Blockchain Implementation in Today's Security Settlement Process

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Abstract

Since its inception around 2009, distributed ledger technology, simply referred to as blockchain, has been thought of as a revolutionary idea that could seriously disrupt and change the financial services industry. Blockchain is a decentralized network that contains every single past network transaction and as a result of this is immutable. Each transaction, which is contained in a block, must be approved by a series of connected nodes that verify previous blocks, through the use of cryptography, before additional transactions can be added. Additional blocks are added to previous ones creating a chain, hence the name blockchain. This technology is mostly used as the backbone of cryptocurrencies - digital tokens that can be transferred between parties which do not rely on central parties to facilitate the change of ownership.

The current process of security settlement which is used to transfer ownership of financial securities such as common stocks and bonds could be made more efficient, secure, take less time, and be made less costly and risky by the implementation of a consortium blockchain by a central securities depository, such as The Depository Trust Company (DTC). However, the new system would need to be able to handle all volume processing requirements of the legacy system currently in place, and the advantages of this new technology must outweigh blockchain network constraints and the conversion cost. Considering the amount of resources that would need to be exhausted to migrate from the legacy system to one based on blockchain, it may not be in the best interest of a central security depository, such as DTC, to make the change. However, by implementing a new set of processes that rely on blockchain technology, DTC and their parent organization will be able to strengthen their competitive advantage in their respective industry.

Contents

Introduction

The emergence of new technologies create opportunities to enhance and possibly revolutionize current processes and also create new products and services. Distributed ledger technology, more commonly known as blockchain, is one of these technologies, and although it is still in its infancy it has created unprecedented levels of excitement in many different industries such as agriculture and manufacturing.[1] The financial services industry, specifically firms that engage in activities related to the trading and settlement of financial securities such as equities and corporate debt, would benefit immensely from the implementation of distributed ledger technology in their operational processes, as these firms rely on practices that blockchain will help improve. Blockchain, which will be discussed in detail in following sections, is simply a decentralized ledger "...in which all committed transactions are stored in a chain of blocks. The chain continuously grows when new blocks are appended to it."[2] If adopted, blockchain technology would offer many advantages over legacy systems such as added operational efficiency, improved security and auditability, and significant cost savings.[3]

One organization in particular, The Depository Trust & Clearing Corporation (DTCC), along with its subsidiaries which include The Depository Trust Company (DTC) and The National Securities Clearing Corporation (NSCC) are currently positioned where the introduction of distributed ledger technology could prove beneficial to their operations, as well as all counter parties that are involved in the process of trading financial securities. By adopting advanced security settlement practices through the use of blockchain, DTCC will be able to sustain and improve their current competitive advantage in a strongly consolidated industry. Efficiencies created by the use of this emerging technology will entice new clients to leave their current service providers to be part of DTCC's expansive settlement network.

In order to fully comprehend the process behind how DTCC will adopt blockchain, as well as the associated benefits and challenges the new technology will bring, one must

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[1]Tripoli, Mischa, and Josef Schmidhuber. *Emerging Opportunities for the Application of Blockchain in the Agri-Food Industry*. Food and Agriculture Organization of the United Nations, Aug. 2018, 3.
[2] Sheng, Zibin, et al. *Blockchain Challenges and Opportunities: A Survey*. Int. J. Web and Grid Services, 2017, 2.
[3] Ibid., 3.

understand: the current trading and settlement process of financial securities that occurs in the United States and globally; the development and role of central securities depositories (such as DTCC); and a high level understanding of distributed ledger technology. Following these discussions will be an outlined plan detailing the steps that will be followed in order for DTCC to successfully implement blockchain into their daily processing routines, as well as the associated benefits. Lastly, possible challenges and problems will be addressed.

David Rutter, founder and CEO of R3, a distributed ledger technology company and leader of a consortium of more than 200 firms in the research and development of blockchain usage in the financial system, stated that distributed ledger technology has created a once in a generation opportunity to change the way financial institutions do business as its use will substantially drive down the cost of business."[4,5] If firms within the financial services industry ignore the capabilities of this disruptive technology then they risk the possibility of being displaced by more innovate organizations that focus on the utilization of emerging technologies, such as blockchain.

