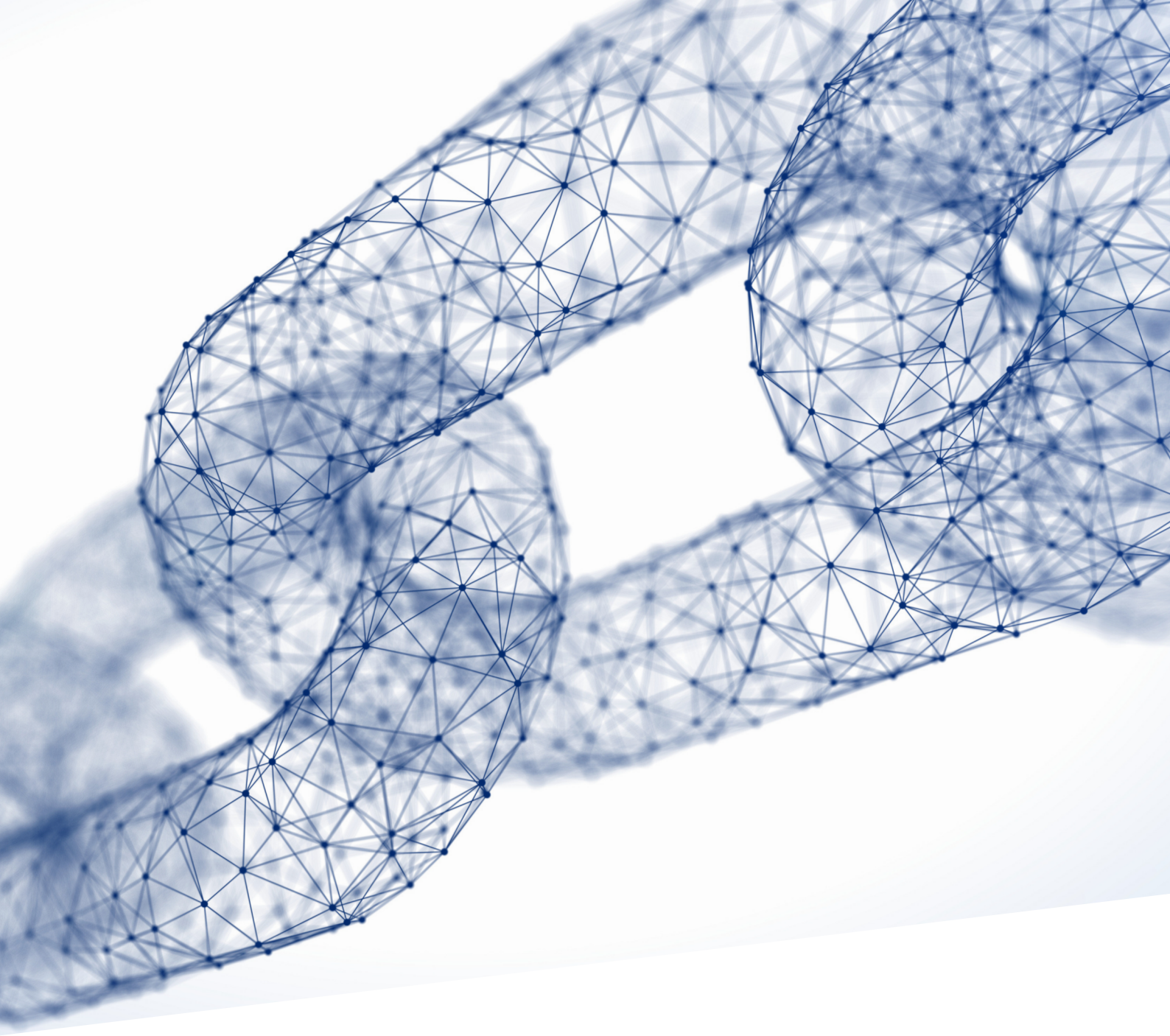

Orange Paper

Blockchain

Powering Unprecedented Supply Chain Visibility

syncron

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How Manufacturing Changes Have Impacted Supply Chain Visibility

Smart manufacturing – which harnesses data and puts machines at the center of decision making – is rapidly becoming commonplace. Customers' on-demand mindsets, where products should always be up and running, and service should be instantaneous, is fueling a massive transformation across the global manufacturing sector. As a result, manufacturers are redefining the way they do business, adopting new technologies to transform the customer experience and improve financial performance.

