The Technology of Blockchain

Subjects: Computer Science, Information Systems
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Blockchain is a system of records created using cryptography to link and secure blocks (of records) and is stored on a peer-to-peer network that adheres to a “consensus protocol” which enables it to work without centralized management. It is a revolutionary technology that has immense potential to create a long-lasting impact. It is speculated to be a key technology that shall be part of the Industry 4.0 revolution.

Keywords: bitcoin ; cryptograpy ; cryptocurrency ; trust ; transparency ; immutability ; traceability ; security ; database ; sustainability

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1. Introduction

1.1 History

Blockchain was conceptualized by Satoshi Nakamoto[1] in 2008. It is not known whether Satoshi Nakamoto is a single person or a group of persons. Satoshi Nakamoto authored the white paper of bitcoin[2] and also created and deployed the bitcoin network. The building blocks for this technology like Merkle Tree[3], etc were created much earlier starting in the late 1980s and in the 1990s.

1.2 Blockchain for a new researcher

In simplest terms blockchain is a database technology (technology to store data) which promises important properties like trust, transparency, traceability, immutability, decentralization, etc. Blockchain is essentially a distributed systems technology which means that multiple copies of data are stored essentially on different network nodes. It is a peer to peer exchange which does not require any trusted third party. This absence of a trusted third party distinguishes it from a traditional distributed database and creates a requirement for a consensus mechanism.

1.3 Byzantine Generals Problem and Fault Tolerance

Blockchain systems solve the Byzantine Generals Problem. This makes it possible for the blockchain to achieve verifiable decentralized consensus, even with malicious nodes, making it much more fault-tolerant.

1.4 Consensus Algorithms

There is no perfect consensus protocol. Many options exist like

(a) Proof of Work

(b) Proof of Stake

(c) Delegated Proof of Stake

(d) Proof of Authority

The legendary Bitcoin network uses the Proof of Work.

1.5 Cryptocurrency

A currency which stores all associated transactions on a blockchain is called a cryptocurrency. Bitcoin is the most popular cryptocurrency followed by Ethereum. Hundreds of cryptocurrencies have emerged and there are crypto-exchanges where cryptocurrencies can be traded for each other or for regular currencies.

2. Benefits of Blockchain Technology

2.1. Traceability

The emergence of blockchain technology appears to be a tailor-made solution for improving traceability in the supply chain [4]. From a customer perspective, product information, including origin, production, modifications, and custody, provides much-needed assurance to the customers [5]. Traceability is one of the key measures of operational efficiencies [6]. In a supply chain (SC), from a quality-assurance perspective, while it is desirable to trace each ingredient of the end product, it is difficult to ensure the same because of the varying interests and priorities of the stakeholders [7]. This aspect highlights that the successful application of blockchain technology requires the standardization of traceability processes and interfaces. Consumer preferences differ with regards to three technological systems supporting traceability, namely Near Field Communication (NFC) [8], Radio Frequency Identification (RFID), and Quick Response (QR) code particularly due to the cost impact associated with the adoption of these complementary technologies [9].

2.2. Transparency

Blockchain technology can address the question of how to enhance accuracy and transparency while moving goods through a global supply chain [10]. Blockchain allows us to store easily auditable provenance knowledge securely. The integration of blockchain in the supply chain architecture can lead to a more transparent, reliable, authentic, and secure system [11]. Blockchain technology allows easy implementation of transparency features among multiple parties by compilation and verification of information [12]. Because of the benefit of real-time transparency, blockchain technology is a recommended tool for sustainability in the manufacturing industry [13]. Transparency as an extrapolation of “trust” is needed both inside and outside the government, for more participative decision-making processes in the sustainable supply chains [14].

2.3. Trust

A single version of the truth is a revolutionary concept considering how supply chains operate today [15]. The potential of blockchain to create trust resonates strongly in the supply chain world, where a lack of trust is a significant barrier for collaboration [16]. “Trust” has been identified as the blockchain’s most significant advantage, from a supply chain perspective [17]. A blockchain can replace the burden of proof that users need while exchanging information, and this could unlock huge efficiencies. Cyber-physical systems that enable modern supply chains can gather trust and security in transactions through blockchain technology [18].

2.4. Digital Identity

Blockchain networks can store various kinds of important information and provide a digital identity. Immutable document exchange networks have begun to emerge in global trade. Such a digital identity will change societal views on identity, privacy, and security. Hence, the digital identity will work as a primary construct for the stakeholders in the supply chain [19].

2.5. Frictionless Collaboration

Frictionless collaboration accelerates cycle times and enhances operational efficiency by improving internal coordination and supplier performance [20].

2.6. Anti-Counterfeiting

Any compromise to the healthcare supply chain affects the well-being of the patient. Blockchain can eliminate the problem of fraudulent attacks, as records can be updated only through smart contracts. Annually, USD 200 billion is lost to counterfeit drugs, and the only blockchain is being vouched as a possible solution to bring a unified tracking system that can prevent such counterfeiting [21]. The human and financial loss due to errors in the medication supply chain can bring a fresh wave of security in the healthcare sector. Blockchain shall be central to such a strategy [22]. The development of blockchain technology-based solutions to improve this information exchange from a managerial and political point of view shall lead to the prevention of fraud [23].

