.1. Research approach

Blockchains represent decentralized systems enabling secure recording and verification of transactions, thereby eliminating the need for centralized intermediaries. At the core of each transaction lie key elements such as gas, transaction fees, and validation mechanisms, which vary from one Blockchain to another.

Hence, it is necessary to execute a set of transactions for each selected Blockchain to evaluate them in various scenarios. Particularly, the management of university diplomas via Blockchain perfectly showcases the revolutionary potential of this technology in the education sector, thereby adding a relevant dimension to our analysis. Recording diplomas on a Blockchain ensures their immutability and authenticity, facilitating verification processes for employers, institutions, and individuals while reducing the risks of fraud and falsification. This specific use case highlights the adaptability and relevance of Blockchains for specific use cases, further emphasizing the need for thorough evaluation in different contexts.

3.2. Research design

The design of test scenarios to evaluate Blockchain transactions must be carefully planned to reflect realistic and representative use cases.

In our study, we focus on testing basic money transfer transactions to assess the ability of each Blockchain to handle these fundamental operations.

Regarding the initial conditions, we examine the initial state of the Blockchain, meaning its behavior when operating in a test environment with standardized parameters.

Transaction parameters include transaction fees, gas (for Ethereum), and gas limits, which should be preconfigured. At this stage, we have defined the initial data and the content of each transaction.

Move to the execution stage, which involves emitting the transaction, validating it by verifying the signature, and ensuring that the user has sufficient funds to complete the transaction. Then, the transaction is included in a block through the mining process (in the case of Proof of Work) or validation (in the case of Proof of Stake), followed by confirmation of the transaction by a certain number of subsequent blocks to ensure its security.

To execute this process, it is necessary to collect metrics to determine which Blockchain is the most optimal. To do this, we gather and analyze the following measures:

Processing Time (Hashemi Joo et al., 2020): The time required for transaction confirmation is measured.

Transaction Throughput (Shamieh et al., 2020): The number of basic transactions processed per unit of time (e.g., transactions per second - TPS) is recorded.

Transaction Costs (Ahluwalia et al., 2020): The transaction fees associated with each transaction are recorded.

This "Basic Transactions" scenario aims to evaluate the performance, speed, and costs associated with simple transactions on each Blockchain. The measures and metrics collected in this context help establish a solid basis for comparison among different Blockchains, highlighting their strengths and weaknesses in handling basic transactions.

3.3. Research tools

The most popular Blockchains selected in our study are Ethereum (Ranganathan et al., 2018), Polygon (Rana et al., 2023), Cardano (Busayatananphon & Boonchieng, 2022), EOS (Song et al., 2022), and Stellar (Khan et al., 2019). Our choice is based on several key factors, including their proven efficiency, speed of transaction processing, and reputation for security (Oumaima et al., 2023). We opted for these specific Blockchains because of their distinctive features, which place them at the forefront of the Blockchain industry.

Each of these Blockchains brings a unique set of features and functionality to our comparative study. By including them alongside Ethereum, we will be able to carry out a comprehensive and informed evaluation, based on empirical data (Leible et al., 2019), to determine which Blockchain best meets our specific needs in terms of performance, security, scalability, consensus, and cost. This approach ensures that our choice is fully informed and aligned with the requirements of our particular use case.

The language used to code Blockchain transactions is Python, as it is popular in the innovative field and offers a wide choice of libraries relevant to our study.

For this reason, we opted for test cryptocurrencies, which are handled by tools that manage electronic wallets as well as explorers for each one. The following table summarizes the post-programming information required for this study (see Table 1).

Table 1. Test cryptocurrency management tools

Crypto-currencies	Test Blockchain	Wallets	Explorers
Ethereum	goerli	Metamask	goerli.etherscan.io/address/0x35aa1eabed7f9a7dd943331dfe474c465230db92
Polygon	Mumbai	Metamask	mumbai.polygonscan.com/address/0x35aa1eabed7f9a7dd943331dfe474c465230db92
EOS	EOS	Anchor	explorer.testnet.evm.eosnetwork.com/address/0x35aA1eaBEd7f9A7dD943331DFe474c465230Db92
Stellar	XLM	Rabett	testnet.stellarchain.io/accounts/GCAYZQGGUJHIOQRJW SVH6DDDXXTAVZNALWYN34ZN4SJ63VBMPNLAC7CD
Cardano	ADA	Onligne	preview.cardanoscan.io/address/addr_test1vznsdtkf99n96gmw95evzc9aug6t92hdx8rszj7euz9vydgddec7mv

3.4. Data analysis procedure

To establish this study, we need to define the steps to be followed from the choice of cryptocurrencies to the testing phase.

