CONNECTED MANUFACTURING
An Innovative Approach using New-Age Technology

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Abstract
The objective of industrial technology in today’s digital era is to bring together the best capabilities of channel partners so products can be taken to market faster, more cost-effectively and with more value-for-money. This paper analyzes the use of IoT and Blockchain, along with other cutting-edge technologies, in making manufacturing companies more effective and competitive. The intent is to show the relevance of technology in achieving business goals, enhancing value for manufacturers and, effectively, enriching the end user.
Introduction

Manufacturing supply-chains are exhaustive and complicated, encompassing a huge number of partners with mission critical dependencies. To cope with these complications, manufacturers are evolving from a human dependent manufacturing to digital driven manufacturing. They are also transforming traditional supply chains to multi-digital supply chain networks \(^1\) by adopting a host of nascent technologies like digital twins, virtual reality, cloud technologies, robotics, analytics and more. But even as these technologies are solving several problems, there are still several challenges faced by manufacturers. This paper lists out some of these issues, especially faced by larger corporations, and explores innovative solutions to solve them.

Trends in manufacturing

The adoption of new technologies is transforming the operational practices and organizational capabilities of supply chain networks. Based on research \(^2, 3, 4, 5\) , it is observed that there are 5 key trends emerging:

1. **Collaborations:** According to IDC \(~80\%\) of supply chain interactions will happen through cloud-based networks \(^6\).

2. **End-to-end Visibility:** Integrated businesses adopt digital solutions to adapt to real-time information flow and inventory visibility.

3. **Asset Tracking:** Companies are going the extra mile to track products and keep them operational.

4. **Product as a Service:** By 2020, 40 percent of the top 100 discrete manufacturers will provide product-as-a-service platforms.

5. **Customer Expectations:** Businesses and individuals expect increasingly fast and reliable delivery, instant information and best-of-breed performance. They expect manufacturers to deliver a greater variety of products, in shorter time spans.

These trends are making manufacturers adopt technologies to fulfill orders more quickly and efficiently, while also providing visibility of inventory and order status. The aspects not covered yet by these new solutions are detailed in next section.

Problem identification

Interviews conducted with some of the leaders and consultants in manufacturing and review of research literature shows that there are still areas of concern where no out-of-box solution or matured technology is available (or affordable). Many of these issues are being currently handled using complex processes, painstaking reports, arduous manual effort of follow up as a process and development and maintenance of processes in systems or point-to-point integration. These issues, listed based on a general market view and not specific to any manufacturing industry:

1. **Country of Origin Tracking:** There is currently no transparent supply chain mechanism for tracing the provenance or country of origin of individual products dynamically at every source of manufacturing and across every transaction in the system.

2. **Connected supply chain visibility:** Today, complexity has made supply chains networks shift to multi-tier, nonlinear models. Connecting different trade partners through a single thread to share information seamlessly, digitally and, most importantly, in a tamper proof way, is a challenge. With the traditional Plan-Source-Make-Deliver model becoming obsolete, an effective communication mechanism across partners is a challenge.

3. **Smart factory operations and scheduling:** There is a definitive need to bring different suppliers and service providers onto a single platform to facilitate proactive decision making and drive actions. This also needs to be supported by deeper insights.
of maintenance analytics, proactive monitoring and the capability to predict component shortages (to move from reactive to planning).

4. Supplier evaluation and certification process: There is a need to centralize and integrate suppliers for specific products or platforms to increase efficiency, synergy and above all transparency. This calls for a move away from the traditional supplier certification process towards a more centralized, tamper proof technique of supplier evaluation, certification and cataloging of supplier repository.

5. Factories of the future: The need of the hour is to develop a holistic and integrated view of how the factory or distributor of the future should technologically look like and what should be the key technologies driving and benefitting them.

A closer look at these problem statement indicates two major issues.

1. Most of the problems are about bringing multiple partners together into a platform and have them work in tandem together.

2. The other challenge is the ability to share data securely to bring in transparency and visibility. It also brings to the forefront aspects of data security, scalability and cost.

Currently, there is no direct solution or mechanism with traditional technology to solve these problems.

Problem detailing and solutions

Though there can be several different solutions, this paper focuses on the adoption of IoT and Blockchain, supported by processes and people, to solve the challenges described above. These technologies can be effectively used to improve supply chains and better serve the end customer:

1. Country of Origin Tracking

Blockchain based solution for Provenance and Transparent Supply Chain with Country of Origin Tracking (Transaction based Country of Origin)

The solution is to setup a blockchain network and bring in all manufacturers (and contracts) into the network and track the Country of Origin right from when the component manufacturing completes. Figure-1 shows a high-level conceptual model of the process to track the provenance and country of origin for each product manufactured and delivered to the end customer. These processes are today adopted by companies from industrial and consumer goods products manufacturing domain. The blockchain network will track the country of origin and the transfer of ownership at every node point, thereby making the product traceability transparent and readily available. The solution is enabled by bringing in lot numbers or serial numbers to the product (to uniquely track each product) and ensuring every trading partner is a part of the blockchain network. It is not necessary that the lot or serial control must be in the native system of transaction, it can be designed to be only in the Blockchain.

