ZIBELINE INTERNATIONAL™ PUBLISHING

ISSN: 2616-5961 (Online)
CODEN: IMCSBZ

Information Management and Computer Science (IMCS)

DOI: http://doi.org/10.26480/imcs.01.2021.01.05

REVIEW ARTICLE

A METHODOLOGICAL REVIEW ON APPLICATIONS OF BLOCKCHAIN TECHNOLOGY AND ITS LIMITATIONS

Mahak Modani, Satyam Patidar, Sushma Verma*

Department of Computer Science and Engineering, Medi-Caps University, AB Rd, Pigdamber, Rau, Indore-453331, India
Corresponding Author Email: sushma.verma@medicaps.ac.in

ARTICLE DETAILS

Article History:

Received 21 October 2020
Accepted 24 November 2020
Available online 10 December 2020

ABSTRACT

Earlier, Blockchain technology was used mainly for Crypto-currency, which visualizes the Bitcoin and Blockchain technology as identical. As of now around 3000 crypto-currencies are present, among them Bitcoin is the largest Crypto-currency. This paper presents a Systematic Literature Review (SLR) of the applications of Blockchain technology over different areas. This paper focuses on various areas and applications where Blockchain technology is used. Researchers and academicians have utilized Blockchain in numerous fields. Based on the previous works, a universal classification of Blockchain based application is considered of various domains such as financial application, integrity verification, governance, Internet of Things (IOT), health care management, privacy and security, education and data management etc. This paper also converses about the few of the limitations of Blockchain technology.

KEYWORDS

Application, Bitcoin, Blockchain, Crypto-currency, Digital Ledger, Digital Signature, Trusted Time Stamping.

1. INTRODUCTION

In 1991, Stuart Haber and W. Scott Stornetta have published a paper '*How to time stamp a digital document*' (Scott, 1991). The objective behind this paper was to extend the use of audio, video and text documents in digital form. The author proposed a solution that provides the time stamps of the users. The time stamping used provided the digital footage as soon as the document is created or modified. In the provided solution, the hash of the documents were calculated and sent to Trusted Time Stamping (TTS) followed by digital signature of the document using digital signature and then sent to the client. In other solution, the need for centralized TSS evade and the hashes of documents were calculated (Scott, 1991).

In the succession Satoshi and Nakamoto published paper in 2008 and in 2009, referring to Stuart Haber and W. Scott Stornetta (1991, 1993, 1997) and additional (Nakamoto, 2008). They launched Bitcoin software using Blockchain technology which came into limelight. The concept of Blockchain technology was discussed by many but Satoshi and Nakamoto made the technology in trend by creating the concept of digital currency (Crypto-currency) that became popular. Bitcoin works on distributed peer to peer (P2P) network technology i.e. Crypto-currency or digital assets exchange via a distributed network. The proposed solution evades the double spending problem by using peer to peer network. Some characteristics of Blockchain technology are security, robustness, transparency and audibility. The details of transactions in Blockchain are stored in blocks and each block is linked with the previous block to form chain and every block contains a hash of previous block.

Blockchain technology works on a decentralized system i.e. there is no central authority which has lone power (Nakamoto, 2008).

A. *Public Blockchain:* As the name suggests it is open for public, completely decentralized and distributed. By entering into the Blockchain platform one can behave as authorized node and can perform transactions by becoming a part of the Blockchain network. The node even starts mining. Some famous Blockchain platforms are Bitcoin, Ethereum and Litecoin. In public Blockchain decision making takes place using consensus algorithm that shows the proof of work.

B. *Private Blockchain:* It is a closed Blockchain network and not completely decentralized. Private Blockchain belongs to an individual or organization. The decision making rights are in hand of a central authority i.e. whom to give mining rights. The examples of private Blockchain are Hyperledger fabric, Corda, Ripple (XRP).

C. *Consortium Blockchain:* It is a semi-decentralized Blockchain. In these more than one organization has the right to manage Blockchain networks. Examples of consortium Blockchain are Quorum and Hyperledger.

D. *Hybrid Blockchain:* Hybrid Blockchain combines properties of both private Blockchain and public Blockchain. The Benefits of hybrid Blockchain can be seen under business that is there is a facility by which they can show the data which they want and keep private data safe by hiding those. Example of a hybrid Blockchain is Dragon chain (Sharma, 2019).

