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A Comparative Analysis of Public Versus Private Blockchain Platforms for Academic Credential Verification

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ABSTRACT: Some of the major challenges associated with academic credential verification comprise forging of certificates, slowness of manual credential verification and absence of data ownership. A decentralized and tamper-proof Blockchain technology is available, but institutions are uninformed on how to choose between a public or a private platform. The study performs a comparative study of the subject of public blockchain (Ethereum) vs. aPrivateblockchain(HyperledgerFabric)in terms of scholarly credential authentication based on secondary analysis of existing literature on the topic dating 2018-2025. Five metrics of performance are analyzed: transaction throughput, latency, cost, security and scalability. Findings indicate that the private blockchains can far outperform the public blockchains by all metrics, and with 1000-3500 TPS (in contrast to 15-30 TPS), milliseconds latency (in contrast to seconds-minutes), negligible costs (in contrast to 0.50-50pertransaction),andmoreimportant scalability. Public blockchains are only beneficial to transparency but adversely affect privacy and performance. The results offer practical advice to institutions, suggesting that most academic credentialing uses should be done on private/ consortium blockchains.
Keywords: Blockchain, Academic Credential Verification, Public Blockchain, Private Blockchain.

I. INTRODUCTION

A. BackgroundofAcademic Credential Systems

Conventional systems of academic credentials have core databases, which are operated by institutions. Such systems have severe problems such as data corruption, malicious access, single point of failure, and lengthy verification systems. Forging of certificates is verycommonandthestudentsdonotowntheir records [1]. Employers face challenges in authenticating credentials, which creates an urgent necessity to have more secure and transparent means.

B. OverviewofBlockchain Technology

Blockchain is a distributed registry of cryptographically recorded transactions over network nodes that are decentralised. Upon recording, data is not subject to any modifications without the unanimous decision ofthedata,thusitisimmutable.Timestamps are used to connect transactions within each block to the last blocks [2]. Single authorities are removed by their decentralized nature, cryptographic security ensures unauthorized changes,andblockchainissuitableinusecases that need a sense of trust and openness.

C. Publicvs.PrivateBlockchain Platforms

Public blockchains such as Ethereum are availabletoanyone,andarefullydecentralized and transparent but have low throughput and high transaction costs. Permissioned blockchainslikeHyperledgerFabricareprivate in nature, provide controlled access, quicker transactions and less expensive [3]. Their alternatives come at the trade-offs in the field of decentralization, performance, scalability, and privacy of academic credential management.

D. ProblemStatement

The centralized academic record systems are prone to the breach of data, manipulation and delayin verification.Thereis noagreementon whether academic credentialing is best suited on the public or the private blockchain platform. Institutions do not provide a comparative analysis to help them choose the platform in terms of their needs that include security,cost,scalability,andperformance[4]. This study fills in this gap, with a systematic comparison between the two types of blockchain.

E. ResearchAimandScope

The study seeks to carry out a comparative study of open and closed blockchain solutions to academic credential verification. This paper looks into Ethereum as a public blockchain implementation and Hyperledger Fabric as a private blockchain. The performance measurements involve the transaction throughput, latency, cost, security, and scalability [5]. The research is confined to the secondaryanalysisoftheavailableliteraturein 2018-2025.

II. LITERATURE REVIEW

A. CentralizedAcademicRecord Systems: Limitations

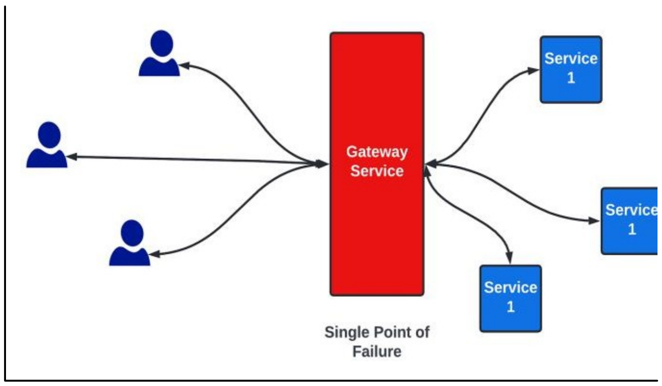


Figure1:Single PointofFailure

(Source: https://miro.medium.com)Centralized systems keep academic records in one institutional database,making them susceptibletohacking,in-houseabuse,and malfunctions in the systems. Confirmation can bedonemanuallywithaninstitutionand employerswhichcanalsotakeweekstobe confirmed.Formingforgeryofcertificatesisso prevalent,becauseitisimpossibletooffer against tamper-proof assurance, when centralized architectures are concerned. Studentsdonothaveownershipandportability of data [6]. These restrictions indicate the inappropriateness of centralized systems in providing secure and effective credential management.

