Overview of Taxonomy and Ontology Approaches for the Classification of Blockchain Components

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Abstract: - Blockchain and the distributed ledger technology (DLT) that underpins it are progressively being incorporated into the infrastructure of the biomedical, academic, financial, and governmental sectors. Blockchain facilitates immutability, traceability, transparency, and decentralized data storage. Consensus is a collection of algorithms applied in complicated blockchain networks of users, technology, and transactions to achieve security, stability, and scalability. Researchers and practitioners use technology- and ontology-based approaches to comprehensively address the complexity of blockchain technology and categorize its constituent parts. This article provides a brief overview of key blockchain concepts and reviews the literature for articles that categorize the elements of decentralized blockchain systems. The purpose of this article is to give readers a summary of open-access, free scientific studies that thoroughly explain the intricacies of blockchain. To do this, articles published between January 2018 and January 2023 are searched for in the scientific database Google Scholar. A narrative style review is used to assess fourteen articles. The investigation demonstrates that taxonomy and ontology based approaches simplify technological complexities and highlight connections between blockchain-related concepts.

Key-Words: - blockchain, consensus protocol, stability, transactions per second, taxonomy, ontology

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1 Introduction

A blockchain is a decentralized ledger system made up of digital files containing information about computer-based transactions. The system operates through a time-stamping mechanism that confirms the validity of the data that passes through the network. The blockchain is constructed by a series of computer programs that record, verify, and validate transactions, with the legitimacy of these transactions determined through consensus protocols [1], [2], [3]. These files are organized into blocks, which are immutably linked to form a chain [2], [3], [4], without the need for a central authority or administrator [1], [2], [5]. Applications for blockchain include government operations, asset management, business processes, supply chain transparency, and military cybersecurity and data integrity[6], [7], [8], [9]. Participants in blockchain transactions are incentivized to create blocks by solving computational puzzles, for which they are rewarded with cryptocurrency [1], [2].

1.1. Structure of blockchain

There are four fundamental types of blockchains based on their capability to enhance security, prevent counterfeiting and fraud, and encrypt critical information across a network of computers [10].

The first type is the public blockchain, which is a permissionless distributed ledger that allows anyone to become a member and conduct transactions [11]. An example of a public blockchain is Solana [12], used for fast, low-cost, and scalable app development.

The second type is the private blockchain, which operates within a private context and only allows permissioned members to conduct transactions [11]. An example of a private blockchain is Hyperledger by IBM, which is used for tracing food-related outbreaks [13], [14], [15].

The third type is the hybrid blockchain, which combines elements of both public and private blockchains, including algorithmic organization of blocks and permissioned access to data and transactions [16]. An example of a hybrid blockchain is Aergo Enterprise by Samsung, used for exchanging information, tokenized goods, and supply chain registries between blockchains [17], [18], [19].

The fourth type is the consortium blockchain, which is formed by a partnership of multiple organizations. Data in this type of blockchain can be public or private, and the ledger can be partially decentralized [20], [21], [22]. An example of a consortium blockchain is Voltron-Contour, used for digitizing documents [23], [24], [25], [26].

1.2. Consensus Mechanisms for Public Blockchain

Consensus protocols are critical algorithms in a blockchain's decentralized network that guarantee the validity and consistency of data and transactions between participants. There are several types of consensus protocols, each designed to meet specific requirements such as low energy consumption, scalability, low latency, high throughput, and enhanced security [27], [28], [29], [30].

For example, Proof of Stake consensus prioritizes low energy consumption, Proof of Authority consensus focuses on scalability and fast processing of transactions, Delegated Proof of Stake consensus prioritizes low latency, Proof of Work (PoW) consensus emphasizes high throughput, and Proof of Work consensus prioritizes security by providing mechanisms against cyber-attacks and double-spending. Aptos is a Proof of Stake blockchain.

Here, are presented several methods for achieving consensus in a permissionless public blockchain network. The first method uses proof of work, which necessitates powerful computing resources to solve cryptographic puzzles and produce the subsequent block in a series of transactions [31]. The ability to produce a new block is granted to the network user who solves a challenge first, or the first miner. Consensus over a block is computationally intensive, which makes it slow yet cryptographically secure. The concept of proof-of-work was first put forth in 1993 to combat network spam emails and denial-of-service attacks. In order to validate new blocks in the Bitcoin network, Satoshi Nakamoto introduced the PoW concept in 2008. Proof of stake (PoS), a different strategy, solves the high computational cost and resource constraints of PoW for creating a block. In order to be selected at random as the authors and validators of a block, participants in a blockchain must prove their possession of a certain quantity of digital currency, a process known as "staking." On the Bitcoin Talk forum, a fresh strategy was put out in 2011 to overcome the PoW's shortcomings [31]. Similar to PoW, the PoS technique reduces operational costs and energy consumption, protects a blockchain, and stops unauthorized users from approving fraudulent transactions [31]. The proof of authority approach is based on the standing of participants in the network. Based on the reputation of their identification, participants are chosen for creating and validating blocks in this case. A different consensus method focuses on historical evidence. The first blockchain to incorporate historical proof was Solana in 2019 [32]. This method uses a timeline of events to come to a consensus on a block in a decentralized network. Here, participants have timestamped activities. The timestamps are subsequently incorporated into the blockchain itself. By removing the reputation and scalability problems, Proof of History (PoH) breaks the time barrier, making blockchain lighter and faster [32], [33], [34], [35]. The practical byzantine fault tolerance (PBFT) protocol, which relies on rounds of activities to reach consensus, was proposed by Castro and Liskov in 1994. For instance, participants engage in three rounds of communications, such as pre-prepare, prepare, and commit, to gain agreement on generating a block [36]. The Byzantine faults, such as fail-stop, failure to return a result, response with an inaccurate result, response with a deliberately misleading result, and response with a different result to different parts of the blockchain network, are supported for the first time by a state machine replication mechanism using this technique [37], [38].

1.3. Security in Blockchain

The core of a blockchain network is comprised of data structures such as ordered, linked lists of transaction blocks that are protected by multiple layers of security using cryptography [39]. This security is based on the principles of cryptography, decentralization, and consensus. Each block is linked to the previous blocks in a cryptographic chain that is difficult to tamper with [40]. Cryptography is a technique based on probability and game theories for encrypting information, which can be performed through symmetric encryption that uses a shared key or asymmetric encryption that uses a public and private key [41], [42], [43]. Advanced cryptography includes hash functions [43], [44], [45], digital signatures [43], [46], [47], and zero-knowledge proofs to secure transactions and protect their anonymity and confidentiality [48].

