Blockchain for Business: Opportunities and Future Directions

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Blockchain or distributed ledger technology (DLT) is a tamper evident and tamper resistant list of records called blocks which are linked in a secure and encrypted way. Blockchains have the potential to disrupt many of the existing businesses processes. Blockchain-enabled applications span across many sectors such as asset management, supply chain management (SCM), energy, finance, healthcare, governance, Internet of Things (IoT), privacy, hospitality operations, data management, etc. The drivers of blockchain adoption include durability, immutability, privacy, transparency, security, tokenization, etc. The barriers to adoption include inter-organizational, intra-organizational, system-related and external barriers. This paper explores the business opportunities, challenges and future directions of blockchain technologies. Blockchain maturity may still take many more years to happen despite few successful implementation use cases.

Keywords: Auditability, Blockchain, Business, Challenges, Opportunities, Security, Supply Chain

1. Introduction

In blockchain (BC), every block or ledger is a piece of data, which is mathematically encrypted. To make the blocks tamper-evident, each block is cryptographically linked to the previous one after validation using a consensus mechanism. This becomes an append-only chain because the newly added blocks make modification or tampering of the older blocks more difficult. A BC network user can be a person, organization, government, and so on. A node is an individual system within a BC network which stores a copy of that BC on a computer, and a full node stores the entire BC to ensure validity of the transactions. A lightweight node does not store a copy of the BC but pass their transactions to full nodes. The miner nodes generally compete against each other to produce new blocks and get rewarded for their work.

In BCs, the digital ledgers are implemented with or without central repositories and authorities. Accordingly, the BCs are classified into public or permission-less BCs, private BCs and permissioned or consortium BCs (Viriyasitavat et al., 2019). With public BCs, the system is open to any new participant and all participants can read and validate the new blocks. Cryptocurrencies such as Bitcoin and Ethereum are examples of public BCs where the users have the freedom to join, participate and leave the system. With private BCs, the new nodes are read, validated and accepted by a central authority. In private BCs, all nodes are predefined and trusted, and the owner has the maximum rights. Permissioned BCs are hybrid public-private systems such as Ripple and Stellar, often organized as a consortium. With consortium BCs, the read rights and validation rights could be limited to a certain number of nodes and new nodes are accepted based on consensus. R3CEV is one of the largest financial industry BC consortiums with more than 70 global financial companies being part of it.

BCs have evolved through versions from 1.0 to 4.0. *Blockchain 1.0* represents digital currencies such as Bitcoin, enabling money transfer, remittance and digital payment. *Blockchain 2.0* includes smart contracts and the examples include Ethereum and the finance BC consortium *we. Trade*. The smart contracts are programs that can automatically execute upon meeting certain predefined conditions. *Blockchain 3.0* are decentralized applications with their backend code running on a decentralized BC. The examples include *Aion, Wanchain,* and *Polkado*t projects. *Blockchain 4.0* proposes to include artificial intelligence (AI) in BC applications (Agnelis et al., 2019). AI allows machine learning (ML) whereas BC guarantees data accuracy. Thus, BCs can feed accurate data into the AI system resulting in much better performance, and *Cognitive Scale* is an example system for the combination. *Seele* and *#MetaHash* are also examples for *Blockchain 4.0* which promise to have faster algorithms, cross-chain support, capacity to update the protocols without the need of a hard fork, and increased security.

2. Business Opportunities

BC technologies have created lot of interest (Andoni et al., 2019) in asset management, energy sector, supply chain sector, finance sector, real-estate sector, governance sector, C2C commerce, academic community, etc. BC offers a decentralized platform where consumers and suppliers can connect directly without intermediaries. This reduces the transaction costs and time and minimize errors or conflicts in contracts. The BC startup *SyncFab* is an example platform which guarantees product tracking and quality assurance (Li et al., 2019). Their crypto currency can be used as a utility token for the transactions over the platform. BC uses in education include IPR protection for educational content, keeping of permanent student records, student identity and credentials verification, automatic credit transfers, etc. BCs can thus reduce the costs, eliminate frauds, save time by eliminating the manual verification of transcripts, and so on in the education sector. BCs can be used for handling the identities of migrant people (Hughes et al., 2019b). For example, lots of people from the rural areas of North and East India travel to the South and West regions of India for employment. These migrant family members are off the local government records and often untraceable when some crime gets reported. BC can help the local governments in setting up tamperproof records for such migrant families which could be useful for maintaining migrant children's school records, providing health support, providing social welfare schemes, etc.