3. Impact of Blockchain Technology

Blockchain technology is considered an essential part of Industry 4.0, along with other technologies, like the Internet of Things (IoT) and Big Data. As a revolutionary technology, blockchain exerts a noticeable impact on society, law, and governance. Some of its applications, such as voting based on blockchain technology, have political implications. Blockchain has even impacted organizational design by creating the possibility of decentralized autonomous organizations. Concerning its use in cryptocurrencies, various countries have taken different stances regarding Bitcoin, ICOs, and other blockchain applications. The positive aspect is that blockchain is not just one network, but comprises multiple networks with different consensus mechanisms and other specifications. There are multiple levels of tokenization that can help the adoption of certain blockchain networks; however, certain networks may be banned in more conservative or risk-averse countries. Tokenization provides four key advantages to all investors and sellers—greater liquidity, faster and cheaper transactions, enhanced transparency, and increased accessibility. Tokenization is not an essential component of all blockchain-based applications. However, it is the key behind most of the disruptions in the financial sector, and it serves as a basis for ICOs.

4. Blockchain and Sustainable Supply Chain Management

The authors have recently reviewed the literature for blockchain technology for sustainable supply chain management in great detail [24]. The review has developed an Emerging Technology Literature Classification Level (ETLCL) framework, which has wide applicability.

The merits of blockchain technology for SCM and logistics have been studied for quite some time. These studies have proposed to use blockchain technology for managing the supply chains of companies in the fields of manufacturing, agriculture, food, pharmaceutical, e-commerce, airlines, hotels, and retail, as well as within the supply chains of many others sectors. The role of blockchain in the supply chain is to act as an inter-organizational system; this starts with tracking the journey of products from raw materials to finished goods. Tokenization, low-energy-consuming consensus protocols, and smart contracts have added new dimensions to the potential of blockchain technology in SCM. Economic performance, social performance, and environmental performance form the three pillars of sustainability. It is often a challenge for businesses to follow sustainability practices while delivering improved environmental and financial performance. The social performance calls for a democratic design where the rights and needs of all stakeholders are protected. There are long-term benefits for promoting sustainable development objectives, which are also referred to as the triple bottom line. While boosting its competitive advantage, an organization can engage in activities that have a positive environmental and societal impact. This aspect must be analyzed in terms of supply chain activities. In this context, it must be noted that collaboration plays a crucial role in optimizing the flow of goods, information, and financial transactions. Very often, the supply chain participants have conflicting interests and priorities. There also exists a technological barrier of incompatible systems used by different parties to track shipments. Firms can address these challenges by integrating sustainability into their overall strategy. This will help firms to make a positive impact on the economy, society, and environment.

Nir Kshetri has received a huge number of citations for his paper titled “Blockchain’s roles in meeting key supply chain management objectives” [25]. This paper by Nir Kshetri, published in 2018, addresses the fundamental question of the applicability of blockchain technology in fulfilling the objectives of SCM. On the dimension of cost alone, multiple use cases make it economically sensible to have blockchain tokens for smaller transactions as well. Like all digital technology, blockchain helps eliminate paper records, thereby reducing the cost of regulatory compliance. Cost-related benefits also accrue from proper handling of a crisis involving the defective products and the total collapse of mechanisms for partners engaged in low-quality and counterfeit ingredients. There are also benefits that come in the dimensions of speed and dependability. Digitizing the physical process reduces the number of human interactions involved bringing in speed. Digital certification based on blockchain technology implies increase trust or dependability. Risk reduction in another supply chain performance dimension where blockchain technology-based solutions score over other solutions. It is important to note that blockchain technology makes it possible to verify sustainability, i.e., the indicators related to sustainability can become more quantifiable and meaningful. Blockchain solutions are more flexible than traditional IT solutions.

Kristoffer Francisco and David Swanson wrote a seminal article, “The Supply Chain Has No Clothes: Technology Adoption of Blockchain for Supply Chain Transparency” [26]. This paper emphasizes that each and every product that goes through the supply chain has a long history. However, much of this history is not captured in the form of data anywhere in the current scenario. Moreover, the data that may exist in silos are not transparent. Many unethical practices often happen in the supply chain. These negative practices often create financially crippling situations. Some examples of negative practices are the use of child labor or the unethical use of natural resources. The adoption of blockchain technology as a

foundational framework for supply chain traceability has been studied by using the well-known Unified Theory of Acceptance and Use of Technology (UTAUT). In the age of information technology revolution where customers are empowered, it is essential to provide more and more information about the products purchased. Blockchain technology can easily provide a high level of supply chain transparency, which cannot only help answer customer queries but also gain substantive competitive advantage.

Sara Saberi, Mahtab Kouhizadeh, Joseph Sarkis, and Lejia Shen are among the few authors who have discussed blockchain technology's relationship to SSCM [27]. It investigates the question of how blockchain can address and aid sustainability in the supply chain. It concludes by identifying four major adoption barrier categories for blockchain technologies. These are as follows: (a) inter-organizational barriers, (b) intra-organizational barriers, (c) technical or system-related barriers, and (d) external barriers.

5. Conclusions

The blockchain technology gained prominence because of its use in Bitcoin and the latter's prevalence, adoption, and rising price. Today, cryptocurrencies, initial currency offerings (ICOs), and cryptocurrency exchanges have become common, with the emergence of a new cryptocurrency or an ICO becoming commonplace. Blockchain is the technology that provides foundations to develop a cryptocurrency like Bitcoin and also other cryptocurrencies, and it has been proven to be robust, efficient, and a secure means of exchanging currency. The broad use of blockchain for cryptocurrencies has led to its popularity and prompted an examination into its possible applications. Evidence shows that blockchain may revolutionize many fields, not just finance. Using the concept of Gartner's "hype cycle" to access the maturity of blockchain technology, it is opined that blockchain technology is currently at the peak of the "hype cycle" and anticipates that its next stop would be the "trough of disillusionment" [28]. Analysts agree that the creation of a "trust model" of the entire system is a precondition for allowing the existing platforms of any of the enterprises to reach any real level of maturity.

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