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# CHALLENGES AND OPPORTUNITIES OF BLOCKCHAIN TECHNOLOGY IN INDUSTRIAL APPLICATIONS*

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ABSTRACT. Digital technology is changing the world, one industry at a time. It is still unclear if and to what extent the manufacturing industry is impacted by the innovative blockchain technology. Although a fairly new technology, it has many practical use cases and new applications of the technology are continuously introduced.

The paper presents an assessment of the current maturity phase of Blockchain and evaluates the challenges and benefits of potential applications in the manufacturing industry. Further the paper explores the potential use cases for the manufacturing industry by giving an overview of the existing blockchain solutions. Moreover, the highlights from the World Economic Forum 2017 are reported where a set of actions was given that will move this technology forward.

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**1. Background on blockchain technology and Internet of Things.** Blockchains are distributed ledgers that create a permanent and shared record of every transaction associated with an asset and in this way an unbroken chain of trust is created. Each record is time-stamped and appended to the event before it [1]. Blockchains have the potential to generate breakthroughs in three areas: visibility, optimization and demand.

More specifically, the decentralized software protocol for managing a shared dataset, enabled by a public distributed ledger system, allows the tracking and recording of assets and transactions without the presence of a central trust authority or intermediary. It relies on public key encryption or cryptography, which makes it difficult for hackers to change or steal data. It enables peer-to-peer exchange of data, assets and currencies through rules-based smart contracts in a more efficient, transparent and cost-effective manner [2].

With this technology, businesses can explore new business opportunities and emerging ecosystems built on sustainable foundations. Blockchain makes data storage, sharing and protection cyber secure; contracts are embedded in digital code and stored in transparent shared databases where they are protected from tampering. Processes, tasks and payments have a digital record and signature which is validated, stored, and shared.

For the individual, Blockchain can secure and simplify the process of voting online, paying taxes, applying for a mortgage or opening a bank account. For society, it secures record keeping and sharing for and between local authorities, government agencies, banks and businesses. On a global level, Distributed Ledger Technology (DLT) facilitates international collaboration on environmental matters, security and trade [3].

Although a fairly new technology, Blockchain has many practical use cases and new applications of the technology are continuously introduced. This development is shown by a survey from the World Economic Forum in 2015, which predicts that 10% of global GDP will be stored on the Blockchain by 2027. The key challenges and opportunities in relation to DLT/Blockchain are summarized below [3].

Challenges:

- The potential high costs of initial implementation, perceived risks associated with early adoption of DLT/Blockchain, and possibility of disrupting existing practices may pose significant challenges to businesses.
- The lack of clarity about the improvements the technology offers over existing solutions may delay its adoption by businesses. In the absence of widespread DLT/ Blockchain adoption, the broader economic impact of the technology in the medium and long term is difficult to determine.
- There is uncertainty related to the way current regulatory frameworks would apply to DLT/Blockchain and the changes that might be needed in the event of wider adoption of DLT/Blockchain across sectors.
- Potential security vulnerabilities and concerns about data privacy are seen as significant challenges, particularly if users entrust DLT/Blockchain solutions with personal data.
- Key obstacles remain with respect to the legal enforceability of smart contracts, primarily related to the lack of clarity regarding the definition of smart contracts and their implementation through DLT/Blockchain.

Opportunities:

- By automating processes and reducing the need for third-party intermediaries, DLT/Blockchain solutions have the potential to provide significant efficiency gains and cost savings for businesses and end-users.
- The growth of the DLT/Blockchain ecosystem could result in the creation of novel business and economic models, such as new forms of business collaboration and cryptocurrencies.
- The decentralised nature of DLT/Blockchain and the lack of a central point of failure could facilitate transactional systems to become more resilient and secure.
- DLT/Blockchain has the capability to empower users by putting them in control of their own information, and it has the potential to improve users' trust in carrying out transactions.
- DLT/Blockchain technology could be used to implement the underlying mechanism for smart contracts and enable the use of smart auditing capabilities across different sectors.

**The intersection of Blockchain and the Internet of Things (IoT)—IBM Blockchain.** As the Internet of Things continues to grow at a rapid rate, its sensors and devices are becoming more commonplace in communicating information about the status of "things". With its new Blockchain integration, the IBM Watson IoT Platform enables devices to send data from these things to private Blockchain ledgers for inclusion into shared transactions with tamper-resistant records. Blockchain's distributed replication allows business partners to verify each transaction, so there is no longer a need for central control and management. The Blockchain records what each participant does and everyone is accountable in the overall transaction.

Using the Watson IoT Platform (`https://www.ibm.com/internet-of-things/spotlight/watson-iot-platform`), IBM makes it possible for groups of participating parties to use information from IoT devices, such as geo-location, with smart contracts running on the IBM Blockchain networks or fabric.

The IBM Watson IoT Platform allows devices to participate in Blockchain transactions, communicating to Blockchain-based ledgers to invoke transactions defined by the smart contract. It also provides data mapping between the data format in the devices' messages and the data format required by the contract. These transactions update information in the ledger. The smart contract helps define many of the terms that the parties agree to follow. These smart contracts can even signal additional actions outside of the Blockchain, like ordering a replacement part or placing a service call.

IBM Blockchain differs from other Blockchains in that it was designed from the ground up to meet the needs of the enterprise. The IBM Blockchain fabric uses the Linux Foundation's Hyperledger open source project as their basis. The Hyperledger Project is a collaborative effort between more than 40 members. The goal is to advance Blockchain technology through cross-industry open standards for distributed ledgers [6].

