



BLOCKCHAIN AND ITS APPLICATIONS IN SETTLEMENT OF SECURITIES AND PAYMENT

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Abstract

This paper will compare and contrast the current DVP securities settlement and corporate action processes with the cutting-edge DLT-Based settlement processes. Functional description of the architecture that can offer bank customers a joint view on assets will be investigated. The regulatory considerations behind Blockchain settlement solution will further be discussed.

1. CURRENT DVP SECURITIES SETTLEMENT AND BASIC CORPORATE ACTION PROCESSES VERSUS DLT-BASED PROCESSES

This section will introduce the working principle and involved parties for both (a) current Delivery Versus Payment (DVP) securities settlement and corporate action processes and (b) Blockchain-based settlement and corporate action process. The similarities and differences between the two options will be highlighted and summarized.

1.1 Current securities settlement and corporate action processes

Working Principles for Current Securities Settlement

The current Delivery Versus Payment (DVP) securities settlement involves two linked obligations namely the payment of cash and delivery of securities (European Central Bank and Bank of Japan, 2018). It can be generally divided into three steps: (1) Receive and match buy and sell instructions from delivering institutions; (2) Check and verify the sufficiency of cash and securities holdings in the accounts of the trading parties respectively and confirm the instructions via delivery matching system; (3) Execute instructions including the transfer of cash and securities position between the involved parties. During the settlement process, the central security depository (CSD) will act as a central custodian, manage and record the cash and securities holdings for each transaction via book-entry systems. The settlement date for securities is usually denoted as Trade Day plus two days (T+2) for the manual procedures involved. The detailed process will be described below:

Process of Current Settlement

This section will explain the current DVP securities settlement process with an example. Suppose Investor A want to sell 100 shares of securities valued at \$10 per share via DVP:

1. During the trade execution stage, Investor A instructs DVP to broker (e.g. Bank A) to sell 100 shares of securities at \$10 in the market. This matches with receive versus payment (RVP) instruction from Investor B to broker (e.g. Bank B) who would like to buy the 100 shares of securities at the same price.
2. Bank A and Bank B check whether sufficient share holdings and cash are available for Investor A and Investor B respectively.

3. After confirmation of assets, the buy and sell instructions are confirmed and forwarded to a central counterparty (CCP), which will act as a seller to the buyer and buyer to the seller. Clearing members will on behalf of buy side and sell side place/receive collateral to the CCP until the instructions mature to avoid liquidity and counterparty credit risks.
4. CCP will forward settlement instruction to the Central Security Depository (CSD). The CSD will then debit 100 shares from CSD's Bank A security account and credit \$1,000 to Bank A's cash account, vice versa for Bank B.
5. Bank A and Bank B perform second level settlement by transferring the related cash and securities to Investor A and Investor B.

During the whole process, the depot bank has to trigger reconciliation of the holdings with the Central Security Depository (CSD) in regular interval. The depository can provide full listing of the bank position via SWIFT instruction and the depot bank can compare the list with the in-house view. Differences occur will be examined and follow up to be corrected.

Current Corporate Actions Process (Dividends, Coupon payments)

Corporate actions are bundles of non-trading events decided by the security issuer impact on the security holders (European Central Bank, 2018). For example, merge or spilt of shares, stock change and voting in Annual General Meeting (AGM). This section will focus on discussing the basic corporate actions process – Payment of dividends and coupons.

The general process is as below:

1. Security issuers inform the issuer CSD for the details of Dividends payments/ Coupon payments (on bonds or obligation) the corporate action announced.
2. CSD will process the information including the deadlines, payment date, Ex dates and record dates and communicate with depot banks/ custodian institutions to update the payment and date information.
3. On the ex-date, new buyers of the security cannot owe the dividend. The depot bank will identify all the customer holdings on the date of record that are entitled for payment.

4. The issuer CSD triggers the payments/ proceeds to custodian institutions. On the date of payment, the depot banks credit the gains to client's cash accounts, calculate the taxes, and apply reporting rules if cross border payments are involved.

Involved parties in current settlement and corporate actions process

From the explanations and steps above, we can identify the following major participants:

1. Clients/Investors: Place buy/ sell instructions during trade
2. Depot banks/ custodian institutions: Act as a custodian for safekeeping
3. Exchange: Trading platform
4. Central counterparties (CCP): Netting, act as buyer for seller and seller for buyer
5. Central security depository (CSD): Manage cash and securities holdings for custodians in both DVP settlement and corporate actions

