Data and Metadata. 2025; 4:201
doi: 10.56294/dm2025201

ORIGINAL

Blockchain Network for Regulation Decentralized E-Government Systems

Red Blockchain para la Regulación de Sistemas de Gobierno Electrónico Descentralizados

Hayder A. Nahi[1] ✉, Ali Khalid Ali[1], Mohamed Ali Alaraji[2], Zahraa Jawad Mohi[3], Noor Thamer Mahmood[4], Akmam Majed Mousa[1], Moatasem Mohammed Saeed[1], Rusul A.Almansoori[1]

[1]Computer Center, Al Qasim Green University. Babylon 51013, Iraq.
[2]Ministry of Interior.
[3]College of Environmental Sciences, Al Qasim Green University. Babylon 51013, Iraq.
[4]Computer center, University of Babylon. Hilla, Iraq.

Cite as: Nahi HA, Khalid Ali A, Ali Alaraji M, Jawad Mohi Z, Thamer Mahmood N, Majed Mousa A, et al. Blockchain Network for Regulation Decentralized E-Government Systems. Data and Metadata. 2025; 4:201. https://doi.org/10.56294/dm2025201

Submitted: 15-05-2024 **Revised:** 10-09-2024 **Accepted:** 23-02-2025 **Published:** 24-02-2025

Editor: Dr. Adrián Alejandro Vitón Castillo

Corresponding Author: Hayder A. Nahi ✉

ABSTRACT

The combination of blockchain network with e-government systems carries convert possible for increasing transparency, trust, in addition to the efficiency in common managements. This paper looks into the implementation of blockchain technology to evolve a decentralized frame for e-governance, holding high difficulties of fraudulence, inefficiency, and loss of liability in conventional systems. The results detect that blockchain has the ability for notably increase transparency and trust over 30-50 % via unchangeable and demonstrable data records, decreasing fraud over 75 %. Furthermore, the systems that depending on blockchain-use enable authentication procedures to be 60-80 % rapidly compared to classic techniques, simplification official paper verification and approval processes. Additionally, this paper emphasizes reducing expenditures of 20-30 % resultant procedure automation and lessens reliance on mediators, giving further sustainable governmental functioning. As well, the results of blockchain's scalability permits decentralized e-government platforms to process 50-70 % extra transactions without compromising performance, pretending its viability for extensive common services. These outcomes emphasize the possibility of blockchain to revolutionize e-governance via promoting a further transparent, efficient, and reliable system. This paper supplies a foundational framework for policymakers and technologists work toward to extend blockchain solutions in common managements, facilitating the road for a decentralized and national centric governance model.

Keywords: Blockchain; E-Government; Smart Contract; Decentralization; Transparency.

RESUMEN

La combinación de la red blockchain con los sistemas de e-gobierno lleva a convertir posible para aumentar la transparencia, la confianza, además de la eficiencia en las gestiones comunes. Este trabajo estudia la implementación de la tecnología blockchain para desarrollar un marco descentralizado de e-gobierno, teniendo en cuenta las altas dificultades de fraude, ineficiencia y pérdida de responsabilidad en los sistemas convencionales. Los resultados detectan que blockchain tiene la capacidad de aumentar notablemente la transparencia y la confianza en más de un 30-50 % a través de registros de datos inmutables y demostrables, disminuyendo el fraude en más de un 75 %. Además, los sistemas que dependen del uso de blockchain permiten agilizar los procedimientos de autenticación en un 60-80 % respecto a las técnicas clásicas, simplificando los procesos oficiales de verificación y aprobación en papel. Además, este documento hace hincapié en la reducción de los gastos de 20-30 % resultante de la automatización de procedimientos y disminuye la

dependencia de los mediadores, dando un funcionamiento gubernamental más sostenible. Asimismo, los resultados de la escalabilidad de blockchain permiten a las plataformas descentralizadas de administración electrónica procesar un 50-70 % más de transacciones sin comprometer el rendimiento, lo que demuestra su viabilidad para amplios servicios comunes. Estos resultados ponen de relieve la posibilidad de que blockchain revolucione la gobernanza electrónica mediante la promoción de un sistema más transparente, eficiente y fiable. Este artículo proporciona un marco fundacional para que los responsables políticos y los tecnólogos trabajen para extender las soluciones blockchain en las gestiones comunes, facilitando el camino hacia un modelo de gobernanza descentralizado y centrado en el país.

Palabras clave: Blockchain, E-Government; Smart Contract; Descentralización; Transparencia.