For example, the IBM Blockchain (see IBM Watson IoT) is as follows, in summary:

- A private Blockchain infrastructure of distributed peers that replicates the device data and validates the transaction through smart contracts.

- A permissioned Blockchain that makes it possible to define who can join—allowing participants in a business network to see only what they have been given rights to see on the Blockchain.
- A Blockchain infrastructure that helps establish trust, accountability and transparency while streamlining businesses and enabling new business models.

**Industrial Internet of Things.** The application of IoT to the manufacturing industry is called the IIoT (or Industrial Internet or Industry 4.0). The IIoT will revolutionize manufacturing by enabling the acquisition and accessibility of far greater amounts of data, at greater speeds and more efficiently than ever. Many innovative companies have started to implement the IIoT by leveraging intelligent, connected devices in their factories. The IIoT is widely considered to be one of the primary trends affecting industrial businesses today and in the future. Industries are pushing to modernize systems and equipment to meet new regulations, to keep up with increasing market speed and volatility, and to deal with disruptive technologies. Businesses that have embraced the IIoT have seen significant improvements to safety, efficiency, and profitability, and it is expected that this trend will continue as IIoT technologies are more widely adopted.

Thanks to low-cost electronics, miniaturization and near-ubiquitous wireless connectivity, the IIoT opens up new commercial opportunities in both industrial and consumer sectors. Many of the early-stage applications focus on point solutions for high-value industrial assets. Examples include remote monitoring and diagnostics for jet engines and industrial machinery. The same principles apply to assets that operate in groups. Thus, a logistics manager can optimize delivery routes for a fleet of vehicles, while a beverage vendor has better information for stock control and replenishment schedules across its collection of connected vending machines [3].

To deliver reliable and high-quality services, these types of applications depend on IIoT service-enablement platforms. Several IIoT applications may share infrastructure components such as communications networks, data centers and cloud computing services. This is the commercial model for many IIoT service providers which support tens or hundreds of enterprise customers and their individual, silo applications.

Future IIoT applications and systems will extend the boundaries of these silo approaches. The one-dimensional IIoT stack will evolve orthogonally to support interoperability. Not only does this add value to individual applications, it is also the basis for innovative, cross-silo opportunities.

The following Figure 1 shows a simple scenario of two separate testbed environments, each supporting two IIoT applications comprising application logic (App #n) and associated connected devices.

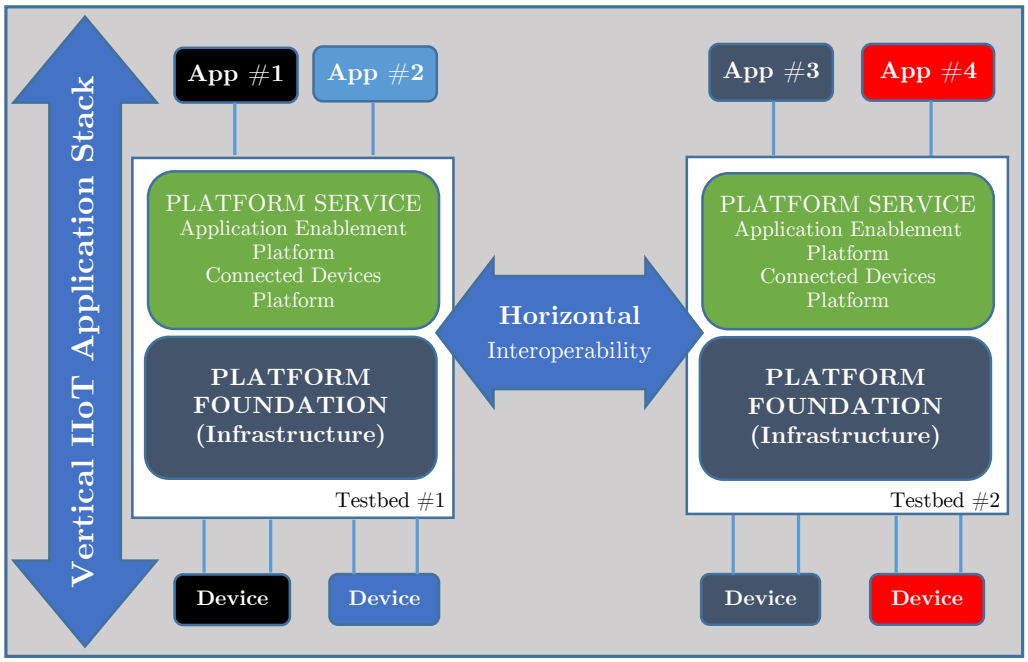


Fig. 1. Vertical and horizontal dimensions of IIoT solutions [3]

For a horizontal platform to be effective, participating service providers have to work to a standard. On one level, this ensures technical interoperability. On another level, individual platform users benefit from a set of standard operating procedures [3].

Just like the Internet and its many backbone service providers, the IIoT market will support multiple horizontal platforms for competitive reasons. Geographic and regulatory factors about data governance will also play a role.

Some platforms will specialize in key verticals such as communications services, intelligent transport services and smart city services, for example. However, when adhering to a common standard, there is no technical reason to prevent these platforms and their IIoT applications from interoperating. This means that smartphone-based applications from the telecommunications sector could interact with environmental sensors or smart-utility applications. Similarly, platforms for consumer-oriented, connected-car applications could interoperate with intelligent transport and smart city platforms.

