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A Review of Applications of Blockchain Technology in the Middle East

Mahmoud Alsakhnini[1], Dr. Yazeed Almoaiad[2]

Abstract

This review study offers a thorough analysis of blockchain technology's Middle Eastern uses. Egypt, Morocco, Tunisia, Libya, Algeria, Turkey, UAE, Saudi Arabia, Bahrain, Iran, Iraq, Jordan, Lebanon, Palestine, Yemen, and Qatar are included in the study. This article investigates the potential applications of blockchain technology in a variety of areas, including finance, supply chain management, and public service delivery. The paper outlines the constraints and prospects of adopting blockchain technology in the Middle East and underlines the potential benefits of this technology for the region, such as enhanced transparency, security, and efficiency. The report finishes with a discussion of the future prospects for blockchain technology in the Middle East, as well as the need for ongoing research and development in this field. This study contributes to a deeper understanding of the role of blockchain technology in the Middle East and gives insights that can assist policymakers and corporate leaders in maximizing this technology's full potential.

Keywords: *blockchain technology, Middle East, applications, finance, supply chain management, public service delivery, challenges, opportunities, transparency, security, efficiency, future prospects, policy-makers, business leaders.*

Introduction

In the recent years, both business and academia have paid close attention to blockchain technology. The original iteration of this technology, which was first presented in 2008, was a cryptocurrency called Bitcoin (Nakamoto, 2008). It's true that cryptocurrencies are the most well-known applications of the blockchain (Beck et al., 2016), increasingly, the technology is being implemented in a wide range of applications and industries that extend far beyond cryptocurrencies. Peer-to-peer networking, game theory, and cryptography are all combined in the blockchain technology. Originally known as the distributed ledger, or blockchain, is the database that underpins the cryptocurrency known as bitcoin. It employs computer techniques to securely and privately record transactions as a chain of blocks. Smart contracts, in which the business rules governing an agreement are recorded on the blockchain and executed concurrently with the transaction, are also utilized by blockchain.

Blockchain uses digital signatures to confirm the authenticity of transactions. The resilient architecture of the blockchain protects the distributed ledger, which is its primary advantage.

[1] Ph.D. scholar in Al-Madinah International University – Faculty of Computer and Information Technology 57100 Kuala Lumpur- Malaysia
Skyline University College, School of Computing- University City of Sharjah- United Arab Emirates
Email: m.alsakhnini@gmail.com
[2] Al-Madinah International University – Faculty of Computer and Information Technology 57100 Kuala Lumpur Malaysia
Email: yazeed.alsayed@mediu.edu.my

Time, complexity, and cost savings are some other advantages of blockchain technology. Blockchain holds the potential to streamline finance and trading procedures and enhance regulatory oversight. Transactions become immutable and updateable only through consensus among peers over the network thanks to a decentralized consensus process. Traditional third-party functions in a transaction are replaced by this design protection. Consensus and immutability regarding the transfer of assets within a business network could be provided by the blockchain distributed ledger. A private blockchain is employed by organizations such as banks and operates within their premises. The entire blockchain system is controlled by the organization, unlike public blockchains, which are open to everyone and run by anonymous users. A hybrid blockchain, on the other hand, combines the features of both public and private blockchains and is accessible only to a selected group of trusted, verified users who are authorized to update and manage the network. As the technology advances, various industry groups are demonstrating its potential use across different sectors and its commercialization is underway (Laroiya, C., et al., 2020).

The growth of Blockchain technology, which brings a new method of conducting business and has disrupted the operations of many public and private organizations, was aided by the interconnectivity and worldwide collaboration made possible by the Internet (Makridakis & Christodoulou, 2019). It has a significant impact on the financial system, and digital currency is widely used. The adoption of legal frameworks that boost and support the acceptability of this technology is necessary given the rapid proliferation of blockchain applications. The experience illustrates that national blockchain policies that offer solutions at all levels are more advantageous for businesses, governments, society, and the economy. Many Blockchain platforms and apps are well-known, beginning with Bitcoin and then Ethereum, which serve as platforms for developing decentralized applications using smart contracts and provided inspiration for a brand-new idea known as the "token economy." Applications that are now being developed in the voting, digital identification, banking, and health sectors serve as examples of how blockchain may one day be applied to solve complex business problems. A new school of thinking is currently developing on block chain's potential to promote international efforts to advance environmental sustainability. This article examines the Blockchain application in the Middle East region and gives an overview of related literature as well as a conceptual study of digital platforms and ecosystems, blockchain technology, and information technology (IT). Finally, a review and debate of Middle Eastern Blockchain technology's prospects and challenges.

Background

Digital Platforms and Ecosystems

Many different research contexts have seen substantial study of digital platforms. These platforms are relevant to the software development industry and have been studied by scholars such as Constantinides et al. (2018), Gawer and Cusumano (2008), and Morris and Ferguson (1993). Digital platforms and ecosystems have become increasingly important in today's business world. A digital platform is a type of software that enables users to access and interact with various services, applications, and data. On the other hand, a digital ecosystem is a group of interdependent organizations, people, and systems that share a common digital platform. This literature review will provide an overview of the key concepts, definitions, and research on digital platforms and ecosystems.

Definitions and Key Concepts

Digital platforms and ecosystems have been defined and conceptualized in different ways by various scholars. However, there are some common definitions and key concepts that are widely accepted. According to Hagiu and Wright (2020), a digital platform is "a two-sided market that intermediates between two or more distinct groups of users, such as buyers and sellers, and provides a platform for them to transact with each other." Digital platforms typically provide infrastructure, tools, and services that enable users to interact, transact, and create value. On the other hand, a digital ecosystem is a "complex network of organizations, individuals, and technologies that interact to create, distribute, and consume products or services in a particular economic or social context" (Jacobides et al., 2018). Digital ecosystems are characterized by interdependence, collaboration, and competition among different actors and systems.

Platform and Ecosystem Design

The design of digital platforms and ecosystems is a critical factor that determines their success or failure. Scholars have identified various design principles and strategies that can enhance the value and sustainability of digital platforms and ecosystems. One key design principle is to create a multisided market that facilitates interactions and transactions among different user groups (Gawer and Cusumano, 2014). Another important design strategy is to leverage network effects, which refer to the positive feedback loops that arise when more users join a platform or ecosystem (Rochet and Tirole, 2003). Furthermore, digital ecosystems should be designed to foster collaboration and co-creation among different actors (Jacobides et al., 2018). This can be achieved through the use of open APIs, data sharing agreements, and other forms of interoperability.

Business Models and Governance

Digital platforms and ecosystems have unique business models and governance structures that differ from traditional firms. Scholars have examined various business models and governance mechanisms that can enable digital platforms and ecosystems to create and capture value. One common business model for digital platforms is the freemium model, which offers basic services for free but charges users for premium features (Anderson, 2009). Another popular business model is the platform as a service (PaaS) model, which provides a platform infrastructure for developers to build and deploy their own applications (Korhonen et al., 2014).

In terms of governance, digital ecosystems often rely on decentralized governance mechanisms that enable self-organization and self-regulation among different actors (Adner and Kapoor, 2016). However, there is also a need for formal governance structures to address issues such as intellectual property rights, data privacy, and cybersecurity.

Challenges and Opportunities

While digital platforms and ecosystems offer many opportunities for innovation and growth, they also face several challenges and risks. Scholars have identified various challenges and risks that digital platforms and ecosystems need to address to ensure their sustainability and success. One major challenge is the emergence of platform monopolies and the concentration of market power in a few dominant players (Zuboff, 2019). This can lead to reduced competition, increased inequality, and loss of control over personal data. Another challenge is the need to ensure trust, security, and privacy in digital ecosystems (Kshetri, 2018). Digital ecosystems are

vulnerable to cyber attacks, data breaches, and other forms of malicious activity that can undermine their legitimacy and reputation. Finally, digital platforms and ecosystems also face challenges related to regulatory compliance and legal frameworks. As digital platforms and ecosystems transcend national boundaries and jurisdictions, there is a need for international and cross-border cooperation to develop appropriate regulations and standards (Kenney and Zysman, 2016).

However, digital platforms and ecosystems also offer many opportunities for innovation and value creation. They enable new forms of collaboration, knowledge sharing, and resource utilization that were not possible before (Jacobides et al., 2018). They also provide opportunities for entrepreneurship and job creation, particularly in the digital economy.

Future Directions

Digital platforms and ecosystems are likely to become even more prevalent and influential in the future. Scholars have identified several trends and directions that are likely to shape the evolution of digital platforms and ecosystems.

One trend is the increasing use of artificial intelligence and machine learning to enhance the functionality and intelligence of digital platforms and ecosystems (Eisenmann et al., 2019). This will enable platforms and ecosystems to provide more personalized and relevant services to users.

Another trend is the growing importance of blockchain technology and decentralized architectures in digital ecosystems (Swan, 2015). Blockchain technology offers a secure and transparent way of managing transactions and interactions among different actors in a digital ecosystem. Finally, there is a need for more research on the social and ethical implications of digital platforms and ecosystems. Scholars have raised concerns about the potential negative consequences of digital platforms and ecosystems on privacy, security, democracy, and social cohesion (Zuboff, 2019). Therefore, there is a need for interdisciplinary research to explore these issues and develop appropriate policy and governance frameworks.

They are a software platform with a customizable architecture that offers basic functionality and communicates with additional modules via defined interfaces (Tiwana et al., 2010, p.676). The expansion of online platforms is fueled by complementary resources (Teece, 1986), which make it easier for individuals and enterprises to use technology to design and produce digital services, often known as "apps" or digital services. Personal computing (Bresnahan and Greenstein, 1999), online systems (Evans et al., 2006), smart mobile phones (Tiwana et al., 2010; Yoo et al., 2010), electronic games (Iansiti and Zhu, 2007; Romberg, 2007), automobiles technologies (Henfridsson and Lindgren, 2010), the music recording industry (Tilson et al., 2013), and healthcare are a few examples of industries where digital platforms (Agarwal et al., 2010). The creation of digital services is seen to be a means of fostering thriving digital ecosystems while meeting the various needs of platform users (Hanseth and Lyytinen, 2010). So, platform owners will move their attention from development to distribution, marketing, brokerage, and operations of digital services (Meyer and Seliger, 1998; West and Mace, 2010).

The Blockchain: Overview

The fundamental ideas behind blockchain technology emerged in the late 1980s and early 1990s. Submitted to the ACM Transactions on Computer Systems in 1990 and published in 1998, Leslie Lamport's PartTime Parliament describes a consensus mechanism for making decisions in a computer network where the machines or network may not be trustworthy

(Lamport L., 1998). A chain of digitally signed information was used as an electronic ledger to prove the authenticity of signed documents in 1991, assuring that none of them had been altered (Narayanan, A. et al., 2016). In recent years, blockchain technology has emerged as a key invention with potential applications in a variety of industries and sectors. This is a summary of blockchain technology, with citations to back up the information supplied.

