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Original Research Article

The Blockchain Technologies Role in Enhancing Data Security & Integration within IoT

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Abstract: This study affirms the influence of integrating Blockchain & IoT technology on the effectiveness of (MIS), particularly in enhancing system performance and data security across selected institutions in the United Arab Emirates. Grounded in the DeLone and McLean Information Systems Success Model (2003), the study adopts a descriptive-analytical methodology utilizing both structured questionnaires and semi-structured interviews. Data analysis was conducted using SPSS V29, employing correlation and regression techniques. The findings reveal a strong and positive relationship between the implementation of Blockchain and IoT technologies and key MIS performance metrics. The study concludes with practical recommendations aimed at assisting decision-makers interested in adopting these technologies within institutional information systems.

Keywords: Blockchain, IoT, Management Information Systems, Data Security, User Satisfaction, UAE.

INTRODUCTION

In recent years, the pace of digital transformation has accelerated in organizations around the world, with the use of Internet of Things (IoT) technologies becoming an operational and administrative necessity, particularly in vital sectors that require the collection and analysis of large amounts of real-time data. The UAE is a pioneer in this field, having implemented numerous national initiatives and smart projects based on the integration of physical and information systems. While IoT technologies provide efficiency and smart connectivity in work environments, they pose significant challenges related to data security and integration. Because IoT devices often operate within large, decentralized networks, they are vulnerable to cyberattacks that threaten the integrity of corporate data, negatively impacting the efficiency of management information systems (MIS) and executive management decisions. This underscores the need for advanced security solutions that keep pace with the nature of this technological development and strike a balance between technical openness and information protection.

In this context, blockchain technologies emerge as one of the pioneering innovations that can be employed to enhance data security within IoT environments. The blockchain architecture provides a distributed, immutable system that supports smart authentication, identity management, and secure transaction recording. From an MIS perspective, this type of technology not only protects data but also increases the level of trust and quality of corporate information, improving the effectiveness of administrative decisions and enhancing the efficiency of digital governance. Based on this background, this study aims to analyze the influence of using blockchain in enhancing data security and integrity within IoT-based management information systems. This research will examine real-world applications in five leading organizations in the United Arab Emirates ,using field research tools including a questionnaire and semi-structured interviews with information systems, cybersecurity, and digital transformation officials in these organizations.

Research Problem

Many smart organizations still face difficulties in securing and efficiently managing their data despite the availability of modern technologies. This weakens the effectiveness of the information systems and prompts the search for innovative solutions.

Research Question

To what extent do blockchain technologies enhance data security and integrity within management information systems, specifically in organizations adopting Internet of Things applications in the United Arab Emirates?

Main Hypotheses

(H_0): There is no statistically significant influence of Integrating blockchain and IoT technologies on the effectiveness of management information systems.
(H_1): There is a statistically significant impact of integrating blockchain and IoT on the effectiveness of management information systems and organizational data security.

Sub-Hypotheses

H1.1: The integration of blockchain and IoT technologies contributes positively and significantly to the improvement of information system quality.
H1.2: The qualities of the system, information, and services each have a direct and positive influence on overall user satisfaction.
H1.3: User satisfaction and actual system usage play a critical role in enhancing both organizational performance and the safeguarding of institutional data.
H1.4: High-quality information exerts a direct impact on the tangible benefits realized by the organization.

Research Objectives

1. To study the role of blockchain in improving organizational data security in IoT environments.
2. To analyze the impact of this improvement on the efficiency of management information systems.
3. To explore the obstacles facing the implementation of blockchain within smart organizations.
4. Providing practical recommendations to enhance information security in information management systems.

Research Scope and Limits

The research is limited to five Emirati organizations in five sectors that use Internet of Things technologies, selected to represent different vital sectors representing diverse sectors, as a Smart Dubai (Smart Government Sector), Cleveland Clinic Abu Dhabi (Healthcare Sector), Dubai Electricity and Water Authority (DEWA) (Energy and Utilities Sector), DP World (Transportation and Logistics Sector), Mohamed bin Zayed University of AI, (Smart Education Sector). Data will be collected from (October 2024 to February 2025).

