Blockchain Convergence: Analysis of Issues Affecting IoT, AI and Blockchain

Sasho Guergov[1] and Neyara Radwan[2,3]

[1]Technical University of Sofia, Faculty of Industrial Technology, Bulgaria, Sguergov@tu-sofia.bg
[2]King Abdulaziz University, Jeddah-21589, Saudi Arabia.
[3]Suez Canal University, Ismailia, Egypt, nrhassan@kau.edu.sa

Abstract

The purpose of this study is to appraise the integration or convergence issues influencing the mutual functioning of blockchain, AI, and IoT. The study argued that the recent developments in the field of IoT and blockchain prediction have involved the integration of innumerable classification schemes to establish a hybrid model. The introduction of the hybrid technique relies on the prediction performance that strives to override the limitations of any available architectural scheme. This study offers a comprehensive exploratory appraisal of the issues influencing the successful integration of IoT and blockchain in regards to functionality and effectiveness of security, trust, and flawless communication issues. The exploratory research methodology was used in analyzing the issues affecting the integration of blockchain, artificial intelligence (AI), and the internet of things (IoT). The findings indicated that the integration challenges influencing the effective operations of blockchain, AI, and IoT as a single system involve security, scalability, accountability, and trust of communications. The study recommends that successful and effective integration will enhance the development of new business models as well as the digital transformation of market corporations. Accordingly, new approaches to convergence should ensure that executives address the new technology demands to obtain significant gains in efficiency.

Keywords: Internet of Things, common operating picture, artificial intelligence, Blockchain

1. INTRODUCTION

New developments in the integration frameworks between IoT and blockchain in different fields have sparked debates concerning the actual framework that should be adopted by firms desiring to benefit from the convergence of the two technologies [1]. As one of the principal concepts guiding new prospects of industrial revolution, the Internet of Things (IoT) has achieved immeasurable milestones[2]. Globally, the projected growth of IoT was about $170 billion in 2017 and is expected to be about $560 billion by end of the financial year 2022 [3]. Although countless professionals have indicated that IoT is the new industrial revolution, key challenges have affected the performance of IoT, starting from the ancient days in which there was the lack of a protected ecosystem covering all the construction blocks of IoT design as well as the scalability issues affecting the entire system. The number of devices operating in any IoT system has been one of the primary issues affecting the performance of IoT since its introduction[4].

It is commendable that the IoT has enhanced a common operating picture (COP) handling many applications and aspects of modern day life [5]. Blockchain, in this regard, has enhanced the effectiveness of COP because it has advanced the operations of wireless network and sensor devices that could not otherwise communicate via the conventional IoT network [6], [7]. Blockchain, artificial intelligence (AI), and IoT are the principal technologies that have driven the next phase of digital transformation [8]. It is projected that these technologies will enable for the creation of new business models, including autonomous agents, digital version of IoT, receiving or sending money via blockchain technology, and autonomous decision-making as independent agents of economy [6].

The IoT has enabled a complex connection of things or objects, powered by sensing, communication units, and processing, to identify physical events, interact with their environments, and exchange data[9]. The objective of such interactions is to monitor processes or make decisions concerning events requiring human interventions [10]. Perhaps the most renowned inspirations related to the rise of IoT systems was the need to foster the real-time information collection as well as the need to offer remote and automatic control mechanisms that have replaced current conventional control and monitoring systems across industries [10], [11]. The integration between IoT, AI, and blockchain will introduce a new system architecture that will control and advance most of the ineffective procedures associated with the welfare of humankind.

2. THEORETICAL FRAMEWORK

The theoretical framework adopted in this study considered the limitations of the existing shreds of research on the most effective convergence architecture for AI, blockchain, and IoT. The current research, in this regard, utilizes generalized philosophies and theories concerning the effectiveness of convergence between the three aspects of modern industrialization, including blockchain, AI, and IoT [12]. The theories considered in this depends on the fact that the distributive ledger aspect of blockchain is one of the solutions for the existing security and privacy challenges.

2.1 INDUSTRY DESCRIPTION

The general industry guiding the integration of IoT, AI, and blockchain has produced innumerable scales of information requiring power, network connectivity, storage, and processing. The objective of convergence, in this regard, is to transform available data into meaningful services and information. Along with concerns such as network scalability and reliable connectivity, data privacy and cybersecurity are issues of critical importance regarding the networks serving IoT and related systems [13]. The current industry involves centralized designs that have widely been used to connect, authorize, and authenticate different IoT network nodes.