Based on the intended audience, the evolution of Blockchain can be recognized as Blockchain 1.0. Due to implementation of Distributed Ledger Technology (DLT) first application was Crypto-currency. The first Crypto-currency introduced was Bitcoin and now it is the most popular and famous currency. Blockchain 2.0 includes smart contract, tiny computer programs present in Blockchain. Smart contracts reduce the

Quick Response Code	Access this article online	
	Website: www.theimcs.org	**DOI:** 10.26480/imcs.01.2021.01.05

Cite the Article: Mahak Modani, Satyam Patidar, Sushma Verma (2021). A Methodological Review on Applications Of Blockchain Technology And Its Limitations. *Information Management and Computer Science, 4(1): 01-05.*

cost of verification by removing involvement of the middle man as it is impossible to tamper or hack smart contracts. Blockchain 3.0 is used by large industries such as government, Banking, health sector and many more (Zhao et al., 2016; Swan, 2015).

The objective of this paper is to look into Blockchain technology and its current practical Application. The rest of the paper is organized as follows. Section 2 presents descriptive analysis. Section 3 describes Systematic Review of Blockchain Application. The Limitations of Blockchain in various fields is explained in section 4 and section 5 concludes the paper.

2. Descriptive Analysis

A study analysed around 260 research papers. The use of descriptive analysis is ternary (Casino, 2019). The aim is to provide appealing understanding on the subject of research trends in Blockchain technology and its applications that helps to envision the research approaches which are developed till now in the scientific creative writing. It provides classification organization of Applications of Blockchain.

Here it also provides year wise analysis of research papers. The number of publications increased rapidly in 2017.Untill 2016 around 40 research papers were published in 2017 this number increased to 180. Therefore in the last couple of years, research work significantly enhanced the Blockchain application domain. This highlights the rising and increasing nature of Blockchain technology. In the initial years Bitcoin was considered as the substitute of Blockchain. As a result, researchers were trying to inbuilt communications rather than exploring its Applications. From 2016 onwards, Blockchain enabled Applications were published in the form of research work.

The domain specific distribution is explained in Figure 1. From the analysis, we became aware of 11 domains of Blockchain based Applications. Business oriented Applications contribute a large part subsequently governance, IOT and data management Applications.

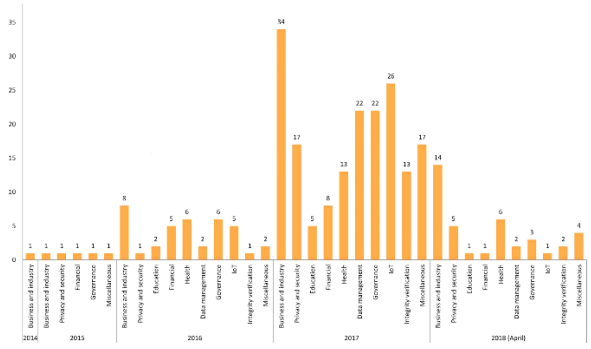

Figure 1: Domain Specific Distributions

3. Systematic Review of Classification of Blockchain

There are different conducts to classify the Blockchain précised in Figure 2. One is financial and other is non-financial (Crosby et al., 2016). The financial basis contains Crypto-currency that contributed majorly in existing Blockchain networks and non-financial is on the basis of Blockchain versions (Zhao et al., 2016; Swan et al., 2015). In this study, we introduce an Application oriented classification. It is quite different from other related works because it uses difficult statistical tactics rooted in literature, hence it is suitable to the current Blockchain development.

3.1 Financial Application

Blockchain is applicable in diverse fields together with business services, settlements of financial assets, prediction market and economic transactions (Haferkorn et al., 2014). Blockchain performs an important role in the sustainable growth of the global economy, provides gain to consumers and the whole society in general (Nguyen et al., 2016). Blockchain enabled Applications are utilized for financial belongings, for instance securities, flat money and derivative contracts (Paech et al., 2017). It provides huge variation to capital markets and more appropriate ways to perform operations including securities, digital payments and derivatives transactions, financial auditing or cryptographic payment and exchange (Gao et al., 2018; Cawrey et al., 2014). The world's huge banks such as Barclays and Goldman have joined forces to organize an operating Blockchain. Global Payment Steering Group (GPSG) is also an example of bank cooperation. Ripple has created the Crypto-currency used behind GPSG, called XRP [13]. This enables global payment and currency exchanges through open source infrastructure. An information provider named Prediction Market Systems (PMS) can impact business and Crypto-currencies. Viacoin is an open source Crypto-currency which features script merge mining. It is an implementation of PMS. It is a type of proof of work (POW) which provides faster transactions than Bitcoin. The assets such as currencies or products are referenced by bitshares. Bitshares are digital tokens which are stored in Blockchain . Blockchain implementation also provides cost saving in areas akin to Central Finance Reporting, compliance, centralised operations and business operations.