These economic, demographic and technological changes are leading to a new industrial revolution, or Industry 4.0. With sensors providing more data about equipment and parts than ever, there is a huge opportunity to truly optimize the complete supply chain.

Modern supply chains remove preexisting boundaries that previously restrained businesses. The always-on, connected nature in which today's world operates bridges the gap between manufacturers and customers in even the most remote locations and can create unprecedented growth opportunities. However, this growth, both in terms of reach and capacity, has also made the global supply chain more complex and volatile.

In the last 50 years, the pattern of manufactured goods' trade has undergone drastic changes. With the rise of globalization, companies have been moving manufacturing processes from industrialized regions to low-income countries, and more and more companies are outsourcing parts of their supply chain in pursuit of cost reduction. Manufacturers are constantly striving to improve their revenues and profits and to increase their market share, employing complex distribution networks to ship growing volumes of goods further and further away from the original production site. These networks comprise various entities: distributors, warehouses, carriers, ports and customs offices, but all too often, the large number of stakeholders leads to limited visibility, poor traceability, unstandardized processes and data silos.[1]

To overcome these new challenges, manufacturers must find ways to increase supply chain visibility (SCV), a key success metric of effective logistics and distribution operations. Visibility, or the ability to track goods in all tiers of the supply chain, from the manufacturer to the end customer, enables capital reductions, improves customer satisfaction and reduces operational risk. Research shows that a lack of visibility into all steps of the supply chain process is perceived by the industry as a major issue; nearly half of the top supply chain and logistics managers across several industries believe that – along with business process synchronization and access to accurate information – a lack of SCV is the biggest obstacle to achieving supply chain goals today.[2]

The Complex World of Supply Chain Ecosystems

When analyzing SCV, it's important to distinguish between two types of supply chains. The first type is one with a dominant entity, the second is characterized by more even distribution of power between participants. The former is referred to as ***unipolar*** and the latter as ***multipolar***. We feel that these terms, borrowed from international politics, accurately encapsulate the differences in the distribution of power in complex supply chain ecosystems.

In a world of unipolar supply chains, a centralized inventory management solution, like Syncron Inventory™, empowers leading manufacturers to maximize product uptime and deliver exceptional after-sales service experiences. This allows for the easy establishment of control towers and ultimately, achieved SCV.

A related quality of supply chain is traceability, which is the ability to learn a product's path through the supply chain to its current location. There are a lot of initiatives in the space of blockchain applications that focus on traceability, while the aspect of visibility is neglected.

This paper addresses that gap, and demonstrates how difficult it can be to establish control towers, and, consequently, to enable SCV in multipolar supply chains. But, a novel blockchain solution can easily overcome the challenges of achieving SCV in multipolar supply chains.

Improved Visibility as a Key Success Metric

SCV – the ability for manufacturers to track parts, components or products to their destination – is the key to balancing service and cost. Visibility enables collaboration between suppliers and buyers. It brings responsiveness, reliability, and flexibility to supply chain operations.[3] Suppliers can greatly benefit from gaining downstream visibility into stock levels of their customers because it allows them to forecast sales more accurately and to increase sales revenue thanks to improved availability. By getting an accurate demand forecast, suppliers decrease their safety stock, thus reducing stock-keeping costs.

On the other hand, buyers can leverage visibility to better manage the risk of shortages that negatively affect the customer experience. In cases when a part is required to fix a broken machine, the information on where it can be found is a critical asset. Buyers have the ability to make more educated sourcing decisions based on their suppliers' stock data, and in the case of a shortage at one supplier, they can swiftly switch to another that is able to meet their expectations towards order fill rates and lead times.

To address these expectations, manufacturers must transition from a reactive, break-fix model to a subscription-based uptime guarantee to further increase customer satisfaction. Gaining fuller visibility is pivotal for the efforts to shift to a service model that maximizes machine uptime.

In supply chain management, visibility increases collaboration not only between immediate business partners, but also along the whole chain. The benefits of collaboration grow exponentially with the number of involved parties. An example of this is optimizing inventory across multiple echelons of the supply chain, rather than locally for each stock-keeping location. The purpose of this approach is not to generate an optimal solution for each participant, but one that is optimal for the whole supply chain.