2.2 LITERATURE REVIEW

The integration and performance issues affecting convergence of blockchain with the IoT has been addressed by many scholars. One of the main concerns of the issues affecting the seamless integration involve the fact that integrating these technologies focused on the prediction performance by filling the gap of limited literatures on the previous classification or convergence techniques [14]. In modern world, artificial intelligence, IoT, and blockchain technologies have been acknowledged as innovations that can promote the existing business processes, disrupt entire market economies, and establish new business models. For instance,

blockchain can enhance business process efficiency, security, transparency, and trust because of its decentralized, distributed, and shared ledger [15].

Issues affecting convergence or integration between AI blockchain, and IoT has often been neglected based on many factors. For example, these three technologies are often used separately and selectively based on the demands of a specific firm. These innovations, however, should be implemented collectively now and in the future [16]. One potential integration platform between these technologies is the use of IoT to provide and solicit data, with blockchain offering the setup rules of engagement and infrastructure while the AI maximizing the rules and process optimization [17], [18].

Information process integration for security, trust, and seamless flow is one of the principal objectives of connection IoT, AI, and blockchain. There are many solutions for addressing the vulnerabilities and threats affecting the operations of IoT. IoT has played a crucial role in the daily organization level by ensuring the ease of working in diverse enterprises [19]. Accordingly, the threat level existing in IoT deviecs is relatively high, indicating that the assessment and integration demands of the different models must be guaranteed to ensure orientation [19]. Because IoT security is critical commensurate with the activities of hackers and malicious users, it is arguable the current architectures are often prone to attacks.

Convergence between AI, blockchain, and IoT has also been discussed by several shreds of literature. It is outlined that the use of AI, along with the abilities of IoT has enhanced treatments targeting patients suffering from Hepatitis C, a blood-borne infection that is often asymptomatic in the initial phases [20]. The progression of hepatitis C throughout the final phases often complicates the treatment and diagnosis process. Accordingly, a system based on AI and machine learning algorithms can assist healthcare providers in offering effective diagnoses in the early stages [21], [22]. Based on the effectiveness of the blockchain in ensuring seamless, secure, and confirmed flow of information, it is arguable that the convergence of AI, blockchain, and IoT can significantly enhance the services given to patients suffering from hepatitis C.

2.3 Problem Statement, Research Gap, Research Contribution

Many pieces of research have tackled the issues, capabilities, benefits, and challenges facing the integration of AI, blockchain, and IoT [23], [24]. The existing studies, however, have only

focused on particular areas, including health, finance, and agriculture, with finance being at the forefront of most emerging studies [25], [26]. Despite the evident success of the convergence of blockchain with IoT in some of these fields, the analysis of converging AI, blockchain, and IoT has not been addressed in most of the existing bodies of literature [27]. Accordingly, this study strives to determine the opportunities and challenges of integrating these three technologies using the best architectural model to enhance the accountability and accuracy of offering a broad range of services [28].

3. RESEARCH MODEL AND HYPOTHESES

The analytical approach was considered as the best research design for this research. An analytical mechanism denotes the application of appraisals to decipher an issue down to its specific elements appropriate for finding a solution. Generally, the analytical approach is also referred to as formal analysis [29]. The primary challenge linked with the analytic approach, however, is that the existing tools are limited to the specific problems they can identify and solve [30]. The approach adopted in this study is founded on the fact that the issues influencing integration between IoT, blockchain, and AI include the common elements such as efficiency, trust, accuracy, and scalability [31], [23]. Commensurate, the research design or model hypothesizes that integrating the three technologies can produce significant outcomes for organizations over time [32].

3.1 METHODOLOGY AND RESEARCH DESIGN

The adopted methodology was the quantitative research design. The selected research method focused on the performance of organizations that have implemented the AI, blockchain, and IoT in delivering services to public. Quantitative research was important for this study because it is crucial to identifying trends and averages to predict or evaluate causal associations that generalizes outcomes to a broader population in the end [33]. This research method was adopted as an experimental and correlational research technique because it formally examines the predictions or hypotheses based on statistics.