1. The choice of cryptocurrencies is based on popularity, DApp usage, high level of security, and accessibility of test cryptocurrencies.
2. Creation of a wallet for each, and adding test cryptocurrencies using online faucets (Faucets are devices used to control the flow of liquids, typically water, from a plumbing system. They are commonly found in sinks, bathtubs, and showers).
3. Test explorers and standard test APIs (APIs (Application Programming Interfaces) allow software programs to communicate with each other by exchanging data and services) to ensure accessibility.
4. Once we've have ensured that the environment is set up properly, we move on to defining the points to be set when creating transactions.

In our study, we have executed several types of transactions that vary according to the size of data sent for each proposed Blockchain, to guarantee an environment of comparison in terms of transaction fees, estimated fees, and confirmation time according to this variation in size.

We have therefore chosen 4 forms of transaction.

- a. A transaction with a minimum size, i.e. without the addition of university degree data
 - b. A transaction with a single diploma (JSON format). Its size is around 300 bytes (approximation).
 - c. A transaction with the maximum amount of data, which varies from one Blockchain to another.
 - d. Pass each diploma in a separate transaction, and execute several transactions at the same time, with the number of transactions depending on the maximum value of diplomas passed for each Blockchain, unlike the previous case, which manages the maximum number of diplomas in a single transaction, to make a comparison between them.
5. Once we have 4 examples of transactions for each Blockchain, and each one presents a particular case, we are led to make a comparison between them to deduce the most optimal Blockchain for our field of activity, and this is done according to several criteria, namely :
- a. Transaction fees,
 - b. Estimated costs
 - c. Confirmation time

3.5. Participants

For user accounts, we create two accounts: one as the sender (User A) and the other as the receiver (User B). Each of these accounts has an initial balance in the respective cryptocurrency (test coins).

3.6. Data analysis techniques

Blockchains represent decentralized systems enabling secure recording and verification of transactions, thereby eliminating the need for centralized intermediaries. At the core of each transaction lie key elements such as gas, transaction fees, and validation mechanisms, which vary from one Blockchain to another. For instance, gas serves as a measure used in Blockchains like

Ethereum to quantify the work required to execute a transaction or smart contract. Transaction fees, also known as gas fees, represent costs paid by users to perform transactions on the network, and they can vary based on factors such as transaction size and network congestion (The level of congestion in blockchain networks measures the amount of traffic or activity at a given time, thus influencing transaction processing delays and associated fees).

The estimation cost for each Blockchain studied is to be used as a reference for the results we deduce from the transactions performed.

To do this, we need to define the criteria taken into consideration to calculate the transaction costs for the chosen Blockchains.

Most of the costs of these Blockchains are based on the gas price or the basic fee, and the transaction size limits (see Figure 1).

Ethereum	polygon	cardano	stellar	EOS
•Gas Price, Gas Limit, Gas Used	•Gas Price, Gas Limit, Gas Used	•Base Fee, Additional Fee, Transaction Size	•Base Fee, Number of Operations	•CPU, NET, RAM

Figure 1. Criteria for calculating the transaction cost for each Blockchain

The only peculiarity is that in the case of the EOS Blockchain, the calculation of the cost of publishing a transaction uses a resource model based on CPU, NET, and RAM, as shown in Table 3, rather than a direct transaction fee model like that used in other Blockchains. Users must stake EOS to access these resources(Mercan et al., 2020). CPU and NET resources are temporary resources, loaned according to the quantity of EOS tokens staked. The cost in terms of CPU and NET depends on the current network load. For a simple transaction, CPU and NET requirements are generally low and can be covered with a small quantity of stored EOS tokens. RAM memory on EOS is a permanent resource and its cost can vary according to market demand. The cost of RAM is paid only once, and resources remain allocated until they are explicitly released. A simple transfer transaction doesn't usually require a lot of RAM, but it is important to note that adding metadata (which is the case in our study) can slightly increase RAM requirements.