Trading and Settlement Process

Overview

The trading of financial securities would not be possible if it wasn't for the advent of financial exchanges which have been in existence for thousands of years.[6] A financial exchange is a place where parties can purchase and sell financial instruments or securities.[7] The financial markets and exchanges have been operating with basically the same methods as we know them today for two centuries. One of the most recognizable securities exchanges is the New York Stock Exchange (NYSE) which dates back as far as 1792.[8] Although securities trading can be

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[4] *The R3 Story*. R3, 2018, https://www.r3.com/about/. Accessed 15 Apr. 209.
[5] Bloomberg Technology. (2018, March 22) *R3 CEO Says Blockchain is a Once in a Generation Opportunity for Financial Markets* [Video File]. Retrieved from https://www.youtube.com/watch?v=4iquzKJWhSg
[6] Beattie, Andrew. *The Birth of Stock Exchanges*. 12 Mar. 2019, www.investopedia.com/articles/07/stock-exchange-history.asp. Accessed 16 Apr. 2019.
[7] Ibid.
[8] Britannica, The Editors of Encyclopaedia. *New York Stock Exchange*. Encyclopædia Britannica, Encyclopædia Britannica, Inc., 25 Oct. 2018, www.britannica.com/topic/New-York-Stock-Exchange.

traced back thousands of years, detailing the complete history is beyond the scope of this paper, however it is important to understand how the trading process operates.

To place a trade, an individual or institution would work with a broker - a trusted party who facilitates the trade by working directly with an exchange. (Exchanges are usually open Monday-Friday with the exception of several major holidays.) For example, the purchaser of a security will use the services of a broker, who will find a trade counterparty (the seller), and execute the trade on an exchange. Once the trade has been executed or completed, the settlement process can begin. The comprehension of the settlement process is imperative to understanding how distributed ledger technologies can disrupt the entire post trade process.

The settlement process involves the steps taken to transfer ownership of an asset between parties. This crucial process was very cumbersome up until the 1970's because financial securities, such as an institution's common stock, were all represented by physical certificates. In order to transfer ownership, someone working for the exchange would have to receive the physical certificate from the seller, or the institution holding the security on behalf of the seller also known as a custodian, update it with the purchaser's name, and send it to the purchaser or the purchaser's custodian.[9] This part of the post trade process, which seemed simple during the early days of exchanges, soon because a massive problem as trading volume increased significantly. This issue became so severe that throughout the 1970's the "...stock exchanges had to shut down one day a week to catch up with what were then considered to be soaring equity trade volumes."[10] It was during this era where the industry adopted new technology that enabled dematerialization, or the elimination of paper certificates.[11]

Central Securities Depositories

Before industry wide dematerialization could occur, there was a need for a central party to administer the new technologies that were to be adopted in the trading and settlement process to replace the antiquated system that relied on paper certificates. This need led to the creation of

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[9]Barone, A. (2019, April 17). *Learn About What a Custodian Is*. Retrieved April 18, 2019, from https://www.investopedia.com/terms/c/custodian.asp
[10]Morris, Virginia B., and Stuart Z Goldstein. *Life Cycle of a Security*. Lightbulb Press, Inc, 2010, Intro.
[11]Ibid., 10

central securities depositories, or CSDs, which secure physical certificates in a single location. All securities held at a CSD have one thing in common - they are fungible - meaning they are interchangeable. An example of a common fungible security is a dollar deposited in a bank. When you deposit a dollar into your account, you are not likely to get back the exact same dollar when you want to make a withdrawal. The same concept occurs with financial securities held within CSDs. In order for this to be possible, all securities held at a CSD are registered with the same name. For instance, all securities held at DTCC are registered in DTCC's nominee name of Cede & Co.[12]

Because shares are registered in one name, CSDs do not have to re-register the ownership name whenever a security's ownership changes, the CSD just needs to update their records electronically, using what is known as book-entry accounting method: the book-entry accounting method used by DTCC is known as the Book Entry Direct Registration System, or DRS.[13,14] This differs from the old process used when trading physical certificates as the owner's name on the actual certificate needed to be updated. The importance of CSDs cannot be overlooked as they are one of the main parties in any security transaction, and help "...automate, centralize, standardize, and streamline processes critical to the security and reliability…" of the financial markets.[15] The Depository Trust Company, a subsidiary of the Depositry Trust and Clearing Corporation, is based in the United States and was formed in 1973 due to the aforementioned paper intensive crisis of the 1970's. DTC is the world's largest CSD, settling nearly $1.48 quadrillion in securities transactions in 2009 alone.[16]

DTCC's Settlement Process

Giving credit to dematerialization and book-entry accounting methods, which were based off of cutting edge technology at the time, and the role of newly formed CSDs, the trading process could now be standardized to offer consistent trade settlement periods. The