1.4. Programming Languages for Blockchain Tasks

Blockchain platforms require a suite of tools to perform different tasks [49], [50] such as a user interface, like a browser-based application; the use of smart contracts, which are programmed sets of if-then instructions to automate workflows [51]; and software development kits (SDKs) to help develop application program interfaces (APIs) [52]. These toolsets are encoded in a combination of different programming languages. Three such combinations are discussed to illustrate the importance of programming languages in blockchain processes. First, the Aptos network runs on the Rust-based programming language "Move." This language has a compiler and virtual machine as its foundation [53]. Second, the Solana blockchain utilizes Rust and TypeScript for its on-chain programs and app building scaffolding [54], [55], [56]. Lastly, the Binance chain employs Go, TypeScript, and Solidity for its modules [57], [58], including a Go-based client for interacting with the Ethereum blockchain [59], a Threshold Signature Scheme for authorizing transactions, and JavaScript SDK-based communication between modules [60].

1.5. Layers-based Structure

The understanding of blockchain technology can be approached from two perspectives: architecture and protocols. According to Bhutta et al. [43], the architecture for maintaining a functioning blockchain consists of five layers: the application layer that supports infrastructure like the Internet of Things or health records; the contract layer that provides a platform for programming modules such as smart contracts; the incentive layer that rewards network participants for their activities within the blockchain network; the consensus layer that uses algorithms to reach agreement between participants for block creation, for example, proof of stake; the network layer that enables the development of a distributed networking mechanism and data verification mechanism; and the data layer that manages data timestamping and hash functions [43], [61]. The protocols, on the other hand, are a set of rules that govern the functioning of the network. A blockchain protocol is comprised of four layers designed to enhance the utility of the network: Layer 0, which consists of hardware and connections that support the rest of the layers; Layer 1, which facilitates processes such as proof of stake, timestamps, or smart contracts; Layer 2, which enhances transaction scalability by integrating off-chain solutions like state channels, a mechanism for network participants to directly interact with each other outside of the blockchain [62] and Layer 3, which is the user interface layer or the application layer of the blockchain protocol [62], [63], [64].

1.6. Essential Blockchain Concepts

This paragraph provides an overview of essential concepts related to blockchain technology. Cryptography involves mathematical techniques for creating security protocols that govern blockchain networks, with keys being a central component for cryptographic operations. Encryption is the process of transforming plaintext into cipher text, making the data unreadable. A hash function is a mathematical expression that creates a one-way relationship between input data and a unique output, ensuring the data's integrity. A digital signature uses private-public key cryptography to verify authorship. Timestamps are used to record the date and time of blockchain events. Decentralization refers to the ability of the ledger to exist on different nodes interconnected in a network that operates on a Peer-to-Peer (P2P) basis, with each node acting as both client and server. A virtual machine simulates a computer system to store and process data in a blockchain network. Transaction is the transmission of data across the distributed ledger. Note that each transaction is recorded as a block of data. TPS (transactions per second) refers to the number of transactions a network can process. Web3 encompasses principles of decentralization, user data ownership, and cryptocurrency.

Cryptocurrency is a digital payment system and decentralized trading network, and tokens are digital representations of assets, claims, or utilities within a blockchain network. Non-fungible tokens (NFTs) are unique digital identifiers for non-interchangeable assets, claims, or utilities. Miners are special nodes in a network that validate transactions and generate and attach blocks, with the computational solution of these problems incentivized by cryptocurrency [41], [65], [66], [67], [68], [69], [70], [71], [72].

Stability is another key concept in relation to blockchain technology. It is related to the proposition that transactions on a blockchain that are rewarded with cryptocurrencies should have the capacity and capability to endure transient extreme occurrences. Long-term probabilistic stability is used to achieve such an attribute. An alternative name is high probability of survival [73].

1.7. Taxonomy and Ontology in Blockchain Technology

The field of blockchain technology is comprised of intricate mathematical concepts and highly developed software and hardware systems. To better understand and organize the key functionalities and applications of blockchain systems, researchers leverage knowledge organization systems (KOS also known as Simple Knowledge Organization System) such as taxonomy and ontology. This section provides a brief overview of the basics of taxonomy and ontology in blockchain [74], [75], [76].

1.7.1. Taxonomy

Taxonomy is a hierarchy of inheritance [77], [78], [79]; it is a systematic method of organizing and classifying knowledge in a specific domain, such as Bloom's taxonomy which is based on cognitive, affective, and psychomotor domains [77], [80]. This section provides an overview of taxonomy concepts and their applications. Taxonomies play a crucial role in research and real-world projects [81], [82], [83], as the formal classification of concepts and entities helps researchers and practitioners alike to better understand and analyze complex domains such as blockchain [80], [83], [84]. To develop a taxonomy, Nickerson et al. [81] suggest a three-stage approach. Stage one defines the taxonomy's purpose and meta-characteristics, while stage two involves determining taxonomy objects, dimensions, and characteristics through inductive or deductive iterations. Stage three evaluates the taxonomy against the established criteria [80], [81]. The aim of taxonomy is to arrange complex information in a clear and simplified manner for effective communication and understanding [85]. In order to accomplish this, a taxonomy is predicated upon the four fundamental components of: identification, characterization, classification, and nomenclature [85]. Identification involves assigning correct names and placement to taxonomy levels and elements, while characterization establishes connections between levels and elements. Classification organizes elements in a simplified way, and nomenclature is the proper naming of elements in a scientific manner [82], [85].

1.7.2. Ontology

Ontology can be described as systematic representation of concepts and the relationships between them in a specific domain [86], [87], [88]. In the field of blockchain, researchers use ontologies to encode the intricate concepts and principles that make up this technology with the aim of capturing relevant background knowledge. In this section, a brief summary is provided of ontology-related terms commonly used in the blockchain domain. Both the academic and industry communities utilize ontologies to depict knowledge about distributed ledger technologies (DLTs), consensus protocols, cryptocurrency, and their applications. The industry also uses ontologies to represent information about transactions, timestamping mechanisms, and to integrate blockchain platforms. By combining knowledge from both the academic and industry with user data, it is possible to develop a variety of intelligent applications, such as an ontology for improving the interoperability of blockchain applications [89] or for schematically representing the structure of blockchain components, such as consensus protocols [90].

