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# BLOCKCHAIN AND SUPPLY CHAIN MANAGEMENT: AIRCRAFTS' PARTS' BUSINESS CASE

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**Abstract**

To serve target customers better than their competitors, supply chain management (SCM) teams today look into new technologies such as Big Data, Internet of Things (IoT) and Blockchain. These new technologies allow managers to develop and provide complex supply chain services and products faster with improved reliabilities. With these technologies, SCM teams can build complex models of a supply chain or systems of supply chains using a data-driven approach. With the growth of aviation domain across the world, there has been increasing demand in aircraft for airlines and other customers. In this domain, SCM teams deal with complex networked supply chains for aircraft's spare part purchase and delivery for aircraft's maintenance and repair. Aircraft's spare parts are shipped to single assembly hubs, located globally. All parts come with certain life expectancy, specific requirements and maintenance attributes. With thousands of spare parts, hundreds of parameters, and number of manufactures distributed globally, SCM team need to deal with very large amount of data. In this paper, we use an industrial scenario of aviation industry SCM to demonstrate the necessity of having decentralized system based on distributed data-driven application technologies such as Blockchain, not only to assist in maintaining inventory of the aircraft's parts but also to monitor the performance, usage, etc. This will help to achieve a transparent network of supply chain for aircraft's parts and reduce the risk of availability of aircraft's parts in black market. These new data-driven technologies when embedded into SCM scenarios will help the SCM managers to analyse the supply, demands, source of availability of spare parts and provide methods to procure them from the right sources.

**Keywords:** Supply Chain Management; Blockchain; Aircraft's Parts; Segment; Distributed Data-Driven Application Systems

## 1. Introduction

Supply chain management is the backbone of any industrial sector. Different industrial organizations, distributed globally and specialized in manufacturing of particular types of products are operated as production houses for particular segments, which would be required by another manufacturer to produce another product or part of final product. Before reaching the final product, individual parts of the product go through series of supply chains called multi-tier supply chain. Aviation industry represent perfect example of how complex this process can be and how all this process works.

Individual parts or aircraft body segments are imported, a proper inventory is maintained and then assembled domestically. Aircraft may overhaul to another region depending on type of service required.

These supply chains are well regulated and properly monitored by individual companies at their individual levels. There is a possible risk of parts or segments replacement, bad quality replication, and decommissioned or preceding products being sold in black markets. There is no single supply chain of product manufacturing but a web on interdependent manufacturers, heavily depended on each other for segment production. There are certain pre requisites that should satisfy specific requirements before moving forward in this chain that would make product worth and efficient for future use. In most cases, when specific requirements are not met, they are either returned or remanufactured, further increasing the delay in obtaining the final products.

Traditional SCM models and approaches are useful when the amount of data to be processed is relatively small and the complexity of the problem is low. But what about larger problems with a lot more data, like in case of the aircraft's spare parts business? This challenge requires new data-driven techniques such as Big Data and Blockchain. This emerging technologies will push us into the next era of SCM design and Industrial Internet of Things (IIoT) applications.

In this paper we take industrial scenario for aviation's supply chain management, on which, we implement the concept of Blockchain technology where each transactions is monitored by individual tiers of this supply chain, later smart contracts platform between individual tiers can monitor quality and proper flow of products in this chain. Individual databases at individual level will record and update all transactions that would be flowing along different tiers. This concept and technology into supply chain management can really bring significant added value to business process through more easy flow, higher reliability and better quality in aircrafts parts or segments.

The remainder of this paper is organized as follows. First we discuss the exploitation of SCM at different levels of OEMs (Original Equipment Manufacturers), MRO (Maintenance, Repair and Overhaul) businesses in aviation industry. Then we discuss a related and important area – the protection of supply chains from counterfeiting, followed by an idea of Blockchain integration in a tier to develop and model a transparent and reliable chain. Section 5 discusses approaches to apply Blockchain to the SCM in industry as well as its application in aviation. Section 6 continues and focuses this discussion on Blockchain applications in aircraft's parts business. Finally, in Section 7 we discuss methodological issues in Blockchain, especially in the context of smart supply chain management. We will talk about supply chain, its features and how problems in future can be overcome.