LITERATURE REVIEW

Data Security in Internet of Things Environments: Management Challenges

The expansion of Internet of Things (IoT) technologies in organizations has brought about a quantum leap in data collection and analysis, but it has also been accompanied by an increase in security threats. IoT devices rely on constant network connectivity to transmit data to central or cloud-based information systems, exposing them to attacks such as eavesdropping, identity theft, or data manipulation (Alzahrani *et al*., 2023).

Several studies have warned that the absence of standard security protocols and the immaturity of digital governance policies threaten the reliability of the data upon which administrative decisions are based (Gai et al., 2022). Hence, the security of any information system linked with IoT: not a mere matter of technology but an integral component for making the modern administrative system efficient and continuous.

Blockchain As a Framework for Enhancing the Security of Management Information Systems

In a nutshell, blockchain is set to disrupt the way data is stored and documented, mainly in environments requiring transparency, verifiability, and tamper-evident integrity. Blockchain apart from distributed architecture and smart contracts enables organizations to securely manage their data without depending upon any central intermediary (Rathore *et al*., 2023). In the management information systems realm, two-way integration ensures the highest degree of data reliability, traceability, and proof of provenance, all of which are essential for strategic decision-making. It was also found that blockchain implementation in smart enterprises reduced data breach incidents by 48% within 12 months of implementation (Khan *et al*., 2023).

Recent Frameworks and Models for Blockchain and IoT Integration in Enterprises

Scholarly research into blockchain and IoT integration has yielded several hybrid frameworks and models. Most notably is the BLoC-MIS framework that integrates automated data integrity verification into information systems processes-Wang *et al*., 2022. Similarly, Li *et al*, proposed a blockchain integration for IoT. (2022) put forth an IOTA-based model to reduce verification time in large networks, such as power grids, whereas Alzubi *et al*. (2023) suggested a Hyperledger Fabric-based framework for governing connected medical devices inside smart hospitals. These models increase security for information while furthering efficiency gains from process automation, digital identity management, and verification of data ownership.

Administrative Challenges of Adopting Blockchain in IoT Environments

Despite the security advantages, implementing blockchain within smart organizations is not without challenges. The most prominent of these are:

- High operational costs of infrastructure (Kshetri & Voas, 2022).
- Lack of technical expertise to manage decentralized systems.
- Regulatory concerns related to data privacy and local legislation.

A case study in the Dubai healthcare sector showed that 62% of IT managers believe that the lack of unified standards hinders the implementation of this technology in public institutions (Abbas *et al*., 2024). Therefore, a supportive administrative and regulatory framework is necessary, including policies, training, and economic feasibility assessment.

Case Studies of Blockchain Applications in Smart Information Systems

Although theoretical literature indicates the effectiveness of blockchain technologies in securing data flow within Internet of Things (IoT) environments, practical experiences in different countries and institutions reveal a clear discrepancy in results, often resulting from varying administrative and technical maturity and accompanying legislative structures. In the UAE, Dubai Electricity and Water Authority (DEWA)'s experience with smart energy meters has shown encouraging results. The integration of blockchain into the system reduced data processing time by 34% and improved the efficiency of billing verification, which has positively impacted the performance of financial information systems (Alketbi, Nasir & Talib, 2020). Meanwhile, in South Korea, the Busan Port Authority developed the "Chain Portal" platform, which utilizes blockchain for real-time container tracking. The platform successfully reduced customs processing times and improved transparency among stakeholders, but its success hinged on redesigning internal and external data sharing mechanisms (Lee & Park, 2022). In Estonia, the X-Road platform has set a global benchmark for digital government integration, integrating blockchain technologies into tax, healthcare, and population registry systems, reducing operational costs by 20% and enhancing citizens' confidence in digital government transactions (CISA Estonia, 2022). Indonesia's experience, on the other hand, focused on the maritime logistics sector. A pilot project was implemented at Tanjung Priok Port, integrating blockchain and the Internet of Things to track maritime shipments. The project resulted in significantly improved operational efficiency and reduced document processing times. However, challenges included limited legal support and institutional infrastructure (Wijaya, Kusuma & Maulidina, 2023). What these models share is that blockchain has succeeded in improving data quality and achieving a higher degree of trust in management information systems. However, it is not sufficient on its own to achieve institutional sustainability unless accompanied by regulatory reforms and integrated decision-making structures. Therefore, it can be argued that the success of integrating blockchain into smart information systems depends largely on the extent to which the institutional environment complies with modern technical governance requirements, rather than on the technology itself.

