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The Trend of Exploring the Use of Distributed Ledger Technology in the Capital Market

Masafumi Kondo†, Go Hosaka†, Nobushige Doi†, Atsushi Santo†

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† Fintech Laboratory, New Business Development, Corporate Strategy, Japan Exchange Group , Inc. (jpx-fintech@jpx.co.jp)

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Contents

I. Introduction

Blockchain and distributed ledger technology (DLT), the underlying technology of such notable cryptocurrencies as Bitcoin, has attracted attention in the financial industry, resulting in numerous experiments to apply the technology to capital market infrastructure all over the world. Financial institutions, such as banks, exchanges, or CCP/CSDs, initially researched and tested the technology separately, but some of them have recently started conducting joint PoC (proof of concept) or considering pilot utilization in production environments among limited participants.

In Japan, Japanese Bankers Association announced[1] that, by this autumn, they were planning to develop a test environment in which banks can jointly test new financial services using DLT, and 61 domestic financial institutions (as of July 2017) have participated in a consortium[2] for considering using DLT to centrally provide domestic and foreign exchange services and establishing real-time and 24-hour payment infrastructure. Overseas, The Depository Trust & Clearing Corporation (DTCC) announced[3] that they will apply DLT in stages for Trade Information Warehouse (TIW), the post-trade processing service for OTC credit derivatives such as Credit Default Swap (CDS), and Australian Securities Exchange (ASX) plans[4] to close deliberations by the end of this year on whether they will implement DLT for replacing its post-trade service infrastructure.

There have been some recent technological developments surrounding DLT. Corda became open sourced in November 2016, and Hyperledger Fabric version 1.0 ("Fabric v1.0") was officially released in July 2017. The Enterprise Ethereum Alliance[5] was established in March 2017, and many financial institutions have already joined the alliance. JPMorgan Chase & Co. developed Quorum, a customized DLT platform based on Ethereum, in-house and open sourced it in October 2016.

Japan Exchange Group (JPX) established a research group in 2015 and has studied the applicability of DLT on capital market infrastructure, and the findings and analysis gained through the study were published as a report written by members of the group in August 2016[6]. This current report describes the trends in technological development and some issues with utilizing DLT in the capital market after the publication of the previous report. The report also comments on the expected changes in capital market infrastructure going forward based on the examinations.

While DLT has been developed and experimented in many industries, this report focuses on the financial industry, especially the use cases related to the trading of securities, bonds, and derivatives. Though the scope of this report has been limited to trading of financial instruments, there are numerous topics and on-going experiments related to DLT. As such, this report may contain some inaccuracies, and we ask for your understanding. In order to optimize or transform businesses drastically by utilizing a new technology, industry-wide knowledge sharing and open discussion are necessary. We hope this report contributes to

[1] https://www.zenginkyo.or.jp/news/detail/nid/8042/
[2] Launched by SBI Holdings, Inc. and SBI Ripple Asia Co., Ltd. in August 2017 (http://www.sbigroup.co.jp/english/news/pdf/2016/0819_a_en.pdf)
[3] http://www.dtcc.com/news/2017/january/09/dtcc-selects-ibm-axoni-and-r3-to-develop-dtccs-distributed-ledger-solution
[4] http://www.asx.com.au/services/chess-replacement.htm
[5] The consortium that aims to customize Ethereum, a DLT platform for public use, to meet the requirements from enterprise point of view such as confidentiality and performance
[6] http://www.jpx.co.jp/english/corporate/research-study/working-paper/b5b4pj000000i468-att/E_JPX_working_paper_No15.pdf

further technological development and global efforts in the application of DLT to capital market infrastructure.

II. Development of DLT Platforms

In this chapter, we will provide an overview and describe the common features of Hyperledger Fabric, Corda, and Quorum, the primary open source DLT platforms that have been explored for use in the financial industry (collectively, "DLT platforms for capital markets")[7]. Descriptions on Hyperledger Fabric are based on findings gained through our research and PoC, but those on Corda and Quorum are based on information in the public domain.

1. Overview and Basic Functions of each DLT Platform

(1) Hyperledger Fabric

Hyperledger Fabric is the representative DLT platform that has been developed under Hyperledger[8], a consortium that aims to develop open-source DLT platforms and peripheral tools. Hyperledger Fabric version 0.6 has been used in many PoCs conducted by financial institutions, but the specifications of Fabric v1.0 are drastically different from the previous version. The basic components and functions of Fabric v1.0 are as follows.

- Endorser
  Node that executes a transaction and sends it back to the client with a result and signature

- Orderer
  Node that determines the sequence of transactions and broadcasts them as a block to other nodes in the DLT network

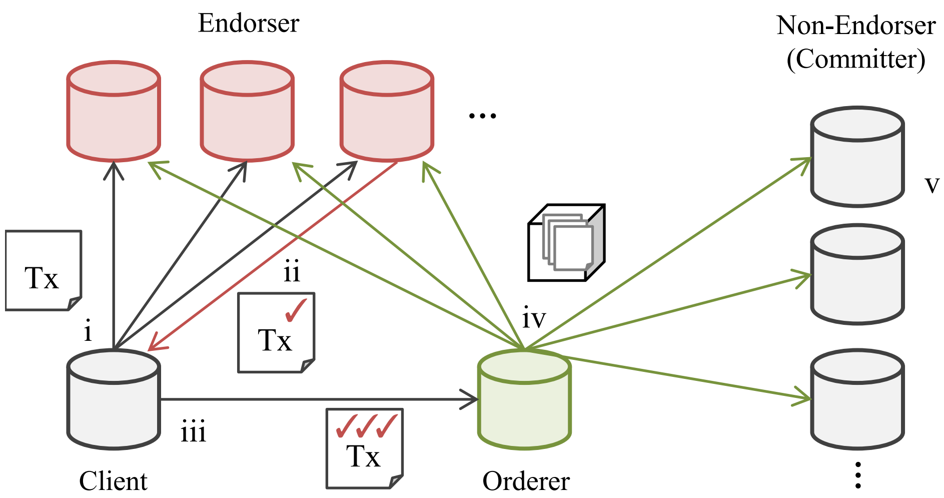
- Endorsement Policy
  Configuration for defining which node is the endorser or how many endorser signatures are required for a transaction to be endorsed