B. BlockchainforAcademic Credential Verification

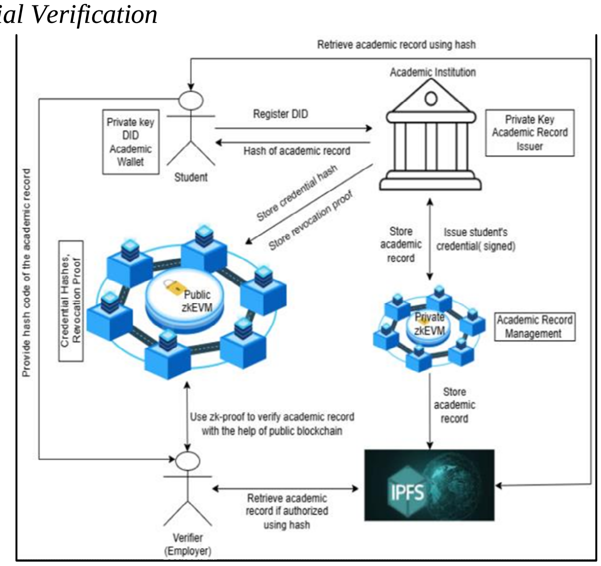


Figure2:Zero-knowledgeblockchain academic verification system (Source: https://www.mdpi.com)

Academic credentials can be stored on blockchain in a decentralized, immutable way. On-chain cryptographic hash of certificates guarantee verification without institutions by tampering. Smart contracts automated validation eliminating the verification time, which took days, to a few seconds [7]. Scientists have already shown blockchain-based prototypes that obtain a high degree of integrityandtransparency,whichcanbe consideredapromisingmethodtoeradicate credential fraud and simplify authentication.

C. PublicBlockchainPlatforms: Ethereum-Based Solutions

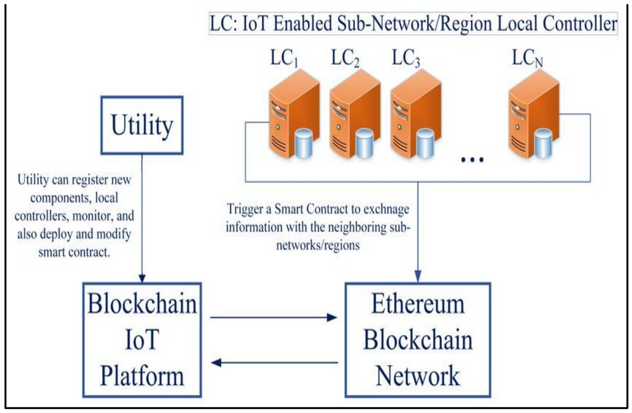


Figure3:Ethereumblockchainnetwork architecture

(Source: https://encrypted-tbn0.gstatic.com) The most popular publicblockchainincredentialingofacademicsisEthereum.The literatureindicatesthatEthereumoffersfull decentralizationandvisibilitybuthasalow transactionthroughput(15-30TPS)andhigh gascostswhenthereisnetworkcongestion(15-30 TPS) [8]. Studies have provided successful proof-of-concept deployments, and large universitieswiththousandsofcredentialsdaily find scalability a challenge.