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[12]Ibid., 10
[13]Ibid., 4
[14]DRS. (n.d.). Retrieved May 7, 2019, from
http://www.dtcc.com/settlement-and-asset-services/securities-processing/direct-registration-system
[15]Morris, Virginia B., and Stuart Z Goldstein. *Life Cycle of a Security*. Lightbulb Press, Inc, 2010, iii.
[16]Ibid., iii

implementation of a three business day settlement period was adopted, and has since been reduced to just two business days in 2017.[17] For equity trades, the settlement process begins the day the trade is made. This day is referred to as the trade day, or T.[18] During trade day, the order is communicated with the broker and is placed on an exchange to be executed. Once the trade has been executed, details are sent by the broker through the use of a system known as TradeSuite ID, to the National Securities Clearing Corporation (NSCC).[19] This is the first stage in the settlement process, also known as the input stage, and is where trade confirmations between the seller and buyer are matched on NSCC systems.[20] During the first stage, NSCC becomes the central counterparty, or CCP, and acts as a seller for every buyer and a buyer for every seller. NSCC's capacity as a CCP "...guarantee[s] a trade will [be] complete[d] even if an original party to the trade goes bankrupt or similarly defaults."[21] Once this stage has been completed the trade information is then passed onto another system, the Inventory Management System, or IMS, during what is known as the processing stage: "IMS provides a staging area for a participant's transactions by offering various inquiry and prioritization options, audit trails and transaction update capabilities."[22] If asset delivery methods are accepted by the receiving institution, the trade can finally be put into a ready for settlement status to be finalized.

Stage three, known as the settlement stage, occurs on T+1. It is during this stage where information from the previous stages is passed to DTC for final settlement processing. The main activity that occurs during stage three is known as netting, which is the process that "...consolidates the amounts due from and owed to a firm across all the different securities it has traded to a single net debit or net credit."[23] For instance, if a firm has two clients, one who buys asset X and one who sells asset Y, the debit of the purchase and the credit for the sale will be netted together so the firm only has to remit one payment. Payment is made through the Fedwire

[17]*Embracing Disruption: Tapping the Potential of Distributed Ledgers to Improve the Post-Trade Landscape.* DTCC, Jan. 2016.

[18] Morris, Virginia B., and Stuart Z Goldstein. *Life Cycle of a Security*. Lightbulb Press, Inc, 2010, 8

[19] TradeSuite ID. (n.d.). Retrieved April 29, 2019, from http://www.dtcc.com/institutional-trade-processing/itp/tradesuite-id

[20] Understanding the DTCC Subsidiaries Settlement Process. (n.d.). Retrieved April 29, 2019, from http://www.dtcc.com/understanding-settlement/index.html

[21] Morris, Virginia B., and Stuart Z Goldstein. *Life Cycle of a Security*. Lightbulb Press, Inc, 2010, 8

[22]IMS. (n.d.). Retrieved April 29, 2019, from http://www.dtcc.com/settlement-and-asset-services/settlement/inventory-management-system

[23]Morris, Virginia B., and Stuart Z Goldstein. *Life Cycle of a Security*. Lightbulb Press, Inc, 2010, 8

system which is confirmed by the Federal Reserve on T+1. The day after this occurs, settlement is complete, and the purchasing party now has legal ownership of the security.

The trading and settlement process relies on many different parties that are all basing their inputs and outputs on the same data. This process can be made more efficient by introducing the new, cutting edge technology known as distributed ledger technology (DLT), or simply blockchain. (The settlement process described here is specific to DTCC, and inorder to use their services institutions must register with DTCC to become a DTC Participant. Each participant is given a unique number which is used when settling trades.)

Introduction of DLT, or Blockchain

History and Uses

The concept of DLT was first introduced in a white paper report authored by Satoshi Nakamoto in 2008. This technology was originally created to be used in electronic peer-to-peer payment systems[24] so trusted third parties would not need to be used, such as a bank. Blockchain is the underlying technology of cryptocurrencies: "A cryptocurrency is a digital or virtual currency that uses cryptography for security."[25] Some of the more popular cryptocurrencies include Bitcoin, Ethereum, and TRON, however it is important to note that blockchain technology is not synonymous with cryptocurrencies - these virtual currencies simply just use their own versions of decentralized ledger technology to operate.

Cryptocurrencies are not the only use of blockchain technology. Over the course of the last 5 years distributed ledger technology has been implemented to simplify back office processing of large institutions. Additionally, new companies that specialize in this technology, such as R3, have been created, and large technology companies such as Microsoft and IBM have created specific business units to offer Blockchain as a Service (BaaS), all with the goal to help institutions manage and implement decentralized ledger technology. The following sections

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[24]Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System. 1. Retrieved May 5, 2019, from https://bitcoin.org/bitcoin.pdf?

[25]Frankenfield, J. (2019, March 12). Cryptocurrency. Retrieved May 5, 2019, from https://www.investopedia.com/terms/c/cryptocurrency.asp

discuss the technology behind blockchain that is important to understand for the scope of this paper - not all technical details of distributed ledger technology have been included.

