Blockchain Technology Application: Challenges, Limitations and Issues

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Abstract

This paper presents the review of the challenges, limitations and issues of the Blockchain technology in various industries and applications. Blockchain technology is an emerging technology. It was initially introduced as an application used for crypto currency named Bitcon. Its properties are immutability, running on Peer-To-Peer Network and the most important feature is decentralization. A thorough literature review was done through searching in reputable journal databases like Web of Science and Scopus from year 2015 to 2020. Selected keywords has been used in searching for the appropriate and right papers. Based on the result, the common challenges of this technology were the privacy, security, protocols, laws and regulations, scalability, latency, throughput and energy consumption as applied to the healthcare systems, financial institutions, smart contract, Internet of Things (IoT) and governance. By defining these challenges, future Blockchain technologist and developers can improve the whole technology.

Keywords: **Blockchain, Crypto Currency, Limitations, Challenges and Issues**

I. Introduction

The popularity of Blockchain has grown so much in recent years because of the introduction of the Bitcoin [1]. Its properties are immutability, running on Peer-To-Peer Network and the most important feature is decentralization. Blockchain is derived from the old ledger system of bookkeeping. Now, it is processed by millions of computers digitally and is publicly available for all who is inside the network. This is developed and derived from the concept of Satoshi Nakamoto in 2008 short after the Global Financial Crisis on the same year. It was applied in Bitcoin crypto currency during its early years. Aside from the crypto currency application, it is also currently applied in health, finance, governance, technology, supply chain and procurement technology. But inside the development of the respective industries lies constraints and limitations which are addressed in this paper for future development.

There are known limitations of the Blockchain technology. Thus, the objective of this paper was to review, discuss and evaluate the limitations and challenges of blockchain technology in various applications such as energy consumptions, privacy and security, healthcare, cloud storage and computing, finance, smart contracts, internet of things, governance and professionals.

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II. Blockchain Technology Architechture

The structure of the blockchain includes the type of blockchain, the node where it operates, the hash, data and transaction flow functions and other technical details. Blockchain is derived from an encrypted ledger system which serves as database distributed in the network by which the technology behind Bitcoin [1], Etherium [2] and other crypto currencies like the internet and owned by numerous people.

A. Elements in Blockchain Technology

Blockchain introduces elements which can be found to all of its application. Basically, the network of Blockchain runs through its nodes and inside the node, blocks can be found. The following are the elements in Blockchain:

1. Node

The function of the node is to permanently store the information across the network making it decentralized. This is very different from the banking system which is centralized. Node also performs activity like initiating and validating a transaction and/or perform mining. All nodes are trusted in sharing the platform and provided with latest

copy of the Blockchain. This system makes all information, located inside the block, consistent across the network and prevents single-point-of-failure which is a problem for a centralized network [3]. Mohanta et al. [3] demonstrated node connections (See figure 1).

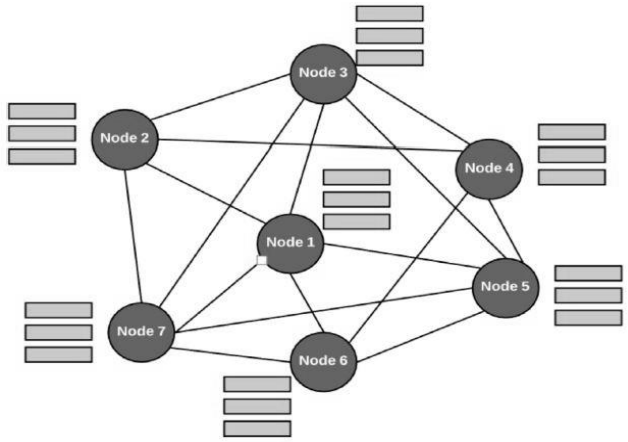

Fig 1. Node Distribution Inside the Network

2) Block

Block is where valid transactions are theoretically stored because of a distributed ledger system. It is usually located inside the node here new and existing transactions are validated and broadcasted across the network of nodes. Transactions are grouped depending on the time frame in which they occurred and stored inside the block. When S. Nakamoto [1] first proposed the Bitcoin in 2008, the author stated that about 500 transactions or 1 MB can fit inside a block. But today, the block can grow up to 8MB.

