

A survey on opportunities and challenges of Blockchain technology adoption for revolutionary innovation

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ABSTRACT

In the “Industry 4.0” era, blockchain as well as related distributed ledger technologies has been an unmissable trend for both academy and industry recently. Blockchain technology has become famous as the innovative technology that underlies cryptocurrencies such as Bitcoin and Ethereum platform. It also has been spreading with multiple industries exploring their capabilities and new blockchain use cases springing up on a daily basis. Its emergence has brought a great deal of impact on how the information will be stored and processed securely. Furthermore, almost of advocates say that blockchain will disrupt and change everything from education to financial payments, insurance, intellectual property, healthcare,... in the years to come. However, a comprehensive survey on potential and issues of blockchain adoption in academy and industry has not been yet accomplished. This paper tries to conduct a comprehensive survey on the blockchain technology adoption by discussing its influences as well as the opportunities and challenges when utilizing it in the real-world scenarios.

CCS CONCEPTS

• Applied computing • Security and privacy

KEYWORDS

Blockchain, Blockchain adoption, Decentralization, Security, Future trends of Blockchain.

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1 INTRODUCTION

The technology industry first started significantly paying attention to blockchain terminology when Bitcoin was launched in 2008. Blockchain technology serves as a real-time bookkeeping or digital ledger that is incorruptible, enforces transparency and bypasses censorship. It creates an unalterable record, since each entry is time-stamped, given an identification code and then linked to the previous entry. Researchers agree that blockchain has certain features that is a cutting-edge technology transforming virtually every aspect of global business. Currently, it is well applied in the financial field, but still lacks to find the appropriate utilization of large scale blockchain adoption in modern society. A joint survey by PwC and VeChain [1], was conducted between November and December 2017, has found that most enterprises prefer to setup their own research and development (R&D) teams to investigate the blockchain. According to this statistic survey, entrepreneurs and founders are more enthusiastic about blockchain technology with 93%, followed by marketing and sales department 68.4%, educational and scientific department 66.7%, media 42.9% and IT & high-tech department 41.9%. Among companies which have already implemented Blockchain technology, 50% chose the field of security traceability, standing out from other fields of application, according to report [1].

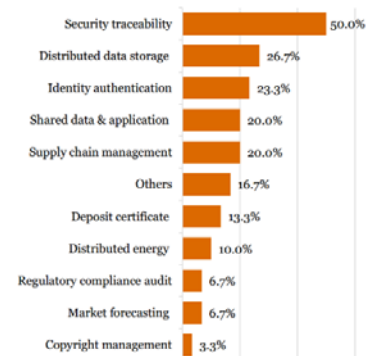


Figure 1: Fields of Blockchain implementation [1].

Data analyzed by Thomson Reuters [2] from the World Intellectual Property Organization (WIPO) indicated that in 2017,

more than half of the 406 blockchain related patent applications were from China with 225 blockchain patents, followed by the US and Australia with 91 and 13 patents respectively. This is due to the Chinese government has taken an official interest in developing Blockchain technology in the country. In more details, the of iPR's research [3] indicates that Alibaba heads the list with a total of 90 patents focused on blockchain-related technologies. In the second place is IBM, with 89 filings, whereas Mastercard occupies the third position with 80 filings. The fourth is Bank of America with 53 blockchain patents.

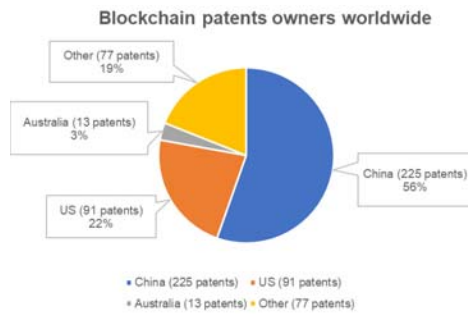


Figure 2: China leading with the most blockchain patent applications in 2017 [2].