Based on the required data to perform a comprehensive quantitative analysis of the data on convergence issues affecting the integration of blockchain, Ai, and IoT, trust issues was the

major element involved in the process. Trust is one of the primary concerns that has affected the integration of blockchain with IoT and AI [34]. The quantitative approach, in this regard, involved the different procedural steps appropriate to the existing study. Principally, the advantage of using a quantitative research method is that the design is necessary regarding the use of factual data needed to address research questions [34], [35].

In the process of determining the most appropriate quantitative method for the study, the study relied on the proportion supporting the assisted perception, which concerned the distribution of respondents according to age, residence, household income, and marital status, among others [36]. Additionally, the study data focused on the number of companies that have performed based on issues such as level of education and understanding of key issues guiding data use and the need for historical evidence.

3.2 POPULATION/SAMPLE/UNIT OF ANALYSIS

The sampling, population, and unit of analysis was regarded as one of the fundamental elements of the study. In this research, it was considered that the companies that have implemented some of the suggested frameworks have understood some of the most influential elements, including, among others, the challenges, benefits, and opportunities associated with any of the emerging issues [29]. Regarding the study and associated measures, it is arguable that the study determined the efficiency of the suggested approach because of the urgent need to foster the transaction rate occurring through blockchain transactions [30], [37].

According to the exploratory design of the suggested framework, this study considered the fact that the efficiency of any applicable approach should follow the contribution of the following specific elements: transaction efficiency (described as the study equation –(1)), n (number of business transactions happening through the integrated AI, IoT, and blockchain platforms), communications trust via trust (t), and the nature of security associated with the transactions (s). It is noteworthy that this model relies on the findings and design of the study conducted by Ghazal et al., in which the analysis relied on the equation outlined below

$$Effectivity\ of\ performance = s+n+t(n) \qquad (1)$$

The inclusion of n depends on the fact that the data used in the appraisal relied on the procedural developments of blockchain in the development of convergence metrics between AI, blockchain, and IoT [38]. In one of the papers published by the individuals supporting the convergence of blockchain, AI, and IoT, Ghazal et al. argue that the computation of the immediate communication trust focuses on enhancing the trust of consumers concerning the most detailed model of the blockchain.

4. ANALYZING DATA

Equation 1 presented above outlines all the variables that have been used in presenting all the data aspects in this study. Accordingly, once this process improves, it is arguable that the integrated architecture covering convergence of IoT, AI, and blockchain will outline a comprehensive sequence of tests to determine the accuracy of handling the challenges influencing the existing block chain models [39]. In this study, the immediate test concerned the computation of trust transaction that majorly focused on the capacity of companies to improve the level of trust in the suggested blockchain models. It is arguable that this aspect was obtained via seeking the attitudes of the different users concerning their ability and capacities to obtain the outlined requirements.

The data model, commensurate with the qualitative analysis study has many inferences. Firstly, the level of consumer/customer trust is determined by adding the scale of successful transactions (St) to the number of unsuccessful transactions (Zt). The outcome of this figure is divided by tt (the aggregate or total transactions). In this regard, (2) provides the actual number of transactions associated with any type of transaction.

$$T \text{ or transactions trust} = (St+Zt)/tt \qquad (2)$$

Based on the equation above, it is difficult to determine the security of the transactions that can happen without allowing or understanding of the detected threats. In this regard, it is arguable that the threat numbers is computed by dividing ts (solved threats) with the overall risks or threats identified in the entire convergence system.

The number of secure transactions following the convergence of AI, IoT, and blockchain (S) is denoted by Equation 3:

S = (td –ts)/td. Which reflects the number of transactions as

N = transaction days (dt)/average daily transaction (adt); that is:

N =9dt/adt

4.1. DISCUSSION OF THE RESULTSS

It is arguable that one of the many challenges affecting effective integration of AI, IoT, and blockchain is the existence of heterogeneous alternative outlining the variety of IoT devices and applications that needs to integrate AI and blockchain with IoT tech founded on their requirements and demands [40]. Generally, these alternatives are only founded on particular use cases that cannot suit a broad range of devices and applications in this specific sector.

As a result, new studies should advocate for the development of a set of standards and protocols that can support the essential and basic needs of all IoT devices and applications rather than introducing applications/devices that can only operate via IoT networks. The combined potential of AI, IoT, and blockchain is immeasurable. Based on existing kinds of studies, it is arguable that the amalgamation of AI, IoT, and blockchain technology can unlock several new business architectures for the accrual of funds from IoT devices and applications [41]. The results presented in the formulas and considerations outlined above resonates with the fact that the security of transactions have the accuracy that reflect the percentages produced by the following formulas. When comparing the models, it is appropriate that the architecture controlling the design of the tables indicate centralization as about 100% of the model. These results indicate that either of the algorithms applicable in the development of a perfect architecture can help address all the concerns of blockchain, AI, and IoT convergence in both the short and long-terms.