Details of Blockchain Technology

Blockchain has many appealing characteristics; first it is a network and can also be used as a searchable database that has built in rules and security which maintains integrity and its own history.[26] Additionally, this technology "...holds a complete list of transaction records like a conventional public ledger..."[27] which is very attractive for use cases that need to track transactions, such as in the setting of DTCC with respect to security trading and settlement. Understanding that blockchain is basically an electronic ledger makes it easy to realize why the technical term for this technology is distributed ledger technology.

Transaction processing on a blockchain network is completed by various nodes that are all connected to the network via computers which verify the complete history of the entire blockchain before completing additional transactions. This is where 'distributed' comes from in distributed ledger technology: all transactions are distributed to all nodes connected to the network. Each transaction, or series of transactions, is included in a block which is then built onto the preexisting series of transactions, hence the term blockchain.[28] Because all nodes are continuously validating the transaction history, and each transaction spreading across the network needs to be confirmed and recorded on all nodes across a network, the network is immutable and nearly impossible to tamper with.[29,30] All nodes need to be in consensus in order for a transaction to be approved and added to the blockchain. Due to the sensitivity of the data that DTCC and its subsidiaries deal with on a daily basis, the immutability and security that blockchains offer cannot go unnoticed.

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[26]*Embracing Disruption: Tapping the Potential of Distributed Ledgers to Improve the Post-Trade Landscape.* DTCC, Jan. 2016, 5.

[27]Sheng, Zibin, et al. *Blockchain Challenges and Opportunities: A Survey.* Int. J. Web and Grid Services, 2017, 4.

[28]Chiu, J., & Koeppl, T. (2018). Blockchain-based Settlement for Asset Trading. Queen's Economic Department. Retrieved May 5, 2019.

[29]Sheng, Zibin, et al. *Blockchain Challenges and Opportunities: A Survey.* Int. J. Web and Grid Services, 2017, 6.

[30]Blockchain Innovation in Wealth and Asset Management. (2017). Ernst & Young. Retrieved May 5, 2019, 2.

Additional Characteristics

Permissionless vs. Permissioned

It is important to understand that not all blockchain networks offer the same network rights to participants. Some networks are permissionless, which means that anyone can become a node on a network, enabling complete decentralization of control.[31] This is true for the Bitcoin network where an individual can become a node on the blockchain by simply downloading the proper computer applications.[32] From there, nodes can compete with other nodes to complete transactions for a reward, a concept known as mining.[33] It should be noted that mining is not as simple as downloading an application - large amounts of computing power are needed.

The opposite of a permissionless blockchain is a permissioned one, which is where nodes must be allowed to participate and join the blockchain network: "A blockchain could be permissioned where some trusted parties have been designated to update and manage the information stored."[34] If DTCC were to implement a blockchain to aid their operational processes, a permissioned one should be used to restrict sensitive client information from being open to anyone.

Public, Private, and Consortium Blockchains

In addition to being permissionless or permissioned, blockchains can be classified as either a public, private, or consortium blockchain. A public blockchain allows anyone to view all network transactions which promotes transparency. The blockchain as discussed by Nakamoto in "Bitcoin, A Peer-to-Peer Electronic Cash System" would be classified as a public blockchain: "The public can see that someone is sending an amount to someone else, but without information

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[31]Netis Group. (2018, May 30). The Difference Between Permissionless and Permissioned Networks. Retrieved May 5, 2019, from
https://medium.com/netis-group-blog/the-difference-between-permissionless-and-permissioned-networks-5acd05578676
[32]Ibid.
[33]Ahamad, S., Nair, M., & Varghese, B. (2013). A Survey on Crypto Currencies. ACEEE. Retrieved May 5, 2019.
[34]Chiu, J., & Koeppl, T. (2018). Blockchain-based Settlement for Asset Trading. Queen's Economic Department. Retrieved May 5, 2019, 3.

linking the transaction to anyone."[35] Exchanges used for security trading also share this transparency capacity as anyone can view recent trading volume. Many financial websites, such as Google Finance, Yahoo Finance, and Fidelity's website show recent trades where trade size and price is published. Confidential aspects of the trade such as parties involved are not open to be seen by the public. Public blockchains are also decentralized: nodes do not belong to one specific group.

Private and consortium blockchains do not offer the same level of transparency to the public as a public blockchain does, and are not completely decentralized. A private blockchain is a network that is not open to the public, and could describe a network that is used internally at an organization for different operational processes. A consortium blockchain is one that is owned and used by a group or consortium. "[A] consortium blockchain is partially centralized, and [a] private blockchain is fully centralized as it is controlled by a single [organization]."[36]

Blockchains have both a permission type and a classification. For instance, a permissionless public blockchain is open for the public to see all transactions, and anyone can become a node on the network. A permissioned consortium blockchain exists when there is transaction transparency within the group however a node must be authorized to verify and add transactions to the blockchain. In a use case scenario where DTCC would implement distributed ledger technology to increase the efficiency of their post trade and settlement process, either a permissioned private or permissioned consortium blockchain could be used.

