Introducing Contemporary Blockchain Platforms

Malak Suliman Alrumaih †
361200251@qu.edu.sa
Computer Science department
Qassim University, Burydah , KSA.

Summary
Blockchain and its infrastructure technology have expanded rapidly in the last decade and are in high demand, but there is a lack of comprehensive studies on those platforms. Blockchain is a new technology based on the distributed digital ledger system. Decentralized trust is one of the key factors behind the blockchain-based system. Transparency of such a system is better than a conventional centralized ledger system. By using a blockchain-based transaction system, any business organization can harness key benefits like data integrity, confidentiality, and anonymity without involving any third party in control of the transactions. Since the blockchain is used in numerous applications and the horizon is expanding at an unprecedented pace. So, there is a need for an introducing and reviewing of blockchain platforms. In this paper, we have reported a review on existing contemporary blockchain platforms. In particular, From the existing studies, we have identified eighty blockchain platforms and the majority of them have a lack of technical details. To provide the researchers a comprehensive introducing on blockchain platforms to perform a broad guideline for future research and investment in the blockchain domain.

Key words:
Blockchain, platforms, Distributed Ledger, Bitcoin, Decentralized Trust. Ethereum, Hyperledger.

1. Introduction

The term 'blockchain' was first mentioned and utilized in Bitcoin cryptocurrency, although the core concept was proposed in 1991 with the idea of timestamping [1] . The official blockchain was developed by Satoshi Nakamoto, who authored the bitcoin white paperback in 2008 and created bitcoin's original reference implementation. It is a peer-to-peer electronic transaction method that transfers the payments directly to the intended recipients without relying on any third party [2].

In simple terms, a blockchain refers to a decentralized transaction and data management technology through the internet. It maintains a list of data records in the form of blocks that are growing continuously due to new transactions and managed by the participating nodes. It provides anonymity and data integrity without any third-party interference in control of the transactions. Moreover, all the blockchain platforms provide high-level privacy and security, as the technology was designed initially for cryptocurrency [3] [4].

Manuscript received April 5, 2021
Manuscript revised April 20, 2021
https://doi.org/10.22937/IJCSNS.2021.21.4.2

With this property of trusted transactions, many businesses are trying to be on the blockchain map and take advantage of its attractive features, including reducing paperwork, transferring money without commissions, and confirming identities more easily. More importantly, it increases the security with a shift from centralized data security to a more decentralized network processing with high efficiency [5]. Consequently, transactions are faster, secure, and more transparent. These reasons make the leading IT companies and institutions, like IBM, race to develop different types of blockchain platforms. Their rigorous research and rapid development efforts enabled the blockchain platforms to serve various domains within a short period of time, such as the internet of things, healthcare, government, Industry, and others [6].

2. The growth of Blockchain

There is an exponential growth of blockchain's use in businesses. Around fourteen countries are investigating to create their official cryptocurrencies, and currently, more than 300 large corporations and establishments are operating with a Hyperledger blockchain [7]. Ethereum, a globally decentralized platform, has grown 50 times in financial terms. There is around $2.1 billion global investment in 2018 on blockchain solutions. Over the past year, the number of blockchain-related LinkedIn job postings has tripled. The global blockchain market size is expected to be $39.7 billion by 2025 [8] [9].

In a financial sector such as banks, we also found critical growth, with 69% of banks currently experimenting with blockchain technology. Thirty-three percent of banks have foreseen a commercial blockchain introduction in subsequent years. The potential annual savings for banks using blockchain technology was estimated to be eight to twelve billion dollars [8].

Another study looks at the blockchain development in bitcoin platforms and points out that the blockchain investment is close to $3 billion in 2020 and will rise until it hits $39.7 billion by 2025 [9].

In addition, software that uses the bitcoin blockchain for financial use only has increased to approximately 269.82 gigabytes by the end of March 2020 [10],

It seems, in the next few decades, blockchain and its infrastructure technology will be very popular. According

to many research papers and journals, this technology has been applied in various real-life fields. Many researchers agree that IoT and 5G communication technology will positively influence blockchain applications by overcoming previous network limitations and providing secure and stable online networks [10].

3. Blockchains Related SLRs

In this section, we will go through those studies and present their summaries. It will provide a glimpse of existing meta-research in the blockchain domain. In following section, we organized those studies under their respective domains.

During 2019-2020, there were many studies on blockchain core technology. In this section, we have highlighted the most important of these research studies.

Henry et al [11] presented Bitcoin and Ethereum platforms in detail. This study concluded that blockchain's application should not be limited to the financial sector. Jaoude and Saade [12] analyzed the current standing of blockchain technology and explored its application domains. As identified, blockchains' unique features are privacy, security, anonymity, decentralization, and immutability. It also reported that there is an increasing concern for blockchain's environmental impact due to the high energy requirement to deploy and maintain the network.

Some researchers talked about security which is the most important factor of blockchain implementation. Hassan et al [13] discussed the security vulnerabilities and cyber-attacks on blockchain networks and cryptocurrencies. They also attempted to analyze their countermeasures. As identified, the blockchain network's most vulnerable entities are asymmetric cryptography, transactions, proof-of-work, mining, and cryptocurrency's network. They found that more than 50% of the study papers focused on the blockchain technology itself, rather than cryptocurrency-related blockchain technology.

Paul et al [14] have carried out another research on this aspect that highlights opportunities available for future research in cybersecurity areas outside the realm of IoT. It analyzed the blockchain works in the cybersecurity domain and shed light on their future, particularly on blockchain security in IoT, blockchain security for AI data, and sidechain security. Blockchain could be the key element of future internet security infrastructures due to its decentralized nature that does not require intermediaries to complete a transaction.

A. K. B. Sumaiya [15] conducted an interesting SLR. She emphasized the prospects, current positions, and challenges of blockchain adaption from the Indian market context. Besides, she also discussed the features and characteristics of different blockchain platforms.

