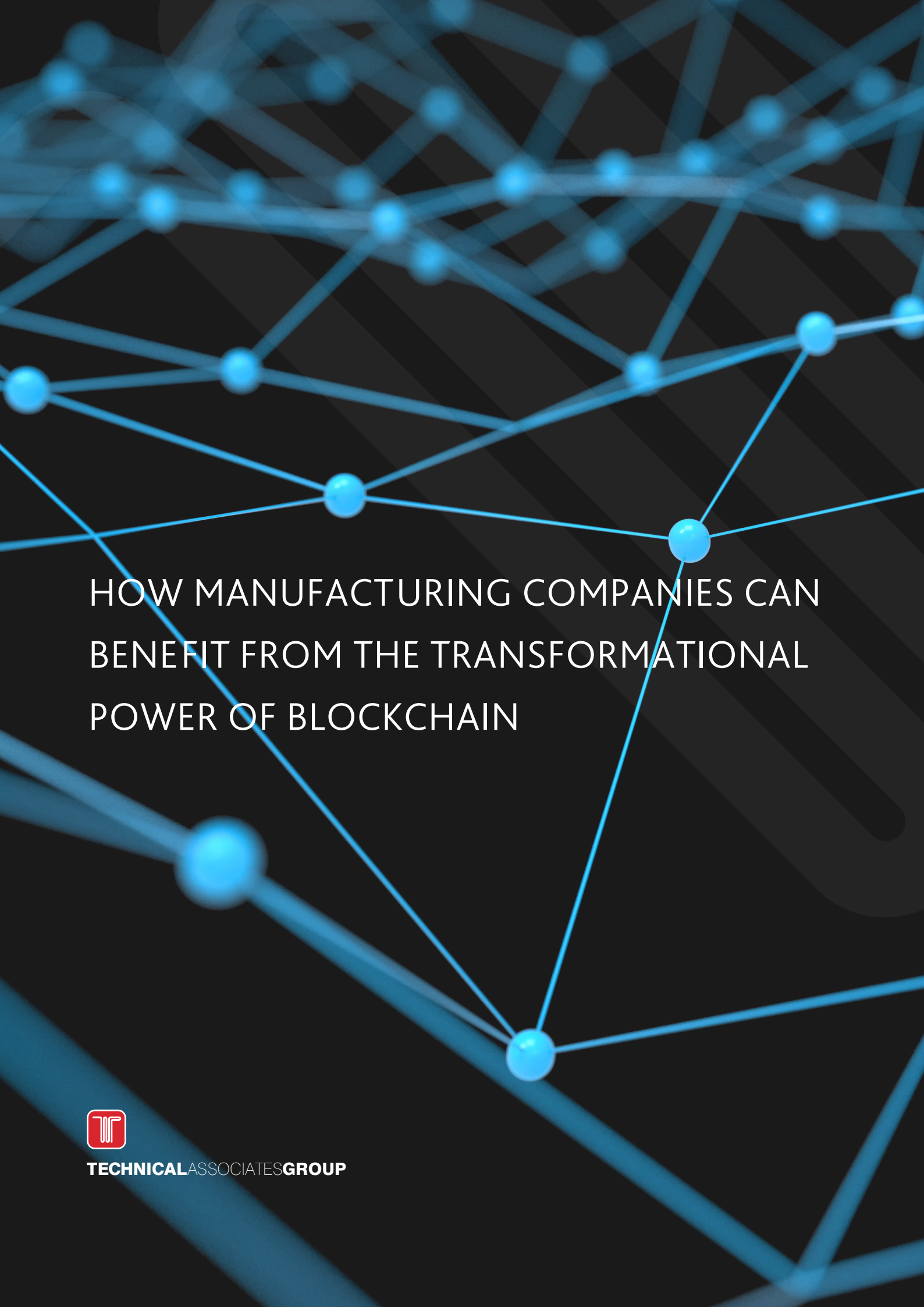

HOW MANUFACTURING COMPANIES CAN BENEFIT FROM THE TRANSFORMATIONAL POWER OF BLOCKCHAIN

TECHNICALASSOCIATESGROUP

INTRODUCTION

The development of blockchain - a digital technology used to record transactions between business partners or to store data – is causing huge excitement in financial sectors. The technology promises to deliver a trusted, distributed ledger that allows third parties with shared business processes to work seamlessly together in a totally transparent way. In financial and legal transactions, it could deliver efficiencies wherever data needs to be recorded.