Blockchain technology is a distributed, decentralized ledger that enables secure and transparent transactions. It was initially created to support the digital money Bitcoin, but has since been adapted for a variety of different applications. Each node in the network keeps a copy of the blockchain, which holds a record of all transactions. Transactions are grouped into blocks and added to the chain in a manner that prevents them from being modified or removed, thereby producing an immutable record of all transactions. Because blockchain technology is decentralized, it is very resistant to hacking and fraud. It reduces the necessity of a central authority for authenticate transactions, hence increasing efficiency and decreasing expenses. The transparency of the technology also means that it can be used to increase trust in transactions and reduce the risk of fraud or corruption (Nakamoto, S., 2008). Nakamoto's article disclosed the design for the majority of modern cryptographic strategies (although with alterations and variants).

Blockchain technology can be applied to a range of use cases, including supply chain management, identity verification, voting systems, and financial services. The technology could change the way these industries work by making things more open and safe and by decreasing expenses. Blockchain networks come in different forms, such as public blockchains, private blockchains, and consortium blockchains. Private blockchains are restricted to a specific group of users, while public blockchains, such as the Bitcoin blockchain, are open to anyone. Consortium blockchains are owned and operated by multiple organizations (Tapscott, D., & Tapscott, A., 2016)

Bitcoin is the first of many blockchain applications (Yaga, D. et al., 2019). The article offers a thorough introduction to blockchain technology, covering its history, operation, and prospective applications. The article discusses the characteristics of blockchain technology, such as its decentralized nature, immutability, and security features, and provides examples of how it can be implemented in areas such as financial services, supply chain management, and healthcare. It also addresses the challenges and limitations of blockchain technology, such as scalability and interoperability issues, and highlights the need for continued research and development to address these challenges. The "double-spending issue" is the method for preventing financial mistakes. What's to stop someone from "spending" a digital dollar as many times as they like by simply copying and pasting it like a block of text? For previously digital currencies, the problem of duplicate spending prevented true decentralization. The ability to conduct business directly with other users without the need of a trustworthy middleman was the main advantage of utilizing Bitcoin. Furthermore, it made it possible for individuals who had the ability to add new blocks and maintain copies of the ledger—known as miners in the context of Bitcoin—to acquire brand-new bitcoin in a certain manner. The automated payouts to the miners enabled the system's decentralised management without the need for coordination. Using a blockchain and consensus-based maintenance, a self-policing technique was devised to ensure that only legal transactions and blocks were added to the network (Chevet S., 2018). Figure 1 explains in brief how Bitcoin works (Frugal Innovation and the New Product Development Process, n.d.).

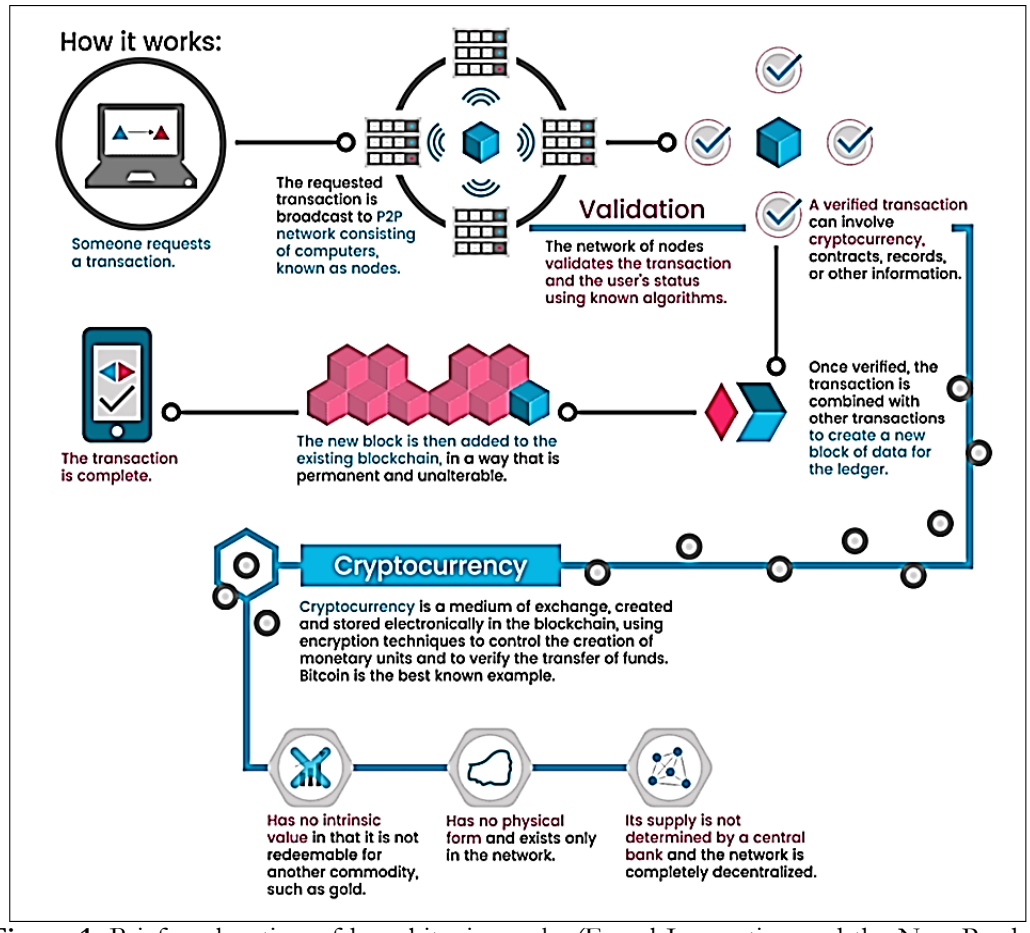

Figure 1: Brief explanation of how bitcoin works (Frugal Innovation and the New Product Development Process, n.d.)

Bitcoin is implemented using public key infrastructure (PKI), which assigns each user a pair of public and private keys (Housley, R. 2004). The public key is utilized as the Bitcoin wallet address, while the private key is used for user authentication. A transaction includes the sender's public key, multiple recipients' public keys, and the amount being transferred. This transaction is recorded in a block, which is added to the chain of blocks in about 10 minutes. All blocks are stored on the nodes' disk storage and contain data on all transactions made. Nodes keep track of all transactions on the Bitcoin network and use them to verify the accuracy of new transactions. Nodes are rewarded for their role in ensuring transaction accuracy through the process known as mining, validated by Proof-of-Work, a crucial component of blockchain technology. Once every transaction has been confirmed by all nodes, a consensus is reached, and new blocks are added to the chain of older blocks, creating a single, unbroken chain known as the Blockchain, which serves as the public ledger technology used by Bitcoin (Yli-Huumo, J., 2016).

Blockchain has significantly taken over the world as a result of the success of digital currency. A distributed ledger, often known as a blockchain, is a write-only data structure that is maintained by numerous nodes with varying degrees of trust in one another. A special protocol that enables information to be transferred between numerous entities inside a system forms the basis of blockchain innovation. Because system members are linked together using

encrypted identities and effectively communicate with one another through distributed communication, middlemen are not needed. Then, after being sent to all nodes, each transaction is recorded in a never-ending ledger chain. Many projects are using blockchain technology to validate papers and identities as a result of the increase in data breaches, extortion, and fraud (Lee, J. H., 2017).

The architecture of blockchain technology is basic and easy to adopt, removing all layers of complexity for all parties involved. Figure 2 illustrates a basic blockchain construction (Junestrand, 2019).

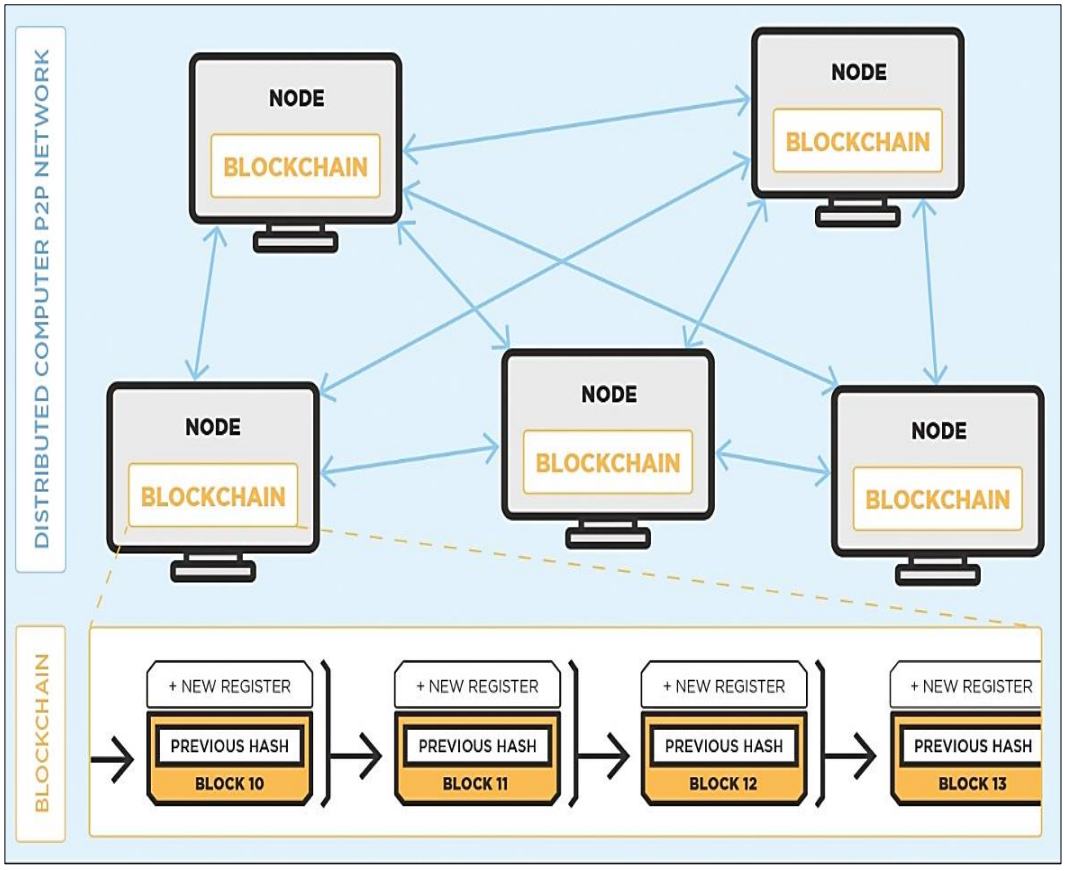

Figure 2: Architecture of Blockchain (Junestrand, 2019)

Users of the blockchain network propose potential transactions using various software options such as desktop applications, smartphone apps, digital wallets, and web services. These transactions are then sent to one or more nodes within the blockchain network, which can include both publishing and non-publishing nodes. The transactions are then spread to other nodes in the network, but this does not automatically add the transaction to the blockchain. Once the transactions have been disseminated, they must wait in a queue in some blockchain implementations before being published to the blockchain by a designated publishing node. The blockchain is constructed by linking blocks together and storing the hash value of each block's header in the next block, as shown in Figure 3 in the form of a generic block chain (Yaga, 2018).