To do this, we estimate the cost in RAM for a single transaction, using data from a single diploma (JSON format). Calculated from the number of characters in the memo parameter, which includes the diploma data.

Calculate the total RAM needed in bytes

memo = "Nom: OUMAIMA, Prenom: OUADOUD, Age:"

memo_length = len(memo)

total_ram_needed = Transaction_base + memo_length

With: Transaction_base = 300 bytes (approximation of transaction size without data).

Calculate the cost in EOS

ram_price_per_kb = 0.1 # Example price in EOS per KB

ram_needed_kb = total_ram_needed / 1024

cost_in_eos = ram_needed_kb * ram_price_per_kb

With: the value 0.1 shows the average cost of RAM (in EOS per KB), in which case we can estimate the total cost.

To apply this calculation in our study, we take into account the maximum memo size in each transaction to set the number of diplomas that can be passed in a single transaction.

For this reason, the following table shows the calculation of an estimate of publication costs based on these criteria for each type of transaction mentioned above (see Table 2).

Table 2. Estimate of EOS transaction costs

Transaction type	Total RAM required (bytes)	Estimated cost (in EOS)
A transaction with a minimum size	300	0.03
A transaction with just one diploma	514	0.05
A transaction with maximum data	8192 (8 KO)	0.8
Each diploma in a separate transaction (16 transaction)	13024(12.72 KO)	1.27

Table 3 provides a comprehensive overview of the number of diplomas that could be processed on each of the proposed Blockchain platforms. This capacity is determined by the total transaction size, which encompasses the data payload required to encode and manage each diploma. For each Blockchain, the table summarizes the estimated number of diplomas that can be handled, taking into account factors such as transaction throughput, block size limitations, and network performance. Ethereum, Polygon, Cardano, Stellar, and EOS are evaluated to highlight their respective efficiencies and constraints in handling the bulk processing of university diplomas. By comparing these estimates, the table offers valuable insights into the scalability and practicality of each Blockchain platform for educational credential management.

Table 3. Estimated transaction costs & maximum number of diplomas for each Blockchain

Estimating transaction fees (USD)				
Blockchain	Simple transaction	Transaction with data	Transaction with max data	Maximum number of diplomas
Ethereum	1,13	5,4	432	38
Polygon	0,00084	0,004	0,08	38
EOS	0,06	0,2	19	5
Cardano	0,0657	0,0797	0,35	90
Stellar	0,000001	0,000005	0,0001	16

4. Results

Intrapersonal intelligence, learning facilities, social support, and independence were obtained from filling out a questionnaire, and mathematics learning outcomes were obtained from the final

The results of the study show that the execution of each transaction differs, more specifically in terms of cost. This is clearly evident from the theoretical results obtained when calculating the estimated publication costs based on the criteria defined for each type of transaction mentioned. Based on the responses provided, table 4 provides a detailed summary of our study, where we apply the selected comparison criteria to various types of transactions. These criteria include transaction fees, confirmation times and scalability. For each Blockchain platform Ethereum, Polygon, Cardano, Stellar, and EOS, we assess how well they handle different transaction types associated with the issuance and electronic management of university diplomas.

The table categorizes transactions based on their complexity and data requirements, ranging from simple diploma verification requests to more data-intensive transactions like diploma issuance and updates. By applying our comparison criteria to these transaction types, we were able to evaluate the practical performance of each Blockchain under different operational scenarios.

For transaction fees, we measure the cost associated with each type of transaction on the respective Blockchains. Confirmation times are analyzed to determine the speed at which transactions are validated and added to the Blockchain. Scalability is assessed by examining how well each platform can handle an increasing number of transactions without compromising performance.