Saiful Rizal et al [16] discussed blockchain's implementation possibility for the service computing system domain. The paper highlighted some important blockchain characteristics, such as consensus algorithm, cryptography, automation of data management, decentralization, immutability, data integrity, and transparency, to enhance the service computing system's security. Ethereum has been identified as the most common platform to build service computing systems. As reported, service computing platforms' security can be enhanced by utilizing novel blockchain features, like a consensus, cryptography, data management, decentralization, efficiency.

Al-Breiki et al [17] were interested in oracle blockchain. They discussed the security weakness and trust issues of oracles used in blockchain systems. He also discussed various trust models for blockchain oracles proposed in the literature. The main challenges of trusted oracles are smart contract engineering, security and privacy problems, responsible oracles, design challenges, implementation challenges, and external data semantics and governance. In addition to discussing different blockchain platforms, Moezkarimi et al [18] proposed and discussed an evaluation framework for blockchain platforms, including assessing the platform's internal components, security and privacy, data storage unit, smart contract unit, interactions, and the support community. Belotti et al [19] discussed blockchain technology's evaluation over time, like their implementation steps, their consensus mechanisms, across different blockchain platforms in detail. Gao et al [20] talked about the implementation challenges of blockchain technology from the following point of view- security vulnerabilities, selfish minings, and performance-limiting factors (e.g., scalability and availability).

Vysakh Anilkumar [21] presented a survey on a blockchain platform. In this study, various blockchain simulation platforms were discussed and compared to help the decentralized application (DApp) developers choose the best implementation option. It suggested that the Truffle suite is ideal for testing and development. The remix is better for compilation, error detection & correction, and Mist and Geth are more useful for easy deployment. In addition to discussing various blockchain frameworks, their components, and structure, this report also talked about the implementation challenges of blockchain technology.

The hardware of blockchain also takes place on an SLR field. Emanuel and Aidan [23] in their review work attempted to identify heterogeneous blockchain architectures and their hardware implementation challenges. They pointed out multiple issues that could seriously impact blockchains' adaption, such as power consumption and resource waste. Blockchain technology will be more scalable and efficient if those issues are addressed.

Some researchers went deeper into blockchain studies. Those SLRs were interested in smart contracts in blockchains which refers to an executable code that basically depends on the Blockchain technology to sign an

agreement among untrusted parties without third parties [24]. Wang et al [25] systematically discussed blockchain-powered smart contracts and their challenges including reentrancy vulnerability, transaction-ordering dependence, timestamp dependence, lack of reliable data feeds, and privacy issues. Leka et al [26] discussed smart contracts, their implementations and classified their vulnerabilities. Kongmanee and Hewett [27] discussed the security issues of blockchain smart contracts. They proposed a system-independent, language-independent model checking approach that identifies security breaches in the smart contract. The proposed smart contract is modeled and verified by the NuSVM model checker.

Eigelshoven et al [28] identified thirty-three consensus algorithms and categorized them in accordance to their research's concept matrix. Their analysis revealed that the existing consensus algorithms differ in their sustainability contribution (e.g., energy consumption, scalability, and consensus fairness in the social sphere).

4. Blockchain Platforms in Details

During our study, we grossly categorized blockchain platforms into two categories based on the number of publications. Any platform referred by more than three papers was considered as a major platform. The rest of them categorized as minor platforms. In the following sections, we discuss six major blockchain platforms in detail. At the end of the chapter, we also summarize other minor platforms.

4.1 Major Platforms

According to our criteria, Bitcoin, Ethereum, Hyperledger Corda, MultiChain, and Cosmos are major blockchain platforms. In below, we have a detailed discussion on each of those platforms.

4.1.1 Bitcoin

After the financial crisis in 2008, Nakamoto Satoshi proposed a digital cryptocurrency called "Bitcoin" in his seminal white paper. It was launched to recover the public faith in financial institutions [29].

After its inception, Bitcoin spread widely, not only as a cryptocurrency but also as a set of procedures, theories, concepts, and methodologies to securely maintain many financial operations. Bitcoin is a digital cryptocurrency under a permissionless blockchain network or open blockchain network. It means that any person with the necessary hardware support can connect to the network [29] .

Bitcoin is similar to ordinary coins, so any person within the Bitcoin environment is supposed to have a coin wallet. Any participant can pay to another participant using the Bitcoin issued for him by the network. To carry out a transaction, a person needs to enter the required data; the system validates the authenticity of the data. All the transactions are recorded in a blockchain that is part of a digital public ledger. The ledger itself is stored in the Bitcoin network [16] In other words, Bitcoin is a digital currency tool for buying and selling different products online. It uses encryption techniques to manage the transaction process and generates currency units [5].

Any client can access all the data recorded in the public ledger except the identity of another client. All the data and transactions are processed through hash functions to enhance safety and security. Once a user starts a transaction, he should specify an address, and the privacy of the address can be identified as private or public [30]. This is the basic design of the blockchain, and all following amendments or changes depend on this foundation.

A central supervisory authority is not sufficient and proper for an open ledger system. To ensure the validity of a transaction during execution a fundamental agreement, called "Consensus", was introduced among all members nodes of the blockchain network. It stops the computational process in case of any detected fraud. Such a process requires a massive processing capacity. So in case of any attempt to change or amend the chain of a block by fraud, multiple honest nodes detect the surge of the computation process and verify the validity of the transaction through a majority of votes [29]. Many cryptographic functions, like the Secure Hash Algorithm (SHA) are used to maintain the security of data. Such functions are a part of the Merkle – Damgård construction, and there are variations of Secure Hash Algorithms such as SHA-2, SHA-256, etc. All of them can be applied to enhance the security of Bitcoin data.