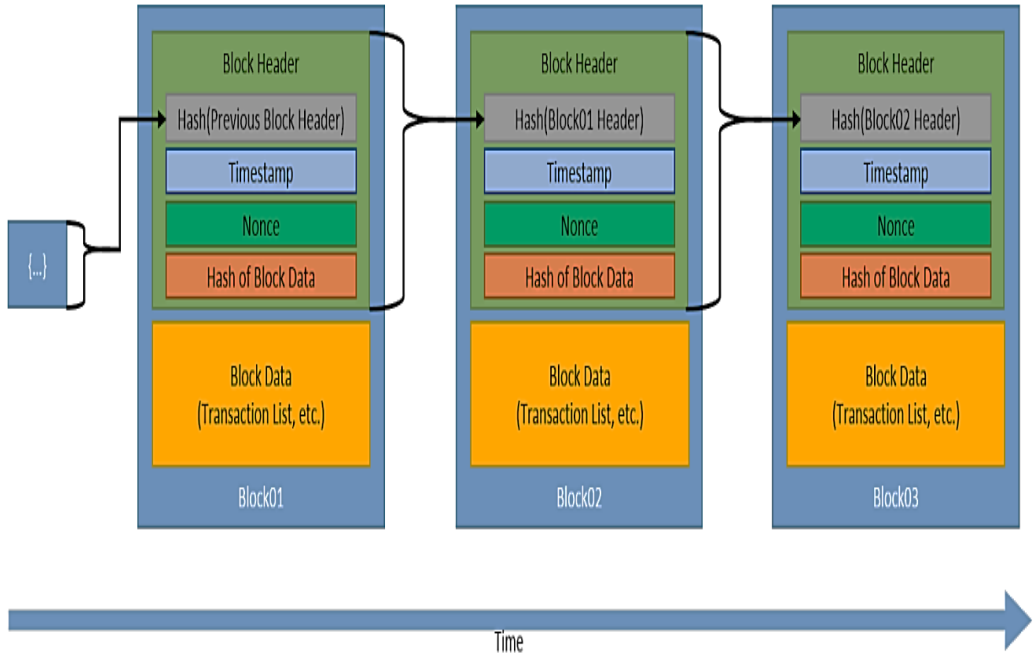

Figure 3: Generic Chain of Blocks (Yaga, 2018)

The two key characteristics that must be identified while analyzing blockchain technology are trust and decentralization (Tama, B. A., et al., 2017). The following parts will provide information on trust and decentralization in blockchain technology while taking into account both of these important aspects.

The blockchain technology's decentralized method conceals its most crucial characteristic (Seebacher, S., & Schüritz, R., 2017). The network is specifically protected by a proof-of-work system, which eliminates the need for any outside parties to validate and record transactions. This protocol aids blockchain technology users in reducing their reliance on outside intermediaries to secure all transactions and assets (Böhme, R., et al., 2015). Because the complete technical code is available to everyone as open source, there is no chance that a backdoor could be built into the system (Hull, R., et al., 2016). This open access provides users with secure and convenient access to the blockchain, allowing them to have control over the safety of their funds, unlike traditional banks who control their customers' assets. Key elements such as shared and public interfaces (Sun et al., 2016), peer-to-peer verification of transactions (Garman et al., 2013; Kosba et al., 2016), smooth flow of information (Sun et al., 2016), and cryptography-based security (Zyskind & Nathan, 2015; Xu, 2016) demonstrate the reliability and trustworthiness of blockchain technology. Blockchain technology stands out for its decentralization, which offers censorship resistance and immutability (Seebacher and Schüritz, 2017). This is particularly important as it ensures that individuals' assets or funds are protected and not subject to the control of a third party (Tama, B. A., et al., 2017). In addition, due to the arising out of the utilization and decentralized qualities of blockchain technology, neither the government nor cyberterrorists would be able to access the personalized ledger created for individual use. Computing can use the built-in proof-of-work function to solve any kind of complex mathematical problems. Furthermore, the popular consensus technique known as proof-of-work is presently used to connect millions of autonomous nodes. As a result,

protection against the potential dilution of the money supply is ensured, reinforcing the confidence that the assets are secure (Seebacher, S., & Schüritz, R., 2017). The crucial characteristics of decentralization incorporated into blockchain technology are best illustrated by a select few key terminology, such as member anonymity (Zyskind, G., & Nathan, O., 2015), the capacity for automation (Xu, J. J., 2016; Guo, Y., & Liang, C., 2016), data redundancy (Hull, R., et al., 2016), and peer engagement in development "versatility" (Zhao, J. L., et al., 2016).

Smart Contracts and Ethereum

Smart contracts are self-executing computer programs that can automatically enforce the terms of an agreement between two or more parties. They are intended to automate operations and reduce the need for intermediaries, such as lawyers or banks, in the enforcement of contracts. Nick Szabo proposed the notion of smart contracts in 1994, but the advent of blockchain technology has made them easier to construct and execute (Szabo, N., 1994). When certain criteria are met, smart contracts are programmed to automatically execute the provisions of a contract. For example, if a smart contract is created to facilitate a real estate transaction, it might be programmed to release the funds to the seller only when the title of the property is transferred to the buyer.

Ethereum is an optimal blockchain system for the formulation and execution of smart contracts. It was launched in 2015 and enables developers to build decentralized applications (DApps) that can automate a wide range of processes, from financial transactions to supply chain management. The benefits of smart contracts include increased efficiency, lower costs, and greater transparency. They can help reduce the need for intermediaries, eliminate the potential for fraud, and streamline processes. Moreover, smart contracts can be programmed to enforce an agreement's terms impartially and without human interference.

In 2013, Vitalik Buterin, a Canadian developer aged 19 at the time expanded on the Nakomoto whitepaper to publish a paper titled A Next-Generation Smart Contract and Decentralized Application Platform. By leveraging the advantages of Bitcoin's proof-of-work, hashing, and incentive system for miners, Buterin developed a new blockchain called Ethereum, whose main advancement was the addition of a Turing-complete language. This suggests that the Bitcoin blockchain performed poorly owing to architectural limitations, whereas the Ethereum blockchain performed well in order to take advantage of the computational power harnessed by the incentive structure. Due to the integration of the Turing-complete language into the Ethereum blockchain, it is now possible to write "smart contracts," or computer code that is encoded in a blockchain and executed by miners. A smart contract is a collection of computer code and data that can be stored on a blockchain network using cryptographically signed transactions (Examples of smart contracts include Ethereum's smart contracts and Hyperledger Fabric's chaincode). The nodes of the blockchain network execute the smart contract, and the results are recorded on the blockchain. All nodes executing the smart contract must reach the same conclusion (Yaga, D. et al., 2019). Users of the blockchain network can conduct transactions that transmit data to a smart contract's open functionality. Using the user's input, the smart contract runs the appropriate procedure for providing a service. Because of command is on the ledger and is therefore tamper-evident and tamper-resistant, it can be utilized as a trustworthy third party, among other things. Computation may be made, data can be kept, attributes can be displayed to indicate a publicly accessible status, and, if necessary, funds can be automatically transferred to other accounts. It's not even required that it serve a financial purpose. The use of smart contracts in a multi-party transaction can bring about benefits such as verifiable data, increased transparency, improved decision making, reduced reconciliation costs, and quicker transaction times, as it can automate and streamline business processes. Figure 4 illustrates the brief concept of how a smart contract works (Agrawal, 2023).

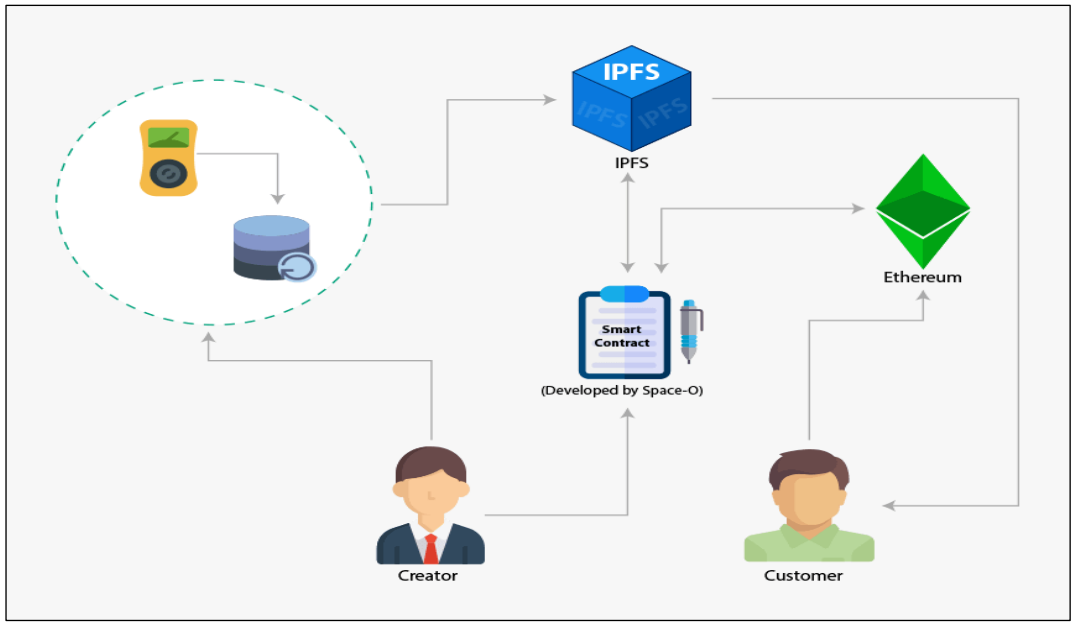

Figure 4: Figure 4: Brief explanation of how smart contract works (Agrawal, 2023)

he nodes that publish new blocks on the blockchain also run the code for smart contracts at the same time. Some blockchain systems have publishing nodes that validate the results from nodes that execute the smart contract code instead of actually running it themselves. When using smart contracts on public blockchain networks that support them, such as Ethereum, users must pay a fee called "Gas fees" to cover the cost of executing the code. Most NFT solutions rely on blockchain platforms that utilize smart contract technology to ensure the proper execution of their order-sensitive operations.

Non-Fungible Tokens (NFTs)

Described as a "on a blockchain, a cryptographically unique, indivisible, irreplaceable, and verifiable token that represents a specific digital or physical object," a Non-Fungible Token (NFT) serves this purpose (Valeonti, F., et al., 2021). NFTs were first brought up in 2012 when "Colored Coins" for Bitcoin, a name for tokens that reflect any form of physical asset, such as real estate, cars, and bonds, were introduced (Rosenfeld, M., 2012). Dieter Shirley, a programmer who contributed to the Ethereum source code repository and created the digital treasures videogame CryptoKitties, proposed the ERC-721 smart contract protocol in 2017. This brought about the evolution of NFTs into their present form, creating a brand new category of Ethereum tokens. Prior to the introduction of the ERC-721 standard, most Ethereum tokens were built on the ERC-20 standard for the sake of interoperability, which is characterized by its ability to allow for interchangeability and substitution. As a result, all cryptocurrencies on the Ethereum platform, excluding Ether which is the native cryptocurrency, are created using an ERC-20 contract. ERC-20 tokens are interchangeable and can be exchanged with any other tokens of the same type. Besides ERC-721, which is considered the "gold standard," other smart contract protocols have been introduced for creating NFTs. The ERC-1155 "multi-token standard" provides more flexibility in managing NFTs by allowing batch transactions, reducing gas costs and reducing carbon emissions by 90%. Another significant standard is EIP-2981, which ensures universal support for royalty payments across all NFT marketplaces and ecosystems. This standard addresses the issue of a

lack of standardization and interoperability among ecosystems when it comes to enforcing resale rights on different platforms. Finally, it is anticipated that the use of fractionalized NFTs (F-NFTs), which allow for fractional ownership of NFTs, will increase, especially for high-value collectibles (Garnett, K., & Neuburger, J., 2021). You may say that Ethereum outperforms other blockchains mostly due to its market dominance.