Future IIoT systems will support interoperability and common service-enablers for IIoT applications (see Table 1). These will enable multiple organizations to cooperate through common operating procedures and multi-sided, commercial models. [3]. Three key benefits of using Blockchain for IoT are summarized below.

Table 1. Key benefits of using Blockchain for IoT (Source: Watson Blockchain IoT)

| | |
|---|---|
| Build trust | Build trust between parties and devices<br>Reduce risk of collusion and tampering |
| Reduce costs | Reduce costs by removing overhead associated with middlemen and intermediaries |
| Accelerate transactions | Reduce settlement time from days to near instantaneous |

**2. Blockchain use cases.** Blockchain use cases in different industries, which might also be transferred to the manufacturing industry, will be illustrated before we focus specifically on use cases linked to manufacturing. In Table 2 below an overview of Blockchain use cases across industries is presented [2].

Table 2. Overview of Blockchain use cases across industries [2]

| Use case | Examples | Description |
|---|---|---|
| Cryptocurrency | – Bitcoin, Litecoin, Dogecoin | – Digital coin used for payments |
| Smart contracts | – Utility Settlement Coin | – Currency backed by cash assets of the bank, used to decrease settlement time |

| | | |
|---|---|---|
| | – Hyperledger Fabric | – Project for implementation of confidential smart contacts |
| Crowdfunding | – Swarmcoin | – Direct transfer of equity to ventures |
| Prediction markets | – Predictious<br>– Fairlay | – Efficient implementation of prediction markets |
| Energy markets | – Smart Grids by LO3 Energy | – Local trading of solar energy |
| | – Wien Energy | – Trading of energy between utilities |
| | – Innogy | – Solution for automated billing of electrical vehicle charging stations |
| Smart property | – Telia<br>– Landshypoteket<br>– SBAB<br>– ChromaWay | – Transfer of property rights, for assets such as land or other tangible assets, using blockchain |
| | – Binded<br>– Pixsy<br>– TinEye<br>– Ascribe | – Storage of intangible assets, such as intellectual property, wills, art and other documents |

The potential use cases are ever expanding from payments to asset ownership, from insurance claims to intellectual property, and from applications in RegTech to integration with the IoT.

Thirty non-financial use cases of Blockchain technology are summarized in Figure 2 below.

**Smart contracts.** With the introduction of smart contracts, the number of use cases increased dramatically. Smart contracts can be described as "bundles of coded logic or procedures which sit beside the entries in the ledger." If the preconditions of the contract are satisfied, the business operations agreed upon will automatically commence and do not require additional human interaction. The benefits of using smart contracts are numerous. Reduction of transaction costs and increased transparency are two key elements achieved through increased digital efficiency by cutting out the middleman. Reducing the settlement time will not only yield a quicker transfer of assets, but also reduce the default risk in case the counterparty is not

paying. Further development in the trading industry has been made with the help of Blockchain [2].

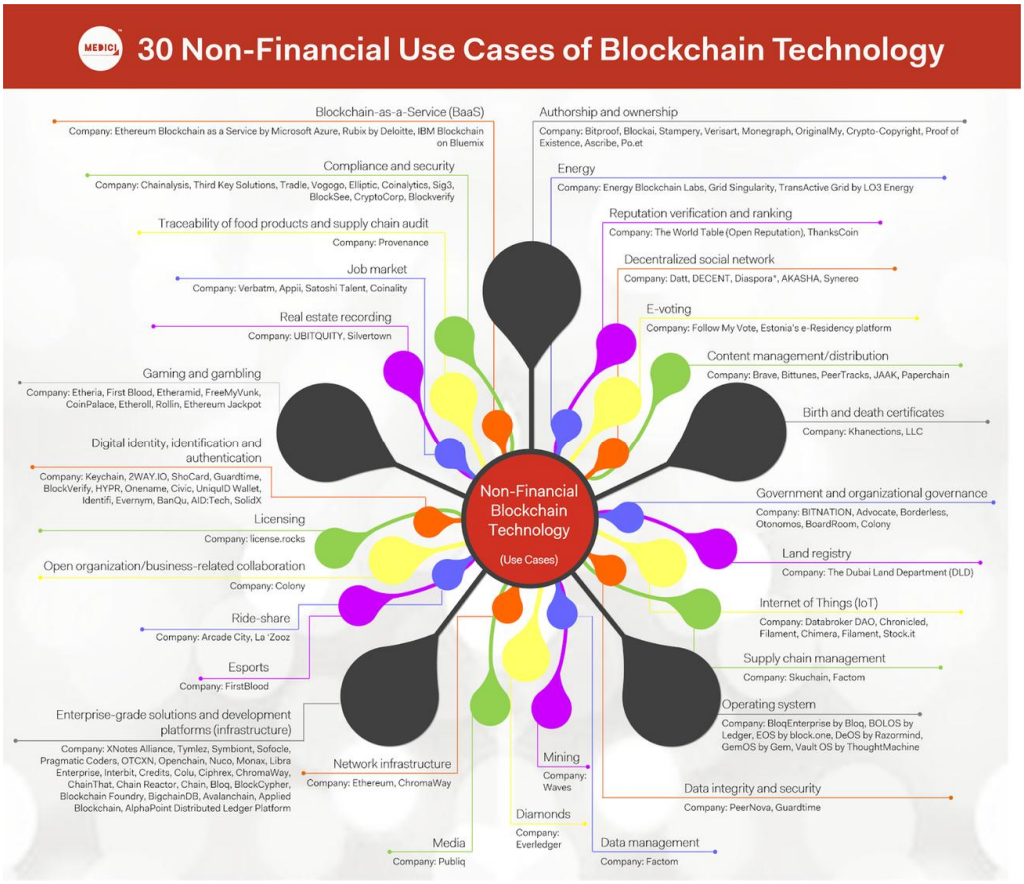


Fig. 2. Summary of 30 non-financial use cases of Blockchain technology[1]