INTRODUCTION

Blockchain technology was first presented in implementations of cryptocurrency.[1,2] blockchain are temper-proof, transparent, digital ledgers executed as distributed networks of peer-to-peer nodes that make transactions secure and do not need to be approved by a centralized authority. Every transaction's information is hashed and stored in blocks, the block also stores the hash of the previous block so that this chain of blocks is called ledger.[3] In this way, a group of users can keep track of their transactions in a shared ledger, preventing them from being changed after being added to the blockchain. Consequently, the blockchain enables peer-to-peer nodes, without a trust relation, to give-and-take data without the need for third parties or intermediaries. Any type of data could be digitized, including currency, contracts, medical records, education records, certificates, the sale and purchase of goods and services.[30]

One application of using blockchain is e-government which refers to using internet services to deliver the services provided by the government to the citizens online. In adopting this technological approach, citizens' and businesses' transactions with government authorities can be decentralized, and data integrity and immutability can be ensured.[4]

Although this technique provides many advantages, there are raised concerns about the privacy of the users since they provide sensitive data which needs to be protected properly from adversaries. In order to implement the proposed solutions, legal restrictions, like those established by the General Data Protection Regulation (GDPR),[5] have to be considered as well as respecting user privacy through spreading transactions in the ledger, while supplying access to public management teams and other stakeholders as necessary.

Background

Blockchain technology

Blockchain technology is a peer-to-peer decentralized network which maintains a constantly growing shared database over the Internet figure 1. As a name, blockchain refers to the process of chaining together multiple transactions to form a block of records.[6] Once transactions are executed, they are hashed and stored in the blocks. In addition to storing information about the transactions, a new block contains the hash of its preceding one. A hashing method is used to secure, integrate, and identify information in the blockchain.[7]

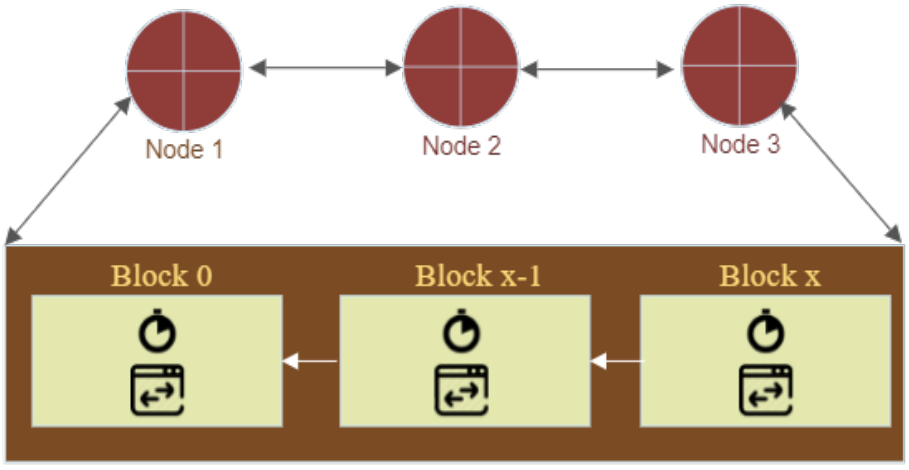

Figure 1. Blockchain technology framework[3]

E-government

E-government uses Information and Communication Technologies (ICT) for providing user-friendly services to the citizens across various departments.[8] Such services make it possible for public and private sectors of organizations to communicate using web portals regardless their physical locations, at the same time improving the transparency, convenience, quality of the public service. Nowadays, most of the countries are required to utilize digital communication among businesses, citizens, and the government.[9,31] E-government usage provides tractability and transparency which make officials and administrators more responsible and democratic. E-government systems are divided into 4 categories: Government to Business, Government to Citizens, Government to Employees, and Government to Government.[10]

Role of Smart Contracts in Governance

Smart contracts represent a transformative part in governance via increasing transparency, effectiveness, in addition to the confidence in decision-making procedures. The deem and pass agreements work to automate and impose predetermined rules, lessen the require for mediators and decreasing official inadequacies. Regarding systems of decentralized governance, like Decentralized Autonomous Organizations (DAOs), smart contracts simplify transparent voting,[28] guaranteeing justices and accountability. Additionally they enable real-time carrying out of decisions, like expenditure or resource allocation, depending on the consequences of collaborator input. Through giving immutable records and automating congregation procedures, smart contracts construct confidence amidst participants, achieving for extra transparent in governance systems, efficient, and reliable.

Literature Review

Blockchain technology was earliest established in[11] work towards at designing a decentralized and reliable digital currency that can keep away from various financial danger. It is generally related accompanied by virtual currency since the bitcoin is the biggest effective and famous application of blockchain.[12] Newest, the mentioned currency with the basic blockchain have got notable acceptance.[13] These days, the blockchain has look good a main and favorable technologies and executed on the far side of crypto currency implementations, particularly in security of health data supply chain networks, financial applications of blockchain and E-government.[14,15,16,17]

Actually certain blockchain structures supplying versatile and pliable platforms to execute a diversity of applications, for example, Quorum, Ethereum, Corda. As long as make mention of performance, Thus structures normally be calculated in expressions of throughput, latency, and scalability.[18] The others in[19] offer exploration about the performance of jointly Ethereum with Hyperledger Fabric, marking that the Hyperledger exceeds the Ethereum in a performance.