BC allows open innovation where research or product ideas can be uploaded into systems for funding or partnership (Li et al., 2019). Here all data are notarized through BC and only encrypted data are shared between parties. BCs have lot of opportunities in businesses where transaction reliability and efficiency are of primary focus. Examples could be in tracking food distribution and supply processes. In transportation logistics also, BC can be used to increase efficiency and transparency (Li et al., 2019). The second-generation BCs such as Ethereum allows applications to support games, asset management, etc. which could be useful in building new business models (Li et al., 2019). The BC serves as a development platform for decentralized and very secure software applications. This setup is open to incremental innovation by participants. As there are no intermediaries, the costs would be less for new entrants (Hughes et al., 2019a) and technologies like AI and IoT make them more competitive. The disintermediation and automation increase the speed and reduce the overall expenditures. BC allows tamperproof storage of voter credentials and digitized land documents, and monitoring land registration, driving the governance initiatives. A musical BC can ensure ownership and licensing rights to every stakeholder, including the artist. The BC transactions have non-repudiation property where stakeholders cannot deny or dispute their entries to the BC transactions (Hughes et al., 2019a). Li et al. (2019) proposed a BC-enabled workflow operating system (Bc-WfOS) which could serve as a central platform for sharing heterogeneous logistics resources with stakeholders.

Many issues with SCM can be addresses with BC. Here the concerned parties can automatically ascertain the ownership of goods, monitor the shipping process and request payments on receipt of goods without any deceit. Every participant in the supply chain with a private key will make an entry in the BC on the status of the product. This allows every member to identify where mishandling has happened (Hughes et al., 2019a). This is particularly important in supply chains handling luxury items such as precious stones and jewelry, and for items such as postal services, clothing and apparel, food items, etc. for ensuring the authenticity of the items. Choi (2019) describes how BC can be useful in diamond authentication and certification. Authentication is important in supply chains dealing with used and recycled products also. The authenticity of products can be permanently stored in the BC which could be verified by the other parties. The authentication certificate can be locked with a product using an IoT device (Hughes et al., 2019a). The security and convenience of BCs increase with more participants (Tönnissen and Teuteberg, 2019). BCs make the supply chain information stable and immutable, contributing to supply chain social sustainability. BCs help in tracking substandard products thereby minimizing recall of products, contributing to sustainability and reducing emissions. People are willing to buy green and environment friendly products. BCs can authenticate genuine green products accurately which is extremely difficult to identify otherwise. BC's immutable record keeping allows human rights assurance, fair and safe work practices, etc. (Saberi et al., 2019).

The BC technology (Zhao et al., 2019) can transform the world's food system by revolutionizing the agri-food value chain management with respect to traceability of products, immutability of product information, authentication of the manufacturing processes and sustainable water management. The products can be tracked from farm to fork through BC and IoT sensors. Now consumers can take informed decisions on their food choices. This traceability and transparency can contribute to improved customer relationships, better efficiency, reduced risk of food recalls, and so on (Bumblauskas et al., 2019). Among the buyers of farm produce, BC can create the quality confidence and ensure that the farmers are paid according to the fair farmpPrice (FFP) rating (Hughes et al., 2019b). In food supply chains, traceability of ingredients is mandatory to ensure the quality of the food (Behnke and Janssen, 2019). However, the present food supply chains are with organizations having different interests and they may not share traceable information about food ingredients, which could be rectified by BCs. The work by Vaio and Varriale (2019) uses BC technology for airport operations, promoting cooperation between the stakeholders to reduce fragmentation, inefficiency, and uncoordinated operations. Filimonau et al. (2019) shows how hospitality business can benefit from the BC services which include simple and safe money transfers and payments, offering credit facilities to stakeholders, transferring of airline loyalty points to other airlines, etc.