The secure and favorable characteristics of Bitcoin allow its use in various domains, other than the banking and financial fields. However, the platform is not widely used in nonfinancial enterprises due to the constraints imposed on its use [29]. The most common among these constraints is a misconception and failure to distinguish between Bitcoin as a digital cryptocurrency and a blockchain platform. The great success of Bitcoin as cryptocurrency overshadowed its platform characteristics. Secondly, data accuracy can't be guaranteed against human faults. As data cannot be changed after being recorded in the blockchain, a faulty record exists even after discarding it. Finally, due to its open nature, various security threats are always a reality.

4.1.2 Ethereum

Canadian Vitalik Buterin invented Ethereum as an advanced version of Bitcoin due to the demand for an adaptable blockchain platform that can serve many purposes with no undesired limitations. Ethereum adopts a similar approach as Bitcoin. It works as a cryptocurrency for financial transactions and also provides smart contracts [31] to support other forms of transactions. In 2014 Vitalik introduced the Ethereum concept in a publication, then the

platform was developed for the public and became ready for use in the same year [29]. Vitalik examined Bitcoin and concluded that there is a lack of programming languages in the platform. Accordingly, he developed Ethereum as an open-source, public, secure, and distributed ledger platform where all transactions are subject to smart contracts [31]. The network allows the fulfillment of a Turing-complete programming language using algorithms with the help of Ethereum Virtual Machine (EVM) [32]. After its inception, the platform got rapid popularity. Ethereum constitutes 50% of the market share, estimated at 31.4$ billion in February 2020 [33].Ethereum is a platform to develop and launch distributed applications. It supports high standards of authenticity and security for the developed applications. Transactions are done with the minimum possible costs, and no third party is required to approve. Due to these advantages, it is possible to develop advanced applications based on this technology, which is used in different fields like education, the internet of things, health care, e-commerce, e-government, e-voting, industry, multimedia, etc. According to our study, the internet of things, healthcare, and banking are the top application domains for Ethereum applications [34].

4.1.3 Hyperledger

Hyperledger was developed and introduced by the Linux Foundation in December 2015 as a distributed ledger technology and an open-source blockchain network that requires approval before using the system. It is a modular platform characterized by its ability to host a robust industrial platform and is equipped with limitless properties and tools for developing applications. Moreover, Hyperledger provides extensive features that programmers and concerned corporations might require to develop and release their models [35].

Hyperledger is an open medium and not attached to a particular cryptocurrency like Bitcoin and Ethereum. At the very beginning, Linux Foundation sponsored Hyperledger due to its interest in hosting and introducing open-source blockchain projects. They aimed at addressing the most challenging data-centric problems around the world. They wanted to enhance and outspread public knowledge for blockchain projects at the enterprise level, as of the designing stage till the lunch and marketing [36].

Hyperledger is an enormous co-operative industrial project, initially started with ten members and then expanded to include around a hundred of the biggest companies working in the relevant fields [1].

Hyperledger's primary concern is to create a proper environment required for pipelining permission blockchain frameworks. Hyperledger also brings together many projects, ensuring a significant advance in the industrial field. The platform includes five frameworks: Fabric, Sawtooth, Aroha, Burrow, and Indy. These frameworks use through Hyperledger and provide various tools such as Cello, Composer, Explorer, Quilt, and Caliper. The most common among these tools is Cello, which facilitates framework operation on demand and is considered a dashboard for keeping the statistic and status monitoring of the blockchain system [37].

Generally, all Hyperledger frameworks are composed of three leading roles such as- Committer, Endorser, and Consenter. The Committer's role is to register the transactions, authenticate and approve (by a consensus algorithm) in the specified ledger. It can work as an endorser subject to some limitations, and Committer peers too can work as an endorser subject. The Endorser's role is to handle untrustworthy or malevolent transactions and simulating validated transactions performed in the blockchain, and it also can act as a Committer. Finally, the Consenter is responsible for running transaction validation or determine the ledger specified for the transaction Consensus part; it also has Plug and Plays features [1].

4.1.4 Corda

Like other blockchain platforms, Corda is a distributed ledger platform for handling financial agreements and is adopted particularly in regulated corporations operating in the financial field. Corda also is a private and permissioned platform, which is similar to other blockchain systems, but without design properties [38].

Corda platform was presented for the first time in 2014 by R3 as R3 CEV. There is no cryptocurrency in Corda, and its use initially uses business concepts such as crypto, consulting, exchanges, and ventures [39].

Corda is not considered as an actual blockchain platform by some researchers. It just provides some functions that could be used in financial operations. The implementation in Corda requires a high level of scalability. Because their transaction generation does not follow the same order in all cases, and each user can record several interest states so that such interest states might overlap [40]. Moreover, Corda is not limited to any consensus algorithm and mostly uses a BFT-SMaRt as its consensus mechanism. State chains only accept a limited number of participants to ensure full confidence and avoid double-spending [41] [42]. Corda was developed through smart contract code and equipped with reusable functions. It also uses JVM for contract validation and execution. To reapply and take advantages of previous codes, Corda uses huge JVM libraries and functions, side by side with certain thirds parties' codes. It also enhances Corda connections [21].

4.1.5 MultiChain

MultiChain is a leading off-the-shelf blockchain platform affiliated with Bitcoin. It is also a private and permissioned blockchain platform. MultiChain is used to develop and deploy private blockchain between and within establishments. MultiChain was an unprecedented advancement in blockchain technology distribution among

financial institutions by enhancing security and privacy and providing user-friendly packages [43].

MultiChain is characterized by easy configuration and its ability to integrate with different blockchains simultaneously. At first, each node should configure itself before being employed in a transaction. The use of the Multichain platform has various advantages, including its ability to record and store data quickly and immediately when executing transactions, the availability of a high-level abstraction for assets and streams, etc. [44]. The ability to operate with Windows, Linux, and Mac servers; and the simple API and command-line interface provided through the platform are advantageous too [45].

Furthermore, MultiChain based applications can be developed using various programming languages, including Python, C#, JavaScript, PHP, Ruby. Also. It is characterized by easy installation and configuration and a high level of transparency and security. It is an optimal option for the next-generation blockchain [46].