Although NFTs have clear promise, it's crucial to keep in mind that employing this new technology entails costs for creating and trading crypto collectibles as well as potential hazards that should be taken into account by any person or organization considering using it. To record new transactions on the relevant blockchain, one must pay "gas fees," which are costs paid to node operators (Schwartz, D., et al., 2021), any other blockchain-based transaction, the production and trading of NFTs, etc. The proper functioning of a blockchain is dependent on node operators, who run software that "maintains a full copy of the blockchain" and "broadcasts transactions over the network," giving their computer's resources (such as RAM, disk space, and bandwidth) to it. Figure 5 illustrates the role of Gas fees.

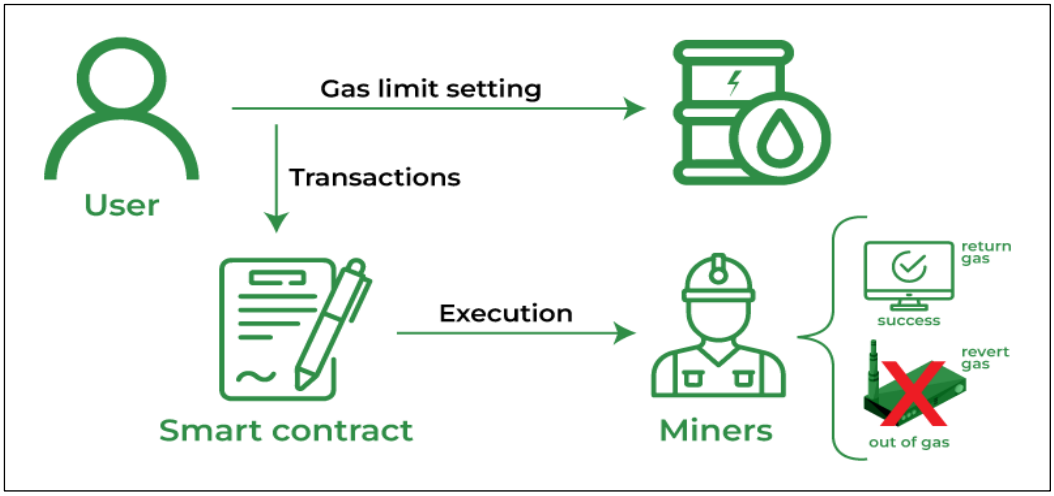

Figure 5: Role of Gas Fees (Ethereum - Gas and Fees - GeeksforGeeks, 2022)

Literature Review

Blockchain technology for regional integration

There are still significant barriers preventing the widespread use of blockchain technology, especially in the cryptocurrency space, even though it is increasingly becoming a significant disruptive force. Cryptocurrencies like Bitcoin and Ethereum have grown in popularity, but as a result, they are now slow and expensive to use, impeding widespread acceptance as a medium of exchange. In comparison to traditional financial platforms like Visa, which have the capability of handling hundreds of transactions per second, cryptocurrencies like Bitcoin have a limited processing capacity and can only manage around seven transactions per second (Warburg et al., 2019). The value of cryptocurrencies is uncertain and volatile. Mining, the process of validating transactions by adding blocks to the network, requires a lot of energy and therefore has a large carbon footprint. To address this, new methods for consensus, such as Proof of Stake, are being developed that do not consume as much energy. Additionally, off-network "Layer 2" platforms are being introduced to increase speed, scalability and reduce the

impact on the main network. Despite current challenges, blockchain technology is gaining popularity across various industries worldwide.

Blockchain's effects on society, politics, and the economy

Although blockchain technology is still in its infancy, it is being quickly adopted by a variety of businesses and governments, and there are several examples of how it is changing parts of our social, political, and economic lives.

- **Economic impacts:** By facilitating better access to cash and financial services, cryptocurrencies have the potential to support economic growth as a store of value. In many nations throughout the world where unreliable institutions and excessive inflation rates have harmed national economies, its value proposition is clear. The overprinting of fiat money by central banks has resulted in hyperinflation, which has severely damaged the economies of many emerging nations. A variety of middlemen are required in the current economic system to confirm transactions and foster confidence. These drive up prices and slow down advancement. It is feasible to handle the flow of value directly utilizing blockchain technology, eliminating the need for middlemen and allowing for practically instantaneous transmission. The mediator is replaced by an algorithmic consensus process in a distributed, peer-to-peer network, protected by strong encryption. By expediting cross-border business and reducing transaction costs, blockchain has the potential to have a big impact on global trade. There are several stakeholders that can create conflict and impede regular trade operations in the global supply chain, comprising financial institutions, shipping companies, companies that import and export goods, customs and port officials, and regulatory bodies (Grossman, M., 2022).

- **Politic impacts:** Blockchain can contribute to building crucial element of trust between nations. facilitating political fusion. According to Reinsberg (2018), blockchain-based smart contracts that automatically carry out when predetermined circumstances are satisfied can offer the governance necessary for international agreements to be taken seriously. Atzori (2015) investigates how nation-states might become less important in the future due to blockchain technology. According to Hegadekatti (2017), blockchain technology has the potential to build networks to establish regional unions, which would benefit society and the economy in a number of positive ways. This is further evidence that integration must go beyond the nation-state to close the trust gap. Government corruption may be effectively eradicated using blockchain technology in areas including procurement contracts, government contracting, land registry data, business ownership registers, and money disbursements.

- Social impacts: The idea that blockchain technology could be applied to advance society is gaining traction. Although blockchain was initially intended to be a rival to the current financial system, it has a larger possibility of revolutionizing industries such as education, healthcare, non - discrimination, and the environment in developing nations (Domjan, P., et al., 2021). The enormous costs associated with sending donations across borders have made blockchain technology an essential tool for humanitarian help. Typically, it is difficult to verify whether and how money reaches its intended recipients and is utilized since there is a lack of transparency and oversight. In contrast to conventional humanitarian aid efforts, smart contracts built on the blockchain can speed the fundraising process and reduce the friction caused by the use of many intermediaries. The World Food Program (WFP) and the United Nations Children's Fund are two of the international organizations that are using blockchain technology to help refugees and ensure food security. Other international organizations using blockchain technology include organizations that promote gender equality (Chin, C., 2018).

Blockchain adoption in the MENA

The application of blockchain - based in MENA nations varies considerably. In the Middle East and North Africa (MENA) region, some rich Gulf States are leading this area in technology innovation, investing in start-ups, and fostering tech-centered communities and policies. However, across most of the MENA region, the use of cryptocurrencies is limited and mainly focused on remittances, combating hyperinflation, bypassing sanctions, or financing terrorism. This is due to the fact that six countries have absolute bans on cryptocurrencies and the majority of the others have issued government warnings (Papadaki and Karamitsos, 2021). However, as expanding numbers of nations begin experimenting with the technology, changes are imminent. The adoption of this technology faces numerous difficulties, such as a lack of a taxation structure, a lack of regulations, a shortage of competent workers, and low levels of awareness. The absence of data protection legislation akin to those in the EU (GDPR) presents another difficulty for the Middle East region. Data protection legislation in Kuwait, Oman, the United Arab Emirates, and Saudi Arabia are less thorough compared to those in Bahrain and Qatar, which passed data protection regulations in 2019 and 2016 respectively. The free zones in the UAE, such as the International Financial Center (DIFC), are regulated by international privacy laws (Smith, 2020). In the lack of appropriate legal and regulatory frameworks, rapid blockchain implementation also increases the danger of cybercrime.

Much progress has been made in the MENA region thanks to the widespread use of blockchain and cryptocurrency technology in many Gulf States. Particularly making significant progress in creating their legal and policy frameworks for blockchain technology are the countries of Bahrain, Saudi Arabia, and the United Arab Emirates (UAE). It is now more important than ever To establish a new economic and sustainable future because long-term oil production prospects are deteriorating. As a result, several nations have made substantial efforts to establish regulations and governance frameworks for both cryptocurrencies and blockchain technology. The Gulf states are ahead of the rest of MENA in adopting blockchain and cryptocurrency technology. By enacting progressive financial rules, they are enticing overseas investment to the region and encouraging entrepreneurs to form partnerships with traditional financial institutions. These countries have a history of following innovation trends rather than initiating new ones. However, this is changing in the financial technology sector, as they launch ground breaking legislative initiatives and become major players in digital transformation, bringing about radical change on a global scale. These governments are supporting new entrepreneurial ventures, providing practical work spaces, and allowing individuals to experiment with technology through "sandboxes." They are positioning themselves as leaders in the Fourth Industrial Revolution (Buller, 2020). Foreign investors and entrepreneurs are starting to pay attention to these pro-cryptocurrency regions as the ecosystem expands. For example, to support and legitimize cryptocurrencies, the US-based cryptocurrency payments company Ripple Labs is already partnering with banks in Saudi Arabia and the United Arab Emirates (Abdel-Qader, 2020).

- **Bahrain**: To become the region's top technological hub, Bahrain, a small island nation, has taken the lead in supporting innovative fintech and blockchain projects. The Central Bank of Bahrain has promoted the Crypto-Asset Module, a framework for regulating and granting licenses to crypto-asset businesses. The government has also encouraged companies to trial cryptocurrency products and services in sandboxes that it has authorized. A research was conducted in 2020 to look into the country's interoperability status and assess the extent of e-government maturity (Ghanem & Alsoufi, 2020). The use of blockchain technology has the potential to improve services in the Kingdom of Bahrain and increase citizen satisfaction (Ghanem and Alsoufi, 2020).

- **Iraq**: The use of cryptocurrency was outlawed by the Iraqi Central Bank in 2017. Citizens have been forced to seek black market sources for cryptocurrency activities due to this limitation and the lack of any regulatory framework for the industry (Bapir, 2021).

- **Iran**: In the wake of the COVID-19 outbreak, US sanctions, and soaring inflation, the Iranian government began investigating the feasibility of establishing a legal structure for cryptos in May 2020. It was revealed at the beginning of October 2020 that mining will be legalized and used as a means of paying for imports. When it comes to financing their imports, the Central Bank of Iran has devised a scheme in collaboration with the Ministry of Energy that will allow them to buy bitcoin directly from miners (Asia Times, 2020).

- **Kuwait**: Cryptocurrency assets like Bitcoin, Ethereum, and Dogecoin have drawn criticism from the Central Bank of Kuwait due to their volatility and potential for fraud. (Faridi, 2021).

