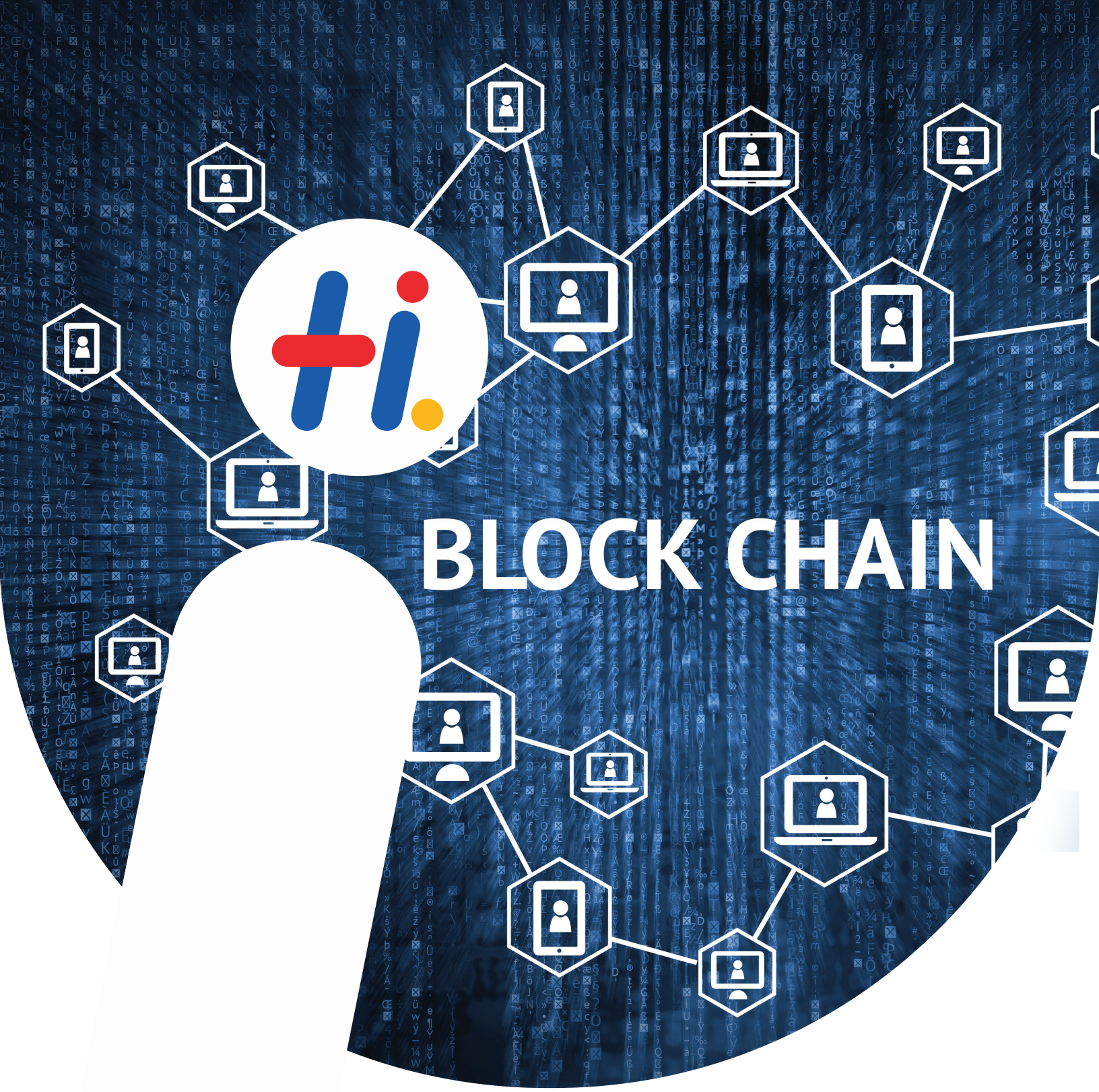

Distributed Ledger Technology (Blockchain) – Smart Contract Automation

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Author information

Bhupendra Panchal

Version: 1.0 | Date:

1 Blockchain – New Era of Business Changes

While I write this paper on blockchain, a barrage of existential questions interrupt my train of thoughts: Why someone should read about a technology which is already available for almost 10 years? Does it make sense to explain the basics of blockchain, when hundreds of online literatures are already available? What could be a new perspective on the technology, which will help my readers?

Although there are no easy answers to these questions, I will try to share insights which can be useful for the reader. I also learnt that very little has been written and discussed on the industry-wide utilities of blockchain and its current challenges.

So, I will keep the introduction of Blockchain very brief and focus more on the use cases of blockchain across various industries. The paper will also cover some really cool implementations of the blockchain technology with the help of examples and Hexaware's approach for blockchain applications.

1.1 What is Blockchain?

In layman terms, Blockchain is a ledger shared between multiple stakeholders, where each one has a copy of the ledger. The core technology behind the Blockchain is called Distributed Ledger Technology (DLT).