An example of use of smart contract is the Hyper Ledger framework, an open source project, where IBM is a major contributor to the code development. The project involves ABN-AMRO, Intel, JP Morgan, Red Hat, VMware, Wells Fargo and other actors. There are numerous projects based on

[1] Source: Elena Mesropyan. 30 Non-Financial Use Cases of Blockchain Technology. In: MEDICI Global Inc., 18 December 2017. https://gomedici.com/30-non-financial-use-cases-of-blockchain-technology-infographic.

the Hyper Ledger framework; one is called Fabric, which allows actors on a marketplace to set up confidential agreements through smart contracts [2].

At the current stage of development, the lack of clarity may restrict smart contracts to simple agreements in which there is minimal subjectivity as to whether terms have been fulfilled and in which those terms can be represented in a simpler, binary fashion (i. e., the contract is either fulfilled or not fulfilled). A number of these challenges stem from the perceived lack of clarity and varying definitions of smart contracts themselves rather than from DLT/Blockchain as a technology [3].

**Energy markets.** Energy markets face the shift towards a market of consumers with decentral production. Energy microgrids based on Blockchain address this challenge. LO3 Energy has developed a technology for trading of solar energy locally using a peer-to-peer Blockchain solution. The first real application with 50 physical units has been tested one year ago in Brooklyn, in cooperation with Siemens. The project "Brooklyn microgrids" applies smart meters for tracking energy generation and consumption combined with smart contracts for energy transactions between actors on the grid. One key question raised is the scalability of the project. Specifically, the computing power that is needed for validating the microgrid transactions and is increasing with the grid size is considered as one of the key challenges for scaling the project.

Other actors trying similar concepts are Wien Energy, whose focus is on energy trading between utilities, and Innogy, which conducts tests with blockchain to automate the billing process of charging stations for electrical vehicles. Further development in the energy sector has been made by the startup Electron, which is creating technology that enables customers to faster switch their electricity suppliers [2].

**Blockchain technology in the manufacturing industry.** The abovementioned applications are a brief overview of possible uses of Blockchain technology in different industries. While the majority of research projects is still focused on the technology itself and applications in the finance industry, the interest in exploiting Blockchain in the manufacturing industry is increasing. Especially the application of Blockchain for supply chain management and auditing is investigated by several start-ups and large companies. In addition,

the role of Blockchain for Industry 4.0 and the Internet of Things is discussed and some companies are combining Blockchain solutions with 3D printing to enable new manufacturing processes. An overview of the use cases that are introduced in this section is given in Table 3 below [2].

Table 3. Overview of Blockchain use cases in the manufacturing industry [2]

| Use case | Examples | Description |
|---|---|---|
| Supply Chain Management and Digital Product Memory | – IBM and Maersk | – Tracking of containers during the shipping process |
| | – Province | – Recording of all important product information throughout the entire supply chain |
| | – Everledger | – Registers certifications and transaction history of diamonds on blockchain |
| Internet of Things and Industry 4.0 applications | – Factom Iris | – IoT device identification over blockchain |
| | – Super Computing Systems | – Sensors that timestamp data on the blockchain to save them from manipulation |
| | – Tale Data Processing<br>– Talepay | – Marketplace to allow customers to sell their data from IoT devices |
| | – IOTA | – Cryptocurrency and blockchain protocol especially developed to meet the demands for IoT applications |
| | – IBM Watson IoT | – Platform to save selected IoT data on private blockchain and share it with all involved business partners |
| 3D Printing | – Genesis of things | – Platform to enable 3D printing via smart contracts |
| | – Moog Aircraft Group | – Ensuring safe 3D printing of aircraft parts on blockchain |

**IoT and Blockchain for supply chains.** An IoT device could be used in many different ways as part of a supply chain. For example, a temperature sensor could be embedded in a package to track the temperature throughout the shipment process. It stores the data locally and sends it to the

private Blockchain through the Watson IoT Platform at numerous waypoints (factory, depot, grocery store) upon receiving connectivity [6].

Business value of Blockchain for supply chains—Using Blockchain for this transaction allows all business partners to access the same temperature data without requiring central control. A business rule could have been triggered in real time to:

- alert the factory that the shipment had arrived at the grocery store;
- automatically trigger payments to be made by the factory to the carriers;
- automatically generate an invoice to be sent to the grocery store.

IBM and the leading shipping company Maersk tested the application of Blockchain in logistics. They showed that a Blockchain can be used to track containers during the shipping process. The goal of the project was to reduce the effort and paperwork that is necessary for the shipment. Through the platform, all actors in the supply chain can access the information that is relevant for them and they can act on it. In the future, other players such as shippers, freight forwarders, ocean carriers, ports and customs authorities shall be included in the platform. By reducing the paperwork, providing important information more rapidly and preventing shipping fraud, IBM and Maersk hope to reduce the shipment costs dramatically [6].