Benefits of Blockchain in the Post-Trade and Settlement Process

Looking at the entire post trade and settlement process, one realizes how imperative central securities depositories are in today's financial system, specially DTCC and its subsidiaries. DTCC, together with DTC and NSCC are involved in nearly every aspect of the settlement process that occurs in the United States and some foreign countries, and already

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[35]Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System. 6. Retrieved May 5, 2019, from https://bitcoin.org/bitcoin.pdf?
[36]Sheng, Zibin, et al. *Blockchain Challenges and Opportunities: A Survey*. Int. J. Web and Grid Services, 2017, 6.

oversee the current systems that facilitate settlement. "The breadth of DTCC's services across the post-trade lifecycle make the organization uniquely suited to drive further efficiencies across U.S. clearing and settlement processes..." by implementing blockchain technology into their current operational systems infrastructure.[37] The use of distributed ledger technology by DTCC will streamline current processes more so than they have already been, which will save cost and improve the efficiency of the entire financial system.[38] These benefits will firsthandely impact two groups: those using current DTCC settlement systems as well as the end consumer.

The first group that will benefit from the shift away from antiquated, legacy systems, to new ones utilizing distributed ledger technology, are the parties involved with using (inputting and receiving output from) the current systems. DTCC, its subsidiaries such as DTC and NSCC, and DTC participant organizations fall into this group, and the following are the direct benefits of using blockchain. Blockchain based systems have the capability of reducing system vulnerability to technology threats such as cyberattacks and hacking as well as natural disasters.[39] If a permissioned blockchain is used, only authorized nodes will be able to process transactions. Additionally, the immutability of past records make it nearly impossible to adjust transactions in the favor of one party. Utilizing blockchain technology will also reduce the vulnerability of the settlement systems during natural disasters: the current systems are not fully automated so if an office was to lose power then operational processes could not be completed. Blockchain will automate the entire process, so even if one office of DTCC or their subsidiaries was nonoperational, security settlement could still continue because distributed ledger technology relies on many different nodes simultaneously processing requests. The threat of system downtime due to natural disasters may not be totally eradicated, but it is significantly reduced if the system uses DLT.

One process that many financial institutions must undergo are audits by different organizations such as the U.S Securities and Exchange Commision (SEC), or the Federal Depositors Insurance Corporation (FDIC). DTCC, including its subsidiaries, as well as all of it's participant institutions are SEC registered firms meaning they are subject to audits and have to

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[37]Modernizing the U.S. Equity Markets Post-Trade Infrastructure. (2018). DTCC, 11. Retrieved May 7, 2019.
[38]Sheng, Zibin, et al. *Blockchain Challenges and Opportunities: A Survey*. Int. J. Web and Grid Services, 2017, 3.
[39]*Embracing Disruption: Tapping the Potential of Distributed Ledgers to Improve the Post-Trade Landscape.* DTCC, Jan. 2016, 5.

operate under strict SEC compliance regulations.[40] Audits include researching firm operating procedures, processes, and system integrity, which can be costly and time consuming due to current processes. However, "...since each of the transactions on the blockchain is validated and recorded with a timestamp, users can easily verify and trace previous records through accessing any node in the distributed network."[41] The use of blockchain will increase the efficiency of external and internal audit processes, something that current legacy systems which rely on centralized technology could not offer.[42] Additional benefits of implementing distributed ledger technology that would be recognized by users of the current settlement system include improved workflows, the reduction of process related risk, improved reliability of current security infrastructure, and reduced settlement processing inefficiencies.[43]

End users, or those who place trades which will eventually be settled through DTCC and its subsidiaries, will also benefit from the implementation of blockchain technology in the post trade and settlement process. The main risk that is apparent in the current financial system is market, or systematic risk. This risk involves "...the possibility of an investor experiencing losses due to factors that affect the overall performance of the financial markets in which he or she is involved."[44] Market risk is higher when settlement times are long due to the increased chance of fluctuating market prices, and the fact that individuals cannot place trades on securities that are currently in the process of being settled.[45]

Take the following example into consideration: an individual purchases shares of Company X and the trade is executed in the open market on an exchange to be settled in two days time. On T+1, Company X releases financial statements that drastically reduce the share price, making it so the purchaser would like to immediately sell their recently purchased shares of the company because they believe that the share price is expected to decline in the foreseeable future. Unfortunately, the individual cannot place trades on shares that have not settled yet,

