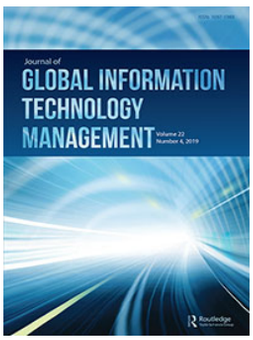

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EDITORIAL

The Blockchain: Opportunities for Research in Information Systems and Information Technology

Introduction

Blockchain technology is regarded by many IT innovators and experts as one of the most significant technological innovations in recent years in the field of digitization of secure ownership of assets. The technology is founded upon the concept of a distributed ledger, a way of decentralized cataloging and accounting for large volumes of data. Blockchain is viewed by many as a disruptive technology that "will revolutionize business and redefine companies and economies." (Iansiti & Lakhani, 2017, p. 4)

There is growing anticipation at present that the blockchain technology will have a profound impact on many sectors of the industry including, for instance, financial services, supply chain management, manufacturing, transport, healthcare, fashion, and entertainment (Lindman, Rossi, & Tuunainen, 2017; Saberi, Kouhizadeh, Sarkis, & Shen, 2019; Tapscott & Tapscott, 2016). The impact materializes through the improved use of a decentralized, global infrastructure of the digital world with the introduction of novel applications and business models. All this recent progress notwithstanding, academic research in the IS/IT field has been lagging behind the practical advances of this technology. In particular, a definitive framework to study the current public and private blockchain applications has not yet emerged. Indeed, there remains many unexplored avenues and directions for IS research in this field. One especially important research problem that calls for immediate attention focuses on the investigation of many subtle sociocultural aspects of the use of this technology, which bind together individuals, organizations, and the society at large. Some other significant topics of research include a theoretical understanding of the disintermediated online trust behavior of suppliers and consumers, prospective ranges of IOT (the Internet of Things) applications of blockchain, diverse legal issues involving IT/IS digital contracts across blockchain platforms, and so on. The present editorial will prove useful not only to those researchers who have earlier made attempts to publish IS research on the blockchain and cryptocurrency usage technology but also to those who intend to explore the new field and look forward to publishing their work for the first time in the near future.

Computing and Technology

A Bit of History

Sometime after the crash of the global financial industry in 2008, the idea of the bitcoin cryptocurrency and its underlying distributed ledger technology was released in a white paper and emailed to a community of cryptography and computation experts by an unknown person or persons using the name Satoshi Nakamoto (Nakamoto, 2009). The software was also made available in the form of open source code at that time. The real identity of Nakamoto is still unknown and rather controversial, but it has, from time to time, been attributed to various cryptography experts and computer scientists or even to some groups of them (Wikipedia-Nakamoto, 2017). By 2011, Nakamoto had completely disappeared from the Bitcoin development community.

Digital Cryptocurrency

The idea of the digital cryptocurrency was established in a trusted protocol, which was grounded in a set of rules that guaranteed the integrity of data exchanged in distributed computations across billions of computers all over the world without the need for authentication provided by a trusted third party, such as a bank, MasterCard, Visa, or even PayPal. This revolutionary idea immediately caught the attention of many individuals in the computing world and caused a considerable flutter in the dovecotes of the financial world, including governments, a large number of multinational firms and business houses, as well as the commercial and the social media. The trusted protocol is embedded in the blockchain architecture of the globally distributed ledger. Although many ledgers have subsequently been developed, the bitcoin blockchain has remained the largest and the most popular one for online digital transactions distributed across the network.

Blockchain Architecture and Characterization

As illustrated in Figure 1, a blockchain is a chain of blocks that contains a complete record of transactions that may be publicly or privately distributed (hence, decentralized) to all users of the chain. Each block is a data structure that contains a header and a body. The header keeps various bookkeeping information, such as the block version, a timestamp, a cryptographic hash identifying the previous block, and so on. The body of the block consists of a transaction counter together with all of the valid transactions. The number of transactions that can be contained in a block is limited primarily by the block size as well as by the size of the individual transactions. The starting block of a blockchain is called the genesis block, because no block in the chain precedes it. Typically, the chain keeps growing in size with the addition of new blocks to the blocks already present in the chain.