Table 4. Practical studies: transaction costs based on comparison criteria

comparison criteria	Testing a transaction without a diploma	Testing a transaction with a single Diploma	Testing a transaction with maximum Diplomas	Test max transactions for a single Diploma
Ethereum				
Transaction fees(USD)	2,64	6,22	257,87	236.36
Confirmation time(s)	15	30	60	40
Polygon				
Transaction fees(USD)	0,0018	0,0042	0,18	0,1596
Confirmation time(s)	3	5	5	6
EOS				
Transaction fees(USD)	0,02082795	0,03472915	0,5562168	0,8826716
Confirmation time(s)	2	3	3	4
Stellar				
Transaction fees(USD)	0,000111	0,000111	0,000111	0,000111
Confirmation time(s)	3	5	5	6
Cardano				
Transaction fees(USD)	0,0902	0,0905	0,04	8,145
Confirmation time(s)	20	30	40	45

The results, summarized in Table 4, provide a clear comparison of each Blockchain's strengths and weaknesses across these criteria. This comprehensive analysis offers valuable insights into which Blockchain platform is most suitable for specific types of transactions in the context of university diploma management, aiding institutions in making informed decisions for their credentialing systems.

In order to analyze the results more effectively, we represent them graphically to facilitate their interpretation. This visualization enables us to determine which Blockchain is most compatible with our study on the automation of university degrees.

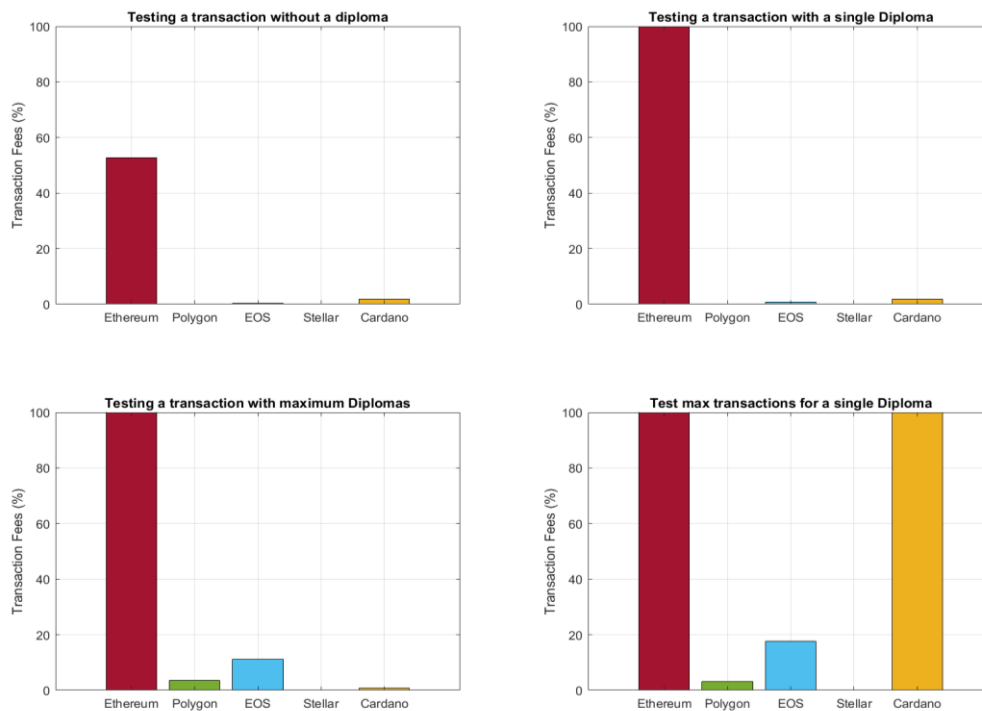


Figure 2. Practical study of transaction fees based on transaction types

We analyze various criteria such as transaction costs (see Figure 2 & Figure 3), execution time (see Figure 4), and memory usage. By comparing these parameters, we will be able to propose specific solutions and improvements to optimize the use of other Blockchains. This holistic approach helps us make informed recommendations for academic institutions looking to adopt Blockchain technology for the management and verification of their degrees.

As a result, the comparative analysis carried out between the Ethereum, Polygon, Cardano, Stellar, and EOS Blockchains is based on these criteria to obtain the optimum Blockchain for our field of study

Blockchain is a revolutionary technology with different cost criteria depending on the platform used. Different Blockchains such as Ethereum, Polygon, Cardano, Stellar, and EOS each have distinct cost criteria. Ethereum uses gas price, gas limit, and gas usage, while Polygon shares similar criteria tailored to its Ethereum scaling.

Cardano offers a fee structure based on the base fee, additional fees, and transaction size. Stellar distinguishes itself by its base fee and number of transactions, while EOS assesses costs based on CPU processing time, NET bandwidth, and RAM usage.