But as blockchain develops, so its potential is being envisaged in wider sectors. In manufacturing, for instance, blockchain could deliver an accurate means of controlling intellectual property, ensuring inventors get the rewards they deserve for their technological advancements. It could also deliver smarter supply chain and logistics, opening up new ways of monitoring the movement of materials, contracts and payments as goods are transported globally.

Blockchain could also underpin new distributed manufacturing models brought about through the development of 3D printing, while playing a vital role in the Internet of Things by allowing the more effective monitoring of manufacturing facilities to ensure that equipment operates within its defined scope of action and that machine-to-machine payments are received accordingly.

In short, blockchain holds transformational potential across manufacturing. This whitepaper charts the historical development of blockchain, analyses recent advances in the technology and assesses a variety of revealing use cases in industrial settings.

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WHY BLOCKCHAIN MATTERS

The emergence of blockchain - a decentralised, tamper-proof digital database of transactions - holds the promise of true transformational potential across a multitude of sectors. In the near future, blockchain-enabled smart contracts and distributed ledgers, rendered with tamper-proof cryptographic technology, look set to present opportunities for companies across the world, re-engineering business processes and filling the trust void that often exists today.

Immediate benefits are clear. The ability to create, validate, authenticate and audit contracts and agreements in real-time, without third-party intervention, would be hugely advantageous for financial institutions such as banks. But there could be enormous impact on other sectors such as engineering and manufacturing, too. Blockchain distributed ledgers could, for instance, solve many of the problems that engineers face around intellectual property – ensuring that those who create value receive the rewards they are entitled to. The technology could also act as a fundamental driver of Industry 4.0, with the peer-to-peer nature of the architecture providing the solution to many current concerns around data sharing. This presents particular value as manufacturing companies look to move towards new business models based upon the concept of servitisation, where manufacturers move away from being a traditional supplier of products and towards a position of selling services based on factors such as machine uptime and availability.

There's also huge potential in the supply chain and logistics sectors, with blockchain technologies providing more secure and transparent tracking of all transactions. Every time a product moves through a supply chain, the transaction could be recorded, creating a permanent history of a product, from manufacture, distribution and sale, and onwards through the entire lifecycle towards disposal. This could also act as a powerful weapon in the fight against counterfeiting of industrial goods. In short, it's not over-excited hyperbole to suggest that blockchain could revolutionise the way that manufacturers go about their day-to-day operations.

BLOCKCHAIN HISTORY AND PROGRESS

So where did blockchain come from? And how does it work? Initially, blockchain was conceived as a means of underpinning the Bitcoin peer-to-peer crypto currency, which has been used among the internet community as digital money since around the beginning of 2010. Blockchain is effectively the supporting architecture that allows Bitcoin users to transact. But while crypto-currency has attracted a lot of media attention, it is the broader application of blockchain technology which holds exciting potential for industrial sectors.

In terms of how it works, a blockchain is a decentralised ledger of all transactions in a network. Using blockchain technology, participants in the network can confirm transactions without the need for a trusted third party intermediary. Someone in a network would request a transaction, and this would be broadcast to other computers (nodes) in the network. The network of nodes validates the transaction using agreed algorithms, and the transaction is complete. The new block is added to the network's blockchain, in a way which is permanent and unalterable. The verified transaction is combined with other transactions to create a new block of data for the ledger. It's essentially a distributed, peer-to-peer register, which stores every transaction between agreed agents, on a global basis, holding immutable records of historic data covering any transactions made.

