Aide-Mémoire

Vol 2, Issue 6, 07 May 2020

Blockchain Technology: More Than Just Bitcoin

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Among other disruptive industry 4.0 technologies such as artificial intelligences (AI), internet of things (IoT), big data analytics and robotic, blockchain technology is considered as the backbone of the fourth industrial revolution itself, which has become a buzzword used by media outlets, professional technology institutions, policy discussions and the academic community. Furthermore, blockchain has received widespread attention thanks to the rise of Bitcoin – one of cryptocurrencies that has remarkably grown since its debut in 2008. Currently, it is estimated that almost 3,000 cryptocurrencies are active in market capitalization, in which Bitcoin ranks first among all of them, followed by ETH (the Ethereum), XRP (Ripple Currency) and Bitcoin Cash (Rivet, 2019).

Cryptocurrency, however, is just a part of blockchain technology. It is very common to see that the terms "Bitcoin" and "Blockchain" are used interchangeably, despite the fact that Bitcoin is powered by blockchain. In other words, blockchain is the system that offers the technology capability to create cryptocurrency. Despite its significance and potentials, it is only until 2014 that blockchain began to attract more investments as more people realize its potentials, which could be unlocked in various sectors and industries, including healthcare, supply chain, education, insurance and even elections (Marr, 2018). Besides, it is hard to imagine or draw an exact number for how many people living in this Industry 4.0 generation actually understand about the blockchain. This aide-mémoire will thus provide a fundamental comprehension and discussion of blockchain technology, its potentials and challenges across different sectors, industries, and fields.

❖ The Beginning of Blockchain Technology

In 2008, Satoshi Nakamoto, an anonymous person or organization, published a whitepaper titled "Bitcoin: A Peer-to-Peer Electronic Cash System" that proposed a digital payment system, which would operate on a peer-to-peer and decentralized basis (Nakamoto, 2008). The system aims to be an alternative to the existing digital payment platforms, which solely rely on central authorities for assets recording of customers on ledgers. In fact, the need for trust ensured by central authorities as third parties is significant in a low-trust environment, when sellers want to make transactions with unknown buyers over distant communication or vice versa.

However, the dependence on third parties such as banks and other financial institutions to authorize transactions between parties is subjected to several constraints, including operational and mediatory costs, errors, frauds and time-consuming process (Pratap, 2018). For example, since some digital payments are reversible, which might lead to disputes between merchants and customers, the third parties will need to mediate between the two parties, and therefore charging extra costs for the mediation and services. In addition, a digital cash system without a central authority could face a