5. CONCLUSIONS AND RECOMMENDATIONS

The objective of this study was to assess the most recent and adopted architectures of blockchain. The analysis involved comparing the most popular, recent, and interesting consensus algorithms as well as evaluating the integration between IoT, AI, and blockchain via illustrating the existing field researches. The paper also offered a comprehensive overview of the distruptive studies on the topic that current authors have continued to investigate. The

findings indicated that the convergence between AI, blockchain, and IoT can enhance the adequacy of computational level as well as efficiency in optimizing the energy consumption of connected devices. AI, IoT, and blockchain are technologies that will continue to be integrated in myriad dimensions. This paper contends that the integration of these innovative models will occur because services, products, and business models will benefit from the diversity of these technologies. Generally, these business models can be widely adopted by any independent agent, including cameras, trucks, machines, cars, and numerous sensors.

REFRENCES

[1] T. M. Ghazal, M. T. Alshurideh, and H. M. Alzoubi, "Blockchain-Enabled Internet of Things (IoT) Platforms for Pharmaceutical and Biomedical Research," in Proceedings of the International Conference on Artificial Intelligence and Computer Vision (AICV2021), Jun. 2021, pp. 589–600. doi: 10.1007/978-3-030-76346-6_52.

[2] S. Y. Siddiqui, A. Haider, T. M. Ghazal, M. A. Khan, I. Naseer, S. Abbas, M. Rahman, J. A. Khan, M. Ahmad, M. K. Hasan, A. Mohammed. A, and K. Ateeq, "IoMT Cloud-Based Intelligent Prediction of Breast Cancer Stages Empowered With Deep Learning," IEEE Access, vol. 9, pp. 146478–146491, Oct. 2021, doi: 10.1109/ACCESS.2021.3123472.

[3] A. Pieroni, N. Scarpato, and L. Felli, "Blockchain and IoT Convergence—A Systematic Survey on Technologies, Protocols and Security," Applied Sciences, vol. 10, no. 19, p. 6749, Sep. 2020, doi: 10.3390/APP10196749.

[4] T. M. Ghazal, "Positioning of UAV Base Stations Using 5G and Beyond Networks for IoMT Applications," Arabian Journal for Science and Engineering, 2021, doi: 10.1007/s13369-021-05985-x.

[5] P. Sandner, J. Gross, and R. Richter, "Convergence of Blockchain, IoT, and AI," Frontiers in Blockchain, vol. 3, p. 42, Sep. 2020, doi: 10.3389/FBLOC.2020.522600.

[6] M. Maroufi, R. Abdolee, and B. M. Tazekand, "On the Convergence of Blockchain and Internet of Things (IoT) Technologies," Journal of Strategic Innovation and Sustainability, vol. 14, no. 1, Mar. 2019, doi: 10.33423/jsis.v14i1.990.

[7] E. Rehman, M. A. Khan, T. R. Soomro, N. Taleb, M. A. Afifi, and T. M. Ghazal, "Using blockchain to ensure trust between donor agencies and ngos in under-developed countries," Computers, vol. 10, no. 8, 2021, doi: 10.3390/computers10080098.

[8] T. M. Ghazal, R. A. Said, and N. Taleb, "Internet of vehicles and autonomous systems with AI for medical things," Soft Computing, pp. 1–13, Jul. 2021, doi: 10.1007/S00500-021-06035-2/TABLES/5.

[9] T. M. Ghazal, "Internet of Things with Artificial Intelligence for Health Care Security," Arabian Journal for Science and Engineering 2021, pp. 1–12, Aug. 2021, doi: 10.1007/S13369-021-06083-8.