According to professional services company PWC [1], there is a simple means of identifying where blockchain could be of help in business environments. It suggests that for any specific process where four out of the six following examples apply, blockchain could add value.

- **Multiple parties share data and need a common view of data**
- **Multiple parties update data and these actions need to be recorded**
- **Participants need to trust that the actions that are recorded are verified as valid**
- **Intermediaries add cost and complexity**
- **Interactions are time sensitive, with delays adding costs**
- **Transactions created by participants are dependent on each other**

If those are the designated qualifiers, then there are also clearly identifiable benefits to using blockchain, suggests the PWC research note. The technology has the potential to dramatically reduce costs and complexity, as it can be used to orchestrate and automate interactions with external parties, as well as internal processes. It also promises to speed up transactions, with blockchain's verification system having the potential to enable near to or real-time processing and settlement of transactions. Blockchain can also eliminate data duplication, as it provides a single shared view of the truth in a network, reducing data entry duplication and reconciliation. And due to its distributed nature, blockchain can increase resilience over current transaction systems as there are no single points of failure.

In terms of interest in blockchain, it was the banks that became the first-movers in 2015, recognising blockchain as a opportunity and as a threat to existing transaction methods. Soon after, governments became interested in the technology, recognising its potential to reduce bureaucracy and to increase citizen-to-government trust.
Now, it is the turn of large industrial companies to explore how blockchain might impact their organisations. Only recently, for instance, both Airbus and Daimler AG officially joined the Hyperledger Project, the Linux Foundation-led open source collaborative group that was set-up to advance cross-industry blockchain technologies. Airbus and Daimler will now work alongside Hyperledger-founding organisations such as IBM to understand how blockchain might be applied across their internal and external structures. This is likely to lead to proof-of-concept work and pilot studies in areas such as supply chains, where blockchain could increase the net level of trust while also boosting traceability.