[40]LEGAL & REGULATORY. (n.d.). Retrieved May 7, 2019, from http://www.dtcc.com/legal
[41]Sheng, Zibin, et al. *Blockchain Challenges and Opportunities: A Survey*. Int. J. Web and Grid Services, 2017, 7.
[42]*Embracing Disruption: Tapping the Potential of Distributed Ledgers to Improve the Post-Trade Landscape*. DTCC, Jan. 2016, 13.
[43] Ibid., 5.
[44]Chen, J. (2019, March 12). Market Risk. Retrieved May 7, 2019, from https://www.investopedia.com/terms/m/marketrisk.asp
[45]Chiu, J., & Koeppl, T. (2018). Blockchain-based Settlement for Asset Trading. Queen's Economic Department. Retrieved May 5, 2019, 8.

which could take up to 5 calendar days, resulting in a loss that would not have occurred if settlement time was quicker or in real time, something that blockchain based security settlement processes offer. (If the trade was executed on a Thursday, and the next day, Friday, was a holiday where the markets were closed, the individual wouldn't have access to these shares until Tuesday, as the settlement process only operates on business days.) The elimination of a market day, or the adoption of real time settlement due to the implementation of distributed ledger technology in the settlement process, will significantly reduce risk exposure for many individuals as it will reduce the current settlement time of two business days.[46]

Blockchain technology, if introduced to the post-trade and settlement process will be beneficial to DTCC, its subsidiaries, and participant organizations, as it could reduce current system vulnerability as well as make current auditing processes and compliance measures more efficient and cost effective. Additionally, this technology would reduce settlement speed which is very crucial to limiting market risk for individual and institutional traders.

Implementation

Proposal

Distributed ledger technology can be used in several capacities. First, a permissioned private blockchain could be used to make DTCC's internal processes more efficient while the industry still uses the current T+2 settlement period. However, the most beneficial implementation would be a more decentralized approach which is where DTCC and the industry as a whole adopts a shortened settlement time of T+1 through the use of a consortium, permissioned blockchain. To be a consortium blockchain, the network will be owned and run by a group of involved parties, such as DTCC and all DTC participant institutions who will act as system nodes. The reasons to pursue distributed ledger technology exists, and if decided to be considered, DTCC would need to follow a strict schedule. The whole process, which should take no longer than three years, is detailed below. This proposed timeline makes the assumption that

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[46]Modernizing the U.S. Equity Markets Post-Trade Infrastructure. (2018). DTCC, 7. Retrieved May 7, 2019.

industry regulators will approve the implementation of distributed ledger technology and the migration to a T+1 settlement time, however real time settlement could eventually be adopted.

Timeline

Year 1 - Analysis, Design, and Approval

Quarter 1: Feasibility Study

The first step in the entire process is to conduct studies and research determining whether the implementation of blockchain in the security settlement process is actually feasible. DTCC would initiate these studies and possibly hire external sources such as companies specializing in this new technology to aid in this process. During this phase, DTCC will decide if the industry should shift to a T+1 or shorter settlement time, such as real time. It is known that shorter settlement times create efficiencies and reduce risk exposure, which was proven when the migration from T+3 to T+2 was approved. Other factors to be taken into consideration during this phase include analyzing the need for industry wide technology infrastructure updates, the need for more computing and processing power, and the possible need for increased computer storage space as the blockchain contains all previous transactions and will only continue to grow in the future.

Quarter 2: Industry Working Group

After initial research has been conducted and aggregated by DTCC, the formation of an industry working group will need to be completed as there are many parties involved in the settlement process. During the initial stages of creating a plan to migrate from T+3 to T+2, DTCC created an Industry Steering Committee, comprised of approximately 20 participants across key market segments, which was tasked with "...providing governance, direction, and support for the effort to migrate to a T+2 settlement cycle."[47] Participants in this committee included The Association of Global Custodians (AGC), The Investment Company Institute (ICI), The Securities Transfer

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[47]Shortening the Settlement Cycle: The Move to T 2. (2014). 8. Retrieved May 11, 2019, from http://www.ust2.com/pdfs/ssc.pdf

Association, Inc. (STA), and The Securities Industry and Financial Markets Association (SIFMA).[48] The organizations that participated in the T+2 committee should be included in the committee for blockchain and reduced settlement periods as well. Any previous research conducted by DTCC will be brought to this committee for further action. If in agreement, the committee will move forward to get regulatory approval by the SEC and the Financial Industry Regulatory Authority (FINRA).

