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Blockchain in Aerospace and Aviation Industry – Fundamentals and use cases

Devinderpal Yadav
MS in Software Engineering, BITS Pilani, India

ABSTRACT

For many years, businesses and in some cases many industries have been built on simple principle of trust between multiple parties. However, this business of trust is about to be disrupted and transformed with the advent of blockchain technology. Blockchain can be defined as distributed ledger technology that can record transactions between parties in a permanent and secure way. Blockchain has been identified as one of the technology that may have a major impact on the future of aerospace and aviation industry among other drivers of change such as supply chain management. The future will likely to be a place where every part has a trusted digital identity and historical records that are immediately accessible to those with the right authorization. This paper to some extent explains the blockchain capability that facilitate the use of blockchain technology in Aerospace and Aviation Industry with various use case. Through its methodology, a detailed analysis of the blockchain fit in the industry is made in this paper. Blockchain technology offers a simple and easy way in which the information is immutable and temper proof.

Keywords: Blockchain; Distributed Technology; Aerospace And Aviation; Consensus; Supply Chain Management

I. INTRODUCTION

Blockchains are considered as public as well private ledgers containing transactional data within their decentralized data structures, which form the series of tightly connected blocks. Distributed consensus algorithms are implemented for achieving ledger consistency, data integrity, auditability and authentication. The distributed and decentralized nature of blockchains makes the transactions temper proof once they are officially validated by the peers of the network and registered in the block of the chain. Blockchain can allow transactions and payments to be implemented without any intermediary, thus effectively disrupting the way traditional businesses working to date.

What kind of impact could this have on everyday life? Imagine in healthcare, sensitive data from all the stakeholders – from patients to medical companies could be shared using the highest levels of encryption and data protection to greatly improve service efficiency and quality. Or in shipping from the administrative and operational risk of the shipowners to the charter and broker, by bringing more transparency and efficiency. And in Aerospace and Aviation, the data sharing across supply chain, accounting and reconciliation, tracking and locations of assets, certifications, digital identity enable higher level of transparency across various parties involved in the business. These are just some of the many opportunities that blockchain presents. By facilitating the move from a centralized to a decentralized and distributed system (see figure 1), blockchain

effectively liberates data that was previously kept in safeguarded silos.

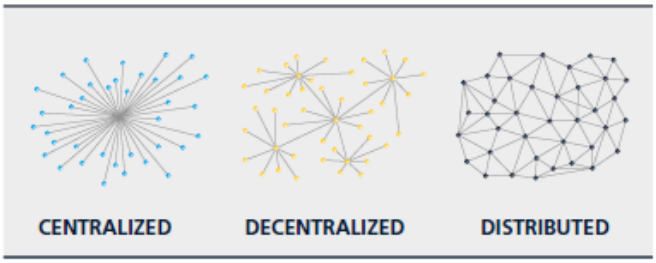

Figure 1 : Going from Centralized to Decentralized to distributed database

Blockchain technology started gaining significant traction when Bitcoin was launched and became popular (See figure 2). Blockchain is the underlying technology of Bitcoin and other digital currencies such as Ethereum. While these cryptocurrencies have unlocked innovation in the digital currency space, there are many use cases leveraging the Blockchain technology for non-currency related areas. Despite its brief history blockchain is gaining popularity in corporate world as well as in the media. Still there are open questions about the roadmap where blockchain is headed, when it will give results and who will benefit most out of it. At this point it is clear that the blockchain applications may have one of the most profound impact on the Aerospace and Aviation Industry, especially the supply chain. This is because supply chain are highly complex with diverse stakeholders, different interest and many intermediaries – challenges that blockchain is well suited to address.

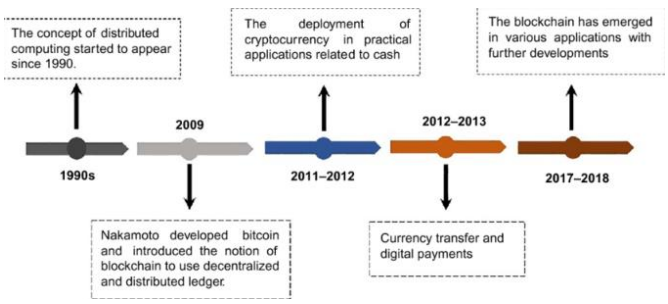

Figure 2 : History of Blockchain

With significant benefits, the overall market for blockchain is expected to boom with some researchers projecting growth of blockcchain technology from USD $411.5 million in 2017 to $7.68 billion by 2022 (Figure 3). Reasons for this rapid growth are the rise in financial sector as well as continuing development of this technology and growth from major vendors. Companies need to understand how blockchain technology can solve many of the underlying challenges through innovations and the likely value and rewards it can deliver especially in Aerospace and Aviation sector too.