Commonly, three kinds of networks are in use that allow blockchain transactions to take place. On a public network, any user can enter into a transaction with any other user. This is the most common method in bitcoin payments, for example. In contrast to this open-network form of transaction, the other extreme is a network of a fully permissioned blockchain that allows one organization or a corporate entity to carry out its dedicated transactions. This is the most common method used when, for instance, a financial institution conducts some businesses using the blockchain technology on its privately controlled network. Somewhere in the middle is a consortium blockchain network that is partially decentralized, in a way that allows only a selected group of users to carry out their transactions on the network. All of the above kinds of commercial transactions employing the blockchain technology share a few key characteristics. These include, among others, anonymity (but not complete privacy protection); real-time record updates; decentralization and disintermediation; and persistency.

The Double-Spend Problem

A central question in digital currency transactions is this: What is the guarantee that a certain amount of digital cash that has already been spent earlier in some transactions will not be spent

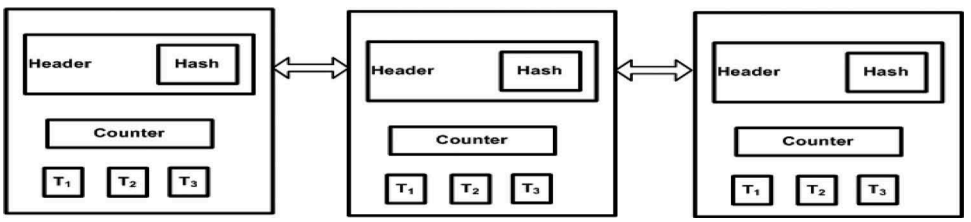

Figure 1. The basic blockchain architecture.

again in the future to conduct some other transactions? This is popularly known as the double-spend problem. In a trustless cash-exchange environment, digital currency can possibly be copied as many times as one desires. Therefore, a trusted, central intermediary (for example, a commercial bank, a government agency, or a credit card company) must keep a ledger to record digital cash that has been used once. The bitcoin cryptocurrency provides a practical solution to this problem, which is embedded in its mining and the distributed ledger protocol of the blockchain. This results in a consensus to be first developed with regard to each transaction on the network before the transaction can be validated and subsequently consummated. The consensus mechanism is based on an algorithm called the proof of work or, in short, PoW.

The Bitcoin Cryptocurrency

Bitcoin is a form of digital cash tied to an online payment system, in which any peer-to-peer transaction is cryptographically authenticated by the underlying blockchain technology. Online cash dealings using bitcoins are decentralized and stored on the blockchain ledger, which is distributed across the computers of practically all bitcoin users or accountholders anywhere in the world. These transactions are continuously updated on the Internet. The anonymity of bitcoins stems from its use of peer-to-peer file sharing and public-key encrypted addresses for carrying out all transactions on the network. The private keys are in the possession of the individual users of the system and are not disclosed. To carry out a transaction using bitcoins, users simply attach their digital signatures to the transaction using the private keys that are in their personal possession. At the other end, the signatures are verified with the public keys that are available on the network. In this way, bitcoin transactions proceed electronically (sometimes with a nominal transaction fee) with the help of a bitcoin wallet as an app running on a mobile device or as a web application executing on a personal computer.

IS Research Challenges and Opportunities

Mobile devices accessing the cloud as well as cloud-based distributed database systems and numerous associated tools for business intelligence and analytics are being increasing adopted in today's globalized business transactions. These recent advances in the field of information technology and systems are opening up a multitude of possibilities in a new world of distributed cryptocurrency transactions and online payments without the need for authentication that would normally be provided by a trusted third party. These transactions are consolidated and protected by sophisticated decentralized computational techniques and related algorithms that can be executed even in apparently trustless environments.