[10] K. Rabah, M. Research, and K. Nairobi, "Enhancing Global Innovation Agenda www.thelakeinstitute.org The Lake Institute Convergence of AI, IoT, Big Data and Blockchain: A Review," The Lake Institute Journal, vol. 1, no. 1, pp. 1–18, 2018, Accessed: Nov. 23, 2021. [Online]. Available: www.thelakeinstitute.org

[11] R. Bibi, Y. Saeed, A. Zeb, T. M. Ghazal, T. Rahman, R. A. Said, S. Abbas, M. Ahmad, and M. A. Khan, "Edge AI-Based Automated Detection and Classification of Road Anomalies in VANET Using Deep Learning," Computational Intelligence and Neuroscience, vol. 2021, Sep. 2021, doi: 10.1155/2021/6262194.

[12] N. Pathak and A. Bhandari, IoT, AI, and Blockchain for .NET. Apress, 2018. doi: 10.1007/978-1-4842-3709-0.

[13] T. M. G. D. K. Mohammed A. M. Afifi, "The Impact of Deploying the Internet of Things and How Will It Change Our Lives," Solid State Technology, vol. 64, no. 2, pp. 2049–2055, Feb. 2021, Accessed: Nov. 16, 2021. [Online]. Available: https://solidstatetechnology.us/index.php/JSST/article/view/9517

[14] P. Singh and N. Singh, "Blockchain With IoT and AI: A Review of Agriculture and Healthcare," International Journal of Applied Evolutionary Computation, vol. 11, no. 4, 2020, doi: 10.4018/IJAEC.2020100102.

[15] R. Naqvi, T. R. Soomro, H. M. Alzoubi, T. M. Ghazal, and M. T. Alshurideh, "The Nexus Between Big Data and Decision-Making: A Study of Big Data Techniques and Technologies," in Proceedings of the International Conference on Artificial Intelligence and Computer Vision (AICV2021), Jun. 2021, pp. 838–853. doi: 10.1007/978-3-030-76346-6_73.

[16] O. Novo, "Blockchain Meets IoT: An Architecture for Scalable Access Management in IoT," IEEE Internet of Things Journal, vol. 5, no. 2, 2018, doi: 10.1109/JIOT.2018.2812239.

[17] M. K. H. R. H. , S. I. S. N. H. S. A. , M. A. M. A. , D. K. Taher M. Ghazal, "Security Vulnerabilities, Attacks, Threats and the Proposed Countermeasures for the Internet of Things Applications," Solid State Technology, vol. 63, no. 1s, pp. 2513–2521, Oct. 2020, Accessed: Nov. 16, 2021. [Online]. Available: https://solidstatetechnology.us/index.php/JSST/article/view/3096

[18] A. J. Dadhania and H. B. Patel, "Access control mechanism in internet of things using blockchain technology: A review," 2020. doi: 10.1109/ICISS49785.2020.9316126.

[19] T. M. Ghazal, M. Anam, M. K. Hasan, M. Hussain, M. S. Farooq, H. M. A. Ali, M. Ahmad, and T. R. Soomro, "Hep-pred: Hepatitis C staging prediction using fine gaussian SVM," Computers, Materials and Continua, vol. 69, no. 1, pp. 191–203, Jun. 2021, doi: 10.32604/CMC.2021.015436.

[20] X. Lin, J. Wu, A. K. Bashir, J. Li, W. Yang, and J. Piran, "Blockchain-Based Incentive Energy-Knowledge Trading in IoT: Joint Power Transfer and AI Design," IEEE Internet of Things Journal, 2020, doi: 10.1109/jiot.2020.3024246.

[21] D. Li, D. Yao, C. Li, Y. Luo, A. Liang, G. Wen, and Z. Jiang, "Nanosol SERS quantitative analytical method: A review," TrAC - Trends in Analytical Chemistry, vol. 127. 2020. doi: 10.1016/j.trac.2020.115885.

[22] S. K. Singh, S. Rathore, and J. H. Park, "BlockIoTIntelligence: A Blockchain-enabled Intelligent IoT Architecture with Artificial Intelligence," Future Generation Computer Systems, vol. 110, 2020, doi: 10.1016/j.future.2019.09.002.

[23] F. Matloob, T. M. Ghazal, N. Taleb, S. Aftab, M. Ahmad, M. A. Khan, S. Abbas, and T. R. Soomro, "Software defect prediction using ensemble learning: A systematic literature review," IEEE Access, vol. 9, pp. 98754–98771, Jul. 2021, doi: 10.1109/ACCESS.2021.3095559.

[24] D. Skarbek, "Qualitative research methods for institutional analysis," Journal of Institutional Economics, vol. 16, no. 4, 2020, doi: 10.1017/S174413741900078X.