Due to the capabilities of adoption, blockchain and its underlying technology have become a promising area to investigate. Many publications and surveys have been made on different aspects of Blockchain. In [4], authors focus on the application of Blockchain in a specific field – financial institutions in Korea in 2017. Another survey in [5] makes an overview of security and privacy issues in Blockchain along with their impact with regards to different trends and applications. Adoption as well as application in the real life can be considered as an important motivation to research and develop new technologies, therefore this paper aims to take an overview of not only blockchain – a rising technology that is attracting the world but also its early applications in many fields of life. It conducts a literature review of the current landscape of blockchain adoption as well as some miracles needing to overcome. We firstly focus mainly on familiar fields which are essential to human life such as finance, healthcare, education, transportation,... before taking a deep research in specific areas. The structure of the survey is as follows. Section 2 describes the concepts of blockchain technology and related techniques. Section 3 discusses on some opportunities and challenges provided with the adoption and growth of blockchain. Section 4 classifies main industry sectors with real-world use cases blockchain can disrupt and revolutionize daily lives in The Fourth Industrial Revolution. The conclusion is in Section 5.

2 Understanding of blockchain technology

2.1 Blockchain concepts overview

Initially created to support the Bitcoin cryptocurrency, blockchain has much potential in relevant areas for adoption

within many industries. It is what's known as “decentralized” model and is considered by advocates to be tamper-proof, cheaper, immutable, time-stamped record keeping and more efficient. In fact, there are many techniques are put together consisting of cryptography, mathematics, networking and the sharing economy model. It uses peer-to-peer (P2P) networking without the involvement of centralized server. However, aiming to address synchronization issues from distributed database, blockchain technology considers consensus algorithms as the backbone of its operating principle.

A blockchain is nothing more than a register storing transactions, called a ledger. This ledger is not kept by one trusted entity, but it is decentralized over a network. Anyone on the network can read the ledger, but no one can modify a transaction once recorded in the ledger. It provides a series of networks of databases that let users create, disseminate and store information securely and efficiently, eliminating the need for a central authority and providing greater transparency for transactions every step of the way.

The user who wants to initiate a transaction would broadcast the data into the whole P2P network. After that, the other nodes or users who receive data validates the data authenticity using a particular consensus algorithm such as Proof-of-Work, Proof-of-Stake, Practical Byzantine fault tolerance (PBFT), etc..on the block that requires validation. The verified data is stored into a new candidate block, then. The consensus algorithm is responsible for adding the candidate block to the blockchain with the admission of all nodes in the P2P network. Hence, hackers would need to hack into multiple systems to change any information which they intend, this principle leads to make the data almost unable to hack once data stored in the blockchain. It gets rid of the need for a third-party intermediary, like a bank, or public certificate authority, etc.

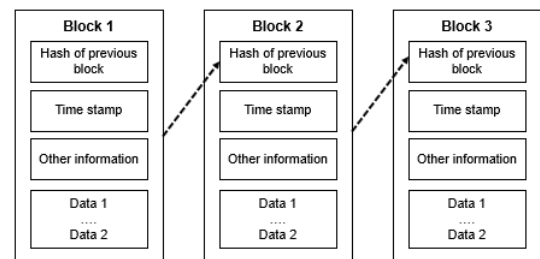


Figure 3: Linked list connection between blocks in blockchain.

When it comes to the structure and components of blockchain, the security technologies including Hash, Digital Signature and Cryptography play the important role to ensure secure integrity and reliability of transaction records without third service provider. Figure 3 illustrates the structure of blockchain. Beside a timestamp and transaction data, each block contains a hash of the prior block, and a “nonce” value, forming a digital fingerprint linking the blocks to form a blockchain.