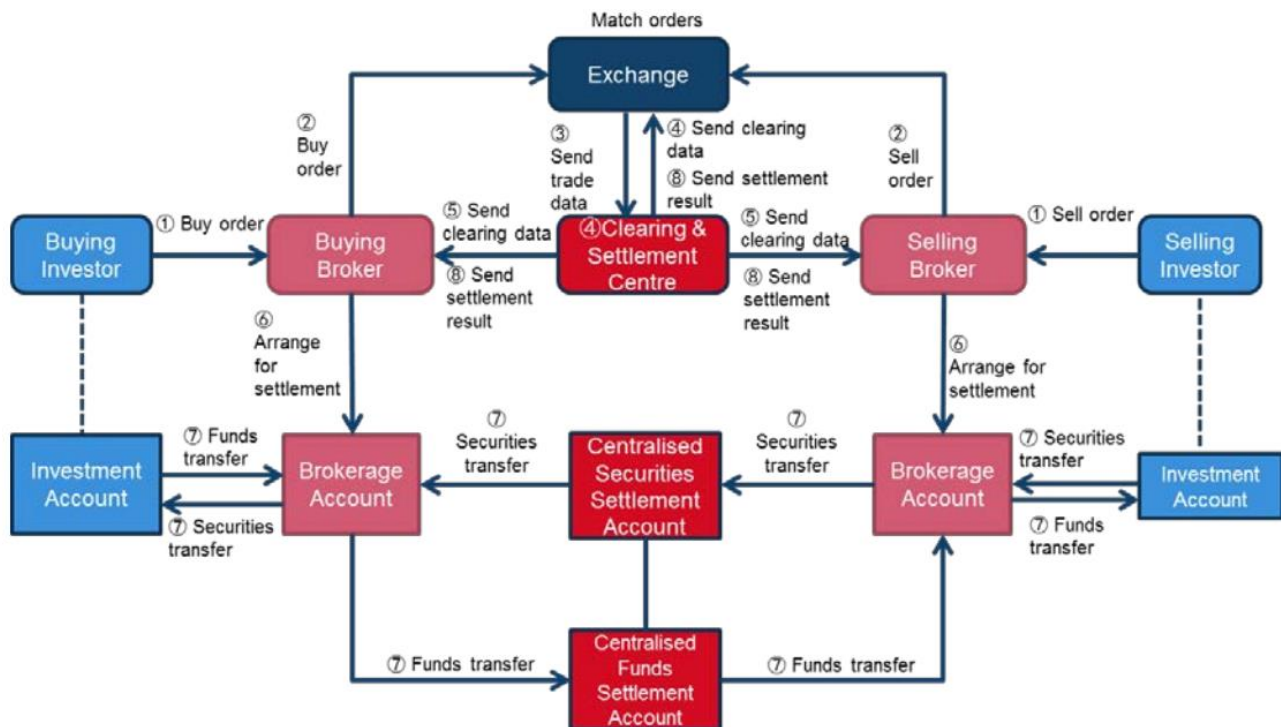


Fig. 1 HKEX (2018) https://www.hkex.com.hk/-/media/HKEX-Market/News/Research-Reports/HKEx-Research-Papers/2018/CCEO_Fintech_201810_e.pdf

Figure 1 summarizes the current settlement process and the respective parties involved. To conclude, the current settlement and corporate actions process rely heavily on central authorities. During the settlement and payment process, a lot of manual procedures, reconciliations, counterparties and financial intermediates are involved. Therefore, the settlement date for most international markets is set as T+2, 2 days after the trade date to give time for the reconciliation processes and clearing of cash and securities holdings.

1.2 Blockchain-based settlement and corporate action process

Working Principles for Blockchain-based settlement

Distributed ledger technology (DLT) in which the blockchain technology is the process of adding cryptographically signed data blocks as a chain of immutable records, while distributed ledgers is a decentralized database where several participants collaborate to consent the correctness of data (Oliver Wyman, 2016). Blockchain-based settlement is a distributed and peer-to-peer process where transaction data blocks are created in a chain of records and individual blocks are linked to previous blocks using the hash values of the later in such a decentralized database. These networks of databases can operate securely without the need for a central authority (e.g. CSD), every participant can get simultaneous view of the data.

In the DLT network, participants are considered as nodes of the distributed ledger system and are responsible to build and maintain the distributed ledger. Without the central authority, new information/ transactions added to the ledger have to undergo validation and be broadcasted among all the nodes to achieve consensus in order to be updated in the distributed ledger.

During the validation process, mining is an important way for proof of work process. The first node that solves the computationally demanding calculation helps to build a transaction block. Since mining process requires lots of investment in computer resources, participants must have incentives to perform mining. For example, the cryptocurrency company "Bitcoin" awards miners who successfully build transaction blocks certain amount of Bitcoins.

In securities settlement process, problems will arise in terms of security and incentives issue above. Therefore, another distributed ledger called "Permissioned ledger" (ECB and BOJ, 2018) is introduced where the ledger can be controlled by central authorities and only trusted participants are allowed to maintain the ledger. Validation nodes can just check and validate transactions without the mining tasks.