Basically, block is divided into 2 parts, the title and the information or content, block header which contains majority of the information like the hash value from the previous block, the merkle tree, the date of transaction and the degree of difficulty (See Figure 2).

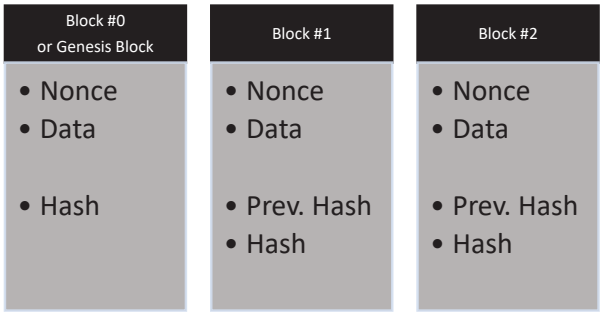

Fig 2. Parts of a Block Element

3. Anatomy of a Block

The block header contains the previous hash and the information inside the block. The way it adds the previous information or hash makes it tamper proof. Mining Statistics and with the help of miners helps in creating and validating a new block. This mechanism as part of algorithm which requires hashing and encryption is complicated enough to make blocks tamper proof as it broadcast across the network.

The merkle root verifies and organizes the transaction inside the block. The subsequent block hash can be changed by changing the transaction which makes data mining a tough challenge. SHA256, a 32 byte hash, is used for hashing and making it tamper proof when Proof of Work is validated across the network. Mohanta et al. [3] shows how Merkle Tree Root is used (See Figure 3)

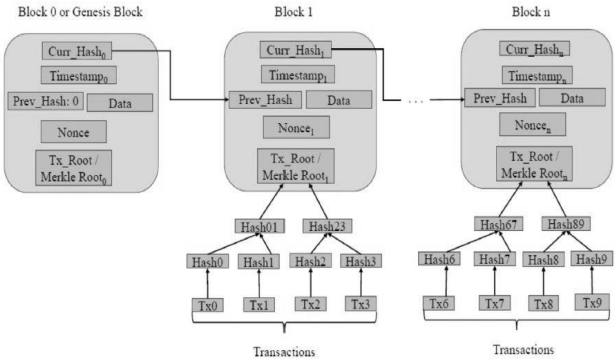

Fig 3. The Merkle Root

B. Point-To-Point Network (P2P)

Blockchain operates like a distributed ledger system [4]. It allows information to be stored globally in the form of blocks located across the network through nodes at the same time letting anyone on the network see everyone's data almost real time. With this, it is difficult for one user to tamper or gain control of the network The main goal of this kind of network are the following; to allow members of the network to synchronize their view of the system state and, secondly, to disseminate peer information in order to allow peers to reenter the system after a disconnection [5].

1) Types of Blockchain

Blockchain is classified according to characteristics and protocol, network usage and applications. Public Blockchain is a fully decentralized network, permission less and no individual or entity controlling it. All transactions are fully transparent by allowing anyone to participate. On the other hand, Private Blockchain is the opposite of Public Blockchain, wherein participants are required to ask consent to join the network. Only the entity inside the network will gain permission to transact and the notable difference compared to Public that it is centralized. This kind of setup is for enterprise that needs other function of Blockchain but requires centralized data and transactions. Consortium

Blockchain is almost the same with Private Blockchain, however, the notable difference is that Consortium Blockchain is managed by a group or a team rather than individual and more collaboration are achieved, hence, increasing the efficiency of the network. The combination of Public and Private Blockchains is a Hybrid Blockchain. The Hybrid Blockchain shares similar characteristics like scalability, security and privacy protection level which comes from private blockchain. The main difference are the type nodes, such as *leader* node, is selected to verify transactions instead of a single entity. This presents a partially decentralized design where a leader node act and provide permissions to other users [6] [7]. Table 1 summarizes the main characteristics of Blockchain network with respect to its applicable characteristics.