## 2. Challenges in Smart Supply Chain Management

Protecting legitimate supply chains from counterfeiting has become a significant challenge. In 1998, the OECD's report on the Economic Impact of Counterfeiting [1] showed that counterfeit products were often made by the same manufacturer that was contracted to produce the authentic product. The counterfeiting strategies are increasingly sophisticated as in many cases counterfeiters apply the same technologies and use the same suppliers as legitimate brands [2]. Thus, a variety of counterfeiting strategies has emerged and affects the legitimate supply chain such as genuine parts or products are stolen from the legitimate supply chain (e.g.: disposed-of genuine products are recovered), factory over-runs or near copies are illegally produced by sub-contractors, counterfeit products and genuine products are bundled and distributed together.

Over the past years many industrial sectors have been reporting cases of infiltration of counterfeit products into their supply chains. For instance, the aviation sector has been expressing strong concerns about the detection of counterfeit aircraft 's parts in the legitimate supply chain. Such detections have been reported both in the civil and military aircraft supply chains in the US as well as in Europe.

Several factors contribute to this phenomenon. First, global supply chains constitute a complex and large network of actors involved in production and distribution processes. In such circumstances, many companies find it difficult to map and monitor their suppliers and sub-suppliers beyond the second tier of their supply chains. This limited visibility results in lower control over the supply chain and thereby increased exposure to a variety of risks such as counterfeiting. In some cases, these vulnerabilities allow illicit networks to penetrate legitimate supply chains and exploit the services provided by supply chain intermediaries.

Therefore, it becomes urgent to take the necessary measures such as smart SCM techniques to better protect legitimate supply chains from counterfeiting threats, including by enhancing cooperation between supply chain actors, improving information exchange and security, and actively promoting transparency and best practices in SCM.

The smart SCM vision relies on extensive use of sensors to monitor the supply chain status and ICT to adapt activities and operations of the supply chain to meet its objectives. Realization of the smart SCM vision requires solution of many technical challenges. To serve target customers better than their competitors, supply chain management (SCM) teams today look into new technologies such as Big Data, Internet of Things (IoT) and Blockchain. These new technologies allow managers to develop and provide complex supply chain services and products faster with improved reliabilities. With these technologies, SCM teams can build complex models of a supply chain or systems of supply chains using a data-driven approach.

Blockchain is a paradigm that involves dynamically incorporating real-time transactions into chains of blocks in order to steer the information exchange process of an application system. Information on a Blockchain exists as a shared database which isn't stored in any single location, meaning the records it keeps are truly public and easily verifiable. No

centralized version of this database exists for a hacker to corrupt. Hosted by millions of computers simultaneously, its data is accessible to anyone on the internet.

The Blockchain network automatically checks in with itself every ten minutes. A kind of self-auditing ecosystem of a digital value, the network reconciles every transaction that happens in ten-minute intervals. Each group of these transactions is referred to as a "block". Two important properties result from this:

- **Transparency:** data is embedded within the network as a whole, by definition it is public.
- **It cannot be corrupted:** altering any unit of information on the Blockchain would mean using a huge amount of computing power to override the entire network.

In theory, this could be possible. In practice, it's unlikely to happen. Taking control of the system to capture Bitcoins, for instance, would also have the effect of destroying their value.

Blockchain technology initially was introduced in cryptocurrency where because of decentralized ledger, it was easy to record all the financial transaction among all the actors simultaneously avoiding any kind of error. However, following to Don and Alex Tapscott: "The blockchain is an incorruptible digital ledger of economic transactions that can be programmed to record not just financial transactions but virtually everything of value." [3]

The Blockchain concept of other domains has been lately proposed but yet to be implemented. In aviation industry there is increasing demand of aircraft, and logistics or supply chains play important role in support of the aviation industry. Introduction of the Blockchain technology into SCM practice of aviation industry will enhance the aviation industries' performance and increase the passengers' safety.