BLOCKCHAIN USE CASES IN INDUSTRIAL SETTINGS

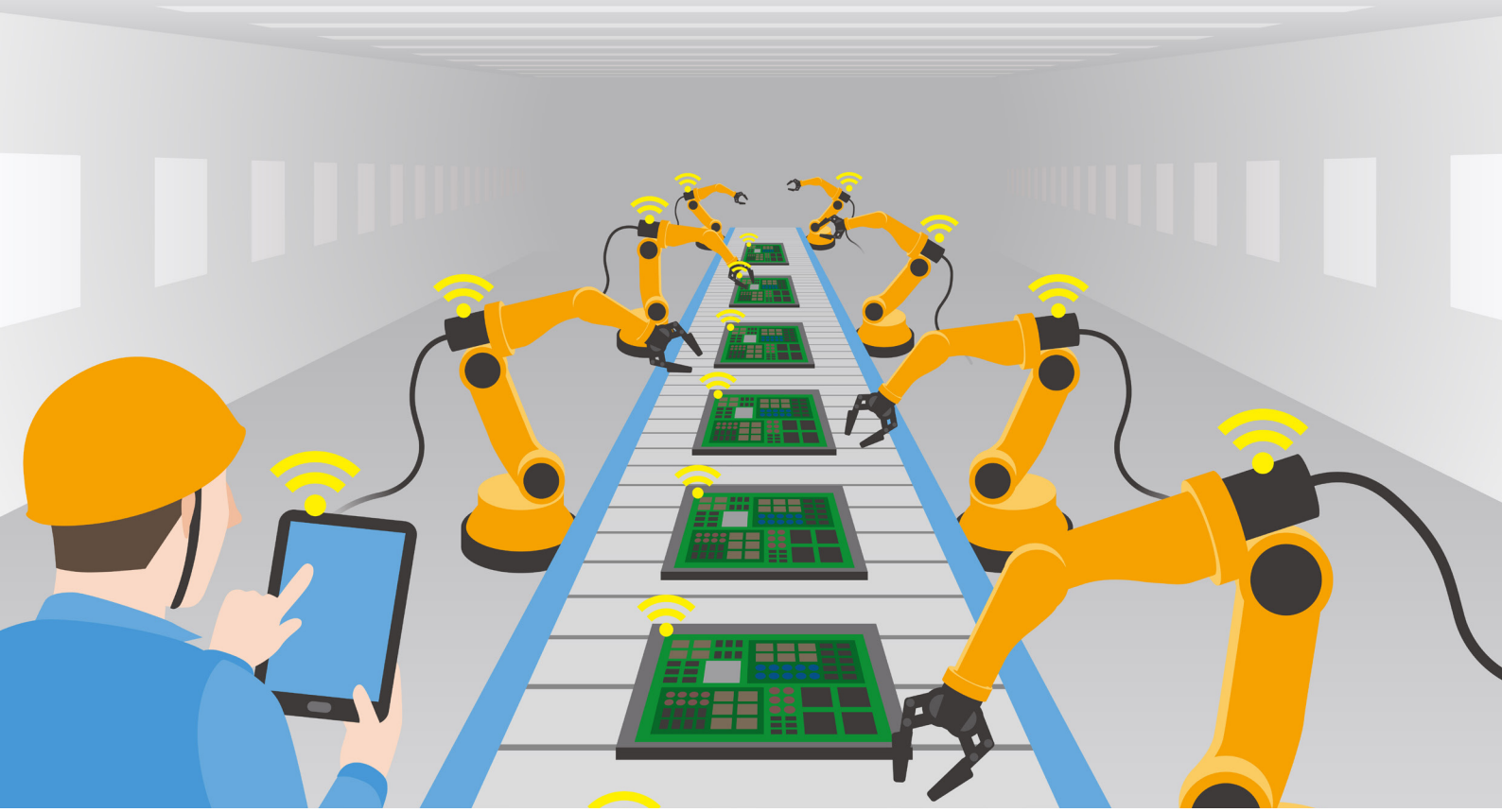
So where might some of the key use cases for blockchain within engineering and manufacturing start to emerge? The first is in the area of intellectual property. Here, the blockchain could be used as a digital vault to protect and secure value and to provide a secure registry of intellectual property for the manufacturing industry with little or no cost that is usually associated with the current long-winded process of IP registration. If the manufacturing industry adopts a blockchain for patent with the rules clearly defined and enshrined in a smart contract to be executed by the blockchain, it has the potential to transform the entire patent IP registration process with speed, process efficiency and transparency. Agency, legal and coordination cost could be eliminated or drastically reduced. Furthermore, traceability and visibility of modifications and updates would be easy on the blockchain because of its structure. Potentially, then, an immutable digital record, tracking details such as IP ownership and derivative work, could be committed to the blockchain, with a smart contract configured to kick off

UK government funds blockchain trials

It's not just the manufacturing industry that is getting excited by the potential of blockchain. A detailed report [3] on distributed ledgers released in 2016 by the UK government's chief scientific advisor predicted that the technology could transform the delivery of public services, redefining the relationship between government and the citizen in terms of data sharing, transparency and trust and making a leading contribution to the government's digital transformation plan.

Since then, the government has committed £10m to the Alan Turing Institute to investigate digital currencies and distributed ledger technologies, with a series of case studies to be conducted by research partners showing how blockchain could be used for public applications. Use cases could include implementing blockchain to manage the distribution of grants from education authorities to higher education students, or as a means of monitoring the distribution of foreign aid from the Department for International Development all the way through to on-the-ground organisations in overseas countries.

