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ORIGINAL RESEARCH ARTICLE

A transient survey on blockchain technology: Topology, challenges and applications

Arunima Sharma

Independent Researcher, G-1, Rajender Nagar, Sector-3, Sahibabad, Ghaziabad, Uttar Pradesh-201005, India; arunimasharma7893@gmail.com

ABSTRACT

Recently, there has been a gigantic amount of attention that received by blockchain technology. Serving as an entrenched ledger, this technology allows a decentralized transaction. In modern life, numerous fields as applications of blockchain technology are emerging, which includes the Internet of Things (IoT), financial sector services, reputation system, and many more. Due to different properties like auditability, persistency, decentralization, and anonymity. blockchain technology serves extensively in academic and industrial sectors. Issues with security and scalability are the two main concerns that need a solution in regard to this technology. This paper represents a brief overview of blockchain technology. Furthermore, there are different challenges and advantages listed in this paper.

Keywords: decentralization; ledger; IoT; blockchain technology network

1. Introduction

Blockchain is categorized as the distinctive categorization of a digital ledger, consisting of an incremented list of records commonly known as blocks that are linked to each other via cryptography. In this technology, each distinctive block contains three elements, which include a timestamp, the previous block's cryptographic hash, and a Merkle tree. When the block was created, timestamp proved the existence of transaction data. A chain is formed in this technology as each block contains previous block information, forming a linkage to the ones before it with adding blocks. If the data of all subsequent blocks contained within the respective blocks doesn't have an effect due to the alteration of data in a given block, so that the BC transactions once they get recorded are irreversible. Data in BC technology is kept in the distributed ledger. The transactions recorded in a distributed ledger, which are written, read, and verified in a BC network by the participants, are provided by availability and integrity via BC technology. Cryptographic protocols and primitives like digital signatures, hash functions, and many more secure and support the BC systems. In a trustless environment, BC delivers users with the looked-for features of decentralization, autonomy, integrity, altercated great academic and industrial attention in the topical few years, anonymity, auditability, and transparency[1–3].

By using computer network technology, which is peer-to-peer (P2P), blockchains are managed to use it as a publicly distributed ledger. Although BC records are not fixed, BC forks are probable. BC may be reflected as secure by design and accompanied by a distributed computing system apiece high Byzantine fault

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tolerance[4]. The BC was created by a person (or group of people) using the name (or pseudonym) Satoshi Nakamoto in 2005[5] to act as the public distributed ledger for cryptocurrency transactions of Bitcoin[6].

Section one consists of **Figure 1**, which depicts the basic layout of the BC network, and **Figure 2**, which represents the roadmap of the evolution of BC technology.

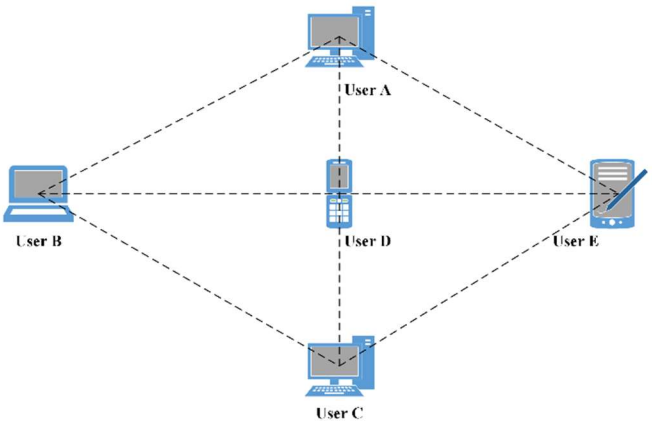

Figure 1. Basic layout of blockchain technology network.

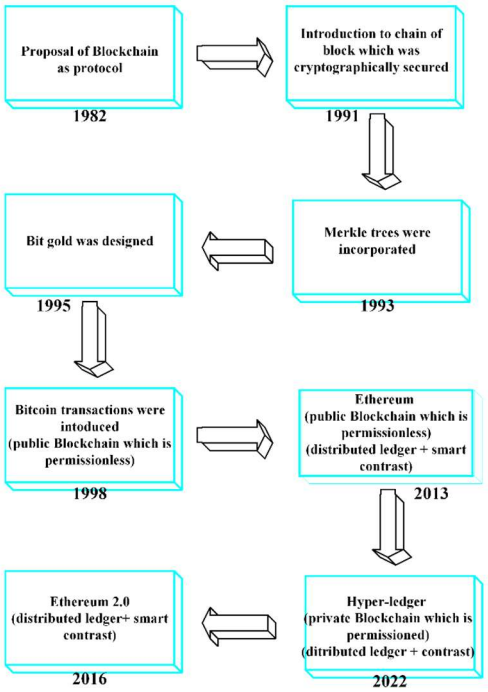

Figure 2. Roadmap of the evolution of blockchain technology.