A more technical definition would be: Blockchain is known as the underlying framework for Distributed Ledger Technology (DLT). As the name suggests, it is a series of blocks (files) chained together and is distributed to all creators of the blocks (validators/miners), which provide access to the participants of distributed ledger.

Each block has set of transactions validated through mutual consensus algorithms, cryptographically signed to form perpetual and immutable records. Blockchain framework was first implemented for Bitcoin (crypto currency).

1.2 Permissioned VS Public Ledger

Permissioned ledger is a ledger shared by a closed group of business entities, where each entity is registered member of the network. Each entity's legal existence is recorded in a centralized registry. These closed networks will have validators and stakeholders who participate in for specific business purpose. This is more like a B2B model of DLT.

Public Ledger is an open ledger, where there is no identifying authority for any of the participants in the transactions, and it is more of a B2C approach.

We will stick to Permissioned Ledger as the basis, as we will explore how blockchain works in a B2B environment with the help of few examples.

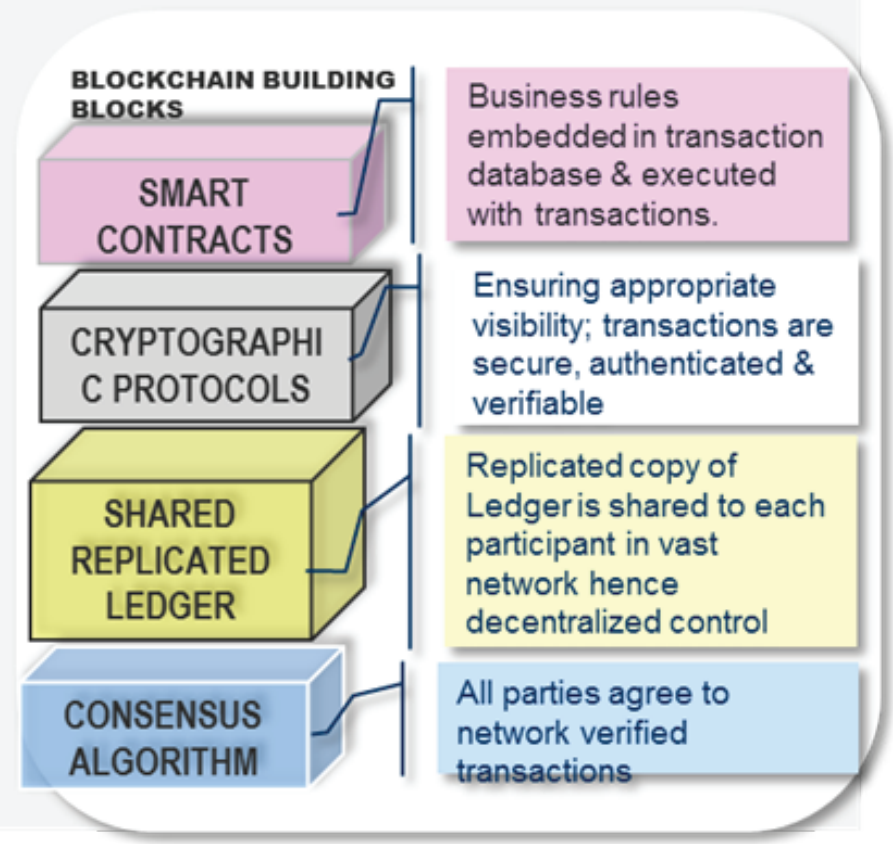
1.3 Building blocks of Blockchain and how they work

- **Shared Ledger:** A series of blocks (files) in the blockchain framework form a shared or distributed ledger. As explained prior, blockchain is a series of blocks chained together where each block has prior blocks' address in the header information, which helps validators to read the ledger in the right sequence. Shared ledger or distributed ledger allows each validator to run the consensus algorithm based on the immutable records, which is a prior set of transactions in the ledger.

- **Cryptographic Protocol:** For the transactions to be securely transmitted over the network, each platform provides series of cryptographic algorithms on different P2P protocols.

- **Consensus Algorithm:** It's an algorithm provided by the blockchain platform which has the mechanism to decrypt the transaction received, and validate the transaction for genuineness. Then decrypt the blocks of blockchain to read the records of truth to validate and process the transaction to be part of the ledger.

- The protocol allows a network to agree updates to the database collectively, with a certainty that the overall dataset remains correct at all times without the need for a central governing authority.



How they work

Let's suppose ABC Corp., a multinational company, has its manufacturing plants across multiple geographies. The company is spending a lot of time reconciling transaction records, such as purchase order, invoice, payment through multiple banks, erroneous records. The reconciliation causes delay in payments to vendors, which eventually affects checks and balances of the company, due to additional interest levied.

Each manufacturing plant of ABC receives invoices from the local vendors for the inventory ordered, the invoices are then entered into the system against respective purchase orders. A workflow is triggered based on the entry of the invoice. The respective unit heads of manufacturing plants approve ensuring goods were received as per the purchase order and invoice is not exceeding purchase order value and inventory received. After the approval, the transaction is sent to the finance department for processing the payment. Since the volume of transactions are high, the system generates daily payment feeds for the respective local banks, to process in nightly batches. Payments are made from the escrow account of each plant, which is managed by a local bank. Some vendors supply inventory to more than one plant of ABC located in different geographies.