Blockchain could also be used as an official register of government-licensed assets, or as a means of logging property transactions.



payment to the owner of the IP when it was used. The beauty of blockchain is that it can be designed to employ privacy services – so it's content could be completely transparent to someone like a regulatory agency, but transactions between designated parties in the blockchain could be kept secret to and made unavailable to any third parties. It's the multi-faceted nature of the fabric of the blockchain, with these 'islands' of confidentiality, that hold potential for development.

Supply chain and logistics is another area where blockchain is creating huge excitement, opening up completely new ways to track the flow of materials, contracts and payments as goods are transported across the world. In the near future, real-time visibility of exactly what materials have arrived where, who handled them and where they came from could be recorded on the blockchain, helping drive efficiencies through manufacturing organisations, while enhancing security, reducing fraud and cutting bottlenecks that arise from third party verification. At present, logistics involves a lot of documentation such as bills of lading, invoices and other forms of authentication. The automation of this process trail through blockchain could slash the cost of managing logistics operations.

Supply chain financing is another area where the blockchain could re-engineer existing business models. Invoice settlements could be automated over the blockchain for members of the network without the need for a third party, reducing individual transaction times to a matter of minutes, minimising delays across the supply chain.

Indeed, some of the world's biggest industrial players have already recognised the potential of blockchain in supply chain and logistics applications. IBM and the global transportation giant Maersk, for instance, are developing a collaboration to use blockchain technology to help manage and track the paper trail of tens of millions of shipping containers across the world by digitising the supply chain process from end-to-end.

The solution, which is based on Hyperledger blockchain infrastructure, will enable the real-time exchange of original supply chain events and documents through a digital infrastructure, connecting an agreed number of parties including shippers, freight forwarders, ocean carriers, ports and customs authorities. The blockchain will provide each participant with end-to-end visibility based on their level of permission. Each participant can view the progress of goods, understanding where a container is in transit. They can also see the status of customs documents, or view bills of lading and other data.

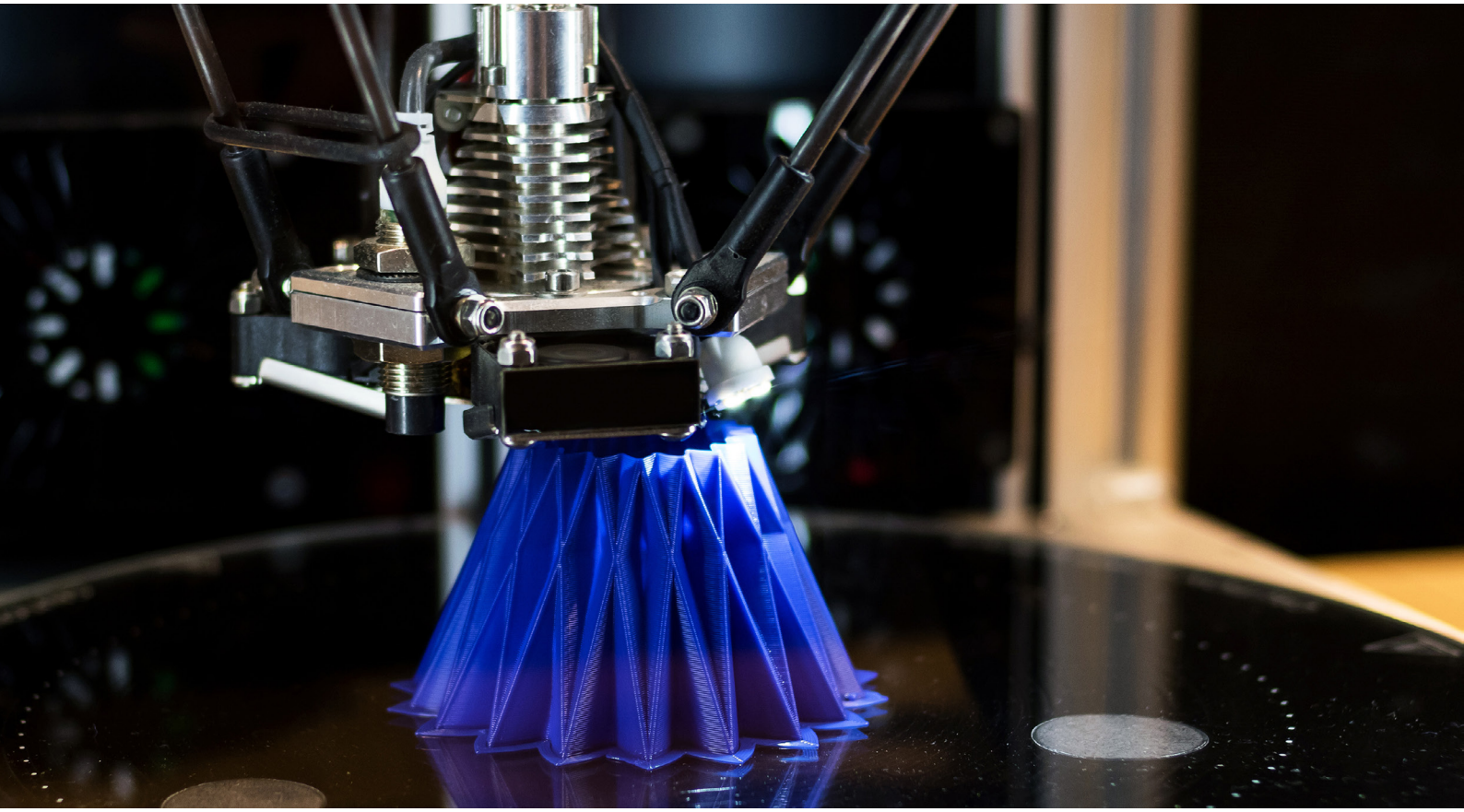
Detailed visibility of the container's progress across the globe is enhanced with the real-time exchange of original documents. No one party can modify,