3.2 Governance

The official accounts of populace and enterprises are managed by government throughout the years. The way of record keeping by local or state level governments can be changed using Blockchain technology (Hou et al., 2017). The Blockchain technology can make government services more efficient and eliminate corruption. This is because Blockchain provides accountability, automation and safety. Blockchain can integrate physical, social and business infrastructures in a well turned-out city (Ibba et al., 2017; Sharma et al., 2017b). Blockchain maintains the validity as offered by public authorities. It can offer services including registration or legal papers, identification and marriage contracts in a decentralized and efficient way (Swan et al., 2015). It can also be used in patent management and income taxation systems. Decentralised passport service is provided by the World Citizen Project which identifies citizens all over the world (Akins et al., 2014).

3.3 Citizenship and user services

In everyday life, there is a requirement of mechanisms which can determine every user accurately and authenticate their identity credentials such as name, address, credit record and other personal attributes (Buchmann et al., 2017). Uport, Shocart and Sovrin are the 3 decentralized approaches which are discussed by Dunphy et.al. in their paper (Dunphy et al., 2018). According to a recent study, one sixth of the world's population are deprived of the evidence of their continuation. Immigrants and refugees may suffer in this situation. Thus, Blockchain can offer equality and opportunities worldwide (Roberts et al., 2017).

Using a Blockchain based company which provides Application Program Interface (API) to enable verification interface name of company is Pavilion.io. It ensures to eradicate the need of ecommerce buyers or third party providers. One can establish the inter connection between digital content and real world deals using Internet Of Agreement (IOA). This is the subsequent creation of electronic commerce.

3.4 Electronic vote

For quite a lot of years, the voting system has been evaluated as trustable and evitable development which could accelerate the voting process, the cost can be reduced and democracy can become more powerful (Boucher et al., 2016). The design of existing voting system is centralized and rely on owner thus it is not trustable enough (Moura et al., 2017). Decentralised voting system establish framework to initiate distributed decision making, for example Bit Congress and Liquid Democracy (Deitz et al., 2014; Schiener, 2014). We can gain confidence of voters and election organizers using Blockchain technology, because it offers an open source, peer to peer, decentralised and independent certifiable network (Hsiao et al., 2017).

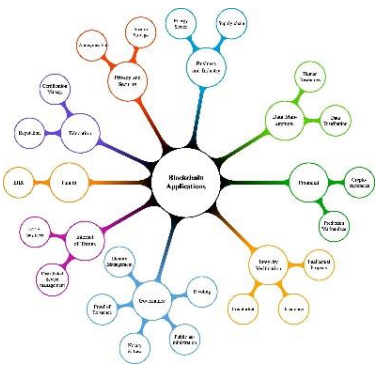

Figure 2: Blockchain Applications

3.5 Internet of Things

According to a study, 90% of the total data in the world is created in the last four years (Marketing, 2017). The reason behind this rapid increase of data is: one is the arrival of the Internet of Things, secondly, the population growth. Blockchain technology and its capabilities are driving the attention to invest in implementation of decentralized IOT platforms (Novo and Oscar, 2018). When plenty of smart devices are interconnected in heterogeneous scenarios, it provides secure and auditable data exchange. One more merit of decentralized fashion is high scalability and skilful management (Sharma et al., 2017a).

One can gain secure and real time payment services and the traditional commerce can be enhanced. FileCoin is one of the Applications which are a memory storage provider. API calls monetisation can be enabled by EtherAPI's. In the coming years, IOT technology can be utilized to connect devices with their accounts which are based on Crypto-currency (Christidis et al., 2016). As a result, micro transactions can be executed in exchange for services. Several problems can be resolved such as high maintenance expenses of centralized systems. The security of IOT and wireless sensor networks (WSN) can be increased by decentralized and secure P2P models (Daza et al., 2017).