Through merge blockchain and big data technologies in all their activities, governments are working concerning data analysis and interpretation and evidence-based conclusions and pursuit of determining newly discovered policies for a government. All assists governments in encouraging sustainable evolution to hold up flexible the communities.[20,21] So long as the world is testify fast assumption of blockchain strategy, with an predicted market cost exceeds 176 USD billion on 2025,[22] its uses within e-government is as well obtain foundation.[23] The governments that based on Blockchain have the ability to e-government operations, attain evolved levels of capacity, and make better the administration of the common advantages.[24,25]

Blockchain network can be utilized so as to appear to be a platform to convert the e-business work manners to provide completely incorporated services and impose usual business principles.[13] That technology can gain the government and the popular in guaranteeing identities, documenting confidence, swapping assets amidst parties about sides, and creating digital contracts.[26] Blockchain network is very secure and a not closed, distributed ledger which has ability records all transactions among parties expertly and in a confirmable and endless manner.[27] These advantages can increase the construction of tough societies, through keeping path of data through many actions and actors, trusting and ensuring the implementation of duties, and enabling the up growth of many transparent and responsible governments.[21] Also a very important topic about the virtual judge was presented in this paper.[32]

Blockchain and E-Government

Blockchain technology is altering the route governments works via providing safety, transparent, and efficient findings for public management. Due to decentralized characteristic and unchangeable record, blockchain give the governments to increase confidence and accountability in all procedures. Via digitizing sensitive activities such as identity confirmation, voting systems, and common records administration, governments can minimize fraud, get rid of inefficiencies, and warrant the accuracy, integrity, consistency, and validity of data. Also promotes data sharing among managments, enabling real-time cooperation and efficient services for nationals.

In the field of digital governances, blockchain gives tight e-governance platforms where nationals have the ability to interact with government services smoothly. Smart contracts automate management's procedures,

such as social protection distribution and tax gathering, enclosing compliance with determined rules while decreasing functioning costs. Also, blockchain's capability to produce unchangeable voting systems for gives democracy via enabling transparent, traceability, and reachable elections. Some countries such as Estonia and Dubai are revolutionary blockchain-used governance sample, establishing its possibility to streamline managerial frameworks globally.[29]

Finally, Blockchain promotes nationals enabling via decentralizing control their personal data. The way to digital identity that grant individuals control over the information that called Self-sovereign identity (SSI), individuals can be in charge of their own data in stable manner and share it with government official state offices when required. This way not only improves data confidentiality but also corresponds with the rules of digital sovereignty. Furthermore, blockchain technology permits governments to cooperate over borders on cases such as supply chain transparency, climate monitoring, and digital trade. Via leveraging blockchain, digital governments can enhance trust, get better efficiency, and warrant inclusivity in the distribution of public services.