As the payments are made to multiple vendors through multiple bank accounts, a reconciliation is required to weed out duplicate records and erroneous transactions. Reconciliation is a complex process, which later requires a lot of human effort for erroneous records to be fixed.

As we are clear with problem statement of ABC Corp., let's find out how the blockchain/distributed ledger helps resolve the situation.

Since ABC is big customer for all its banks, the banks will provide a platform to ABC's payment processing. The platform will take up invoice processing for ABC and will manage the process as bill discounting. Even vendors liked the platform because brings in more transparency to the system and reduces their headache of following up with finance teams of each plant. The bank will charge nominal fees for bill discounting to vendor and will charge nominal fees to ABC for taking over its invoice processing, payment processing and eliminating reconciliation of records.

The suggested platform is distributed ledger/blockchain between banks and the company. The bank recommended process change. For instance, instead of ABC receiving invoices, the invoices will be sent to the respective banks. The banks would post the invoice to the blockchain platform, where ABC Corp. would create an interface for its system to validate the invoice against every purchase order, and make payments accordingly.

Now let us understand how the building blocks of distributed ledger/blockchain work to achieve this. **Before we proceed with an example, we must understand what a 'smart contract'** is. A program written in native language of the blockchain platform, Smart Contracts executes a set of business rules to validate a transaction. Each transaction type has its own business rules and hence each transaction type has its own smart contract.

Let's say ABC Corp. holds an escrow account with banks "BOA" & "BOB". As per the current business flow, we have following transaction types:

1. Invoice validation against purchase order
2. Redeem Invoice
3. Charge Fees to Vendor
4. Charge Fees to Manufacturer

The banks would have created a smart contract for each of the transaction types mentioned above. Let's take the example of transaction type 'Invoice validation against purchase order', banks' Smart Contract will validate following business rules:

i. Invoice is not paid off prior by the other bank. Smart Contract will read from blockchain/records of payment from the company
ii. The invoice is due for payment
iii. The invoice is from a registered vendor of the manufacturer ABC Corp. – read from the system of records
iv. Purchase order number and vendor name on the invoice has matching record of purchase order in ABC's system and Items invoiced are same as purchase order and the unit prices and quantity match with purchase order record - read from the system of records
v. Amount mentioned in the invoice is less than or equal to the purchase order amount – any prior invoice payments made against the same purchase order
vi. Whether terms and conditions of the payment is either full or part

There can be more business rules depending on the complexity of the process. All these rules are validated by the Smart Contract ensuring the requested invoice transaction is genuine and terms & conditions of payment are met. The transaction is then processed by the bank and the same is available on the blockchain of the company.

*Note: As a thumb rule, banks ensure each Smart Contract validates only one transaction type i.e. business rules. Each business rule can be separate routine/function, which can be a reusable component.

Blockchain API: It is a program which provides interface between disparate systems of records and blockchain platform. APIs are developed in the native language of the blockchain platform. A single API can manage multiple transaction types, which means an API can interface with multiple disparate systems. The other approach is to have an API for each disparate system for its own transaction type.

In our example, the bank's Smart Contract validates and finds the transaction to be genuine, a notification is sent to Blockchain API of ABC on the blockchain to read the invoice record and send the data to ABC's invoicing system.

As this is done, the bank's payment blockchain API is activated, which activates the "Redeem Invoice" smart contract of bank. Smart Contract calls the bank's API interface with internal payment system to fetch the vendor bank details. "Redeem Invoice" Smart Contract will ensure the vendor details match between ABC Corp. and the bank records with KYC tagged to the account.

Once "Redeem Invoice" Smart Contract has validated all business rules, the bank API for making payment is activated, so the amount is transferred to respective bank account.

Once the payment is processed by the bank, the transaction is made part of the blockchain with the payment transaction details against the invoice, along with bill discounting fees charged to the vendor and invoice processing fees to the company are also recorded.

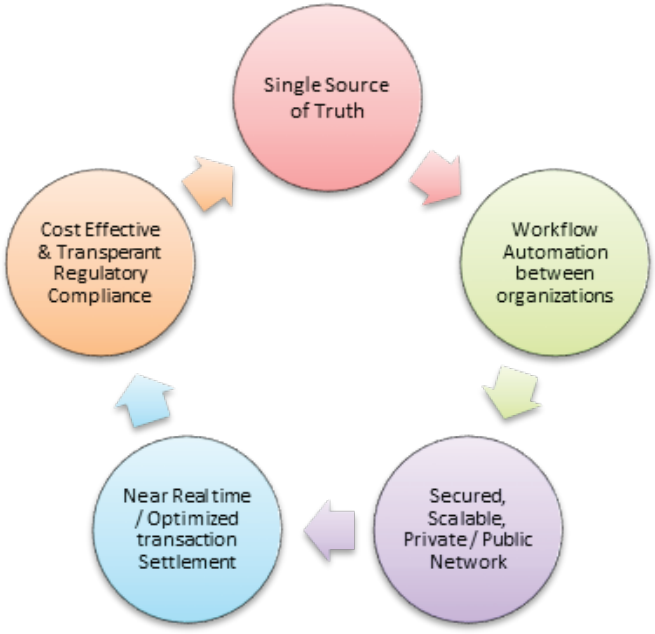
The same process is replicated across other banks, where the ABC Corp. blockchain API will read the transactions details from blockchain to update the accounts payable in its financial system.