On the other hand, IOT also has certain demerits including low computational power and storage capabilities of IOT devices; this restricts the use of Blockchain. A previous study has put forward an alternative way through which drawbacks can be overcome and IOT Applications can be enhanced (BuccaFurri et al., 2017). Recent research presented a lightweight and simple Blockchain based architecture for IOT (Dorri et al., 2017).

3.6 Healthcare Management

Blockchain technology has various Applications in the healthcare Industry including online patient access, sharing patient's medical data, public health care management and many more (Patel et al., 2019). The patient's medical record, data, prescriptions, medical history can be easily managed and accessed by Electronic Healthcare Records (HER). EHR uses Blockchain as a protocol thus guarantees security as well as privacy of patient's data (Xia et al., 2017). It stores the records in a distributed way, there is no centralized hub in the system which can be breached or corrupted by hackers. The data is collected and gathered from diverse sources and unified in a single storage (Grey Healthcare Group, 2017).

The data is publicly accessed and verifiable across non-affiliated provider organizations. It also maintains the information related to the patient's clinical progress throughout the treatment. It is the area where the Blockchain has the highest growth rate in healthcare management. Blockchain is also beneficial in areas like clinic trial, precision, medicine, drug counterfeiting, and user oriented medical research.

3.7 Privacy and Security

The huge amount of personal and sensitive data is present in both public and private authorities. Even though General Data Protection Regulation (GDPR) controls the processing of data but then also there is a need for high security. This gap can be filled using Blockchain platform (Politou et al., 2018). It can amplify the security and scalability of big data. This is done by using efficient data storage systems implemented on data mining methods (Bozic et al., 2016).

A decentralized version of Domain Name Server (DNS) can be established by namecoin which is an open source Blockchain (Haferkorn et al., 2014). DNS offers security, efficiency and privacy. Alexandria is another example of open source Blockchain model which is a decentralized library providing freedom of speech to every individual. The concept of digital identity services can be implemented in both the systems. In this way it enables security by verifying every individual's identity (Zhang et al., 2017). A study proposed three types of identities of Blockchain P2P protocol. 1) The services provided by Applications in which user's credentials are accessed for operational and business related motive. 2) Nodes that maintain the Blockchain and get rewards in exchange. 3) The users can interact with Applications (Zyskind et al., 2015).

A Blockchain based smartphone is developed by SIRIN LABS which enables fee less, secure and fast transactions (Labs, 2014). There is an antimalware in the market named BitAv which increases virus pattern distribution (Noyes et al., 2016). In this way, it can enhance security and reliability in distributed networks also.

Limitation: There are several methods which are proposed to enrich the transactional security such as mixing services or zero knowledge proof. In former methods, the funds are transferred from *N* input addresses to *M* output addresses.In this way, users avoid using the same address again. The Applications which implement this method are mixcoin and coinjoin though there are methods available for transaction security but then also it is one of the most challenging aspects (Bonneau et al., 2014).

3.8 Education

In a universal learning environment, the issues such as vulnerability, security and privacy can be resolved by Blockchain (Bdiwi et al., 2017). The Educational records and reputations can be stored in Blockchain (Sharples et al., 2016). Other study also proposed the use of Blockchain based distributed systems for reputation systems (Dennis et al., 2015). In previous study, blocks are added in Blockchain related to the achievements and rewards of students by teachers (Devine et al., 2015). We can provide more security by implementing Educational Certificate Management by Blockchain. Moreover, the academic learning process can be enhanced using Blockchain. This includes collecting, analyzing and reporting of data for improving decision making (Grech et al, 2017). Blockchain can be further be utilized for publishing manuscripts as well as its verification (Spearpoint et al., 2017).

3.9 Business and Industrial

Business and industries are shifting towards Blockchain because it provides transparency, enhanced security, improves traceability and reduced costs by removing third parties. Currently many e-business models are adopting Blockchain technology. Many authors have proposed business ideas in which transactions between nodes are done through smart contracts on distributed ledger Blockchain (Zhang et al., 2015). In the e-commerce sector Blockchain is very useful because it brings transparency in transaction and transactions are tamper proof, so trust among buyers' increases. The authors also consider the importance of food safety and agro-food supply chain traceability using Blockchain technology (Tian and Feng, 2016).

4. LIMITATIONS

After explorations of several papers in relevant fields, limitations and usability of Blockchain can be derived. Nowadays Blockchain technology is adopted in many research fields and business fields but every emerging technology has its challenges and limitations. In this section, some of its limitations are discussed.