2.2 Types of Blockchain

Dating back to the early stage, blockchain launched as a public permissionless technology when it was used for leveraging Bitcoin. Since then, other types of blockchains have been designed to meet growing requirements. These can be classified as a cooperation of public/private and permissionless/permissioned manner. Overall, public or permissionless blockchains are open, decentralized and slow. In contrast, private/permissioned blockchains are more centralized and closed, either partially or completely. They're also more efficient in case the system requires privacy and control. With this approach, a central authority grants privileges to only one or more entities to read, write and verify transactions. Each type fits a specific set of use cases. Organizations or enterprises must be aware of the tradeoffs when they select a relevant type of blockchain for their purpose. It's also significant to note that for some use cases, traditional centralized databases may be suitable instead of a blockchain.

To be more precise, there are mainly three forms of blockchain technologies, including public blockchain, private blockchain, and consortium blockchain that have emerged after Bitcoin presented blockchain to the world [5]. The most obvious benefit of public blockchain is that it allows everyone that is part of creating and maintaining the distributed ledger to be part of the ecosystem. As its name suggests is the blockchain of public, meaning a kind of blockchain which all participants can freely access data, make and verify transactions. This leads to reduce the performance of verification and consensus status. On the contrary, private blockchain is a private property of an individual or a company where controlling right belongs to only one organization. They strictly manage participants who are allowed to be involved in the verification and validation of transactions. The significant advantages of private blockchain consists of higher level of privacy, fast transaction handling when compared to public blockchain due to the decrease in the number of validators. This type of blockchain is pertinent to traditional governance model as the centralized information management system like banks, financial institutions or governments. Consequently, the consortium blockchain is the intermediate type of two previous categories, public and private blockchain. This type of blockchain aims to cut off the single autonomy which gets granted in just one company by using private blockchains. Consortium blockchain operates under the management of more than one organization which in a way withstands the whole network against a single point of failure. Organizations can use consortium type to resolve the problems of privacy and slow transaction speed in the public blockchain, whereas still strengthen security through a set of predetermined companies or identities. Thus, consortium blockchain can be used for such transactions or activities between a group of organizational partnerships with great advantages.

3 Opportunities and challenges for blockchain development and adoption

Researchers and strategy makers are comparing blockchain to the spread of the Internet in the 1990s since become a major influence on life. Although the blockchain will do to the Industry 4.0 sectors what the Internet did to media and communication, blockchain is still looking for strong footing outside of early adopters [6].

3.1 Policy normalization and strategy

The policy normalization plays the key role in blockchain technology research, development and adoption for countries. Currently, it is the most concerned challenge for bringing blockchain into many fields on a daily basis. As mentioned in PwC's survey on application of Blockchain [1], though many different industries do not share the same figure of concerns about industry standards, lack of understanding and talents, market readiness, techniques, etc; policy normalization always ranks on the top 3 list among all the industries. Once consortiums or business enterprises desire to apply blockchain to their activities and services management, most of them do not need to take into consideration input cost as a vital factor. They are willing to allot money into blockchain adoption provided that there are already promising or successful blockchain use cases. In case of policy normalization is set appropriately, a large number of companies will take chances on this technology to gain great benefits as soon as possible.

Being a new technology with many undercovered and unpredictable chances as well as issues, Blockchain still faces with the legal regulation's acceptance. Cryptocurrency is one of the most famous applications of blockchain, but not all nations have admitted it to be used in many financial activities. Several meetings have been held to debate or discuss the possible regulation for cryptocurrency with many dissenting opinions. Some small countries use it as a new capital attracting chance, even issue their own token like Venezuela, while Argentina, Australia, Turkey, South Africa, and the United Kingdom decided not to regulate cryptocurrencies in a meeting of G20 countries. However, governments around the world still recognize the value of blockchain distributed ledger technology. Switzerland is one of pioneers in applying blockchain with several blockchain startups and taxation or legal protection policies for these companies [7]. Government in London also becomes a venue encouraging startups in investigation of new technology and building their regulatory framework to support these activities [6]. In China, the Supreme Court has legalized the utilization of blockchain to resolve disputes [8]. On the other hand, U.S regulations consider this technology with more deliberations, but the investments from some prominent companies or organizations can make changes in the trend of usage and regulation of blockchain. Korean National Assembly also has a meeting to terminate the ICO ban and discuss the creation of Blockchain island in this country [9].