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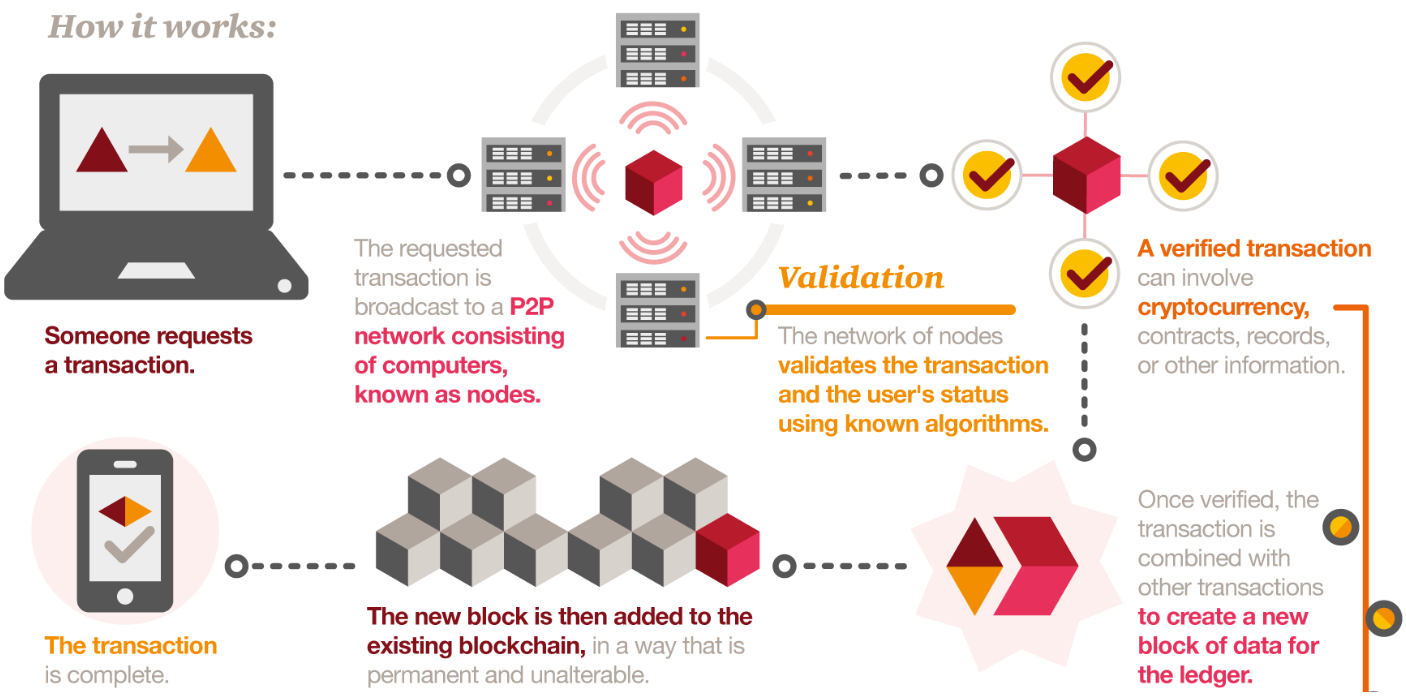
double-spending problem, which is when a user spends a digital coin or token repeatedly.

In order to solve these problems, Satoshi introduced Bitcoin as a non-trust-based payment system, replacing the need for central authentication channels with a decentralized mechanism. At the heart of Bitcoin lies the foundation of blockchain technology, which acts as a distributed and decentralized ledger for transaction recording. In other words, blockchain functions as a data storage system that records transactions and other sorts of information in a chain of blocks, and the chain will keep growing when new blocks are appended, creating a list of transaction history in chronological order (Bobeshko, 2018).

Potentials of blockchain, however, was not fully realized in the beginning as Bitcoin's blockchain was only implemented for the use of cryptocurrency. In 2013, a computer scientist and one of early contributors to Bitcoin community, Vitalik Buterin, initiated another public blockchain platform called Ethereum, which has a different programming language that allows developers to create decentralized applications (dApps) and explore a broader use of the technology such as the development of smart contracts (Bitwala, 2019). Successfully launched in 2015, Ethereum's cryptocurrency has the second largest market capitalization after Bitcoin and has attracted thousands of peer networks. Most importantly, smart contract technology has drawn giant technology companies to invest on blockchain. For instance, Microsoft Azure has integrated Ethereum's smart contract functionality into its cloud computing platform to provide program developers with a fast and secure processing capability (Johansson, 2019).

How Blockchain Technology Works



Source: PwC

❖ Core Elements of Blockchain

Even blockchain is often dubbed as a novel technology, its architecture is built from different existing technologies. For instance, a blockchain ledger makes use of the concept of *peer-to-peer (P2P) network* to allow anyone to maintain and update the ledger (Rosic, 2017). Therefore, blockchain database is not controlled by central servers but a number of computers or nodes, which are tasked with verifying and validating transactions requested by users. Also, the same version of ledger is distributed and stored by individual nodes, making transaction records transparent and accessible to the network peers. For the most part, this decentralized and distributed nature is one of integral parts of blockchain security since data and information are not stored in a single space, which could be a single point of failure and a central target for cyberattacks.