The constituents of an ontology are concepts, relationships, functions, and axioms. Concepts are formalizations of a domain's constituent parts. Relationships link concepts. Functions calculate specific tasks by associating an output to one or more parameters. Axioms are statements that are claimed to be true in a domain under description [88], [91], [92], [93].

This paragraph outlines an approach for creating an ontology for a specific domain. The process starts by acknowledging certain guidelines, such as the absence of a single correct way to model a domain, the iterative development of an ontology, and the requirement for concepts and relationships to reflect actual or logical objects. The domain to be covered by the ontology and its scope must then be determined. Utilizing existing ontologies can aid in the creation of a new ontology. The next step involves listing the terms and their properties that will be incorporated into the ontology. Subsequently, a concept hierarchy must be established. This includes encoding the most general concepts in the domain and then gradually specializing these concepts. Relationships are then defined to provide insight into the structure of the domain, based on the concepts being described. Finally, the newly developed ontology should be evaluated for consistency in the class hierarchy, transitivity of hierarchical relations, and the presence of cycles in the class hierarchy [94], [95].

1.8. Research Purpose

However, additional research into the design and components of blockchain could further assist academics and professionals in comprehending the intricacies of this technology. Therefore, the purpose of this overview is to investigate and summarize the categorization of blockchain components and to draw attention to the interactions, advantages, and constraints of the history, authority, and stake consensus protocols, transactions per second, and stability blockchain mechanisms, as reported in the literature. The remainder of this article is organized in the following sections: Methodology, Results and Discussion, Conclusion.

2. Methodology

This section discusses the research technique, which comprises the scientific database, search strategy, filtering procedure, and inclusion and exclusion criteria. This methodology identifies (i) publications about consensus protocols of history, stake, and authority; transactions per second; and stability, (ii) classification of the above-mentioned blockchain components with the use of taxonomy and/ or ontology, and (iii) identification of potential future research opportunities.

2.1. Review of Literature Approach

Articles are found by searching the scientific database Google Scholar [96]. The chosen articles are examined and discussed using the narrative overview format. The narrative overview is a method for systematically summarizing the information in the examined literature. It also facilitates the discussion of complexities of blockchain technology and to look for in-depth qualitative insights in comprehensible form [97], [98]. The development of a problem or its management, such as the tracking and transfer of the ownership of a variety of tangible or intangible assets, can be highlighted for further analysis in the context of the broader perspective of blockchain [97], [98], [99], [100], [101], [102].

The search query utilizes the Boolean 'AND' and 'OR' operators in Google Scholar [103]. The "AND" operator reduces the number of search results by identifying terms in a search query. The "OR" operator combines multiple search terms that are part of a search query. Examples of search terms include the following: (("blockchain" OR "blockchain-based" OR "decentralized") AND (("transactions per second" OR "tps" OR (") AND (("consensus" OR "proof of *" OR (("proof of history" OR (("proof of authority") or (("proof of stake"))). The search is further organized by the application of search filters. As an illustration, the most current date is used to order any type of item, including citations, during a five-year period.

The following exclusion criteria are manually applied to the obtained collection of articles: first, publications that do not examine the consensus protocols related to the history, authority, and stake algorithms as well as taxonomy and ontology as subjects; second articles with restricted access; third, publications that emphasize centralized or permissioned blockchains; fourth, papers that are inconsistent in their analysis or not written in English language.

Two researchers manually analyze the research objectives, approaches, and findings of the obtained articles to determine their applicability to this investigation. Consensus is used to resolve discrepancies between the researchers in the ratings given to each article.

Table 1. Collection of articles for review

No.	Author	Year	Type of study	Objective	Consensus protocols Authority, History, Stake	Stability	Transactions per second	Summary	Category
1	Abdelmaboud et al.	2022	Survey	survey and tutorial on the use of blockchain in IoT systems, creation of blockchain taxonomy for IoT applications	Proof-of-stake, Proof-of-Authority	deterministic shared consensus protocol	few transactions per second can be handled by many existing blockchain implementations	blockchain technologies, protocols, and properties e.g., decentralization; blockchain for IoT thematic taxonomy	Taxonomy
2	Bashar et al.	2019	Comprehensive review of literature	comprehensive review of the working principles of consensus protocols in blockchain-based cryptocurrencies	Proof of Authority, Proof of Stake, Proof of History	-	-	a comprehensive classification of consensus mechanisms based on their building blocks	Taxonomy
3	Bouraga	2021	Research paper	Taxonomy-driven classification framework of consensus protocols	Proof-of-Stake	PREStO framework	On Panda: 1200 TPS with a network size of 100; On FastBFT: throughput of about 500 operations per second	highlights of constructs important for the design of new consensus and comparison of existing consensus protocols	Taxonomy
4	Ferdous et al.	2020	Systematic analysis of consensus algorithms	novel taxonomy of consensus properties, capturing different aspects of a consensus algorithms	Proof of Authority, Proof of Stake	-	Bitcoin and Ethereum at 7 and 15−25 TPS respectively, DPoS currencies EOS at 50 and 4000 TPS respectively, Tron 2000 TPS, proof of cooperation by FairCoin crypto-currency at 10.6 TPS	taxonomy of properties for consensus algorithms, taxonomy-driven generation of groups of incentivized and non-incentivized consensus algorithms	Taxonomy
5	Hang et al.	2022	Review of blockchain technology in clinical trials	Taxonomy-based explanation of blockchain technology for the process and management of clinical trials	Proof of Stake	-	Bitcoin is limited to 7 transactions per second, Ethereum is limited at 15 tps	taxonomy to identify aspects of clinical trials that blockchain technology can benefit from	Taxonomy
6	Labazova et al.	2019	Research paper	taxonomy of blockchain applications for six blockchain application areas across eight technical dimensions	Proof-of-stake	-	-	Taxonomy-based integration of technical and application knowledge to guide the development of blockchain-based systems	Taxonomy
7	Nijsse and Litchfield	2020	Survey	Classification of consensus methods applied to current blockchains	Proof-of-stake, Proof of Authority	-	Bitcoin can handle 7 TPS, and Litecoin can handle 56 TPS.	Taxonomy-based categorization of 69 blockchain consensus protocols: scarce resource, fault tolerance, block proposal mechanism,	Taxonomy