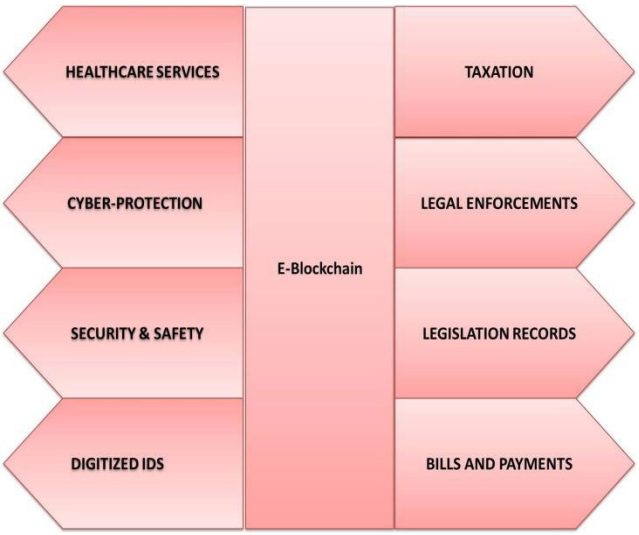

Figure 2. Using Blockchain with regard to Government services

Proposed System

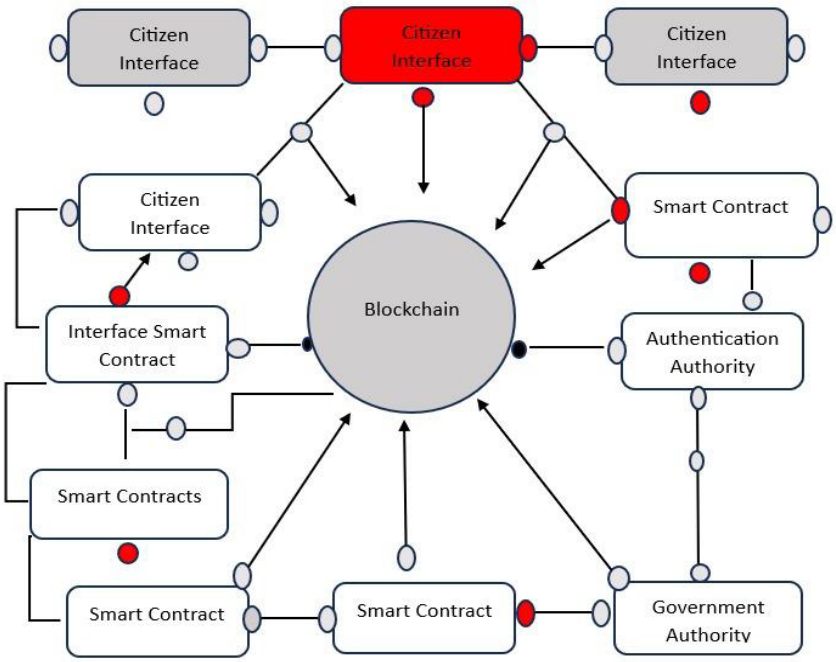

Figure 3. Components of proposed system

The system uses blockchain technology to produce a decentralized, safe, and transparent platform for e-government services figure 3.

The system goals to progress capacity, trust, and accessibility via removing mediators, automating procedures combined with smart contracts, and make sure data consistency. Following is an simplification of each one of the component of the system table 1.

Table 1. Component of the system Description

Component	Description	Role in the System
Blockchain	A decentralized, distributed ledger used for keeps each of transactions securely and immutably.	A basic for keeping and validating data. Guarantees transparency, security, and ease of access for whole system parts.
Citizen Interface	A user-affectionate platform for citizens to react with all services of the government.	Permits nationals to demand services.
Smart Contracts	Automatically at a specified time executing contracts with determined regulation stocked on the blockchain.	Automates repeated missions such as validating requirements or release certificates.
Government Departments	Different government sectors (e.g., tax, social services) linked to the system.	Process and validate demands presented by citizens.
Authentication Authority	Responsible for confirming user's identities and validating official papers.	Warranties authenticity of a user's who uses system submissions utilizing blockchain-stored records.
Public Services	Various of electronic government services supplying to nationals (e.g., tax, license renovations).	Make ease the providing of common services.
Nodes	Decentralized entities in the network of blockchain that check or prove transactions.	Warrant the blockchain integrity and security.
Immutable Records	Invulnerable storage of whole systemtransactions.	Warrant data integrity and block fraud via creating records immutable the moment that append to the blockchain.
Verification Data	Safe information holds on the blockchain for validating a person who presented submissions.	Documentation identity specifics, digital signatures, and document hashes with blockchain records over authentication.

The Citizen Interface algorithm 1 is offered to make more intelligible citizen interaction with all services of government services through supplying a user-affectionate platform for presenting demand and tracking their progress. It proves the users input data, creates a individual request ID utilizing a integration of national specifics and timestamps, and stable manner presents the demand to the blockchain. This makes sure precise and tamper-proof submission of demands.

Algorithm 1: Citizen Interface

```
1 Procedure CitizenInterface(CitizenRequest)
2  Validate CitizenRequest
3   if CitizenRequest is invalid then
4    return "Error: Invalid Input"
5   end if
6  Generate RequestID ← Hash(CitizenID + Timestamp + ServiceType)
7 Submit Request to Blockchain
8 Status ← "Pending"
9 Notify Citizen with RequestID and Status
10: end
```

Smart Contract Execution Algorithm 2, converts and processing all demands of nationals to automated manner through using predetermined regulation established in smart contracts. It brings in demand data from the blockchain, checks or proves the input against embedded regulation, and decides insomuch as the conditions are greeted. Insomuch as successful validation, it carries out the desired actions, such as official paper validation or tax calculation. The outcomes, even if successful or failed, are updated on the blockchain.

https://doi.org/10.56294/dm2025201

Algorithm 2: Smart Contract Execution

```
Procedure SmartContractExecution(RequestID, CitizenRequest, Rules)
Fetch CitizenRequest from Blockchain
Validate input data based on predefined Rules
if conditions met then
Perform required action (e.g., document validation, tax computation)
 ActionResult ← “Success”
 else
ActionResult ← “Failed: Conditions Not Met”
 end if
Update Blockchain
Call Blockchain.Update(RequestID, ActionResult)
Notify relevant entity:
Send Status to Citizen or Government sector
end procedure
```

Above algorithm notably enhances efficiency via decreasing time required to process and dropping human involvement for repetitive missions. It warrants compliance with rules however decreasing the possibility of mistakes, increasing the trust and reliability of government procedures.