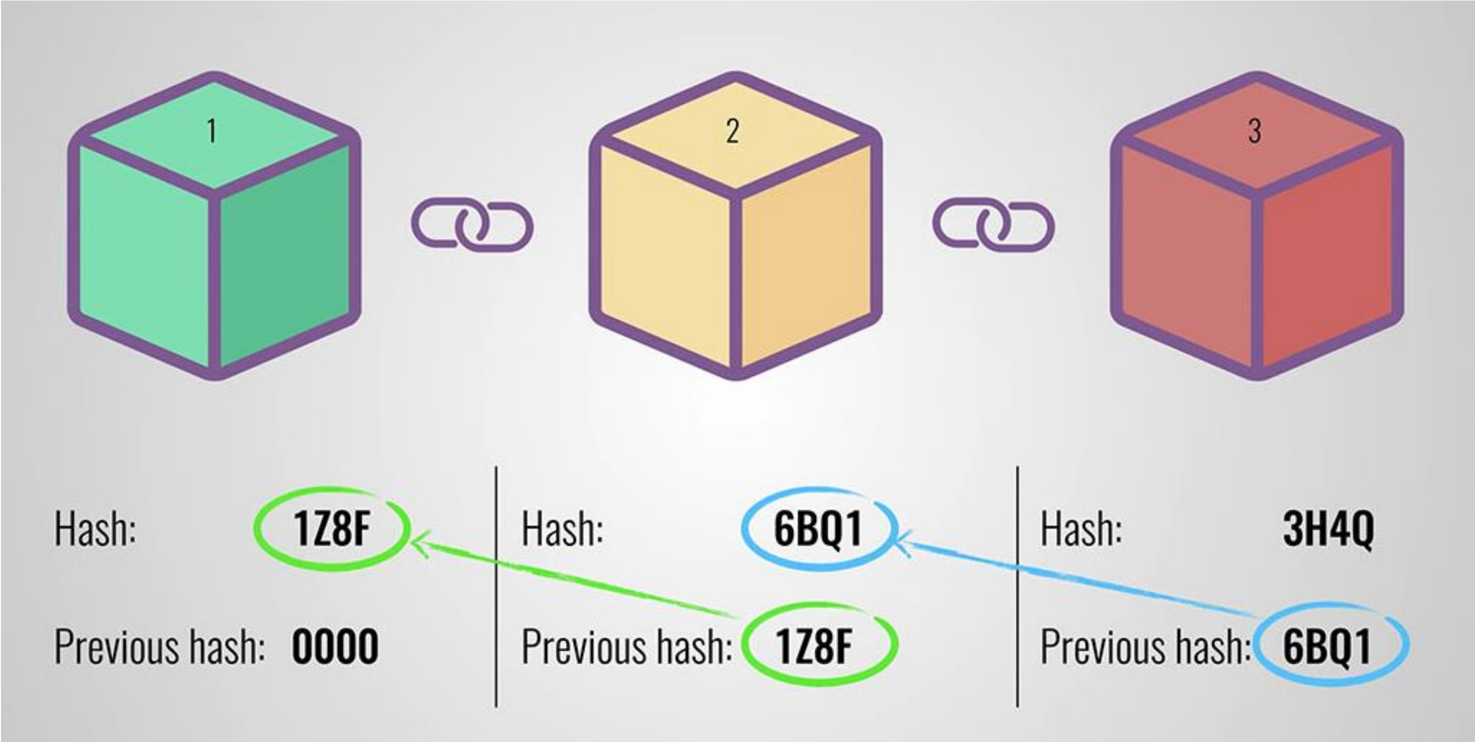
Because blockchain is a decentralized and an open environment in which everyone can participate, there is a chance that malicious nodes would tamper with or exploit transaction records on the server. The solution is to adopt a consensus mechanism so that nodes can collaboratively agree that a legitimate block of transactions created by an honest node could be added to the chain. Blockchain platforms can choose different types of consensus rule, including the proof-of-stake algorithm (PoS) and the practical Byzantine-fault-tolerance algorithm (PBFT) (Haughn, 2017). But the most common one is the *proof-of-work algorithm* (PoW), which is used by the Bitcoin blockchain. To add a new block to a blockchain on Bitcoin network, special nodes which are called ‘miners’ will compete with one another to solve complex mathematical problems to find a correct string of number or nonce (Rosic, 2017).