No.	Author	Year	Type of study	Objective	Consensus protocols Authority, History, Stake	Stability	Transactions per second	Summary	Category
								transaction finality, network timing assumptions, network accessibility, and network communication	
8	Sharma and Lal	2020	Comparative study	Analysis of strengths and weaknesses of proof based and voting based consensus algorithms	Proof of Stake	Stability is a feature for blockchain security	-	Presentation of blockchain consensus algorithms and characteristics through comprehensive comparison and analysis	Taxonomy
9	Syed et al.	2019	Comparative analysis	Focus on existing literature reviews of the core blockchain architecture and its application areas: Internet-of-Things (IoT), Healthcare, and Business	Proof of Authority, Proof of Stake, Proof of History	-	Proof of work protocols support7 TPS	Use cases of blockchains to explore possibilities to work in the domains of IoT security, healthcare, business vehicle tracking, real estate, banking	Taxonomy
10	Tasca and Tessone	2019	Comparative study	Taxonomy-based highlight of standard technical reference models of blockchain architecture	Proof-of-stake, Proof of Authority	probabilistic consensus-stabilizing consensus to decrease disagreement over time	Transactions per second (or TPS) is a quantitative parameter to redesign and improve blockchain technology	Taxonomy tree-driven summarization to study and navigate across different blockchain architectural configurations	Taxonomy
11	Yeow et al.	2018	Review of literature and categorization	Generation of thematic taxonomy based on extensive literature review and categorization of existing decentralized consensus systems	Proof-of-stake	-	-	Focus on the edge-centric IoT evolution from cloud-centric IoT and on decentralized structure to counter centralized structure security problems	Taxonomy
12	Zheng et al.	2018	Comprehensive survey	Creation of blockchain taxonomy, introduction to typical blockchain consensus algorithms, review of blockchain applications, discussion of blockchain technical challenges and advances	Proof of stake	-	Bitcoin is restricted to 7tps	Comprehensive survey on blockchain, overview of blockchain technologies including blockchain architecture and key characteristics, typical consensus algorithms, comparison of protocols, investigation of typical blockchain applications, list of challenges and problems that hinder	Taxonomy

No.	Author	Year	Type of study	Objective	Consensus protocols Authority, History, Stake	Stability	Transactions per second	Summary	Category
								blockchain development, summarization of approaches for solving these problems	
13	Chen	2019	Research paper	Study of granular aspects of ontology in blockchain technology	-	-	-	Examination of blockchain technology from a database perspective, with an emphasis on granular aspects of ontology	Ontology
14	Khan et al.	2022	Survey and ontology	Ontology-based systematic knowledge classification and explanation to structure the survey on blockchain consensus algorithms for resource constrained IoT systems	Proof of Stake	-	About Hash graph: 2.5×10^5 TPS	Understanding and classifying blockchain consensus algorithms regarding IoT use cases and a formally specified ontology for blockchain consensus algorithms to reason about the properties of the algorithm's ontology, demonstration of ontology by applying to the literature on blockchain consensus algorithms to understand their limitations with respect to the IoT application	Ontology

Table 2. Overview of research challenges, approaches, and contributions

No.	Author	Research challenge	Research approach	Research contribution	Category
1	Abdelmaboud et al.	Current survey studies classify blockchain approaches based on architectural components and the mode of blockchains	Taxonomy-driven classification of blockchain technologies, applications, and approaches based on blockchain modes, protocols, technologies, and properties critical for security and privacy solutions for IoT applications	Thematic taxonomy based on crucial parameters and discussion of important and common blockchain platforms that support the IoT, key roles of blockchain in IoT systems, investigation of recent advances reported in the literature, open challenges, and future research directions in the IoT	Taxonomy
2	Bashar et al.	Researchers develop fair, scalable, and efficient consensus protocols for blockchain applications, since April 2019, exist more than 2000 active cryptocurrencies, which rely on consensus protocols	Exploration of prominent consensus protocols in the top 50 cryptocurrencies by market capitalization, discussing their use-cases, as well as their relative weaknesses and strengths	Comprehensive review of working principles of commonly used consensus protocols in blockchain-based cryptocurrencies, taxonomy-based categorization of consensus protocols to delineate public and private blockchains and a thorough comparative evaluation	Taxonomy
3	Bouraga	Currently, many surveys discuss consensus protocols that address limitations of seminal ones; however, new consensus protocols emerge regularly, and improvements are also put forward on a regular basis	Information to researchers and practitioners about the current research state of consensus protocols, discussion of the emergence of new consensus protocols, comprehensive classification framework integrating knowledge from multiple literature, generation of new classification dimensions	Taxonomy-based classification framework for the categorization of blockchain consensus protocols based on origin, design, performance, and security, 28 protocols are utilized to demonstrate the applicability of the framework	Taxonomy
4	Ferdous et al.	Existing studies of consensus algorithms have incomplete discussions on the properties of the algorithms and fail to analyze several major blockchain consensus algorithms in terms of their scopes	Analysis of a wide range of consensus algorithms using a comprehensive taxonomy of properties and by examining the implications of different issues still prevalent in consensus algorithms in detail	Visualillustration of consensus algorithms, analysis of over hundred crypto currencies belonging to different categories of consensus algorithms to understand their properties presentation of a decision tree of algorithms to be used as a tool to test the suitability of consensus algorithms under different criteria	Taxonomy
5	Hang et al.	Existing literature lacks a comprehensive survey on the adoption of blockchain in clinical trials	Punctilioustaxonomy of blockchain technology in clinical trials according to the literature, comprising decentralized scenarios, decentralized practices, blockchain types, deployment methods, and consensus algorithms	Detailed review of the state-of-the-art blockchain technology in clinical trials, overview of issues in current clinical trial research, discussion of characteristics and premier advantages of blockchain solutions in clinical practice and the underlying concepts, thematic taxonomy for the evaluation of the role of blockchain in clinical trials regarding trial-related scenarios and practices, blockchain type, and consensus protocol, highlights of ongoing efforts to use blockchain technology in clinical trials, summarization of challenges and future research directions toward using blockchain technology in clinical trials	Taxonomy
6	Labazova et al.	Low number of successfully developed blockchain-based systems pointing to a research gap between blockchain applications and technical blockchain characteristics	Creation of taxonomy, which comprises six blockchain application areas that are classified across eight technical dimensions	Delimitation of blockchain application areas, identification of new technical dimensions, link of applications to technical knowledge on blockchain to guide development of blockchain-based systems, overview of current blockchain-based systems	Taxonomy
7	Nijsse and Litchfield	A degree of misunderstanding about how consensus is applied across blockchains	Rational classification of 19 consensus methods applied to current blockchains: clock-cycles, bits, tokens, votes, time, and biometrics	Taxonomy categorizing blockchains by consensus family across seven dimensions: scarce resource, fault tolerance, block proposal mechanism, transaction finality, network timing assumptions, network accessibility, and network communication	Taxonomy