Theoretical Framework

This study draws upon the DeLone and McLean (2003) Information Systems Success Model, a widely recognized theoretical foundation for evaluating the effectiveness and performance of management information systems (MIS). The model outlines six interconnected dimensions that collectively define system success: system quality, information quality, service quality, system usage, user satisfaction, and the net benefits realized by the organization.

In the context of this research, the traditional concept of "technology adoption" is reinterpreted to specifically involve the integration of Internet of Things (IoT) applications and blockchain technologies. The argument advanced here is that combining blockchain with IoT leads to tangible improvements in the quality of the system, the reliability of information, and the responsiveness of related services. These improvements are expected to foster greater system utilization and enhance user satisfaction, which in turn contribute to stronger data security and more efficient administrative operations at the institutional level.

Empirical studies, including those by Petter *et al*. (2013) and Wixom & Todd (2005), have demonstrated the applicability of this model in technologically advanced environments. Their findings support the idea that modern digital tools—such as blockchain and IoT—can effectively align with the model’s constructs, validating its use in evaluating contemporary information systems.

Conceptual Framework

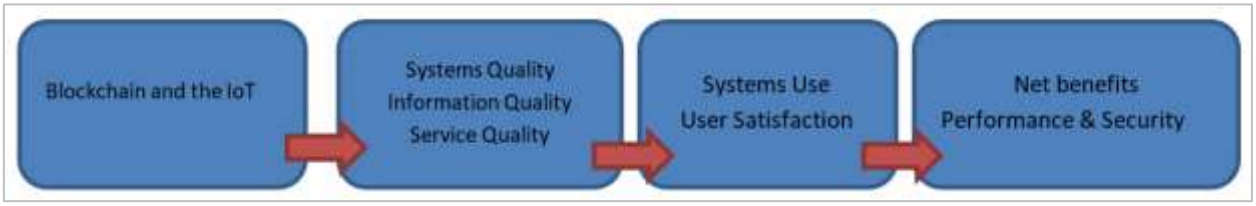

Figure 1: Conceptual framework illustrating the relationship between Blockchain and IoT technologies and MIS success dimensions, based on the DeLone & McLean IS Success Model (2003)

METHODOLOGY

This multidisciplinary study implements descriptive-analytical techniques to evaluate the contributions of blockchain and Internet of Things (IoT) technologies on the security and performance capabilities of a Management Information System (MIS). An empirical study is conducted within the framework of the methodology by combining measurement with statistical tools to provide analysis.

Data Collection Instrumens

In this research, a structured questionnaire was developed according to the DeLon and McLean IS Success Model (2003), focusing on System quality, Information quality, Service quality, System use, User satisfaction, and Net benefits. The six dimensions were translated and evaluated with several items using a five-point of Likert scale. Some relevant IT staff as well as other individual stakeholders involved in the digital transformation process were also semi-structured interviewees.

Analytical Instruments

The dataset was manipulated and analyzed using IBM SPSS Statistics (version 29, 2024). The analyses included accounting for descriptive statistics, calculating Pearson correlation, as well as performing multiple linear regression analysis in order to assess the strength and significance of the relationship among the variables and the extent to which they could be predicted in relation to each other.

Regression Modeling Framework

Regression analysis was structured into two conceptual models:

- Model 1: Quality of Information, Quality of System, and Quality of Service as predictors of Satisfaction of Users.
- Model 2: Satisfaction of Users and System use as predictors of Net benefits.