- Channel[9]
  Configuration that defines which group of nodes share a single ledger

While the previous version uses a consensus algorithm based on Practical Byzantine Fault Tolerance (PBFT), Fabric v1.0 offers flexibility in the consensus process[10] thanks to its endorsement policy and data confidentiality that limits the number of nodes sharing a single ledger through the use of channels. The execution process of transactions in Fabric v1.0 is shown in Figure 1.

[7] Development of Hyperledger Fabric is not solely for use by the financial industry.
[8] To date, multiple DLT platforms have been developed in parallel within the Hyperledger, attracting initial source codes from varied participating institutions.
[9] The execution instance of smart contract (called "chaincode" in Hyperledger Fabric) is created in each channel respectively, and the endorsement policy is defined in each instance.
[10] Process to create consensus among participating nodes on the contents, sequence, and results of transactions

Figure 1: Execution process of transactions in Fabric v1.0



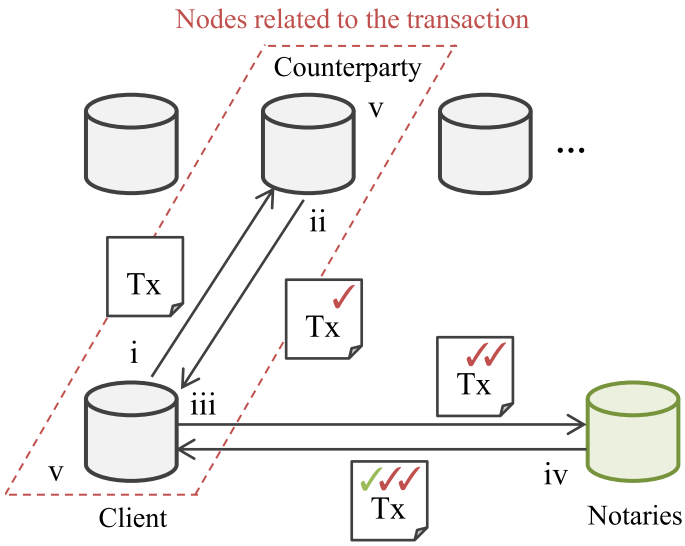
i. Client sends transaction to endorsers.
ii. Endorsers execute the transaction and reply with executed results and signatures.
iii. Client gathers sufficient number of signatures from endorsers defined in endorsement policy and sends transaction with signatures to orderer.
iv. Orderer combines transactions into block with sequence and broadcasts.
v. Each node validates each transaction under the endorsement policy and commits it to the respective ledger.

(2) Corda

Corda is a DLT platform developed in the R3 consortium[11], which consists of more than eighty financial institutions (as of June 2017). Corda employs unspent transaction output (UTXO)[12] as its data model (same as Bitcoin) and defines a specific role to prevent double-spends called notary services. Notary services manage the history of previously spent transactions, and the client has to request a certification of uniqueness, which means the transaction has not been spent yet, for the transactions set as input states in the newly issued transaction. Notary services can be operated by either a specific node as a single instance or decentralized multiple nodes with consensus algorithm. Transactions are shared and executed in only the nodes owned by parties related to each transaction. The execution process of transactions in Corda is shown in Figure 2.

[11] Launched by R3 CEV LLC in September 2015
[12] Data layout of transactions has input and output states, and the newly issued transaction consumes past transactions as its input states.