In an effort to capture the entire supply chain, the start-up Project Provenance Ltd. is trying to secure the traceability of certifications and other important information of products on a Blockchain. The idea is that every product gets a "digital passport" that proves its authenticity and helps to determine its origin, thereby preventing the sale of fake goods. According to the company, customers know "surprisingly little about most of the products" they consume every day. A lot of valuable materials are wasted after the end of the product life cycle. In addition, poor working and environmental standards exist for many products. In contrast to existing solutions, where independent third-parties certify the product (e. g., Fairtrade, Soil Association), Provenance uses a Blockchain to register every step of the production process. This ensures that the transfers of ownership are explicitly authorized by their relevant controllers without having to trust the behavior or competence of an incumbent processor. For the different participants in the

supply chain, different software solutions exist to access the Blockchain, to extract the relevant information for this participant and to confirm the step in the production process. Afterwards, the buyer can scan the product (e. g., via QR-Code or NFC) and access the information from the Blockchain to check every step of the production process [6].

Another start-up that is trying to increase the trust in products is "Everledger". It uses Blockchain to register diamonds and secure their transaction history and ownership. In the future, the start-up plans to extend the application of their technology to more luxury goods. In addition, the CEO of Everledger believes that the technology can also be beneficial to identify machines in an IoT context [6].

**Internet of Things and Industry 4.0 applications.** Solving the identification problem of IoT devices and reducing the vulnerability during this process are the goals of Factom Irisy. They realized that the current form of authentication based on certificates from authorities is too expensive for the IoT and that the scalability is questionable. Therefore, they want to register the devices on a Blockchain to create a digital identity of the device which cannot be manipulated. It also offers the advantage that the information about the device can be dynamically updated and added in comparison to traditional certificates [3].

The Super Computing Systems AG published a whitepaper in which they propose the usage of Blockchain to timestamp sensor data for Industry 4.0 applications. To increase the level of trust between different parties, they want to create sensors that can save and thereby timestamp their data on a Blockchain. As a result, it can be ensured that the data was not manipulated afterwards and that all standards were met [3].

Besides using Blockchain to solve problems of IoT and Industry 4.0 applications, Tile Data Processing Inc. investigates the usage of Blockchain to provide access to data that is generated by IoT devices. The idea is to enable customers to sell their IoT data via the service "tilepay", where they can register and collect their data and decide who can purchase it. Companies which are interested in the data can subsequently purchase the real-time data and make a direct peer-to-peer payment to the customer via Bitcoin.

Before exploiting Blockchain for IoT applications, there are several technical challenges that need to be solved, mainly the limited scalability, the low verification speed and the incurring transaction fees. IOTA, a cryptocurrency especially built for the IoT, solves those problems by using a different kind of algorithm. Instead of using a classic Blockchain, a directed acyclic graph called tangle is used. Every participant who wants to make a transaction needs to approve two earlier ones first. In case of conflicting transactions, a tip selective algorithm is used and the more likely one is chosen. As every user needs to work to make transactions, no additional transaction fee is necessary, which helps machine-to-machine microtransaction to become economically reasonable. At the same time, the new algorithm increases the verification speed and allows a better scalability.

To enable small and midsized companies to leverage the benefits of IoT, IBM has introduced their Watson IoT platform. The platform helps companies to save selected IoT data to a private Blockchain, which is used to share the protected data among all business partners involved. While the platform is open to all industries and use cases, it is developed expressly for supply chain, trade lane, asset management, regulatory and compliance use cases. In addition, IBM offers a consulting service to help customers implement their projects on the platform.

Other concepts for IoT platforms based on Blockchain have been proposed but not practically deployed yet [3].

**3D printing platforms.** Blechschmidt/Stöker (2016) published a working paper on how Blockchain can eliminate the overhead in the manufacturing industry, which they call the "trust tax". In the paper, they introduce the project "genesis of things", which is a cooperation of several companies, including Cognizant Technology Solutions GmbH, Innogy SE and Commerzbank AG. The goal of the project is to create a platform based on Blockchain to facilitate the 3D printing supply chain. As a PoC, titanium cufflinks with a unique ID and digital product memory were produced using the platform. First, the designer registers his product design on the Blockchain. To protect it from plagiarism the design is encrypted. Then the design file uses smart contracts to automatically negotiate pricing, find the nearest and cheapest 3D printer and negotiate conditions with the customer and the

logistic service provider. All those steps are carried out without a middleman. After the order is produced, the Blockchain provides a digital product memory, which includes the entire product history, e. g., the materials used in production or the ownership of the product. This knowledge can not only increase the trust of the customers but also enables large cost savings when it comes to warranty, maintenance or recycling [3].

The Head of CIO Advisory at Cognizant Technology Solutions, Burkhard Blechschmidt, plans to extend the project in the future to include leading users as well as certification agencies. Small and midsized companies could benefit the most from using 3D printing for manufacturing, especially through saving inventory costs and producing spare parts. Those users are often less digitalized and afraid to use 3D printing, because they are worried about intellectual property theft. The major challenges with the project were to convince customers of the benefits of using Blockchain and to answer technical questions as to which architecture to use or how the payments are made. In addition, it is still a challenge to include the entire supply chain, because there are often manual production steps involved and some machines do not allow their data to be accessed digitally [3].