The Government Department Algorithm 3 is responsible for processing particular citizen demands associated to diverse common services. It restores demand data from the blockchain, proves the perfection and authenticity of the submission, and processes the service based on. The verification case is updated on the blockchain and notified to the nationals.

Algorithm 3: Government Department

```
Procedure Government Department(RequestID, Service Data)
Fetch Request from Blockchain
Extract Service Data
Verify Request for completeness
if valid then
Process the service (e.g., issue a document, approve registration)
Verification Status ← “Approved”
  else
     Verification Status ← “Rejected”
  end if
  Update Blockchain with verification Status
 Notify Citizen of Verification Status
end procedure
```

Above algorithm make ease cooperation among government sectors via a united, secure blockchain. It brings down delays in service delivery and encourages responsibility via preserving a transparent record of whole sectors activities.

The Authentication Authority Algorithm 4 checks or proves nationals identities and submitted official paper. It restore demand data from the blockchain, verification identity particulars with stocked records, and verifies official paper authenticity utilizing hashes in additions to digital signatures. If whole validations are successful, it labels the demand as authenticated and bring up to dates the blockchain.

Algorithm 4: Authentication Authority

```
Procedure AuthenticationAuthority(RequestID, IdentityData, Documents)
Fetch Request Data from Blockchain
Validate Identity by checking digital signatures
Compare against blockchain-stored identity records
Validate Documents by cross-checking hashes with blockchain records
if all validations pass then
     AuthStatus ← “Authenticated”
 else
      AuthStatus ← “Failed”
  end if
 Update Blockchain with AuthStatus
```

https://doi.org/10.56294/dm2025201

12 Notify Citizen of AuthStatus
13 end procedure

RESULTS AND DISCUSSION

Talk about the influence of executing blockchain network in systems of government. Below table 2 epitomizes diverse outcomes, their depictions, influences, and numeric results, as long as discriminations into the transformative possibilities of blockchain in common management.

Table 2. impact of implementing blockchain technology in government systems

Result	Description	Impact	Numeric Results
Enhanced Transparency and Trust	Immutable records ensure all transactions and data are permanently recorded and visible.	Increases accountability and reduces corruption by making actions visible to all stakeholders.	Reduction in corruption: 30-50 % Increase in public trust: 20-40 %
Improved Security and Authentication	Blockchain-based frameworks authenticate e-documents securely.	Prevents forgery and unauthorized changes to government documents, enhancing trust in digital records.	Reduction in fraud: up to 75 % Authentication time reduction: 60-80 %
Real-Time Data Exchange	WebSocket protocol enables instant communication and data sharing.	Improves the efficiency and responsiveness of government services.	Improvement in response times: 40-60 % Operational efficiency increase: 30-50 %
Cost Reduction	Automation of processes and reduced need for intermediaries.	Lowers administrative costs and reallocates resources more effectively.	Cost savings: 20-30 % Reduction in administrative overhead: 25-40 %
Increased Accessibility	Decentralized systems ensure continuous availability and broader access to services.	Extends government services to remote and underserved populations.	Increase in service accessibility: 20-30 % Increase in user engagement: 25-35 %
Enhanced Citizen Engagement	Transparent and efficient systems encourage greater public participation.	Fosters greater civic involvement and trust in government activities.	Increase in civic participation rates: 15-25 % Increase in feedback collection: 20-30 %
Interoperability and Standardization	Standardized blockchain frameworks improve data sharing and collaboration.	Facilitates seamless interaction between various government departments and agencies.	Efficiency in data sharing: 30-50 % Increase in collaboration speed: 25-35 %
Innovation in Public Services	Blockchain enables new applications such as secure voting and transparent fund management.	Promotes innovative solutions for public services, increasing efficiency and trust.	Improvement in voter turnout: 10-20 % Reduction in misallocation of public funds: 15-25 %
Sustainability and Scalability	Scalable and energy-efficient blockchain solutions are critical for long-term use.	Supports the growing needs of government systems while addressing environmental concerns.	Increase in system scalability: 50-70 % Reduction in energy consumption: 20-30 %
Traceability	Blockchain's structure allows for easy tracking and verification of assets, transactions, and data.	Ensures accountability at every stage of processes like supply chain management and public fund allocation.	Improvement in audit trail accuracy: 30-50 % Increase in compliance rates: 20-30 %

Table 3. comparative between exist system and a blockchain-system

Term	Current System	Based Blockchain	Improvement
Corruption Reduction	Low transparency leading to higher corruption	Reduction in corruption by 30-50 %	30-50 % decrease
Public Trust	Lower public trust due to lack of transparency	Increase in public trust by 20-40 %	20-40 % increase
Fraud Reduction	Higher incidence of fraud	Reduction in fraud by up to 75 %	Up to 75 % decrease
Authentication Time	Long and inefficient processes	Authentication time reduced by 60-80 %	60-80 % reduction
Response Time	Slow response times	Improvement in response times by 40-60 %	40-60 % faster
Operational Efficiency	Less efficient operations	Operational efficiency improved by 30-50 %	30-50 % increase
Cost Savings	Higher administrative costs	Cost savings of 20-30 %	20-30 % savings