Figure 2: Execution process of transactions in Corda

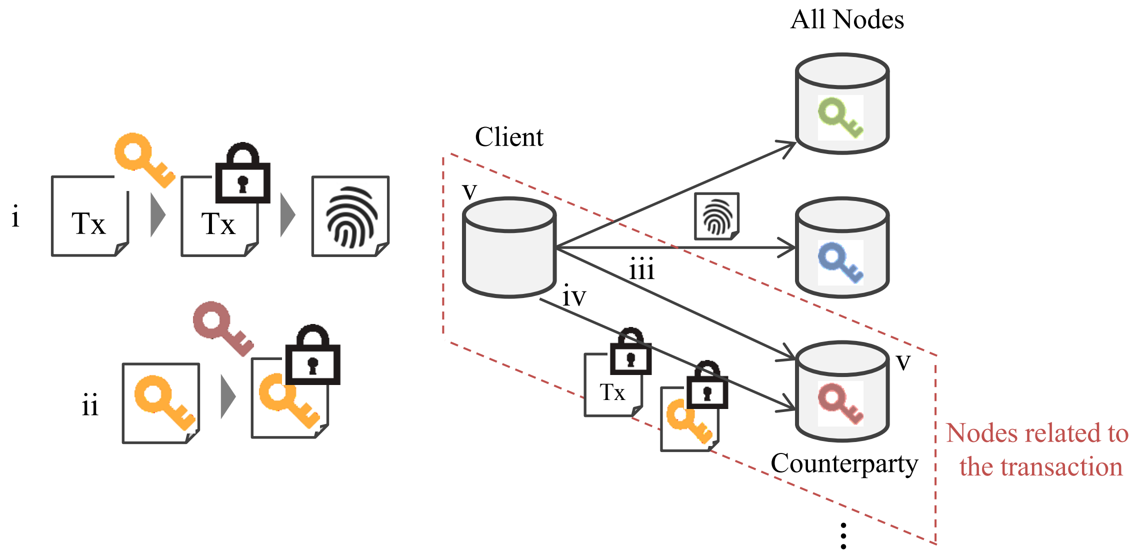


i. Client sends transaction to the node owned by counterparty of the transaction.
ii. The counterparty confirms the transaction and replies with signature.
iii. Client also signs the transaction and requests certification of uniqueness for the transactions set as input states in the newly issued transaction.
iv. Notaries sign the transaction if they have not already signed other transactions consuming any of the proposed transaction's input states.
v. Each node related to the transaction executes and commits the transaction to the respective ledger.

(3) Quorum

Quorum is an enterprise-focused version of Ethereum supporting data confidentiality mainly for the financial industry. There are two types of transactions in Quorum: public and private. The execution process of public transactions is the same as it is in Ethereum, but private transactions are shared and executed in only the nodes owned by parties related to each transaction, and only the hash of encrypted private transactions are shared and stored among all nodes. The execution process of private transactions in Quorum is shown in Figure 3.

Figure 3: Execution process of private transactions in Quorum

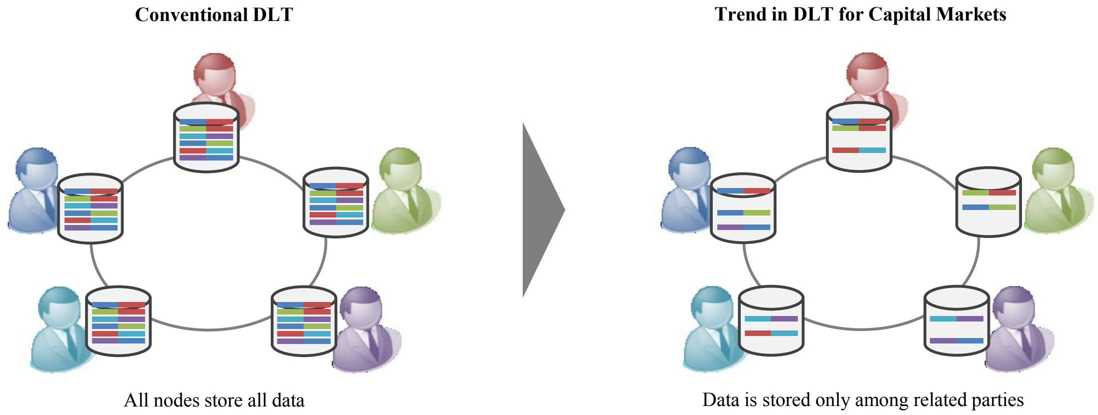


i. Client generates symmetric key, encrypts newly issued transaction with said key, and calculates hash value of encrypted transaction.
ii. Client encrypts the symmetric key with public key of the node owned by counterparty of the transaction.
iii. Client broadcasts the hash value to all nodes.
iv. Client sends encrypted transaction and encrypted symmetric key to the node owned by the counterparty.
v. Each node related to the transaction executes and commits the transaction to the respective ledger after the parties agree to it.

2. Distinctive Features of DLT in Financial Industry

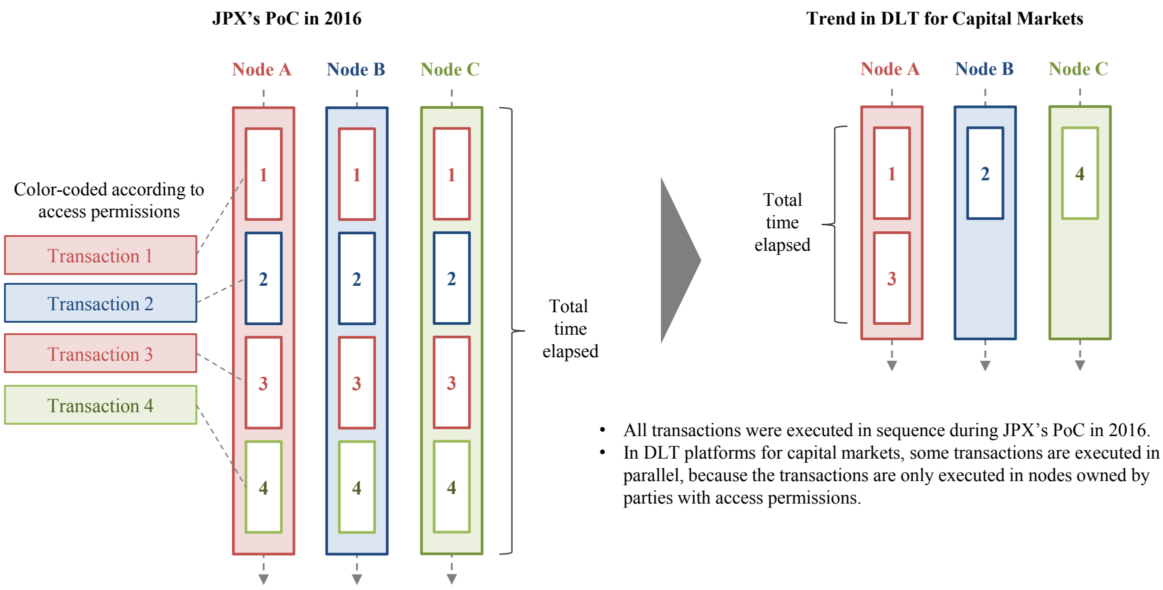
It can be surmised from the descriptions of the features of DLT platforms for capital markets presented in the previous section that data confidentiality among participants has been thought to be crucial in the financial industry. The original intent of DLT is to be able to share a common ledger that stores all data among all nodes, and some of the DLT platforms implemented data privacy and access control by public key infrastructure under such a premise. However, there has existed the possibility of tampering and peeping by means of hacking by insiders of financial institutions owning nodes, because transactions and data on the ledger need to be temporarily decrypted when executed. There is also ongoing concern over the vulnerability of existing cryptographic techniques. In light of such state of affairs, some have considered utilizing homomorphic encryption, which enables calculation without decryption, for DLT. However, the implementation of homomorphic encryption in the capital market, where the trading practice of assets is more complicated than that of cryptocurrencies, seems to be difficult, because enabling complicated calculation without decryption causes serious declines in performance. Consequently, executing transactions and storing data only among nodes owned by parties related to them is the latest trend in DLT platform for capital markets (Figure 4).

