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Blockchain distributed ledger technology: An introduction and focus on smart contracts

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Abstract

The rapid evolution of the blockchain and distributed ledger technology and the associated applications will require many changes in the way business is transacted and how transactions are recorded. Significant R&D investments in blockchain environments and the maturation of application uses of "smart contracts" and other types of self-executing tools are establishing frameworks for expanded use, infrastructure growth, and further development. The realization of the impact of these investments is currently changing entire business processes, transforming industries, and impacting governments globally. This global disruptive impact is a major technology evolution and will be transformational to society over the next several decades much as the Internet has been over the last 30 years. As these changes will be especially transformational to fundamental accounting processes, tools, and methodologies of today, accounting and finance professionals would be wise to embrace the technological challenges associated with blockchain technology.

KEYWORDS

blockchain, smart contract, transformational technology

1 | INTRODUCTION

Just over ten years have passed since Satoshi Nakamoto released the original Bitcoin whitepaper, *Bitcoin: A Peer-to-Peer Electronic Cash System* and introduced the world to one of the most promising technologies for the future—the blockchain distributed ledger technology (Nakamoto, 2008). The impact of blockchain technology has already and will continue to change the accounting profession and corporate finance in many ways. Specifically, the rapid evolution of the *blockchain* and *distributed ledger technology* (DLT) as well as associated applications will require many changes in the way business is transacted and how we account for transactions. Most importantly, due to the trustless or self-governing nature of the blockchain network structure, many of our professional job roles and responsibilities—such as auditing and assurance services, banking, finance and treasury management, logistics and risk management—are likely to be completely redefined. Currently, according to Forbes, five of the top 10 companies investing in blockchain are from the United States and include JPMorgan Chase, Berkshire Hathaway, Bank of America, Wells Fargo, and Apple (Del Castillo, 2018). With the recent announcement of a major investment in blockchain by Ernst & Young (Multimillion-dollar investment in EY Blockchain Analyzer 2019), all four of the top accounting and audit firms are now heavily investing in DLT developments.

2 | BLOCKCHAIN: AN ADAPTABLE DATABASE TOOL

In its simplest sense, blockchain technology represents a new adaptable database that offers a method for creating transaction ledger entries, vetting and validating the transaction entries, and storing them in a tamper-proof ledger. The unique value created by use of this tool is that after posting an entry to the blockchain ledger, the technology transforms what is required to trust the validity of the change in the balance in the ledger. Historically, accountants and finance

professionals have managed ledgers using double-entry accounting and relied on third-party intermediaries, such as financial institutions, to transfer funds. These processes mandate trust in the intermediary and require continuous confirmation and validation of balances. The blockchain ledger technology utilizes cryptography, hashing, and algorithms for proof of work in a process referred to as mining; creates a new form of digital currency from the tokenization process; and introduces a new method of storing immutable data in a distributed ledger.

These attributes change or eliminate the need for trust. As use of DLT continues to grow and is adapted to traditional ledger applications, there will be a significant reduction or elimination of the need for third-party trust. For example, if a transaction is recorded between Company A selling a widget to Company B for 1 unit of cryptocurrency, there will be no need for separate AR and AP subledger entries, nor will there be a need for a check to clear through the Federal Reserve system. The two companies will be able to establish a "smart" contract and share the same set of ledger data. Upon validation of terms of the contract, the transaction will execute and be posted into the blockchain. The cryptocurrency unit will be immediately transferred from Company B to Company A. The record of the transaction is then stored in the blockchain in an immutable tamper proof distributed ledger with absolute certainty of the ownership of the cryptocurrency unit.

The true brilliance of blockchain technology is derived from the application of a distributed network of computers called "nodes" to store a "copy" of the transaction data in sequenced "blocks." These nodes or "miners" are typically computers running programmed algorithms that are "hashing" or creating a proof-of-work validation of transactions before writing them to the ledger. Users may also participate as a node on the network, but more typically users participate via a digital "wallet" on a site that allows access and the ability to transact with their digital assets or tokens. Clearly, the evolving blockchain infrastructure is beginning to change how business is transacted on a global scale and, undoubtedly, finance and accounting professionals will soon be very involved in the routine use of this technology.

Within a year of its introduction, the first bitcoin (BTC) public purchase transaction was recorded. In this initial transaction, two Papa John's pizzas were purchased for 10,000 BTC, which at today's BTC exchange rate would be a handsome price of roughly $90,000,000! Very quickly, significant global infrastructure and regulatory evolution began as the reality of a token, or cryptocurrency—a new form of digital asset—began to serve as a means of exchange globally. In late 2013, 19-year-old Russian programmer Vitalik Buterin released a whitepaper, *A Next-Generation Smart Contract and Decentralized Application Platform*, introducing his application of blockchain technology (Buterin, 2013). The bitcoin blockchain ledger was limited in scope and application because it is restricted to only recording and tracing BTC ownership. Therefore, Buterin, along with his cofounders British programmer Gavin Wood and Canadian entrepreneur Joseph Lubin, developed the Ethereum blockchain as a platform to serve as the primary foundation for "smart contract" application uses of the blockchain ledger. Providing this type of a platform allowed developers to begin implementation of self-executing or "smart" contracts.