TABLE 1.
TYPES OF BLOCKCHAIN AND ITS PROPERTIES

Property	Public	Private/ Consortium	Hybrid
Consensus	Costly PoW	Light Pow	Light Pow
Mechanism	All Miners	Centralized Organization	Leader Set Node
Identity	Anonymous	Identified Users	Identified Users
Anonymity	Anonymous	Trusted	Trusted
Protocol Efficiency	Low	High	High
Energy Consumption	High	Low	Low
Immutability	Almost Impossible	Collusion Attack	Collusion Attack
Ownership	Public	Centralized	Semi Centralized
Management	Permission-less	Permissioned Whitelist	Permissioned Nodes
Transaction Approval	Minutes	Millisecond	Millisecond

C. Consensus Protocol

Consensus protocol maintains order of the system by acting as host or server. It make sure that all nodes receives and maintains the distributed ledger [4]. It requires exchange of information across all nodes in the network to reach consensus. Consensus protocol somehow helps secure the whole network against malicious and offline node, with the advantage of its Peer-to-peer network. Through this protocol, the network can minimize the occurrence which could harm the whole network [8].

1) Proof of Work (PoW)

Proof of Work can be interpreted as the creation of block, it provides validity with the work done to a block through the computing power by miners hosted by the node. It is a competition by nature and it requires all participating node to solve the cryptographic puzzle. By solving the puzzle, you have the right to create a new block through the validation of proof of work [9] , hence, rewarded with a bitcoin [10]. The correct combination of hash requires constant adjustment of nonce wherein great amount of computing power is needed [11]. Figure 4 shows the flow of PoW described by Zhang et al, 2020 [6].

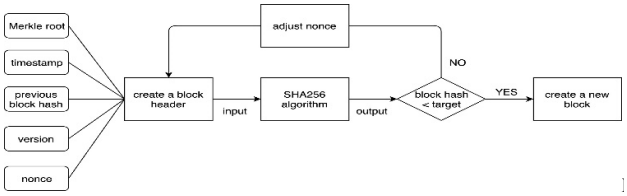

Fig 4. Process Flow of PoW

2) Proof of Stake (PoS)

Proof of Stake allows validation by random selection of node rather than the computational power in which Proof of Work depends. This type of consensus provides less computational power utilization since block validation is randomly chosen to the highest bidder. . The chances of being chosen to be the validator will vary from the security deposit [12]. Figure 5 shows the flow of PoS described by Zhang et al, 2020 [6].

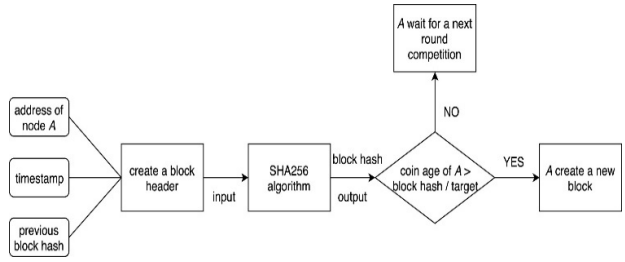

Fig 5. Flow of the Validation Process of PoS

3) Delegated Proof of Stake (DPoS)

The principle behind Delegated Proof of Stake is to let nodes with stake to vote or elect verifiers. This way stakeholders can vote a delegate the right to create their block and reduces the computational power usage to zero [13]. If delegates are unable to generate blocks on the expected time, stakeholders can select another node to the work for them. Figure 6 shows the flow of DPoS described by Zhang et al. 2020 [6].