As you can see blockchain is maintaining complete traceability and is single source of truth, hence no reconciliation is required.
As explained above, in bill discounting, a manufacturing company can hold similar escrow account with another bank "BOB". The bank "BOB" is also part of the same Blockchain platform, so the ledger is replicated between "BOA" and "BOB" banks where the similar set of transactions can occur.

1.4 Top 5 benefits of Blockchain:

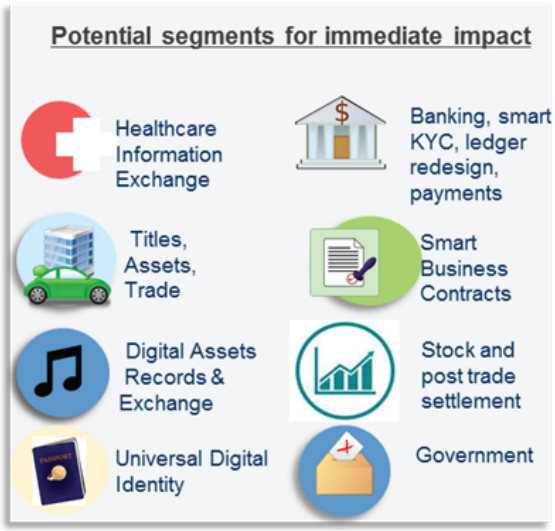
Following are top 5 benefits of blockchain:

1. Acts as a single source of truth
2. Provides automation of workflows between organizations
3. All Transaction are within Secured Network – Cash flows and exchange of assets
4. Provides near real time or optimized transaction settlement cycle
5. Has inbuilt feature to provide cost effective transparent regulatory compliance



2 Few of the Potential Segments for Immediate impact are:

1. Healthcare
   a. Potential area of implementation –
      i. information interchange
      ii. whole sale to retail inventory flow and cash flow
2. Banking
   a. Potential area of implementation –
      i. Know your Customer (KYC)
      ii. Trade Finance (Bill Discounting / Letter of Credit)
      iii. Short term collateralized loans - Collateral Management
      iv. Asset / Equipment Finance – Leasing
      v. Payments
3. Reality / Asset Trades
   a. Potential area of implementation –
      i. Titles of assets
      ii. Mortgage
      iii. Asset Financing
4. Media Industry:
   a. Potential area of implementation –
      i. Ownership of Digital assets on the shared Ledger
      ii. Exchange of records
5. Capital Markets
   a. Potential area of implementation –
      i. Securities Transaction
      ii. Asset Servicing
      iii. Derivatives Transactions
      iv. Short term Cash instruments
6. Government
   a. Potential area of implementation –
      i. Unique identifier – electronic voting
      ii. Registration of Properties
      iii. Sharing of Criminal Records
      iv. Sharing of trade data between foreign ministries