3.2 Privacy Preservation

Data has become essential to the optimal operation of our economy, society and our lives, such as to critical infrastructure, medical devices and even autonomous cars. Big Data and metadata continue to grow with profound consequences. As the global data sphere explodes in size, so does gap between the amount of data that should be secured and the amount that undoubtedly is. Data requiring security includes corporate financial data, personally identifiable information, daily individual activities and medical records. Machine learning, natural language processing and artificial intelligence hold the potential to make data analysis dramatically more frequent, efficient, flexible. As a result, more data means more vulnerability. Recently, with scandals like Facebook & Cambridge Analytica [10], data privacy preserving has come into the public spotlight making everyone more aware of the implications of data and just how valuable it can be, both for consumers and corporations. Recently, blockchain has been gathering a lot of interest. Many industries can profit from the advantages of blockchain. Nevertheless, applications with more restricted privacy or participation requirements cannot rely on public blockchains.

3.3 Lack of human resource

With dramatic development and capability of adoption in many sectors in recent years, human resource demand for blockchain is increasing significantly but in short supply. As Upwork report, at the end of 2017 and the beginning of 2018, Blockchain engineering ranked the second place in the most demanded skills in the marketplaces around the world [11]. In Q1 of 2018, it became the most fastest growing skill with more than 6000 percent growth over the same period in 2017, according to a newer report [12]. Not only new growing companies but also classic ones desiring to catch up this technology are seeking for developers in blockchain development, especially skilled experts. To supply Blockchain workforce to existing demands, lots of universities or educational organizations have taken into account this promising technology in their courses and academic program [13]. The Australian University RMIT has partnered with some blockchain-related enterprises to concentrate on virtual currencies and distributed ledger, a course called Developing Blockchain Strategy [14] gives students a chance to get used to blockchain technology and apply to the real world. The Instituto Tecnológico de Buenos Aires (ITBA) of Argentina has offered a new online course about cryptocurrencies which is “Bachelor’s Degree in Cryptoeconomy: Blockchain, Smart Contracts and Cryptocurrencies” [15], allowing students to understand what cryptocurrencies are, how they affect the economy and how virtual currencies behave. In USA, the NYU Stern offers a cryptocurrency course for undergraduate students with more than 100 participants. Using Coursera [16] for searching blockchain-related courses will result in about 15 different available courses. Beside courses from universities, some notable organizations also get into the race to this technology like IBM with “IBM Blockchain Foundation for Developers” [17] or 5-week “Blockchain: Foundations and Use Cases” course [18] of blockchain start-up ConsenSys Academy.

Along with universities or enterprises, governments also have their preparation to apply blockchain. South Korean has built their own 6-month training course to train and turn more than 40 participants into blockchain experts in order to provide support for employment and business start-ups or professional training [19]. While developers with trained blockchain skills is limited, some start-ups also consider fresh computer science graduating from top engineering schools such as UC Berkeley, Stanford and MIT CS or people attending a coding school as a potential workforce, despite the difficulty in recruiting [20].

4 Blockchain adoption in Industry 4.0

Numerous potential blockchain-based applications have already been created several recent years. This section provides a brief view of realistic use cases on blockchain adoption not long ago.

4.1 Financial and banking services

Blockchain was constructed first for the financial industry and so it is the home of the original use cases. Ant Financial, a payment affiliate of Jack Ma’s e-commerce giant Alibaba, owns and operates China’s largest online and mobile payments network Alipay, is using some of the \$14 billion treasure chest it just raised to invest in blockchain technology. In June 2018, it has taken a step towards dramatically lowering the cost of sending money overseas, in a move that will help the hundreds of thousands of Filipinos working in Hong Kong [21]. AlipayHK, the Hong Kong version of Ant Financial’s Alipay wallet on the Chinese mainland, launched a Blockchain-based Remittance Service, aims to eventually cut the cost of these remittances to near zero. With this application, Hong Kong’s large Filipino working population can send funds to family back home quickly and securely. According to Ant Financial, AlipayHK wallet is the first of its kind globally.

