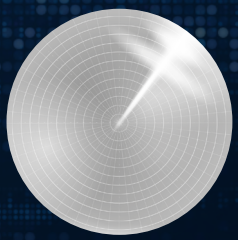
BLOCKCHAIN IN LOGISTICS

Perspectives on the upcoming impact of blockchain technology and use cases for the logistics industry

2018



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PREFACE

Dear Reader,

What if we could remove the need for intermediaries in the world of logistics? What if transactions could be verified, recorded and coordinated autonomously without third parties? If this could be done, it would eliminate an entire layer of complexity from our global supply chains.

This is the promise blockchain presents to the logistics industry. Right now, this technology is still far from maturity with many challenges to overcome before it can be successfully deployed at scale in the logistics industry. Likely the biggest challenge will be in achieving successful industry adoption through collaboration and even coopetition between diverse supply chain stakeholders that have legacy processes and varying interests.

But early applications of this emerging technology across a number of industries – from finance to energy, and manufacturing to retail – suggest blockchain has a favorable chance of achieving its full potential in future. When it does, this technology will facilitate greater efficiency and new business models including faster and leaner global trade logistics, superior transparency and traceability in the supply chain, and increased automation of commercial processes in logistics.

Exploring the very latest analysis, opinions and findings, and drawing on a number of fascinating use cases to identify key success factors for implementation, this trend report aims to answer:

- **What is blockchain and what are the key challenges?**
- **How is this technology already being applied across industries?**
- **What opportunities could blockchain deliver to your logistics operations?**

We hope that you enjoy reviewing the concepts and real-life applications presented here. In addition, we look forward to future collaboration with your organization – together we can unlock the value of blockchain in logistics.

Yours sincerely,

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1 UNDERSTANDING BLOCKCHAIN

1.1 Disrupting the Business of Trust – The Emergence of Blockchain Technology

For centuries, businesses and in some cases entire industries have been built on the 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 a distributed ledger technology that can record transactions between parties in a secure and permanent way. By 'sharing' databases between multiple parties, blockchain essentially removes the need for intermediaries who were previously required to act as trusted third parties to verify, record and coordinate transactions. 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.

What kind of impact could this have on everyday life? Imagine in healthcare, sensitive data from all stakeholders – ranging 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 finance, companies and customers could potentially adopt a common digital currency as an alternative to traditional money, reducing the cost of transfers and enabling micro transactions. And in logistics, data sharing across the supply chain could enable higher levels of transparency, empowering consumers to make better choices about the products they buy. These are just some of the many opportunities that blockchain presents.

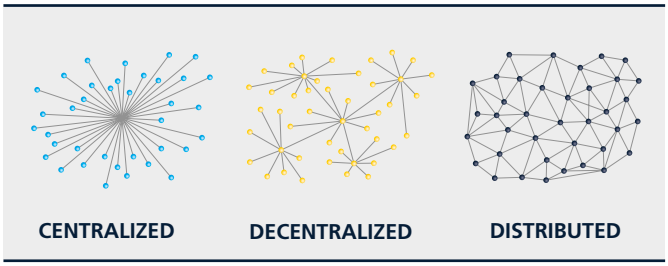


Figure 1: Going from a centralized to a decentralized, distributed database using blockchain; **Source:** DHL

Despite its brief history (see figure 2), blockchain is currently enjoying a rapid rise to prominence in corporate agendas as well as in the media. Mainstream awareness can be largely attributed to its original application as the underlying technology of digital currencies, in particular bitcoin (see figure 3 on next page).