D. PrivateBlockchainPlatforms: Hyperledger Fabric Solutions

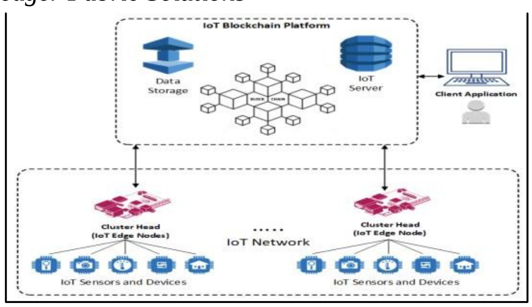
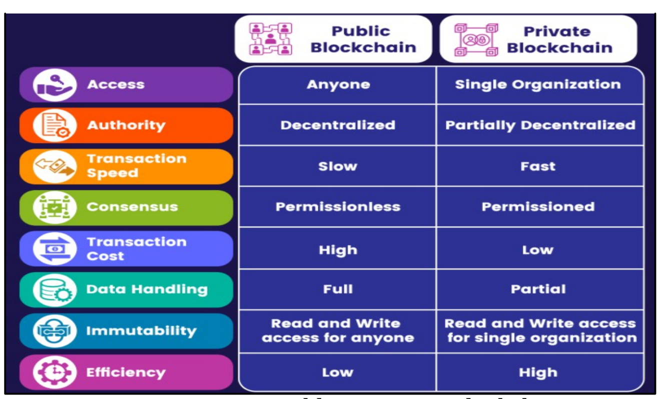


Figure4:HyperledgerFabricBlockchain for Securing the Edge Internet of Things

(Source: https://www.mdpi.com) Hyperledger Fabric is a permissioned blockchain that provides easyaccess, a greater transaction throughput (up to 3500 TPS) and low transaction costs. Research shows that Fabric is better-suited to institutional applications because of data privacy settings, and regulatory requirements [9]. In Fabric, researchers have deployed academic record systems with much better performance and scalability than its public counterparts.

E. ComparativeStudiesonPublicvs. Private Blockchains



	Public Blockchain	Private Blockchain
Access	Anyone	Single Organization
Authority	Decentralized	Partially Decentralized
Transaction Speed	Slow	Fast
Consensus	Permissionless	Permissioned
Transaction Cost	High	Low
Data Handling	Full	Partial
Immutability	Read and Write access for anyone	Read and Write access for single organization
Efficiency	Low	High

Figure5: PublicVsPrivateBlockchain

(Source: https://101blockchains.com) Thereispaucityofcomparativestudiesdirectly pitting private against public blockchains with regardtoacademiccredentials.Theavailable literature suggests that permissioned Blockchainsaremoreefficientintermsof throughput and costs, whereas in the case of establishing the public blockchain better transparency and decentralization are granted. There is still no agreement regarding the best platform choice. The vast majority of comparisons are not empirical but based on ideas, which needs systematizing assessment.

F. ResearchGapsIdentified

The literature contains various gaps: none of the studies empirically compare public and private blockchains in academic credentialing; none of them offer formal performance indicators; none of them study corresponding costs and benefits analysis across different platforms; no one has guidelines on how to select a platform, depending on institutional needs;noonehasproperly-validatedscalability assertions. These gaps are tried to fill in this paper using systematic secondary analysis.

III. METHODOLOGY

A. ResearchType

In this study, a secondary analysis method is used, which involves systematic review and synthesis of literature on a particular topic in the form of peer reviewed journals, conferences, books and other credible sources found online. There are no major experiments and data gathering. This approach suits the comparison of the public and private blockchain platforms since it makes use of the already blended knowledge of the various studies to come up with holistic findings.

B. Data Collection Strategy

Informationisgatheredinonlinedatabases suchas IEEE Xplore, SpringerLink, ScienceDirect, ACM Digital Library and Google Scholar. Keywords to be searched are: public blockchain, private blockchain, Ethereum, Hyperledger Fabric, academic credential verification and blockchain education[10].Publishedmaterialsthatdate backto2018-2025areabstractedonlyto make the findings relevant and up to date.

C. Inclusion and Exclusion Criteria

Sources that are included include peer-reviewedjournals,conferencepapers,and authoritativebooks.Othersourcesthatwillnot beincludedarenon-peer-reviewedopinions, blogposts,cryptocurrency-onlystudies,and studieswhichdo notexplicitlyconsider blockchain in academic credentials. The numberofsourcestobeanalyzedisabout20- 25.Thisguaranteesqualityandrelevanceof effects produced through synthesis.

D. ComparativeAnalysis Framework

The comparative scheme is implemented in a structured manner and looks at four aspects such as security properties, transaction, cost structure, and scalability. Being compared to each other are public blockchain (Ethereum) and private blockchain (Hyperledger Fabric). All platforms are rated according to the same criteriasoastobefairlyandsystematically compared to each other in all the identified metrics.