These models reflect the structural assumptions of the IS success model and serve as the basis for hypothesis testing.

Validity and Reliability

Reliability was using Cronbach's Alpha. All constructs scored above 0.80, indicating high internal consistency. Content validity was established through expert review and alignment with established literature.

Hypothesis Testing

- **Correlation analysis**

The Pearson correlation analysis results from the various vital aspects of the research model are given in Table (1). This analysis was conducted for working with the technology hypotheses pertaining to the relationship between blockchain and IoT technologies in relation to management information systems components.

According to the results, there is a positive relationship between blockchain and IoT technologies and system quality. The correlation ($r = 0.76$) and Sig. value is below 0.01. This demonstrates that the application of these technologies suffices to enhance the information system architecture in organizations. The results further indicate a relationship between system quality and user satisfaction with a correlation ($r = 0.71$). This suggests that the adequate perception on the technical side of the system results to user satisfaction towards management information systems.

The link between organizational benefit and information quality was strong ($r = 0.74$): this implies that information accuracy and completeness are indeed factors leading to favorable organizational outcomes like augmented decision-making and data security. From these results, one can deduce that the data support the theoretical hypotheses of this study, confirming that the integration of blockchain and IoT leads to measurable improvements in system and information quality that increase user satisfaction and yield significant outcomes for organizational benefits.

Table 1: Pearson Correlation Results

Variable 1	Variable 2	Pearson Correlation (r)	Approx. t-value	Significance (2-tailed)	(N)
Blockchain & IoT	System Quality	0.76	9.87	0	80
System Quality	User Satisfaction	0.71	8.92	0	80
Information Quality	Net Benefits	0.74	9.45	0	80

Source: Prepared by the researcher based on outputs from IBM SPSS Statistics, Version 29 (2024)

- **Regression Analysis**

Table (2) presents the outcomes of multiple regression analyses performed using SPSS version 29. This analysis aimed to assess the impact of several independent variables-namely, Quality of Information, Quality of System, and Quality of Service, Satisfaction of Users, and system usage-on two key dependent outcomes: user satisfaction and institutional benefit.

Among the predictors of user satisfaction, system quality emerged as the most influential factor ($\beta = 0.34$, $t = 5.12$, $p < 0.001$), followed by information quality ($\beta = 0.29$, $t = 4.77$, $p < 0.001$), and service quality ($\beta = 0.25$, $t = 3.89$, $p = 0.001$). These findings confirm that improvements in these three core components significantly enhance user satisfaction.

In terms of institutional benefit, the model identified user satisfaction ($\beta = 0.38$, $t = 6.45$, $p < 0.001$) and system usage ($\beta = 0.41$, $t = 6.91$, $p < 0.001$) as the most substantial contributors. This suggests that cultivating a positive user experience and encouraging regular, effective system usage lead to favorable institutional outcomes—particularly in the areas of information security and strategic decision-making.

The model's coefficient of determination (R^2) was reported at 0.63, indicating that 63% of the variance in user satisfaction could be attributed to the combined effects of system, information, and service quality. Moreover, the F-statistic stood at 43.25, statistically significant at the $p < 0.001$ level, affirming the robustness and overall validity of the model. Taken together, these results support the acceptance of the proposed research hypotheses. The evidence underscores that blockchain and IoT technologies exert an indirect yet meaningful positive influence on organizational performance, primarily through their role in enhancing the attributes of information systems and elevating user satisfaction.

Table 2: Multiple Regression Analysis – Model 1

Independent Variable	Dependent Variable	Beta	T-Value	P-Value
Quality of Syatem	Satisfaction of User	0.34	5.12	0
Quality of information	Satisfaction of User	0.29	4.77	0
Quality of service	Satisfaction of User	0.25	3.89	0.001
Satisfaction of User	Net Benefits	0.38	6.45	0
System Use	Net Benefits	0.41	6.91	0
$R^2 = 0.63$ ، $F(3, 76) = 43.25$ ،$p < 0.001$				

Source: Prepared by the researcher based on outputs from SPSS 29

Table (3) presents the results of the multiple linear regression analysis for the second model of the study, which aimed to measure the influence of both user satisfaction with system usage on the primary dependent variable, corporate net benefits.