- **Jordan**: One of the most notable efforts to tackle the Syrian refugee crisis was launched in Jordan in 2017. The concept links the bank to the refugees' digital identity data while using Blockchain technology for payment transfers (Juskalian, 2018). The initiative improves efficiency and transparency while assisting in the tracking of monies used by the World Food Program (WFP). The WFP officially reports that more than 106 000 refugees are now receiving cash transfers. WFP and UN Women began investigating potential for female refugees to join in the UN Women pay for work initiative in 2018. (WFP, 2018).

- **Lebanon:** One of history's worst economic disasters is the Lebanese one. The value of Lebanon's national currency has decreased by more than 90% in recent years. (Lautissier, 2021). Digital identity verification: Blockchain can be used to create a secure and tamper-proof digital identity system. In Lebanon, the National Digital ID program is exploring the use of blockchain technology for this purpose (UNDP, n.d.).

- **Oman**: It seems to also look at blockchain technology's benefits. The first financial transaction on the blockchain was carried out by the autonomous organization Oil and Orbit Group (Alexandre, 2020). While Oman's government learned about its blockchain technology in 2018 and acknowledged the various industries in which it may be used. Now, Dhofar, its largest bank, uses ripple (AMEinfo, 2020).

- **Palestine**: Israel's economic siege on Gaza, which has severely restricted the passage of products, has wreaked havoc on the region's economy, where unemployment is close to 50%. (Saqan, 2021). Trade is handled in Israeli shekels, US dollars, and Jordanian dinars since Palestine lacks an official currency. The acceptance of cryptocurrencies, which offer a reliable replacement, is popular across the country. The Israeli shekel is currently being replaced by a digital currency at the request of the Palestinian Prime Minister (Gibbs, 2019).

- **Qatar**: One of the top producers of oil and gas worldwide, is considering using technology in its energy industry. The recently named governor of the Qatar Central Bank (QCB) believes that blockchain technology has significant use in the energy sector through the adoption of the oil and gas supply chain, and in the infrastructure sector through the use-cases for strategic asset management. Additionally, the nation is reportedly loosening its cryptocurrency regulations as it investigates various use cases in the government system, including the Qatar residency permit.

- **Saudi Arabia**: The monarchy realizes the need to completely diminish its dependency on oil and is seeking to reinvent itself as a blockchain-driven nation (Anthony, 2021). The Saudi Arabia 2030 project provides a comprehensive plan for transitioning to a new economy, which has led to increased use of bitcoins in the country. The collaboration between the central bank and monetary authority with Ripple Labs to enhance the country's payment system is one example of this trend (Papadaki and Karamitsos, 2021). Through the development of blockchain and decentralized finance (DeFi) technologies, Saudi Arabia hopes to diversify its economy and become a center for innovation as part of its Vision 2030 plan (Lago, 2021). The SAMA Regulatory Sandbox has been established by the Saudi Arabian Monetary Authority (SAMA) for testing and research as it explores blockchain technology for financial services (Hafiz, 2020).

- **Syria**: Syria's civil conflict has severely damaged its political institutions, economy, and rule of law. There is a considerable degree of poverty and suffering among the institutions. Similar to other conflict-ridden regions of the world, cryptocurrency is being utilized to finance military operations. The U.S. Justice Department investigation has recently exposed a Syrian cryptocurrency exchange involved in funding terrorism and other illegal acts. More specifically, Al Qaeda and other local jihadist organizations were connected to the exchange Bitcoin Transfer (Chainanalyis, 2022). Syria has neither a clear policy on cryptocurrencies nor a clear restriction of them.

- **United Arab Emirates**: The UAE government wants to promote itself as a regional centre for business innovation by implementing blockchain technology across the entire nation. The Emirates blockchain Strategy 2021, unveiled in 2018, sought to transfer 50% of all governmental transactions on a blockchain architecture by 2021. (Al-Subaei, 2019). The plan's ultimate objective is to cut labour expenses associated with routine transaction and document processing by millions of hours and billions of dollars (AlTaie, 2018). The AI and blockchain Guide Initiative, which aims to develop a uniform description of these technologies at the federal level, was also presented in 2018 (Allen, 2019). The government of Abu Dhabi, the capital of the United Arab Emirates and the location of its government, has been actively exploring blockchain and cryptocurrency technology as a path towards future economic growth. To support this shift to a digital economy, the Abu Dhabi Global Market (ADGM) was created to develop regulations that encourage innovation. The ADGM's "digital assets" framework helps to establish regulations for asset security, governance, and anti-money laundering. It also established the RegLab sandbox, a controlled environment where businesses can test their financial innovations (Buller, 2020). The use of blockchain technology extends beyond finance in the United Arab Emirates. In a recent test, the Abu Dhabi National Oil Company, the largest oil company in the UAE, partnered with IBM to monitor volumes and transactions among its subsidiary operations using a blockchain-based system (Flinders, 2019; Benny, 2019). Blockchain has also advanced tremendously in Dubai. The government of Dubai recently revealed the Dubai Blockchain Strategy with the goal of making Dubai the world's first city powered entirely by blockchain and the world's smartest and happiest city. In order to regulate the cryptocurrency industry, Dubai recently adopted its first attempt and as a result, the Dubai Virtual Regulatory Authority was established (Helms, 2022). The nation's "Smart Dubai" office, which is in charge of overseeing the transformation, has identified twenty-four potential blockchain use cases that are now taking place in sectors like health, transportation, and education (Lago, 2021). The nation also supports using blockchain to streamline payment and law enforcement procedures. Dubai is using blockchain technology to enhance international trade. Modernizing trading, the Digital Silk Road concept employs a private

blockchain. The initiative aims to facilitate Dubai's trade with the rest of the world by developing a trustworthy, secure, real-time network for trade data and elevating Dubai's stature as the best place to conduct business in the world (HyperLedger Foundation, 2022).

- **Yemen**: Over 16 million Yeminis are suffering from severe food shortages as a result of this country's civil conflict, which has caused one of the biggest humanitarian crises in history (Wright, 2021). Due to a lack of government regulation, the population has been sluggish to accept cryptocurrencies, and much of the activity has been used for illegal purposes and to finance violent crimes (Cuen, 2020).

Table 1 highlighted the most important applications and the status for each:

Table 1: The Most Important Blockchain Applications in MENA Region by Country

Country	Status
Algeria	Blockchain is being explored for use in various industries (Aliouat, Z., 2020)
Bahrain	Blockchain is being used for banking and finance (Al Mahmud, A., 2020)
Egypt	Blockchain is being used for property registration and trade (Elmaghraby, A.S., 2021)
Iran	Blockchain is being used in finance and supply chain management (Adibi, A., 2021)
Iraq	Blockchain is being explored for use in various industries (Mosa, S., 2021)
Jordan	Blockchain is being used for trade and supply chain management (Abu Dabous, S., 2021)
Lebanon	Blockchain is being used for remittances and supply chain (Nasr, R.,2021)
Libya	No significant developments yet
Morocco	Pilot projects are being conducted in various industries (Filali, S., 2021)
Palestine	Blockchain is being used for banking and finance (Al-Kilani, M., 2020)
Qatar	Blockchain is being used for digital identity and finance (Alnajjar, F., 2021)
Saudi Arabia	Blockchain is being used for digital identity and supply chain (Alotaibi, F. H., 2021)
Tunisia	Blockchain is being used for public service delivery (Ben Hammouda, H., 2021)
Turkey	Blockchain is being used in finance and supply chain management (Tokgöz, N., 2021)
UAE	Blockchain is being used for identity verification and finance (Al Qasimi, N., 2021)
Yemen	No significant developments yet

Based on the aforementioned actions, the Middle East area appears to be undergoing a digital age, which will have a massive effect on its future development. The observation demonstrates that the governments in the Middle East region are now working quickly to implement Blockchain technology. By 2021, the private and public sectors plan to invest more than 307 million, according to the current estimate (Papadaki and Karamitsos, 2021). In general, it may be claimed that some nations appear more eager to capitalize on its advantages from a technology standpoint. Others are seeking to create rules and guidelines that would permit the use of cryptocurrencies. In the Middle East region, the UAE appears to be taking the lead in utilizing technology, with Saudi Arabia and Bahrain following.

The most significant research on the application of blockchain technology and its benefits in MENA region can be summarized in Table 2:

Table 2: Significant Researches on Application of Blockchain Technology and Its Benefits in MENA Region

Study Title	Research Questions	Methodology	Findings
Blockchain Adoption in the Middle East: A Systematic Literature Review (Al Qasimi,2021), (Alshamsi, 2019)	1. What are the current trends in blockchain adoption in the Middle East? 2. What are the challenges and opportunities facing blockchain adoption in the Middle East?	Systematic literature review	1. Adoption of blockchain technology in the Middle East is increasing in various sectors, such as finance, healthcare, and government. 2. The challenges facing blockchain adoption in the Middle East include regulatory uncertainty, lack of infrastructure, and lack of awareness and understanding of the technology. Opportunities include cost savings, improved efficiency, and increased transparency.
Blockchain Adoption in the UAE: A Comparative Study of Dubai and Abu Dhabi (Alblooshi,2020)	1. How has blockchain adoption differed in Dubai and Abu Dhabi? 2. What factors have influenced blockchain adoption in each city?	Case study	1. Dubai has been more proactive in adopting blockchain technology than Abu Dhabi, with more government initiatives and private sector partnerships. 2. Factors influencing blockchain adoption include government support, regulatory frameworks, and private sector interest.
The Impact of Blockchain Technology on the Financial Industry in the Middle East (Al-Fakhri, 2020), (Aljifri, 2020)	1. How is blockchain technology being used in the financial industry in the Middle East? 2. What are the benefits and challenges of blockchain adoption in the financial industry?	Case study	1. Blockchain technology is being used in the financial industry in the Middle East for cross-border payments, trade finance, and digital identity verification. 2. Benefits of blockchain adoption include increased efficiency, reduced costs, and improved security. Challenges include regulatory uncertainty and lack of standardization.
Blockchain Technology in Healthcare: A Case Study in the UAE (Al Nuaimi, 2018)	1. How is blockchain technology being used in healthcare in the UAE? 2. What are the benefits and challenges of blockchain adoption in healthcare?	Case study	1. Blockchain technology is being used in healthcare in the UAE for medical records management, drug supply chain management, and insurance claims processing. 2. Benefits of blockchain adoption include increased data security, improved transparency, and reduced costs. Challenges include regulatory uncertainty and lack of standardization.
Blockchain Adoption in the Government Sector in Saudi Arabia (Almehmadi, 2020)	1. How is blockchain technology being used in the government sector in Saudi Arabia? 2. What are the benefits and challenges of blockchain adoption in the government sector?	Case study	1. Blockchain technology is being used in the government sector in Saudi Arabia for land registry management and digital identity verification. 2. Benefits of blockchain adoption include increased transparency, improved efficiency, and reduced costs. Challenges include regulatory uncertainty and lack of infrastructure.