E. PerformanceMetrics

This is performed using five performance indicators: transaction throughput (TPS), latency(verificationtime),transactioncost(gas fees or operational cost), security level (immutability and access control), and scalability (capability to support more users) [11]. These measurements are based on literature and offer quantitative and qualitative foundation on which platforms can be compared.

F. EthicalConsiderations

All references are well cited to prevent plagiarism.Resultsarereportedinatransparent manner with no preferential omission of evidence opposing the findings. There is no data creation and manipulation. Academic fair use is the use of copyrighted materials. This helps make the research remain intact and credible and adheres to ethical aspects in the process of secondary analysis.

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IV. RESULTS AND ANALYSIS

A. TransactionThroughput Comparison

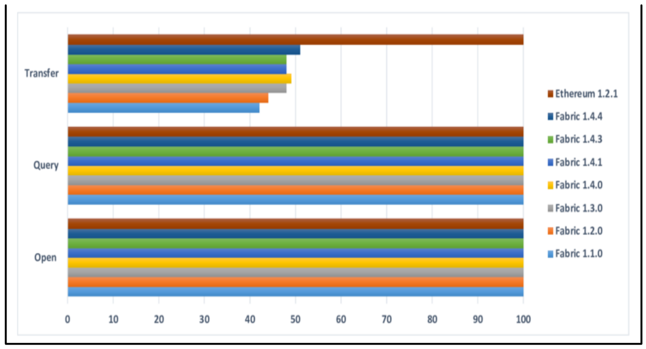

Figure6:SuccessratesofHyperledger Fabric and Ethereum

(Source: https://www.researchgate.net) Ethereum andotherpublicblockchain systems canhandleabout15-30transactionspersecond (TPS) and it cannot support large educational institutions that issue thousands of credentials each day. During network congestion, throughputisfurtherreduced.Inthecaseof private blockchain platforms such as HyperledgerFabric1000-3500TPSisunder thesame condition.Higheracquisitionvolume ofverificationwouldcausehighcapacity academic institutions to be delayed heavily on the public blockchains. Institutions The throughputoftheinstitutionalworkloadwith private blockchains is sufficient, thus they are moreappropriateinlargedeployments[12]. Thisisacriticalthroughputgaponwhicha platformcanbeselectedbyinstitutionalsize and volume of transactions.

B. LatencyandVerificationSpeed

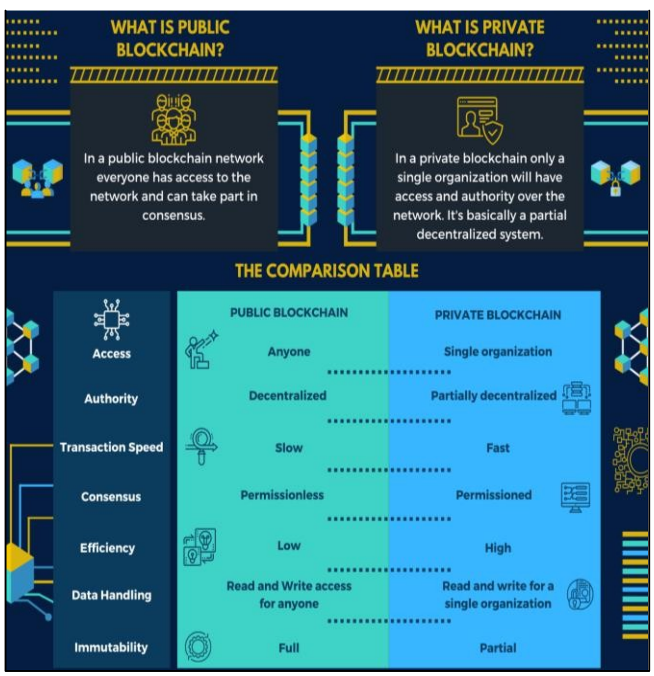

Figure7: PublicVsPrivateBlockchain

(Source: https://101blockchains.com) Publicblockchainlatencyofverificationcan range between 15 seconds and several minutes basedonnetworkcongestionandthecostinthe formofgasfees.Theverificationofprivate blockchainsrequiresmillisecondstoseconds becauseofpre-authorizedvalidatorsandno miningrace.Tocheckacademiccredentials, theresultsneededbytheemployerandthe institutionarealmost instant[13].Nanosecond verificationisalwaysachievedthroughprivate blockchains,whereasunacceptable delaysare generated by public blockchains. Execution of smartcontractsonHyperledgerFabrictakes 0.5-2 seconds to complete, whereas Ethereum takes12-60secondstoexecute,whichis evidently beneficial when it comes to permissionedplatforms.