DLT and blockchain technology offer many opportunities to streamline the securities settlement process. The same study by ECB and BOJ (2018) reveals that there are two approaches to perform DVP settlement in DLT environment, as illustrated in Figure 2.

1. Single-ledger DVP: Exchange of both securities and cash are processed as a single transaction and recorded in the same ledger.
2. Cross-ledger DVP: Exchange of both securities and cash are separately processed in two distinct ledgers. This requires mechanisms or intermediaries to establish connection or coordination to communicate between ledgers.

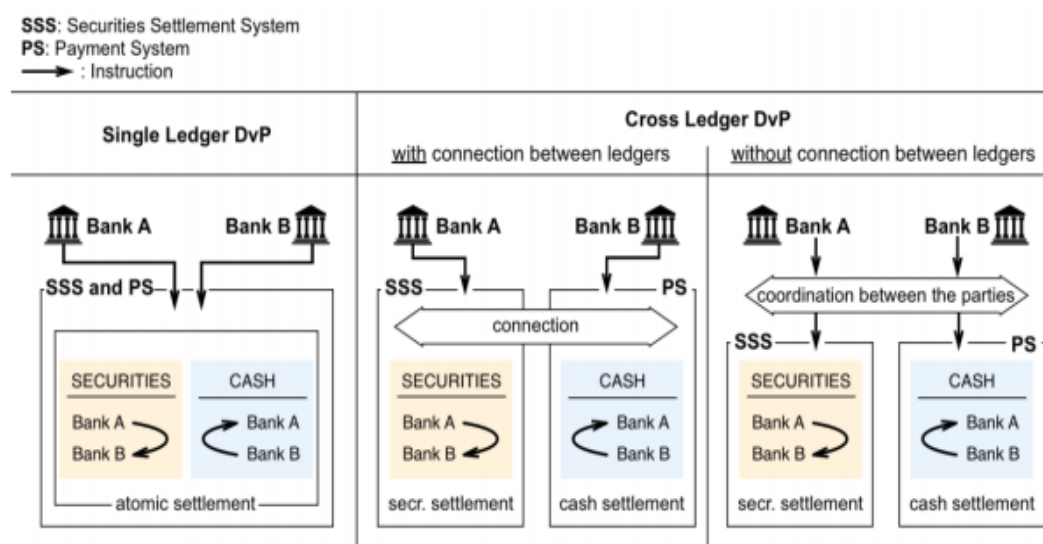


Fig. 2 ECB and BOJ (2018)

https://www.ecb.europa.eu/pub/pdf/other/stella_project_report_march_2018.pdf

To follow common practice of the industry, this paper will assume the Blockchain-based settlement is built on permissioned ledger and focus on single-ledger DVP settlement process.

Process of Blockchain-based Settlement

This section will explain the blockchain-based securities settlement process with an example. Similar to the previous example, suppose Investor A want to sell 100 shares of securities valued at \$10 per share via DVP:

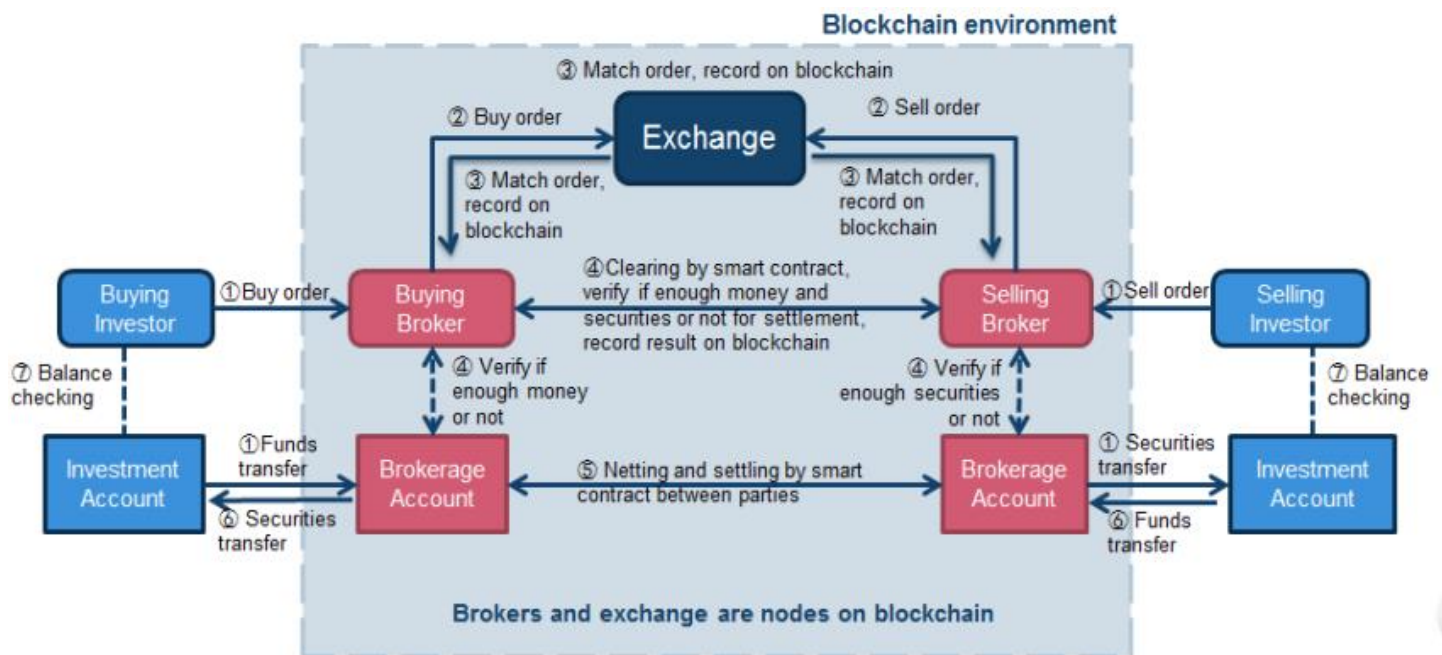


Fig. 3 HKEX (2018) https://www.hkex.com.hk/-/media/HKEX-Market/News/Research-Reports/HKEx-Research-Papers/2018/CCEO_Fintech_201810_e.pdf

1. Investor A execute a sell order for 100 shares of a security at \$10. Bank A (broker for Investor A) and Bank B (broker for Investor B) sign and send trade orders to the exchange. The matching system in Exchange matches the buy order from Investor B who wish to purchase the share at the same price.
2. Exchange uploads successful trading data and details (e.g. trading time, parties name, volume, price) to blockchain and broadcasts to all nodes. The transaction is signed by private key of Exchange and encrypted by the banks public keys.
3. Smart contract will verify whether the securities and cash holdings in real time according to the account records in the blockchain by bank A and Bank B. It will also calculate commissions and taxes in between.
4. Bank A and Bank B verifies the instructions respectively and send full-signed instructions to consensus mechanism. The trade is put on a queue of signed valid transactions and recorded with timestamp in the blockchain.
5. After getting consensus among the nodes, the trade is confirmed and the result will be written in the blockchain as illustrated in Figure 4. Smart contract performs netting and settling and real-time transfer of securities and cash will occur between trade parties.

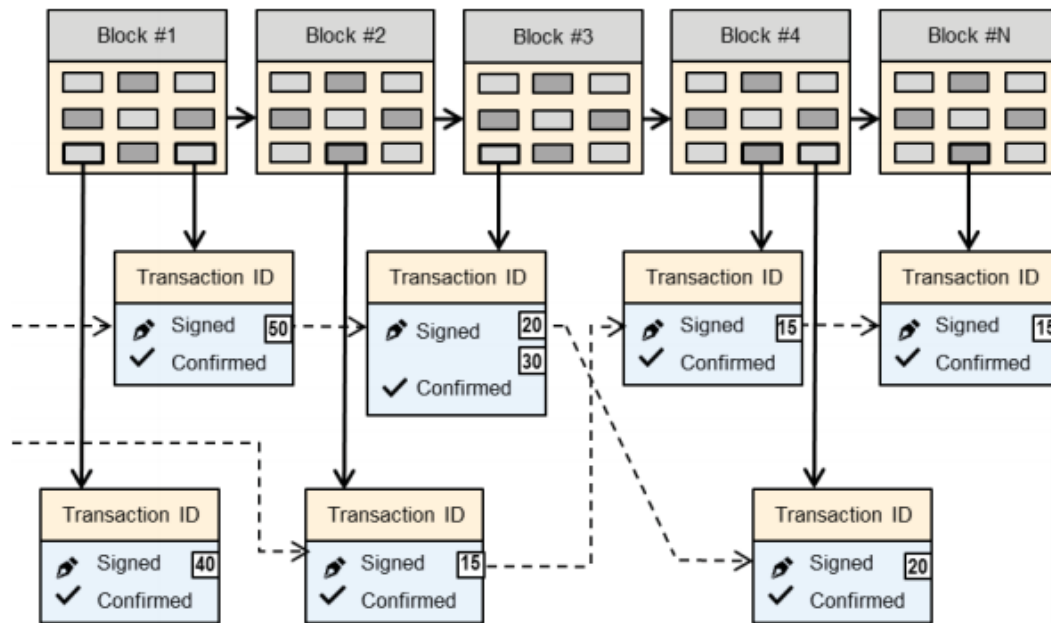


Fig. 4 ECB and BOJ (2018)

https://www.ecb.europa.eu/pub/pdf/other/stella_project_report_march_2018.pdf

6. Bank A and Bank B will then transfer the relevant cash (\$1,000) and securities (100 shares) to Investor A and Investor B account respectively.