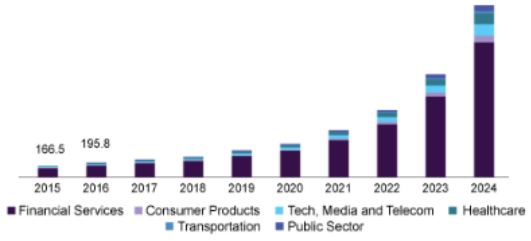

Figure 3 : Blockchain growth in various sector

II. BLOCKCHAIN TECHNOLOGY – KEY FEATURES

The Blockchain technology is fascinating, innovative and impactful and conceptually it is a type of distributed structure where transactions are transparent among parties and these transactions will be added into the database only on their consensus or agreement. Hence at the end, it's a trusted decentralized database where it is not administered by a single member but the group of members in the network. Whilst traditionally data resides on a central infrastructure, with back-ups and redundancy measures, the Blockchain technology embraces a distributed architecture. In simple terms the Blockchain technology is a decentralized database, additionally leveraging crowd computing and infrastructure. The transformative power of

blockchain makes its different because of its features. The key features are:

1. **Data transparency**: The data into the blockchain is entered with a proper validation and the records are accurate, secured and temper proof. Instead of multiple parties maintaining copies of their own dataset, every stakeholder receive controlled access to a shared dataset creating a single source of truth. Hence the data in use is most recent and reliable.
2. **Security**: All transaction records in the blockchain are encrypted and permanently stored making it really hard to modify. All records are linked through hash function and whole chain need to be altered for changing a single transaction.
3. **Consensus**: Consensus in blockchain provides trust in the network. The transactions in the blockchain is committed only when the nodes are agreed to that transactions. Hence at the end whatever the transactions are committed in the blockchain are true to all the nodes.
4. **Smart Contracts**: Legal contracts that are normally executed manually are automated or digitized in blockchain. It enforces the stakeholder to follow rules and process steps as per agreement. These are self-executing computer programs where the actions occur automatically once the contract conditions are met.

Blockchain as a digital platform keeps whole history of all the transactions between the stakeholders across the network in a temper and revision proof. All transactions that were created between the stakeholders are checked by cryptographic algorithms and then grouped into blocks that are then added to the blockchain. To illustrate how these features discussed above works in blockchain, here is an example (Figure 4):

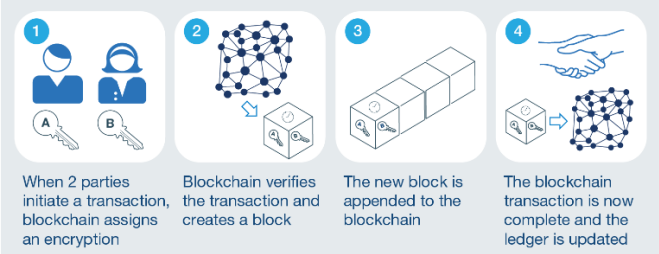

Figure 4 : Method of operations in Blockchain

Blockchain technology does not introduce an entirely new pattern. Instead, it builds on the old template of a ledger, which logs the transactions over a period of time (See figure 5). Traditional ledger are owned by one entity such business, organization, banks or groups and controlled by designated administrator. The administrator can implement changes to the ledger without requiring consensus from the ledger's stakeholder (See figure 5).

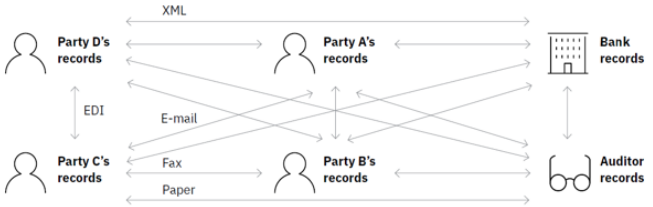

Figure 5 : Traditional way of sharing information

In contrast blockchain is a shared, distributed ledger among a network of stakeholders that cannot be updated by any one administrator. Instead, it can only be updated with agreement of network participants and all changes to the distributed ledger are auditable. (See figure 6)