3 Blockchain Use cases for Capital Market:

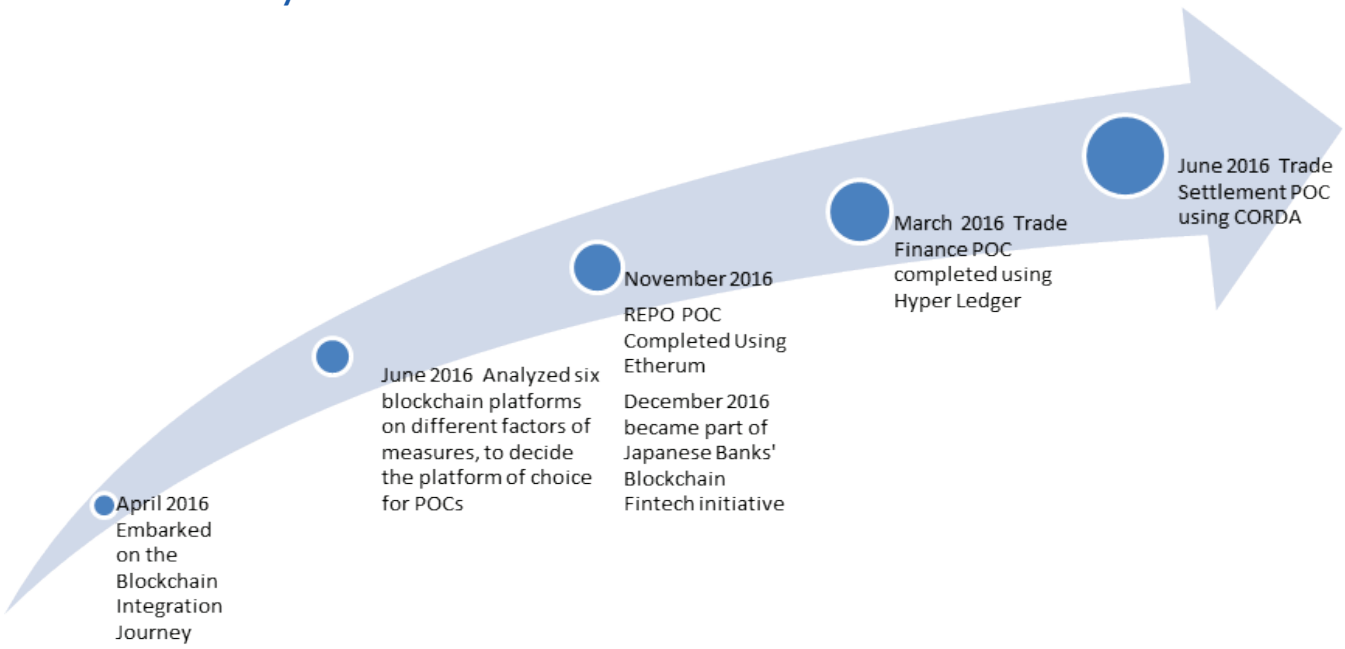
1. Trade Settlement –
    a. Blockchain can provide near real time settlement platform of trades and single source of truth. Post trade settlement, activities such as movement of cash and security can be made part of blockchain between custodians and banks.
2. Short Term cash instruments
    a. All cash instruments such as REPO (Repurchase Agreement), reverse REPO, MSFT (Master Security Forward Transaction), BSB (Buy Sell Back) and SBS (Sell Buy Back) are OTC instruments and are executed through Bloomberg/Custodians platforms. Blockchain Smart Contracts can validate workflow for these short term cash instruments and provide collateral management as well.
3. Know Your Customer (KYC)/Know Your Customers' Customer (KYCC)
    a. KYC / KYCC requires single source of truth to be maintained for all applications and same can be achieved using Blockchain. It can be shared across all applications as single source of truth with complete accuracy.
4. Transfer Agency – Retails Chain Management
    a. Transfer agencies sell mutual fund products to High Network Individuals / Retails investors through their platforms. Blockchain can help record collection of funds from investors, allocation of units to investors and payments to Transfer Agents. It reduces Reconciliation effort across platforms.
5. Fund Administration
    a. Creation of funds and changes on static data of funds can be made part of Blockchain, where all downstream systems can consume from it.
6. Debt Security Issuance (Sell Side)
    a. Complete process of Debt instrument Issuance can be ported on blockchain, which can serve as single point of KYC. Blockchain can even help in interest payment and redemption as it can store bank accounts information.
7. Equity Issuance (IPO)
    a. Equity issuance through IPO can be made easy using Blockchain. Similar to Debt issuance explained prior.
8. Corporate Actions – Dividend payouts
    a. Dividend payments to holders of the equity can be made easy.
9. Electronic Voting – for AGM
    a. Corporates can use blockchain for E-voting to get stakeholders opinion on Agendas of Annual General Meeting.

4 Current Challenges for Blockchain

From 2008 till date, too many platforms for blockchain have emerged in the market. Each platform has its own implementation approach, consensus algorithm and P2P protocol. We can say that they are distinct in many ways. Following are a few of high level challenges for blockchain:

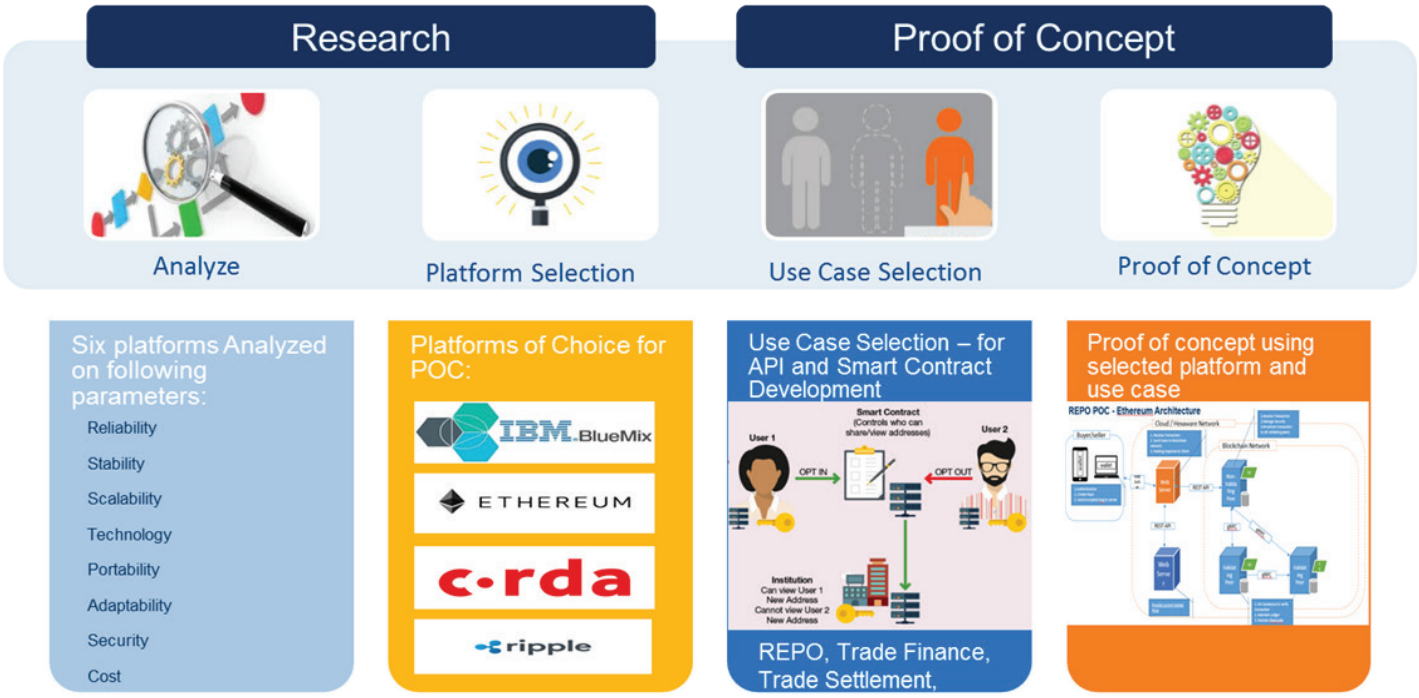
1. Need for Global ID implementation – for seamless flow of transaction between blockchain platforms even in permissioned ledgers, global id would be required
2. Digital assets unique id for transaction consistency – Lot of assets such as bonds, OTC instruments, properties can be traded on blockchain platform only once each asset has digital asset id which can identify each asset uniquely
3. Protocol for Cross network communication for seamless, platform agnostic transaction posting
4. Standardization rules for each type of transaction – Since most of the asset trading is based on OTC agreements which are customized to Nth degree, writing smart contract to validate each term and condition will mean writing a new smart contract for each deal which defeats the purpose
5. Legal implications with digital crypto currency