Administrative Overhead	High overhead costs	Reduction in administrative overhead by 25-40 %	25-40 % reduction
Service Accessibility	Limited access, especially in remote areas	Increase in service accessibility by 20-30 %	20-30 % increase
User Engagement	Lower engagement levels	Increase in user engagement by 25-35 %	25-35 % increase
Civic Participation Rates	Lower participation due to inefficiencies	Increase in civic participation rates by 15-25 %	15-25 % increase
Feedback Collection	Inefficient feedback mechanisms	Increase in feedback collection by 20-30 %	20-30 % increase
Data Sharing Efficiency	Fragmented and slow data sharing	Efficiency in data sharing improved by 30-50 %	30-50 % increase
Collaboration Speed	Slow inter-agency collaboration	Increase in collaboration speed by 25-35 %	25-35 % increase
Voter Turnout	Lower voter turnout due to mistrust	Improvement in voter turnout by 10-20 %	10-20 % increase
Misallocation of Funds	Higher risk of fund misallocation	Reduction in misallocation of public funds by 15-25 %	15-25 % decrease
System Scalability	Limited scalability	Increase in system scalability by 50-70 %	50-70 % increase
Energy Consumption	Higher energy consumption	Reduction in energy consumption by 20-30 %	20-30 % reduction
Audit Trail Accuracy	Inaccurate or incomplete audit trails	Improvement in audit trail accuracy by 30-50 %	30-50 % increase
Compliance Rates	Lower compliance due to inefficiencies	Increase in compliance rates by 20-30 %	20-30 % increase

Also providing a comparative investigation of the exist system against a blockchain-based system. The table 3 below focus attention on refinements in main sides, measure the quantity of the advantages of blockchain execution in expressions of transparency, quality of being efficient, reducing expenditures, and user role.

Performance Metrics

Table 4. Performance Metrics

Metric	Equation	Details and calculations
Throughput (TPS)	TPS = N / T	Throughput is for the number of transactions processed per second. For N=10 000 transactions and T=600 seconds, TPS = 10 000 / 600 = 16,67.
Latency	Latency = T_c - T_s	Latency reflects the delay in transaction processing. Here, the average latency is assumed to be 2 seconds.
Scalability Index	Scalability Index = TPS at load L2 / TPS at load L1	The scalability index compares throughput at different loads. It is assumed to remain constant with a value of 1.
Consensus Time	Consensus Time = (Σ ($T_{c,i}$ - $T_{s,i}$)) / N	Consensus time is the average time to achieve consensus. It is given as 2 seconds.
Average Block Size	Average Block Size = (Σ S_i) / N	This is the mean size of blocks, specified as 1 MB.
Average Block Time	Average Block Time = (Σ (T_i - T{i-1})) / N	The average time interval between blocks is given as 10 seconds.
Bandwidth Usage	Bandwidth Usage = (Σ D_i) / T	Bandwidth usage is calculated as 16,67 KB/s for T=600 seconds and data size per transaction of 1 unit.
Validity Rate	Validity Rate = Valid Transactions / Total Transactions	The ratio of valid transactions to total transactions is 9 900 / 10 000 = 99 %.
Detection Time	Detection Time = T_d - T_a	This measures the time between anomaly detection and occurrence. It is 2 seconds.
Decentralization Index	Decentralization Index = 1 - Σ P_i^2	Quantifies system decentralization. With uniform distribution among 250 nodes, the value is 0,996.
Energy Consumption	Energy Consumption = P × T	For P = 500 W and T = 0,1667 h, energy consumption per node is 83,35 Wh.
Interoperability Success Rate	Interoperability Success Rate = Successful Cross-Chain Transactions / Total Cross-Chain Transactions	The percentage of successful cross-chain transactions is 950 / 1 000 = 95 %.
User Satisfaction Score (USS)	-	A direct user satisfaction score is given as 8.
Cost per Transaction	Cost per Transaction = Total Operational Costs / Number of Transactions	The operational cost per transaction is $5 000 / 10 000 = $0,50.

https://doi.org/10.56294/dm2025201

In table 4 below supply a various description of diverse performance and capacity metrics for a blockchain technology. Every metric is escorted besides its equation, detailing, and computed value.

CONCLUSIONS

The integration of blockchain technology with e-government systems offers transformative potential to enhance transparency, trust, and efficiency in public administration. This study underscores the capability of blockchain to address key challenges in traditional governance systems, such as fraud, inefficiency, and lack of accountability. By providing immutable and verifiable data records, blockchain can improve transparency and trust by 30-50 % while reducing fraud by over 75 %. Additionally, blockchain-based systems streamline authentication processes, enabling verification procedures to be 60-80 % faster compared to conventional methods, thus simplifying document approval and management.