Theoretical Concerns

Until quite recently, the majority of the challenges in distributed financial transactions that were performed online have centered primarily on technical and legal issues. With the advent of the new blockchain technology, new research directions are opening up in distributed transactional systems involving online payment modes of digital cash as well as dealing with the business intricacies of asset allocation and management platforms (Lindman et al., 2017). These encompass not only financial transactions but also records of legal and public proceedings, such as marriage and birth certificates, court notices, registration and sale deeds, and so on. Other instruments include smart contracts, buying and selling of real estate as well as many other hard assets, such as gold, diamonds, and vehicles. These challenging issues are pushing the frontiers of IS research in directions which would have been unimaginable even a few years previously.

A major theoretical issue in blockchain IS research concerns the dialectical relationship between the openness of a digital transaction and its purported anonymity. A framework for correctly addressing this relationship must provide a way to ensure the benefits of both without actually sacrificing the accuracy of either. How the public-private and its more general form of multisig encryption mechanisms could theoretically address this challenge is a research question of primary importance. A considerable amount of interest in IS research has already concentrated on issues of open source code, systems, as well as computational platforms. How the openness inherent in the digital cryptocurrency and its underlying blockchain technology is adapted to the domain of openness research in IS is a matter of high theoretical interest to IS researchers. A related issue whose implications are not entirely clear at this time is the fundamental governance structure of the open-source software development communities that are responsible for implementing and enhancing the blockchain technology (Lindman et al., 2017). This issue is popularly known as the "governance crisis problem."

Another research question of major theoretical importance revolves around the issue of trust-consolidation in online transactions. The trust angle has been intensively elucidated both by IT/IS researchers in the areas of e-business and e-commerce as well as by marketing researchers and economists in the areas of online shopping, consumer behavior, and online retail and digital marketing. In almost all kinds of online exchanges, trust is looked upon as the most fundamental mechanism for minimizing the complexities and the attendant uncertainties of the transactions that are carried out in the electronic marketplace. What, then, are the corresponding conditions of cryptocurrency-based e-commerce transactions that are essential for the formation of trust between interested parties intending to carry out these transactions? What exactly is the basic object that is to be trusted in the first place in this regard? Is it the openness of the transactions themselves? Their anonymity? The cryptographically encoded protocol? Or, perhaps some combinations of all of them? In addition, questions arise as to whether the source of the basic uncertainty in the process stems from the decentralized nature of the systems themselves and/or from the specific type of the transactions that are digitally executed on the network.

Next arises the question of risks inherent in cryptocurrency-based transactions. How are the concerned risks to be identified, assessed, and mitigated in the absence of any trusted third-party intermediaries that oversee the genuineness of the transactions? Judging by the advertised trustworthiness of the blockchain technology, can an element of risk be ultimately converted to an opportunity for business? Both for the online consumer as well as for the organization involved in cryptography-based transactions, the theoretical potential of a risk-benefit analysis is immense. Such an analysis can facilitate the process of conceptualizing better and more efficient services and as well as the formulation of more robust and trustworthy protocols.

It goes without saying that we do not have a complete understanding of many of these theoretical issues at present, and the research gap in this area is particularly prominent. There is, therefore, an immediate call for research to theoretically clarify some of these doubts and misunderstandings and thereby to provide a better understanding of the critical issues from the IS perspective.

Practical Considerations

The blockchain technology constitutes the bedrock of cryptocurrency-based transactions in all kinds of network environments, including many trustless ones. To address some of the critical issues of practical importance in this field, an IS researcher can broadly classify the issues into two primary categories: individual issues and organizational issues. An individual issue that has surfaced with major impact on the IS discipline in recent years is related to the assessment and evaluation of the innovative service solution provided by the blockchain technology. To be sure, the cryptocurrency-driven online exchanges are relatively novel service-delivery experiences for customers who are traditionally brought up in transaction environments that are always controlled by trusted third-

party intermediaries. Without the guaranteed protection and safety provided by one of these agencies, the customers might initially feel completely out of place in the new environment of this technology and subsequently face an uphill struggle to learn and be comfortably familiar with its novel service-delivery structure. How this new technological innovation will enhance customer confidence in and satisfaction with cryptography-driven currency exchanges is a subject of active research today. Besides, when large business organizations and governments are also involved in these transactions, further innovations in processes as well as products are simultaneously called for.