In addition to customer expectations, businesses face increasing stakeholder expectations, industry standards, environmental regulations and global trade rules that create additional challenges. Achieving supply chain compliance is yet another reason why companies must focus more on visibility. The lack thereof may lead to non-compliance due to inability to respond to changes in the supply chain, such as dynamic shifts in customer behavior.[4]

But, depending on the type of the supply chain within which they operate, how can businesses achieve the aforementioned benefits through the use of centralized or blockchain solutions?

Inventory Management Effects on Unipolar Supply Chains

Employing an intelligent inventory management system works well in unipolar supply chains, where a single entity can convince all participants to adopt a single centralized solution. For example, when an original equipment manufacturer (OEM) purchases a single solution license, such as Syncron Inventory™, for all its branded dealers, they have the ability to use stock and stock transfer data to calculate and maintain desired service levels for all parts. Because these calculations require precise information on warehouses' stock data, continuous data sharing between warehouses and the central system is essential.

Another advantage of introducing a centralized system to optimize inventory for multiple participants is an ability to gain a real-time insight into the supply chain status. Users benefit from a comprehensive view of the stocking situation across the whole supply chain and see the information in a more unified and aggregated way. To support this, the system offers data validation – an important step, as data comes from multiple entities – which can use different formats and business rules internally.

To provide a good insight into the past, the system loads and processes various historical data. For example, historical demands are analyzed to properly classify processed parts. One of the features provided as part of demand analysis is seasonality detection. Many parts in the agriculture or automotive industries are used seasonally and if such a pattern is detected, prediction becomes much more precise. The product lifecycle deduced from past demand improves long-term predictions.

Accurate demand predictions are essential for both inventory optimization and for providing users with SCV. Based on demand analysis, the system calculates a forecast of future demands. One of the methods available is a statistical forecast which analyzes time series to predict the future. Another type of forecast available is a causal forecast, which requires many types of additional information such as machine running hours or turn on / turn off cycles. Finally, installed base is another example of data used to enhance forecast accuracy as it provides information about the population of serviced machines in which a spare part is used.

At the core of an intelligent inventory management solution are the replenishment calculations, making sure to optimize inventory levels according to configured service levels and to keep stock at a minimum to save money for our customers. Configuration of the desired service levels for stocked parts is either provided by logistics experts, or calculated by the system based on the general configuration of targets. Replenishment takes into account multiple available data types such as forecasted demand, supplier lead times, supplier prices and available delivery modes, and replenishment calculations are aimed at determining how much stock is needed at which warehouse so that chance of a run out is small while keeping the stock level low. These calculations consider variability of demand as well as lead time from the supplier to provide enough buffer to cover for a probable run out situations.

Advanced multi-echelon inventory calculations look at stock levels holistically across the supply chain. It requires tight collaboration between dealers and suppliers and is more complex to perform but provides even higher cost savings than single-echelon optimization. Based on replenishment calculations, an inventory management solution like Syncron Inventory™ generates order recommendations for parts, where orders can be reviewed and approved manually or automatically by the system according to preconfigured rules. Accepted orders are executed to cope with the predicted future demand.

Visibility Challenges Within Multipolar Supply Chains

In order to achieve total visibility, let's revisit the two types of supply chains: unipolar and multipolar. Multipolar supply chains are intercompany and devoid of a single dominant entity with enough influence to impose changes on the whole supply chain, while unipolar supply chains are either intracompany or intercompany with a single dominant entity.

A good example of a unipolar supply chain in the after-sales world is a self-run model implementation in which an OEM sets up its own regional distribution centers (RDC) or hires third-party logistics to establish RDCs to make a regional distribution to branded dealers. Here, obviously, it's the OEM that is a dominant driving force of the whole supply chain. Typical examples of multipolar supply chains are these buyout model implementations in which an OEM relies on independent, multi-branded wholesalers to act as regional agents for spare parts' distribution. Moreover, fierce competition and standardization processes make after-sales spare parts a viable alternative to OEM products. In such configurations, large wholesalers or alternative parts manufacturers wield almost equal power over the network as the OEM, which in turn leads to multipolarity.

It must be noted that it's advisable for OEMs to choose a self-run distribution model (unipolar) over a buyout distribution model (usually multipolar).[5] Nonetheless, when buyout model is already implemented the challenge of transition to the self-run model is enormous and therefore rarely undertaken.