While the bitcoin blockchain is focused on BTC as currency and records only the peer-to-peer movement of the BTC token, Ethereum focuses on providing a blockchain infrastructure as a platform or as a foundation for other decentralized ledger applications that are called "dApps." Using a programming language, typically Solidity, Ethereum developers can code an assortment of automated procedures into digital transactions. dApps are used to establish smart contracts by defining contract management procedures such as conditional enforcement and performance measurement, or by defining payment allocations with the steps executed and recorded into the Ethereum network. Currently, a vast majority of finance dApps are being built on the Ethereum DLT platform. The business logic processing steps or "chaincode" in smart contracts utilize the blockchain hashing, mining, and distributed ledger attributes to functionally maintain the easily auditable and immutable ledger with a much more robust data set.

As use of blockchain and smart contract technologies began to develop, important distinctions in the operational use of the blockchain became imperative to understand. These distinctions are determined by the intended participation in the blockchain environment. In the case of Bitcoin and Ethereum blockchains, the networks are considered "open" and "public." This means there are no restrictions on participation in the blockchain. The blockchain is completely decentralized, and no one has control over the network of users. This allows anyone at any given point in time the ability to join or leave (public) and the ability to read or write a transaction or even audit transactions (open) within the public blockchain ecosystem. Despite the lack of restriction, the ledger is tamper-resistant and trustless, resulting in self-governance without the need for oversight.

Another key feature of an open and public blockchain environment is the ability to maintain the privacy of the data with control over anonymity and confidentiality. This functionality is maintained using encryption and the assignment to the user of a "key" or blockchain token address, which associates the user with the tokens "owned." Transactions made directly to the blockchain do not capture any personal identifiable information, thus the token address is the control over ownership. Connecting

the private key to a user wallet or by implementing the use of a smart contract dApps and chaincode, allows users to also capture and maintain other pertinent identifiable information associated with the transaction.

While privacy and confidentiality are important in an enterprise or industry setting, the use of an absolute unrestricted public blockchain environment with anonymity is not necessarily practical or desired. Thus, eventually closed and private blockchain ecosystems developed. In this type of blockchain network, the participants—both users and miners—are permissioned, and the type of participation allowed is controlled. However, it is important to understand that it is possible to develop a private or permissioned application that functions on a public platform such as Ethereum.

There are also applications of DLT that fall in the categories of public and closed or private and open. Exhibit 1 depicts application of the various operational uses of each type design structure.

Many industries, including the accounting profession, immediately recognized the disruption that the blockchain technology represented and the need for a framework for building blockchain ecosystems. By 2015, two consortiums were formed to explore the continuing evolution of the various blockchain structures. These groups focused on creating a defined, flexible umbrella of architecture, standardization, controls and efficiency, within the programming structure of the DLT (Gruychev, 2019).

An initial group of approximately 50 global financial companies established R3, a distributed ledger technology firm. Introduced in 2016, the R3 organization's DLT platform, Corda serves as an enterprise level DLT digital asset ecosystem primarily for the financial services, trade finance, insurance, and healthcare industries. R3 has grown to over 300 firms and is beginning to see commercial deployments of Corda including live securities lending transactions. This ecosystem is focused on launching applications for the trade finance, collateral lending and syndicated loan markets and foreign exchange. The other consortium, Hyperledger, and its DLT technology referred to as Hyperledger Fabric, is hosted by the Linux Foundation. Much of the original development of Hyperledger Fabric was done by IBM. The focus of the Hyperledger Fabric is also on chaincode standardization and controls, but not industry specific, as it aims to interconnect members on its network across business sectors (Gruychev, 2019).

Gruychev (2019) provides some examples for each platform and where use cases are ongoing, as follows:

EXHIBIT 1 Applications of blockchain design structures[a]

Public and closed	Public and open
Voter record keeping system	Currency systems
Vote recording process	Betting system
	Video games

Private and closed	Private and open
Tax return systems	Supply chain applications
Law enforcement systems	Government financial records
Video games	Corporate public financial reporting

[a]Adapted from *Public* Vs. *Private Blockchain in a Nutshell* (Massessi, 2018)

2.1 | R3 Corda

- Loan/Finance applications
- Insurance applications
- Healthcare record keeping

2.2 | Hyperledger fabric

- Logistics and supply chain applications
- Assets lifecycle such as real estate or insurance contracts
- Airlines or travel agent record keeping
- Bond derivative transaction network
- Finance applications