4.1.6 Cosmos

Cosmos is a novel blockchain network architecture. It is proper to be used with multiple blockchains and allows parallel blockchains to communicate and interoperate while retaining their security properties. A network of many independent blockchains is called zones. Those zones are powered by a high-performance, consistent, secure consensus engine. Cosmos consists of many zones that can control the operations in the blockchains [47].

4.2 Minor Platforms

Many platforms are not addressed to a great extent by the researcher community, and we defined those as minor platforms. In our study, any platform referred by less than four papers tagged as a minor platform. These platforms were developed to address some functional issues or to be used in a particular field. In most cases, such platforms are usually based on other recognized ones and equipped with additional functionalities. In the following sections, we will discuss these platforms based on the study papers.

4.2.1 Exonum Platform

Exonum platform is used to build applications on a top complex cryptographic primitive with very low overhead imposed by the execution environment. It was developed using REST programming languages [48].

4.2.2 IBM's ADEPT System

It was the most powerful blockchain platform in cloud computing. It was an early attempt to apply blockchains in the cloud. It was integrated with the Bluemix platform to establish an excellent example of early cloud-based blockchain. It is used in many IoT systems. This platform has showcased scalable storage of IoT data and provides a platform for micro-payments [49].

4.2.3 Quorum

Quorum is suitable for applications that require high-speed and high handling capacity and functionality for carrying out private operations executed among a group of validated and authorized users. It derived most of its features from Ethereum and it is considered a private version of it. We can also trace some features from Ethermint [50]. The security protocol of Quorum integrates Ethereum and Tendermint security protocol which addresses some of the difficulties arising from adopting blockchain technology in the financial field and beyond [51].

4.2.4 Stellar

It is an open-source payment platform that do not require any trusted third part, and through which rapid and international transactions could be implemented using any of currency pair. It is suitable for both fast and cheap transactions. Steller's unique distributed exchange policy allows business exchange among different assets. It is not a public platform, and through it, financial organizations can choose to transact with other trusted financial organizations from whom they can receive a proof before boarding an end user. Stellar has its own consensus mechanism to validate and secure data [52], [53].

4.2.5 QTUM

It is a public blockchain developed particularly to serve light weight, versatile business distribution, involving a Litecoin wallet for mobile usage and a transaction level modeling abstraction layer. Through this platform, there is no difficulty in transferring data among lite wallets and the core wallet of the blockchain. Ethereum for mobile devices had some issues which was resolved by QTUM. The benefits and impacts of QTUM are similar to a great extent to other Ethereum platforms. However, among the major constraints encountering the platform are related to the security standards adopted for financial technologies [54].

4.2.6 EOS

It is one of the first 3rd generation blockchain DLT platforms. It was developed as a contender for Ethereum and aimed to solve some of its limitations such as scalability, development environment limitations, and governance by using Delegated Proof of Stake (DPoS). EOS provides vertical and horizontal scaling facilities for decentralized applications and makes it possible to perform millions of transactions per second. EOS also incorporates novel

features such as fee-less transaction off-context actions that improve performance, recovery from stolen keys, etc. [55].

4.2.7 NEO

NEO is a blockchain platform that is recognized to provide a large ecosystem. It includes multiple Software Development Kits (SDKs) for developing many languages on GitHub in both the official account and the community account. NEO also provides a private network and both the networks use delegated Byzantine Fault Tolerant (dBFT) algorithm, which was introduced by the NEO Team. NEO also uses the concept of "fuel" currency to control this process, this currency is called NeoGas it is used to "fuel" the smart contracts and avoid excessive processing [55], [56]

4.2.8 ARK

ARK Ecosystem can be used by developers of blockchain platforms to improve and innovate a sovereign blockchain equipped with all the necessary functionalities and properties. ARK based applications are privileged to get a wide range of services provided by ARK Blockchain Platform, including its ability to connect and integrate with various blockchains, the stable integration of custom business logic, its flexibility and implementation of the customized transaction, and its ability to connect with international and local support systems. All of these advantages are provided through practical developmental experiences [57].

4.2.9 Ripple

The Ripple is a currency exchange and a permissioned enterprise blockchain platform specified for finical use. It has its own currency like bitcoin itself, and was established in 2012. It was a currency exchange system that uses real-time gross settlement (RTGS), and remittance network as its protocol of function, does not contain any smart contact [39], [58].

4.2.10 Ethermint

Ethermint is providing a scalable, high-throughput Proof-of-Stake blockchain that is fully compatible and interoperable with Ethereum. It is a very active development domain that supports a very fast development run. So, the subjects can ask for regular change during the production. It was built using the Cosmos SDK that runs on top of the Tendermint Core consensus engine. It was combining the features of Ethereum by running it as an application over its development engine and at the same time get the benefit from Tendermint's PoS implementation [59].

4.2.11 Nebulas

It is a blockchain that tried to learn from Ethereum's massive scale and makes its smart contracts more efficient by adding two new features to their design. The first one is a fair ranking algorithm known as the "Nebulas Rank"(NR) algorithm. It suggests a universal measurement value to help identify a higher dimension of information. It is similar to Google's PageRank, which combines liquidity, speed, width, and depth of capital blockchain to provide a fair ranking for blockchain users. The other feature was self-evolving. Nebulas blockchain would be advantageous over other public blockchains regarding developmental and survival potential. It also allows developers to respond faster to loopholes with upgrades and prevents enormous losses caused by hacking. The last one was accomplished by the construction of a blockchain application ecosystem. They develop the PoD (Proof of Devoting), an algorithm based on the devotion of accounts on Nebulas. This algorithm uses NR as the measure of value to identify the accounts with great devotion. The ecosystem grants those accounts an equal probability of being bookkeepers on an equal basis [60].