![Figure-1: A Blockchain network to trace back origin and track country of origin](image-url)
2. Connected supply chain visibility

*Connected multi-tier digital supply network and Multi-ERP/ Multi system supply chain visibility*

The result of globalization is the multi-tier, multi-system, multi-partner value chain system. Manufacturing companies mostly have their assembly and sub-assembly plants in different geographies (low cost economies like eastern Europe, south America, Asia), suppliers in different countries (Asia) and on different ERP systems. This multi-tier, multi-system supply chain brings with it scores of problem like demand-supply synchronization, supply chain visibility issues, trust issues, longer lead-times and a need for more cohesive and closer interaction, to name a few. The solution to the problem is to build a single tier system to seamlessly and transparently share information, establish visibility of demand and supply, and bring all partners onto a single platform. This can only be achieved through a blockchain system as the system will bring all partners into a single system architecture while bringing the data onto a single platform. Capturing and integrating data from disparate systems is always challenging but can be resolved by bringing in IOT sensors and devices into the network. These devices can help capture and integrate data from warehouses, 3PL trucks and customer-owned products. Figure-2 depicts a conceptual diagram of how trading partners on different systems can be brought together onto a single platform, be the launch pad to share seamlessly and transparently, solve the supply chain visibility problem and help synchronize the demand and supply with smart contracts (as smart contracts can be triggered when there is any change in demand or supply). In Figure-2, the two most important systems to highlight is the IOT system to capture data and Blockchain system to store data and build analytics on top of it.

*Figure-2: A blockchain network for solving the multi-tier, multi-system supply chain problem*
3. Smart factory operations and scheduling

Factory operations typically involve multiple suppliers and third-party support providers for supplying materials and providing maintenance among other things. Traditionally, the onus of synchronization with suppliers, manufacturers and supporting organizations lies with the factory. Factories are supposed to schedule material requests and maintenance tasks. It is seen that at times this causes disruption and failure, perhaps from the factory’s inability to foresee an event (breakdown), react in a timely fashion to a breakdown or from lack of preparation of a partner to provide material. The solution to this problem has two facets. The first is to capture and develop data driven analytics which can provide insights into probable problems or approaching conditions of failure. Secondly is to transmit these probable problems or conditions to partners, for them to plan, prepare and react as needed. The first facets of data driven analytics will have aspects like predictive analytics of maintenance and failures, as well as profiling and forecasting the need of different material. The second facet is to bring all material and operations support suppliers to the same network through Blockchain and feed them with real-time data, so they can plan, prepare and react better. The use of IOT can be leveraged to facilitate data capture and Blockchain can update the partners, transparently and in real-time. There can be smart contracts on the blockchain which can garner more attention on certain data sets or inform suppliers of certain anomalies in data indicating a potential problem for them to prepare for. Figure-3 below shows the conceptual model. The predictive analytics portion is fed into blockchain and drives actions at the partners end, with blockchain bringing in the partners together. The predictive analytics data which is fed into the blockchain system can even help facilitate and develop synergies among partners for a smoother overall operation. It can drive reports or alerts at supplier’s end indicating attention. The synergy created by Blockchain is currently not possible with any other technology or system and is the ideal solution to ensure smooth factory operations with predictive analytics.