3 | BLOCKCHAIN TECHNOLOGY APPLICATION: SMART CONTRACTS

The concept of a smart contract is simply the ability to use programmed automation to affect the exchange of money, property, or other items of value without conflict in a transparent method that requires no trust services of a middleman, such as a bank or attorney. Smart contracts are differentiated not only because the contracts define the rules and penalties contained within the agreement, as is the case with traditional contracts, but also because they are designed to automatically enforce those obligations. Buterin explained the smart contract approach as a series of programmed steps where first a record of an asset or currency is transferred into a program and subsequently the program validates a condition and determines where the recorded asset should go (Buterin, 2017). By recording the movement into the decentralized ledger, the transfer is stored and replicated on all nodes, giving the transfer a certain security and immutability. Because of the efficiency in cost and time, and the elimination of mistrust between parties, smart contracts are of intense interest to global businesses across many industries.

The autonomous power that smart contracts offer has resulted in significant use cases that have implications for both businesses and individuals. Some of those applications are detailed below (Coleman, 2016):

3.1 | Simplifying insurance claims processing

Envision the insurance claim process triggered automatically when someone is involved in an automobile accident. The smart insurance contract would recognize the event via a sensor on the vehicle and begin the claim, capture all the specific details such as police records, extent of damage and repair logistics, and record these facts on the blockchain to determine the exact amounts due and trigger execution of payments to the parties at the appropriate points in time.

3.2 | Efficiency in mortgage approval and loan servicing

Smart mortgage contracts can automate connecting the lenders and borrowers and perform underwriting functions in an efficient and less error-prone process. Loan servicing smart contracts can automate the process for accepting mortgage payments, managing escrow accounts for homeowners' insurance and property tax payments, and updating property records and liens.

3.3 | Managing the supply chain

Smart contracts and DLT have proven to bring immediate value to supply chain management. Creating an immutable chain of custody involving the flow of goods from raw materials to finished product has tremendous impact on many industries. Using smart contracts to record changes in ownership rights as items move through the supply chain allows certainty in confirming who is responsible for the product at any given time and creates an absolute auditable trail of origination. Moreover, the efficiency in recordkeeping allows opportunity for dramatic improvements in customs regulation and the flow of international trade.

3.4 | Copyright protection

There is significant research and investment in the use of smart contracts for royalties and copyright protections. These uses are designed to ensure correct royalty payments are received by the proper owner of the royalty rights by using DLT to track of ownership rights and effect transactions for usage.

3.5 | Smart identities

DLT and smart contracts afford an opportunity for individuals to own and control their digital identity. Personal smart contract transactions can define legal identity and capture limitless personal data such as medical history, reputation, or credit history as well as validate asset ownership and obligations.

3.6 | Recording and reporting financial data

Financial recordkeeping and reporting likewise will utilize smart contracts and DLT for improvement in accurate and transparent financial data recording. The business to business ecosystems being developed in Corda and Hyperledger Fabric will ultimately provide an ability to eliminate banks from the daily application of trade finance. The immutable ledger will allow vendors and customers to exist and share one ledger—one company's Account Payable becomes another company's Account Receivable. The smart contracts and the dApps will continue to evolve, driven by the many value creation elements, efficiency, cost, immutability, and simplicity in verification and reporting.

There are numerous exciting blockchain developments ongoing in the finance area. Recently the major global banking payment network SWIFT announced that it has launched a proof-of-concept gateway to link R3 Corda to its platform. SWIFT, which has over 10,000 banks in its network and has had pilot blockchain programs in place since 2016, is focusing on serving the market of high-value corporate payments on its B2B blockchain platform. Additionally, VISA has made recent significant investments in its B2B DLT platform focused primarily on cross-border transactions (Partz, 2019). These developments indicate that the time has come to recognize the changes that the transition to these platforms will have on finance and accounting professionals' roles within organizations. Examples of roles that are changing include treasury and cash management, which are directly impacted by developments in investments and borrowing, the banking system, and payment networks. Accounts payable and receivables roles will see impacts from new payment methods and digital currencies. Inventory management and logistics management will begin to have access to greater chain of custody data, and risk management roles will be impacted most dramatically as businesses strategically manage the disruption caused by this evolving technology.

4 | THE PACE OF CHANGE IS ACCELERATING

As with the early years of the evolution of the Internet, blockchain technology and all the investment in various uses is chaotic and difficult, if not impossible, to completely comprehend or visualize in context. However, it is clear that the distributive ledger technology of blockchain has transformative potential to change global business activity. The transformation will change the fundamental ways that society processes and conducts transactions and the methods it will use for recording transactions and maintaining accountability of assets. It has been stated that blockchain will do to accounting, finance, and legal what the Internet did for communications, advertising,

and media. The Internet is 30 years old as of this writing and has provided a platform to communicate, advertise, and interact with one another—personally and in commerce—in ways that were not even imagined in 1989.