4.2.12 BlockCloud

There is a significant relationship between Cloud Technology and blockchains, and BlockCloud is to enhance such relations. BlockCloud provides a data provenance architecture. It is one of the leading blockchain technology to implement operations based on data for clients and providers, using the cloud within federated cloud settings. It needs to achieve access control policy enforcement by collecting provenance data required for user operation and uses the Proof of Stack and tamper-proof environment. BlockCloud operation is based on virtual machines staked resources existing in a corresponding cloud computing setting when collecting data and releasing such data through the blockchain network. Moreover, BlockCloud establishes a public log based on time for all transactions carried out by users on cloud data. There is no need for any third party to facilitate the interaction. Also, a receipt on the blockchain is specified for each provenance entry to ease any future validation. ProvChain blockchain receipt is also used to validate each provenance data entry [61].

4.2.13 Ekiden

Ekiden was developed as an extension of Tendermint and Ethereum. It is a virtual machine aimed at exploiting blockchains and trusted enclaves having complementary security properties. These properties can be combined effectively to provide a robust, generic platform for confidentiality-preserving smart contracts. The outcome is a powerful programming model. It qualified to overcome significant challenges encountering smart contracts executed in blockchains. Finally, it has been proved that

Ekiden could be adopted to implement a variety of secure decentralized applications computing sensitive data [63].

4.2.14 Steemit

Steemit is a platform used for social media purposes. Information presented on social platforms cannot be accessed or controlled by any entity. Users get awards for their participation in the platform. Steemit adopted Delegated Proof of Stake (DPoS) consensus algorithm for developing a social media platform that is highly decentralized in nature. These developing blockchain-based social media platforms have proved to be highly effective in terms of designing, consensus protocol application, and users awarding system [65]

4.2.15 CUREX

CUREX platform is a secure private platform developed to control and communicate electronic information in healthcare systems, taking into account all related confidentiality, security, and legal requirements. CUREX is characterized by its promoted information technology security, privacy, decentralized blockchain designing, which enhanced its risk assessment ability and transaction performance. Moreover, because CUREX development based on an agile methodology, all the features and properties highlighted in this research subject to regular inspection and assessment throughout the development of the platform [66].

4.2.16 Polkadot

Polkadot is a scalable multi-chain framework. It focuses on providing a single chain of varying degrees of generality over potential applications. It differs from the general concept of the public chain. Polkadot is a set of independent chains with pooled security and trust-free interchain transact ability. Any use of this blockchain should be parallelized over parachains. Each parachain is conducted by a different segment of the Polkadot network. Polkadot leaves much complexity to be addressed at the middleware level [47].

4.2.17 Redes

It is a permissioned chain and not intended to imposing code execution obligations by smart contracts. With Redes, data storage hardware-specific actuation and control operate separately. Structuring the chain allows the benefits of developing distributed consensus while leaving code execution control with individual network operators who can optimize various combinations of hardware in their environment. The Redes blockchain is unique, as it assumes an inherent value for the data itself [67].

4.2.18 Wanchain

Wanchain is a public blockchain that supports smart contracts' execution using Solidity. Wanchain supports ring signature-based private transactions and decentralized cross-chain functionality. A developer can write smart contracts, build a DAPP or issue a fungible/non-fungible token on Wanchain. Through cross-chain features, any blockchain's assets can be connected with and circulate on Wanchain. These include assets from public, private, as well as consortium chains [68].

4.2.19 Lisk

It provides a javascript blockchain application platform that can be used for public or private purposes. It supports a robust DPoS consensus in its blockchain application programming. The initial distribution on the Lisk blockchain was 100,000,000 LSK. Today, the Lisk blockchain distributes block rewards of 2 LSK, and it will change to the final block reward of 1 LSK in October 2020, on which it will stay forever [69].

4.2.20 AURA

AURA is based on the Ethereum Quorum blockchain and uses the Microsoft Azure cloud computing platform. Recently, this platform is used to allow customers to verify the authenticity of luxury goods. Corporations like ConsenSys, LVMH, and Microsoft support AURA to serve the entire luxury industry [70].

4.2.21 Libra

Libra is a permissioned blockchain-based payment system proposed by the American social media company Facebook, Inc. The plan also includes a private currency implemented as a cryptocurrency. It was launched in 2020 [71].

4.2.22 Parity

It is a blockchain with the right privacy at the use case level. This blockchain designs a Light- client-first design for mobile applications and IoT. It has On-chain governance protocol upgrades and private Ethereum transactions with proof of authority consensus to provide a technology that could facilitate and rapidly develop the perfect blockchain according to user needs [72].

4.2.23 IOTA

The IOTA tangle can be publicly available, or accessed via permissions, using capable of using POW, so running a system that requires a large number of data points can hit a bottleneck when the transactions are attached to the tangle [73]

There are many platforms that were only mentioned for a few times and there are no much details describing such platforms, like: BigchainDB [74], Wave [75], Startic [51], Cocos, IOST, Nervos, and Ultrain, ChainIDE, Zcash [64] , origin chain [62] etc. [76].

4.3 Minor Generic Platforms

During our study, we found some relatively unknown generic platforms to support domain-specific customize blockchains. Such as:

I. Blockchain Based Energy Transaction Platform [77].

II. Blockchain-based Data Protection Framework [78].

III. Organic Integrated Decision-Making Platform [79].

IV. Blockchain Game Platform [80].

V. Semantics Empowered Blockchain Database (SEBDB) [81].

VI. BLOCKBENCH [82].

VII. Dynamic Monitoring and Decision Systems Platform (DyMonDS) [83].

5 Conclusion

Blockchain is a new technology that supports Bitcoin as digital currency, and blockchain is applied in different domains. Blockchain technology can be used in different fields, including; healthcare, finance, energy, supply chain, IoT, insurance, transportation, business, and resources management. Moreover, the internet contributes to the technological development in the information and communication field by using new blockchain technology in enhancing Bitcoin. Blockchain promotes information revolution through facilitating transactions without a third intermediary.