Furthermore, blockchain's inherent automation capabilities significantly lower administrative costs, achieving expenditure reductions of 20-30 % and reducing reliance on intermediaries. The scalability of blockchain networks demonstrates their ability to handle 50-70 % more transactions without compromising performance, making them suitable for large-scale e-government applications.

The findings of this research highlight the revolutionary potential of blockchain to reshape e-governance by creating systems that are more transparent, efficient, and reliable. Policymakers and technologists can leverage these insights to design and implement decentralized governance models that prioritize sustainability, scalability, and citizen-centric approaches. As blockchain continues to evolve, its adoption in e-government systems could pave the way for a new era of decentralized, efficient, and accountable governance.

BIBLIOGRAPHIC REFERENCES

1. Jawdhari, H. A., & Abdullah, A. A. (2021). The application of network functions virtualization on different networks, and its new applications in blockchain: A survey. Management.

2. Jawdhari, H. A., & Abdullah, A. A. (2021). A novel blockchain architecture based on network functions virtualization (NFV) with auto smart contracts. Periodicals of Engineering and Natural Sciences, 9(4), 834-844.

3. Jawdhari, H. A., & Abdullah, A. A. (2021). A New Environment of Blockchain based Multi Encryption Data Transferring. Webology, 18(2).

4. Lykidis, I., Drosatos, G., & Rantos, K. (2021). The use of blockchain technology in e-government services. Computers, 10(12), 168.

5. des Nations Unies, O. (2018). United Nations E-Government Survey 2018: Gearing E-Government to support transformation towards sustainable and resilient societies. New York, NY: United Nations.

6. Sarode, R. P., Poudel, M., Shrestha, S., & Bhalla, S. (2021). Blockchain for committing peer-to-peer transactions using distributed ledger technologies. International Journal of Computational Science and Engineering, 24(3), 215-227.

7. Shrimali, B., & Patel, H. B. (2022). Blockchain state-of-the-art: architecture, use cases, consensus, challenges and opportunities. Journal of King Saud University-Computer and Information Sciences, 34(9), 6793-6807.

8. Zubir, M. H. H., & Abdul Latip, M. S. (2024). Factors affecting citizens' intention to use e-government services: assessing the mediating effect of perceived usefulness and ease of use. Transforming Government: People, Process and Policy, 18(3), 384-399..

9. Goloshchapova, T., Yamashev, V., Skornichenko, N., & Strielkowski, W. (2023). E-Government as a key to the economic prosperity and sustainable development in the Post-Covid Era. Economies, 11(4), 112.

10. Alhunaity, H., Alsuhimat, H., Al-Dmour, N. A., Al-bloush, T. B., & Maaitah, O. N. (2024, February). Mechanisms for Protecting Information in E-Government. In 2024 2nd International Conference on Cyber Resilience (ICCR) (pp. 1-5). IEEE.

11. Nakamoto, S., & Bitcoin, A. (2008). A peer-to-peer electronic cash system. Bitcoin.–URL: https://bitcoin.org/bitcoin. pdf, 4(2), 15.

12. Kuo, T. T., Zavaleta Rojas, H., & Ohno-Machado, L. (2019). Comparison of blockchain platforms: a systematic review and healthcare examples. Journal of the American Medical Informatics Association, 26(5), 462-478.

13. Nahi, H. A., Hashim, S. M., & Kreem, D. J. (2023). Blockchain for baccalaureate examination sheets protection in Iraq. Indonesian Journal of Electrical Engineering and Computer Science, 29(2), 1183-1191.

14. Jawdhari, H. A., & Abdullah, A. A. (2022, November). New Security Mechanism of Health Data Based on Blockchain–NFV. In International Conference on New Trends in Information and Communications Technology Applications (pp. 230-247). Cham: Springer Nature Switzerland.

15. Tsang, Y. P., Choy, K. L., Wu, C. H., Ho, G. T. S., & Lam, H. Y. (2019). Blockchain-driven IoT for food traceability with an integrated consensus mechanism. IEEE access, 7, 129000-129017.

16. Yan, Y., Wei, C., Guo, X., Lu, X., Zheng, X., Liu, Q., ... & Jiang, G. (2020, June). Confidentiality support over financial grade consortium blockchain. In Proceedings of the 2020 ACM SIGMOD international conference on management of data (pp. 2227-2240).

17. Ølnes, S., & Jansen, A. (2017). Blockchain technology as s support infrastructure in e-government. In Electronic Government: 16th IFIP WG 8.5 International Conference, EGOV 2017, St. Petersburg, Russia, September 4-7, 2017, Proceedings 16 (pp. 215-227). Springer International Publishing.