4.1 Suitability of Blockchain

Across the world many companies and different sectors are moving towards Blockchain technology. Before adopting Blockchain technology one should inspect the system requirements and suitability of Blockchain based solutions. There are a restricted number of frameworks designed in the methodical literature to estimate the suitability of Blockchain based Application.

Databases are mutable in nature i.e. in database prebuilt entities have access to modify and insert in database. The prebuilt entities may have precise roles, but their roles are known like authorized users can only insert into database but not have right to change content of database whereas owner can completely alter database whether database is centralized or decentralized i.e. owner can delete content or completely change structure of database.

4.2 Latency and Scalability

Nowadays online transactions such as Unified Payment Interface (UPI) and internet banking or transactions through credit/debit cards are done in a few seconds but in case of Bitcoin transactions it takes approximately 10 minutes to add a block, this network time is also known as Block-Time. Therefore, Blockchain architecture faces some serious latency issues.

A recent study has proposed the idea to decouple a block into two parts also called Bitcoin next generation. One key block is for leader election and another micro block to store transactions. So, nodes compete to become

leaders and competition among nodes is responsible for micro block generation (Eyal et al., 2016).

4.3 Quantum Resilience

In Blockchain, there are two major primitives for signing the transaction: hash key and public key encryption.SHA-256 algorithm is most commonly used in hashing. Using Grover's algorithm, a quantum computer needs 2^128 to crack this algorithm. This makes SHA-256 unaffected by quantum. On the other hand, Elliptic Curve Digital Signature Algorithm (ECDSA) is used for public key encryption. It can be broken once a big enough quantum computer is built. Most of the block chains practice public key encryption. This makes Blockchain insecure.

4.4 Blockchain Implementation and Interoperability

Blockchain Applications are increasing rapidly. The diverse implementation of Blockchain leads to a hard interoperability issues. Most of the companies in the US are conspiring to fetch Bitcoin exchange traded funds to the market (Bitcoin, 2018). It would be easy for the users and international funds to invest in Bitcoin, if it would be regulated properly. But due to unregulated development Crypto-currency, resulted in spectacular attacks (Rochard, 2014). This may also lead to malicious currency exchange results in crisis.

4.5 Data Management, Privacy and Security

Blockchain provides benefits regarding security and privacy of data management however it has some limitations also (Lin et al., 2017). Today also, privacy and confidentiality is an issue. The confidentiality of data can be achieved by adapting several implementation mechanisms (Greenspan and Gideon, 2015). However, it depends on implementation methodology, context of the system i.e. (for example IOT networks are required for some implementations). Thus it is not a panacea.

4.6 Big Data and Artificial Intelligence

Nowadays whatever activity we do on the internet is watched and data is stored. Based on data accessed, websites recommend us according to our likes and dislikes. Problem of managing big data can be solved by Blockchain secure and verifiable structure (Karafiloski et al., 2017). Artificial intelligence is adopted in almost every field. Artificial intelligence solutions can be implemented by smart contracts, to manage its particular characteristics.

Obviously, the utilization of AI and big data empower many fascinating and interesting Blockchain based Applications which could increase the transparency of such technologies.

5. Conclusion

Blockchain has diverse Applications but also has some limitations. There is a requirement to address all such issues. As a result, Blockchain offers durability, scalability as well as high efficiency. The highlights of this technology are not unique if analyzed individually but the combined implementation of all these features make it ideal for all requirements.

As the Blockchain will be more developed, more the Applications will increase, more the interest of industries will increase. However, many researchers are trying to utilize Blockchain instead of traditional databases. But, it is projected that traditional databases are best for some scenarios. Thus, Blockchain cannot be a universal remedy.

Acknowledgements

We thank Pramod Kumar of the Indian Institute of Technology (Indian School of Mines), Dhanbad for his assistance with the appropriate ideas in scripting this paper.

References

Akins, Benjamin W., Jennifer L. Chapman, and Jason M. Gordon. 2014. A whole new world: Income tax considerations of the Bitcoin economy. Pitt. Tax Rev. 12, 25.

Bdiwi, Rawia, Cyril De Runz, Sami Faiz, and Arab Ali Cherif. 2017. Towards a new ubiquitous learning environment based on Blockchain technology. In 2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT), 101-102. IEEE.

Bitcoin ETf Channel. 2018.