In this study, we attempted to identify blockchain platforms mentioned in the contemporary research literature. The task was challenging due to an unprecedented expansion of blockchain applications and related literature in the last few years. In this paper, we have presented all the platforms we have identified in an organized way.

Acknowledgments

Many thanks of Dr. Mohammad Mahdi Hassan to assist me in this research.

References

[1] M. Ahmed, I. Elahi, M. Abrar, U. Aslam, I. Khalid and M. A. Habib, "Understanding Blockchain: Platforms, Applications and Implementation Challenges," Paris, France, 2019.

[2] S. Nakamoto, "Bitcoin A peer-to-peer electronic cash system," Manubot, 2008.

[3] M. Conoscenti, A. Vetrò and J. C. D. Martin, "Blockchain for the Internet of Things: A Systematic Literature Review," in *13th International Conference of Computer Systems and Applications (AICCSA)*, Agadier, 2016..

[4] S. Han, Z. Xu and L. Chen, "Jupiter: A Blockchain platform for mobile devices," in *2018 IEEE 34th International Conference on Data Engineering*, Hongkong, China, 2018.

[5] M. Swan, Blockchain: Blueprint for a New Economy, O'Reilly Media, 2015.

[6] L. Ismail, H. Hameed, M. AlShamsi and M. AlHammadi, "Towards a Blockchain Deployment at UAE University:Performance Evaluation and Blockchain Taxonomy," UAE, 2019.

[7] I. Production, "Hyperledger blockchain," [Online]. Available: https://www.ibm.com/blockchain/hyperledge.. [Accessed 2021 2 20].

[8] A.Winston, "Blockchain Infographic: Growth, Use Cases, Facts," in *Dzone security*, 2018.

[9] S.Liu, "worldwide-blockchain-technology-market-size," 2020. [Online]. Available: https://www.statista.com.

[10] X. Hu, Y. Zheng, Y. Su and R. Guo, "IoT Adaptive Dynamic Blockchain Networking Method Based on Discrete Heartbeat Signals, Sensors,," vol. vol. 20, pp. pp. 1-15, p. 1, 2020.

[11] H. R. Andrian, N. B. Kurniawan and Suhardi, "Blockchain Technology and Implementation : A Systematic litrerature review," IEEE Xplore, 2018.

[12] J. A. Jaoude and R. G. Saade, "Blockchain Applications usage in different domains," 2019.

[13] A. Hassan, M. Z. Mas'ud, W. M. Shah, S. F. Abdul-Latip, R. Ahmad, A. Ariffin and Z. Yunos, "A Systematic Literature Review on the Security and Privacy of theBlockchain and Cryptocurrency," in *OIC-CERT Journal of Cyber Security*, 2020.

[14] o. p. Paul, J.TayloraTooska, D. A. Dehgha and R. M.-K. RaymondChoo, "A systematic literature review of blockchain cyber security," in *Digital Communications and Networks*, 2020.

[15] A. K. B. Sumaiya, "A Study of Emerging Areas in Adoption of Blockchain Technology and it's Prospective Challenges in India," in *Women Institute of Technology Conference on Electrical and Computer Engineering (WITCON ECE)*, INDIA, 2019.

[16] S. Rizal, H. R. Andrian, N. B. Kurniawan and Suhardi, "Secure Service Computing System Platform Based On Blockchain - A Systematic Literature Review," indunisea, 2019.

[17] H. AL-Breiki, M. H. U. Rehman, K. Saleh and D. Svetinovic, "Trustworthy Blockchain Oracles: Review,Comparison, and Open Research Challenges," UAE, 2020.

[18] Z. Moezkarimi, F. Abdollahei and A. Arabsorkhi, "Proposing a Framework for Evaluating the Blockchain Platform," 5th International Conference on Web Research (ICWR), IRAN, 2019.

[19] M. Belotti, N. Božic, G. Pujolle and S. Secci´, "A Vademecum on Blockchain Technologies: When, Which, and How," IEEE COMMUNICATIONS SURVEYS & TUTORIALS, 2019.

[20] W. Gao, W. G. Hatcher and W. Yu, "A Survey of Blockchain: Techniques, Applications, and Challenges," USA, 2018.

[21] V. Anilkumar, J. A. Joji, A. Afzal and R. Sheik, "Blockchain Simulation and Development platforms: Survey, Issues and Challenges,"Proceedings of the International Conference on Intelligent Computing and Control Systems (ICICCS 2019), INDIA, 2019.

[22] E. Popovici and A. O. Mahony, "A systematic Review of Blockchain Hardware Acceleration Architectures," in *2019 30th Irish Signals and Systems Conference (ISSC)*, Maynooth, Ireland, 2019.

[23] M. Alharby and A. V. Moorsel, "Blockchain-Based Smart Contracts : A Systematic Mapping Study," *Computer Science & Information Technology (CS & IT,* pp. pp. 125-140, 2017.

[24] S. Wang, Y. Yuan, X. Wang, J. Li, R. Qin and F.-Y. Wang, "An Overview of Smart Contract: Architecture, Applications, and future trends," IEEE Intelligent Vehicles Symposium (IV), 2018.

[25] E. Leka, B. Selimi and L. Lamani, "Systematic Literature Review of Blockchain Applications: Smart Contracts," in *2019 International Conference on Information Technologies (InfoTech)*, 2019.

[26] J. Kongmanee, P. Kijsanayothin and R. Hewett, "Securing Smart Contracts in Blockchain," in *34th IEEE/ACM International Conference on Automated Software Engineering Workshop (ASEW)*, 2019.

[27] F. Eigelshoven, A. Ullrich and B. Bender, "Public Blockchain A systematic literature review on the sustainability of consensus algorithms," in *2020 European Conference on Information Systems*, Marrakech. Morocco, 2020.