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C. CostAnalysis

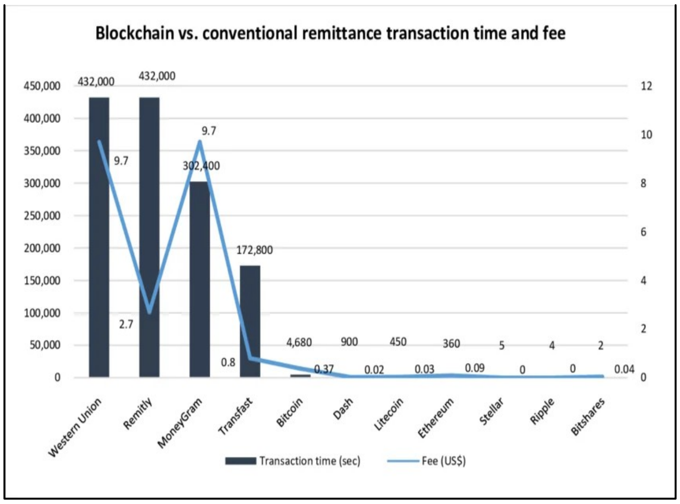

Figure8:Blockchainvs.Conventional Remittance Transaction

(Source:https://encrypted-tbn0.gstatic.com) Transformingpublic blockchain consumes gas costsofbetween0.5,and50ormoreinperiods ofhighload.Acceptingananualissueof 10,000 credits, the institutions might spend up to $5,000-500,000, which is costlyto afford in termsofmoneyinthecaseofapublic blockchain. In private blockchains, there is no transactiongasfee,theonlycostishosting, development of new infrastructure, and maintenance.Theaverageyearlycloudhosting costofHyperledgerfabricsisapproximately between5,000and20,000.Theconsortium modelsalsosavecostsastheyallowsharingof costs between more than two institutions [14]. In general, large-scale academic credentialing is economically infeasible using public blockchainsbecauseoftheirrandomhighcosts of doing transactions.

D. SecurityandImmutability Assessment

	Public Blockchains	Private Blockchains
Access level	Anyone	Single organization
Participation	Permissionless Anonymous	Permissioned Identities are known
Security	Consensus mechanism Proof of Work / Proof of Stake	Pre-approved participants Voting / multi-party consensus
Performance	Slow transaction speed	Lighter blockchain Fast transaction speed

Figure9: Privatevs.Public Blockchains

(Source: https://miro.medium.com) Public blockchains are somewhat more decentralizedandtransparentwiththousandsof nodesauthenticatingthetransactions.Onceitis sure,thenimmutability.Nonetheless,thereis no assurance of data privacy as in all cases all transactions are visible publicly. Similarimmutabilitywithrestrictedaccessisavailableinprivateblockchains,anditsdataprivacy would be better in the case of student records. Security mechanisms rely on consensus: EthereumisbasedonProof-of-Work/Proof-of-StakeandHyperledgerFabricisbasedonpluggableconsensus[15].Bothofferdata protectioncontrolsbyensuringtamper-proof storage,althoughpermissionedaccesscontrols and optional data encryption allow the use of private blockchains to comply more with data protection regulations.

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E. ScalabilityEvaluation

Property	Public Blockchain	Consortium Blockchain	Private Blockchain
Consensus determination	All miners	Selected set of nodes	One organization
Read permission	Public	May be public or restricted	May be public or restricted
Immutability	Almost completely tamper-proof	Potential for tampering	Potential for tampering
Efficiency	Low	High	High
Centralized	No	Partial	Yes
Consensus process	Permissionless	Permissioned	Permissioned

Figure 10: Comparison of public, consortium and private blockchains

(Source: https://encrypted-tbn0.gstatic.com) Public blockchains have high scalability constraintsthatlineartransactionprocessing and block size imposes. Partial improvements comewithacostinlayer-2solutionswhich makesthemmorecomplex.Instead,private blockchains enhance theirsizethroughhorizontalscaling,consistingofadditionalpeernodesandwithanefficientconsensusprotocol. Hyperledger Fabric promotes the channel architecture that isolates transactions among particular network participants, which is effective in distributing workload. In the case of multi-institutional deployments across the universities, the scalability offered by the private blockchain consortia is better [16]. Without fundamental architectural modifications, the scale of a typical public blockchain to a national-scale academic credentialing system is impractical, which means that the only viable choice in implementing such systems is a private platform.