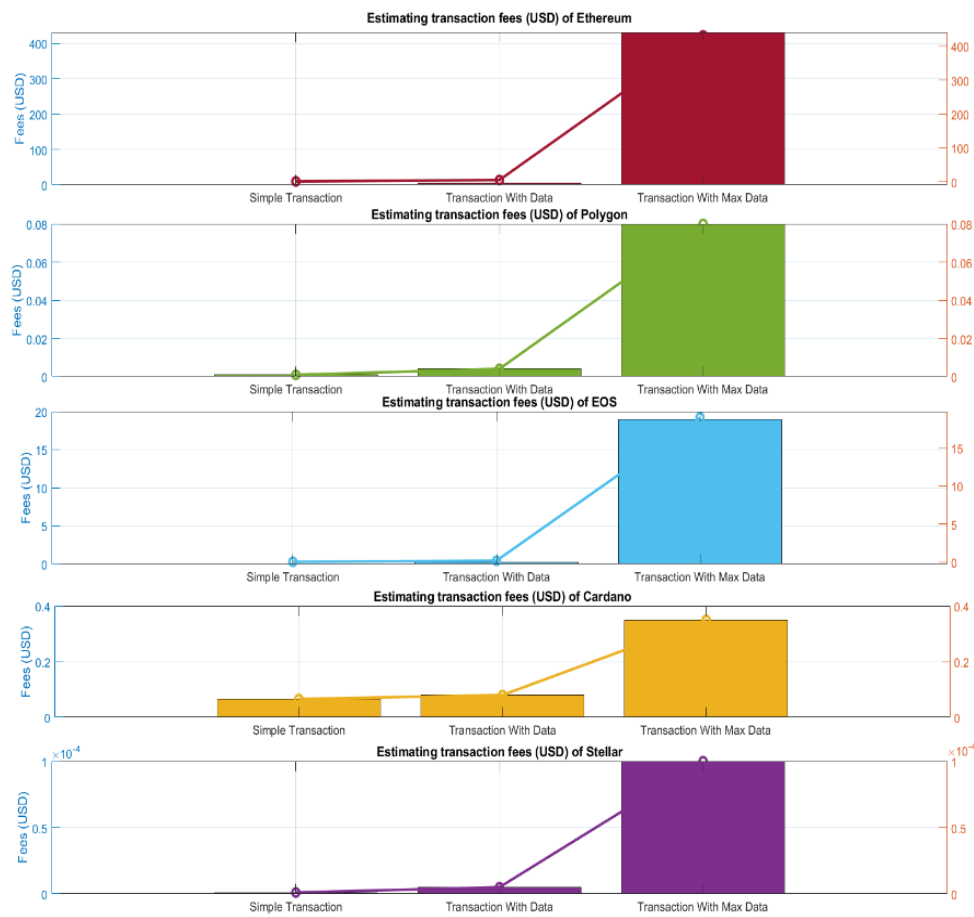


Figure 3. Practical Study of Transaction Fees Based on Comparison Factors for each Blockchain