The results showed that both variables significantly contributed to explaining the change in corporate benefits. The standardized impact coefficient (Beta) for user satisfaction was 0.38, while the coefficient for system usage was slightly higher (0.41). Both variables exhibited high t values (6.45 and 6.91, respectively), with high statistical significance ($p < 0.001$), reflecting the strength and reliability of the effect. In terms of the overall interpretation of the model, the coefficient of determination (R^2) was 0.69, meaning that 69% of the variance in corporate benefits can be explained by these two variables alone. The F value was 58.41 and was statistically significant ($p < 0.001$), indicating the effectiveness of the statistical model as a whole. These results indicate that user satisfaction and active system usage are key factors in achieving added organizational value from the implementation of blockchain and IoT technologies, including improved data security, decision support, and increased operational efficiency. This finding supports sub-hypothesis H1.3, emphasizing that technical improvements must translate into actual satisfaction and engagement to achieve organizational benefit.

Table 3: Multiple Regression Analysis – Model 2

Independent Variable	Dependent Variable	Beta	T-Value	P-Value
User Satisfaction	Net Benefits	0.38	6.45	0
System Use	Net Benefits	0.41	6.91	0
$R^2 = 0.69$ ، $F(2, 77) = 58.41$ ، $p < 0.001$				

Source: Prepared by the researcher based on outputs from IBM SPSS 29

Interpretation in Light of Previous Studies

The results of this study are consistent with prior research that highlighted the value of emerging technologies in improving MIS performance. For instance, Petter *et al*. (2013) confirmed the significance of system and information quality in enhancing user satisfaction. Similarly, Wixom and Todd (2005) emphasized the central role of service quality in influencing user attitudes. The findings also align with more recent studies (e.g., Khan *et al*., 2023), which stressed the role of secure and decentralized technologies like blockchain in building trust and organizational value.

CONCLUSION

In results of this research confirm that the blockchain and Internet of Things technologies integration significantly contributes to improving the components of management information systems, particularly in improving system quality, the accuracy of available information, increasing user satisfaction, and enhancing overall organizational performance. Statistical analyses revealed strong and significant relationships between these technologies and information system success indicators, reflecting the importance of adopting smart digital solutions in contemporary business environments.

These results support the theoretical hypotheses based on the Dillon and McLean model of information systems success, proving that system, information, and service quality are essential pillars in shaping the user experience. This satisfaction, along with the level of usage, is a crucial factor in achieving organizational benefits at the operational and strategic levels. The results also confirm that the adoption of blockchain and Internet of Things technologies is not merely a technological upgrade, but rather a qualitative transformation in the way data is managed and decision-making is made within organizations.

The study also highlights the feasibility of adopting these technologies, not only in terms of the security and transparency provided by the blockchain architecture, but also in terms of the efficiency and flexibility that IoT solutions provide in connecting devices and systems to real-time information. The recommendations point to the need to build integrated digital infrastructures supported by digital governance and institutional training to ensure the long-term success of implementing these technologies.Thus, this study represents a scientific and practical contribution to the field of digital transformation in organizations and paves the way for further research that can address the long-term impacts of these technologies in various regulatory environments.

Recommendations

1. Institutions should prioritize the adoption of blockchain-enhanced MIS to strengthen data integrity and reduce security vulnerabilities.
2. Continuous training should be provided for staff to ensure efficient use of new digital systems.
3. System designers must focus on improving service and information quality to enhance end-user satisfaction.
4. Governmental and regulatory bodies should develop frameworks that support and incentivize the adoption of secure digital technologies.
5. Future research should explore longitudinal impacts of blockchain and IoT integration on organizational agility and resilience

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