An ascending list of records, usually known as blocks, which are commonly linked via the usage of a phenomenon called cryptography, is called as blockchain. The respective block contains three parts mainly, those are: i) previous block's cryptographic hash; ii) transaction data; and iii) timestamp. The main reason for this phenomenon is that the data can't be changed in any given block retroactively without any change in the subsequent blocks. For the validation of new blocks and inter-mode communication, the adheration of a protocol is done when a BC is used as a distributed ledger, which is commonly managed by P2P network. The BC has been pronounced as "an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way"[3]. In the digital modern era, via a transmission channel that is affected by intruders, data flows from one point to another. The major concern of the researchers is the

confidentiality and privacy of the data. Hence, BC technology is the solution to the problem, hence providing a P2P communication security. BC technology often finds its applications mainly in the domains of healthcare, supply management, industry, and most importantly, IoT.

2. Technological background

A dissertation titled as "Computer systems established, maintained, and trusted by mutually suspicious groups" by cryptographer named as David Chaum in 1982 proposed BC as protocol[7]. The work on security via cryptography is provided to the chain of blocks epitomized by Haber and Stornetta in 1990[8]. They introduced this phenomenon with the aim of no tampering with document timestamp. Merkle trees were fused into the design by Haber, Stonetta, and Bayer in 1992 by refining the efficiency via the allotment of several document certificates, which are collected in one block[9].

A person named as Satoshi Nakamoto conceptualized the first BC, which was decentralized. Nakamoto introduced a new phenomenon that used hash cash-like methods to improve the existing design. The new method aims at not much importance given to the process by trusted parties as to timestamp blocks. Another use of this new design was to introduce s parameter, which served difficulty in stabilizing the rate at which the block was being added to the chain. This new design was the core component implementation for the cryptocurrency Bitcoin, serving for all transactions as public ledger on the network. The file size in August 2014 of Bitcoin BC regarding the transactions contained in records occurring in the network did reach to 20GB[10]. In Buterin's whitepaper, Ethereum was proposed in year 2013[11].

Ethereum is a software. It is an open-source decentralized blockchain software with functional smart contract. Ethereum's development was crowdfunded in year 2014. In a trustless distributed application w.r.t a network, Ethereum enables people to each other on its own BC. Ethereum 2.0 helps in the upgradation of an Ethereum network aiming at boosting the security, scalability, speed, and efficiency of the respective network. From 2010 to 2022, the respective upgrades did have three phases[12].

3. Contribution

- The paper dowries a brief overview on blockchain technology. We provide an overview of different types and categories of blockchain and their respective applications and uses.
- Furthermore, technical challenges and recent advances are briefly listed. Different types of BC technology have been discussed briefly with application domain of the respective technology.
- This paper briefly explains every aspect of the technology. Section four discusses the structural aspects and design of the respective technology.
- Section six discusses the different types of BC technology.
- Section eight describes the different applications of BC technology serving in different domains.
- This paper also contains a conflict of interest section.
- Paper is completed in Section nine.

4. Structural methodology

Actually, we define a BC as an extensively distributed, decentralized, and largely public domain technology. A BC is commonly considered as a digital ledger that consists of records known as blocks, which are used for recording transactions widely across many computers. As a result, no block can be altered, which is involved retroactively with no alteration in all subsequent blocks[13].

This phenomenon consents the network users to audit and authenticate data transactions that are independent and relatively inexpensive[14]. The database of BC technology is autonomously managed by the usage of a network, which is categorized as P2P, and a server, which is distributed timestamp. The authentication, which is collective self-interests done via mass collaboration power[15]. A BC technology is described as value-exchange protocol[16]. A BC technology has different layers[17], which are:

1) Infrastructure (hardware)
2) Data (blocks transactions)
3) Networking (node discovery, information propagation[18] and verification)
4) Consensus
5) Application

Section four comprises **Figure 3** pictorially depicting Blockchain formation and **Figure 4** describing the block structure.