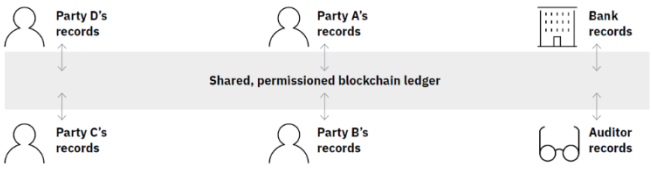

Figure 6 : Sharing information in Blockchain

Blockchain can be of three types:

1. Public Blockchain
2. Private Blockchain
3. Federated/ Consortium Blockchain

Bitcoin is considered to be the first public blockchain. Most of the business organization either for private blockchain or federated blockchain depending on the use case. In private or federated blockchain the stakeholders or entities are known and the transaction is committed only after the permission of certain set of stakeholder consensus (See figure:7)

Table 1: Types of Blockchain

Characteristics	Public Blockchain	Private Blockchain	Federated/ Consortium Blockchain
Access	Anyone	Single Organization	Multiple Selected Organization
Participants	Permission less	Permissioned Known entities	Permissioned Known entities
Security	Consensus mechanism Proof of work	Pre-approved participants	Pre-approved participants
Transaction speed	Slow	Lighter and Faster	Lighter and Faster

III. AEROSPACE AND AVIATION - AREAS OF APPLICATION

As blockchain technology takes its shape, businesses in almost every industry are researching how to capture new opportunities. This will give some of the examples as an area of applications focusing on aerospace and aviation sector:

1. **Supply chain management**: Supply chain is defined as the line of various points (See figure 7) involved in producing and delivering goods, from procurement stage to the end customer. In aerospace industry as well there are large supplier base from where different parts are procured from different regions of the world. Since because of the complexity of the supply chain network, it has become difficult to trace events in the entire supply chain. Lack of transparency into the network, buyer and customers cannot be sure of the true value of the products and services. Blockchain in this case can give below advantages:

a. Tracking and tracing in blockchain gives the opportunity to digitise the physical assets and products and can be tracked right from the place of origin to the end customers where it is used in manufacturing and delivering.

b. Decentralized structure gives the ability for the participation of the stakeholders in the entire blockchain network. The records are created digitally and with the consensus with the stakeholders.

c. The records are cryptographically immutable make it more secure and temper proof.

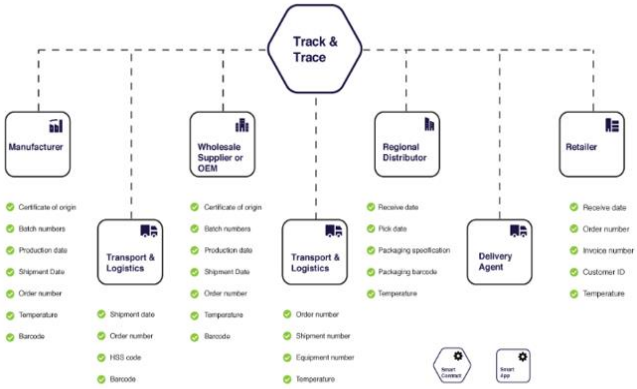

Figure 7 : Points in Supply Chain to track

2. **Aircraft Maintenance records**: In the current state many aircraft manufacturers and airlines stores the aircraft maintenance records in a

centralized database system. Some of the challenges the current industry faces with the current architecture are:

a. Airlines data in a centralized database could be easily manipulated or tempered.
b. Since every stakeholder maintain their own database and set of copies, it become time consuming to extract information in case of audit or accident.
c. It is difficult to share the information with other parties like manufactures or airlines companies. They are all working in silos.
d. Paper based records are stored currently which has a high chance of loss of information.

Blockchain will make the different stakeholder to come to a common platform which is secured and temper proof. Hence the reliability of information in blockchain will be more as every record is stored in an encrypted form. Some of the benefits it can have is:

a. It is more transparent to the passengers to know the health score of any aircraft.
b. Maintainance information in blockchain can help companies to lease or buy resale aircraft
c. Maintenance records stored in blockchain can be used in investigation and audit in case of any accidents.
d. It can help to calculate the annual cost of the repair and can help in taking decision on the ROI.