But, it's more difficult to achieve visibility in case of multipolar supply chains than it is for unipolar supply chains. To prove this, compare the difficulties in establishing control towers between these two types of supply chains. Control towers are important, as they can be used for offering services to monitor and direct end-to-end activities in supply chains. They are also prerequisites for achieving SCV. For unipolar supply chains, however, it's natural that the initiative of establishing control tower may only be driven by the dominant entity. It's also obvious who should absorb the initial costs related with control tower implementation: the dominant player.

In the multipolar supply chain case, we have several equally influential entities that must agree on establishment of the control tower. This is a difficult endeavor due to lack of trust and mutually agreed objectives between the supply chain parties and problems with allocating implementation and maintenance costs. Establishing control towers has been studied in the context of CPFR initiatives which goes beyond providing a joint visibility. CPFR, which stands for Collaborative Planning, Forecasting and Replenishment, is a business practice that combines intelligence of multiple trading partners in planning and fulfillment of customer demand. In theory, a CPFR process does not depend on technology, but in practice its successful implementation requires a control tower, be it centralized or distributed.

A study conducted by Panahifar et al have proven that the two biggest obstacles for CPFR implementation in inter-company supply chains of automotive spare parts industry are: IT infrastructure problems and lack of mutually agreed objectives.[6] As inter-company supply chains are usually multipolar and successful, CPFR implementations require establishing control towers, the study confirms our assumptions about the difficulty of achieving visibility in multipolar supply chains.

How Blockchain Powers Unprecedented Visibility

Blockchain technology is considered to be one of the most transformative emerging trends of our time. Its first and most widely adopted application is Bitcoin, a cryptocurrency created in 2009 by Satoshi Nakamoto. Thanks to blockchain technology, different parties can transact digital assets, and in the case of cryptocurrencies like Bitcoin, these assets are digital currencies. In other applications, the assets can be titles, shares, intellectual property or other digitized securities.

It's likely that, similar to the financial services industry, blockchain technology will transform other industries, including after-sales service, and various manufacturers have been already looking into ways of capitalizing on those opportunities. Many initiatives are underway to implement blockchain technology to transform various aspects of supply chains, including enabling visibility and traceability, payment processes, next-generation loyalty programs, maintenance and repair logs, and telematics.

A blockchain is a distributed ledger that keeps a record of transactions between parties. Each participant can maintain their own copy of the ledger, which makes blockchain technology a distributed alternative to traditional databases. However, while centralized databases are perfect for storing large volumes of data in a relational form and handling queries, blockchain technology facilitates collaboration and introduces transparency across a network.[7]

Because of its characteristics, blockchain technology is a perfect building block for an integrated data layer for the supply chain that ensures visibility between counterparts. Using a distributed ledger removes the need to directly integrate heterogeneous systems in order to exchange data. Instead, each entity only integrates with the blockchain.

Unlike a traditional ledger, a blockchain is not controlled by one entity. By removing the central arbiter, this technology eliminates the need for intermediaries. Instead, at the inception of a network, a data protocol for sharing data within the network is defined. Owing to its distributed architecture, blockchain technology guarantees that no single participating party will be able to take control over the whole network, which is crucial in the world of multipolar supply chains.

Cooperating parties could use a blockchain to publish their stock level information as transactions, and this data could be updated on a real-time basis, made available for authorized parties and used for optimization of inventory and replenishment planning. Ultimately, new entities can join the network and use a computer program, called node, to communicate with the