**Figure-3: Smart factory maintenance using IOT and Blockchain**
4. Supplier evaluation and certification process

While most OEM manufacturers have several suppliers to deal with, this is especially true for automobile and hi-tech sectors. With thousands of suppliers as trading partners, there are multiple checks and balances in place for safety, security, compliance, insurance and authenticity of suppliers. Suppliers are required to provide valid and current certificates and keep these up to date for manufacturers to review and use (especially for products for which suppliers provide insurance). These certificates relate to general operations, guarantees and warranties, design sharing, tax filing status and latest governmental norms qualifications. Tracking and keeping it current is one of the major tasks for OEMs. There are complete departments in OEMs with the task of ensuring supplier certificates are compliant and current. Often, OEMs have to follow-up with third party accreditation systems for authentication. Though the onus of compliance should lie with suppliers, it is normally the OEM who must follow up and get the latest documents or confirm authenticity. The problems are manifold: the sheer number of different certifications, cumbersome validation processes for the validity of current certificates and issues with retrieving the history of a supplier’s certificate. All these issues can be simplified with the mature technology of Blockchain with a single portal for all the OEM’s suppliers to upload and update their certificates to. This will be also be accessible to all third-party accreditation authorities which needs to endorse these. OEMs will have to setup and own the blockchain system and bring the suppliers and accreditation partners into the network. A consortium can also be initiated by the OEM based on Blockchain where all suppliers’ certificates will be available and ready to be used for all consortium members. The consortium can potentially have multiple manufacturers (of similar types) and their supplier’s information on one platform. A typical example is a consortium for car manufacturers, truck manufacturers, semiconductor manufacturers or computer hardware manufacturers. Smart contracts will help detect falsification of data, validate data and help identify and stop usage of expired certificates. They will also help initiate accreditation for any new submitted document and trigger notifications to suppliers to re-submit valid certificates upon expiry. Figure-4 shows a theoretical aspect of the flow of information and how the interactions will happen between different parties and the blockchain system/consortium.

![Figure-4: A blockchain network for supplier evaluation and certification process](image-url)
5. Factories of the future

Industry 4.0

The factories of tomorrow must be thought out today as the future is closer than it appears, and the breakneck speed of innovation is helping shape the ideas of tomorrow. The important constituents of factories of the future will be processes and technologies commensurate with the times, which provide automation while gaining efficiency and insights. They will be connected, intelligent, automated, safe, transparent and serve as the perfect example of cyber-physical integration. This is also the paradigm of Industry 4.0 and how it is going to shape up. Figure-5 shows a conceptual model of a Factory of the Future, enabled through the various channels of IOT, Blockchain, Analytics, etc. which interacts seamlessly with the virtual and physical world.

Connected – It will have real-time monitoring using various mechanisms like IOT integrated devices which provide instant machine health data or bots on the shop floor which take instantaneous action upon a failure. There can also be an opportunity for industrial augmented reality in the manufacturing lines.

Automated – The automation of factories will improve throughput, enhance employee safety, reduce variability & waste, and, most importantly, increase customer satisfaction. The supply chain will be improved with higher visibility through blockchain, with the ability to provide a single platform to bring all partners together. The broader aspects of Industrial Internet of Things (IIOT) and digital twins can automate many of manual activities happening today, while also providing a simulation capability which is missing. Blockchain can greatly increase trust and confidence, thus automating or eliminating many reporting processes.

Intelligent – They will have AI/ML driven predictive maintenance and analytics which will enhance operational efficacy while reducing costs. Advanced data and video analytics will provide situational awareness and operational intelligence while reducing risk and helping avoid emergencies. There can also be quality indicators of the final product based on real-time data and analytics. Other indicators can simulate and predict the remaining useful life of machines, based on data analytics.

Safe – Computer vision cameras and video analytics will be used by factories of the future for safety and compliance. There could be wearable devices to monitor safety, efficiency and accuracy.

Transparent – Blockchain networks, comprising of manufacturers, third-party logistics providers, distributors and end customers will bring in transparency on products, order status and provenance. Blockchain and IOT together will provide insights in the way goods are stored and transferred from the factory to the customer.

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**Figure-5: Conceptual model of Factory of Future (FoF)**
Discussion & Conclusion

The convergence of Blockchain with other emerging technologies like IoT and Artificial Intelligence will make processes and supply chains in manufacturing easier to manage. Blockchain and IoT will help reduce cost, reduce dependencies on other system and improve communications. It will also help ensure you get the right product at the right place and at the correct cost. The challenges faced by manufacturers are spread across all aspects of supply chain from Plan, Source, Make and Deliver. What their focus should be in each of these stages is listed below:

**Plan:** Focus on improving supply chain visibility. The planning process in supply chain can help companies gain an advantage over their competition with better decision-making through improved visibility.

**Source:** One of the aspirations for every supply chain manager is to bring in transparency on provenance of products. Enabling Product provenance and Supplier certifications can greatly enhance user experience and provide an edge.

**Make:** Manufacturing is at the very heart of every supply chain, especially in a factory produced product. For any manufacturing company, efficiency, visibility, transparency and product quality marks their competitiveness. Solutions like Smart factory scheduling and Factory of the Future which are making factories transparent, intelligent, connected and automated are a cornerstone to success against competition.

**Deliver:** Making products reach the end customer in the desired state and at desired time with real-time information sharing and visibility is a challenge for every manufacturer. Track and Trace using IoT with Blockchain can help companies achieve this and empower their end users.

The adoption of Blockchain with IoT for manufacturing supply chain is of great benefit to manufacturers and end customers. The solutions described above will help manufacturers adopt new technologies, improve their supply chain and gain an advantage in an increasingly competitive market.

References