Also known as mining, this work needs a large amount of computing power, and the difficulty is based on the current power spent by miners on the network, the number of users and the blockchain network load (Tar, 2018). After a number of calculation attempts, a successful miner who found the nonce can broadcast his block to the server for other nodes to verify and append to the chain. In return, the miner will be given incentives in a form of tokens for his proof of work and contribution to the system. Bitcoin, for instance, rewards successful miners with its coins.

Besides the utilization of P2P network, blockchain incorporates cryptographic technologies into its security architecture to provide users with a high level of privacy. Essentially, most of technical processes behind blockchain are involved with *cryptographic hash functions*. They are hash algorithms used to convert an input of any length – the input could be transaction information or any other digital information – into a fixed string of output which is known as a ‘hash’. An input of a content will always result in the same string of output or hash. In contrast, a slight change in the input will create a different hash (Rosic, 2017). For example, Bitcoin uses SHA-264, which is one of hash algorithms, to transform transaction information into a string of hash before including them in blocks. In other words, transactions information stored in individual blocks are just a bunch of those hashes which cannot be reversed to their original forms.

Cryptographic hash functions also make blockchain immutable, meaning that once a bundle of different hashes is stored in a block, it is tamper-proof and highly resistant to alteration and damage. Specifically, a block has a hash pointer that contains transaction hashes and address of the block before it (Rosic, 2017). It acts as a chain that binds every other block together. As a result, a change in a piece of information in a block will change the hashed transactions and hash pointers of the previous blocks, disrupting the whole blockchain. But the attempt is impractical to accomplish since it requires a huge amount of hashing power, and irregularities in hashes will be immediately detected by nodes.

How a Block is Chained to Another Block



Source: Lawrence & Schiller

Another form of cryptography that blockchain implements is asymmetric cryptography or public key cryptography, which is a cryptographic method used to secure privacy of communications and information of users. Particularly, asymmetric cryptography provides a user with two types of key: a public key and a private key (Rosic, 2017). These two keys work hand in hand, which is similar to the use of a username and password of an account but with extra steps. For instance, if user A wants to send a private message to user B, user A needs to use the public key of user B to encrypt his message – the message, then, became a string of hash – and send it to user B. The encrypted message can be decrypted or opened by the user B's private key, which is only known to the user B alone.

The use of the public key cryptography also creates a digital signature for users for authentication purpose (ConsenSys Academy, 2018). To illustrate, imagine that user A just wants to ensure user B that his message is truly made by him and has not been tampered with by hackers during the delivery, user A can use his private key to sign the message and send it to user B. In order to open the signed message, user B will use the public key of user A. If it can be opened, user B will know that the message is indeed made by user A and has not been violated by any hackers.

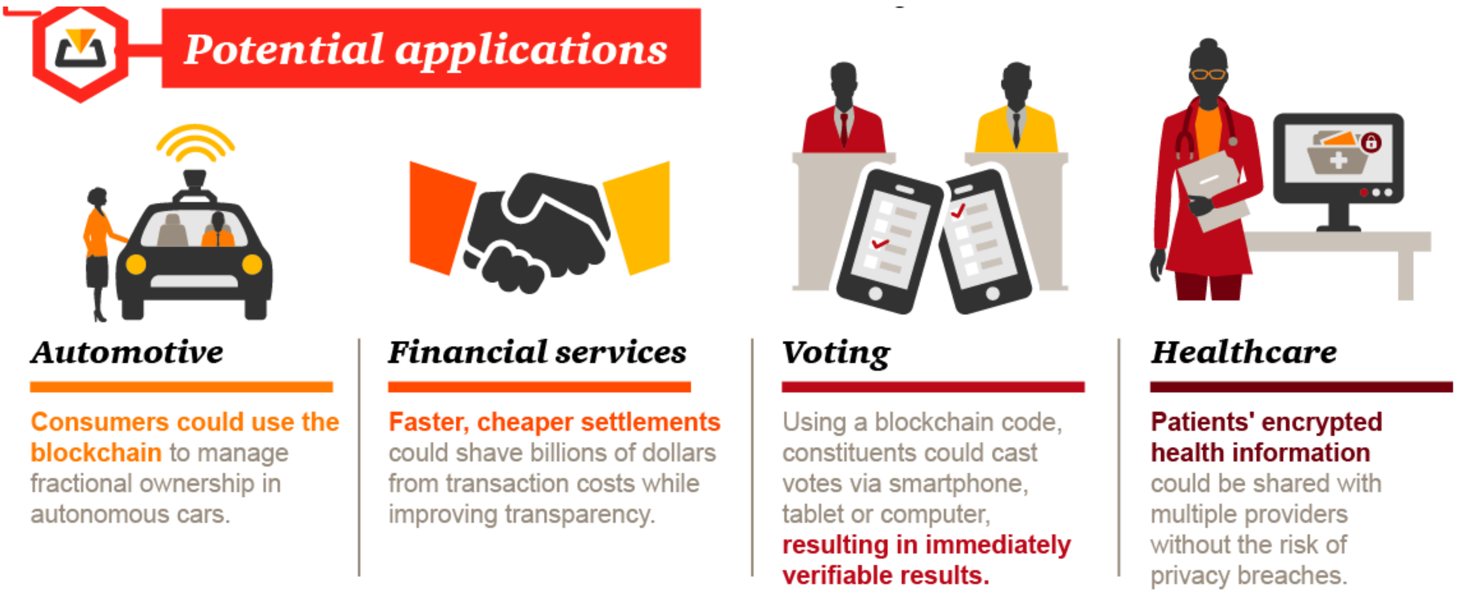
❖ Blockchain Potential Applications in Multiple Sectors and Industries