By collaborating with EMQ company, Alibaba’s rival - Tencent, has also launched a Hong Kong-Philippines remittance service through its popular mobile app, WeChat. It is recognized as the mobile messaging service that has evolved into the China mainland’s largest social network, as well as a popular online platform for payments and money transfers. “We Remit” feature in Tencent’s WeChat app provides an alternative way for nearly 200,000 overseas Filipinos in the city to send money home, which is reported that transfers took under 10 minutes [22]. Users can top up the money in their WeChat mobile wallet, which is where the funds sent via “We Remit” originate, by paying the amount needed at any of the more than 900 7-Eleven stores in Hong Kong.

Likewise, Dubai which dubbed as the “city of the future”, plans to set its sights on becoming the world’s first Blockchain-powered government. This Gulf’s city is rapidly transforming into smart city since it embraces artificial intelligence (AI) and begins implementing blockchain plans, particularly real estate sector. According to the strategy by the Smart Dubai Office, blockchain will be utilized for all government documents by 2020 to set paperless state of UAE [23]. The adoption of blockchain in real estate, however, is only a first stage. Adaptation to

innovative technologies and applying them in serving society and economy will help to enhance the efficiency of government performance in Dubai and the whole UAE. However, Dubai's blockchain strategy presents challenges due to lack of technical skills and infrastructure to assist all the technology's functions. Therefore, Dubai will also completely create a shared platform, called Blockchain as a Service, to support Dubai government agencies use blockchain in various projects. In October 2017, UAE government also revealed its own blockchain-based cryptocurrency, called emCash, enable citizens to pay for various government and non-government services. According to Dubai government's announcement [24], the blockchain-based emCash will allow UAE residents use the digital currency via an emPay [25] wallet app on their smartphones, to make varied payments, from their daily coffee and children's school fee to utility charges and money transfers. With emCash, emPay users will have the option of a secure digital currency, and merchants receive such payments in real time without passing through intermediaries.

4.2 Education

As mentioned in the "Blockchain in Education" report of Joint Research Council of the European Commission [26], some organizations have implemented researches to apply blockchain to education, which means Blockchain adoption in teaching and studying related operations has drawn government and community's attention. We have overviewed some typical applications of blockchain in education, as follows.

Blockchain technology can be utilized in issuing digital certificates to overcome some disadvantages of both paper and regular digital one. While there are still some problems in certificates issuing like the complicated verification process, the universally-used standards for digital signatures used in these certificates or the significant control of third-party certificate provider, blockchain-based infrastructure is aimed to secure, share and verify learning achievements in such an easier way. The best explanation for this is that Blockchain can keep a list of issuer and receiver for every certificate with the hash values in a public database identically stored in many places that is infeasible to modify. No intermediary parties are needed to complete the validation of a certificate, anyone having access to that document can be the validator. Thus, we also use blockchain for certifying and identifying vendors, storing an e-Portfolio, managing Intellectual Property, etc.

A research of Open University-UK uses blockchain as a trusted ledger to enhance standards for badging, certification and reputation, since it can determine the ownership of an asset. According to Professor Domingue, Director Knowledge Media Institute (KMI), a progression embeds open badges within the blockchain project. Ethereum is used to get badges into smart contracts. Over 170,000 students have provided opportunity to badge all OU courses and notarized them on the blockchain.

Blockcerts [27] is an open standard for Blockchain educational certificates developed by MIT Media Lab and Learning Machine, allows not only education institutions but also government to build their own software to issue and verify certificates.