5 Hexaware's Journey in Blockchain

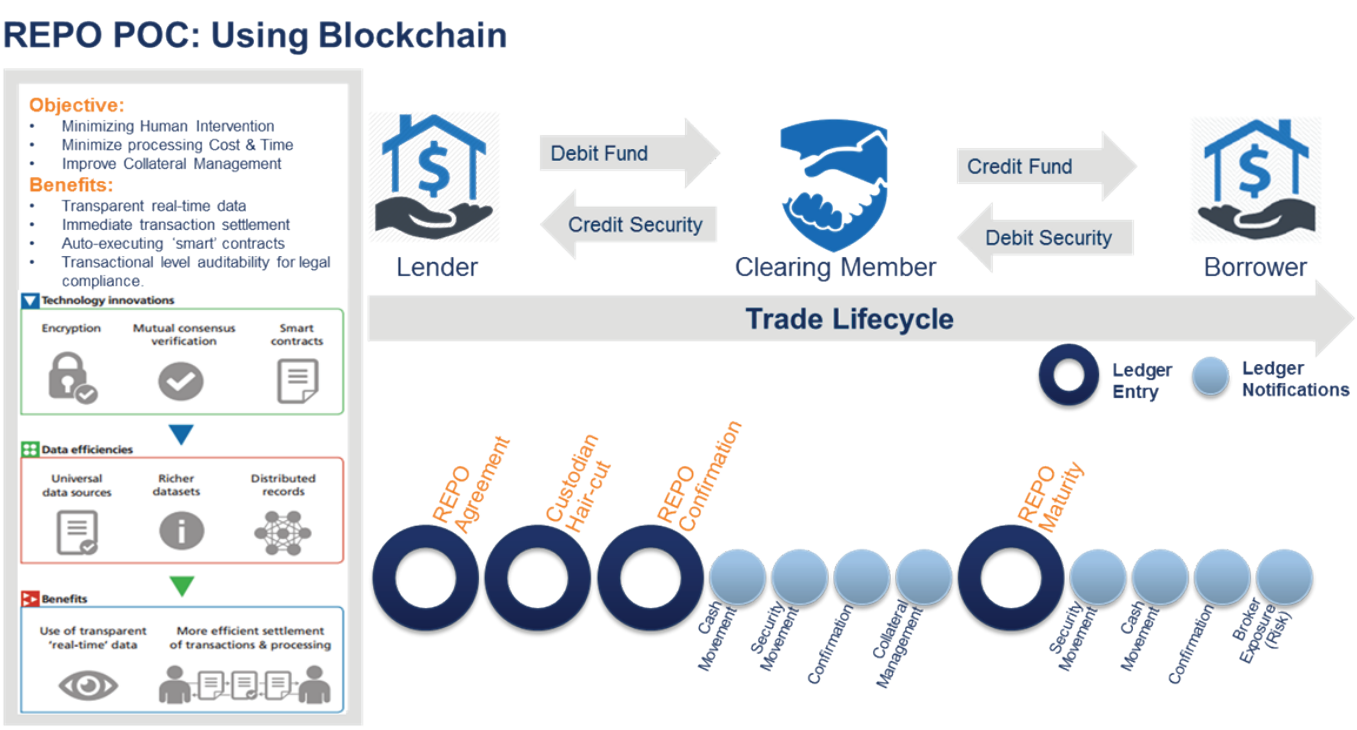


6 Hexaware Blockchain POCs

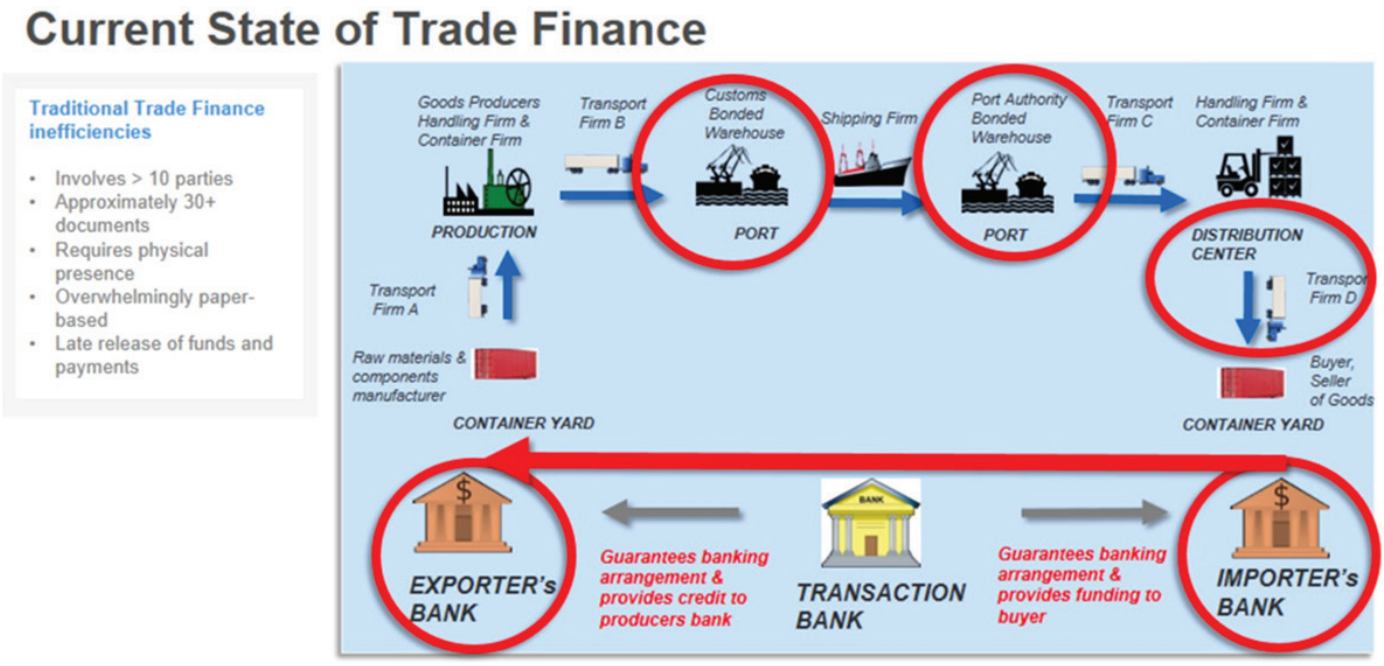
6.1 Hexaware's Approach to Blockchain



6.2 REPO POC using Ethereum Blockchain platform



6.3 Trade Finance POC using Hyper Ledger Fabric (IBM Blue Mix) Blockchain platform

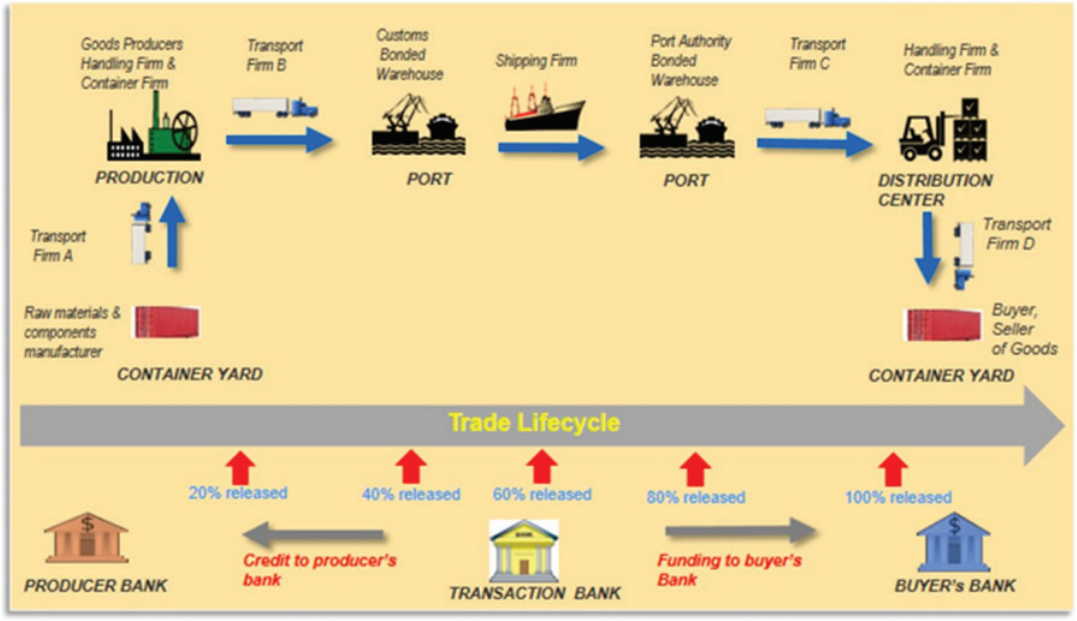


Trade Finance on Blockchain connected to IoT

Objectives:
- Customize and expedite trade financial instruments in international trade
- Reduce disputes, delays and liability

Solution:
- LOC and smart contracts on Blockchain
- Link Blockchain to sensors which track physical good movement (IoT) for evidence to smart contract.

Benefits:
- Exchange of value occurs as trade cycle advances: Cargo advances through checkpoint
- Unambiguous shared view across importer, exporter, both port authorities, banks.
- Easy reuse of smart contract assets on other trade deals.



7 Hexaware Blockchain Service Offerings

1. **Blockchain Insights**
    a. Hexaware can provide insights into
        i. Basic concepts of Blockchain
        ii. Comparison of different well known Blockchain
        iii. Different Blockchain implementation approaches

2. **Advisory Services on Systems Architecture**
    a. Help select the platform of choice for implementation, and can define different approaches possible with each of the Blockchain platform
    b. We can provide detailed comparison on different factors such as scalability, reliability, stability, adaptability, limitation, cost etc.

3. **Blockchain Business Case Assessments**
    a. Study candidature of business use case identified by the customer and provide independent assessment detailing pros and cons, high level cost of implementation, valuation of Blockchain implementation from short term and long term business objectives perspective

4. **Proof of Concept, Prototype build Services**
    a. Hexaware can help customers to identify a use case and create a proof of concept, prototype build services

5. **Blockchain Feasibility Studies, Strategy and Roadmap**
    a. Understand customer business objectives and provide feasibility study on implementation of blockchain