Figure 4: Guaranteeing confidentiality by physically segregating data



Compared to the process in conventional DLT, executing transactions only in specific nodes proves to be advantageous in terms of performance. As stated in our report published in 2016, sequential execution of all transactions in every node led to bottleneck on transaction throughput during the PoC conducted by JPX that year. The throughput in DLT platforms for capital markets is expected to be improved, because the transactions to be executed in different nodes can be processed in parallel (Figure 5).

Figure 5: Parallel execution of transactions



Given that now a transaction is not necessarily shared among all nodes, there have also been changes to the consensus process, which has been deemed as one of the most important factors of DLT. As can be seen in the endorsement policy for Fabric v1.0 or notary services for Corda, the rules of consensus in such DLT platforms are flexibly configured by users, and those functions also make it possible to eliminate the consensus process by giving the authority to approve transactions only to a specific node. Assuming that a DLT network consists of only mutually trusted existing financial institutions, simplifying or omitting the consensus process seems to be a viable option, because it is difficult to fathom that some nodes would simultaneously behave abnormally as a result of hardware failures or malicious intentions. The pursuit of confidentiality and performance[13] rather than byzantine fault tolerance has led to the subdivisioning of functions and roles in the latest DLT platforms for capital markets. As such, it only seems natural to move away from the rigid consensus processes associated with conventional DLT.

3. Comparison with existing technology

As summarized in this report, DLT platforms for capital markets have vastly evolved from the original intent of DLT in an effort to satisfy the practical requirements of financial institutions. In this regard, some have pointed that these platforms now do not differ much from existing distributed databases[14]. Distributed database is a technology that allocates data separately into several different databases managed by a single entity mainly for performance (load balancing) and scalability, and it generally does not provide byzantine fault tolerance. Since DLT platforms for capital market enable flexible consensus process configuration and physical data segregation, there will be many similarities to distributed database depending on the design of those features, and performance and technological maturity on distributed databases seem to be better than those of current DLT platforms. In a distributed database, data is dispersed according to value or range of specific keys determined in advance. Therefore, data does not overlap between different databases. In DLT platforms for capital markets, however, because they focus on both data confidentiality and frictionless data sharing among related parties, the same data can be shared among some nodes, and that is able to be determined flexibly at every transaction. Also, in terms of data availability, while data lost in one node may be recovered[15] from another node in DLT platforms for capital markets, redundancy is required for each database in a distributed database scheme (Figure 6).

While the difference between the two may be minute from the viewpoint of their technical characteristics as databases, DLT platforms for capital markets cover a wider range of services[16] and can be considered as customized packages designed to leverage existing distributed database technology to improve the efficiency of work flows among different entities (Table 1). They are expected to evolve as databases and messaging middleware[17] that can be utilized in various industries.

[13] According to the experiment conducted by Bank of Japan, throughput performance deteriorates as more nodes participate in the consensus process. (https://www.boj.or.jp/announcements/release_2017/data/rel170227a5.pdf)

[14] While there have been several types of distributed databases, this report mainly describes the characteristics of Mongo DB.

[15] As described in the next chapter, recovering data from another node has some issues while it seems to be possible in theory.

[16] Not only data base management systems but also virtual machines for running programs as smart contracts, messaging functions among nodes, and developer’s toolkit

[17] General-purpose software that operates common processes for specific types of use cases between business applications and the base layer, such as an operating system and hardware