Blockcerts's aim is to "provide a common set of patterns so that credentials can be issued and verified across any blockchain, and across different market domains", this can avoid the inconsistency in standards. Blockchain and powerful cryptography have created the Blockcerts open platform for digital certificates and reputation. Blockcerts has four basic components: Issuer, Certificates, Verifier and Wallet [28]. Issuer takes the responsibility of creating digital certificates, which include information about skills, achievements, or characteristics of a student. Verifier is someone who can verify these issued certificates. Each student has their own wallet to store their certificates and share them to others if necessary.

MIT started using Blockcerts to issue digital certificates for people in a community in 2015, which allows recipients to have more control over their certificates without relying on any third-party. Learning Machine certificates, a commercial solution developed over Blockcerts, is used in 2017 to issue diplomas for student groups in MIT and Sloan School of Business [26].

4.3 E-commerce

Most of business activities existing nowadays serve as middlemen. Sellers and customers cannot communicate directly to each other but over a third-party. As a result, an amount of additional fee needs to be paid for any activities done. For example, selling products using the payment system of PayPal will increase the price of the items, since sellers must charge maintenance or service fees to PayPal [29]. In the centralized database of existing business systems, organization manages and takes the control over all user's data. Many data-breaching-related issues have occurred. Using blockchain technology in e-Commerce, the entire database of sellers and customers can be decentralized in multiple places and users can remain their ownership of the information.

Blockchain gives a new approach for e-Commerce. It allows us to trade and interact directly without middleman, so no any additional fees are acquired to be paid. Decentralized marketplaces enable people to get corresponding values based on their contributions, no third-party benefits from keeping or maintaining data of users.

Many organizations in the world have applied blockchain technology to their products and provide their customers with good services. OpenBazaar [30] is an open source network that utilizes blockchain technology and Bitcoin for payment in its business operations. Unlike Ebay or Amazon, in OpenBazaar with a decentralized marketplace removing the control of a single organization, customers and sellers do not rely on any third-party to get their communication established, thus the trade is a peer-to-peer transaction. There are no fees to list items in this system and so does selling an item, which gives its sellers and customers more freedom and privacy. To take the advantages of Blockchain-based system, OpenBazaar provides a search engine for browsing items from the decentralized database. Moreover, payment using Bitcoin is more secure, private. This payment system has less risk of identity theft and requires lower cost to use.

4.4 Healthcare monitoring system

The operation mechanism of today's health-related systems has a number of limitations. One of those is that patients hardly have access to their own health records, therefore they will have no idea about the sharing of these data among unknown parties. Moreover, as mentioned in [31], exchanging health data cross-border of European nations is on high demand and attracts attention of many research projects to solve this problem based on realization of a standard health data format to share this information. As a result, a secure, standard method for exchange clinical data among member states is needed.

According to a report by analyst firm Frost & Sullivan [32], blockchain technology will revolutionize the healthcare industry by 2025. Blockchain gives the capabilities of reorganizing patient data and ensuring the security of interoperability among parties, such as patient, doctors, hospital, or clinic, with relevant privileges. It also has functionalities of drug traceability by recording all data involved in vaccine manufacture and transport including getting vaccines from manufacturers, storage facilities, cold chain distribution, hospitals, and even usage. In addition, by coordination of medical agencies, it can leverage healthcare domain with improving the authentication of records and enhancing the accuracy of diagnoses relying on historical health records of patients in various places. As a result, more effective treatments and cost-effective healthcare service can be provided to patients. These developments are already underway, with startup cryptocurrencies targeting the inefficiencies of the current healthcare industry. Frost & Sullivan's Transformational Health report also asserts that blockchain technology "holds the potential to save billions of dollars by optimizing current workflows and disintermediating some high-cost gatekeepers".

Specifically, engineers are looking to blockchain technology to resolve long-standing problems involving data operability, cybersecurity, insurance notarization, and medical billing fraud. By utilizing blockchain technology, every action related to a piece of medical infrastructure can be recorded and assessed, with regards to the cost versus the usage, the period of waiting for patients and therefore demand, the scheduling of maintenance checks and the authenticity of the supplier. Personal Health Record (PHR), Population Health, Personalized Medicine are important elements which have great promise with the adoption of blockchain in healthcare industry.