[25] S. McGinley, W. Wei, L. Zhang, and Y. Zheng, "The State of Qualitative Research in Hospitality: A 5-Year Review 2014 to 2019," Cornell Hospitality Quarterly, vol. 62, no. 1, 2021, doi: 10.1177/1938965520940294.

[26] R. M. al Batayneh, N. Taleb, R. A. Said, M. T. Alshurideh, T. M. Ghazal, and H. M. Alzoubi, "IT Governance Framework and Smart Services Integration for Future Development of Dubai Infrastructure Utilizing AI and Big Data, Its Reflection on the Citizens Standard of Living," in Proceedings of the International Conference on Artificial Intelligence and Computer Vision (AICV2021), Jun. 2021, pp. 235–247. doi: 10.1007/978-3-030-76346-6_22.

[27] E. Nehme, R. el Sibai, J. Bou Abdo, A. R. Taylor, and J. Demerjian, "Converged AI, IoT, and blockchain technologies: a conceptual ethics framework," AI and Ethics, 2021, doi: 10.1007/s43681-021-00079-8.

[28] K. Ateeq, M. R. Pradhan, B. Mago, and T. Ghazal, "Encryption as a Service for Multi-Cloud Environment," International Journal of Advanced Research in Engineering and Technology (IJARET) , vol. 11, no. 7, pp. 622–628, Jul. 2020, Accessed: Nov. 17, 2021. [Online]. Available: https://www.researchgate.net/publication/344308747_Encryption_as_a_Service_for_Multi-Cloud_Environment

[29] M. Kaur and S. Gupta, "Blockchain Technology for Convergence: An Overview, Applications, and Challenges," in Blockchain and AI Technology in the Industrial

Internet of Things, IGI Global, 2021, pp. 1–17. doi: 10.4018/978-1-7998-6694-7.CH001.

[30] M. A. M. A. D. K. Taher M. Ghazal, "Data Mining and Exploration: A Comparison Study among Data Mining Techniques on Iris Data Set," Journal of Talent Development and Excellence, vol. 12, no. 1, pp. 3854 – 3861–3854 – 3861, Jun. 2020, Accessed: Nov. 16, 2021. [Online]. Available: https://www.iratde.com/index.php/jtde/article/view/1339

[31] F. Zhang and Y. Zhang, "A big data mining and blockchain-enabled security approach for agricultural based on internet of things," Wireless Communications and Mobile Computing, vol. 2020, 2020, doi: 10.1155/2020/6612972.

[32] T. M. Ghazal, T. R. Soomro, and K. Shaalan, "Integration of Project Management Maturity (PMM) Based on Capability Maturity Model Integration (CMMI)," European journal of scientific research, vol. 99, no. 3, pp. 418–428, Apr. 2013.

[33] W. Li, P. Duan, and J. Su, "The effectiveness of project management construction with data mining and blockchain consensus," Journal of Ambient Intelligence and Humanized Computing, 2021, doi: 10.1007/s12652-020-02668-7.

[34] M. Nassar, K. Salah, M. H. ur Rehman, and D. Svetinovic, "Blockchain for explainable and trustworthy artificial intelligence," Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery, vol. 10, no. 1, 2020, doi: 10.1002/widm.1340.

[35] J. Borenstein and A. Howard, "Emerging challenges in AI and the need for AI ethics education," AI and Ethics, vol. 1, no. 1, 2021, doi: 10.1007/s43681-020-00002-7.

[36] M. A. M. Afifi, D. Kalra, T. M. Ghazal, and B. Mago, "Information Technology Ethics and Professional Responsibilities," International Journal of Advanced Science and Technology, vol. 29, no. 04, pp. 11336–11343, Dec. 2020, Accessed: Nov. 16, 2021. [Online]. Available: http://sersc.org/journals/index.php/IJAST/article/view/34696

[37] B. Farahani, F. Firouzi, and M. Luecking, "The convergence of IoT and distributed ledger technologies (DLT): Opportunities, challenges, and solutions," Journal of Network and Computer Applications, vol. 177, 2021, doi: 10.1016/j.jnca.2020.102936.

[38] H.-T. Yang, "Artificial Intelligence and Blockchain Convergence Trend and Policy Improvement Plan," Informatization Policy, vol. 27, no. 2, pp. 3–19, 2020, doi: 10.22693/NIAIP.2020.27.2.003.