[28] B. P. Rankhambe and H. K. Khanuja, "A Comparative Analysis of Blockchain Platforms – Bitcoin and Ethereum," in *2019 5th International Conference on Computing Communication Control and Automation (ICCUBEA)*, India, 2019.

[29] ARUNMOZHI MANIMUTHU, G. REJIKUMAR, DRISHTI MARWAHA, "A Literature Review on Bitcoin: Transformation of Crypto Currency Into a Global Phenomenon," *IEEE ENGINEERING MANAGEMENT REVIEW,* vol. 47, no. 1, pp. 28 -35, 2019.

[30] A. Anjum, M. Sporny and A. Sill, "Blockchain standards for compliance and trust," in *IEEE Cloud Computing*, 2017.

[31] S. Makridakis and K. Christodoulou, "Blockchain: Current Challenges and Future Prospects/Applications," Future Internet, 2019 pp. 1-16, p. 11..

[32] G. A. Oliva, A. E. Hassan and Z. M. (. Jiang, "An exploratory study of smart contracts in the Ethereum blockchain platform," in *Empirical Software Engineering*, 2020.

[33] T. Ahram, A. Sargolzae, S. Sargolzaei, J. Daniels and B. Amaba, "Blockchain Technology Innovations," in *IEEE Technology & Engineering Management Conference (TEMSCON)*, USA, 2017.

[34] V. Dhillon, D. Metcalf and M. Hooper, The Hyperledger Project, CA: Apress, Berkeley, 2017.

[35] I. Production, "Hyperledger blockchain," 20 6 2020. [Online]. Available: https://www.ibm.com/blockchain/hyperledge.

[36] E. Androulaki, C. Cachin, C. Ferris, S. Muralidharan, C. Murthy, B. Nguyen, M. Sethi and C. Stathakopoulou, "Hyperledger Fabric: A Distributed Operating System for prmission Blockchains," in *Proceedings of the thirteenth EuroSys conference*, 2018.

[37] T. Q. Ban, B. N. Anh, N. T. Son and T. V. Dinh, "Survey of Hyperledger Blockchain Frameworks: Case Study in FPT University's Cryptocurrency Wallets," in *Proceedings of the 2019 8th International Conference on Software and Computer Applications*, 2019.

[38] V. Clincy and H. Shahriar, "Blockchain Development Platform Comparison," in *IEEE 43rd Annual Computer Software and Applications Conference (COMPSAC)*, USA, 2019.

[39] N. Teslya and I. Ryabchikov, "Blockchain Platforms Overview for Industrial IoT pourpose," in *PROCEEDING OF THE 22ND CONFERENCE OF FRUCT ASSOCIATION*, Russia, 2019.

[40] M. Kassab, J. DeFranco, T. Malas, V. V. G. Neto and G. Destefanis, "Blockchain: A Panacea for Electronic Health recordes ?," IEEE/ACM 1st International Workshop on Software Engineering for Healthcare (SEH), 2019.

[41] Y. Yan and B. Duan, "Blockchain technology in the Internet Plus: The collaborative development of power electronic devices," CHINA, 2016.

[42] G. Greenspan, "MultiChain Private Blockchain—white Paper," 2015.

[43] M. Avantaggiato and P. Gallo, "Challenges and Opportunities using MultiChain for Real Estate," in *IEEE International Black Sea Conference on Communications and Networking (BlackSeaCom)*, Italy, 2019.

[44] Mohamad Kassab et al., "Exploring Research in Blockchain for Healthcare and a Roadmap for the Future," IEEE TRANSACTIONS ON EMERGING TOPICS IN COMPUTING, 2019.

[45] A. Ismailisufi, T. Popović, N. Gligorić, S. Radonjic and S. Šandi, "A Private Blockchain Implementation Using Multichain Open Source Platform," in *24th International Conference on Information Technology (IT)*, Montenegro, 2020.

[46] K. Luo, W. Yu, H. M. Amjad, S. Wang, L. Gao and K. Hu, "A Multiple Blockchains Architecture On Inter-Blockchain Communication," in *2018 IEEE International Conference on Software Quality, Reliability and Security Companion*, China, 2018.

[47] D. Korepanova, M. Nosyk, A. Ostrovsky and Y. Yanovich, "Building a Private Currency Service Using Exonum," in *IEEE International Black Sea Conference on Communications and Networking (BlackSeaCom)*, 2019 .

[48] M. Samaniego and R. Deters, "Blockchain as a Service for IoT," in *2016 IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom)*, canada , 2017.

[49] O. Dib, A. Durand, K.-L. Brousmiche and E. Thea, "Consortium Blockchains: Overview, Applications and Challenges," *International Journal on Advances in Telecommunications,* vol. 11, pp. 51 -64, 2018.

[50] P. P. Ray, D. Dash, K. Salah and N. Komar, "Blockchain for IoT-Based Healthcare: Background,Consensus, Platforms, and Use Cases," in *IEEE SYSTEMS JOURNAL*, India, 2019.

[51] M. Agrawal, D. Amin, R. Gala and H. Dalvi, "Blockchain-based Universal Loyalty Platform," in *2019 IEEE International Conference on Advances in Computing, Communication and Control (ICAC3)*, India, 2019.

[52] W. Zhao, S. Yang and X. Luo, "On Consensus in Public Blockchains," USA, 2019.

[53] G. Bello and A. J. Perez, "Adapting Financial Technology Standards to Blockchain Platforms," in *ACM Southeast Conference*, USA, 2019.

[54] S. Benahmed, I. Pidikseev, R. Hussain, J. Lee, S. A. Kazmi, A. Oracevic and F. Hussain, "A Comparative Analysis of Distributed Ledger Technologies for Smart Contract Development," in *2019 IEEE 30th Annual International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC):*, CANADA, 2019.

[55] R. Henry, A. Herzberg and A. Kate, "Blockchain Access Privacy:Challenges and Directions," in *IEEE Security & Privacy*, 2018.