No.	Author	Research challenge	Research approach	Research contribution	Category
8	Sharma and Lal	Transactions that take place in a blockchain network need to be validated by network nodes. Validation can potentially create confusion if nodes attempt to broadcast a new block simultaneously. To resolve this problem, a blockchain network uses a procedure to reach a common agreement about the current state of the distributed ledger between all nodes. This is done with a consensus algorithm. A consensus algorithm establishes trust between the anonymous nodes in a blockchain.	Discussion of various consensus algorithms and analyzes the comparative study of different consensus algorithms	Presentation of popular blockchain consensus algorithms and their characteristics through comprehensive comparison and analysis	Taxonomy
9	Syed et al.	Existing literature discusses the possibility of applying blockchain technology in various areas, such as, healthcare, IoT, and business, however, few review papers that target specific areas, instead of a complete overview of blockchain-related research	Presentation of a comparative analysis of core blockchain architecture, its fundamental concepts, and its applications in three major areas: the Internet-of-Things (IoT), healthcare, business and vehicular industry, discussion of challenges and proposed solutions, complete ecosystem of blockchain of all the papers reviewed and summarized, analysis of blockchain platforms, their consensus models, and applications	Taxonomy of blockchain architecture and its applications according to existing literature review of core blockchain architecture and its application areas e.g., Internet-of-Things (IoT), Healthcare, and Business	Taxonomy
10	Tasca and Tessone	Variations in blockchain software architectures pose a number of concerns from different perspectives, specifically when it comes to heterogeneity. Heterogeneity is a problem for the future development of blockchain technologies, because it will prevent their development, adoption, and stimulation of innovation	A comparative study across the most widely known blockchain technologies is conducted with a bottom-up approach	Taxonomy tree, for timely, honest intellectual exercise to be used as preliminary supporting material for all those interested in reducing blockchain complexity	Taxonomy
11	Yeow et al.	Shortage of comprehensive reviews on decentralized consensus systems for edge-centric Internet of Things that elucidates myriad of consensus facets, such as data structure, scalable consensus ledgers, and transaction models	Scrutinization of pros and cons of state-of-the-art decentralized consensus systems, extensive literature review and categorization based on existing decentralized consensus systems, thematic taxonomy	Main contributions: (i). Present an extensive literature review of state-of-the-art DCSs for edge-centric IoT with their pros and cons. (ii). Propose and design a thematic taxonomy for DCSs foredge-centric IoT to categorize the literature based upon the common features among these systems. (iii). Analyze existing methods to highlight the crucial facets and characteristics of edge-centric IoT DCSs. Lastly, some open research issues are put forward	Taxonomy
12	Zheng et al.	there is no comprehensive survey on the blockchain technology inboth technological and application perspectives	Comprehensive survey on the blockchain technology, blockchain taxonomy, discussion of typical blockchain consensus algorithms, review of blockchain applications and technical challenges and recent advances in tackling the challenges	Taxonomy of blockchain systems: read permission, immutability, efficiency, centralized, consensus process	Taxonomy
13	Chen	Since blockchain technology opens a new paradigm of thinking and practice, the philosophy behind it (particularly ontology) deserves much attention	Leverage of ontology in blockchain technology from a unique perspective: granular computing	Examination of blockchain technology from a database perspective, with an emphasis on granular computing to ontology	Ontology

No.	Author	Research challenge	Research approach	Research contribution	Category
14	Khan et al.	Consensus algorithms are mostly designed to work in extensive computational and communication environments for network security and immutability, which is not desirable for resource-restricted IoT applications. Many solutions are proposed to address this issue with modified consensus algorithms based on the legacy consensus, such as proof of stake (PoS) and new non-linear data structures, such as DAG. A systematic classification and analysis of various techniques in the field will be beneficial for both researchers and industrial practitioners. Existing surveys provide classifications intuitively based on the domain knowledge, which are infeasible to reveal the intrinsic and complicated relationships among the relevant basic concepts and techniques	A powerful tool of systematic knowledge classification and explanation is introduced to structure the survey on blockchain consensus algorithms for resource constrained IoT system	An ontology-based classification of different consensus mechanisms based on their logical implementation details: a novel consensus ontology, subclassification of the CONB.owl Ontology is provided, extended the CONIoT.owl ontology for non-linear classes of CONB.owl ontology. ontology-guided comprehensive survey is provided on blockchain consensus algorithms for resource-constrained IoT Systems	Ontology

Table 3. Research hypothesis, data utilization, and constraints

No.	Author	Research question/ hypothesis	Number of research studies/ projects reviewed/ described	Constraints/ challenges of the study	Category
1	Abdelmaboud et al.	how blockchain technology can be used to broaden the spectrum of IoT applications	Twenty (20) related surveys	Several problems and necessary restrictions should be explored and overcome before using the blockchain approach in IoT applications. This survey will assist researchers in identifying and addressing the issues associated with designing and integrating blockchain-based technologies for IoT applications	Taxonomy
2	Bashar et al.	Identification of a broader set of protocols will allow for a deep comparative understanding of how blockchain technology is being implemented today	Comparative evaluation of attributes among nine (9) cryptocurrency consensus protocols	-	Taxonomy
3	Bouraga	The belief is that this work is relevant and important for two reasons. Firstly, blockchain is a fast-evolving topic, new consensus protocols emerge regularly and improvements are put forward. Secondly, a comprehensive classification framework is proposed, integrating knowledge from multiple works in the literature, as well as introducing classification dimensions that have not been proposed before.	Review of twenty-eight (28) new consensus protocols	First, exclusion of blockchain block structure/content, second, focus on only most recently developed consensus protocols	Taxonomy
4	Ferdous et al.	A wide variety of crypto-currencies targeting different application domains has introduced an array of unique requirements that can only be satisfied by their corresponding consensus mechanisms. This fact has fueled the need not only to examine the applicability of existing consensus algorithms in newer settings, but also to innovate novel consensus algorithms	More than hundred (>100) top crypto-currencies belonging to different categories of consensus algorithms to understand their properties and to implicate different trends in these crypto-currencies	The principal focus of this article has been to explore and synthesize the consensus algorithms available in different blockchain systems. However, there are other distributed ledger systems, which do not rely on any blockchain-type structure. Instead, they utilize other structures to represent their respective ledgers. Examples of two such prominent crypto-currencies are IoTA and NANO	Taxonomy