Figure 6: Difference in operation for data redundancy

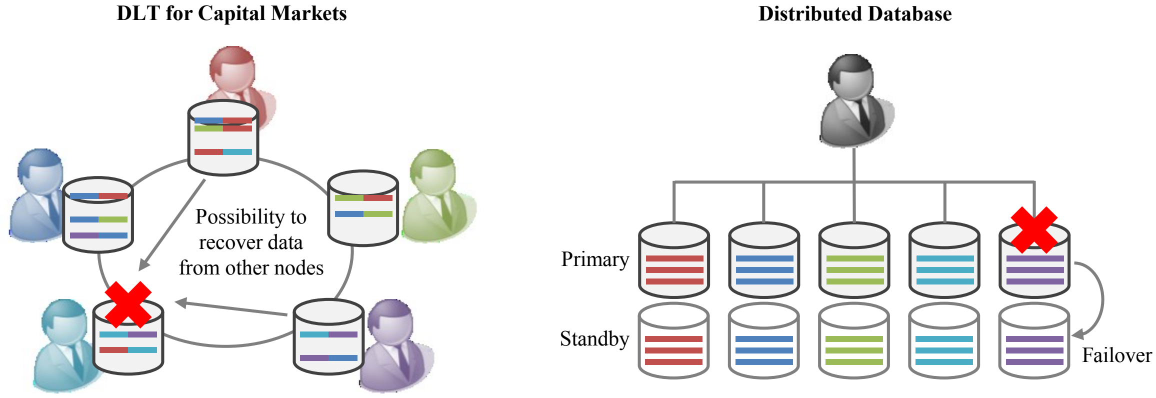


Table 1: DLT platforms for capital markets vs. distributed databases

	DLT for Capital Markets	Distributed Database
Main Purpose	Frictionless data sharing with data confidentiality	Performance (load balancing) and scalability
Governance	Could be jointly managed by multiple entities	Managed by a single entity
Data Distribution	Able to determine nodes to share data in every transaction	Determined in advance according to value or range of specific key
Byzantine Fault Tolerance	Configurable according to use case and network participants	None *Assumed to be managed by a single entity
Data Availability	Possibility to recover data lost in one node from another node	Needs to have redundancy in each database

III. Studying Potential Utilization in the Capital Market

Ever since research and experimentation on DLT became widespread in the financial industry, many have repeatedly pointed to the possibility of DLT's improving efficiency in a wide range of operations in the capital market or even drastically transforming it. Moreover, in terms of recent changes in the regulatory environment surrounding the capital market, there has been increasing momentum to reform the existing process of development and management of IT systems by using new technologies. However, though PoC testing and technological development of DLT has been actively conducted all over the world, some issues still remain in terms of production use.

1. Complicated Regulatory Environment and Expectations of DLT

Given that IT systems in the financial industry need to be especially reliable, the general consensus over time has been for financial institutions to develop business applications and operate IT systems, including hardware, on their own to the extent possible. However, recent changes in the economic/financial environment and, by extension, in financial regulations have gradually magnified the burden of maintaining such on-premise IT systems[18] at each financial institution.

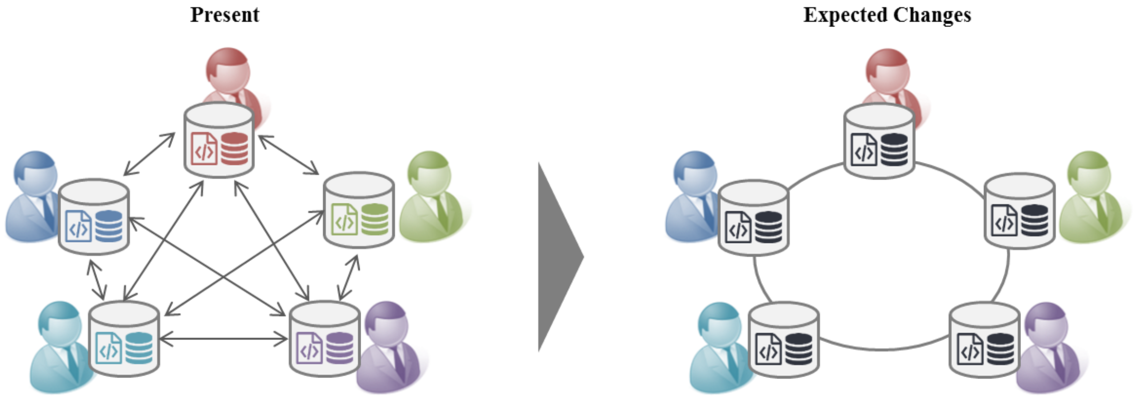
Case in point, the 2008 financial crisis unleashed numerous discussions on financial regulatory reforms, which would later be rolled out in succession over the years to the present day. One example is Basel III, the series of financial regulatory reforms led by the Basel Committee on Banking Supervision (BCBS), which were implemented in phases starting in 2013 and due to reach full implementation in 2019. Another example is OTC derivatives market reform jointly led by BCBS and International Organization of Securities Commissions (IOSCO), which has been implementing related regulations for the purpose of monitoring and reducing systemic risk. Though such regulatory reforms have been conducted under international cooperation, because such international organizations as BCBS cannot legally enforce those rules at the financial institutions targeted by said regulations, all they can do is provide guidelines to the regulatory authorities in each respective jurisdiction, which ultimately move on to having the regulations subjected to legislative procedures. Consequently, while related laws legislated in each country are equivalent in principle, small differences may exist as a consequence of varied business practices across different countries. Financial institutions, especially those that do business internationally, are burdened with the task of having to appropriately and efficiently adapt their business work flows and IT systems to match rapidly changing regulations based on an understanding of the laws legislated in multiple countries at any given time.

If DLT can be successfully applied to work flows in the capital market, then the basic functions and formats of business applications among related financial institutions will be standardized in the form of smart contracts. Under the rapidly changing economic/financial environment encompassing regulations, it has become increasingly difficult for each institution to independently revise related work flows and IT systems. Sharing knowledge and developing/using applications mutually in non-revenue-generating areas (i.e., post trade or back office processes) can reduce costs and certainly be an effective solution. Moreover,

[18] Refers to IT system hardware that is housed by the service provider itself on its own premises or that is installed and operated at data centers or other similar facilities contracted by the service provider

standardization of applications improves efficiency of operation by reducing data conversions; and, it is also expected that faster processing will be achieved by seamless data exchange among related entities on DLT networks. Realizing these aspects seems to become essential for the capital market, because the recent regulatory reforms have forced tighter time limits for operations, such as trade reporting or margin transfer, for the purpose of reducing systemic risk (Figure 7).