Another company that is using Blockchain in combination with 3D printing is the Moog Aircraft Group. They want to use 3D printing to enable a point-of-use and time-of-use supply chain, where aircraft parts can be printed exactly when they are needed, saving inventory, import and logistic costs. In this project, the Blockchain is used to securely transfer the data to a verified 3D printer. After the production, it enables authentication of the part, helping technicians to ensure that it was not counterfeit before being installed into an aircraft. A scan of the grain structure of each part is used as a fingerprint, guaranteeing that each individual part can be identified without doubt. In addition, they want to use the platform to produce spare parts for discontinued aircraft models. Currently, the technology is used to register conventionally produced parts, because 3D printed parts are not allowed for flying yet, but in the future the system will be upgraded to allow decentralized production. The vision is that customers in the future will only buy digital supply items and can decide on their own when and where to produce the part on a network of certified 3D printers [3].

**Innovative implementation of a large-scale, multi-party, intelligent transport system.** oneTRANSPORT is a large-scale, intelligent transport system (ITS) trial, partially funded by Innovate UK. It involves eleven public and private sector organizations with an operational footprint that covers about 10% of the population of England [3].

The trial is a useful reference model for future IIoT applications due to its target use-cases and system architecture. Specifically, several different user groups share a common IIoT platform and service-enablement capabilities. This offers significant commercial, technology-management and interoperability benefits. There are obvious commercial benefits from platform sharing and the pooling of expertise across different disciplines. These are important priorities for budget-constrained public sector agencies whose core mission does not extend to significant capital investments in IIoT technologies [3].

Standardization delivers additional technology-outsourcing benefits in terms of supplier diversity and a long-term features road-map which is inherent to the standardization process. Interoperability is central to the operational philosophy and underlying platform. This simplifies the process of creating cross-silo applications and lays a foundation for business innovation.

The trial makes use of over 200 types of data assets belonging to the five customer organizations and to two other transportation system and infrastructure managers, Clearview Traffic Group and WorldSensing [3].

Connected devices and sensors, of course, are not the only source of data for this trial or most other large-scale IoT applications. A journey-planning application, for example, uses information about planned road closures (e. g., at peak traffic times or on public holidays) as well as occasional lane closures due to planned and emergency roadwork. The platform requirements for such IoT applications include common service functions to source data from back-end, enterprise IT systems, from electronic spreadsheets and even from notes in handwritten manifests. This diversity of data sourcing comes close to the notion of a 'web of things.' It means that IoT platforms need the versatility to handle new and increasing numbers of data-input formats [3].

Creating smart factories using IIoT is a trend that will undoubtedly grow in the coming years. Changes resulting from this phenomenon will not

only contribute to the growth of manufacturing automation, but will also evolve a new forecast of direction of economic development, called the outcome economy. This will be the result of the transition of traditional companies on the digital market [4].

**Business applications.** As Blockchain strategies gain traction and DLT matures, forward-looking companies have proven these concepts in their sectors. The Australian Securities Exchange (ASX) is using Blockchain to record shareholdings and manage the clearing and settlement of equity transactions. Dubai's Land Department have built Dubai Real Estate Blockchain to record transactions with improved transparency, timestamping and credibility, making buying and moving easier and quicker.

Some of the most compelling use cases have been in tracking items through complex supply chains and around identity management with registries and for licenses. Technical advances have enabled enterprise-grade implementations and production level deployments in manufacturing, financial services, retail, healthcare and the public sector.

Air France KLM is testing Blockchain to track workflows within its aircraft maintenance systems. De Beers have turned to Blockchain to track gems each time they change hands starting from the moment they are dug out of the ground to guarantee diamond purity and ethical source. Intermediaries such as insurers and lawyers have started using the technology to resolve disputes via smart contracts.

*Adding Value and Efficiency.* Blockchain delivers new value propositions and optimises processes; in particular, businesses can start on this new digital technology journey by becoming educated on what possibilities Blockchain/DLT offer, and then develop strategic thinking around how these new technologies could be applied practically in creating new value propositions, new business models and learning from collaborations [5].

Cryptocurrencies like Bitcoin represent much more than digital economic innovations. The true value of the underlying Blockchain technology has only just begun to be explored and potential applications to the Internet of Things and Smart Systems are vast.

### 3. Assessment of Blockchain and evaluation of use cases.

To validate potential applications for Blockchain technology and assess expectable future developments, the current phase of Blockchain needs to be determined first. Based on this assessment one can investigate which of the challenges that companies encounter during the implementation of Blockchain solutions are typical of the development phase and in addition expected developments can be forecasted. Therefore, the interviewed experts in the performed research by Dieterich et al. 2017 [2] were asked to locate the current development phase of Blockchain on the Gartner Hype Cycle.

The Gartner Hype Cycle is a commonly used tool to classify the maturity, adoption and social application of specific technologies. It was developed by the information technology firm Gartner Inc. and shows the expectations of a technology over the time since the technology emerged. The cycle is divided into five phases. After the technology is triggered the enthusiasm increases dramatically and unrealistic expectations emerge. When those expectations cannot be met, the peak is passed and the expectations fall into the trough of disillusionment. Afterwards, when an increasing number of people understand the technology, the slope of enlightenment happens and finally mainstream adoption takes place on the plateau of productivity.