No.	Author	Research question/ hypothesis	Number of research studies/ projects reviewed/ described	Constraints/ challenges of the study	Category
5	Hang et al.	(A taxonomy to identify aspects of clinical trials that blockchain technology can benefit from)	Ten (10) related surveys in the healthcare sector, summary of twenty-four (24) recent blockchain research in clinical trials	To benefit more from blockchain technology in clinical trials. A number of research areas or technologies can be explored for future research and development: Combination with AI and big data, Promotion of unified data standards, Integration of regulators and industry associations	Taxonomy
6	Labazova et al.	What application areas fit blockchains with what technical characteristics?	Six (6) blockchain application areas that are classified across eight (8) technical dimensions	First, the taxonomy cannot identify application areas that may emerge in the future. Second, the identified application areas do not directly capture more complex services, such as prediction markets or crowdsourcing platforms	Taxonomy
7	Nijsse and Litchfield	There appears to be a degree of misunderstanding about how consensus is applied across blockchains	Selected surveys provide sixty-nine (69) consensus methods as empirical data points in the taxonomy	The taxonomy is limited to seven dimensions and concentrates on the meta-characteristic of maintaining the state of a distributed ledger. The taxonomy is a snapshot of the present state of consensus and while blockchain research is expanding, blockchain variants are proposed faster than they appear in academic sources. This study is not a complete listing nor does the taxonomy classify blockchains	Taxonomy
8	Sharma and Lal	Consensus algorithms have promised the stable operation in this technology	Nine (9) consensus algorithms in terms of eighteen (18) characteristics and performance	-	Taxonomy
9	Syed et al.	(Current digital economy and businesses are built on the basis of trusted authorities. Thus, in cases of carrying out transactions, the authorities are consulted regarding the authenticity of the receiving party. The problem with third parties is that they can also be compromised, manipulated, hacked, or misused, which may ultimately incur wrongdoing)	Comparison of blockchain five (5) consensus mechanism, Literature review on nine (9) topics of blockchain and IoT integration, Literature review on sixteen (56) topics of BIoT Application Areas, Literature review of the seven (7) issues and challenges of BIoT, Contribution from research community, twelve (12), Comparison of traditional banking, internet finance, and blockchain businesses- seven (7) parameters	Processes of standardization, legal issues, and rights of individuals and organizations will be investigated in the future	Taxonomy
10	Tasca and Tessone	(Current variations in blockchain software architectures pose a number of concerns from different perspectives, specifically when it comes to heterogeneity)	Twenty-two (22) blockchains analyzed for the taxonomy	Based on the review of the current literature on blockchain technologies, our work is an early stage analysis across existing software architectures with the aim of proposing a taxonomy	Taxonomy
11	Yeow et al.	(To foster distributed edge-centric models, a decentralized consensus system is necessary to incentivize all participants to share their edge resources)	Twenty-eight (28) state-of-the-art and a comparison of DCSs based on the taxonomy	It is for future research opportunities, blockchain and blockchain-less DAG solutions can work cohesively to deliver a complete and comprehensive edge-centric IoT solution	Taxonomy

No.	Author	Research question/ hypothesis	Number of research studies/ projects reviewed/ described	Constraints/ challenges of the study	Category
12	Zheng et al.	Despite the fact that the blockchain technology has great potential for the construction of the future internet systems, it is facing a number of technical challenges: scalability, , centralization, selfish mining strategy, privacy leakage, current consensus algorithms like proof of work (PoW) or proof of stake (PoS) are facing some serious problems, such challenges need to be addressed in the blockchain technology development	-	Limitations of the study as possible future research directions with respect to five areas: blockchain testing, stop the tendency to centralization, big data analytics, smart contract and artificial intelligence	Taxonomy
13	Chen	(Examination of granular aspects of blockchain databases offers a unique opportunity to understand the nature of this new development)	Observations and analysis of implications of research work related to blockchain technology	Granular aspects themselves do not bring blockchain technology to reality; to understand blockchain technology and to advance its techniques, granular aspects must be respected	Ontology
14	Khan et al.	(Existing surveys are based on an intuitive classification of domain knowledge, making it difficult to reveal the intrinsic logical connections between knowledge concepts in the field)	Seven (7) related surveys on Consensus	The main challenge of labeling IoT adaptability is its dependence on a specific problem. Every use case sets a distinct requirement and needs customized solution	Ontology

3. Results and Discussion

147 articles are found using the search terms specified in the methodology section. Then, sixty-seven articles that only cover permissioned blockchain networks are eliminated from the selection using a manual analysis of the abstracts and keywords. The remaining 80 items are manually screened for the following criteria: Research objectives that highlight the structure of blockchain technology; research questions or hypotheses that offer comparative understanding of blockchain consensus protocols; research methods that include the elements of a taxonomy and/or ontology for the categorization of consensus protocols; and keywords like "decentralization," "taxonomy," "blockchain" that highlight the field, subfield, topic, and research challenges. The final list of publications contains fourteen scholarly articles, of which twelve address the classification of related material using taxonomies and two describe the definition of relationships between blockchain concepts using ontology-based modeling. Notably, Table 1's first and second columns list the quantity of papers under review as well as each article's first author.

Taxonomy and ontology methodologies are used in the chosen survey reviews and original research publications to examine blockchain technology's constituent parts. The tabulated information provides an overview of the examined publications' content, research question, objective, methodology, data, and challenges. Based on Table 1, there are two studies that use ontology-based solutions to examine blockchain components and fourteen studies that explore taxonomy-based solutions. Below, is provided an overview of the articles.

Eight of the chosen studies are categorized as surveys or comprehensive reviews of literature[104], [105], [106], [107], [108], [109], [110], [111]; three studies are comparisons of the advantages and limitations of proof-based consensus algorithms and application domains [84], [112], [113]; and three studies are research projects with an emphasis on the taxonomy of blockchain applications and aspects of ontology in blockchain technology [80], [114], [115]. Two studies [105], [113] address the history, authority, and stake consensus protocols, which are the topic of this overview; four studies [84], [104], [106], [108] make reference to the authority and proof of stake protocols; and seven studies [80], [109], [110], [111], [114], [116], [117] go into detail on the proof of stake protocol. The blockchain stability is mentioned as a probabilistic-based method in the following articles [84], [104], [112], [114]. In ten research, the blockchain transactions per second (tps) is mentioned as an existing constraint to the technology's capacity [84], [104], [106], [108], [110], [111], [113], [114], [116], [118].