Blockchain-based Corporate Actions Process (Dividends, Coupon payments)

The blockchain-based corporate actions process will be similar to that of the settlement process. The simplified process is as below:

1. Security issuers upload the details of Dividends payments/ Coupon payments (on bonds or obligation) announced and signed to the blockchain. The broadcast is sent to all the nodes in the chain.
2. Smart contract processes payment date, calculates the dividends/ coupon amounts, taxes, parties involved and verifies the sufficiency of funds on the security issuer account in the blockchain. After accepted by the nodes and confirmation, it will then perform netting between the nodes and transfer dividends/ coupon payments to custodian institutions/ shareholders.
3. The payment/ transaction records will be stored in the blockchain.
4. The shareholders will receive the dividends/ coupon payments on the payment date.

Involved parties in Blockchain-based settlement and corporate actions process

From the explanations and steps above, we can identify the following major participants:

1. Clients/Investors: Place buy/ sell instructions during trade
2. Banks/ Brokers
3. Exchange: Trading platform
4. Central counterparties (CCP): Clearing, transferring payments and securities
5. Central security depository (CSD): Act as gatekeeper (e.g. control access, dispute resolution, regulatory reporting) or may not exist
6. Data miners (May not exist in this case for permissioned ledger): calculates hash values of blocks, creates and updates blocks

According to Bank of International Settlement (2017), other nodes in the blockchain network may involves additional roles as below during the consensus process:

- Asset issuer node: Issuance of new assets
- Proposer node: Update the ledger
- Validator node: Validate proposed changes
- Auditor node: View the ledger

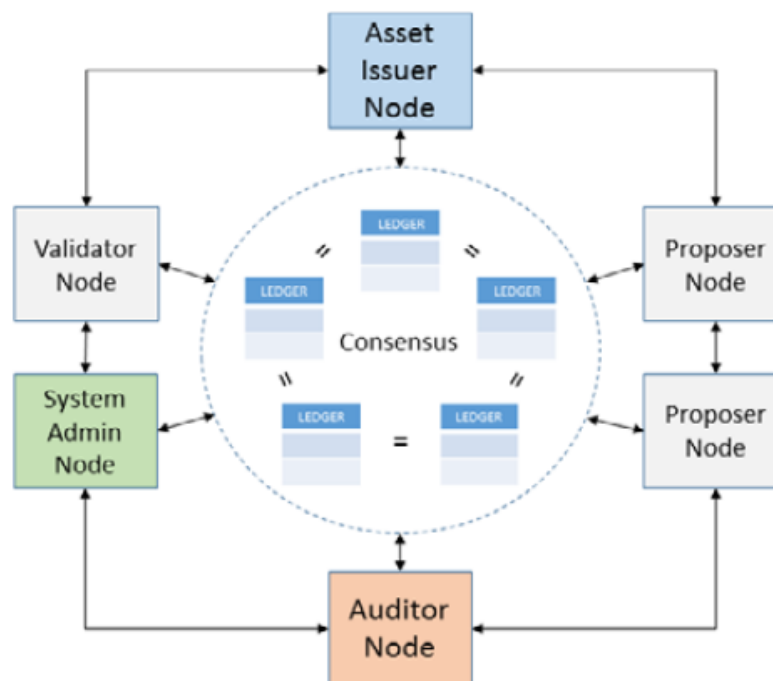


Fig. 5 BIS (2017). <https://www.bis.org/cpmi/publ/d157.htm>

1.3 Similarities and Differences

This section will discuss and explain the similarities and differences between the current securities settlement and corporate actions processes with that of Blockchain-based processes. Securities and payment movements and other aspects will be considered as below:

Similarities

Achieve DVP and present ownership of assets electronically

Both current blockchain-based settlement process can ultimately achieve Delivery-versus-payment (DVP) and ensure that obligations namely the payment of cash and delivery of securities are completed through validation processes. Also, ownership of assets can both represented electronically and participants can view their asset holdings in digital format.

Traditional Operation and Security risks may still apply to both process

Certain operational and cyber security risk may still apply to both processes. For example, both processes are subject to network problems and traditional cyber security attacks. The settlement processes will be delay when the network is down or congested. Target cyber-attacks and Distributed Denial of Service Attack (DDoS) may bring down validating nodes in DLT settlement case and bring down servers in current settlement case. If the validating nodes or servers of the participants are infected by malicious programs or viruses, false or unauthorized transactions may occur in the network.