It is immediately apparent that the Blockchain paradigm is directly applicable to realizing smart supply chains. For example, Blockchain provides an approach to address issues such as creating more efficient and reliable supply chains and to mitigate counterfeiting. This paper discusses the applicability of this paradigm to create more resilient and sustainable supply chains in aviation industry.

## 3. Supply Chain in Aviation

By 2035, there will be a significant growth of passengers' traffic and consequential demand in aircraft, as a result, significant increase in aircraft production is expected [4]. This growth will seek huge demand for more flight carriers, therefore the supply chain should proceed in perfect sequence, without any error. Soaring demands also lead to pressure on the supply chain causing delay and failure. Example, the problem to unhandled this situation could be at any level where the supplier is not able to process demands due to unavailability of products at preceding level [5]. In this environment of supply chain, individual level competes instead of co-operating by not sharing the information. This leads to error as we proceed up the supply chain [6]. Behind every final product, there is a long chain or levels of assemblies, but some researches have combined these individual levels, which produce for OEMs into 3 main tiers supplies [7]:

- Tier 1: This level directly works for OEMs, for example, dealing with engines, brakes, etc. they are first suppliers to the assemblers.
- Tier 2: They are the suppliers to tier 1, they supply products, which are manufacture from their own productions. Example, assembling individual parts of Engine.
- Tier 3: These are individual small-scale component production companies, which usually provide small components like electrical components, raw material.

Figure 1 below is a sample tier representation of Aviation Turbine Company, though this company would be serving at some tier for another "Originating Buyers" i.e. each component of any supply chain at any tier would have its own tier of supplies.

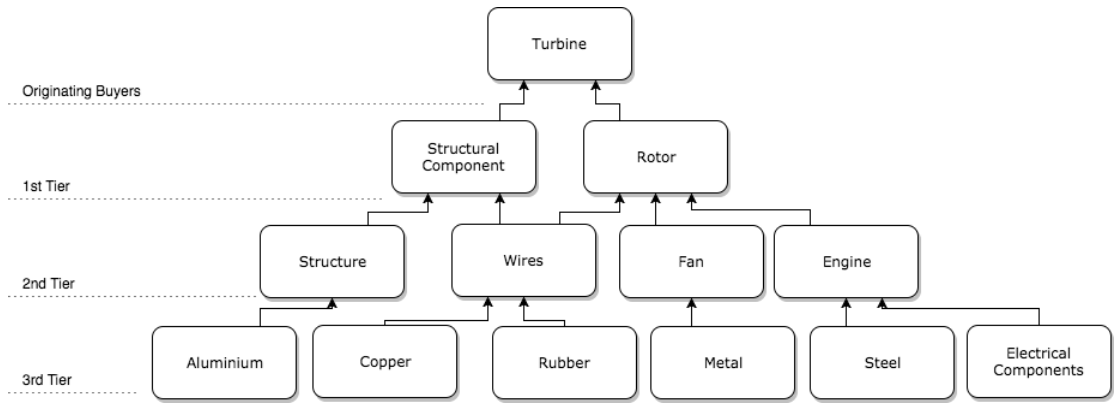


Fig. 1. The aircraft's Turbine's Supply Chain

Even after the proper path of supply chain, the risk and challenges like careful coordination among different bodies, challenges of managing the risk across global network and complex supply network, risks like guarantee, functioning, quality control, usage control, etc. still exist in OMEs. Necessity by the organizations to understand not just the direct suppliers they buy from, but also those who indirectly contribute component or service across the extended supply chain [7].

## 4. MRO Supply Chain Methodology

The purpose in any supply chain is to ensure that right product is produced at the right time and is at proper flow in the chain. It is highly dependent on the external factors like mode of transportation and internal factors like availability of inventories to produce and meet the required demands. These chains consist of exorbitant amount of flow information, product and money [8]. Components of supply chain management are complex but based on:

- Planning of Inventory i.e. from which part of manufacturing hub, it will be easy to procure the required product, etc.
- Development in making relation with supplier of raw material.
- Make i.e. manufacturing and measuring the quality of product.
- Delivering final product to required party
- Run i.e. finally testing or running the product as required.