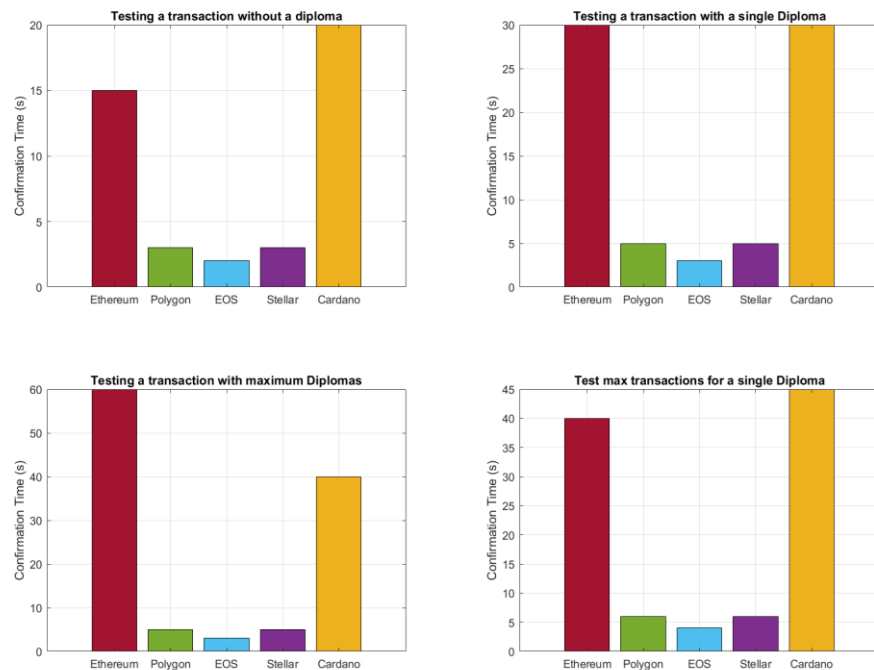


Figure 4. Practical Study of Confirmation Times for Proposed Transactions

5. Discussion

Referring to the results of data analysis, each Blockchain possesses its mechanisms for fee management and validation, such as the slot model in PoS consensus protocols and the use of nonce in PoW (Ouadoud et al., 2023).

Regarding transaction fee models of Polygon and Cardano, they share similarities with Ethereum but may have specific mechanisms unique to their respective networks. On Polygon, besides transaction size and network congestion, the fee model may also consider the complexity of operations and specific fee policies defined by the protocol. For Cardano, transaction fees may be influenced by similar factors such as transaction size, network congestion, and fee policies determined by the protocol. As for Stellar's transaction fee model, it differs somewhat from the Blockchains. Stellar employs a "base fee" mechanism adjusted automatically based on network load to prevent spam attacks. However, unlike Ethereum and other Blockchains, Stellar does not operate on a gas-limited model, and transaction fees are generally minimal and fixed.

Overall, while the basic concepts of transaction fees may be similar across Ethereum, Polygon, Cardano, and Stellar, the specific details and mechanisms of each Blockchain can vary based on their architecture, consensus protocol, and economic model.

Polygon offers very low fees and fast transactions while relying on Ethereum's security but with less decentralization. Cardano guarantees low, predictable fees, combined with enhanced security, although its ecosystem is still under development. Stellar stands out for its extremely low fees and fast transactions, making it ideal for micropayments, although less flexible for complex applications. EOS offers an innovative model with fast transactions and indirect charges for CPU and NET but introduces complexity in resource management and volatility in RAM costs.

For university degrees, where transaction costs and turnaround time are crucial, Stellar seems to be the most suitable Blockchain. It offers very low transaction costs and fast transactions, which are essential for the registration and frequent verification of university diplomas. This Blockchain also minimizes costs while ensuring near-instant finality, making the process of issuing and verifying diplomas both economical and efficient.

6. Conclusion and Perspectives

In conclusion, the Ethereum Blockchain provides the best development tools and community support. Stellar offers the simplest user interface and legal considerations for smart contracts. Finally, the EOS Blockchain offers the fastest smart contracts and the lowest costs. On the other hand, it was found that the Ethereum Blockchain has the highest costs and slowest execution times, that Stellar lacks the smart contract flexibility enjoyed by other Blockchains, and that the EOS Blockchain has the most convoluted environment and documentation, requiring more updates.

Blockchains offer a promising solution for university degree registration, with clear advantages in terms of security, transparency, and efficiency. Among the Blockchains studied, Stellar appears to be the most suitable for diploma transactions, due to its very low transaction costs and speed. However, the choice of Blockchains depends on the specific needs of each institution and the interoperability solutions available to maximize the efficiency and security of these systems.

These findings are in line with those of other researchers included in previous non-formal research work. As future improvements to the evaluation framework, the study should be deepened to add further criteria, and the needs of the field of study should be well specified, to properly target the most suitable Blockchain.

Declarations

Author Contributions. Oumaima: Conceptualization, literature review, introduction, results analysis, discussion, conclusion, suggestions, original manuscript preparation. Tarik: Methodology development, data analysis, contribution to results interpretation, review and editing of the manuscript. Ahmed: Support in literature review, methodological supervision, critical revision of the discussion and conclusion, review and editing. All authors have read and approved the final version of the article.

Conflicts of Interest. The authors declare no conflict of interest.

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Ethical Approval. This research did not involve human participants or animal experiments. Therefore, ethical approval was not required.

Privacy and confidentiality standards were respected throughout the study.

Data Availability Statement. The data supporting the findings of this study are available from the corresponding author.

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