FUTURE SUPPLY CHAIN USING BLOCKCHAIN TECHNOLOGY

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Abstract: ***A regular supply chain limits at bilateral relationship as information, goods and commercial papers always flow along a chain. Use of blockchain can expand this relationship all over the system such that information are shared across the entire network at the same time. Blockchain assures information flow from a single source to all stakeholders thus eliminating any scope for manipulation to suit one party. Blockchain offers unique high-end features including visibility, transparency, provenance, integrity, trustworthiness, confidentiality, privacy, security, immutability, traceability, verifiability , interoperability, scalability, proof-of-existence, reliability, cost-effectiveness, tamper-resistance, versatility and resilience. Blockchain is growing faster than expected and thus delay in formulating strategies for its adoption may prove fatal for companies. Blockchain, thereby, can become the mainstay in supply chain digitization. It is a long way to go to fully realize the potential of blockchain in supply chain efficiency.***

Index Terms: Supply Chain; Block chain; transaction; digitization; traceability; cost effectiveness

1. Introduction

Complex supply chain in the current business environment, extends many geographies, spanning over hundreds of production stages of manufacturing and supplying entities, where bi-directional data flow occurs amongst suppliers to manufacturers to distributors to retailers and finally to customers. A huge number of stakeholders get involved from sourcing of raw material to change of hands of finished products to end-consumer and flow of revenue from customer end to manufacturer/raw material supplier through intermediary stakeholders. However, provenance and history of a product is often not known to upstream actors keeping scope to some stakeholders acting unethically. Customer needs must be shared efficiently and product as well as service deliveries must have tracking system to provide end-to-end visibility in the supply chain. The cutting edge Blockchain technology is emerging as solution to this issue.

2. Evolution of the Concept of Blockchain

Blockchain is derived from path breaking open-source technology introduced to market in 2008 by Satoshi Nakamoto. It has heralded the next industrial revolution after three successive generation starting from steam driven engine, electrical energy, and information science innovations(Chung and Kim 2016; Schwab 2017).

Blockchain is a private initiative towards creation of digital assets logged in a chronological order and distributed across a network making the recording transparent, traceable, immutable and autonomous. Being a cost effective business model through digital transformation in cloud integration, it revolutionizes the way transactions are performed for centuries together. It possesses following unique features:

i. a public distributed database that holds encrypted ledger to ensure details of transactions confidential
ii. involves definite and confirmable record of each transaction
iii. includes a shared ledger up-to-date and verified continually with all participants
iv. shares ownership, position, location and status of assets with all stakeholders

In the blockchain, each new block of transactions is linked with previous blocks in such manner that scope of fiddling is completely eliminated. A series of blocks are stacked one over other with each block connected with its preceding and succeeding block with hash pointers. A block is a compilation of all current transactions by creating hashcodes for each transaction and once verification is done successfully, the block gets added to the blockchain and this way the chain keeps growing. Each block is a repository of transactions and has a specific hashcode as its identity which is unique in nature as hashes are developed with highly complex algorithm that can't be copied or duplicated. Blockchain gets updated every 10 minutes aiding access to latest global data on real time basis. Once a data is entered in blockchain, it can never be removed.

3. Blockchain in minimizing Supply Chain Challenges

"In the long history of humankind (and animal kind too) those who learned to collaborate and improvise most effectively have prevailed" - Charles Darwin

"Without understanding the impacts of goods and services, we buy into systems that deplete natural resources, worsen environmental and social problems and endanger humans and ecosystems. Supply chains are conventionally held secret, limiting the stakeholders who can prevent environmental, social and health and safety problems." - Leonardo Bonanni, Sourcemap founder

In conventional supply chain, a series of bilateral contractual links are connected with lack of trust and openness. Each link is a bottleneck for information flow, trustworthiness and technological improvement. The anticipated risk at each link prolongchain cycle and raise cost resulting in a disconnected supply chain. Thus, the traditional Supply chainlacks in visibility necessary for ensuring accountability, traceability, transparency and efficiency. Visibility across supply chain alongwith transparency allows sharing of internal processes with all stakeholders.In Don Tapscott's words "Greater transparency is an unstoppable force. It is the product of growing demands from everybody with an interest in any corporation – its stakeholder web – and of rapid technological change, above all the spread of the Internet, that makes it far easier for firms to supply information,

and harder for them to keep secrets." In late 90's, Gartner Analyst Arthur Mesher called for a makeover through his famous research titled "The 3 V's of Supply Chain: Visibility, Variability and Velocity".