Figure 7: IT systems challenges and expectations of DLT in the finance industry



- On-premise IT systems required at each financial institution
- Significant cost for data sharing and reconciliation due to siloed architecture

- Lower development costs realized by standardizing application specifications and less work/tasks required for format conversion
- Accelerated overall workflows as a result of seamless data sharing

2. Potential Issues in Production Use

While DLT platforms for capital market have been evolving focusing on data confidentiality and performance, we have found through our research and PoC that some new issues have arisen in tandem with the progress of those aspects. As joint PoCs and pilot use among some related entities on specific use cases have been conducted, it has also become necessary to solve such practical issues as combining system architecture with existing IT infrastructure and governance for development/operation of applications.

(1) Confidentiality

While existing DLT realizes high availability and integrity by sharing all data in every node, a different solution is needed to secure these aspects if each node owns different data[19].

We have conducted tests to realize confidentiality by using channels under Fabric v1.0. However, the issue we encountered is that a special node, which can carry out consistent data exchange between different channels, is necessary for asset transfer across channels as needed because of the current lack of a function to link ledgers across channels. The node would be a single point of failure, and the owner of the node should be highly reliable and neutral for participants, because it needs to have permission to access data on

[19] The acronym CIA takes the first letter of the words “confidentiality”, “integrity”, and “availability”, which represent the most crucial components of information security within an organization. More importance had been placed on integrity and availability at the expense of confidentiality in conventional DLT platforms, and this is now changing in DLT platforms for capital markets.

multiple ledgers. Also, such function should be provided as a basic function of the DLT platform, since the risk for software failure would increase if it is developed as a business application in each use case.

Since Quorum uses a deterministic virtual machine for running smart contracts[20], the same input data and transaction always generate the same output data; therefore, the hash value of private transactions and the sequence of those transactions are shared and agreed among all nodes as a single source of truth for tamper detection and data recovery. Having such a mechanism, data validation and data recovery can theoretically be made possible by bringing transaction data from each node when data inconsistency or data loss occurs in a specific node[21]. However, such operation is essentially a last resort, because it is very hard to carry out such operations in reality. Also, having an administrator node with permission to access all data and transactions might be a more practical solution for preparing data validation and data recovery. Moreover, the report of the PoC conducted by the Bank of Canada indicates that to achieve business continuity, in the case of Corda, data replication mechanisms have to be embedded in each node[22].

As explained above, even though these DLT platforms implement a function for realizing physical data confidentiality, an entity that can serve a special role is necessary to actually make use of said function. Assuming that we would be able to look to such existing financial institutions as CCP/CSDs, banks, or brokers, a trusted third party can take on said special role, but careful attention should be paid in order not to miss out on the advantages of DLT.

(2) Throughput

We have examined throughput performance in Fabric v1.0, and it usually demonstrates higher transaction throughput when compared to the previous version. However, it was observed that the performance deteriorated depending on the condition, and it was due to asynchronous processing between executing transactions and committing results to ledger on Fabric v1.0. Endorsers execute a transaction and send it back to the client with results and signatures, along with the version of the key on the database read by the transaction at execution. When each node commits transactions to a ledger one by one after the orderer broadcasts the transactions as a block with sequence, any transaction with a version of the key older than the latest is rejected (Figure 8).

[20] Quorum is based on Ethereum, and smart contracts are run on the Ethereum Virtual Machine (EVM).
[21] There have yet to be any experiments that use the actual data; therefore, this statement is based solely on the information and literature that is currently available to the public.
[22] http://www.bankofcanada.ca/wp-content/uploads/2017/05/fsr-june-2017-chapman.pdf

Figure 8: Collision check of the key at the commit of transaction to ledger

[Use Case: Bank Account (Deposit, Withdrawal, Payment)]

Database: (key, version, value)

Initial Parameter: (Investor A, 1, 10000), (Investor B, 1, 10000), (Investor C, 1, 10000)

*Version is incremented when the value of the key is updated.

If transactions 1, 2, and 3 are issued simultaneously, then the results replied from endorsers will be as follows:

Transaction 1: deposit JPY5000 on investor A

Read {(key: "Investor A", version: "1")}, result {(key: "Investor A", value: "15000")}

Transaction 2: withdrawal JPY2000 on investor B

Read {(key: "investor B", version: "1")}, result {(key: "investor B", value: "8000")}

Transaction 3: payment JPY 3000 from investor A to investor C

Read {(key: "investor A", version: "1") (key: "investor C", version: "1")},

Result {(key: "investor A", value: "7000") (key: "investor C", value: "13000")}

Nodes process each transaction as indicated below for transactions that are sequenced in numerical order by orderer:

1. Commit transaction 1:

   Update database {(investor A, 2, 15000)}

2. Commit transaction 2:

   Update database {(investor B, 2, 8000)}

3. Reject transaction 3:

   * While transaction 3 has read tuple (key: "investor A", version: "1"), the version of the key "investor A" was updated to "2" at the commit of transaction 1.