There are instances when an aircraft is required service, part replacement, or sometime overhauling where it as a whole may be used for performance testing. Aircrafts move from one place to another for getting serviced as that specific service could be present at some particular place hub. This ensures the quality and performance marking and if there is any error of fault, then it is either repaired or replaced.

## 5. Designing Supply Chain Management with Blockchain Technology

Blockchain technology [9] plays a vital role in today's era of IT. It was initially introduced by Bitcoin, which focused to decentralize the common database used to record transaction between different users by enabling individual ledgers among the users that will update all the transactions anonymously and would be difficult for a single party to manipulate to interfere with. Blockchain calls for traceability, with open ledger we can know which product is transacted to which member of the chain, though two parties stand anonymous.

In aviation supply chain network, User will have the access of involving parties in the transaction. If there is some error or fault in the final product, then we can easily trace it back to the path of supply. We can monitor the progress and with it plan the future manufacturing. In supportive of design principles in Industry 4.0 [10], we propose the following:

- Interoperability: Each individual segment to be enabled with sensor or special id, helping different tiers bodies to connect and communicate among each other.
- Information Transparency: Ability to show the individual processes at each level, for example, if any changes made at any level in this chain all the users will be updated with the change with new details.
- Technical Assistance: This would enable to assist systems to support individual in chain by aggregating and visualizing information comprehensibly for making informed decisions, future planning and resolve problems quickly.
- Decentralized Decisions: Enabling individual companies with make their own decision and to perform their task.

Introduction of Smart Contracts, can help to achieve the desires, required and up to the mark product. This process will have all the details like, serial number, validity of products, i.e. all the information that would guarantee its authentication and uniqueness. Initially the supply chain was reordered on papers and where never digitalized where bundles of record books were piling and lot of time was wasted when details were requiring. Now many multinational companies provide with user the status updates with the location or time of arrival. This helps to attain secure transparency across global chain supply, which will help to reduce frauds, reduce delays, paper works, other wastes, etc.

## 6. Industrial Case Study

Now we will imply Blockchain to aviation industries' supply chain and monitor how, if details that are share across the platforms of individual users in this network, can actually benefits the aviation sectors in terms profit and safety. We will take the help of figure 2 below describing small scenario.

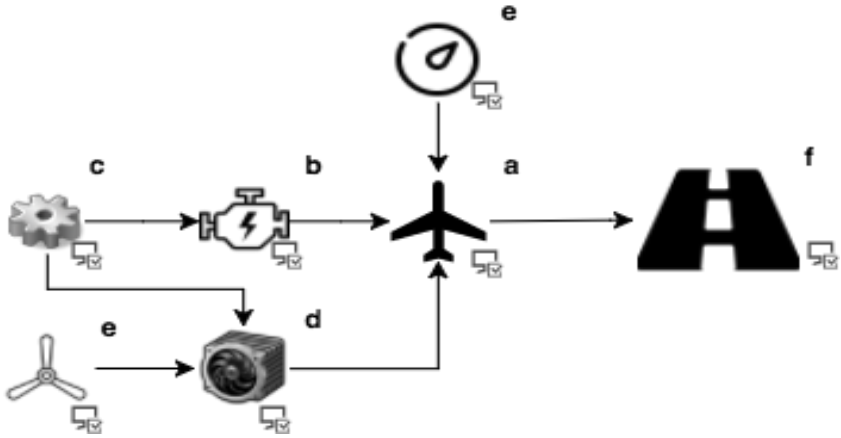


Fig. 2. Small Sample Supply Chain

Let us begin at an assembly hub ‘a’, these assembly hubs procure different parts from different places and are assembled into one individual standing aircraft. This hub is one of the individual bodies of the supply chain that procured parts like engine and turbine from different companied ‘b’ and ‘d’ respectively. When procuring and assembling one part for e.g. turbine into an aircraft at hub ‘a’, a transaction and assembly ledger will be updated across all the members of the network indicating that turbine of unique id along with other segments were assembled together, producing aircraft which itself will act like a new product of unique id. Assembly ledger will keep the record of all the new products generated at each level, which would be integrated with transaction ledger that will show the transacting details among the individual members. This whole network could also works as inventory registry for individual companies along with details of the products, which will show the production details.