3. **Smart Contract**: The aerospace and aviation industry involves many stakeholders such as aircraft manufacturer, airlines, travel agents, airports ground handlers and other industry suppliers. All these stakeholders depend on each other for products and services to serve the customers. The blockchain technology is suitable to streamline procure to pay process through the use of smart contracts. For example to make a settlement upon the service delivery, the digital legal contract called as smart contract can be invoked in order to monitor, invoice, reconcile settlement in the process (See figure 8)

Figure 8 : Steps in Smart Contract

4. **Asset Management**: A digital twin is a dynamic, digital representation of a physical asset which enables companies to track its past, current and future performance through the asset lifecycle. The asset for example a spare part, sends performance data and events directly to its digital twin, even as it moves from hands of the manufacturer to the dealer and ultimately to the owner. Blockchain can be used to securely document everything related to the asset.
5. **Trace and Track**: Trace and track is another important capability which blockchain can facilitate by tracking status and location of valuable assets that change with a high frequency. For example bags of passengers, cargo, spare parts and even aircraft and in more particular if the parties do not trust each other in the process. Blockchain technology offers simple and easy way to record events in the way that is immutable and temper proof.
6. **Certifications**: safety and security are the top priority in aerospace and aviation industry. And it has to undergo a rigorous process of certifications weather its individuals, equipment's or spare parts. With blockchain the certifications process can be streamlined making it more safe and secure in terms of products and services.

IV. BUILDING BLOCKCHAIN CAPABLITY

It's evident that in certain use case blockchain works well. In general the approach should start with a

specific problem and remain solution oriented throughout the process. To decide on the design all possible solution should be analysed and then decide on the type of blockchain weather it's public or private and permissioned or permission less. There are few factors which is encouraged to practice in order to have a success in blockchain initiatives:

1. **Culture of collaboration**: When a company agrees to work with blockchain technology, it requires a close collaboration with various other companies. This is because a huge part involve facilitating collaboration between multiple parties including both public and private entities such as – Aircraft Manufacturer, Airlines, Cargo Service providers, government agencies and many others.

   All these entities have to come together in order to make it successful and get the full advantage of such technology as the trust is involved and the contracts are executed as per the agreement. When more parties agree to use a single blockchain solution, more value is created for such participating organization.

2. **Building knowledge and capability**: For any organization building knowledge and capability is the key to identify and realize the value of new operating model. The companies has to start with a small step and is essential to provide empowering partner organizations and individuals contributors with time, tools and resources. These contributors must be able to liaise effectively within the blockchain ecosystem and with relevant technology players, implementation partners and associations.

3. **Value realization and stakeholder's engagement**: Stakeholders are able to prove and understand the business value of new initiative as well as understand the technical feasibility for their architecture by engaging with blockchain based prototype. Realizing the full value of this technology depends on collaboration with the entire stakeholder ecosystem. It's also important for any company to have the right skillset and resources to execute the prototype for blockchain and understand the full business value. Most commonly below are the questions any organization has to have the answers before taking a decision to go for blockchain technology:

a. Is there a need for a shared common database?
b. Are multiple parties involved?
c. Do the parties involved mistrust each other?
d. Is there a need for an objective, unchangeable log of records?
e. Do the rules behind transactions rarely change?

If the above answers to the questions is "Yes", probably there might be a use case to go for the blockchain technology within the organization.

V. CONCLUSION

Since with every new technology framework, it passes through many phases and many challenges, similar is the case for Blockchain technology. It is necessary to invest further research to overcome those challenges which will pave the intermediate steps towards the adoption in Aerospace and Aviation industry. An intermediate step of having consortium-based, permissioned ledgers, which can be applied on specific cross-organizational domains, can be regarded a s starting point for tackling the research challenges and facilitate the necessary changes based on controlled private ledger environments, where such blockchain features can be managed effectively. Nevertheless, such approaches cannot be regarded as totally decentralized as they still have to rely on central trusted parties who will be responsible to validate the identity of the participating actors and assign the necessary credentials of the blockchain.

Moving from today's era of proving concepts and piloting applications to actually deploying productive solutions at scale will require further technology development, organizational transformation and, crucially, collaboration between all stakeholders. Success depends on all parties working together to transform legacy processes and to jointly adopt new ways of creating logistics value. In the highly fragmented logistics industry, consortia that bring together stakeholders will play a key role in achieving blockchain's potential in the industry.

Finally it is recommended to validate Blockchain as a solution by conducting low risk and low cost testing outside of production environments through prototyping. Open source Blockchain solutions are recommended for early stage prototyping purposes and in some cases for more advanced prototypes and even production solutions.

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