When a collision did not occur thanks to sufficient dispersion of keys read by transactions in high traffic, throughput performance was better than the results gained through the PoC using Hyperledger Fabric version 0.6 conducted in 2016. On the other hand, when we injected large amounts of transactions reading the same key, a lot of collisions occurred. Consequently, high throughput performance was not demonstrated, and it imposed a high load on system resources. It should also be noted that committing transactions to a ledger in each node is processed sequentially in Fabric v1.0. Thus, when we do not use channels, resulting in each node storing all data, all transactions are processed in sequence just as in the previous PoC. This aspect needs further improvement, because, aside from the collision check of the key, it seems possible for committing of transactions to be processed in parallel.

(3) System Architecture

Since the public DLT networks that support cryptocurrencies offer users the option of obtaining such cryptocurrencies via mining as a form of monetary incentive, it results in a non-central authority infrastructure where the participants themselves are responsible for maintenance and operation. However, since it would be difficult to offer such monetary incentives within the scope of the consortium DLT use cases that are primarily outlined in this report, major users would have to burden the costs pertaining to maintenance and operation of infrastructure involved in realizing a shared objective of raising work flow efficiency. In light of such circumstances, the industry has been considering utilizing cloud services for the implementation of DLT to reduce the burden of node possession and that of operating IT systems, as well as to simplify network architecture.

There are two types of cloud services available today that have been garnering attention in the financial industry[23]. One is Infrastructure as a Service (IaaS)[24], which provides basic system resources such as CPUs, memory, or storage. The other is Software as a Service (SaaS), which provides specific business applications on cloud environments (or data centers managed by the service provider). A user can start using DLT applications easily at relatively low costs if the user can establish its node on a cloud environment using IaaS. Since nodes are not excessively dispersed geographically, establishing nodes on the cloud environment is also efficient in terms of network architecture compared with doing it at data centers managed by each separate user. Data center failure can occur due to disasters or human errors even when such infrastructures are operated by leading cloud vendors. Therefore, care should be taken to not geographically concentrate a large number of nodes at a specific data center or in a specific region managed by a single cloud vendor in the event that a number of users have each developed a node on a cloud serviced by the same cloud vendor. Cloud services seem to be a good match for DLT, and combining such technologies can lower the obstacle for production use of DLT. However, it should be considered from a wider perspective based not only on costs and network efficiency but also on infrastructure availability.

The point has been raised, however, that utilizing DLT will not be as important in terms of improving efficiency if cloud services become widespread in the financial industry. Actually, the total costs for the entire financial industry would be reasonable if everyone opted for providing related functions on specific use cases as SaaS across all financial institutions, namely business applications and data storage on cloud environments[25]. It must be noted that such services would create a new single point of failure in the capital market, and there has also been concern that such service providers might have a tremendous influence from gaining a dominant position over the medium to long term.

(4) Governance

Since DLT is a technology that makes related entities use the same basic application as a smart contract, governance of conducting development and maintenance of the application is also an issue for production use. While reconstruction of business work flows seems to be necessary for leveraging the advantages of DLT, collaboration among users and jointly examining specifications in a consortium is surely important

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[23] There had been a longstanding bias against cloud services in the financial industry in terms of information security. However, now that major cloud service vendors have an ample track record of providing a high level of cyber security by studying and testing with top global talents in this area, there is growing acceptance and even support for utilizing cloud services in the industry.

[24] When useful tools are incorporated into development of applications for such functionalities as DBMS, calculation, and analysis in addition to basic system resources, it is commonly referred to as Platform as a Service (PaaS); however, in this report, PaaS and typical IaaS is collectively referred to as IaaS.

[25] If the functions of some work flows in the financial industry were provided as SaaS and became prevalent, we could expect benefits from standardization of applications and frictionless data sharing that are comparable with that of those realized by DLT. Moreover, SaaS providers would be able to manage system resources and data redundancy efficiently in a centralized manner.

for successful production use. DLT platforms and computer language for developing smart contracts to be used should also be open sourced in order to attract participation from a wide range of stakeholders with a common understanding.

Given that a significantly high reliability is required in the implementation of DLT on existing capital markets, a specific entity should be responsible for the quality of the application even in the case of open source development. Looking to the recent conflict in the Bitcoin community over specification changes, it is desirable for a trusted third party to be involved in the consortium in any way since solving such conflict without any mediation is difficult, because there is bound to be conflict among users who also happen to be business rivals. As mentioned in this chapter, when considering actual operation, a trusted third party might be also necessary on the network for utilizing the distinctive aspects on DLT platforms for capital markets in terms of confidentiality. Existing industry associations or market infrastructure operators can serve in these roles, but it is also an option for the members of the consortium to mutually establish a new entity.

Establishing entities to serve in neutral roles for improving industry-wide efficiency is the way the capital market has managed to move forward thus far. As such, some are of the opinion that bringing a trusted third party for utilizing DLT is reinventing the wheel. However, there is a possibility to develop more resilient work flows with lower running cost by using DLT, while also reducing the responsibility taken by the trusted third party for the operation of infrastructure. Long-running and deep trust among existing entities can be leveraged to establish governance structures, benefiting the industry and shortening the road to production use of DLT. As for the implementation of DLT on existing capital markets, transforming the role of the trusted third party is necessary for building more efficient infrastructure instead of eliminating it. At the same time, inventing financial services from scratch by using DLT, such as Initial Coin Offering (ICO), may evolve under decentralized governance structures totally different from the existing capital market.

IV. Conclusion

This report describes the trend of technological development and some issues for utilizing DLT in the capital market based on findings from further research and PoC after the publication of the previous report and the rapidly changing regulatory environment surrounding the capital market. We would like to conclude by commenting on our expectations for the changes in the capital market infrastructure going forward and JPX's recent initiative related to DLT.