Data privacy issues are another concern that both processes will address. Participants have to apply and comply with data protection policies and ensure that information are accurate and correct without leakage to unauthorized parties.

Differences

Blockchain-based settlement is collectively maintained by all participants

Unlike the conventional settlement system where a central party (e.g. CSD) is responsible for maintaining and validating the securities and payments movements, in blockchain-based settlement, participants as nodes participate in building and maintaining the distributed ledger. During transaction process, all the nodes work together to validate transaction data and reach consensus to build records in the ledger. The role of CSD may be simply act as a gatekeeper instead of overall coordinator.

Enhancements on securities and payment movements and corporate actions flow

In current settlement process, settlement process is centralized and involve multiple layers of participants. If the securities transaction happened in different countries or regions, the communication and settlement process will become move complex. When

there are any discrepancies in transaction data, the issues have to be solved manually. This is not efficient due to the high volume of transactions and securities and payment movements every trading day.

Smart contracts in blockchain-based settlement can automatically monitor and control securities and payment movements and transfers. With the fact that all the participants share and maintain the same ledger, this can not only greatly reduce the settlement time and efficiency, but also reduces manual errors during the transaction process.

Also, in such a decentralised database where all the participants could share their information sets, the announcement of corporate actions, cash and securities account holdings can be shared instantly. This would avoid duplicated layers in validating same information sets and would be much efficient to place trade instructions and perform corporate actions.

2. FUNCTIONAL DESCRIPTION OF THE MODULES REQUIRED IN ARCHITECTURE THAT ALLOW CONSUMERS A JOINT VIEW ON ASSETS HOLDINGS

In section 1, the current settlement process and Blockchain-based settlement process are compared. This section will explore and demonstrate the architecture that enable joint account statement for consumer holdings.

Background

It is required that depot banks have to send full accounting listing to clients upon requests. The account statement should contain the account numbers and description, transaction history and reference numbers, the types and amount of assets clients own and the nominal values of the assets. This is to ensure that the banks must have records and audit trails on reconciliation for client claims.

Architecture

In this architecture, we assume that the Blockchain-based settlement system on permissioned ledger is used on asset transactions, the permitted participants are banks, exchange and clearing houses, regulators and auditors. For each asset transactions occur, the trade instructions will be broadcasted to all nodes including individual banks. Validations and consensus will take place before updating the distributed ledger. After getting consensus, smart contracts will calculate and transfer the assets and cash holdings in asset ledger and cash ledger of the involved parties respectively.

We also assume that the Blockchain-based settlement system contains all the information required for the joint view of asset holdings such as client account details, transaction history, reference numbers, nominal values, types and amount of assets clients own. And participants will send instructions to the DLT system whenever there are any updates.

In this model, individual banks / asset custodians can utilize this opportunity to develop internal systems to facilitate the provision of joint view on assets holdings of their clients.

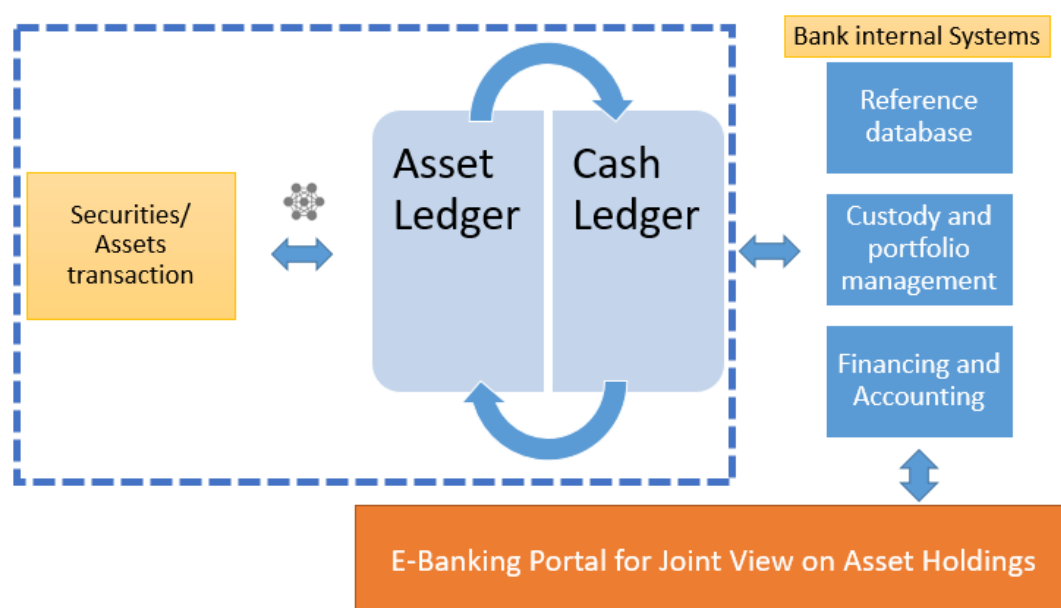
Firstly, individual banks / asset custodians should have a reference database that check differences, continuously synchronize and copy the respective data in asset and cash ledgers of the DLT settlement system. Whenever asset transaction occurs, the reference database will update the reference database simultaneously.