In the storage of electronic health records (EHRs), BCs have the potential to cause major changes. The clinical data of a patient can be stored in a BC with authentication by the specific laboratory. They will be responsible for this data throughout its lifetime and can get commercial benefits when this data is used by other organizations which will also be recorded in the BC. This increases the level of accountability by every stakeholder in the process, leading to better accuracy of the tests and eliminating the chances of data abuse. The ownership of the data still lies with the patient who has every right to decide whether the data should be shared with someone or not (Hughes et al., 2019a). Azaria et al. (2016) proposed an example system for a BC-based EMR called *MedRec* which provides patients a comprehensive and immutable access facility to their medical records and treatment sites. The medical stakeholders can participate in this BC network as "miners". The US pharmaceutical industry uses centralized databases and electronic data interchange (EDI) standard for connecting between manufacturers and distributors, leading to many interoperability issues. With the centralized database, there are risks of diversion and counterfeit of products in pharmaceutical supply chains. BC-based solutions can effectively track and trace the drugs during manufacturing, shipping and distribution. A BC-based system (Wu and Lin, 2019) for pharmaceutical recall can address many of the issues of data tampering and long delays with pharmaceutical supply chains. The recall process includes decision making, investigation, legal actions, etc. and this system reduces the pharmaceutical recall time, ensures transparency and provides data integrity.

BC is revolutionizing (Unal et al., 2019) the financial and banking industry, insurance, money transfer, investments, stock markets, etc. In finance, BC allows real-time and efficient management of client accounts using BC's immutable record-keeping, with provision to access all historical transactions. BC adoption helps businesses to shift from monthly financial cycles to instantaneous transactions (Nawari and Ravindran, 2019). Content-based services use the token economy model of BC to reward for contents in online networks (Tasca and Tessone, 2019). One example is the *SteemIt* social networking service which gives incentives for postings, commenting, or voting (Li et al., 2019). BC allows insurance companies to automate insurance claims, eliminating the chances for fraud and counterfeit claims. This leads to big savings in the verification workload for the agents, resulting in cost advantages for the company (Nawari, and Ravindran, 2019). According to Wang et al. (2020), the BC technology can resolve the cooperative trust issues of industrial Internet of Things (IIoT). A BC-based tamper-proof system can be used as an audit tool for different kinds of hardware products of IIoT. The productivity and operational efficiency of IIoT can be enhanced through BC smart contracts.

3. Challenges

BC is remaining as a technology not well understood by the major portion of our society even today. According to Hughes et al., (2019b), BC adoption needs to overcome various obstacles including many technical challenges. These challenges mostly involve in developing and nurturing the ecosystem needed for BC maturity and wider acceptance. Other major challenges include legal and regulatory compliance issues. Though BC offers lot many opportunities, its wide-scale adoption is mostly prevented (Unal et al., 2019) by the risks associated with regulatory compliance, security, privacy and energy consumption issues. The high anonymity of BCs makes identifying the parties doing illicit transactions such as money laundering very difficult for the regulators. The anonymity permits tax evasions which could be a problem for law enforcing agencies. Risks of inflation due to the possible loss of control on the currency in circulation is another potential threat for the economy. Though crypto currency operates as a substitute for fiat currency, it lacks the legal tender status where customers can refuse it.

The lack of privacy (Hughes et al., 2019b) in BC is because every node in the network maintains the complete history of the transaction data. This history storage can be an advantage from the integrity point of view but a serious limitation to privacy. The replication of the transaction history across all nodes is making BC computationally expensive and causing latency issues which can be a limitation for larger networks. BC uses public key cryptography (PKC) for transaction authentication. PKC uses a key which is a pair of public and private keys, and if the private key is compromised BC does not have any other security mechanism to address it. BC allows only append operations for the transaction blocks and no changes to the transactions are permitted later. This can be viewed as a flexibility limitation of BC. The distributed nature of the BC architecture is making it more robust but can be a limitation in terms of governance and control. When we compare the processing speed, limited by the block size, Bitcoin processes about 7 transactions per second (TPS) whereas EOS processes an average of 3,000 TPS. With respect to the energy consumption, the Bitcoin mining network is highly inefficient and consumes more electricity than the entire country of Ireland annually (Biswas and Gupta, 2020). BC networks are notorious for lack of vigilance by governments and regulatory bodies. The Darknet marketplaces to sell drugs, hacked information, weapons, stolen credit cards, personal data, and so on are supported with cryptocurrencies. So, it is going to be a challenging task to implement BC platforms with the existing technologies, structure, governance and security (Biswas and Gupta, 2020).