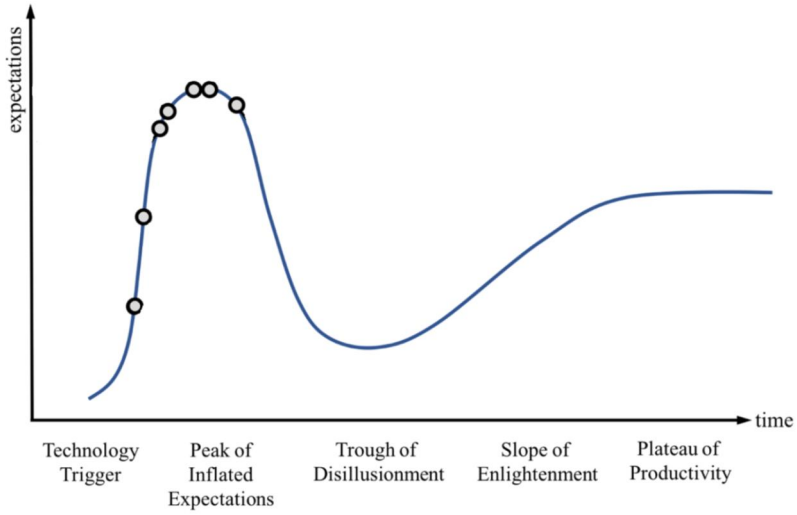


Fig. 3. Assessment of Blockchain in the Gartner Hype Cycle [2]

Figure 3 shows the Gartner Hype Cycle with the estimates of interviewed experts. All agree that Blockchain has not passed the trough of disillusionment yet and most think that Blockchain is currently on the peak of inflated expectations or slightly before or after it. However, some believe the peak is still ahead and that the hype will increase even further in the next couple of years [2].

Once companies have implemented solutions with Blockchain, they are unlikely to switch back to older technologies. In comparison, others advise to be cautious as it is noticeable that most companies still are not searching for many employees that have knowledge about Blockchain, which might be a sign that the hype is not as big as many people believe. Companies that are working on or starting new projects using Blockchain should be prepared to experience setbacks and even loss of interest in their projects [2].

The applications of use cases presented by Dieterich et al., 2017 were clustered according to the time horizon for market entry and their potential for the manufacturing industry is shown on Figure 4.

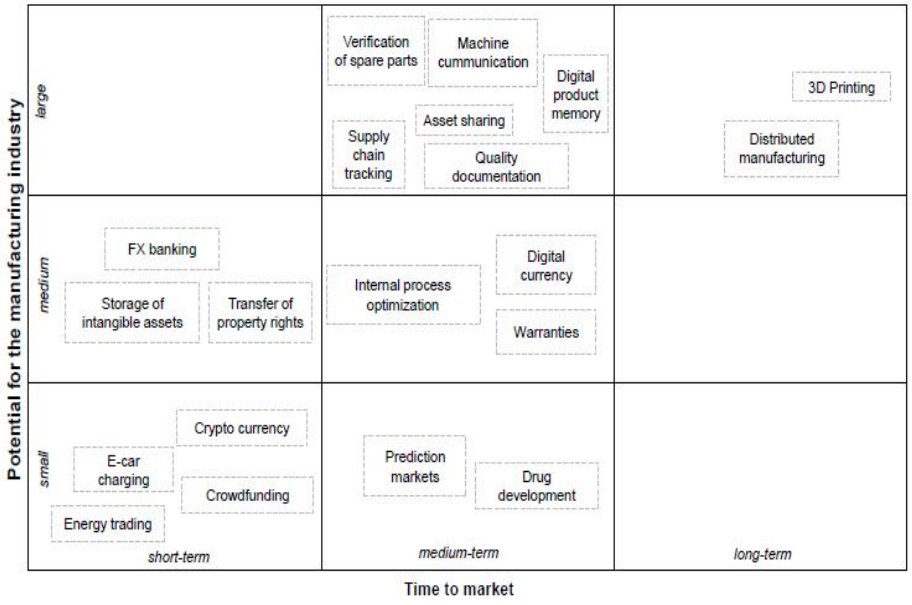


Fig. 4. Blockchain use cases and potential application for manufacturing [2]

These two dimensions were carefully chosen to structure the applications of Blockchain. The first one is "time to market", because currently most use cases are only proofs of concept and still have to master the market entry stage. Sometimes, use cases are more driven by hype without real chances for implementation, but Blockchain as a disruptive technology will develop its impact predominantly in the long-term. Most experts expect the market breakthrough in about five years [2].

The second dimension in the Cross-Potential-Matrix is the "potential for the manufacturing industry". Currently there are not many applications specifically in the manufacturing industry and these also have different potentials for a significant impact. However, considering the manufacturing industry in a broader sense, some use cases might be transferred from other industries, which are called cross-potential. Asset sharing or supply chain tracking can be useful in most industries and even many use cases from the banking and energy sectors could be applied. Companies in the manufacturing industry usually have large energy consumption and as global companies, they need a simple and cost-efficient treasury system.

In the short term, most use cases are related to the finance and energy industries, because there the costs of intermediaries are most obvious. However, in the next years the development will increase and will also impact the manufacturing industry directly, especially concerning data from the IoT and the supply chain. Distributed manufacturing and 3D printing will probably have the largest impact on this industry, but first the companies have to adapt their processes to a more open culture [2].

**4. Conclusion.** Nowhere is digital disruption more evident today than with the Industrial Internet of Things (IoT), enabling manufacturers to collect and analyse data from connected assets, people and places, to deliver actionable insights in an industrial environment. Imagine a factory where customers can validate their order remotely, machine maintenance needs can be predicted, and utilities can be optimised by understanding their loads from a remote dashboard.