[39] "LEVERAGING BLOCKCHAIN TECHNOLOGY FOR SMALL BUSINESSES," Issues In Information Systems, 2020, doi: 10.48009/3_iis_2020_207-216.

[40] D. Kalra, T. M. Ghazal, and M. A. M. Afifi, "Integration of Collaboration Systems in Hospitality Management as a Comprehensive Solution," International Journal of Advanced Science and Technology, vol. 29, no. 8s, pp. 3155–3173, Apr. 2020, Accessed: Nov. 18, 2021. [Online]. Available: http://sersc.org/journals/index.php/IJAST/article/view/16386

[41] H. S. S. Al-Qudah, "Impact of ERP System Usage on Supply Chain Integration: A Structural Equation Modeling, Jordanian Pharmaceutical Manufacturing Case study," Journal of Economics and Business, vol. 3, no. 2, Jun. 2020, doi: 10.31014/AIOR.1992.03.02.233.

[42]. Alzoubi, H. (2018). The Role of Intelligent Information System in e-Supply Chain Management Performance. International Journal of Multidisciplinary Thought, 7(2), 363–370.

[43]. Alzoubi, A., Al-Gasaymeh, A., & Alzoubi, H. (2018). The Impact of Changes in the Qualitative Characteristics of Accounting Information on the Quality of Investment Decisions: A Field Study in the Brokerage Offices. The Journal of Economic and Management Perspectives (JEMP), 12(4), 67-82.

[44]. Alnazer, N., Alnuaimi, M. & Alzoubi, H. (2017). Analyzing the Appropriate Cognitive Styles and its effect on Strategic Innovation in Jordanian Universities. International journal of business excellence, 13(1), 127-140, doi.org/10.1504/IJBEX.2017.085799

[45]. Khafajy, N., Alzoubi, H. & Aljanabee, A. (2016). Analyzing the effect of knowledge management processes in the services' quality in Iraqi commercial banks. International Review of Management and Business Research, 5(1), 302-314.

[46]. Alzoubi, H., Alnazer, N. & Alzoubi, A. (2016). Exploring the Impact of the use of Business Information systems BIS on the organizational performance effectiveness. International Journal of Business and Management Invention, 5(4), 48-55.

[47]. Alnuaimi, M., Alzoubi, H., Alzubi, A. & AL-Shinewi, M. (2015). The Impact of Managers Efficiency on Quality of Strategic Decision-making under Crisis Management. European Journal of Business and Management, 7(26), 156-166.

[48]. Alrubaiee, L., Alzubi, H., Hanandeh, R. & Ali, R. (2015). Investigating the Relationship between Knowledge Management Processes and Organizational Performance: The Mediating Effect of Organizational Innovation. International Review of Management and Business Research, 4(4), 977-997

[49]. Alzoubi, H. & Khafajy, N. (2015). The Impact of Business Process Management on Business Performance Superiority. International Journal of Business and Management Review, 3(2), 17-34

[50]. Alzubi, H., Mohammad, S. & Abu-salma, A. (2015). Evaluating Strategic Quality Management Dimensions Using Analytic Hierarchy Process (AHP) and its Impact on Organizational Success. International Journal of Research in Management, 5(1), 137-150.

[51]. Mohammad, S., Abu-salma, A. & Alzoubi, H. (2015). American Muslims' Perceptions Toward Transforming Islamic Banking System. International Journal of Economics, Commerce and Management, 5(1), 1-16.

[52]. Alrubaiee, L., Al zuobi, H. & Abu-Alwafa, R. (2013). Exploring the Relationship between Quality Orientation, New Services Development and Organizational Performance. American Academic & Scholarly Research Journal, 5(3), 315-329.

[53]. Alzoubi, H. & Khafajy, N. (2010). Analyze the Impact of Managers Awareness of Environmental Uncertainty on Exploiting Strategic Competencies. Egyptian Journal for Commercial Studies, 34(2), 611-625.

[54]. Al-zu'bi, H. (2010). Applying Electronic Supply Chain Management Using Multi-Agent System: A Managerial Perspective. International Arab Journal of e-Technology, 1(3), 106-113.

[55]. Alnuaimi, M., Alzoubi, A. & Alzoubi, H. (2010). Propose a model for Performance Criteria and measuring its impact for Achieving Excellence. Association of Arab Universities Journal, 56(4), 920-941.