The BC intermediaries including digital wallet service providers and clearinghouses for crypto currency transactions replacing the traditional financial intermediaries like commercial banks pose potential threats of increased hacking to customers, financial institutions and governments. For example, the hacking against *Binance* (Unal et al., 2019) resulted in losses of about $40 million in assets, and another $4 billion to the market. This points to the inadequate enforcement of security policies with BC systems. Double spending is a common security risk to BC (Nawari and Ravindran, 2019) where two parallel transactions transfer the same data to different recipients, creating bogus transactions. Another potential security risk to BC is 51% attack where a participant is controlling over 51% of the network and tampering the BC without anyone else checking it. Data malleability is another security issue with BC when the digital signature does not cover all the data in a transaction that is hashed to create the transaction hash. This allows hackers to intercept and modify the transactions. BC gives rise to a privacy issue when a participant can attribute a data to a user by observing the transaction patterns.

In time-critical applications, the delay incurred by transactions is a real concern, particularly with IoT sensors (Viriyasitavat et al., 2019). The finality in transactions is an essential property of BCs and generally public BCs using consensus protocols can guarantee probabilistic finality only. However, the private and permissioned BCs use consensus protocols which can offer faster finality settlement. In BCs, the malicious nodes can collude to exploit and hack the system if the validation process is under their control which could be difficult in public BCs. Private and permissioned BCs are more susceptible to these kinds of attacks where a limited number of authorized nodes do the transaction validation. In operations management (OM), the BC solutions do not guarantee superior performance in terms of effectiveness, efficiency, and sustainability (Vaio and Varriale, 2019). These issues can be addressed if the managers and policy makers can create a collaborative forum to work with a common culture and mutual trust, as shown by Vaio and Varriale (2019) within an airport setting in Italy. Zhao et al. (2019) identified some challenges while applying the BC technology in agri-food value chain management which include storage capacity, scalability, security and privacy, higher cost, regulation issues, throughput and latency issues, lack of skills, etc. Most of these challenges are originated because of the inherent nature and structure of BC technology.

Biswas and Gupta (2020) makes an attempt to identify and prioritize the barriers in BC adoption. They found scalability issues and market-based risks as the most prominent barriers. This is followed by transaction level uncertainties, technology risks, high sustainability costs, poor economic behavior, privacy issues, usages in underground economy, risks of cyberattacks, and legal and regulatory uncertainties. Saberi et al. (2019) classifies the barriers to BC adoption into intraorganizational barriers, interorganizational barriers, system related barriers, and external barriers. Intraorganizational barriers include financial constraints, lack of management support and commitment, lack of policies for using new technologies, lack of knowledge and expertise in BC, organizational culture change management issues, and lack of BC technology tools. The interorganizational barriers include lack of customer awareness, anxiety about the sustainability of BC technology, supply chain coordination issues, information privacy policy difference between partners, challenges in integrating BC technology with supply chains, and cultural difference between supply chain partners. The system related barriers include security challenges, access to technology, negative perception about BC technology, immutability issues, and immaturity of the technology. The external barriers include lack of regulatory policies, market competition and uncertainty, issues with external stakeholders' support, lack of industry involvement in ethical and safe practices, and lack of rewards and encouragement programs.