Taipei Medical University Hospital has applied blockchain technology in their healthcare platform to "improve patient referral services and integrate individual healthcare networks so that people have easier access to their medical records" [33]. Using principles of this promising technology, clinic information of patients is maintained in a list of records – call blocks – which are linked using cryptography. Information in this platform can be a complete set of all medical records, including high-resolution medical images, lab results, and clinical and health exam information, patients can have access to their own records using a password-protected mobile app and hospitals or clinics can request and authorize record sharing easily and securely. This blockchain-based solution also incorporates the additional

security feature of notification and consent before any transfer takes place. As a result, the electronic medical records and electronic health records in multiple health organizations can be combined and the process for inter-hospital transfer can be simplified with minimum risk of security breaches.

Aiming to offer the healthcare industry a secure digital platform for exchanging patient data, a blockchain-based solution for managing sensitive medical data was developed by German Camelot Consulting Group, in April 2018, where all health data transactions are encrypted and stored on an unchangeable blockchain and are carried out directly between the authorized participants [34].

Tencent – the largest internet company by market capitalization in China – uses its Tencent Blockchain platform (also called TrustSQL) to ensure the safety and security in medical treatment [35]. With this technology, the prescription cannot be tampered with and this announcement has been tested with the first "out-of-hospital prescription circulation" service based on their WeChat's hospital reservation and payment services in Guangxi and Liuzhou. Besides healthcare systems, Tencent's platform can be applied in digital assets, logistics information, legal deposit protection.

An Estonia startup called Healthereum [36] has designed a platform based on Ethereum to integrate medical data from multiple sources and encrypt them to ensure the security. Due to the decentralized approach of Blockchain, "human errors, third-party influence, also the risk of tampering and manipulation" can be eliminated. Healthereum platform uses a HHEM token not only as the transactional medium of payment for services but also as a reward for offering referrals or carrying out diagnostics and tests for patients. This platform already has its application in Indian healthcare [37] with welcoming response. Blockchain-based solution is to collect the data in real time, store it on multiple servers to make it hackable resistant, allow the access to authorized people only, and store a newer version every time the file is accessed. Being fascinated by this positive result, the Indian government has announced to take further research on Blockchain technology and its applications in other life's areas.

In August 2017, the first application of Blockchain in the healthcare sector has been launched in China by the cooperation of Alibaba and Changzhou city. Later in the middle of September, IBM Watson and US FDA have signed an agreement in 2 years to discover the potential usage of blockchain in sharing patient data from different medical sources [38].

4.5 Transportation

Nowadays transportation service is the most significant part of daily life. Demand of transportation service is raising day by day though it is facing lots of problems: high customers fare, drivers, expensive operating cost, lack of applications... That's reason why the consumers and drivers are not satisfied on transportation service. Given the recent anti-competition discussion on the Uber-Grab merger, the idea of utilizing decentralized technology to liberate the rideshare drivers may be an intriguing alternative. With blockchain-based approach, participants involving the ridesharing marketplace like drivers

can set their own pricing and terms of transactions to earn fully money from their works without paying for third party. The future of ridesharing is undeniably moving towards decentralized transportation where is less expensive to riders and drivers are paid better.

With the most vital sharing economy technology giants, Uber and Grab, anyone possessing an own car or motorbike can register an account and start driving to earn money. However, drivers cannot totally control their freedom. Service providers still control communication between drivers and riders (customers of drivers), charge service fee, and monitor driver's activities, or drivers picks up and drops their clients. Moreover, drivers must comply service provider's policy and rules. These companies are not exactly the collaborative economy system, as all the involved parties are not to be rewarded for their contributions correspondingly.

Blockchain gives a new approach for transportation sector which can minimize conventional ridesharing transaction fees. By buying tokens on system, drivers can start joining ridesharing services without depending on third party.