Now at individual assembly hubs, will maintain their own supply chain path. At some tire level in this chain, if a product is replaced or tampered and the database of the hub, that will receive this product, is manipulated, due to the decentralized ledger, this process would not be validated as there would be mismatch, for example, may be in serial number and hence this can avoid and kind of future malfunctioning that could have happened.

Once the part is assembled into a plane and is serving for a purpose (commercial, private, etc.), during the overhaul at any maintenance hub, the engineers would have a proper and easy access to check for all the required maintenance, remaining life expectancy of products, hence, reducing the time and increasing the efficiency of work. If any part is close to expiration, it will indicate beforehand and the performance can also be monitored during the working and with parallel monitoring.

## 7. Conclusion

This work is devoted to the application of Blockchain technology to support supply chain system design and operation in aircraft parts manufacturing and distribution sector of aviation industry. Blockchain is inherently capable of providing significant advantages of timely, efficient and transparent transactions to the supply chain systems in the same way it has been proven for the value adding processes in financial/banking systems.

The approach used was to examine most recent works to establish the connection between Blockchain and supply chain taking aviation industry as an illustrative example. This study shows that Blockchain has well established link in supply chain research, and the use of Blockchain in supply chain management (SCM) has been increasing. In logistics, the Blockchain has mostly used as a digital distributed ledger to create a single digital place where all documents related to a shipment could be housed.

One of the key advantages of Blockchain is that it is more secure than traditional IT solutions. We suggest that Blockchain could be effective in enhancing aircraft parts traceability and establishing the authenticity of spare parts. In future, we plan to develop and test the technology to authenticate parts manufactured in Russia delivered to Indian airlines and government customers. The solution takes information from sensors or RFID tags and records it on the Blockchain to track the parts from factory to aircraft. We are also interested in aircraft parts traceability. With the availability of all information on transactions in the supply chain, anticipation for the reduction in counterfeit products would be achievable. Further, the introduction of the smart contract to this network will minimize the possibility of corrupt practices as it can eliminate the involvement of the third party and with the data information spread across, the buyers from different sectors like defence, private players will be self-capable to purchase.

There are some other interesting areas for future investigation of the Blockchain introduction to the SCM practice. In particular, we are also aiming to use Blockchain to lower the cost of doing business in global aircraft parts supply chains, where it is common for a big company to buy spare parts from small manufacturers. This usually increases costs across the end-to-end supply chain. Potentially, the Blockchain technology could greatly reduce the financial costs associated with strategic procurement.

## 8. Acknowledgments

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## 9. References

[1] OECD, (1998) "The Economic Impact of Counterfeiting," [Online]. Available: https://www.oecd.org/sti/ind/2090589.pdf.
[2] M. S. &. J. Busby, (2015), "An exploratory analysis of counterfeiting strategies," International Journal of Operations & Production Management, vol. 35, no. 1, pp. 110 -144.
[3] D. T. &. A. (2016) Tapscott, Blockchain Revolution: How the Technology Behind Bitcoin Is Changing Money, Business, and the World, Penguin Random House, Portfolio, p. 368, 2016-05-10.
[4] Y. M. &. Z. Avdeeva, (2017) "Planning in Aircraft Industry Based on Aircraft Prediction," Unpublished, Moscow.
[5] PricewaterhouseCoopers, "Price Waterhouse Coopers," [Online]. Available: www.pwc.com/aerospaceanddefence.
[6] B. &. P. I. Buchmeister, (2013) "Bullwhip Effect Simulation Of A Supply Chain With Level Constraints," Daaam International Scientific Book, Pp. 133-148.
[7] D. MOCENCO, "Supply Chain Features of the Aerospace Industry Particular Case Airbus And Boeing," Scientific Bulletin, pp. 17-25.
[8] B. Raza, "Supply Chain for MRO," Frankfurt University of Applied Sciences, Frankfurt.
[9] Blockchain, "Blockchain," [Online]. Available: blockchain.info.
[10] W.-I. 4.0, "Wikipedia," [Online]. Available: en.wikipedia.org/wiki/Industry_4.0.