[56]. Mehmood, T., Alzoubi, H, Alshurideh, M., Al-Gasaymeh, A., &Ahmed, G. (2019). Schumpeterian Entrepreneurship Theory: Evolution and Relevance. Academy of Entrepreneurship Journal, 25(4). 1-10, doi.org/10.1080/13662716.2016.1216397

[57]. Alzoubi, H., Ahmed, G., Al-Gasaymeh, A., & Alkurdi, B. (2019). Empirical study on Sustainable Supply Chain Strategies and its impact on Competitive Priorities: The mediating role of Supply Chain Collaboration. Management Science Letters, 10(3), 703-708, doi.org/10.5267/j.msl.2019.9.008

[58]. Alzoubi, H. & Ahmed, G. (2019). Do Total Quality Management (TQM) Practices Improve Organisational Success? A case study of electronics industry in the UAE. International Journal of Economics and Business Research, 17(4), 459-472, doi.org/10.1504/IJEBR.2019.099975

[59]. Al-Gasaymeh, A., Ahmed, G., Mehmood, T. & Alzoubi, H. (2019). Co-Integration Tests and the Long-Run Purchasing Power Parity: A Case Study of India and Pakistan Currencies. Theoretical Economics Letters, 9(4), 570-583.

[60]. Alzoubi, H., Abdo M., Al-Gasaymeh, A. & Alzoubi, A. (2019). An empirical study of e-Service quality and its impact on achieving a value added. Journal of Business and Retail Management Research (JBRMR), 13(4), 138-145.

[61]. Aziz, N., & Aftab, S. (2021). Data Mining Framework for Nutrition Ranking: Methodology: SPSS Modeller. International Journal of Technology, Innovation and Management (IJTIM), 1(1), 85-95.

[62]. Radwan, N., & Farouk, M. (2021). The Growth of Internet of Things (IoT) In The Management of Healthcare Issues and Healthcare Policy Development. International Journal of Technology, Innovation and Management (IJTIM), 1(1), 69-84.

[63]. Cruz, A. (2021). Convergence between Blockchain and the Internet of Things. International Journal of Technology, Innovation and Management (IJTIM), 1(1), 34-53.

[64]. Lee, C., & Ahmed, G. (2021). Improving IoT Privacy, Data Protection and Security Concerns. International Journal of Technology, Innovation and Management (IJTIM), 1(1), 18-33.

[65]. Alzoubi, A. (2021) The impact of Process Quality and Quality Control on Organizational Competitiveness at 5-star hotels in Dubai. International Journal of Technology, Innovation and Management (IJTIM). 1(1), 54-68

[66]. Al Ali, A. (2021). The Impact of Information Sharing and Quality Assurance on Customer Service at UAE Banking Sector. International Journal of Technology, Innovation and Management (IJTIM), 1(1), 01-17.

[67]. Kashif, A. A., Bakhtawar, B., Akhtar, A., Akhtar, S., Aziz, N., & Javeid, M. S. (2021). Treatment Response Prediction in Hepatitis C Patients using Machine Learning Techniques. International Journal of Technology, Innovation and Management (IJTIM), 1(2), 79-89.

[68]. Akhtar, A., Akhtar, S., Bakhtawar, B., Kashif, A. A., Aziz, N., & Javeid, M. S. (2021). COVID-19 Detection from CBC using Machine Learning Techniques. International Journal of Technology, Innovation and Management (IJTIM), 1(2), 65-78.

[69]. Eli, T. (2021). StudentsPerspectives on the Use of Innovative and Interactive Teaching Methods at the University of Nouakchott Al Aasriya, Mauritania: English Department as a Case Study. International Journal of Technology, Innovation and Management (IJTIM), 1(2), 90-104.

[70]. Alsharari, N. (2021). Integrating Blockchain Technology with Internet of things to Efficiency. International Journal of Technology, Innovation and Management (IJTIM), 1(2), 01-13.

[71]. Mehmood, T. (2021). Does Information Technology Competencies and Fleet Management Practices lead to Effective Service Delivery? Empirical Evidence from E-Commerce Industry. International Journal of Technology, Innovation and Management (IJTIM), 1(2), 14-41.

[72]. Miller, D. (2021). The Best Practice of Teach Computer Science Students to Use Paper Prototyping. International Journal of Technology, Innovation and Management (IJTIM), 1(2), 42-63.