F. SummaryofComparative Findings

On all metrics considered, including throughput (3500 vs 30 TPS), latency (millisecondsvsminutes),cost(negligiblevs$0.50-50 per transaction) and scalability, private blockchains (Hyperledger Fabric) are better than public blockchains (Ethernet). Transparency of public blockchains is good; however, it comes at a cost of privacy and performance. In the case of institutional academiccredentialverificationinstant,theuse ofprivateblockchainsisevidentlythebest.The consortia might need the highest level of decentralization which is provided with public blockchains [17]. Choices of the platforms are based on institutional priorities: private to achieve efficiency and public to achieve transparency.

V. DISCUSSION

A. Interpretation of Key Findings

Thefindingsclearlyindicatethatinsteadofthe publicblockchains,theprivateblockchainsare better inperformancewithregardto throughput, latency, cost, and scalabilitywhen verifying academic credentials. This reaffirms thatauthorizedtechniquessuchasHyperledger Fabricaremoreadvantageousininstitutional applicationsboth technicallyand economically. University-scalelevelsoftransactionsare impossibletoprocessonpublicblockchains withoutforbiddingcosts.Ontheotherhand, decentralization and transparency are superior in the case of the public blockchains. The results indicate that the choice of the platform should be based on institutional priorities, and the use of the private blockchains are viable in most universities.

B. ComparisonwithExisting Literature

These results are consistent with other studies that supported the use of permissioned blockchains in education. But they go against initialresearchwhicharguesinfavourofpublic blockchains with the greatest transparency. Previous studies documented Ethereum-based systems that worked but noted the lack of scalability, which agreed with ours. The findingsaddvalueto the previous literatureby offering direct quantitative comparison, which was not in previous studies. This synthesis containsconflictingclaims,andthisisresolved showing that the platform appropriateness is based on unique performance needs and not universal excellence.

C. ImplicationsforAcademic Institutions

Credential management at universities should be done on privately hosted or consortium blockchains, not on a public platform. Hyperledger Fabric provides adequate throughput, real-timevalidation, lowcosts and compliance by the regulation. The small institutionscanalsobecomemembersof consortium blockchains, to share the infrastructurecosts[18].

Publicblockchainsare not advisable unless ultimate transparency is important over performance like in a multi-stakeholder consortium where a public auditabilitywouldberequired.Beforeselecting aplatform,institutionsneedtocarryoutacost-benefit analysisonthebasisoftheir volumeof verification.

D. Trade-offsBetweenPublicand Private Platforms

The critical trade-off is between transparency and performance and privacy. Public blockchainsarefullydecentralizedbutnotfast, cost-efficient, and data protection. The private blockchains are cheaper and offer better performance; however, they do not rely on as many validators. In educational qualifications, confidentiality and effectiveness are of paramount importance, and confidential platforms are preferred. Halfway solutions involvingbothcouldbethebestsolutions,with the public certificate hashes being held on publicblockchainsandtheprivatestudentdata kept off-chain.

VI. LIMITATIONS

There are a number of limitations to this research. The research will follow a secondary research method where all the sources of existing literature are used. This synthesis inherits biases, methodological flaws or inaccuraciesoforiginalsources.Ethereumis only a representative of the public blockchain andHyperledgerFabricisonlyarepresentative oftheprivateblockchain,whichdoesnotallow a comparative analysis. Other platforms like Solana,CordaorQuorumwerenotinvestigated and might have different comparative outcomes. The absence of primary experimental validation will imply that the performance metrics used are considered to be based on various studies sharing different test conditions, network configurations, and evaluation methodologies. Inconsistencies in directquantitativecomparisonscanbepresent. English-language articles published within 2018 through 2025 were taken into consideration, which might reject any non-English studies or studies containing foundations that are older. The speed of development of the blockchain technology implies that capabilities of platforms are being developed often. The adoption of Proof-of-Stake by Ethereum and the continuing innovations in layer-2 can change these performanceaspectsthatarenotfullyreflected inthisanalysis.Therewasnoreal-worldtesting (institutionalworkloads)onlivenetworks.The results are conclusions derived out of the literature, but no experimental verification is provided. It analyzed strictly on technical and economic indicators and not on the aspect of organizational change management, staff trainingneeds,andfactorsofuseradoptionthat haveaconsiderableinfluenceonthereal-world implementation results. The limitations should beovercomebyspecificprimaryresearchinthe future by empirical testing.