Blockhain technology is a game changer in infusing transparency in Supply Chain Management. It is a digital, distributed ledger for storing and transmitting peer-to-peer information and transfer of ownership from one entity to other facilitating trust with global consensus. It ensures recording of all transactions covering date, location, quality, state of the product, price and any other information starting from the time it was created in a chronological order and distributed across a network in a verifiable way. Transition of a product can be documented every time it changes hands thus building a permanent history of the product from manufacture to distributor to end-customer reducing delay, cost and error.

A regular supply chain limits at bilateral relationship as information, goods and commercial papers always flow along a chain. Use of blockchain can expand this relationship all over the system such that information are shared across the entire network at the same time. Blockchain assures information flow from a single source to all stakeholders thus eliminating any scope for manipulation to suit one party. Theledger opens up information on all transaction events amongst trading partners. It ensures digital record of all agreements, tasks, processes and payment with verifiable signatures which can be identified, validated, stored and shared without involvement of any intermediary functions like brokers, lawyers, bankers etc. All stakeholders can freely transact with direct interaction with other party. The ledger is duplicated in many identical databases, each held and maintained by concerned party and when any change is effected in one copy, all the other copies are simultaneously updated. When a product is produced, the inspection agency is informed to check the specifications and the product is either passed or failed by the agency – the charm of blockchain is that this information is visible to all stakeholders so that the shipping agency gets to know when exactly shipping is needed, raw material supplier gets ready for supply to production company, customers get a feel of the journey of the product and at link the concerned stakeholders get their payment electronically the moment their responsibilities are done. Thereby the supply chain recording becomes transparent, traceable, immutable and autonomous.

Blockchain empowers buyer-supplier relation by removing inefficiencies in supply chain instruments including reverse factoring and dynamic discounting. All stock transactions can be settled within seconds, securely and verifiably. This low-cost solution threatens traditional business model with its revolutionary approach. Blockchaincan revolutionize bilateral physical and financial transactions just as TCP/IP did for e-mail enabled bilateral messaging by intensely reducing cost of connectivity. It can be applied in banking, finance, judiciary and commerce. It provides round-the-clock access to products and services. Blockchain technologies alongwith IOT (Internet of Things) ensures improved supply chain provenance. It revolves over a peer-to-peer system, aiding collaboration amongst parties unknown to one another. It facilitates 'Smart Contracts' that ensures payment to supplier as soon as a shipment is delivered. A product with GPS functionality can automatically log status update on delivery triggering payment.

Blockchain can be viewed as an organized supply chain with decentralization of business process that allows multiparty financial transaction with facility of tracking of quantifiable or tangible assets. In simple words, blockchain would almost eliminate transaction costs. Trader A ends up paying say $5 as transaction fee while transferring fund to trader B through current banking system. Such transactions are enormous in number and banks earn extensively out of it. Blockchain facilitates the same transaction with nil or very little fees depending on volume and frequency of transactions. In current banking system, one can only see the transactions made by himself but not made aware how bank is utilizing his money lying in his account. Blockchain allows complete visibility of all transactions be it from your end or bank's end.

4. Block Chain utility in supply chain of select industries

In words of IBM's McDermott, "We see other industries like energy, healthcare and marketing, looking at transformation that really could be happening."

Pharma Supply Chain: For patients and public health systems, blockchain can facilitate electronic health records that can be shared with variant health centres with complete protection of information. In pharma supply chain when ownership of medicines moves from manufacturer to distributor to retailer to patients, the ownership changes and manufacturers have little visibility to track authenticity which may result into counterfeiting. With blockchain, drugs tagged with barcodes are scanned and incorporated in digital blocks during change of hands. Such real time logs can be accessed round the clock by all stakeholders including patients. Each drug can have its own identity on the blockchain to record change of ownership. Blockchain ensures traceability and detection in a cost effective manner. Whille buying drugs, patients get access to full details of chain till manufacturer who handled the drug and can easily make out reliability of the product.

Food Supply Chain: IBM has declared blockchain collaboration with food giants Walmart, Nestle and Unilever to figure out source of adulteration or contamination in seconds. Walmart is already using blockchain to track sales of pork meat in China with complete visibility of processing, storage and sales. In product recall scenario, origin of batches and list of affected customers can be easily traced. Sensitive food products can be fitted with sensors to measure storage temperature, humidity, vibration and transfer to blockhain for record. Any deviation in storage condition than agreed, can be seen by each member of blockchain and corrective actions can be triggered without delay. On the other hand, customers can easily check the source of the food item alongwith its lifecycle by simply clicking on QR-code scan on their smartphone.

Automotive Supply Chain: Inbound - Blockchain with IoT sensors can provide accurate end-to-end view of part location, quantity, status and other important details to concerned parties. OEM gets clear visibility of inventory/spare parts requirements at plant and plans its production schedule accordingly. Thereby, inventory holding cost can be minimized raising inventory turns and in turn profitability. Outbound - Blockchain with IoT sensors can provide accurate end-to-end view of vehicle location and status thereby cutting down erroneous orders leading to optimized inventory holding and reduced lead time.