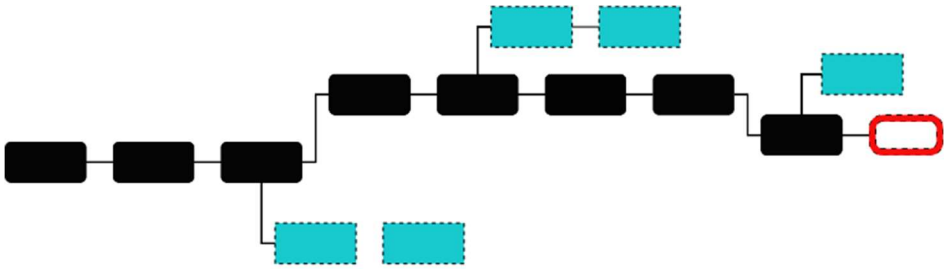

Figure 3. Blockchain formation; black = main blockchain, blue = orphan blocks and red = genesis block.

Figure 4. Block structure.

5. Blockchain architecture

Like conventional ledger, BC is an array of incrementing blocks holding complete list of records containing data transactions[19]. **Figure 4** depicts the structure of a block in the incrementing block sequence, where the block header contains cryptographic hash of the previous block. The pioneer block of the BC without the parent block is known as Genesis block.

5.1. Block

The block merely consists of two things that are commonly known as i) block header and ii) body header.

Block header consists of:

- Version number: depicts which set of rules w.r.t. block validation to trail.
- Parent block hash: it has hash value of 256-bit. The role of this is to point at the preceding block.
- Merkle tree root hash: it depicts the value of hash w.r.t. all the respective transactions taking place in the network.
- Timestamp: in the universal time since 1 January 1970, the current time is depicted in seconds.
- nBits: it depicts the threshold of a target for the hash value of a valid block.
- Difficulty: it depicts the threshold of a hash, which is less as compared to the given target.
- Nonce: it is a 4-byte field. It usually starts with 0 and increments w.r.t. every calculation of hash value.

The body of a block in BC technology consists of transaction counters and data transactions. The extreme amount of data transactions that are contained largely depends on two factors: i) transaction size and ii) the size of a block. The validation of the transactions that are to be authenticated mainly is formed in BC. By the usage of asymmetric cryptography[20].

5.2. Digital signature

There are two different types of keys in cryptography: i) private key and ii) public key. This pair of keys is owned by each user. The main function of the private key, which is kept confidential, is for signing transactions. The digital transactions that are retained are largely broadcast throughout the network. There are two phases involved in the digital signature phenomena: i) signing phase and ii) verification phase. For example, there are two users. One is Aru, and the other is Dev. Aru wants to send a message to Dev.

1) Aru, using the private key, encrypts the data and directs the encrypted data to Dev with the novel data in the signing phase.

2) Dev, with the help of Aru's public key, validates the data in verification phase. In this way, Dev can easily check if the following data is tempered or not.

5.3. Key characteristics of blockchain

BC is depicted to have the key characteristics as follows:

- Decentralization

As in centralized transaction system, which is conventional, each transaction that takes place is validated via a centrally trusted body (example, central bank), which further results to the central serves in relation to the cost and performance bottleneck. In contrast, there is no third party needed in BC.

- Persistency

Once a data transaction is validated by honest miners, it can't be deleted in a BC. The blocks containing invalid data transactions can be discovered immediately.

- Anonymity

Each user with an address that has been generated can interact with BC while not revealing the originality of a user's identity.

- Auditability

Using unspent transaction output model, Bitcoin BC performs storage process in relation to data regarding the balances of respective user[5].

6. Topology of blockchain systems

Section six contains different topologies contained in **Figures 5**, **6** and **7**.

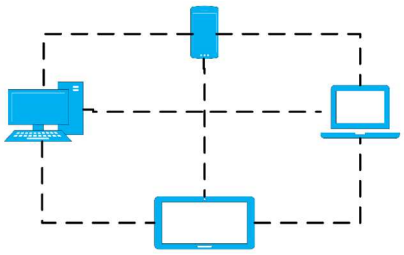

Figure 5. Public blockchain network.

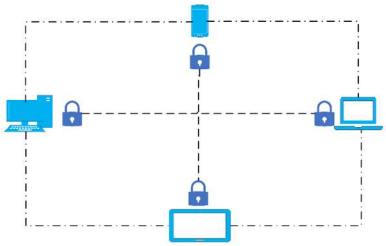

Figure 6. Private blockchain network.