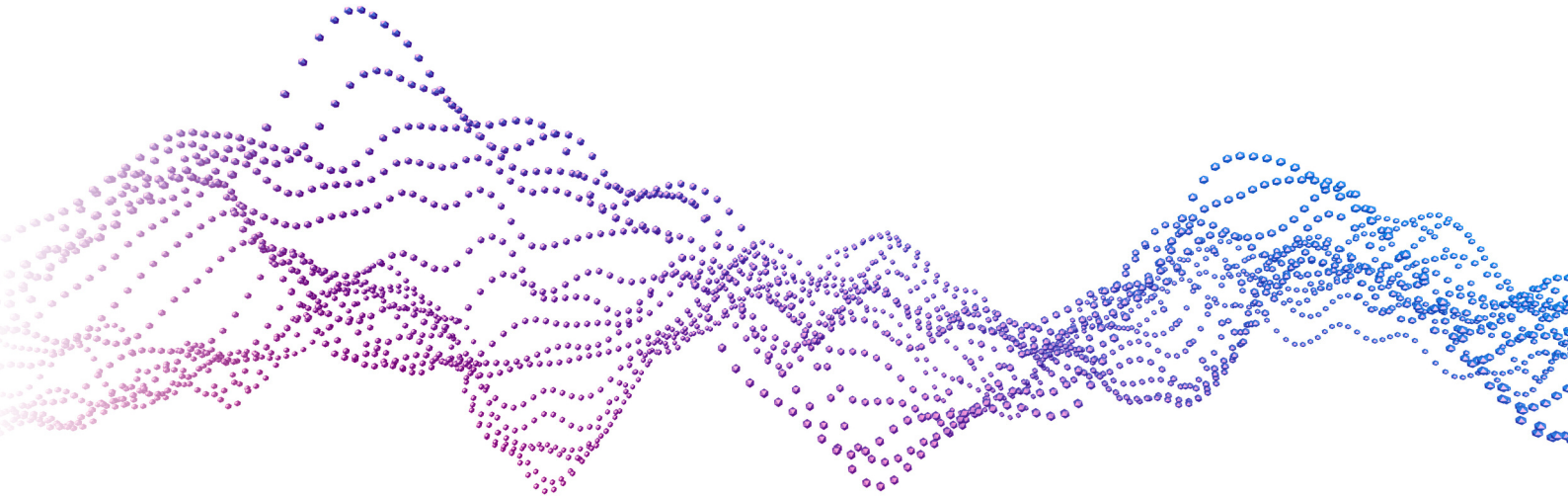
network. Blockchain technology, due to its distributed nature, allows for gradual adoption of the system with new nodes joining as the network expands.

Supply Chain Data Sharing with Blockchain

As an immutable distributed ledger, a blockchain's entries represent single transaction records. Blockchain transactions should not be confused with business transactions, which may require multiple transaction records to be stored on the blockchain, but as transactions approved by all participants of the system using a consensus algorithm.

A consensus between nodes participating in the system is extremely important as it prevents network from fragmentation into separate sub-networks and prohibits hostile nodes from spreading false information across the system. As a result of data sharing and consensus, each server node contains all information about the whole blockchain.

In the case of enterprises joining a common solution to share data privately, permissioned blockchain is the most appropriate. To provide validation and manage business entities joining the system, independent validation authority should be established. Such a solution makes sure that identity of all participants can be verified by a validation authority before access



to network or data is granted. Because of that, network participants can be sure that they are sharing data with their actual business partners. After a business entity is validated and granted permission to join the system, it can manage permissions to their users independently as well as manage their server node and permissions to the data they put into the blockchain.

The most important information to share between partners in a supply chain is stock levels and stock transfers. This can be translated into a blockchain as 3 main types of transactions: ***Declare Stock Level, Stock Sent*** *and* ***Stock Received***.

Using these transactions, business entities declare what stock they have for all parts at a given time. This includes in-transit stock that can be deduced from stock transfers. Because of that, systems that are connected to the blockchain can work completely asynchronously and one participant can declare its data or read data of other participants whenever it's convenient for it. Common attributes included in all of the transaction records on the ledger are:

- Transaction ID which uniquely identifies it on the blockchain,
- Previous transaction ID which is used to establish an order on all transactions,
- Timestamp of the transaction,
- Blockchain address of the entity which uniquely identifies who submitted the transaction to the blockchain.

Each transaction is linked to the previous one and it's signed and encrypted by the entity that posts it to the blockchain. This way, the ledger has a consistent and verifiable state. In this approach, entities have to give each other permissions to see each other's data, allowing for mutual data sharing, a fair practice that could increase openness of network participants.

All parts are uniquely identified by their master product code for a given manufacturer code, and all participants use manufacturer codes consistently. Additionally, all locations owned by a participant of the system are recorded on the blockchain after a business entity joins the system.

The first type of transaction is ***Declare Stock Level***. It's used whenever a stock level changes for a part in one of business entity's stock keeping locations. In addition to common attributes, each stock declaration record contains the following attributes:

- Location ID which uniquely identifies the location where the part is stored,
- Manufacturer code which identifies the manufacturer that produced the part,
- Master product code which identifies the part type,
- Stock quantity which describes the quantity of part stock stored at the location.