In their respective studies of the blockchain and the Internet of Things (IoT), Abdelmaboud et al. [104] emphasize onto security, privacy, and technological difficulties. The researchers highlight security and privacy concerns for this, such as cyberattacks, the proof-of-stake and proof-of-authority blockchain protocols' deterministic nature with regard to the stability mechanism, and their ability to manage a limited number of transactions per second. Additionally, they showcase projects for crucial blockchain platforms like the Hyperledger-Fabric and Ethereum platforms that are integrated with IoT applications. The authors also develop a thematic taxonomy that divides the blockchain architecture into categories such as public or private blockchains, distributed ledger technologies, consensus protocols, and blockchain-based Internet of Things applications like smart health care. The operating concepts of popular consensus protocols, such as proof of stake and proof of authority in blockchain-based cryptocurrencies, are thoroughly reviewed [105].The authors classify the protocols based on the need for permissions, such as permissionless, and they specify the degree of difficulty of blockchain networks, such as proof-of-stake for public blockchain types with a level of computational difficulty of "easy" on the Ethereum platform. The researchers' taxonomy is based on different blockchain consensus protocols. For instance, the discussion focuses on the contrasts between the Ethereum network's EthHash protocol and Casper, a proof of stake method.

In [106] the authors use a thorough taxonomy of properties to examine the limits of various blockchain systems and consensus algorithms in order to fill in any gaps in the present evaluations of the literature on blockchain technology. The authors classify consensus algorithms into incentive-based and non-incentive-based categories by utilizing the taxonomy's architecture. In brief, consensus algorithms for non-cryptocurrency applications, like voting systems, identity management, or supply chains, are classified as non-incentivized and the proof of stake algorithm is classified as under-incentivized [119]. The authors further divide the two groups into the following taxonomies: taxonomy of consensus properties, which specify the structure of nodes within a blockchain network; taxonomy of block and reward properties, which classify quantitative metrics of cryptocurrencies; taxonomy of security properties, which group together properties like non-repudiation; and taxonomy of performance properties, which arrange measures of quantitative performance of a consensus protocols, such as, throughput that returns the number of transactions per second a protocol can process. To address the gaps in previously released review studies on the use of blockchain technology in clinical trials, [107] conducts a review. With regard to decentralized scenarios, decentralized practices, blockchain types, deployment strategies, consensus algorithms, open blockchain technical challenges, security challenges, and organizational challenges, this research creates a taxonomy to make it easier to organize blockchain features. Consensus algorithms are the fourth unit in this taxonomy. The authors define consensus as a rule for transaction confirmation. The proof of stake protocol is discussed here as a method. By using this method, the blockchain's proof is no longer only reliant on its workload. The proof of stake protocol effectively addresses the drawbacks of existing protocols. It accomplishes this through improving the capacity for transaction processing, for instance, by storing the same ledger data at each node and by consuming less energy than existing protocols [120]. The vast computing power of blockchain results in terawatt-hours (TWh) of significant annual electricity usage, which is referred to as "energy consumption." For the control of electrical energy, a blockchain or cryptocurrency network depends on its consensus mechanism [121], [122], [123].

According to Nijsse and Litchfield [108], there is misunderstanding about how consensus is used in various distributed ledger systems among blockchain researchers and practitioners. In order to overcome this drawback, the researchers develop a relational classification of consensus techniques based on seven blockchain-related characteristics: limited resource, fault tolerance, block proposal process, transaction finality, network timing assumptions, network accessibility, and network communication. The end result is a taxonomy that academics can use to decide which areas to focus on for improvement or development as well as to choose a consensus approach.

Yeow et al. [109] fill the gap in the body of systematic literature reviews on decentralized consensus systems for IoT-based technologies. For the purpose of classifying decentralized consensus systems that work with blockchain or blockchainless directed acyclic graph technologies, a taxonomy has been developed. The consensus systems are then categorized using three shared attributes: data structure, scalable consensus ledger, and transaction mechanism. Data types used as an immutable public ledger for transactions, such as directed acyclic graphs, are considered data structures in this context. A scalable consensus voting method known as a "scalable consensus ledger" is necessary for all authorized nodes in a blockchain network to choose the correct successions of upcoming transactions or blocks.

Regarding the use of ontology, Khan et al. [111] point out that existing methodological techniques are constrained in their ability to disclose inherent logical linkages between knowledge concepts in the blockchain domain. The authors present a survey of blockchain consensus methods for resource-constrained IoT systems that is ontology-guided in order to address this difficulty. Formal reasoning is enabled by the classification of the generic consensus algorithm part and the consensus algorithm proposed for IoT systems part of the ontology. The proposed ontology has several classes, such as competitive consensus, which makes use of multiple blockchain participants to start solving the same problem simultaneously; comparative consensus, which refers to the programmatic comparison of the network of a miner selected to create a new block conditional on staking; vote-based consensus, which is computer-based voting for the generation of a new block; and non-linear consensus, which is exemplified by directed acyclic graph and side chains.

Sharma and Lal [112] give an overview and comparison of evidence-based or lottery-based algorithms, such as proof of stake, and voting-based consensus algorithms, such as Paxos, with regard to comparison-based projects. Blockchain systems without authorization use proof-based techniques. Permissioned blockchains use voting-based procedures. The researchers come to the conclusion that better throughput is provided by permissioned blockchain technology at the expense of decentralization. Syed et al. [113] compare the fundamental blockchain designs used in the Internet-of-Things (IoT), business, healthcare, and automotive industries. This research team also examines consensus models in addition to other blockchain components. The authors' taxonomy is represented by a diagram. The diagram's central components display two major categories. First, there are the subcategories of permissioned blockchain, public blockchain, blockchain platforms for IoT, and consensus models under the umbrella category of blockchain architecture. IoT, business, and healthcare are subcategories of the blockchain applications category. These final subcategories are further divided into cloud computing, outsourcing, secure remote patient monitoring, and decentralization and scalability, respectively. In a study that compares blockchains across several platforms, Tasca and Tessone [84] break down blockchains into their component parts. Each blockchain technology is hierarchically categorized by the authors into its core and supporting components. To do this, a taxonomy tree is built to define various functional or logical blockchain individual components and to discover potential varied layouts. The units of network topology, immutability and failure tolerance, gossiping, and agreement are specifically categorized as the consensus component. This taxonomy's objective is to make blockchain technology easier to grasp by minimizing its complexity.