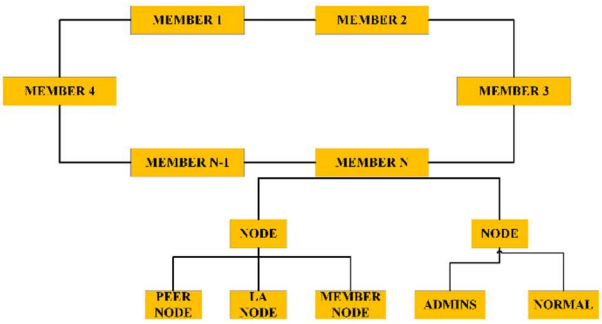

Figure 7. Consortium blockchain network.

Blockchain system is roughly divided into mainly three types: i) public blockchain, ii) private blockchain, and iii) consortium blockchain[21].

6.1. Public blockchain

The first category is public BC. In this type of BC, visibility of records to the common public is available. Everyone and anyone can easily take part in the process.

6.2. Private blockchain

The second category is private BC. In this type of BC, the nodes that are allowed to join the process are from one organization that is specific in nature.

6.3. Consortium blockchain

The third category is consortium BC. So, this type of BC is mainly developed by a large number of organizations that are partially decentralized because a few nodes are selected to evaluate the process.

7. Challenges faced via blockchain technology

As in case of having great potential, BC does face a huge number of challenges, in result limiting a wide usage of the respective technology. The challenges that are being faced by BC technology are as listed:

1) Scalability

The BC is becoming bulky as a result of the incrementing transactions that are taking place every day. The basic role of each and every node revolves around the process of strong the transactions, as hence validating them on the respective BC. This happens because it is checked for the current transactions to see whether the source is unspent or not. The BC of Bitcoin only processes a value near about 7 transactions per second due to restriction on time interval and respective block size which are hence used to generate a block that is new. Hence, it fails in processing a large number of transactions that are accounted for in millions with real time frames. As the blocks in the BC do have small capacity, many transactions that are small in nature get delayed. This is due to the reason for the need of high transaction fee required by the miners for their transactions.

2) Privacy leakage

By using both the keys that are public and private, a certain amount of private information is preserved via BC. Without revealing their real identities. Transactions can take place with the help of public and private keys used by the respective users. Transactional privacy is not guaranteed by the BC[22,23].

This is because it is the public key which is publicly visible w.r.t. the balances and transactions. And also, in the recent study, it has been depicted that a user's information can get revealed via his/her Bitcoin transactions if they are linked to one's respective information[24].

3) Selfish mining

BC is largely vulnerable to invasions of intriguing selfish miners. In the study of Eyal and Sirer[25], it has been stated that cheating is done by using a very small portion of hashing power, whether or not the respective network is susceptible. In a strategy of selfish mining, with no process of broadcasting involved, mixed blocks are kept by the respective selfish miners, and by the satisfaction of some requirements of revelation of private branch is done to the public. All miners did admit that they do have the information about the longer length of private branch as compared to the current public chain. Before publishment of private BC, resources wastage on useless branch was done by honest miners but the private chain is mixed with no competitions by selfish miners. Hence, via this, more revenue was taken by selfish miners.

8. Applications

Due to the nature of BC, which is decentralized and mainly fraud-resistant, it serves many applications w.r.t. many domains.

1) Cryptocurrency

A large number of cryptocurrencies did emerge by the time the first Bitcoin's carrier surfaced in the BC[5]. Due to the characteristics of a Bitcoin, which are consensus mechanism, verifiability, anonymity, and decentralization, the market value of a Bitcoin has equalized to $6300 per basic training certificate[26]. A type of cryptocurrency, Ethereum, was responsible for the creation of public BC platform, which was further used for deploying smart contracts in 2015[27]. As time passed, smart contrasts emerged as the BC technology served in larger range of business domain, sharing economy and Internet of Things (IoT)[28]. In addition to these applications, there are a large number of usage of this technology, like cross-border payments, stock exchanges,

digital identities, financial services, and repurchase agreements. On the basis of Ripple, the technology, which was provided by the exchange network and payment protocol, the Bank of England Santander transferred payments via mobile application in real-time[29].

With the main aim of reducing transaction costs, Bitcoin technology is used by Australian Securities Exchange in the replacement of current clearing system[30]. This further makes the transactions much faster and safer. In the field of experimenting with virtual currency and blockchains, Fider Bank in Germany[31] was the first mainstream bank to dealt with the respective domain. Based on the technology that was dealing with distributed BC, Citibank built independent systems, which were three in number. during 2015.