[56] ARK Ecosystem developers, "ARK Ecosystem white paper," 27 September 2019. [Online]. Available: https://ark.io/Whitepaper.pdf. [Accessed 10 October 2020].

[57] P. Tasatanattakool and C. Techapanupreeda, "Blockchain: Challenges and Applications," in *2018 IEEE International Conference on Information Networking (ICOIN)*, Thailand, 2018.

[58] E. .zone, "High-level Overview," ChainSafe Systems, 20 2 2021. [Online]. Available: https://docs.ethermint.zone/intro/overview.html.

[59] N. Team, "Nebulas Technical White Paper," Nebulas.io, China, April, 2018.

[60] D. K. Tosh, S. Shetty, X. Liang, C. Kamhoua and L. Njilla, "Consensus Protocols for Blockchain-based Data Provenance: Challenges and Opportunities," in *2017 IEEE 8th Annual Ubiquitous Computing, Electronics and Mobile Communication Conference (UEMCON)*, Roma, 2017.

[61] Q. Lu and X. Xu, "Adaptable blockchain-based systems: A case study for product traceability," *IEEE Software,* vol. 34, no. 6, pp. 21-27, 2017.

[62] R. Cheng, J. K. Fan Zhang, W. He, N. Hynes, N. Johnson, A. Juels, A. Miller and D. Song, "Ekiden: A Platform for Confidentiality-Preserving, Trustworthy, and Performant Smart Contracts," in *IEEE European Symposium on Security and Privacy*, 2019.

[63] M. Harikrishnan and L. KV, "Secure Digital Service Payments using Zero Knowledge Proof in Distributed Network," in *5th International Conference on Advanced Computing & Communication Systems (ICACCS)*, India, 2019.

[64] M. Isaja and J. K. Soldato, "Distributed Ledger Architecture for Automation, Analytics and Simulation in Industrial Environments," in *IFAC (International Federation of Automatic Control)*, 2019.

[65] A. J. Diaz-Honrubia, J. M. Zamorano, G. Gonzalez-Granadillo, R. Diaz, M. Konidi, P. Papachristou, S. Nifakos, G. Kougka and A. Gounaris, "An overview of the CUREX platform," in *IEEE 32nd International Symposium on Computer-Based Medical Systems (CBMS)*, europe, 2019.

[66] S. Platt and M. Oliver, "Towards Blockchain for Decentralized SelfOrganizing Wireless Networks," in *IEEE conferrance*, Spain, 2019.

[67] W. Developers, "Wanchain Documentation," [Online]. Available: https://www.explorewanchain.org/#/. [Accessed 10 October 2020].

[68] L. Documentation, "What is lisk," [Online]. Available: https://lisk.io/lsk. [Accessed 10 October 2020].

[69] Aura developers, "aura home page," 2018. [Online]. Available: https://auraledger.com/. [Accessed 10 October 2020].

[70] The Libra Blockchain developers, "The Libra Blockchain," [Online]. Available: https://developers.libra.org/docs. [Accessed 10 October 2020].

[71] P. Blockchain, "Parity Blockchain," [Online]. Available: https://www.parity.io/substrate/. [Accessed 10 October 2020].

[72] B. C. FLOREA, "Blockchain and Internet of Things Data Provider for Smart Applications," in *7th MEDITERRANEAN CONFERENCE ON EMBEDDED COMPUTING (MECO)*, MONTENEGRO, 2018.

[73] F.-C. Adochiei, R. Ciucu, I. R. Adochiei, F. C. Argatu, B. Enache, C. Miron and G. Seritan, "Brain Mapping using a Blockchain Approach," in *The 7th IEEE International Conference on E-Health and Bioengineering*, Romania, 2018.

[74] Wave developer, "Wave home page," [Online]. Available: https://waveplatform.io/. [Accessed 10 October 2020].

[75] C. Fan, H. Khazaei, Y. Chen and P. Musilek, "Towards A Scalable DAG-based Distributed Ledger for Smart Communities," in *IEEE 5th World Forum on Internet of Things (WF-IoT)*, Ireland, 2019.

[76] M. L. D. Silvestre, P. Gallo, M. G. Ippolito, R. Musca, E. R. Sanseverino, Q. T. T. Tran and G. Zizzo, "Ancillary Services in the Energy Blockchain for Microgrids," in *IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS*, 2019.

[77] G. Liang, S. R. Weller, F. Luo, J. Zhao and Z. Y. Dong, "Distributed Blockchain-Based Data Protection Framework for Modern Power Systems Against Cyber Attacks," in *IEEE TRANSACTIONS ON SMART GRID*, China, 2019.

[78] N. Tapus and A. M. Manolache, "Universal resource management andlogistics using blockchain technology," in *22nd International Conference on Control Systems and Computer Science (CSCS)*, Bucharest, 2019.

[79] Q. C. L. L. X. M. Mingxiao Du, "A Blockchain-based Random Number Generation Algorithm and the Application in Blockchain Games," in *IEEE International Conference on Systems, Man and Cybernetics (SMC)*, italy , 2019.

[80] Y. Zhu, Z. Zhang, C. Jin, A. Zhou and Y. Yan, "SEBDB: Semantics Empowered BlockChain database," in *IEEE 35th International Conference on Data Engineering (ICDE)*, China, 2019.

[81] T. T. A. Dinh, J. Wang, G. Chen, R. Liu, B. C. Ooi and K.-L. Tan, "BLOCKBENCH: A Framework for Analyzing Private blockchains," Singaphore.

[82] M. Lauer, R. Jaddivada and M. Ilić, "Secure Blockchain-Enabled DyMonDS Design," in *Proceedings of the International Conference on Omni-Layer Intelligent Systems*, Greece, 2019.

Malak S. Alromaih is a Master Student in the Computer Science Department at Qassim University, Saudi Arabia. She received her bachelor's Degree in Computer Science from King Saud University, Saudi Arabia. Her research interests include blockchain based application development, information security and data mining.