Twenty-eight consensus protocols are reviewed by Bouraga [114], who also suggests a four-category classification scheme based on the origin, design, performance, and security of the protocols. The objective is to educate practitioners and scholars on the current status of research on consensus protocols. The proposed taxonomy expands on previous studies that make use of taxonomies and theories that are related to them, such as Gregor's Theory for Analyzing [124]. The end result is a classification framework with 23 dimensions, nine of which are novel at the time that shows the four categories mentioned above. Labazova et al. [80] talk on the meager profits from successful blockchain-based system development. The search gap between blockchain applications and technical blockchain properties is highlighted by the authors as a reason for this. To solve this problem, a taxonomy that categorizes six blockchain application areas—such as data management and communication—across eight technological dimensions—such as primary consensus mechanisms—is created. The taxonomy's usefulness is illustrated on 89 blockchain-based systems, including white papers, system websites, press releases, and the implementation of systems like Namecoin for data management and Matchpool for communication. The instances mentioned above were selected at random from the study that is being examined.

Chen [125] concentrates on the usage of granular computing on ontology-based blockchain technology when it comes to ontology-based solutions. Granular computing, according to the researcher, refers to computing theories or technologies that use elements and granules. The concentration of indisignuishability, equivalence, similarity, proximity, or functionality of a system is referred to as a granule. It is also emphasized that the main principles of granular computing are hierarchy, granularity, granule, and granulated view. This method allows the ontology to identify various layouts by breaking down the blockchains into their respective functional or logical components. An ontology, according to the author, is officially described as a quintuple O, consisting of the letters I, C, R, F, and A for example O {I, C, R, F, A}. Then, it is mentioned that I represents a collection of individuals, C represents a set of concepts, R represents a set of defined relationships, and F represents a set of functions used to define new concepts from existing concepts. A is a group of axioms that limit the significance of concepts, connections, and functions. The aforementioned granules are inferred by concepts and people. The study comes to the conclusion that a granular viewpoint enhances computational complexity and clarifies the complexity of blockchain components.

The analysis of the chosen articles reveals that, in order to fill knowledge gaps in understanding and applying blockchain, the majority of authors write comprehensive reviews. The intricacy of the technology covered in the aforementioned sections is one cause of blockchain-related gaps. The fact that blockchain and distributed ledger technologies are currently popular in business, banking, biomedicine, and educational institutions for record-keeping, e-transcripts, and copyright protection is another factor [126]. Additionally, cutting-edge organizational models for instance decentralized finance (DeFi), financial technology (Fintech), and internet banking, or metaverse use blockchain technologies to enhance government, e-commerce, and data security processes [127].

The categorization of distributed ledger concepts and blockchain components is the main usage of taxonomy, as mentioned in the chosen articles. The authors intend to give taxonomies that practitioners and researchers could use to better understand and utilize the blockchain technology and its components. Users' ability to search for concepts from upper, more general categories to lower, more particular categories or lateral to topics with similar concepts can be facilitated by the process of arranging and indexing material in a taxonomy. The analysis demonstrates that the proposed taxonomies amass information that is useful and accessible while being integrated into the fields of biology, finance, and IoT.

Similarly, ontology is utilized to hierarchically and relationally represent blockchain components. In this section, the data's constituent parts—such as the consensus methods that serve as the basis for their organization—are studied. The papers under evaluation demonstrate how using the technology is impacted by an understanding of the various blockchain components and how they interact. A blockchain conceptual model is illustrated by using ideas from the issue of comprehending blockchain technology and expanding it with use cases. These articles present a novel method for categorizing various blockchain issues. It's interesting to note that a closer look at the ontologies that handle blockchain-related problems reveals that the classification of blockchain technology can be aided by the classes that have been offered. For instance, binary, ternary, or multiclass ontology-like classification can be used to categorize the difficulty of comprehending and addressing problems relating to consensus algorithms, transactions per second (tps), or stability [128].

The few mentions of stability and transactions per second (tps) indicate the researchers' goals and areas of attention with relation to their knowledge of blockchain technology and its parts. For instance, the chosen papers discuss cryptocurrencies, smart contracts, consensus methods like proof of stake, immutability, scalability, hash algorithms, and homomorphic encryption technologies. However, the researchers in the chosen studies less frequently discuss stability and transactions per second, perhaps because they indicate duplication or are seen as minute details. Issues with tps and blockchain network stability may prove to be two of the biggest barriers to the widespread use of blockchain technology in academia or business. Implementation efforts are likely to be limited due to a potential limitation of blockchain technology that would cause it to fall short of meeting the needs of the academic or business communities in terms of transaction processing, network stability, or ease of data transfer between the blockchain and other technologies.

Blockchain technology is applied across a variety of industries, including IoT, biomedical, education, and finance applications for data transmission and storage, identity management, timestamping, logistics, and smart healthcare. The reviewed research projects indicate that blockchain and each of its elements can solve problems with electronic transactions and application interoperability. In order to develop and incorporate blockchain technology into other fields, it is possible to capture the interest of both academia and industry.

4. Conclusion

This overview looks at the classification of consensus protocols, transactions per second, and stability in scholarly publications using taxonomy and ontology-based approaches. The studied literature demonstrates that the classification of each of the blockchain technology's constituent parts can be used to manage the technology's complexity. To categorize blockchain components in a methodical manner, the researchers use the structure of a taxonomy and/or ontology. The classification of blockchain technology also aids in its comprehension by potential academic and commercial stakeholders. However, this study discovers that descriptions of the connections between the blockchain's proof of history, authority and stake protocols, transactions per second, and stability components—all of which are crucial for effective energy management and transactions—are scant in the articles under review. Therefore, it can be inferred that there is opportunity for in-depth investigation into the aforementioned elements in order to better understand the complexity of blockchain and/or its functionality.

For scholarly literature on blockchain, Google Scholar [96] has been chosen as the only web search engine due to its accessibility, free access to journals and papers, citation-related features, links to libraries, and scientific data bases. The choice of a single source for article selection could have limited the number of publications reviewed and, consequently, the number of methodological approaches for the study of blockchain components. Additionally, the purpose of this overview may be constrained by its focal elements, such stability.

Blockchain is a technology that disrupts both the academic world and the industry. Blockchain redefines and transforms industries in the fields of government, banking, healthcare, and education through transparency, security, and traceability. This review can potentially assist academics and industry professionals to comprehend the core ideas behind blockchain technology and identify papers that address questions associated with its structure.

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