Helbiz [39] is the seamless car sharing solution, allowing users to rent out their private vehicles using blockchain, directly through the phone without any manual involvement. It uses Helbiz token for payment and runs based on an Ethereum dApp, providing a global peer-to-peer rental operation through smart contracts. The driving data and car logs are kept private by encryption and decentralized storage, users can decide who they want to share with. This solution offers an identification mechanism to verify owners and renters using facial scan, fingerprints and signatures. According to RedCab team, RedCab [40] is a company utilizing decentralized techniques for transportation model. By decreasing cost and moreover extended security for trades through decentralization, blockchain technology is the backbone of its business model. More percentage of revenue, which is paid by the passenger goes directly to the driver. Prior to this process model is decentralized without middleman, so the platform will be always less expensive for passengers and driver will get more revenue [41].

Another example is Bounce platform [42], in which drivers are shareholders in the company, so they are extremely committed to passenger satisfaction and democratize the platform for the benefit of active contributors of ecosystem.

Decentralized Autonomous Vehicles (DAV) [43], founded in 2017, is a blockchain-based platform that brings decentralized, peer-to-peer, global innovative transportation. With this solution, autonomous vehicles can discover and authenticate each other, service providers and clients around them in a decentralized approach relying on no central server. Besides blockchain-based communications between users with smart contracts, it also has own peer-to-peer protocol as an alternative. DAV tokens are not only required for accessing the DAV network for each transaction but also helps to confirm identity and track the population that is onboarded, which is something that would then be fully transparent on the blockchain.

4.6 Supply chain

Blockchain is a state-of-the-art technology that increases automation of commercial processes; enabling firms to record information or complete product history for both businesses and consumers throughout the entire supply chain on a distributed ledger, in a secure, irrevocable and immutable manner. Ceaseless and entire traceability becomes possible without any centralized factor or the presence of a third party at every transaction. Regarding to [44], there are many blockchain apps in the global shipping field to track requirement of import and export, for assurance the safety of food chains from farm to table, for tracing raw materials and components in the airline industry.

Experts have indicated that blockchain will significantly address the problem of agricultural traceability, thereby ensuring the transparency of product records throughout the entire agricultural production chain from farm production, post-harvest handling, industrial processing, storage, transportation, to packaging and distribution to consumers. In supporting tremendous potential for agricultural development, the local agricultural sector must collaborate with technicians to develop the technological tools necessary to meet higher consumer demands and enhance consumer confidence. An immutable and transparent traceability technology that manages the supply chain would be a dramatical step towards the innovative future. It enables companies to better understand, prepare for, and exceed in both compliance and customer satisfaction. Solving product transparency and immutability issues as well as providing real-time product information to parties regarding all steps in the supply chain process, Fruitchain [45] is a revolutionary blockchain-based traceability solution in Vietnam, which was first implemented with mangoes produced in My Xuong Cooperative, Dong Thap province. It is remarked as one of the first solutions for the traceability of agricultural products by giving consumers a complete view of the product journey in delivering safe and economical products with blockchain technology and smart contracts. Through the retrieval of traceability information via a QR code stamp, consumers can trace the origin of the product purchased from the retailers or supermarkets.

5 Conclusion

The blockchain technology has been drawing the attention of researcher's owing to its prospects of multi-sector applications outside the finance field where it first started. It is getting closer to its breakout moment with every passing day, as those mentioned in this paper. It has the potential to revolutionize trust, security, and our relationship with our individual data in the online world. With rapidly growing market, blockchain stakeholders such as software developers should seek adopting scenarios for any new application early on. However, as the underlying technology is subject to ongoing intensive research, legal acceptance and workforce demand are still essential issues that this technology needs to overcome. With many real-world use cases of blockchain still to be developed in the coming years,

governmental authority will need to keep an eye on important trends and will have adapted to the legal challenges. Ultimately, it may not only become an exercise for legislators to make the required adjustments for an efficient and fair legal framework but also a promising area and a motivation for coming research to keep up with the technological progress.

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