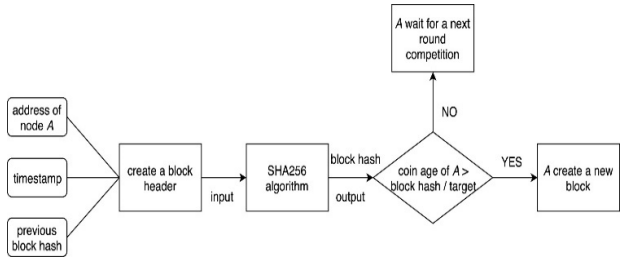

Fig 6. Flow of the Process of DPoS

4) Practical Byzantine Fault Tolerance (PBFT)

Practical Byzantine Fault Tolerance (PBFT) has the advantage of low algorithm complexity yet with high practicality in distributed systems [14]. It guarantees nodes to maintain a common state and take a consistent action in each round of consensus. It can achieve the goal of strong consistency. This is called an absolute-finality consensus protocol [8]. There are the 5 phases of PBFT Mechanism: *request, pre-prepare, prepare, commit* and *reply*. The primary node forwards the information sent by the client to the other nodes. When the third node crashed, the information goes through five phases to reach a consensus across the network. Figure 7 shows the flow of PBFT describe by Zhang et al, 2020 [6].

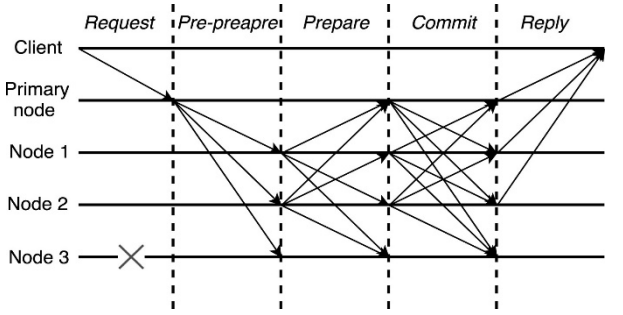

Fig 7. Practical Byzantine Fault Tolerance (PBFT) Mechanism

IV. Methodology

A literature review was carried out by focusing in the libraries of Web of Science (WoS) and Scopus from a period of 5 years (2015-2020). The search topics were blockchain, blockchain and energy consumptions, blockchain and privacy and security, blockchain and healthcare, blockchain and cloud storage and computing, blockchain and finance, blockchain and smart contracts and blockchain and internet of things, blockchain and governance, and blockchain and professionals. The second stage validates the obtained data through a survey from 15 experts both in academe and industry. Finally, the assessment of the obtained information. In this process, the challenges, issues and limitations of blockchain in various applications are determined and summarized.

V. Results and discussion

As an emerging new technology, the immaturity of this technology is its major challenge that brought these concerns. This paper identified that Blockchain Technology has its common and general limitations addressed on many papers through survey, selection and elimination.

A. Energy Consumption

Bitcoin and other crypto currencies are the longest functional application of Blockchain Technology since its development in 2008. In the case of Bitcoin, to create a new block which is broadcasted across all nodes, SHA256 algorithm is used for hashing to make a unique chain. Proof of Work validates this though the network using the computational power in the form of ASIC, FPGA and GPUs and other computing hardware [15]. There are total of 21 million Bitcoins to be mined until around year 2140 [16]. The power consumption in mining Bitcoin is around 125TWh per annum [17]. It leaves a great amount of carbon footprint [18] [17] [19] [20].

B. Privacy and Security

Although Blockchain is secured theoretically, still, there are many concerns about security and privacy being linked to Blockchain. There are personal information or data which might be exploited by black hat individuals. Some issues are exchange of information between systems to another. Below are the Blockchain Technology applications concerning privacy and security [21] [22] [23] [24].