VII. FUTURE ENHANCEMENT

This comparative research can be expanded in a few ways that are outlined in the future. To begin with, it must be empirically tested with real-worldapplication. Infutureresearch,both public and private blockchain implementation shall be applied on real university environments, where transactions throughput, latency, and cost analysis will occur as they happen, and the workloads of the institutions are in operation. This would give actual performance information as opposed to literature based comparisons. Second, it is suggested to expand to other blockchain platforms. In addition to Ethereum and Hyperledger Fabric, future studies would involve other publicly available platforms like Solana, Cardano, and Avalanche and some privately available platforms like Corda and Quorum. An expanded range of comparative analysiswouldbeacompleteguidetoplatform selection. Third, there is the need to develop a decision support model of institutions. An empirical research might result in a tool or matrix available to assist universities choose the most reasonable blockchain platforms according to their unique requirements: the number of students, the number of credits placedeveryyear,financiallimitations,privacy demands,andregulatorynecessities.Fourth,a new direction to explore hybrid blockchain architecturehaspotential.Possiblefuturestudy shoulddevelopandpilotsystemsthatcombine the advantages of both the public and private block chains where data on the anonymized certificate hashes stored in the public blockchain to be transparent but the private student data are stored in permissioned networks or off-chain storage of the data. The uncovered trade-off presented in this study is the inability of transparency and privacy to exist simultaneously. This hybrid solution would address this trade-off. Fifth, it should become connected with the new technologies. Using a combination of blockchain and zero-knowledge proofs would allow selective and non-disclosure of credentials without resulting in all of the student data being revealed. Portable ownership of credentials brought by integration with self-sovereign identities systems would provide students with cross-institutional ownership on their side. Interoperability standards to enable various blockchain platforms to communicate interchangeably should also be investigated. Sixth, five-to-ten years costs and benefits analysis would assist the institutions to comprehend the long-term economic issues. Lastly, user acceptance research on administrator, student and employer attitudes toward either public or private blockchain credentialswouldmitigateadoptionchallenges not discussed in this technical comparative.

VIII. CONCLUSION

This study made a comparative analysis of academically verifying credential blockchain through both a public and privately operated blockchain platform with Ethereum and a representative of a public blockchain and Hyperledger Fabric a representative of a privatelyoperatedblockchain.Itidentifiedfive performance indicators, namely, transaction throughput, latency, cost, security, as well as scalability systematically evaluated through secondaryanalysisofcurrentliteraturethrough 2018-2025. The results are quite evident, showing that the performance of private blockchains is significantlyhigher than that of public blockchain in the majority of metrics that can be related to institutional academic credentialing. Hyperledger Fabric has a throughput of 1000-3500 TPS against Ethereum throughput of 15-30 TPS and saves latency of verification which would otherwise take seconds or minutes. In contrast, the cost per-taxofaprivateblockchainiszero,whereas the gas costs per-tax of a public blockchain lie between $0.50 and $50 and above, so massive scale deployment would be prohibitively expensive.Scalability:Privateblockchainscan achieve better scalability, with channel-based designs (and horizontal scaling). Public blockchains are only beneficial in terms of decentralization and transparency, in which all transactionscanbepubliclyaudited,butthis Transparencyisincompatiblewithstudentdata privacy concerns and regulatory and compliance requirements including GDPR. In thecaseofthecredential managementsystems atmostacademicinstitutions,thebestchoiceis aprivate/consortiumblockchain. Transparency / performance-privacyis the root trade-off that determines which platforms to use, where organizations focus on efficiency, cost-effectiveness,andprotectionofpersonaldatais betterservedbyprivateblockchains,andmulti-stakeholder consortia advantages are more important with public platforms. Hybrids, in which the hashes of certificates are posted publicly,butthestudents'dataiskeptprivately, hold some bright future. This study clarifies contradictory assertions in the literature by showing that the platform suitabilityis a result of particular institutional demands and not universal preeminence, can be applied practicallyto guideuniversities,policymakers, and system designers, and requires future empirical verification and exploration of hybrids in advance of these findings.