delete or even append any record without the consensus from others on the network. This level of transparency, says IBM and Maersk, will help to reduce fraud and errors, reduce the time products spend in the transit and shipping process, improve inventory management and ultimately reduce waste and cost.

The impact of this blockchain solution could have a dramatic effect on the shipping industry, which provides the bedrock for global trade. Ninety percent of goods are carried by the ocean shipping industry each year. Maersk found in 2014 that just a simple shipment of refrigerated goods from East Africa to Europe typically went through nearly 30 people and organizations, including more than 200 different interactions and communications among them.

For shippers, the planned blockchain solution, which will go live later this year, could help reduce trade documentation and processing costs and help eliminate delays associated with errors in the physical movement of paperwork. It could also provide visibility of the container as it advances through the supply chain. For customs authorities, the solution is intended to give real-time visibility, improving the information available for risk analysis and targeting, which may eventually lead to increased safety and security as well as greater efficiency in border inspection clearance procedures.

Another potential use case for blockchain comes with distributed manufacturing models which are being made possible through the emergence of new technologies such as 3D printing. With distributed manufacturing, engineers and designers create new products and then get them made by sending the design files to a remote manufacturing facility. This model effectively lets engineers, designers and inventors to 'rent out' part of a factory as and when they need it. That's where blockchain comes in. Potentially, it could greatly ease the deployment of distributed 3-D manufacturing, as it could enable low-cost, distributed and assured integrity for contracts, product histories, production processes and more. Indeed, a recent partnership between the US-based digital technology company Cognizant [2], energy group Innogy and optical systems firm EOS has resulted in the development of a prototype blockchain-powered shared 3-D printing factory, using the technology to protect high-value



design files from theft or tampering through end-to-end encryption. According to Cognizant, blockchain-enabled smart contracts will allow these files to automatically negotiate terms and conditions such as price and delivery date without the need for a middleman. Smart contracts can also automatically locate the most appropriate printer, based on attributes such as availability, price, quality and location.