Table 2.
Issues in the Privacy and Security

Possible Attacks on Security
51% Vulnerability Attack
Mining Pool Attack
Criminal Activity
Double Spending
Client Security Threats
Privacy key Security
Forking
Transaction Privacy Leakage
Information Storage and Inference
Eternal Records
Border Gateway Protocol (BGP) Hijacking Attack
Selfish Mining

C. Scalability, Latency and Throughput

Blockchain Technology operates majority in Technology industry and offers good opportunity in its on-going

development. Cloud Storage and Computing and Data Back Up are some of its on-going development. Another issue of the Blockchain is the scalability which somehow related to latency and throughput, since all transactions must be validated and stored. As of February 2021, Bitcoin cost approximately 320GB [25] of data storage. This is because of the throughput or transaction capacity that it can process on a period of time. Only 7 transactions per second, a Bitcoin can process on its early years, not even close with the thousands of transaction per second rate of centralized network [26] Although there is much improvement on its TPS on the latest years, it is still considered a challenge since the goal of this network is to have a seamless transaction [27]. Another concern is the integration and validation of existing data with the Blockchain since applying this with the legacy system will require big investment [28].

D. Healthcare

Major challenge related to this application is the Privacy Regulations because there are different kinds of privacy regulations implemented as far as location is concerned. The common examples of this are the CCPA [29], GDPR [30] and LGPD [31]. These regulations may affect one of Blockchain's major application in Healthcare namely the Electronic Medical Record (EMR) [32] and Personal Health Record (PHR) [33]. The consistency in privacy regulation might be the possible solution for interoperability concern with other systems especially in the Medical Machines information exchange [34].

E. Smart Contracts

Blockchain improved many industries through Smart Contract but some of the challenges are addressed here are the generic issues regarding Blockchain as a whole, such as the confidentiality, security and privacy. One of the challenges is the human errors. This issue comes with the manpower coding and programming the contract and its system and one mistake might affect the whole contract as a whole. Another is the jurisdiction concerns. Since every country or local location has different regulations with respect to its constitution, there is no common regulatory board for the Blockchain technology. Last is the interpretation and enforceability. Since people with respect to contracts have different perspective and understanding regarding this matter, however, there should be guidelines on how individual interpret contracts and enforce the law behind this. As contract law varies between different jurisdictions depending on the locations and parties involve, so too with the enforceability of the smart contracts [35] [36] [37].

F. Internet of Things

Major concern with Internet of Things (IoT) is the security and privacy. One can observed the vast growth of the IoT technology. Legal and regulation issues, lack of IoTcentric Transaction Validation Rules, Consensus Protocol and interoperability are some of the concerns when applying Blockchain technology to IoT. The Machine to machine setup or the IoT device integration is one of the major concerns with Blockchain technology [38] [39] [40].

G. Finance

One of the biggest challenge of the financial industry is the centralization of the financial institutions. This contradicts the special feature of the Blockchain technology. However, recent development in the type of technology has addressed this problem [41]. Another challenge is the transaction per second of the financial institution [26]. Aside from that, the cost initiation, implementation and maintenance are of major concerns. These require great amount of funding to initialize and implement because the whole systems includes the hardware and software. Moreover, financial institution require large scale integration and migration from the previous system and maintenance of the whole system. Implementing this might be a big issue for a small financial institution. It also requires literacy and expert personnel to implement, maintain and operate the system [42], since Blockchain is still under development as a whole, technical training is not yet in-depth across the network and its application [43] [44] [45]..

H. Governance - Election

One thing to be considered with this industry is the ability to which it can fully utilize decentrality. This means that the platform of the industry will majority be an internet based. This raises the concern of security especially in the voting process. It has big trust issues and there is still on-going development with Blockchain on how they can secure ballots and are not tampered [46].

I. Blockchain Professional

Blockchain is a new technology and still an emerging technology. The potential contribution of the Blockcahin technology to the industry is promising. Currently, there is a lack of Blockchain professionals despite of its high demand. IT professionals are still under development from shifting to their current industry into Blockchain. This is because Blockchain is not yet that firm with regulations within the respective industry since it is still under development.

V. Conclusion

Like the internet in its early years, Blockchain faces challenges and limitations because of the regulations, clearly because these protocols and regulating bodies for the Blockchain as a whole and its respective industries that are yet to be establish. Also, the currently used legacy system of the Blockchain is not yet stable with the overall performance and applications. The main advantage of pointing out the limitations and challenges in its early development stage is the ability to provide solutions faster than internet's time table. Blockchain could possibly open new ways and solutions to the current global problems.

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