4. Future Directions

Many people still think that BC is an overhyped technology. Lot of hard work and determination by the BC community may be needed to develop the tools and techniques to provide the expected advancements to people, society, culture and business (Hughes et al., 2019a). Andoni et al. (2019) states that most BC projects are in the early development phase, and lot of research is needed with inputs from developers, startups, venture capitalists, and users in making improvements in BC scalability, interoperability, decentralization and security. Moreover, many trials, pilot projects and collaborative efforts will be needed before BC shows its full potential and proving its commercial viability for being adopted in the mainstream business. The International Standards Organization (ISO) is developing the BC standards ISO/TC 307 (Tönnissen and Teuteberg, 2019) which could address some of the standardization issues with BC technologies. The BC technology could be useful in meeting the UN (Hughes et al., 2019b) sustainability goals to address the problems in long supply chains with high potential for corruption, in issues relating to the health and safety of citizens, in governance situations that require transparency and integrity, etc. In construction management (Nawari and Ravindran, 2019), BC technology has the potential to revolutionize the existing design and engineering practices for effective management and utilization of tools enhancing efficiency, 3D design and modeling, cloud-based databases for collaboration, smart contracts, digital asset management, etc. BC technology can substantially reduce the costs in connection with IPR protection and contract execution and check the drops in quality standards. A potential business opportunity could be a BC-based market for design professionals to sell the designs and workflows.

Angelis et al. (2019) explores the relationship between BC technologies and their value drivers using a framework for value analysis in BC adoption. They identify transparency, immutability, privacy, durability and reliability, fault tolerance, democratization, security, risk control, and tokenization as value opportunities in BCs. The value drivers are transaction cost, added services, organization boundaries, and autonomous decision making. The parameters deciding the feasibility and viability of BC technology adoption include scope, resources to adopt and maintain, risk understanding, legal obligations, performance and interoperability. The choice for the technologies includes distributed ledger and centralized ledger. This framework is expected to give decision makers actionable questions and recommendations for BC adoption that creates specific value with respect to the organizational strategy. The characteristics such as immutability, integrity, auditability, disintermediary, validation and transparency (Viriyasitavat et al., 2019) equip BC to revolutionize the business processes though the efforts for integrating BC into main stream business processes is in the early stages. Integration of technologies such as business process management (BPM), IoT, cloud computing, cyber-physical systems (CPS), cognitive computing, artificial intelligence, etc. into Industry 4.0 is a real challenge mostly because of the issues related to conflicting requirements and trade-offs on scalability, security, interoperability, trust, etc. The properties of BC can greatly help Industry 4.0 to achieve its goals such as automation, interoperability, trust, and transparency.

To understand the impacts of BC technology on the market, how it is creating value to customers, and at what cost, etc. requires more socioeconomic research (Burer et al., 2019). In spite of the growth in BC technology adoption, not all businesses benefit from it (Casino et al., 2019). Many users propose BC as a secure alternative to database systems which may not be true. In scenarios where traditional databases are beneficial, it is better to use them instead of going for BCs. BC technology will penetrate more industries and businesses only when the technology becomes more mature. Moreover, the features of the BC need to be tailored to meet the actual requirements of the application. Some interesting questions (Casino et al., 2019) to research about BC include: Whether policy makers will offer subsidies to energy for developing BCs? What will be the impact of BC technology on employment, quality of life, the value system, etc.? How regulatory bodies and governments come with strategies for a cost-effective, smooth and safe transition to an empowered digital society?

5. Conclusions

In this paper we have explored the business opportunities, challenges and future directions in BC research and deployment. Industries and businesses are actively exploring the ways to leverage BC technology and applications. The gaming industry could be a safe testing ground for new BC functionalities considering the business implications. Many Darknet marketplaces for selling illegal drugs, stolen credit cards, and personal data takes payments in terms of cryptocurrencies is a cause for concern. Some of the major economies are still on a 'wait and see' regulatory approach to BCs. Not all businesses are benefiting from BC but only the ones which need immutability, integrity, auditability, disintermediary, validation and transparency. BCs are unlikely to replace the conventional centralized databases and their applications in industry and businesses. It will help reduce corruption in societies as the decision makers will be held accountable for their decisions and approvals. Industry 4.0 together with technologies such as AI and BC are expected to revolutionize automation, trust, and transparency in industry and businesses. However, the BC community will have a herculean task in developing the necessary infrastructure and applications to provide the expected benefits to people, society and business.

6. References

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