Since the reference database may only contain the raw data/ information on asset and cash holdings of customers, there is a need for banks and asset custodians to categorize and present the information in a proper format. Thus, custody and portfolio management system and financing and accounting system should also be developed.

Custody and portfolio management system will store all the clients' information on their current and past asset portfolios. For example, the types and number of funds, securities or investment products that clients owe. While financing and accounting system will be responsible for handling cash ledger, for instance the petit cash transactions, mortgages owe by the clients, interest and taxes. These two systems should contain a validation mechanism with the reference database to ensure data synchronization and correctness.

Finally, the systems should be link to the E-banking Portal of the customers. Such that when the customer login with their own credentials, they can have the joint view of their asset holdings. The portal also ensures that only the restricted person/ party can view the record as asset holdings data are confidential and sensitive.

Figure 6 below summarizes how customers can obtain joint view on their asset holdings:



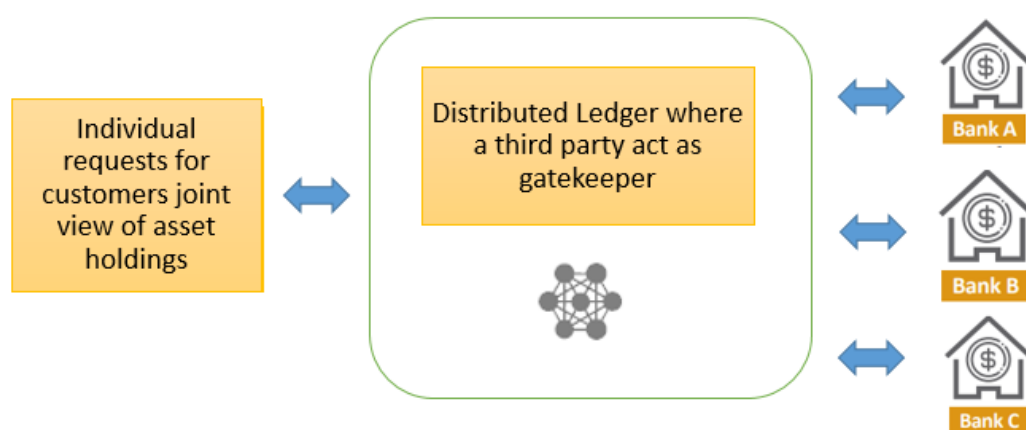
Moving forward

We have discussed how individuals can get joint view of asset holdings in their respective banks. With the help of DLT, it is also possible to build architecture that individuals can get joint view on asset holdings for inter-banks bank accounts.

Through having a DLT infrastructure which a third party act as a gatekeeper, we can achieve the benefits of permissioned ledger. When individual request for the joint view

in the third party application, the instruction will be send to the DLT network. The DLT network will send the request to all the relevant banks through an application program interface and the banks will send the information back and stored in the DLT network. The individual can then retrieve the information from the DLT network on the joint accounts view.

Figure 7 demonstrates the architecture for joint view inter-banks asset holdings:



3. REGULATORY CONSIDERATIONS WHEN ATTEMPTING BLOCKCHAIN SOLUTION FOR SETTLEMENT

Blockchain is an emerging technology where many market players pay attention to. While it offers many benefits and can greatly improve the current settlement process. It is worth to note the regulatory considerations while adopting a blockchain solution for settlement of securities and payment.

Banks /market participants must comply and keep track of the current regulatory framework

While attempting to adopt a blockchain solution in a jurisdiction, banks and market participants should follow the local laws and regulations on running the business of securities and payment settlement. They should also keep track of the regulations regarding the usage of blockchain/ DLT and data handling.

For settlements/ payment process that happen across jurisdictions, banks and market participants have to act cautiously and study the regulations of the jurisdictions carefully in order to avoid beaching of law and result in financial and reputation loss.

They should also check if there are any licensing requirements, be adaptive to changes in industrial environment and international standards. For example, CPMI-IOSCO provides industry guidance and global standard for settlement and other financial market infrastructures (OICU-IOSCO, 2020) that market participants should follow.

Regulators should be flexible and should play a more active supervisory role

Blockchain technology is changing fast, sometimes related laws and regulations may not keep in pace with the technology. Thus, insufficient legal protection may happen for participants during blockchain settlement processes. Regulators should especially pay attention to the cyber security side and the protection of account and transaction data for the sensitiveness nature of those data. Regulators should also review and update regulations regularly to keep up with the emerging technology.