2) Healthcare

In the BC technology, several characteristics were proposed and provided, which are numbered and stated as i) industry collaboration, ii) disintermediation, iii) auditability, iv) new business models, and v) transparency[32]. The main problem hindering healthcare IT, which takes place between the different medical institution, causes scattered medical records. For reliable recording, a platform is created via BC technology, which plays an important role via combining the fragmented the records concerning healthcare[33]. Healthcare problems can have a solution by combining BC technology and artificial intelligence that was claimed by Matthews[34].

3) Advertising

As it was stated, reduction in costs, transparency, efficiency, and prevention of fraud were the core problems that were faced in the respective domain. This can be resolved using BC technology[35]. An amount of $209 billion was spent by digital advertiser on digital domain worldwide in 2017[36]. In the field of digital advertising business, the problems that are being faced are lack of transparency and fraud. They were aimed to be solved by MataX[37] using BC technology. One of the applications known as Ads.txt plus, which is used for the public testing, is designed to rule out the sellers, which are fraud and resellers via a supply chain that is programmatic in nature as a source of software which is open. By using BC technology Premion[38] which is a division of TEGNA, is partnering with Madsive in order to develop a transaction platform for transacting for OTT platform, as it is a leading advertising platform on over-the-top (OTT) digital platform.

4) Insurance

The traditional way of signing insurance policies was mainly on paper. This process resulted in errors and the requirement of human supervision w.r.t. the claims and payments. Due to the distributed ledger nature of BC technology, there is an improvement in insurance domain efficiency w.r.t. the analysis of data concerning IoTs, claims automation, elimination of fraud, and reinsurance[39]. Top chart five insurance biggies came together in October 2016 in order to launch BC insurance industry initiative (B3I). The two main reasons for this joint launch were: i) in the insurance industry to study the feasibility of an application concerning the BC, and ii) in the insurance industry to develop the proofs concept based on BC[28]. The main aim of insureX[40] which is the pioneer alternative insurance marketplace in the world and is based on BC technology, is to solve the inefficiencies pertaining in insurance industry in the present time. Aigang[41] is BC based protocol in the insurance industry. The main aim of this protocol is to enable the developer, companies, and communities to build prediction markets in insurance industry.

5) Copyright protection

With regard to photographs, there is no respect to the copyrights via Napster[42] and Grokoter[43] which were file sharing service from P2P network on the web[44]. Under an intrusion or some attacks, the copyrights are mostly ignored by the file holders. Further hence, problems that largely prevail and are significant in the

respective domain are stated as: i) file sharing that is unauthorized, and ii) usage of content that is copyrighted. BC technology has been used to resolve this problem. With the help of BC technology, a network has been designed that updates and reconciles the copies of a file which has been duplicated across the network thousands of times in order to maintain the records. For each recorded copyright, there is a unique fingerprint created, which is cryptographic, according to Binded[45] which is titled the first copyright platform in the world. COPYTRACK[46] is another copyright platform based on BC technology.

6) Energy

The process with external markets and internal workflows is simplified by using BC technology. This alters the arrangements regarding energy transactions[47]. This process streamlines notable servings like technological efforts, reduced labor works, manual and semi-automatic costs, and many more.

A list of comparison between the technical work done with respect to blockchain technology is mentioned in **Table 1**.

Table 1. Technical comparison between the work done in blockchain technology in different survey papers.

S. No.	Survey paper	Concerned domain	Security problems
1.	Marco Conoscenti (2016)	Specified IoT protocols	The security issues haven't been properly covered
2.	Zibin Zheng (2016)	Moderate	The security issues haven't properly covered
3.	Mandritta Banerjee (2017)	Specifically, IoT	Not specifically addressed
4.	Lakshmi Swa Sankar (2017)	Not mentioned properly	Not specifically covered
5.	Bayu Adhitama (2017)	General study of blockchain technology	Not specifically covered
6.	Xiaoqi li (2017)	Not specifically mentioned	Security issues has been specifically covered
7.	Icron-Chang Lin (2017)	Not mentioned	Coverage of security issues
8.	Debashish Jena (2019)	A general survey on blockchain technology	Covered security issues

9. Conclusion

In this paper, a brief overview of the BC technology is stated. The challenges and applications of the technology have been discussed briefly. The design and architecture are briefly discussed with respect to the technology. The center of the paper is to briefly study all the concepts, challenges, and applications of the BC technology.

Conflict of interest

The author declares no conflict of interest.

Abbreviations

BC: Blockchain technology

NO.: Number

IoT: Internet of Things

P2P: Peer-to-Peer

w.r.t.: With respect to

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