Whenever a business entity sends parts to their business partner, it creates the second type of transaction called ***Stock Sent***. In addition to common attributes, each *Stock Sent* transaction record contains the following attributes:

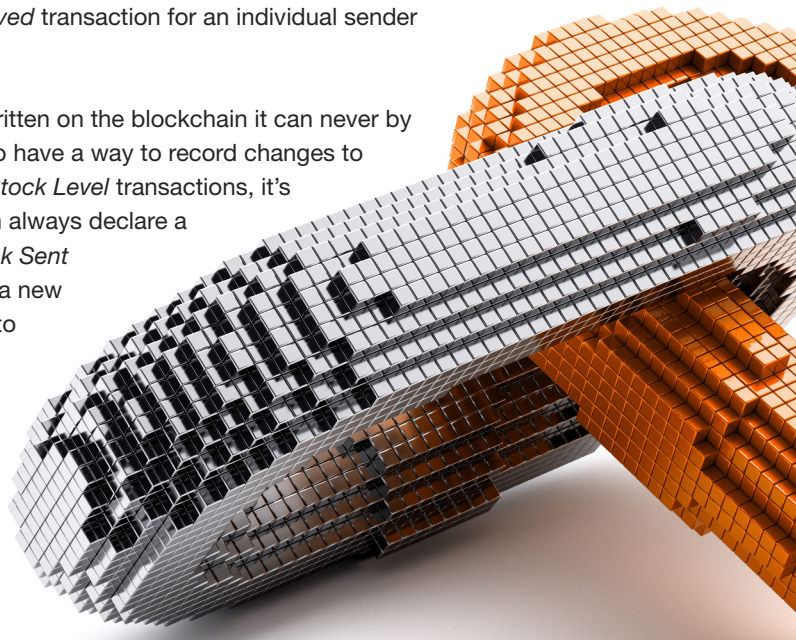
- Sender location ID which uniquely identifies the location from which the part was sent,
- Receiver location ID which uniquely identifies the location to which the part was sent,
- Manufacturer code which identifies the manufacturer that produced the part,
- Master product code which identifies the part type,
- Shipped quantity which describes the quantity of stock sent from the sender location to the receiver location.

The last type of transaction is ***Stock Received***. It's used whenever a business entity receives some quantity of a part from their business partner. In addition to common attributes, each *Stock Received* transaction record contains the following attributes:

- Sender location ID which uniquely identifies the location from which the part was sent,
- Receiver location ID which uniquely identifies the location to which the part was sent,
- Manufacturer code which identifies the manufacturer that produced the part,
- Master product code, which identifies the part type,
- Received quantity which tells how much of that part was received at the receiver location from the sender location,
- Sender transaction ID which uniquely identifies a related *Stock Sent* transaction written by the business partner who sent the stock.

The system requires that received quantity cannot be higher than sent quantity for a related sender transaction. The system also checks that the same *Stock Sent* transaction is not used by two different *Stock Received* transactions – in such a case only the first valid *Stock Received* transaction for an individual sender transaction ID is accepted.

Transactions are immutable – once a transaction record is written on the blockchain it can never by modified or removed. To overcome this limitation, we need to have a way to record changes to existing or past information on the blockchain. For *Declare Stock Level* transactions, it's simple, because, if a mistake occurs, the business entity can always declare a new stock level correcting the previous declaration. For *Stock Sent* transactions to be canceled, the shipping entity can declare a new *Stock Received* transaction for their own location and link it to their earlier *Stock Sent* transaction by submitting relevant sender transaction ID. This will work if no other valid *Stock Received* transaction pointing to the same *Stock Sent* transaction by the sender transaction ID has been recorded earlier.



All transaction records stored on the blockchain are available to authorized systems through API. This way,

supply chain and inventory management software used by network participants can benefit from this data. This simple yet effective set of blockchain transactions is equipped to provide visibility to supply chain participants.