The pilot will also ensure the execution of secure crypto-payments to the owners of the file, as well as royalty payments to designers and other intellectual property owners. Furthermore, blockchain will enable the creation of secure 'digital product memories', which are immutable records of everything from the source of the raw materials used in the product, to where and how the product was manufactured, to its maintenance and recall history.

The pilot factory is one of the first examples of what is known as a software-defined factory. The use of blockchain, will enable the protection of design files during and after the journey to the remote printing location. It will also provide assurance that the 3-D printer can precisely meet desired specifications and quality requirements. Assurance can also be given over the verification that the correct original design has been referenced, the right raw materials were used and the 3D printer operated correctly.

Under this kind of model, blockchain could also provide assurance of payment and the ability for partners to hold each other accountable, along with validation of product information through immutable records that verify the ownership of the product's intellectual property as it moves along the value chain. It also reduces reliance on third-party participants, such as banks, lawyers and even internal accounting functions to measure, minimize or manage risk. Finally, it could reduce the need for middle management employees who currently handle much of the above information. In their place, smart contracts can automatically negotiate payment terms and conditions.

BLOCKCHAIN ROLE IN INTERNET OF THINGS-ENABLED SYSTEMS

If blockchain could play an underpinning role in distributed manufacturing models such as 3D printing, it could also emerge as a major driver in the wider concept of the Internet of Things (IoT), the inter-networking of physical devices, embedded with electronics, software, sensors, actuators, and network connectivity that enable these objects to collect and exchange data. Here, blockchain holds potential as a means of improving security within IoT architecture, and makes the connection of mass-produced, component-level devices from lower levels of the automation pyramid more viable.At present, IoT offers enormous opportunity, but is hampered by the technical complexity of identifying,

connecting, securing, and overseeing a huge number of devices, presenting real challenges for the fabric that underpins the internet. Blockchain, though, could help IoT move away from the existing 'third-party' broker-based network infrastructure, which employs the use of a central cloud server to identify and authenticate individual devices.

As IoT becomes ubiquitous, and is used by a greater number of manufacturing companies to establish new business models, blockchain could deliver advances in the authenticity and integrity of data to follow physical objects or services. The promise of immutable records to make it easier and less expensive for suppliers and customers to transact with one another in a verifiable way would represent an exciting advance, especially as companies look to establish new servitisation contracts which are based on the flow of many small transactions via machine-to-machine communication.

IBM is already sees blockchain as the next generation of transaction systems. Leveraging its Watson IoT platform, it is making it possible for information from devices such as RFID-based locations, barcode-scan events, or device-reported data to be used with a blockchain. Devices will be able to communicate to blockchain-based ledgers to update or validate smart contracts. According to IBM, this will deliver value in three ways. It will build trust between the people and parties that have transacted together – with the indelible record of transactions and data from devices stored on the blockchain providing proof and commanding the necessary trust for businesses and people to cooperate. It will also reduce costs – enable participants to reduce monetary and time commitment costs by ultimately removing the 'middle man' from the process. Transactions and device data are exhibited on a peer-to-peer basis, removing most legal or contractual costs. And finally, it could accelerate transactions – enabling more transactions overall because the 'middle man' is removed from the process. Smart IoT-related contracts allow for firms to reduce time needed for completing legal or contractual commitments.

It's not just large companies such as IBM that are progressing blockchain in IoT. Small start-ups, such as San Francisco-based Chronicled have emerged as disruptive thinkers in the market. Using a proprietary system based on the Ethereum blockchain protocol, Chronicled has devised a method of providing tamper-evident cryptographic chips with unique identities, giving them the ability to write immutable, time-stamped transactions. Once registered on the blockchain, the chips act as incorruptible agents that can write meaningful facts on a ledger. Solutions requiring authenticity verification, item and provenance tracking, proof

Distributed ledgers move beyond blockchain

As blockchain continues to evolve, other distributed ledger technologies which boast their own range of features and benefits are starting to emerge. IOTA, for example, is a scalable, open-source architecture that makes it possible to transfer value without any fees. This holds significant potential for the Internet of Things, where companies are looking to establish new business-to-business models that are based on the ability to settle many, low-value transactions in real time as machines interact together.