Instead of passive prevention, regulators should play a more active role in monitoring this new market trend. Regulators should be flexible, grow and learn the new technology itself. They may cooperate with other market participants. For example, Hong Kong Monetary Authority has adopted “Fintech Supervisory Sandbox” and “Chatroom” mechanism where banks and tech firms can conduct pilot trials of their fintech initiatives and communicate with regulators directly (Hong Kong Monetary Authority, 2020). This can not only ensure that the blockchain solution comply with the rules and regulations, but also foster and encourage technology innovations as a whole. Regulators can thus benefit from new technology and industrial insights which are helpful for policies and regulations drafting and implementation.

On the other hand, regulators can also directly participate in the blockchain solution as nodes in the distributed network. This could allow them to gain complete oversight of all the transactions in the settlement system in real time. Suspicious and malicious transactions can thus be identified easily, preventing money laundering activities by money launders and terrorists. The process of regulatory reporting might also be simplified as regulators can gather the required information directly through the blockchain network.

Besides, nodes can be from different jurisdictions in the blockchain solution. Regulators have to stay alert and may have to regularly liaise with other foreign regulators to gather intelligence and perform cross border supervision.

In conclusion, banks and markets should pay attention to the regulatory considerations arise from blockchain solution in settlement of securities and payment. While banks and market participants should comply with the relevant laws, standards and regulations, regulators in the market should also play an active role to ensure system stability and investor protection. Through collaborations and adaptive change mindset, it is believed that regulatory barriers will be overcome.

Additional complexities

The regulatory considerations in attempting blockchain solutions for market participants in settlement of payment and securities are identified in the previous part. In this part, additional complexities will be discussed and the blockchain solution in section 2 would be used as an example.

Operational considerations

A robust settlement system requires careful planning and operational considerations. For example, one has to ensure the connectivity to the depositories and the network, the linkage to internal cash and securities banking systems, matching of trade executions, timely delivery of securities and payment of cash and so on. In the blockchain solution, participants will be join as nodes in the distributed network. This requires that the collaboration of all the parties involved. If one of the banks is reluctant to technology advancement and refuse to adapt to the change, the whole settlement process might not run smoothly. Therefore, all the market participants must take the initiatives to start the change.

Not only regulators and central authorities also have to review and update the guidelines and procedures for the new blockchain settlement solution, banks have to rethink about how to interact or integrate their internal banking system to the new blockchain solution. They might have to invest in the new technology, redesign internal banking systems and provide training for the employees. For example, the design of systems that submit trade instructions to blockchain solution. Smart contracts and programming logics also have to specifically design to fit the needs of market participants.

Operating and maintenance cost

Another consideration is the decision of who is going to be the first initiator to build the blockchain solution. The design, planning, building, operating and maintenance cost would be very high especially for new technology. This would create financial burden if the cost is bound by a few leading market participants.

The cost of building the financial infrastructure is high. Whether the development cost should be only relied on central banks or shared by participant banks reminds a dilemma. If the cost is shared, the question is how to equally divide the investment proportion.

Also, as mentioned in previous point, market participants may bear extra costs to redesign their infrastructures to adopt to the blockchain settlement solution.

Data privacy, protection and cyber security issues

Transaction data is the most valuable asset in settlement and requires special handling to prevent data leakage. For the blockchain solution in section 2, the architecture must ensure that data privacy and data protection issues are addressed. Since transaction data might be broadcasted for all market participants in the DLT network, regulators have to review corresponding data privacy laws and regulations while market participants should also agree on the quantity of data to be shared.

Although the solution is based on assumptions that permissioned blockchain is adopted and only permitted participants can join, market participants also have to pay attention to data protection issues. Cryptographic keys and access credentials in the blockchain solution should be carefully designed.

In the architecture for having joint views on multiple bank accounts, the question would be who is going to be the trusted independent third party to offer joint views of asset holdings between banks. This trusted third party must be carefully selected and agreed upon all the participants, one example could be the central clearing house jointly operate by participating banks.

Cyber security is another concern for the blockchain solution. If nodes are down due to cyber-attacks like DDoS, settlement process may be delayed. Identity theft and masquerade are security threats that may raise concerns for market participants and may result in data leakage.

Conclusion

In this paper, the current DVP securities settlement and corporate actions process are compared with that of the blockchain-based processes. It is inevitable that blockchain technology shapes the future of securities settlement and can greatly improve settlement effectiveness and efficiency. During the inclusion of Blockchain-based settlement services and systems, considerations and emphasises must be put carefully and seriously on the design and architecture of the required infrastructure, and also on the regulatory perspective.

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