Quarter 3: Regulatory Approval

Receiving approval by regulatory authorities to adopt new settlement technology, as well as shorten the current settlement time is the next step in the process and could be the most problematic as regulators could simply dismiss the cause. It is important that every detail of the process and benefits are prepared by the industry committee before bringing it to the attention of regulatory authorities. Because the approval of the T+2 settlement period is relatively recent, the benefits of shortened settlement times should still be relevant.

Quarter 4: Industry Wide White Paper

Assuming approval for the proposed plan, DTCC and the industry committee's next step would be to publish a report summarizing the changes as well as the benefits of the proposed changes. This step is very important and will be disseminated publicly to the industry so every party will understand the changes and their role in the adoption of the new processes. During this quarter, DTCC and the industry committee will also start planning the blockchain network and will decide if it will be created internally, or if an external party such as a firm offering Blockchain as a Service will be brought in to aid the design and implementation of the new system. It would be advantageous to bring in external firms as they have experience in this space and technological insight to how the blockchain should function.

Year 2 - Adoption and Testing

Quarter 1: Informational Sessions and Infrastructure Updates

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[48]Ibid., 3.

Following Q4's release of an industry wide whitepaper, DTCC along with the industry committee overseeing the adoption of the new process, should conduct industry wide information sessions that will describe the changes that will have to be made and how all affected parties can adopt to these changes. Advantages of the shortened settlement time and the benefits of distributed ledger technology should be emphasized. Additionally, any infrastructure updates should commence.

Quarter 2: Network Applications

At this point in time, the development of the blockchain network should be complete. Assuming a consortium blockchain is used, it is during this period of the time frame where all necessary applications will be downloaded onto each of the nodes' systems.

Quarter 3: Implementation and Testing

Since regulatory authorities have approved the new processes relying on blockchain and the decreased settlement time, and the network and all associated updates have been completed, implementation of the new processes can begin. A parallel conversion method will be used, which is where the old, legacy system will continue to run alongside the new one. Until it is certain that the new system is bug free and working, the legacy system will continue to be used as the official record of settlement. "The safest way to convert from an old to a new system is parallel conversion because if the new system fails, users easily can revert to the old system."[49] Due to the importance of the information which the system processes, a parallel conversion is the best method. Unfortunately, there will be difficulties comparing the legacy system and the new one as they will be operating on different settlement periods: the legacy system will continue to use T+2 while the blockchain based system will use T+1. Also, the additional computational power needed to run both systems simultaneously will need to be considered.

Quarter 4: Analysis and Debugging

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[49]Pearlson, K. E., Saunders, C. S., & Galletta, D. F. (2016). *Managing and Using Information Systems: A Strategic Approach*. New York, NY, USA: John Wiley & Sons.

After completing the implementation phase, system analysis and debugging will need to be conducted. Q4 will focus mainly on making sure the system is working as it should, and no issues arise.

Year 3 - Conversion and the Future

Quarter 1: Continued Network Analysis

During this quarter, performance analysis will need to continue to be performed. It is important to be able to see how the new system will handle end of year/beginning of year trading volume (assuming Q1 is during the first quarter of a calendar year) which historically is at its highest point during the year.[50] Additional debugging will be completed if necessary.

Quarter 2: Going Live

By this time, all system analysis and debugging will be complete. The legacy system can now be retired and the blockchain based system can go live.

Quarter 3: System Reporting

After the new system has been live for a quarter, DTCC and the industry committee should record any issues as well as the performance of the system. Reports should be generated detailing the findings and successes of the new system.

Quarter 4: Awareness and Future Enhancements

Upon the completion of performance reporting completed by DTCC and the industry committee, the reports should be made public for industry participants and the public to read. A meeting should be held between DTCC and the industry committee, and the regulatory authorities to summarize the entire process of development, implementation, and testing. Additionally, future system goals and enhancements should be discussed.

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[50]Hirsch, J., & Mistal, C. (2016, July 21). Annual, Monthly, Weekly & Holiday Volume Patterns. Retrieved May 11, 2019, from https://www.stocktradersalmanac.com/Alert/20160721.aspx

Criticisms and Analysis

Changing current security settlement processes to incorporate distributed ledger technology definitely has its benefits. However, these benefits must outweigh current system capabilities in order to be seriously considered and pursued by the industry. Additionally, a blockchain based security settlement system has some drawbacks. In order for new processes to be adopted, there are four main items that need to be addressed: the capabilities of the legacy system, the current regulatory landscape, network/computational hurdles, and industry wide adoption.