Bonneau, Joseph, Narayanan A, Miller A, Clark J, Kroll J.A, and Felten E.W. 2014. Mixcoin: Anonymity for bitcoin with accountable mixes. In International Conference on Financial Cryptography and Data Security, 486-504. Springer, Berlin, Heidelberg.

Boucher, P. 2016. What if blockchain technology revolutionised voting? Scientific Foresight Unit (STOA), European Parliamentary Research Service.

Bozic, Nikola, Pujolle G, and Secci S. 2016. A tutorial on blockchain and applications to secure network control-planes. In 2016 3rd Smart Cloud Networks & Systems (SCNS), 1-8. IEEE.

Britto, A., Schwartz D., and Fugger R. 2012. Ripple.

Buccafurri, Francesco, Lax G., Nicolazzo S., and Nocera A. 2017. Overcoming limits of blockchain for IoT applications. In Proceedings of the 12th International Conference on Availability, Reliability and Security, 1-6.

Buchmann, Nicolas, Rathgeb C., Baier H., Busch C., and Margraf M. 2017. Enhancing breeder document long term security using blockchain technology. In 2017 IEEE 41st Annual Computer Software and Applications Conference (COMPSAC), 2, 744-748. IEEE.

Casino, Fran, Dasaklis T.K, and Patsakis C. 2019. A systematic literature review of blockchain-based applications: current status, classification and open issues. Telematics and Informatics. 36, 55-81.

Cawrey, D. 2014. 37Coins Plans Worldwide Bitcoin Access with SMS-Based Wallet. CoinDesk.

Christidis, Konstantinos, and Devetsikiotis M. 2016. Blockchains and smart contracts for the internet of things. Ieee Access, 4, 2292-2303.

Crosby, Michael, Pattanayak P, Verma S, and Kalyanaraman V. 2016. Blockchain technology: Beyond bitcoin. Applied Innovation 2(6-10), 71.

Daza, Vanesa, Pietro R.D, Klimek I, and Signorini M. 2017. CONNECT: CONtextual NamE disCovery for blockchain-based services in the IoT. In 2017 IEEE International conference on communications (ICC), 1-6. IEEE.

Deitz, J. 2014. Decentralized Governance Whitepaper. Quora.

Dennis, Richard, and Owen G. 2015. Rep on the block: A next generation reputation system based on the blockchain. In 2015 10th International Conference for Internet Technology and Secured Transactions (ICITST), 131-138. IEEE.

Devine, Peter. 2015. Blockchain learning: can crypto-currency methods be appropriated to enhance online learning?.

Dorri, Ali, Kanhere S.S, and Jurdak R. 2017. Towards an optimized blockchain for IoT. In 2017 IEEE/ACM Second International Conference on Internet-of-Things Design and Implementation (IoTDI), 173-178. IEEE.

Dunphy, Paul, and Petitcolas F.A. 2018. A first look at identity management schemes on the blockchain. IEEE Security & Privacy, 16, 4, 20-29.

Eyal, Ittay, Gencer A.E, Sirer E.G, and Renesse R.V. 2016. Bitcoin-ng: A scalable blockchain protocol. In 13th {USENIX} symposium on networked systems design and implementation ({NSDI} 16), 45-59.

Gao, Feng, Zhu L, Shen M, Sharif K, Wan Z, and Ren K. 2018. A blockchain-based privacy-preserving payment mechanism for vehicle-to-grid networks. IEEE network 32, 6, 184-192.

Grech, Alexander, and Camilleri A.F. 2017. Blockchain in education.

Greenspan, Gideon. 2015. Multichain private blockchain-white paper. URl: http://www. multichain. com/download/MultiChain-White-Paper.

Grey Healthcare Group. 2017. Blockchain: What's Next for Healthcare?

Haferkorn, Martin, and Diaz J.M.Q. 2014. Seasonality and interconnectivity within cryptocurrencies-an analysis on the basis of bitcoin, litecoin and namecoin. In International Workshop on Enterprise Applications and Services in the Finance Industry, 106-120. Springer, Cham.

Hou, Heng. 2017. The application of blockchain technology in E-government in China. In 2017 26th International Conference on Computer Communication and Networks (ICCCN), 1-4. IEEE.

Hsiao, Jen-Ho, Tso R., Chen C.M, and Wu M.E. 2017. Decentralized E-voting systems based on the blockchain technology. In Advances in Computer Science and Ubiquitous Computing, 305-309. Springer, Singapore.