Even though the initial purpose of blockchain was to create a peer-to-peer and decentralized payment platform, the technology has gained a widespread recognition for its potential uses besides digital currency. For this reason, blockchain technology has been under a number of research and development programs which aim to utilize the technology in other sectors and industries. In general, the use of blockchain can be classified into three levels: storage of digital records, exchange of digital assets and execution of smart contracts (Deloitte, 2017).

Basically, blockchain serves as a storage system that can record a wide range of digital information, including ownership and personal documents, study and financial records as well as medical history. Most importantly, the record-keeping ability of blockchain is associated with a high level of integrity and immutability. Therefore, blockchain plays an important role in areas that prioritize preservation and management of digital identity, which could be any digital representations of individuals and organizations. For example, Estonia, which is a well-known country for utilizing blockchain in its governance system, has adopted blockchain solutions for its multi-purpose digital ID card since 2012 (Anjana & Raman, n.d.). Moreover, Estonia has created a blockchain-based health record system, in which 95% of patient data has been preserved, to provide hospitals with access to medical history of patients (Ministry of Social Affairs, n.d.).

In addition, as information stored in blockchain is impossible to be tampered with, the technology can be used for managing transparent and fair elections. For instance, Sierra Leone, a state in West Africa, has become the first country to conduct an election, which was held in 2018, using specialized blockchain to verify votes and prevent election frauds (Perper, 2018). Therefore, election data cannot be manipulated once the voters cast their ballots in the system. Moreover, only eligible voters are able to cast their vote because their identities are checked and validated by peer networks on the blockchain.

Potential Applications of Blockchain



Source: PwC

The inherent characteristics of blockchain which make it as a decentralized, immutable, transparent, and secure database prove to be useful in addressing IoT security challenges. The Internet of Things utilizes the concept of connecting a number of smart devices and gadgets, which are embedded with sensors and chips to collect and transmit data to a network for generating automatic operations[1]. However, IoT devices confront with a major security weakness known as Distributed Denial of Services (DDoS), which hackers use to disrupt vulnerable networks of the devices by sending a number of operational requests repeatedly (Deloitte, n.d.). In addition, as IoT networks rely on centralized servers

[1] See: Chea, M (2020). The Internet of Things (IoT): The Network of Networks. *Cambodia Development Center. 2*(1). Retrieved from http://cd-center.org/en/the-internet-of-things-iot-the-network-of-networks-2/

for processing responses to other devices, the whole network will shut down once the central servers go offline. In this case, blockchain can solve the security breach by decentralizing IoT networks, therefore preventing malicious actors from attacking the networks since they are located at different places (Medium, 2018). Moreover, with consensus protocols and cryptographic process employed in blockchain, unauthorized actors will not be able to trigger data alteration in IoT networks.