Petroleum Supply Chain: Blockchain can eliminate expensive reconciliations by sharing all transactions covering freight rate management including freight order/bill of lading/invoice, track-and-trace, invoice calculation and payment remittance. Each shipment transaction is shared on a digital database with complete visibility to manufacturer, logistics operator, distributor and end-customer. Blockchain facilitates automation of import/export records. Clearing and settlement processes rely on complex multiple databases which can be substituted with one cohesive ledger blockchain.

5. Comparison of typical Blockchain Platforms updated in GitHub

Platforms	Acceptance	Network type	Pricing	Language	GitHub repo
Ethereum	High	Public, Smart Contract based	Ether for transaction and computational services	Python, Go , C++	pyethereum (Python) gpethereum (GoLang) cpp-ethereum (C++)
Hyperledger(Sawtooth Lake)	High	Both Private and Public	Open Source	Python (For Sawtooth Lake)	sawtooth-core (Python)
Open Chain	Medium	Private	Open Source	Javascript	openchain-js (Javascript)
Multichain	Medium	Private, Permissioned	Free, Open Source	Python, C#, JavaScript , PHP, Ruby	savior (Python) c#MultichainLib (C#) Multichain-Node (JavaScript) libphp-multichain (PHP)
HydraChain	Low	Private / Permissioned	Open Source	Python	hydrachain (Python)
IBM BluemixBlockchain	Medium	Private/ Permissioned	Limited free plan with paid upgrade to enterprise plan	Go, Javascript	learn-chaincode (Go) ibm-blockchain-js (Javascript)
IOTA	Low	Public, Permissioned	Based on IOTA Token	Python, C, Javascript	iota.lib.py (Java) ccurl (C) iota.lib.js (Javascript)
Chain	Medium	Permissioned	Enterprise Licensing	Java, Ruby, Node.JS	sdk-Java (Java) sdk-Ruby (Ruby) sdk-Nodejs (Node.JS/Javascript)

Source: Radiostudio - Shyam Purkayastha, Cloud Computing

6. Literature Review

The author of this paper brought out variant characteristics and functionalities cited in various literatures (22 literatures reviewed) as depicted below:

A. Features

i. Blockchain comes with distributed ledger[10,14,15] coupled with security[7,10,15,16,20], integrity[12], immutability[12], privacy[12,14,20], Traceability[22], private-public ledger architecture[14], visibility[14,16], smart contract platform[15], efficiency[16], reverse factoring[16], dynamic discounting[16], interoperability[16], trustworthiness[16,18,20,21], robustness[16], permissionless platform[16], proof-of-existence[18], equality[20],

ii. It aids timestamping, a method that evidences existence of specific information at specific time.[3]Timestamping is one of the most challenging functionality of blockchain towards integration of (B2B) business and (M2M) IoT transactions.[15]

iii. Retrieval and verification of timestamps is possible.[3]

iv. Researchers, authors, journalists, students, artists can have proof of existence of specific information at a given time.[3]

v. Blockchain-based transactions are secure[7], trust-free[7,9,11,12], decentralized[8,9,11], Resilient[9], Scalable[9], Secure[9]& Auditable[9], Autonomous[9,16], transparent[8,12,14,16,18,21], reliable[12], versatile[12], cost-effective[15], tamper resistant[18], peer-to-peer[11],

vi. Using blockchain, existing markets efficiency can be enhanced with profits from entirely new market as well.[11]

vii. It can facilitate economy to get democratized through peer-to-peer production and consumption.[11,14,15,16]

viii. Blockchain Technology can streamline movement of data, information, goods and money on a common shared digital platform.[16]

B. Challenges

i. Cost impacts arisen from regulatory requirements and associated service providers like exchanges, vaults and wallets are disregarded.[2]

ii. Erroneous entries can't be reversed.[1]

iii. Inefficiencies associated with incentive and governance of public ledger platform is ignored which may see light with more competitions coming in.[2]

iv. Blockchain requires trusted third party recording transactions to guarantee information reliability.[3]

v. It does not guarantee reliability of information with many limitations that hinders trustworthy digital records.[6]

vi. Incentive and specific steps for implementation lacks clarity.[4]

vii. Literatures discuss more on bitcoin with less focus on blockchain.[5]

viii. Many of solutions proposed in literatures do not direct tangible evaluation on effectiveness.[5]

ix. There is lack of study w.r.t scalability alongwith throughput and latency.[5]

x. Hindrances include costs, scalability issues and volatility in transaction.[7]