As blockchain continues to evolve, business enterprises in virtually all industries would be wise to consider how blockchain technology might transform their business processes. Often it is not feasible for an organization to create, maintain, and manage a blockchain network or environment. As a result, there are third-party providers known as "blockchain as a service" (BaaS) providers, which offer cloud-based environments on which organizations can build their own blockchain products, apps, or smart contracts. The availability of BaaS significantly reduces the initial investment in blockchain development and/or implementation. BaaS also provides an opportunity for companies to work with skilled technical resources from companies such as IBM, Amazon, or Microsoft in an easy-to-use infrastructure, capitalizing on a wealth of open source resources. Along with the availability of BaaS, these companies also offer significant, inexpensive technical resource material to gain depth of understanding of the evolution and application of uses of the technology. Many companies have committed resources to utilizing the tools provided on these BaaS networks in an effort to avoid the competitive disadvantage that will occur as change in process is implemented. All the major accounting firms have invested significantly in BaaS research and development and are actively providing consulting services to BaaS clients.

The capital markets are a clear leader in DLT adoption, and the impact of DLT on capital markets is a global phenomenon. In an announcement earlier this year, the World Bank stated that it was enabling the use of its blockchain platform for secondary market bond trading, noting that using the distributed ledger technologies was faster, more efficient, and more secure than traditional means. R3 recently reported a wave of capital markets adoption news. Specifically, the company noted that (a) its R3 Corda-based Euro Debt Solution has been used by a German-French-Dutch triad of banks to successfully complete a live commercial paper transaction; (b) a major Japanese financial services company, SBI Holdings, had announced its partnership with R3 to increase the use of Corda in Asia; and (c) 26 French finance companies and five major banks are testing use of Corda for their purposes (Huillet, 2019).

The extensive application of DLT in 2019 is very much a diverse and global reality. This cannot be demonstrated better than to review some of the recent Forbes "top 10 list of blockchain companies to watch" in 2019 (Blount, 2019):

- BiKi.com, a Singapore company founded in June 2018, is a global digital asset exchange building over 1.1 million registered users and 100,000 daily active users in under a year;
- YottaChain, a public blockchain that allows ordinary people to connect to global super-computer and large-scale storage resources;
- HeroToken is building a global DLT environment for billions of unbanked and underbanked loan funds. The intent is to provide a transparent loan marketplace that connects lenders with borrowers worldwide;
- BREACH, a company that insures digital assets by offering products to safeguard user investments;
- KaratGold, a German company, created the KaratGold Coin and developed a robust ecosystem of cross-border blockchain solutions, including the the IMPulse K1 Smartphone, the first phone using Voice Over Blockchain Protocol (VOPB); and
- LiteLink Technologies, a publicly-traded U.S. company developing enterprise platforms and digital wallets to solve problems in the logistics and payment industries by allowing brokers, shippers, and carriers to seamlessly track shipments and settle payments.

These are all creative and innovative evolutions that represent where the uses of the DLT are today. However, the evolution is moving so quickly that it is also recognized that the innovations of today may have a very short shelf life, perhaps as brief as 18 months. One unique adaptation of DLT, that many believe will be the next dramatic blockchain evolution, is called Iota. Iota, developed by the Iota Foundation, introduces new functionality intended to become a transactional layer between the DLT and Internet-of-Things (IOT) devices. Iota also introduces an alternative technique for storing transaction data in a blockchain; its format is referred to as "Tangle." This method dramatically improves the process of validating the transaction, eliminating cost (need for mining rewards), and improving the speed of transactions. Using Iota, IOT devices will be able to communicate with each other and execute payment instructions with one another. Although Iota is still in development, there is substantial effort and investment being dedicated to exploring use cases and testing implications of implementing the IoT payment layer. With greater than 8.3 billion IOT devices in use and expecting the number to more than double to over 18.5 billion by 2025 (Lasse, 2018), a system capable of machine-to-machine interactions in the transaction ecosystem, designed to be secure, immutable, and transaction fee-free will further the transformative impact of distributed ledger technology.

While only time will unveil the full impact of this phase of the evolving technology continuum, the impact on our perception of trust and how business, finance, and accounting are conducted globally will be profound. The accelerated pace of change and the disruption that DLT brings will continue to increase the demands on accounting and finance

professionals. The challenge for them is to continuously keep up to date not only on the technical aspects of their roles but also on the technology, tools, and systems that they work with and manage. The technology disruption also forces ongoing consideration of the skill sets that will be needed in the near future and what services finance and accounting professionals may be called upon to perform. These are truly exciting times with limitless opportunities for those who are prepared for them.

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