Ibba, Simona, Pinna A, Seu M, and Pani F.E. 2017. CitySense: blockchain-oriented smart cities. In Proceedings of the XP2017 Scientific Workshops, 1-5.

Karafiloski, Elena, and Mishev A. 2017. Blockchain solutions for big data challenges: A literature review. In IEEE EUROCON 2017-17th International Conference on Smart Technologies, 763-768. IEEE.

Labs, S. 2014. FINNEY – Secure Open Source Consumer Electronics for the Blockchain Era.

Lin, Chang I, and Liao T.C. 2017. A survey of blockchain security issues and challenges. IJ Network Security, 19(5), 653-659.

Marketing, I. 2017. Key marketing trends for 2017.

Moura, Teogenes, and Gomes A. 2017. Blockchain voting and its effects on election transparency and voter confidence. In Proceedings of the 18th annual international conference on digital government research, 574-575.

Nakamoto, Satoshi. 2008. Bitcoin: A peer-to-peer electronic cash system.

Nguyen, Khanh Q. 2016. Blockchain-a financial technology for future sustainable development. In 2016 3rd International conference on green technology and sustainable development (GTSD), 51-54. IEEE.

Novo, Oscar. 2018. Blockchain meets IoT: An architecture for scalable access management in IoT. IEEE Internet of Things Journal, 5(2), 1184-1195.

Noyes, Charles. 2016. Bitav: Fast anti-malware by distributed blockchain consensus and feedforward scanning. arXiv preprint arXiv:1601.01405.

Paech, Philipp. 2017. The governance of blockchain financial networks. The Modern Law Review 80, 6, 1073-1110.

Patel, Vishal. 2019. A framework for secure and decentralized sharing of medical imaging data via blockchain consensus. Health informatics journal 25(4), 1398-1411.

Politou, Eugenia, Alepis E, and Patsakis C. 2018. Forgetting personal data and revoking consent under the GDPR: Challenges and proposed solutions. Journal of Cybersecurity 4(1), tyy001.

Roberts, Jeff John. 2017. Microsoft and Accenture Unveil Global ID System for Refugees.

Rochard, P. 2014. Speculative attack.

Schiener D. 2014. Liquid Democracy: True Democracy for the 21st Century.

Scott, Stornetta W. 1991. How to time-stamp a digital document. Journal of Cryptology.

Sharma, Kumar P, Chen M.Y, and Park J.H. 2017a. A software defined fog node based distributed blockchain cloud architecture for IoT. Ieee Access, 6, 115-124.

Sharma, Kumar P, Moon S.Y, and Park J.H. 2017b. Block-VN: A distributed Blockchain based vehicular network architecture in smart city. Journal of Information Processing Systems 13(1).

Sharples, Mike, and Domingue J. 2016. The blockchain and kudos: A distributed system for educational record, reputation and reward. In European conference on technology enhanced learning, 90-496. Springer, Cham.

Spearpoint, Michael. 2017. A proposed currency system for academic peer review payments using the blockchain technology. Publications 5(3), 19.

Swan, Melanie. 2015. Blockchain: Blueprint for a new economy. O'Reilly Media, Inc.

Tian, Feng. 2016. An agri-food supply chain traceability system for China based on RFID & blockchain technology. In 2016 13th international conference on service systems and service management (ICSSSM), 1-6. IEEE.

Sharma T.K. 2019. Types Of Blockchain In The Market: Which One Is Better?.

Xia, Bingqing, Ji D, and Yao G. 2017. Enhanced tls handshake authentication with blockchain and smart contract (short paper). In International Workshop on Security, 56-66. Springer, Cham.

Zhang, Ning, Zhong S, and Tian L. 2017. Using blockchain to protect personal privacy in the scenario of online taxi-hailing. International Journal of Computers Communications & Control 12(6), 886-902.

Zhang, Yu, and Wen J. 2015. An IoT electric business model based on the protocol of bitcoin. In 2015 18th international conference on intelligence in next generation networks, 184-191. IEEE.

Zhao, Leon J., Fan S., and Yan J. 2016. Overview of business innovations and research opportunities in blockchain and introduction to the special issue. 1-7.

Zyskind, Guy, and Nathan O. 2015. Decentralizing privacy: Using blockchain to protect personal data. In 2015 IEEE Security and Privacy Workshops, 180-184. IEEE.