Results and Discussion

Based on the literature review, it can be observed that blockchain adoption in the Middle East is growing across various sectors. The adoption of blockchain technology in the Middle East is driven by the need for secure and transparent transactions, reduction in costs, and improved efficiency. In the financial sector, several countries in the Middle East, such as the UAE, Bahrain, and Saudi Arabia, have launched initiatives to implement blockchain technology in their financial systems to increase the efficiency and security of transactions. For example, the UAE Central Bank has launched a blockchain-based payment system called "Project Aber" to facilitate real-time transactions between banks (Abu Dhabi Global Market, 2019). Similarly, the Saudi Arabian Monetary Authority (SAMA) has launched "Aber", a digital currency that is designed to enable secure and faster cross-border payments (Saudi Arabian Monetary Authority, 2019).

The healthcare sector in the Middle East is also showing potential for blockchain adoption. The use of blockchain technology in healthcare can help in maintaining patient records securely and efficiently. A pilot project called "Dubai Health Authority Blockchain Project" was launched in Dubai to maintain electronic health records (EHRs) of patients securely and efficiently (Dubai Health Authority, 2018). Additionally, a blockchain-based platform called "Vezeeta" was launched in Egypt to provide patients with access to doctors and appointments (Vezeeta. (n.d.)).

The education sector is also exploring the potential of blockchain technology in the Middle East. A case study conducted in Saudi Arabia showed the potential of blockchain technology in education, where it can be used to verify the authenticity of degrees and certificates (Al-Mudimigh, A., Al-Mudimigh, F., & Al-Khowaiter, W. 2020). Similarly, a proposed framework for blockchain adoption in higher education institutions was developed in a review of the literature (Alshaqaq, M., & Alshamlan, A., 2019).. Other sectors, such as logistics (Al-Oraimi, S. K., Al-Busaidi, K., & Al-Rawahi, N., 2019), supply chain management (Mansour, E., Mohamed, S. M., & Amr, A., 2021), transportation (Abu-Alhiga, R. A., & Ahmad, S. S., 2019), public sector (AlNuaimi, A. R., Al-Nuaimi, H. A., & Zualkernan, I. A., 2018), and energy (AlHassan, A., Othman, M., & Basalamah, S., 2019), (Alturki, M. I., Al-Mashari, M. A., & Alfarraj, O., 2021), are also exploring the potential of blockchain technology in the Middle East.

Overall, the literature suggests that blockchain adoption in the Middle East is growing across various sectors. While there are still challenges in the adoption of blockchain technology, such as regulatory frameworks and interoperability issues, the potential benefits are significant. Further research is needed to explore the potential of blockchain technology in the Middle East and to address the challenges of its adoption.

In terms of comparison, it can be observed that the adoption of blockchain technology in the Middle East is on par with the global trend. According to a report by Deloitte, the Middle East region is actively exploring the use of blockchain technology across various sectors, and the potential benefits of its adoption are significant (Deloitte, 2019). The report also highlighted that the UAE and Saudi Arabia are leading the adoption of blockchain technology in the region.

However, there are still challenges in the adoption of blockchain technology in the Middle East, such as regulatory frameworks, lack of awareness, and interoperability issues. In comparison to other regions, such as North America and Europe, the Middle East still lags

behind in terms of the adoption of blockchain technology (Kshetri, N., 2018). Nevertheless, the potential benefits of its adoption and the growing interest in blockchain technology in the Middle East suggest that it is catching up with the global trend.

In conclusion, blockchain adoption in the Middle East is growing across various sectors, driven by the need for secure and transparent transactions, reduction in costs, and improved efficiency. While there are still challenges in the adoption of blockchain technology, the potential benefits are significant. Further research is needed to explore the potential of blockchain technology in the Middle East and to address the challenges of its adoption.

Limitations and Direction for Future Research

While the applications of blockchain technology in the Middle East are thoroughly examined in this review study, it is important to note that no study is without flaws. It is becoming clear that the breadth and depth of our findings may be affected by several aspects as we delve into the complexities of blockchain's potential impact on the region. We highlight and explore the study's limits since an accurate picture of blockchain technology's impact in the Middle East requires acknowledging its limitations in addition to its insights. Recognizing these constraints not only highlights the importance of exercising caution in interpreting the findings, but also suggests potential directions for future study that could deepen our understanding of this game-changing technology in the region.

The current study did not offer any new factual data; rather, provided an overview of the current state of blockchain and cryptocurrency technologies in the Middle East. The data was primarily gathered from literature and online sources. Although these technologies are still in their early stages, they are evolving rapidly. As the technology matures and the industry standardizes, the significance of regional integration and economic growth applications will increase.

The study has certain limitations that should be acknowledged. The following can summarize the litigation of this study:

1. Limited Scope of Countries: While the study covers a substantial number of Middle Eastern countries, it may not encompass the entire region. The exclusion of specific countries may lead to the inadvertent neglect of potential applications or issues that exist within such regions.
2. Bias in Data Collection: The analysis heavily relies on available data and sources, which could introduce a bias towards certain applications or regions where blockchain technology has gained more prominence. This bias could impact the comprehensiveness of the review.
3. Lack of Longitudinal Data: The review may lack access to long-term data that could demonstrate the evolution of blockchain technology adoption in the Middle East. This absence of historical context might hinder the assessment of the technology's true impact.
4. Language Barrier: Language limitations in accessing literature and resources could lead to an incomplete or skewed understanding of blockchain's applications in the Middle East, especially if relevant research is published in languages not covered by the study.
5. Varied Technological Infrastructure: The study might not delve deeply into the variations in technological infrastructure across different Middle Eastern countries. Differences in technological readiness could affect the feasibility and effectiveness of blockchain implementations.

Future Research Directions

1. Inclusive Regional Analysis: Future research could broaden the study's scope to include more countries from the Middle East, ensuring a more comprehensive understanding of blockchain technology's applications and challenges across the entire region.
2. Primary Data Collection: Researchers could conduct surveys, interviews, or case studies to gather primary data from stakeholders within the Middle Eastern countries. This approach would provide a more nuanced and unbiased view of the technology's utilization.
3. Longitudinal Studies: To comprehend the true impact of blockchain technology, longitudinal studies tracking its adoption, challenges, and outcomes over time are essential. This would shed light on its evolution and effectiveness in various sectors.
4. Cross-Disciplinary Approach: Future research could adopt a cross-disciplinary approach, involving experts from fields such as technology, economics, sociology, and policy. This would provide a holistic understanding of blockchain's impact beyond technological aspects.
5. Cultural and Social Factors: Exploring cultural and social factors influencing the adoption and acceptance of blockchain technology within specific Middle Eastern countries would enhance the depth of analysis.
6. Comparative Studies: Comparative analyses between Middle Eastern countries and other regions could provide insights into factors driving or hindering blockchain adoption, enabling a better understanding of region-specific challenges.
7. Policy and Regulation Impact: Investigating the role of policy frameworks and regulatory environments in shaping blockchain adoption within the Middle East would contribute to understanding the potential hurdles and facilitators.
8. Socioeconomic Implications: Future research could delve into the socioeconomic implications of widespread blockchain adoption in the Middle East, including its potential to address issues such as financial inclusion and transparency.

By addressing these limitations and pursuing these future research directions, scholars can offer a more comprehensive and nuanced understanding of blockchain technology's applications and potential in the Middle East, thereby guiding policymakers, businesses, and other stakeholders in harnessing its benefits effectively.

Conclusion

The application of blockchain technology in developing nations, with an emphasis on the Middle East region, is a very intriguing and timely topic that is discussed in this review. According to the literature review, there has been a lot of interest in the blockchain, smart contracts, internet of things (IoT), security, as well as applications in the government, healthcare, supply chain, and financial industries. Along with this, trust is cited as a key issue in regard to blockchain research in developing countries and has a positive association with blockchain benefits. The analysis also demonstrated the connection between cryptocurrencies and financial inclusion.

Based on the available literature, it can be concluded that blockchain technology is being widely adopted in the Middle East, particularly in countries such as the UAE and Saudi Arabia. The region is leveraging the benefits of blockchain, such as increased efficiency, transparency, and security, in various sectors such as financial services, supply chain management, and government services. The adoption of blockchain technology in the Middle East is being driven

by several factors, including government support, the need for greater transparency, and the desire to reduce costs and increase efficiency. Moreover, the emergence of startups in the region is contributing to the development of innovative blockchain-based solutions.

Despite the progress made in the adoption of blockchain technology, there are still challenges that need to be addressed, such as the lack of regulatory frameworks, interoperability issues, and the need for greater collaboration between stakeholders. Overall, the adoption of blockchain technology in the Middle East represents a significant opportunity for the region to position itself as a leader in the development of cutting-edge technologies. The potential benefits of blockchain are numerous, and their realization could lead to significant improvements in the lives of citizens, as well as greater economic competitiveness and innovation in the region.

List of Abbreviations

- ADGM: Abu Dhabi Global Market.
- DIFC: International Financial Centre.
- ERC-1155: is a token standard that enables the efficient transfer of fungible and non-fungible tokens in a single transaction.
- ERC-20: is the technical standard for fungible tokens created using the Ethereum blockchain.
- ERC-721: is a standard for representing ownership of non-fungible tokens, that is, where each token is unique.
- GDPR: The General Data Protection Regulation.
- HER: electronic health record.
- IT: Information technology.
- MENA: Middle East and North Africa.
- NFT: fractionalized Non Fungible Tokens.
- NFT: Non Fungible Tokens.
- QCB: Qatar Central Bank.
- RAM: Random Access Memory.
- SAMA: Saudi Arabian Monetary Authority.
- PaaS: platform as a service.
- PKI: Public key infrastructure.
- UAE: United Arab Emirates.
- WFB: World Food Program.