In addition to the record-keeping function, there are still more spaces to explore in regard to the use of blockchain for exchanging digital assets in the financial sector. Generally, transactions in stock markets involve numerous steps and multiple actors and institutions, namely brokers of seller and buyers, transfer agents and clearing houses. Moreover, the reason that trades in stock markets require so much coordination among intermediaries is to ensure that transactions can proceed smoothly and securely (Long, 2018). In other words, they need to make sure each party conforms to the contracts before and after the transfer of asset ownership. To eliminate such constraints, blockchain solutions are being adopted by international stock exchange institutions, including New York Stock Exchange, Tokyo Stock Exchange and Nasdaq, to ease the complicated transaction process (Ervin, 2018).

For this reason, the development of blockchain-based smart contracts is considered a game changer in the sector. Similar to a legal contract, a smart contract is a set of code that is programmed to automatically execute agreements and agreed conditions between two or more parties who involve in exchanging, buying and selling assets digitally (Pratap, 2018a). By utilizing blockchain technology, smart contracts can be built and implemented without involvement of intermediaries, therefore reducing costs, paperwork and time-consuming communication process. In addition, blockchain offers a high level of auditability since each party can track history of asset ownership and every transaction in blockchain database.

❖ Challenges of Blockchain

While blockchain is regarded as one of disruptive technologies against the backdrop of Industry 4.0, the technology also comes with great challenges. A study by World Economic Forum that explored potentials of blockchain in addressing global problems summed up the downsides of the technology which include high energy consumption, security flaws, technology barriers, adoption constraints and legal and regulatory issues (Herweijer, Combes, Swanborough & Davies, 2018).

As cryptocurrency platforms still use certain consensus protocols such as the proof-of-work protocol for mining tokens, a huge amount of electricity will be spent during the process, as they need capable mining computers with large computing power. And even though the energy consumption during mining process varies according to consensus protocols, the energy spent by nodes on the blockchain network is still immense. For instance, it is estimated that a single transaction in blockchain consumes more than 600 kWh of electricity, which is almost the same to the power consumption of an average US household for nearly 22 days (Digiconomist, n.d.).

Despite being known as a distributed and secure ledger, blockchain is also susceptible to a security flaw, namely the 51 percent of attack, which could happen when more than 50% of miners control the majority computing power on the network, which in effect allows them to reverse transactions at will. Consequently, hackers will be able to double-spend tokens and prevent other miners from appending new blocks (Frankenfield, 2019). For example, Bitcoin Gold, which is an open-source division of Bitcoin, lost at least $18 million due to the 51 percent of attack, as a group of miners managed to hold a large amount of hashing power on the network to double-spent its tokens.

There is also a technical challenge, which is scalability, that blockchain technology confronts with. To be specific, when the number of transactions keeps rising, blockchain network could become overloaded because each node has to verify and validate all of them. For instance, Bitcoin could not respond to millions of transactions instantly because only 7 transactions per second can be processed, as the block size and time interval for creating a new block is limited in Bitcoin blockchain (Zheng, Dai & Xie, 2017). Moreover, the scalability challenge leads to a competition problem among users. In other words, users often compete with each other to have their transactions processed first by placing higher verification fees. As a result, nodes will only select the transactions with higher fees to verify first, causing a bias in the verification process (Herweijer et al., 2018).

In addition, while the development of blockchain applications are encouraged in many industries, the adoption pace of blockchain is relatively slow due to some barriers, such as limited trust in the technology and a low level of blockchain knowledge. PwC, for instance, has found that among 600 executives, 45% of them do not trust blockchain due to the lack of understanding of the technology (Inside Bitcoins, 2018). Furthermore, the complexity of the technology is part of the problem, as investment in blockchain applications depends on the level of blockchain literacy of investors (Herweijer et al., 2018). Therefore, investors are not confident enough to bet on the technology for their business transformation. A lack of a friendly user-interface of blockchain applications also contributes to the adoption challenge to a certain extent. To promote the use of blockchain solutions, application developers need to improve front-end design so that users can find the applications convenient to use.