Automation and advanced manufacturing will reshape industry, raising new challenges related to workforce displacement while offering new opportunities to capitalise on the huge volume of real-time data. This IoT data can enable industrial organisations to monitore energy use in manufacturing facilities with smart sensors and analytics, we can lower consumption, improve performance and change the way energy is consumed.

Horizontal IIoT platforms will proliferate once organizations implement multiple IIoT applications across different business units within a single corporation, for example, and in communal environments, such as smart cities and multi-modal transportation systems. Two other factors that will fuel this trend are the favourable economics of shared platforms and the innovation potential of interoperable IIoT applications [3].

The opportunities arising from DLT/Blockchain are vast. Although it is a field characterized by rapid change and uncertainty, steps can be taken to better understand the current realities, drivers of change and impacted sectors. There is a scope for standards to play a role in supporting the technology, for example, to act as an enabler to create the necessary space for the development and adoption of Blockchain/DLT and its market [3].

The obvious benefits of new technologies will lead to their wider adoption and failure to invest in them will make many firms' long-term prospects unsuccessful.

While the goal of the multi-stakeholder approach to the stewardship of Blockchain presented at the World Economic Forum in June 2017 was to create a language and structure to think about the stewardship of Blockchain and not to make specific recommendations to particular stakeholders, some sensible next steps did emerge. The time for global action is now. The experts do believe that people, institutions and industries throughout the world need Blockchain technology. Here is a set of actions that will move this technology forward [7].

Networked institutions: To attract the necessary level of stakeholder participation, experts recommended that respected global networked institutions (e. g., the World Economic Forum, the Internet Society, the Internet Governance Forum, etc.) convene, through an online platform and a series of meetings, a discussion of the governance issues outlined in this report.

The goals are to (a) include key players in the room; (b) provide participants with the taxonomies and frameworks developed in this report so that everyone has a shared understanding of governance challenges and solutions; and (c) forge some informal actions to improve governance, primarily at the overall ecosystem level, but possibly at the two other levels of governance.

Standards networks: To break the deadlock of bitcoin platform development, the creation of the Bitcoin Engineering Task Force (BETF) is recommended as a loosely self-organized, grass-roots technical group comprised of the nine stakeholder groups. It would not be a formal body with a board of directors or any hierarchy. It could operate as a working group of the IETF, W3C or other appropriate organization. Its mission would be the adoption of standards and the engineering and sustainability of Blockchain technology, and it would develop, test and implement new protocols and standards, according to the broad consensus of its membership prior to implementation. Instead of formal membership, attendance at BETF meetings and participation in any BETF online forum would be open to all volunteers. Participants would contribute as individuals, not as representatives of companies or organizations. The community could learn much from the consensus mechanisms and decision-making processes of the IETF and other standards bodies, such as the W3C.

Advocacy networks: To forestall regulatory, legislative, judicial or executive action that might stifle further innovation, Blockchain needs stronger advocacy. The policy and advocacy work of the Chamber of Digital Commerce is exemplary, but the ecosystem needs more. The organizations in every country are encouraged to join the CDC and participate in its work. Networked institutions with global influence, heads of state and chief executive officers could convene to discuss their common interests in developing this new global resource. In collaboration with these leaders, for example, the ecosystem needs a roadmap and action plan for future government officers, representatives and judges at the municipal, state, national and regional levels, designed to help them monitor Blockchain initiatives, assess potential harms and unintended consequences, engage the Blockchain community in discussions, and coordinate with their peers in other jurisdictions prior to issuing legislation or regulation of the technology.

Policy and watchdog networks: Much has to be done to address the need for better monitoring of Blockchain problems and challenges. Consider initial coin offerings. The first jurisdiction to come up with a workable policy for ICOs will attract a flood of ICO activity and economic development for that state. Also consider the environmental impact of Blockchain technology. Under the joint auspices of the World Economic Forum Climate Project and Energy Initiative, it is recommended to form a multistakeholder network to look not exclusively at the energy consumed by mining but also at the energy extended in current production lines and service delivery methods where industries intend to deploy Blockchain technology. The goal would be to explore methods for capturing the heat produced by mining, for harnessing the unused computing power of appliances, and for reducing energy consumption across whole systems. The policy-makers are encouraged to collaborate more deeply and more rapidly.

All stakeholders in the ecosystem – all three levels – must understand these governance challenges and opportunities. Today most players are focused on building their own companies, organizations or platforms and are paying little attention or devoting little effort to the challenges of building a healthy ecosystem. No organization can succeed in an ecosystem that is failing or stalled. Every organization should assign resources, however small, to participate in ecosystem governance.

This second era of the Internet promises to create new opportunities for a more prosperous world. Prosperity is about one's standard of living. To achieve it, people must have the means, tools, and prospects for creating material wealth and thriving economically. For us it includes more – security of the person, safety, health, education, environmental sustainability, chances to shape and control one's destiny and to participate in an economy and society. This is the promise of the Blockchain, the promise of a future where there is prosperity for everyone, but we must act now [7].

Our paper is trying to contribute to the theory by summarizing the Blockchain vision brought by the last World Economic Forum and by use cases with various application, but mostly in manufacturing. Thereby, from a practical perspective, our research facilitates companies' comprehension of the challenges and opportunities of the innovative Blockchain technology.

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