In the practical world, it is essential that the demands of technological innovation be in concordance with those of service-related innovation (Lindman et al., 2017; Tapscott & Tapscott, 2016). Although the practical implications for this association are far-reaching, the demand for a particular form of innovation depends essentially on its utility in the area of its application as well as on the perspective of the potential users. The socioeconomic, educational, and cultural background of the users are critical factors to consider when assessing the impact of the demand of the innovation on the market. For example, is the acceptance of a decentralized payment system, such as bitcoin, natural in a certain rural economy of a country where the majority of the population are poor? If disintermediation is assuredly the guiding philosophy of the blockchain technological movement, how can a smart contract be effectively carried out within a rural community where literacy rate among the users is exceedingly low? Besides, in the latter situation, if the contract is ultimately to be set up by a third party on behalf of the group of individuals wishing to enter into the contract, is it at all conceivable that the role of the intermediary has truly been eliminated in the process? If not, how, then, can the problem of disintermediation be practically solved in this case?

Besides technological gaffes and glitches, the problem of transaction-related disputes is a particularly thorny one when decentralized exchanges are considered. In a situation where the acting parties in an online transaction or a contract are unsure of the proper consummation of the transaction or the contract, it raises both technical as well as legal issues that must be solved offline through manual intervention. In extreme cases, it may even lead to legal or paralegal settlements.

Data Acquisition

Large volumes of data on digital transactions are acquired from online servers and dedicated gateways for designing diverse applications in business analytics using the blockchain technology. One important area is healthcare IT. Acknowledging the high sensitivity of healthcare data pertaining to records of individual patients and medical practitioners, discreet sharing and collaboration in smart medical systems have recently been made possible by intelligent uses of the blockchain public ledger. A research problem of high practical relevance to the IT/IS area concerns the investigation of how medical treatment data (for example, type of disease; doctor's diagnosis; recommended tests; patient's health parameters; etc.) and financial transactions data (for example, prices of medications; treatment fees; operating room charges; etc.) are seamlessly integrated within the ledger.

Digital logistics and supply chains constitute another common business domain where large volumes of real-time online data are exchanged daily. With the help of specialized supply-chain integrators based on a consortium network, many companies that operate in such chains are guaranteed end-to-end data protection and integration of company-specific data needed to make supply-chain transactions free of local oscillations. In these and many other similar applications, large volumes of data are commonly collected from online systems through which the blockchain ledger operates. Many big data and IOT applications are also used to collect such data in real time. Data on the user perception of the use of decentralized exchanges in bitcoins and other cryptocurrencies structured on the blockchain backbone can be collected from participant posts in logistics and blockchain interest groups on Facebook, LinkedIn, Instagram, Twitter, Meetup, Xing and many other popular social media and social networking services. For the purpose of IS research, data collected on the perceived usefulness of decentralized transactions with regard to the purchase, sale,

or advertising of products, utilization of services, viability of current or future technologies, and so on can be mined and analyzed to develop conceptual variables and to understand the relationships between them. For example, user perceptions of transparency in the decentralized currency transaction involving the purchase of a product from a seller located in a different country can be judged against user perceptions of security and ease of use of the transaction.

Global Issues

To be sure, blockchain is a "born-global" technology that is reshaping the global economic order. The technology has a globalized span, connecting users from every corner of the globe and allowing them to carry out cryptograph-enabled, data-secure, decentralized transactions. The implications of the openness of this system of transactions for both individual consumers and businesses are substantial. Such transactions are carried out across many different types of markets and platforms. Because of its diversity, the perception of a particular transaction or a contract may vary widely across users from different geographical regions and countries. With respect to competitive market-based exchanges, the dominance of a particular group of users in certain types of products or services may be foreseen. For an ordinary consumer, however, it is important to identify and assess the specific factor of risk that enters when contracts or exchanges are made with a group that already exercises a strong market dominance in terms of designing pricing strategies for diversified products and services.