Blockchain Security: A Prerequisite for Visibility

The most well-known type of blockchain is public blockchain. In public blockchains, like Bitcoin, anyone can access the network and read or write records into the chain as long as they follow the agreed protocol. An example of a protocol rule is that releasing cryptocurrency from a wallet requires knowledge of a private key. It is, however, not the only way to build blockchains. The other way, more suitable for the needs of providing visibility in supply chains, is a permissioned blockchain. Permissioned blockchains are built in a way that requires authorization for reading the records on the shared ledger, imposing restrictions on who can conduct transactions and who can serve the network by publishing new records into the blockchain.

It has to be noted that many qualities are shared between permissioned and public blockchains:

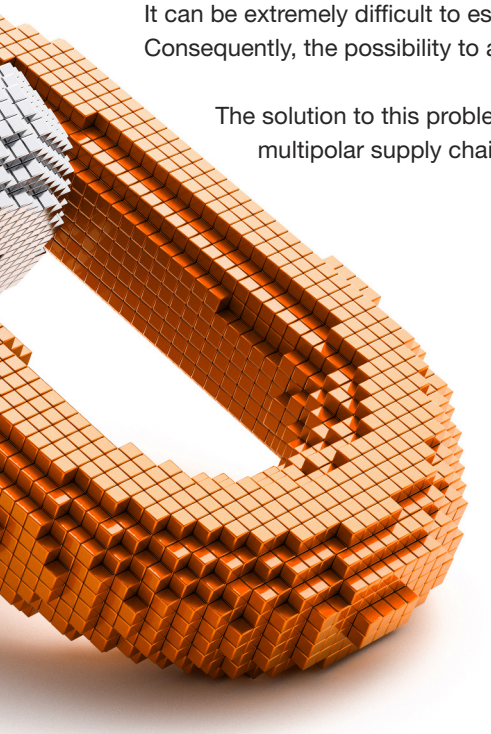
- They are both decentralized,
- Each participant of the network maintains a replica of the shared immutable ledger of all transactions, the integrity of which is guaranteed by the consensus,
- They are both resilient against faulty or malicious participants. Specifically, they both attempt to prevent attacks like the Sybil attack in which an intruder is trying to establish a large group of nodes by forging their identities in order to overrun the consensus of honest nodes.

To ensure security, manufacturers can use permissioned blockchain as a foundation for data sharing in after-sales supply chains, with a group of authorities acting as network facilitators and deciding on who can join the network and who is authorized to propose new records to the chain.

The fact that the network requires high scalability with possibly hundreds of thousands of processed transactions per day means that the best choice for the consensus algorithm is one of the Byzantine fault tolerant (BFT) algorithms belonging to the family of algorithms called Proof-of-Authority. In the case of multipolar supply chains where competitors might participate in the same network, it's essential to support blockchain channels between parties, not visible to other members of the network. Blockchain channels are used to share data between network participants in a secure manner, allowing stock data of any participant to be viewed only by a participant reciprocally releasing its data to the publisher.

Seeing the Big Picture with Blockchain

It can be extremely difficult to establish control towers in multipolar supply chains using traditional centralized solutions. Consequently, the possibility to achieve SCV has been up to this point out of reach for most such environments.



The solution to this problem is a novel blockchain-based system that considerably simplifies the introduction of SCV in multipolar supply chains. This brings the following benefits:

- Entities can freely join and leave the network, which allows for gradual adoption of the system without excessive upfront investment.
- There is no single point of failure, i.e., the network is not dependent on a single entity.
- Each entity has a full replica of all data and in that sense is independent of other participants.
- Vital supply chain information, such as stock levels, can be shared at any time.
- Entities can exchange sensitive corporate data in a secure manner based on the principle of reciprocity.

Blockchain technology has great potential for after-sales service. The visibility it can bring to the industry will revolutionize the way that companies collaborate to tackle the challenges of managing complex supply chains.

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About Syncron

Syncron empowers the world's leading manufacturers to maximize product uptime and deliver exceptional after-sales service experiences, while driving significant revenue and profit improvements. From industry leading investments in research and development, to providing the fastest time-to-value, Syncron's award-winning, cloud-based service parts inventory, price and uptime management solutions are designed to continually exceed customer expectations. Top brands from around the world trust Syncron to transform their after-sales service operations into competitive differentiators.

For more information, visit Syncron.com

[1] https://static1.squarespace.com/static/517969e8e4b0f0be01bf18ff/t/576bf8ef3e00bed738e518d4/1466693876065/Kewill_Improving_Supply_Chain_Effeiciency_Research_SCMR.pdf
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