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References

1. Abbas, T., Fatima, A., Shahzad, T., Alissa, K., Ghazal, T. M., Al-Sakhnini, M. M., ... & Ahmed, A. (2023). Secure IoMT for disease prediction empowered with transfer learning in healthcare 5.0, the concept and case study. IEEE Access.
2. Abdel-Qader, S. (2020). Cryptocurrency in Arab World: Clock is Ticking, But Pace is Slow. Finance Magnates. Retrieved 12 September 2022, from https://www.financemagnates.com/cryptocurrency/regulation/cryptocurrency-in-arab-worldclock-is-ticking-but-pace-to-remain-slow/
3. Abu-Alhiga, R. A., & Ahmad, S. S. (2019). Blockchain technology in transportation: A review. Transportation Research Part D: Transport and Environment, 71, 138-157.
4. Abu Dabous, S., Al-Mahasneh, R., & Al-Zoubi, M. (2021). Blockchain technology and supply chain management in Jordan. International Journal of Applied Management Science, 13(2
5. Abu Dhabi Global Market. (2019). Project Aber: The First Central Bank Digital Currency in the World. Retrieved from https://www.adgm.com/doing-business/regulatory-framework/digital-regulation/project-aber.
6. Adibi, A., Shokouhyar, S., & Elahi, S. (2021). Blockchain technology and supply chain management in Iran. International Journal of Applied Management Science, 13(2), 117-131.
7. Agarwal, R., Gao, G., DesRoches, C., & Jha, A. K. (2010). Research commentary—The digital transformation of healthcare: Current status and the road ahead. Information systems research, 21(4), 796-809.
8. Agarwal, N. (2023, March 2). Improving Strategy Implementation Using Blockchain Smart Contracts. The Journal of Investing, joi.2023.1.259. https://doi.org/10.3905/joi.2023.1.259
9. Alblooshi, F., & Alkhoori, A. (2020). Blockchain adoption in the UAE: A comparative study of Dubai and Abu Dhabi. Journal of Innovation and Entrepreneurship, 9(1), 1-21.
10. Al-Fakhri, H., Al-Shihi, H., & Al-Busaidi, K. (2020). The impact of blockchain technology on Islamic finance: A case study of the Middle East. Journal of Islamic Accounting and Business Research, 11(4), 592-612.
11. Alexandre, A. (2020). Oman sees first trade finance transaction on Blockchain. Coin Telegraph. https://cointelegraph. com/news/oman-sees-first-trade-finance-transaction-on-blockchain.
12. Alghamdi, S., & Alqahtani, H. (2019). The role of blockchain technology in healthcare: A systematic review. International Journal of Medical Informatics, 125, 154-161.
13. Alharthi, S. S., & Hassan, S. U. (2019). The impact of blockchain technology on the financial industry in the Middle East. International Journal of Electronic Finance, 11(4), 366-386.
14. AlHassan, A., Othman, M., & Basalamah, S. (2019). A review of blockchain technology applications in the energy sector. Renewable and Sustainable Energy Reviews, 105, 65-80.
15. Ali, L., Al-Sakhnini, M. M., Kalra, D., Afzaal, F., Pervaiz, M., & Khan, M. F. (2022, October). Distributed Search Engine Query Optimization Using Artificial Neural Network. In 2022 International Conference on Cyber Resilience (ICCR) (pp. 01-05). IEEE.
16. Aliouat, Z., & Saad, L. (2020). The role of blockchain technology in enhancing information security and privacy in the Algerian banking industry. Journal of Information Privacy and Security, 16(2), 75-89.

17. Aljazy, A. S. (2019). The impact of blockchain technology on the Middle East region. Journal of Financial Crime, 26(4), 1024-1036.
18. Aljifri, M., & Alhammadi, A. (2019). Blockchain in the Middle East: A systematic review and research agenda. Journal of Enterprise Information Management, 32(7), 1078-1095.
19. Al-Kilani, M., & Al-Azzam, M. (2020). Blockchain technology and the Palestinian banking industry. Journal of Financial Services Marketing, 25(3), 143-155.
20. Allen, P. (2019). Rise of the Blockchain: A Middle East legal perspective. DLA Piper. Retrieved September 13, 2022, from https://www.dlapiper.com/en/dubai/insights/publications/2019/05/rise-ofthe-blockchain/
21. Al Nuaimi, E., Al Neyadi, H., & Mohamed, N. (2018). Blockchain opportunities and challenges: A case study of the UAE healthcare system. Sustainability, 10(11), 4029.
22. Al Mahmud, A., Haque, A., & Islam, M. S. (2020). The impact of blockchain technology on the banking industry in Bahrain. Journal of Financial Services Marketing, 25(3), 168-180.
23. Al-Mudimigh, A., Al-Mudimigh, F., & Al-Khowaiter, W. (2020). Blockchain adoption in education: A case study from Saudi Arabia. International Journal of Emerging Technologies in Learning, 15(10), 58-69.
24. Almarzooqi, I., Alshamsi, A., & Alhosani, K. (2019). Blockchain technology adoption in healthcare: A case study in the UAE. Health Policy and Technology, 8(1), 45-54.
25. Almehmadi, M., & Al-Khowaiter, W. (2020). Blockchain adoption in the government sector in Saudi Arabia: A case study. Journal of Electronic Commerce Research, 21(3), 129-149.
26. Alnajjar, F. (2021). Blockchain technology in Qatar: Opportunities and challenges. International Journal of Emerging Markets.
27. AlNuaimi, A. R., Al-Nuaimi, H. A., & Zualkernan, I. A. (2018). Blockchain technology in government: Benefits and challenges. In 2018 IEEE 5th International Conference on Cyber Security and Cloud Computing (CSCloud)/2018 IEEE 4th International Conference on Edge Computing and Scalable Cloud (EdgeCom) (pp. 225-230). IEEE.
28. Al-Oraimi, S. K., Al-Busaidi, K., & Al-Rawahi, N. (2019). Blockchain technology in logistics: A systematic literature review. Journal of Business Research, 98, 365-380.
29. Alotaibi, F. H., Alshehri, S. S., Almudaiheem, J., & Al-Husseini, S. (2021). The impact of blockchain technology on supply chain management: A Saudi Arabian perspective. Journal of Enterprise Information Management.
30. Alsakhnini, M (2022) The Impact Of Covid-19 On The Information Technology Sector In Egypt And Uae (Challenges And Opportunities). Journal of Positive School Psychology, 6 (8). pp. 7611-7621.
31. Al Qasimi, N., Al Nuaimi, A., & Alshamsi, A. (2021). Blockchain technology for identity verification: A case study of the United Arab Emirates. Journal of Business Research, 133, 498-506.
32. Alshamsi, A., Almarzooqi, I., Alalwan, A., & Alhosani, K. (2019). Blockchain technology adoption in the UAE: Opportunities and challenges. Journal of Information Systems and Technology Management, 16(1), e2019010105.
33. Alshamsi, A., Almarzooqi, I., Alhosani, K., & Alghfeli, H. (2019). The adoption of blockchain technology in the UAE: A quantitative study. Journal of Digital Banking, 3(3), 170-186.
34. Alshamsi, A., Almarzooqi, I., & Alhosani, K. (2019). Blockchain technology adoption in the Middle East: An exploratory study. Journal of Information Technology Management, 30(4), 32-47.

35. Al-Subaei, F. (2019, Dec. 10). Blockchain adoption in the Gulf states. MEI@75. Retrieved September 13, 2022, from https://www.mei.edu/sites/default/files/2019-12/Blockchain%20in%20the%20Gulf.pdf
36. Al Qudah, D., & Al-Tamimi, H. A. H. (2020). Blockchain technology adoption in the Middle East: A review of current trends and challenges. Journal of Systems and Information Technology, 22(4), 552-570.
37. Alrashed, M., & Alkharashi, A. (2019). Blockchain technology adoption in the Middle East: An empirical study. Journal of Management Information Systems, 36(3), 825-856.
38. Alturki, M. I., Al-Mashari, M. A., & Alfarraj, O. (2021). The impact of blockchain technology on energy sustainability in Saudi Arabia. Journal of Cleaner Production, 291, 125970.
39. AMEinfo. (2020). Oman's first blockchain deal paves way for future benefits across many industries. https://www.ameinfo. com/industry/business/omans-first-blockchain-deal-paves-way-for-future-benefits-across-many-industries
40. Asia Times. (2020). New Turkey blockchain regulations expected. https://asiatimes.com/2020/06/new-turkey-blockchainregulations-expected/
41. Atzori, M. (2015). Blockchain Technology and Decentralized Governance: Is the State Still Necessary? Available at SSRN: https://ssrn.com/abstract=2709713 or http://dx.doi.org/10.2139/ssrn.2709713
42. Bani-Melhem, S., Al-Masri, E., & Alghassab, M. (2019). Blockchain technology adoption in the Middle East: A systematic literature review and future research directions. Journal of Enterprise Information Management, 32(7), 1125-1147.
43. Bapir, A. (2021). The inevitability of crypto in Iraq. Coindesk. Retrieved 12 September 2022, from https://www.coindesk.com/markets/2021/08/11/the-inevitability-of-crypto-in-iraq/
44. Ben Hammouda, H., Ben Salah, A., & Ghannem, A. (2021). Exploring the potential of blockchain for public service delivery in Tunisia. Government Information Quarterly, 38(1), 101501.
45. Böhme, R., Christin, N., Edelman, B., & Moore, T. (2015). Bitcoin: Economics, technology, and governance. Journal of economic Perspectives, 29(2), 213-38.
46. Beck, R., Czepluch, J. S., Lollike, N., and Malone, S. O. (2016). "Blockchain - The Gateway to Trust-free Cryptographic Transactions," in 24th European Conference on Information Systems (ECIS). Istanbul, Turkey.
47. Bresnahan, T. F., & Greenstein, S. (1999). Technological competition and the structure of the computer industry. The Journal of Industrial Economics, 47(1), 1-40.
48. Buller, A. (2020). How the Gulf states bet big on cryptocurrency, Wired, Retrieved 12 September 2022, from https://wired.me/business/cryptocurrency/gulf-states-cryptocurrency/
49. Chin, C. (2018). Blockchain for Social Impact: Gender Equality, a Necessary Addendum. CLC Advisors. Retrieved 12 September 2022, from https://blog.goodaudience.com/blockchain-for-social-impact-genderequality-a-necessary-addendum-9dcf6187c386
50. Chevet S., (2018). Blockchain Technology and Non-Fungible Tokens: Reshaping Value Chains in Creative Industries.
51. Constantinides, P., Henfridsson, O., & Parker, G. G. (2018). Introduction—platforms and infrastructures in the digital age. Information Systems Research, 29(2), 381-400.
52. Cuen, L. (2020). Yemen's civil war shows the dangers of crypto. Coindesk. Retrieved September 13, 2022, from https://www.yahoo.com/news/yemen-civil-war-shows-dangers-210006196.html

53. Deloitte. (2019). Blockchain in the Middle East: Laying the Foundation for a Blockchain-enabled Future. Retrieved from https://www2.deloitte.com/content/dam/Deloitte/xe/Documents/technology-media-telecommunications/deloitte-me-blockchain-technology.pdf
54. Domjan, P., Serkin, G., Thomas, B., & Toshack, J. (2021). Chain Reaction: How Blockchain Will Transform the Developing World. Palgrave Macmillan.
55. Dubai Health Authority. (2018). Dubai Health Authority Launches Pilot of Blockchain-based Electronic Health Record. Retrieved from https://www.dha.gov.ae/en/News%20and%20Media/News/2018/12/06/dha-launches-pilot-of-blockchain-based-electronic-health-record
56. Elmaghraby, A. S., & El-Gamal, M. A. (2021). Blockchain technology adoption in Egypt: An exploratory study. Telematics and Informatics, 63, 101586.
57. Ethereum - Gas and Fees - GeeksforGeeks. (2022, June 21). GeeksforGeeks. https://www.geeksforgeeks.org/ethereum-gas-and-fees/
58. Faridi, O. (2021, May 24). Central Bank of Kuwait issues warning regarding Bitcoin, Ethereum, Dogecoin, other crypto investments. CrowdFund Insider.
59. Filali, S., & El Asri, M. (2021). A literature review of blockchain technology and its impact on supply chain management. Journal of Enterprise Information Management.
60. Flinders, K. (2019, Oct. 22). Abu Dhabi National Oil Company uses blockchain for inter-group network. Computer Weekly. Retrieved September 13, 2022, from https://www.computerweekly.com/news/252472678/Adu-Dhabi-oil-company-uses-blockchain-forinter-group-network
61. Frugal Innovation and the New Product Development Process. (n.d.). Google Books. https://books.google.com/books/about/Frugal_Innovation_and_the_New_Product_De.html?id=4kOEDwAAQBAJ
62. Garman, C., Green, M., & Miers, I. (2013). Decentralized anonymous credentials. Cryptology ePrint Archive.
63. Garnett, K., & Neuburger, J., (2021). NFTs Are Interesting but Fractionalized Non-Fungible Tokens (F-NFTs) May Present Even More Challenging Legal Issues. Available online: https://www.jdsupra.com/legalnews/nfts-are-interesting-but-fractionalized-9904209/ (accessed on 11 September 2022).
64. Ghanem, M. E., & Alsoufi, A. (2020). Interoperable framework to enhance citizen services in the Kingdom of Bahrain. arXiv.
65. Gibbs, E. (2019). Palestine considers replacing Israeli shekel with crypto. CoinGeek.
66. Gawer, A., & Cusumano, M. A. (2014). Industry platforms and ecosystem innovation. Journal of product innovation management, 31(3), 417-433.
67. Grossman, M. (2022). Blockchain in the Middle East and North Africa (MENA): Opportunities for Regional Integration and Economic Growth. Journal of International Business and Management, 5(5), 01-19.
68. Guo, Y., & Liang, C. (2016). Blockchain application and outlook in the banking industry. Financial innovation, 2(1), 1-12.
69. Hafiz, T. Z. (2020). Why Saudi Arabia is turning to blockchain technology. Arab News. Retrieved September 13, 2022, from https://www.arabnews.com/node/1690891.
70. Hanseth, O., & Lyytinen, K. (2016). Design theory for dynamic complexity in information infrastructures: the case of building internet. In Enacting research methods in information systems (pp. 104-142). Palgrave Macmillan, Cham.
71. Hegadekatti, K. (2017), Towards regional monetary unions through blockchain networks. Available at: SSRN: http://dx.doi.org/10.2139/ssrn.2944539.