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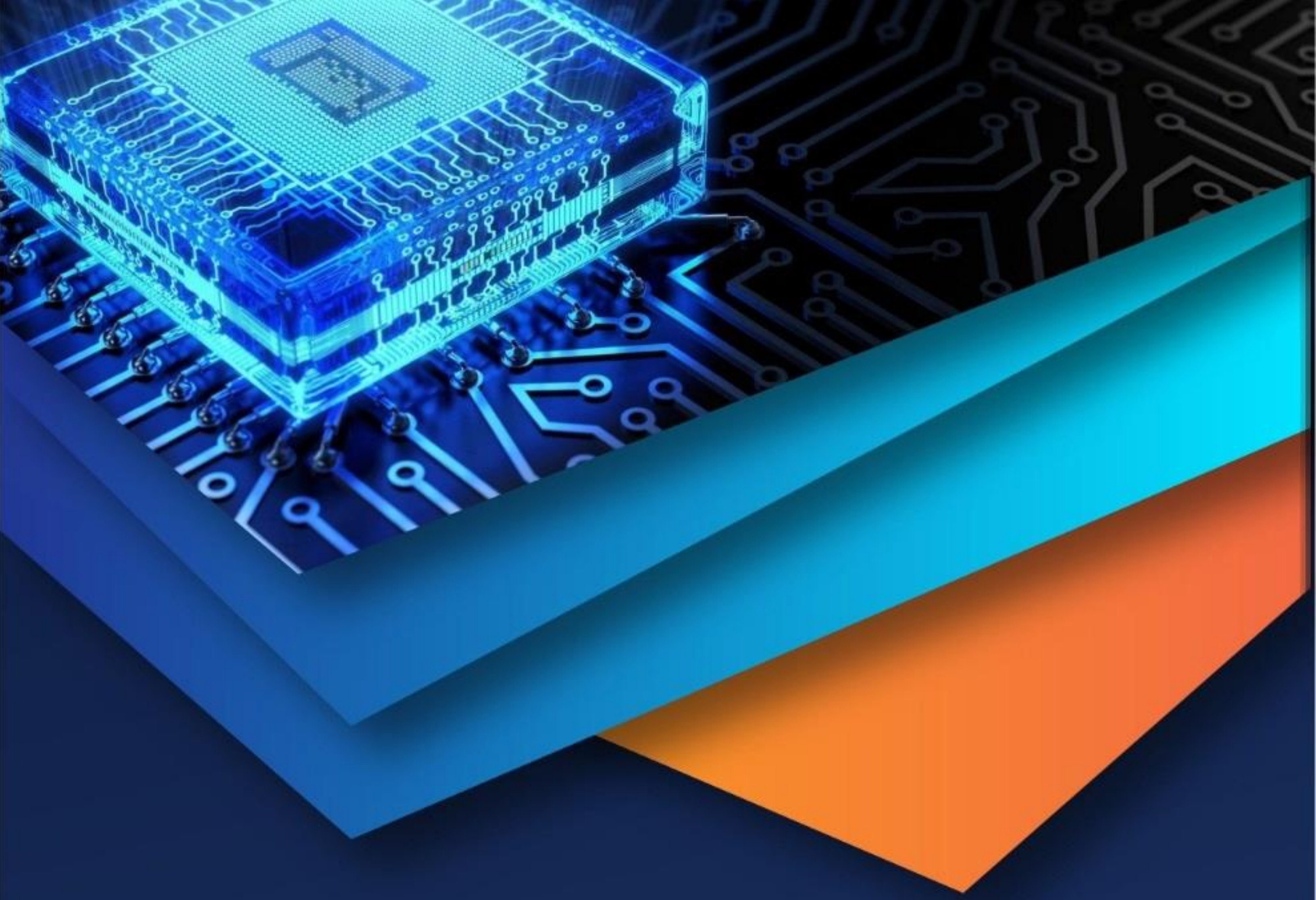

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