From the organizational perspective, new kinds of business strategies and models are required to deal with the decentralized transactions of global span based on the blockchain technology in the open market. For example, what are the distributed currency-exchange implications when crypto-currencies are converted to ordinary currencies? How are the associated risks assessed and mitigated?

Global research implications of the blockchain technology are multifarious. First, transactional transparency embedded in the openness of the technology can be a double-edged sword. The absence of coordination and intermediation of an established institution is unlikely to be interpreted uniformly by people of all cultures and walks of life in all countries of the world. The cultural implications of this aspect of the technology is currently under-researched. Besides, for international transactions in particular, it is an interesting research question to investigate whether disintermediation by means of the technology turns out in reality to be a reintroduction of intermediation in disguise, where traditional intermediaries, such as banks and other financial institutions, retain control over the transactions by redefining their roles within the technology. Besides, is *full* transparency of all blockchain transactions, as advocated by the aficionados of the technology, desirable? We, as IS researchers, are not sure.

The role played by trust in international supply-chain transactions is unclear. Although an open-market economy depends for its smooth functioning on formalized and explicit trust-based agreements and protocols, in many developing and transitional economies of the world, a large number of important business transactions are of informal nature, and trust relationships between the transacting parties are implicit rather than explicit. The problem of how two parties having different business structures and based in dissimilar economies of the world can be linked together to carry out decentralized, trust-based transactions on the international market is largely unexplored at this time. There are indeed great opportunities for IS research in elucidating the issue of trust that underpins blockchain transactions in a truly global business environment.

Sociocultural Implications

The influence of the sociocultural backgrounds of the users on the types of transactions they carry out using the blockchain technology is still not completely understood. Already in traditional IS

research, the question of technology acceptance, adoption, and diffusion is an important one. The sociocultural factors that influence the acceptance of the new form of decentralized exchanges founded upon cryptocurrencies is a key IS research problem.

In many traditional cultures of the world, the importance of trust, contextuality, and subjectivity of human interactions is highly crucial to the success of businesses. For example, there is a large presence of family-controlled and community-driven businesses in many South Asian countries, where the implicit trust existing within various business partners drives the volume and nature of business transactions in supply chain modes among them. With the proliferation of decentralized payment systems, how these players will respond to the system and be able to eventually adapt themselves psychologically to the trust-independent blockchain environment is an interesting question to explore. There are serious contextual factors involved here that influence the potential users of the technology from the families or the communities to change their established views of trust and mutual dependence in business relationships.

Concluding Remarks

For a relatively novel and highly disruptive technology such as the blockchain, it is quite premature to say at present whether it will indeed turn out to be a technological revolution in the making or it will just disappear as one of the biggest technological fiascos in the history of humankind. Notwithstanding a number of serious objections to the use of this nascent technology in the most critical financial and government-mediated exchanges, it does possess a number of promising and useful features of interest and research in the areas of e-business, e-commerce, and even ordinary, day-to-day business transactions. Because of the intrinsic decentralized nature of this technology, the overhead transaction costs of many expensive intermediaries have certainly been reduced to a considerable extent. Besides, the openness of the distributed ledger technology also makes visibility ubiquitous instead of leaving it fully in the control of a chosen few trusted parties. The mind-set of an entire generation of traditional users of the online exchange medium will, of course, take some time to fully adapt to the new philosophy of open, decentralized exchanges. The sociocultural and economic backgrounds of the users, who are distributed all over the world, will play a major role in the ultimate diffusion of this technology. In the coming years, therefore, IS researchers will have multiple facets of this technology to explore both from the individual as well as from the organizational perspectives.

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