1. Expected Changes in the Capital Market

Assuming that the regulatory environment surrounding the capital market will continue to change rapidly, financial institutions will increasingly cooperate in non-revenue-generating areas to improve operational efficiency, and the use of new technologies is expected to be spread as a catalyst. Considering the maturity of the technologies today, it is also assumed that the use of cloud services would spread to raise the efficiency of IT system operations and business work flows before DLT. For example, a new service on Global Payment Innovation (GPI)[26], a project initiated by SWIFT in February 2017, enables the progress of cross-border payment to be traced in real time by sharing information among related banks in the cloud environment, and there have also been an increasing number of services that provide various functions for post-trade processes of financial products as SaaS. On the other hand, it should be carefully considered if the wide range of functions including mission critical businesses can be operated in the cloud, and since the advantages of using the cloud are relatively low for large financial institutions that have plenty of IT specialists, on-premise IT systems and cloud services are expected to be used simultaneously for the time being. Even in such a situation, with DLT as the underlying platform for business applications, seamless data sharing and data integrity can be realized regardless of the IT system architecture of the individual user. It was, in fact, announced that CLSNet[27], a new service being developed by CLS bank, will provide two options for users to connect to the service, one by establishing an own node and connecting through the DLT network, and the other by connecting to the server managed by CLS bank through traditional SWIFT channels. Furthermore, if the linkage between different DLT networks including the public-type is realized when the technology develops even further, alongside the continued development of cryptocurrencies, there is the possibility that the technology can bring revolutionary change to the fundamentals underpinning existing financial services.

As described in this report, since DLT platforms for capital markets have been evolving far from the original concept of DLT to satisfy the practical requirements of financial institutions, there has been opinion that these platforms are not much different from existing technologies. However, it is a highly meaningful process for users of new technologies to proactively study a new technology and provide feedback to developers based on practical needs. We believe that steadily evolving financial services by implementing new technologies for production use in this industry is essential, even if the new technologies are not very different from existing technologies.

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[26] A project that aims to improve transparency and traceability on cross border payment, and also considers the future use of DLT (https://www.swift.com/our-solutions/global-financial-messaging/payments-cash-management/swift-gpi)

[27] A service that provides matching and netting functions for various FX transactions across more than 140 currencies (https://www.cls-group.com/ProdServ/Pages/CLSNet.aspx)

Efforts to implement DLT to the capital market have been shifting from revolutionary use cases inspired by cryptocurrencies to realistic ideas, first and foremost, to improve the efficiency of business work flows by leveraging the trust among existing financial institutions and market infrastructure operators. Enthusiasm has faded slightly due to the shift, and there has been concern that efforts by financial institutions would shrink gradually. Such ups and downs in expectations can happen in the process of developing any new technology, and it is necessary to continue exploring DLT for the medium and long term in view of the push in the Fintech movement for more sophisticated financial services.

This report covers mainly private/consortium type use cases. For public-type services, such as crytocurrencies, even though there are many issues highlighted, we should not forget that that they have been expanding as the world watches in anticipation. The combination of the smart contract for flexible service design and cryptocurrencies presents financial services with new possibilities. Even as we continue to pursue our mission of providing sound financial market infrastructure, it will become increasingly important for us to continue questioning whether the services we currently provide actually benefit our users.

2. Recent Initiative at JPX

As we understand that continuous technological examination and industry-wide discussion are necessary for production use of DLT in the capital market, in March 2017, JPX began a new initiative[28] that officially accepts participation from a wide range of Japanese financial institutions for industry-wide cooperation such as joint PoCs. Thirty-three participating financial institutions (as of September 2017) have been able to communicate with each other on a consortium-members only website for discussion and information sharing on DLT. TSE also released a demo application[29], which implemented the basic functions of the securities market, to facilitate a common understanding on DLT among participating financial institutions. It is also possible for participants or other IT vendors to suggest use cases related to the capital market and conduct needs surveys with other participating financial institutions. Recently, we are seeing a gradual increase in suggested use cases, and two ideas have been escalated to the stage of joint PoCs among interested financial institutions within the scope of JPX's initiative[30].

While various services have rapidly become more convenient thanks to the evolution of information technologies, it is increasingly difficult for the existing capital market infrastructure to respond to changes in the surrounding environment due to complicated and siloed IT system resulting from changes and functional additions over the years. Industry-wide sophistication or replacement of infrastructures also seems to be difficult due to the process where each financial institution develops its IT system on its own or an IT vendor provides it to each company. However, if existing players can cooperate and share knowledge on utilizing new technologies, we can expect progress on the consideration of revolutionary ideas that have so far been deemed as difficult to realize. The fact that financial institutions have increased their joint

[28] Jointly conducted at JPX by Tokyo Stock Exchange, Osaka Exchange, and Japan Securities Clearing Corporation

[29] Based on the application developed in PoCs conducted by JPX in 2016 with a publically accessible demo video (https://youtu.be/Gqbjp4JlqRk)

[30] One project is related to the post-trade processes for Japanese stocks suggested by Daiwa Securities Group Inc. The other is related to Know Your Customer (KYC) operations jointly suggested by SBI Holdings, Inc., SBI BITS Co., Ltd., and NEC Corporation. JPX supports these joint PoCs by providing an environment to deploy and test DLT applications as well as the consortium-members only website to facilitate communications.

efforts since DLT began attracting attention in the financial industry is a sign of positive change. As the efforts spreads across various technologies and business areas, we hope it will establish a new culture to accelerate open innovation for the sustainable development of financial services.