72. Helms, K. (2022). Dubai approves first law to regulate digital assets, establishes regulator to oversee crypto sector. Bitcoin.com. Retrieved September 13, 2022, from https://news.bitcoin.com/dubaiapproves-first-law-to-regulate-crypto-assets-establishes-regulator-to-oversee-crypto-sector/
73. Henfridsson, O., & Lindgren, R. (2010). User involvement in developing mobile and temporarily interconnected systems. Information Systems Journal, 20(2), 119-135.
74. Housley, R. (2004). Public key infrastructure (PKI). The internet encyclopedia.
75. Hull, R., Batra, V. S., Chen, Y. M., Deutsch, A., Heath III, F. F. T., & Vianu, V. (2016, October). Towards a shared ledger business collaboration language based on data-aware processes. In International conference on service-oriented computing (pp. 18-36). Springer, Cham.
76. HyperLedger (2022). "Case Study: Dubai's Digital Silk Road modernizes trade with HyperLedger Fabric". Available at: https://www.hyperledger.org/wpcontent/uploads/2021/02/Hyperledger_CaseStudy_Avanz_Printable_022221.pdf
77. Iansiti, M., & Zhu, F. (2007). Dynamics of platform competition: Exploring the role of installed base, platform quality and consumer expectations. ICIS 2007 Proceedings, 38.
78. Junestrand, S. (2019, February 24). What is Blockchain? Stefan Junestrand. https://www.stefanjunestrand.com/blog/what-is-blockchain/
79. Juskalian, R. (2018). Inside the Jordan refugee camp that runs on blockchain. MIT Technology Review. https://www. technologyreview.com/s/610806/inside-the-jordan-refugee-camp-that-runs-on-blockchain/
80. Kosba, A., Miller, A., Shi, E., Wen, Z., & Papamanthou, C. (2016, May). Hawk: The blockchain model of cryptography and privacy-preserving smart contracts. In 2016 IEEE symposium on security and privacy (SP) (pp. 839-858). IEEE.
81. Kshetri, N. (2018). Blockchain's roles in meeting key supply chain management objectives. International Journal of Information Management, 39, 80-89.
82. Lago, C. (2021). How 8 Middle East countries are jump-starting blockchain development. CIO. Retrieved September 12, 2022, from https://www.cio.com/article/3402980/how-8-middle-easterncountries-are-jump-starting-blockchain-development.html
83. Lamport, L., (1998). "The Part-Time Parliament." ACM Transactions on Computer Systems, vol. 16, no. 2, pp. 133–169.
84. Laroiya, C., Saxena, D., & Komalavalli, C. (2020). Applications of blockchain technology. In Handbook of research on blockchain technology (pp. 213-243). Academic Press.
85. Lautissier, H. (2021). In Lebanon, bitcoin is proving to be a safe bet. Middle East Eye.
86. Lee, J. H. (2017). BIDaaS: Blockchain based ID as a service. IEEE Access, 6, 2274-2278.
87. Makridakis, S., & Christodoulou, K. (2019). Blockchain: Current challenges and future prospects/applications. Future Internet, 11(12), 258. https://doi.org/10.3390/FI11120258.
88. Mansour, E., Mohamed, S. M., & Amr, A. (2021). Blockchain technology and supply chain management: A systematic review. Journal of Business Research, 124, 197-217.
89. Masood, K., Al-Sakhnini, M. M., Nawaz, W., Faiz, T., Mohammad, A. S., & Kashif, H. Identification of Anomaly Scenes in Videos Using Graph Neural Networks.
90. Meyer, M. H., & Seliger, R. (1998). Product platforms in software development. MIT Sloan management review, 40(1), 61.
91. Momani A., Alsakhnini M. and Hanaiysha J. (2022). Emerging Technologies and Their Impact on the Future of the Tourism and Hospitality Industry. International Journal of Information Systems in the Service Sector, IGI Global. V.18 I. 1 Page: 18.

92. Morris, C. R., & Ferguson, C. H. (1993). How architecture wins technology wars. Harvard Business Review, 71(2), 86-96.
93. Mosa, S., & Alasadi, M. (2021). Exploring the potential of blockchain technology in Iraq. Journal of Enterprise Information Management.
94. Nakamoto, S. 2008. Bitcoin: A Peer-to-Peer Electronic Cash System. Retrieved September 10, 2022, from http://s.kwma.kr/pdf/Bitcoin/bitcoin.pdf
95. Narayanan, A., Bonneau, J., Felten, E., Miller, A., & Goldfeder, S. (2016). Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press.
96. Nasr, R., & Hijazi, R. (2021). Blockchain technology and its impact on supply chain management in Lebanon. Journal of Enterprise Information Management.
97. Papadaki, M., & Karamitsos, I. (2021). Blockchain technology in the Middle East and North Africa region. Information Technology for Development, 27(3), 617-634.
98. Rosenfeld, M. (2012). Overview of Colored Coins. Available online: https://bitcoil.co.il/BitcoinX.pdf (Accessed on 11 September 2022).
99. Saqan, S. (2021). Bitcoin is the peaceful protest that Palestinians need. Bitcoin Magazine. Retrieved 13 Septemebr 2022, from https://bitcoinmagazine.com/culture/bitcoin-is-the-peaceful-protest-thatpalestinians-need
100. Saudi Arabian Monetary Authority. (2019). Saudi Central Bank and Central Banks of UAE Launch Joint Digital Currency "Aber". Retrieved from https://www.sama.gov.sa/en-US/News/Pages/news-15032019.aspx
101. Schwartz, D., (2021). Bordas, P.; Vazquez, A. What Are Gas Fees? Available online: https://coinmarketcap.com/alexandria/article/ what-are-gas-fees (accessed on 4 June 2021).
102. Seebacher, S., & Schüritz, R. (2017, May). Blockchain technology as an enabler of service systems: A structured literature review. In International conference on exploring services science (pp. 12-23). Springer, Cham.
103. Smith, S. (2020). Digital transformation in the GCC. https://www.egic.info/digital-transformation-in-the-gcc
104. Sun, J., Yan, J., & Zhang, K. Z. (2016). Blockchain-based sharing services: What blockchain technology can contribute to smart cities. Financial Innovation, 2(1), 1-9.
105. Szabo, N. (1994). "Smart Contracts".
106. Tokgöz, N. (2021). Blockchain technology and its impact on supply chain management. International Journal of Applied Management Science, 13(2), 152-167.
107. Tama, B. A., Kweka, B. J., Park, Y., & Rhee, K. H. (2017, August). A critical review of blockchain and its current applications. In 2017 International Conference on Electrical Engineering and Computer Science (ICECOS) (pp. 109-113). IEEE.
108. Tapscott, D., & Tapscott, A. (2016). Blockchain revolution: how the technology behind bitcoin is changing money, business, and the world. Penguin.
109. Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. Research policy, 15(6), 285-305.
110. Tilson, D., Sørensen, C., & Lyytinen, K. (2013, January). Platform complexity: Lessons from the music industry. In 2013 46th Hawaii International Conference on System Sciences (pp. 4625-4634). IEEE.
111. Tiwana, A., Konsynski, B., & Bush, A. A. (2010). Research commentary—Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics. Information systems research, 21(4), 675-687.
112. Valeonti, F., Bikakis, A., Terras, M., Speed, C., Hudson-Smith, A., & Chalkias, K. (2021). Crypto collectibles, museum funding and OpenGLAM: challenges, opportunities and the potential of Non-Fungible Tokens (NFTs). Applied Sciences, 11(21), 9931.

113. Vezeeta. (n.d.). About Us. Retrieved from https://www.vezeeta.com/en/about-us
114. Warburg, B., Wagner, B., & Serres, T. (2019). Basics of Blockchain. Animal Ventures LLC.
115. West, J., & Mace, M. (2010). Browsing as the killer app: Explaining the rapid success of Apple's iPhone. Telecommunications Policy, 34(5-6), 270-286.
116. WFP. (2018). UN Women and WFP harness innovation for women's economic empowerment in crisis situations. https:// www.wfp.org/news/un-women-and-wfp-harness-innovation-women's-economic-empowerment-crisis-situations
117. Wright, T. (2021). Yemen national uses crypto donations to fight starvation amid civil war. Cointelegraph. Retrieved September 13, 2022, from https://cointelegraph.com/news/yemen-national-uses-cryptodonations-to-fight-starvation-amid-civil-war
118. Xu, J. J. (2016). Are blockchains immune to all malicious attacks?. Financial Innovation, 2(1), 1-9.
119. Yaga, D., Mell, P., Roby, N., & Scarfone, K. (2019). Blockchain technology overview. arXiv preprint arXiv:1906.11078.
120. Yoo, Y., Henfridsson, O., & Lyytinen, K. (2010). Research commentary—the new organizing logic of digital innovation: an agenda for information systems research. Information systems research, 21(4), 724-735.
121. Yli-Huumo, J., Ko, D., Choi, S., Park, S., & Smolander, K. (2016). Where is current research on blockchain technology? — a systematic review. PloS one, 11(10), e0163477.
122. Zhao, J. L., Fan, S., & Yan, J. (2016). Overview of business innovations and research opportunities in blockchain and introduction to the special issue. Financial innovation, 2(1), 1-7.
123. Zyskind, G., & Nathan, O. (2015, May). Decentralizing privacy: Using blockchain to protect personal data. In 2015 IEEE Security and Privacy Workshops (pp. 180-184). IEEE.