Current Legacy System

Before DTCC decides to pursue distributed ledger technology, the current legacy system must be analyzed to determine if the need to incorporate blockchain technology actually exists. One of the main benefits of blockchain technology is decreased settlement time, however "...real time settlement is possible with existing technology and is already the existing practice for some asset classes."[51] Therefore, the case for implementing blockchain technology on the sole basis that it will decrease settlement time is not a valid position. Also, despite the fact that many different parties use the current system, the modern process is already highly efficient, very transparent, and relatively low cost to use (although this may not be accurate if the risk exposure is considered when determining total cost).[52]

Regulatory Landscape

Many believe that the current settlement period of T+2 takes as long as it does because the legacy system is not capable of shortening the period, which is not true. The current convention of T+2 is not the result of technology limitations, but instead is based on laws and the

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[51]Embracing Disruption: Tapping the Potential of Distributed Ledgers to Improve the Post-Trade Landscape. DTCC, Jan. 2016, 7.
[52] Ibid., 16.

market structure. "Modernizing current practices and laws to enable real-time settlement are not dependent on the use of blockchain technologies."[53] The implementation of blockchain alone will not be enough to change the current delay that is set by regulatory authorities.

Another hurdle that must be overcome are global regulatory requirements for data privacy. With the current system, data can be stored on systems within the jurisdiction of the operating country. Today, foreign trade data used by DTCC can be contained to specific servers that are in compliance with these global data privacy laws. However, the new systems that will rely on blockchain technology which will be implemented will distribute every transaction to every node on the system due to its decentralized nature - which will not comply with the current regulations.[54] This fact will raise additional challenges that will need to be addressed if DTCC decides to continue offering services abroad, and may lead to the revision of current law.

Network/Computational Considerations

If a new system were to be adopted that utilized distributed ledger technology it would need to be able to process the the same amount of trading volume that the legacy systems can. "Today, an average of more than 50 million trades are processed daily - which can, and has, spiked on occasion to over 120 million and as many as 25,000 transactions per second during peak processing."[55] It is essential that the new system can offer the same throughput rate as the legacy system, and also meet the industry standard of being able to handle at least two to three times the current market volume peak.[56] It must not be forgotten that a blockchain contains every single past network transaction - larger blocks mean more network storage space and slower network propagation. The blockchain will also only continue to grow in the future, even by more than expected if the average daily number of trades increases. Using the average daily trade volume of 50 million trades means that at the end of the year there will be over 18 billion transactions contained within the blockchain, all which must be verified in order to add additional transactions.

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[53]Ibid., 7.
[54]Ibid., 9.
[55]Modernizing the U.S. Equity Markets Post-Trade Infrastructure. (2018). DTCC, 9. Retrieved May 7, 2019.
[56] Ibid., 9.

Industry Adoption

Another challenge that must be addressed is that current legacy systems are compatible with every party involved in the settlement process, including brokers who submit executed trades through to DTCC to start the settlement process. If a blockchain based settlement process was implemented it must still be compatible with all parties involved in the process. This may be problematic as brokers will incur unwanted costs to update their processes to work with DTCC's blockchain based settlement system. "If blockchain based settlement is not compatible with broker intermediation, then the gain from moving to a blockchain will be reduced."[57] Achieving industry wide implementation will also require the re-architecture of infrastructure and core industry processes that were built and upgraded overy many decades. Lastly, the expenses incurred to develop and implement a distributed ledger conversion project may not justify the migration cost, and could in fact increase the risk of system threats as the technology is relatively new.[58]

Conclusion

Blockchain offers many benefits to all parties involved in the trading and post-trade and settlement process which cannot be ignored by central securities depositories as well as the entire industry. If DTCC were to implement this emerging technology, they would gain a competitive advantage in the industry as more institutions would want to utilize this organization for their services and take advantage of a more efficient process, ultimately passing along the added benefits to the end consumers (anyone placing trades). The adoption of this technology, which could lead to more participants of DTCC's services, would increase their revenues as all participant organizations pay for the services of DTCC.

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[57]Chiu, J., & Koeppl, T. (2018). Blockchain-based Settlement for Asset Trading. Queen's Economic Department. Retrieved May 5, 2019.

[58]*Embracing Disruption: Tapping the Potential of Distributed Ledgers to Improve the Post-Trade Landscape.* DTCC, Jan. 2016.

Looking back at the reason why DTCC was originally formed gives insight into why this organization should look to technologies of the future, such as distributed ledger technology. In the past, DTCC needed to implement new processes because the old settlement process was very burdensome: DTCC simply had a problem and solved it with new technologies of the time. Today, however, is a different story. DTCC is not facing any issues with the use of the legacy system so the need to implement blockchain doesn't really exist. Just because a need for this technology is not apparent does not mean that it should not be researched and considered for adoption. Implementing blockchain technology will reduce DTCC's risk of losing market share to competitors and newly formed organizations that use this technology from the start, disrupting the industry.

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