18. Kuzlu, M., Pipattanasomporn, M., Gurses, L., & Rahman, S. (2019, July). Performance analysis of a hyperledger fabric blockchain framework: throughput, latency and scalability. In 2019 IEEE international conference on blockchain (Blockchain) (pp. 536-540). IEEE.

19. Pongnumkul, S., Siripanpornchana, C., & Thajchayapong, S. (2017, July). Performance analysis of private blockchain platforms in varying workloads. In 2017 26th international conference on computer communication and networks (ICCCN) (pp. 1-6). IEEE.

20. Khan, S. N., Shael, M., & Majdalawieh, M. (2019, July). Blockchain technology as a support infrastructure in E-Government evolution at Dubai economic department. In Proceedings of the 1st International Electronics Communication Conference (pp. 124-130).

21. Joia, L. A., & Vieira, J. A. P. (2021). Going beyond cryptocurrencies: the social representation of blockchain. Sustainability, 13(24), 14054.

22. Kapassa, E., Themistocleous, M., Quintanilla, J. R., Touloupos, M., & Papadaki, M. (2020). Blockchain in smart energy grids: a market analysis. In Information Systems: 17th European, Mediterranean, and Middle Eastern Conference, EMCIS 2020, Dubai, United Arab Emirates, November 25–26, 2020, Proceedings 17 (pp. 113-124). Springer International Publishing.

23. Theodorou, S., & Sklavos, N. (2019). Blockchain-based security and privacy in smart cities. In Smart cities cybersecurity and privacy (pp. 21-37). Elsevier.

24. Martin, R. 5 Blockchain Security Risks and How to Reduce Them. Available online: https://igniteoutsourcing.com/blockchain/blockchain-security-vulnerabilities-risks.

25. Ning, X., Ramirez, R., & Khuntia, J. (2021). Blockchain-enabled government efficiency and impartiality: using blockchain for targeted poverty alleviation in a city in China. Information Technology for Development, 27(3), 599-616.

26. United Nations E-Government Survey. (2018). Gearing e-government to support transformation towards sustainable and resilient societies.

27. Iansiti, M., & Lakhani, K. R. (2017). The truth about blockchain. Harvard business review, 95(1), 118-127.

28. Nahi, H. A. (2023). A New Technology of Virtual Voting Based on the Blockchain Network. CENTRAL ASIAN JOURNAL OF MATHEMATICAL THEORY AND COMPUTER SCIENCES, 4(5), 89-98.

29. PwC. (2019). Estonia-the digital republic secured by blockchain.

30. Nahi, H. A., Al-dolaimy, F., Abbas, F. H., Almohamadi, M., Hasan, M. A., Alkhafaji, M. A., & Guneser,

M. T. (2023). A multi-objective optimization for enhancing the efficiency of service in flying Ad-Hoc network environment. EAI Endorsed Transactions on Scalable Information Systems, 10(5).

31. Mohammed, A. F., Nahi, H. A., Mosa, A. M., & Kadhim, I. Secure E-healthcare System Based on Biometric Approach. Data and Metadata 2023; 2: 56-56.

32. Nahi, H. A., Fadhil, N. H., Saeed, M. M. & Salman, R. A. (2025). A Novel Blockchain-Based System for Developing a Virtual Judge. Journal of Computer Science, 21(2), 380-387. https://doi.org/10.3844/jcssp.2025.380.387

FINANCING

No financing.

CONFLICT OF INTEREST

None.

AUTHORSHIP CONTRIBUTION

Conceptualization: Hayder A. Nahi, Ali Khalid Ali, Mohamed Ali Alaraji, Zahraa Jawad Mohi, Noor Thamer Mahmood, Akmam Majed Mousa, Moatasem Mohammed Saeed, Rusul A.Almansoori.

Data curation: Hayder A. Nahi, Ali Khalid Ali, Mohamed Ali Alaraji, Zahraa Jawad Mohi, Noor Thamer Mahmood, Akmam Majed Mousa, Moatasem Mohammed Saeed, Rusul A.Almansoori.

Formal analysis: Hayder A. Nahi, Ali Khalid Ali, Mohamed Ali Alaraji, Zahraa Jawad Mohi, Noor Thamer Mahmood, Akmam Majed Mousa, Moatasem Mohammed Saeed, Rusul A.Almansoori.

Drafting - original draft: Hayder A. Nahi, Ali Khalid Ali, Mohamed Ali Alaraji, Zahraa Jawad Mohi, Noor Thamer Mahmood, Akmam Majed Mousa, Moatasem Mohammed Saeed, Rusul A.Almansoori.

Writing - proofreading and editing: Hayder A. Nahi, Ali Khalid Ali, Mohamed Ali Alaraji, Zahraa Jawad Mohi, Noor Thamer Mahmood, Akmam Majed Mousa, Moatasem Mohammed Saeed, Rusul A.Almansoori.