xi. It requires certain IT infrastructure like internet accessibility that may come in way for remote providers.[8]
xii. Organizations may not always be in favour of transparent lifecycle and auto generated payments which often are being utilized for business leverage.[8]
xiii. There are several challenges to be addressed e.g. trade-off between consistency and availability, Smart Contract Vulnerabilities, Awareness, Privacy, Efficiency.[9]
xiv. While some organizations may not advocate public ledgers, permissioned/private ledger has limitations in delivering desired outcome of the technology. A combination of both may address the gap in supply chain.[14]
xv. Limited research is available in resolving block collisions and forks.[14]
xvi. Further work needs to be done on trust functionality of public ledger with respect to number of monitors.[14]
xvii. The hype over blockchain has reached its zenith or a little behind and a slope in excitement is expected in coming years.[17]
xviii. Several features of blockchain may need further improvement in terms of authentication, throughput, scalability, cost-effectiveness, latency, security and privacy.[19]
xix. Transparency and trust have reciprocal relationship and implementation of both adds considerable cost with difficult to measure benefits. Tradeoff between transparency/trust and cost/benefit is one of the biggest challenge in blockchain implementation.[21]

C. Adoption/Application

i. Financial institutions of repute Mastercard, Visa, NASDAQ and many more are exploring possibilities of aligning existing business models with blockchain.[10]
ii. Risks associated with blockchain delays its adoption. Very few startups of blockchain may see the light of winning. It may take a decade or two for significant adoption.[10]
iii. Blockchainapplications are mostly in financial sector, private and public record keeping and asset management.[13]
iv. Ethereum, a smart contract platform, has come up with new value-added offerings such as a platform to develop your own virtual currency, or to build decentralized applications or to run decentralized autonomous organizations through the smart contracts.[13]
v. Applications include de-centralized cloud-storage of data, tracking votes in elections and maintaining decentralized notary through the proof-of-existence of legal documents.[13]
vi. Most business activities and our everyday tasks may be automated and handled through blockchain partnered with other technologies.[13]
vii. It can be integrated and used with other technologies to expand its usage. One typical case is where Blockchain is to be used with Internet of Things (IoT) devices and smart contracts initiate and manage automated interactions between these connected devices.[13]
viii. Applications include self-paying cars, usage-based payments and usage in smart cities.[13]
ix. Blockchain can facilitate food and pharmaceutical organizations in meeting regulatory compliance.[14]
x. Public ledger may grow rapidly with varietal nature of shipments covering trans-shipment, load sharing, distance etc.[14]
xi. Blockchain is more pronounced in in multi-echelon and responsive supply chains where higher cost savings can be resulted from information availability with trustworthiness alongwith autonomy of decision-making processes.[16]
xii. Blockchain applications will be pronounced mostly in financial industry.[17]
xiii. Cryptographic assurances, that new age protocols deliver, has ability to go above proof-of-existence that can be utilized in critical clinical trial data management due to tamper resistant functionality of blockchain that prevents all kinds of manipulation.[18]
xiv. Disputes w.r.t design drawings, corporate planning can be handled using blockchain through verification of records in database.[20]

7. Conclusion

Most of the Supply chains being operated today face serious challenges on various fronts like continuous manual intervention, lack of transparency, dearth of interoperability, limited information on product's state during its course of journey from manufacturer to end-customer and the reverse flow. A phenomenal transformation on these challenges can be brought usingblockchain technology. Blockchain offers unique high-end features including visibility, transparency, provenance, integrity, trustworthiness, confidentiality, privacy, security, immutability, traceability, verifiability, interoperability, scalability, proof-of-existence, reliability, cost-effectiveness, tamper-resistance, versatility and resilience. All supply chain events and transactions starting from the time it was created can be made available on real time basis in a chronological order distributed across network in a verifiable way giving high comfort level to sellers, buyers, logistics operators and other stakeholders. Blockchain's timestamping functionality can show presence of data, information at a given point of time. Smart contracts can be adopted to eliminate manual handling and expensive delays alongwith assurance to supplier about payment as soon as shipment is delivered. Blockchain is growing faster than expected and thus delay in formulating strategies for its adoption may prove fatal for companies. Blockchain, thereby, can become the mainstay in supply chain digitization.

The Blockchain once fully evolved will be able to reduce the international transaction costs, mainly arising out of traceability, considerably. The GI (Geographical Indication) and IPR (Intellectual Property Rights) issues in the international transactions can be eased to a larger extent using the blockchain. Cross border transactions involving import-export procedures and documentations can be fastened with an effective blockchain intervention. It is a long way to go to fully realize the potential of blockchain in supply chain efficiency. All stakeholders are eager to utilize this great technology and it is expected to evolve fool-proof given the global involvement in addressing some of the inconsistencies in the technology.

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