The most sensitive challenge of blockchain is associated with legal and regulatory concerns. The fact that blockchain provides users with a high level of privacy and anonymity could lead to illegal uses, those of which include money laundering, drug trade and ransomware attacks. Authorities will have difficulty identifying and tracing sources of transactions because accounts holders are not required to reveal their identities in some cryptocurrency platforms. Besides, criminals and illegal organizations can easily use cryptocurrencies to commit cross-border money laundering since there is no uniform international regulations and laws on the use of cryptocurrency yet. In fact, since 2011, Bitcoin has attracted many online black markets that engage various illegal transactions (Popper, 2020). According to the Chainalysis, trades in dark markets using cryptocurrency reached USD601 million by the end of 2019 (Popper, 2020). Consequently, there are mixed views from government regarding the digital currency's legal status. While countries such as China and Pakistan, ban initial coin offerings (ICO) – a fundraising mechanism which is often used by fraudulent investors – other countries, including New Zealand and Netherland, have improvised regulations and measures to adapt to the use of ICO in their lands (The Law Library of Congress, 2018)

❖ Trends of Blockchain in Southeast Asia

It is not surprising that blockchain technology has gathered attention of ASEAN member states that have tried to embark on digital transformation and the development of digital economy in the region. Due to its conducive conditions, particularly a high level of internet penetration that reached 94.6% in Brunei alone, ASEAN could take advantage of the blockchain to improve its social and economic standards (Asia Blockchain Review, 2019).

In general, while blockchain is maturing, the technology has gained more positive outlooks but also with precautions from governments and the private sector in Southeast Asian countries. As a matter of fact, almost every government in Southeast Asia, including Cambodia, Singapore, Indonesia, and Thailand, have begun to tap the potentials of blockchain technology by creating their own central bank digital currencies (CBDC) (Jakobson, 2019). The National Bank of Cambodia, for instance, is adopting blockchain for its national payment services to improve financial transactions with consumers and commercial banks. According to the World Economic Forum, with this project, Cambodia has become one of the first central banks to trial a blockchain-based application for its central bank digital currency (Hor, 2019).

In addition to digital currency, Singapore, which sets to become a smart and technologically advanced nation in the region, has planned to adopt disruptive technologies such as blockchain, 5G and IoT in building a smart city state (Gorey, 2019). Besides, Electrify – the first Singaporean energy marketplace – has opted for a blockchain-based solution to provide consumers with a new retail electricity experience as well as a great cost reduction the market (Cai, 2018). China also aims to become a technological powerhouse by 2025, which is a move to align itself with the fourth industrial revolution. Despite the fact that ICOs are prohibited in China, the Chinese government has considered blockchain strategic frontier technology in its national industry plan (“China embraces blockchain”, 2019). In addition, blockchain has received a growing recognition from the Chinese leadership. For instance, Xi Jinping, speaking before the Central Committee of the Communist Party of China, has called for the acceleration of blockchain development and encouraged more blockchain-based solutions in technological and industrial innovation plans of China (Foxley, 2019).

While most countries have shown optimism in embracing blockchain for the future of the digital sector, they also prepare themselves against the drawbacks of the technology, especially in preventing illegal movements of cryptocurrency in their countries. For example, Thailand has prepared to amend the Anti-Money Laundering Act in order to control the effects of the flow of cryptocurrency across its borders. For China, the National People’s Congress is pushing for standard regulations to control activities related with cryptography-based applications as it has prepared to launch its first central bank digital currency (Jagati, 2019).

Even though blockchain can be utilized and implemented across different sectors and industries, the most common use of the technology is in the financial sector in which cryptocurrency is impacting financial services and the flow of electronic cash. Still, to ensure that cryptocurrency is used for legal purposes, the governments and relevant stakeholders, such as corporations and international organizations, must build a common ground for approaching challenges that arise from illegal trade activities in unregulated markets and cross-border transactions. Also, for developing countries, such as Cambodia, to realize full potential of blockchain, a great deal of efforts must be taken to promote and encourage research development of the technology in their digital sector.

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