IOTA is based on a new quantum-proof protocol, known as the Tangle, that fundamentally differs from the blockchain, which operates with blocks added in a sequential chain. A limit on the number of transactions permitted in a certain block can present saleability issues.

IOTA's fabric, meanwhile, allows higher transaction throughput by parallelizing validation. As the Tangle grows with more transactions, IOTA becomes faster and more secure with transaction finality happening more quickly as network critical mass is approached.

Potentially, then, IOTA offers many attributes including zero fees, infinite scalability, fast transactions and secure data transfer, making it particularly suited to the emergence of the Internet of Things. Major industrial groups including Robert Bosch, ZF Friedrichshafen and the energy firm Innogy are establishing use cases as they look at how to automate machine transactions in the fourth industrial revolution.

of proximity, and payments can be implemented, something which is technically difficult and expensive to achieve on conventional IoT platforms.

Indeed, the work of IBM, Chronicled and others in the area of IoT proves that blockchain has the potential to enhance collaboration within manufacturing, smoothing the interface between organisations by allowing everyone on the network to see information and updates in real time. At present, there are very many collaboration tools that companies use to work on joint ventures or projects, but most of them need central intermediaries to verify and authenticate information. However, with the blockchain, the manufacturers could establish a sharing system where they could transfer equipment and make settlements over the blockchain network. With a trusted network less prone to manipulation, such servitisation business models could see manufacturers charged only for available uptime, rather than increasing overhead and capex by paying upfront.

IMPLEMENTING BLOCKCHAIN WITHIN MANUFACTURING SETTINGS

It's clear, then, that blockchain holds potential across manufacturing, bringing opportunities for more distributed business models, enshrining IP, shortening supply chains and ushering in emerging technologies such as 3D printing. At the moment, though, it remains just that – potential. Blockchain is attracting disruptive thinkers and is being pushed forward on several fronts, but it still has some way to go before it is ready for implementation on any meaningful scale.

That's not to say that manufacturers shouldn't start considering how the technology might improve their business. Blockchain is coming, and now is the time to start thinking about the impact it might have. Careful choice of use case is critical to a successful blockchain first project, and there are specialist organisations that already exist to help manufacturers navigate the complex ideation process. There's no one-size-fits-all approach to blockchain implementation, but there are some established methods that can support use case selection.

Identifying the specific problem that blockchain could address is the logical starting point, enabling the scoping of the business challenge up front, so that efforts can be totally focused on core – rather than peripheral – issues. The early-stage nature of blockchain means that consultants in the sector recommend starting small, learning, and growing fast, and suggesting the breaking up of large business challenges into smaller projects to decide where to begin.

When considering who are the business network participants involved, and their role in the project, there's a simple rule: if there is no network, it's not a good blockchain use. Once each partner organisation is identified, it's advisable to visibly map out the network of participants to understand their inter-linked role in the blockchain.

It's also crucial to understand the assets that are being transferred across the business network, the information associated with each asset, and under what contractual conditions they move from owner to another. It's important to understand the workflow as it crosses the business network to establish the relevance of the blockchain. And there's a need to understand what legacy systems are involved, and how blockchain can integrate with or work alongside such programs.

These are broad-brush recommendations for early-stage thinking and as with any transformative technology, the devil is the detail. The diversity of application and the complexity of implementation means there is a temptation to put blockchain on the backburner. But the technology is coming, and it's coming fast. That makes blockchain worthy of consideration sooner rather than later.

References

1. Blockchain: An Introduction
2. Cognizant – How Blockchain Can Slash The Manufacturing Trust Tax
3. Distributed ledger technology: beyond blockchain

GLOSSARY

The author would like to thank the following individuals
for their contributions to this White Paper:

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