    b. Define strategy on the mutual agreement of feasibility study
    c. Detailed roadmap on Implementation strategy

6. **Blockchain operating model design**
    a. Design solution for multi partner blockchain operating model

7. **Partnership Support**
    a. Fintech partner for Blockchain support

8. **Blockchain as a Service**
    a. IBM Bluemix, Eris, Ripple, Tendermint, CORDA, Rubix, Ethereum
    b. Hosts blockchain as a service for POC/Prototype testing

9. **Full-scale systems integration -- Blending legacy system functions with blockchain solutions**

About Hexaware

Hexaware is one of the leading, global providers of IT, Application, Infrastructure, BPO and Digital services. Our business philosophy of Shrink IT, Grow Digital allows customers to significantly shrink commodity IT spend while partnering with them to embrace digitalization. The Company focuses on key domains such as Banking, Financial Services, Capital Market, Healthcare, Insurance, Manufacturing, Retail, Education, Telecom, Travel, Transportation, Professional Services and Logistics. Hexaware focuses on delivering business results and leveraging technology solutions by specializing in services like; Application support, development and maintenance, Enterprise Solutions, Human Capital Management, Business Intelligence & Analytics, Digital Assurance (Testing), Infrastructure Management Services, Digital and Business Process Services. Founded in 1990, Hexaware has a well-established global delivery model armed with proprietary tools and methodologies, skilled human capital and SEI CMMI-Level 5 certification. For additional information logon to: www.hexaware.com

NA Headquarters
Metro 101, Suite 600,101 Wood
Avenue South, Iselin,
New Jersey - 08830
Tel: +001-609-409-6950
Fax: +001-609-409-6910

India Headquarters
152, Sector – 3
Millennium Business Park
'A' Block, TTC Industrial Area
Mahape, Navi Mumbai – 400 710
Tel : +91-22-67919595
Fax : +91-22-67919500

EU Headquarters
Level 19, 40 Bank Street,
Canary Wharf,
London - E14 5NR
Tel: +44-020-77154100
Fax: +44-020-77154101

APAC Headquarters
180 Cecil Street,
#11-02, Bangkok Bank Building,
Singapore 069546
Tel : +65-63253020
Fax : +65-6222728