BLOCKCHAIN HISTORY

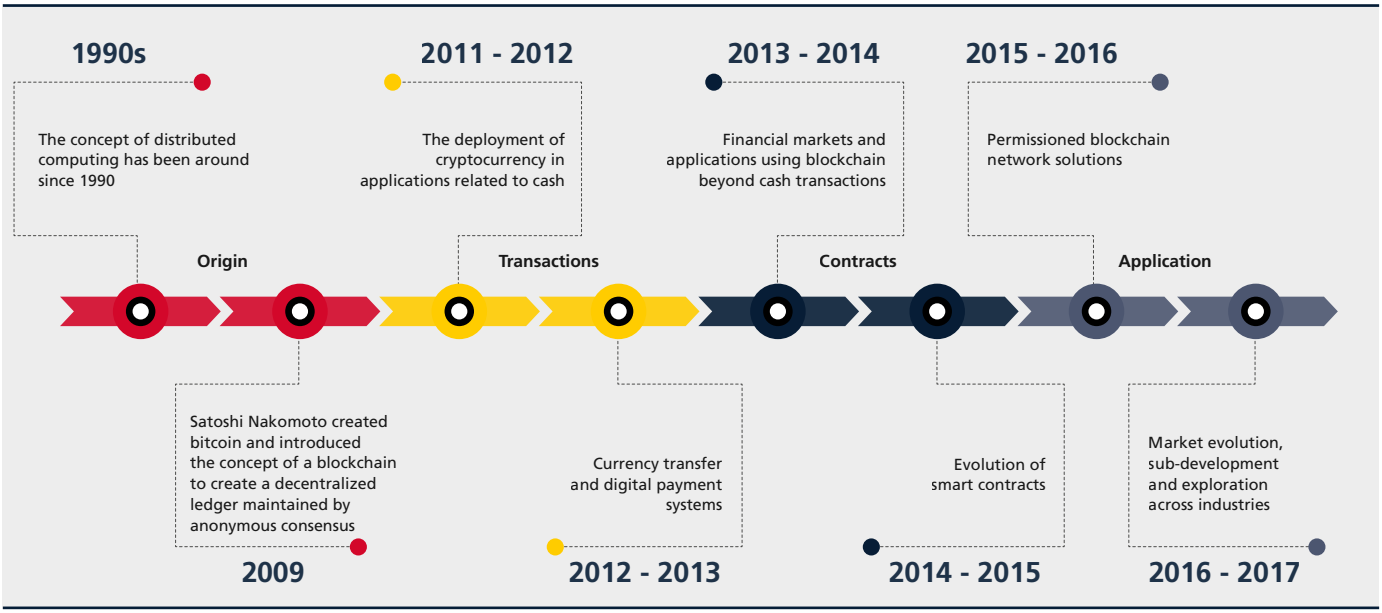


Figure 2: A history of blockchain technology; **Source:** Accenture

Besides the adoption of this technology in powering cryptocurrency networks, there are open questions about where blockchain is headed, when it will yield positive results, and who will benefit most from it. What's clear at this point is that blockchain applications may have one of the most profound impacts on the logistics industry, especially the supply chain. Vipul Goyal, an associate professor at Carnegie Mellon University, states "a lot of companies are interested in blockchain for creating more efficient workflows, but supply chain management is one of the big killer apps".[1]

This is because global supply chains are highly complex, with diverse stakeholders, varying interests, and many third-party intermediaries – challenges that blockchain is well suited to address. In the logistics industry, blockchain can be harnessed in two key ways, namely, to drive efficiency and enable new business models:

- **Drive efficiency:** Blockchain can potentially improve efficiency in global trade by greatly reducing bureaucracy and paperwork. For example, a multi-stakeholder process with a lengthy paper trail could be replaced with an automated process storing information in a tamper-evident digital format.

  Another example is the automation of services that currently require an intermediary such as insurance, legal, brokerage, and settlement services. Blockchain could be used to track a product's lifecycle and ownership transfer from origin to store shelf, even as it changes hands between the manufacturer, logistics service provider, wholesaler, retailer and consumer. It would facilitate and automate each business transaction, enabling a more direct relationship between each participant (e.g., automating payments and transferring legal ownership between parties).

- **Enable new business models:** Micro payments, digital identities, certificates, tamper-proof documents and much more can be introduced and radically improved using blockchain-based services. For example, driver training organizations could replace easy-to-fake paper-based certificates with tamper-proof digital versions that can then lead to new identity-related services. Just as the Internet began a revolution of communication, blockchain technology could disrupt current business practices and models.

With significant benefits in sight, the overall market for blockchain is expected to boom with some estimates projecting growth of blockchain technology from USD $411.5 million in 2017 to $7.68 billion by 2022.[2] Reasons for this rapid growth are the rise in banking, financial services and insurance applications including digital currencies and identities, as well as the continuing development of this technology and growth from major vendors. And while blockchain is not yet fully mature, its huge potential suggests this is the right time to learn more. Companies need to understand how blockchain technology can empower groundbreaking innovations, what obstacles must be overcome, and the likely value and tangible rewards it can deliver, especially in logistics.

WHAT IS BITCOIN?

- Bitcoin is a leading digital currency stored on a global, decentralized peer-to-peer blockchain
- Bitcoins are digital assets or cryptocurrency, meaning they are designed to be used as a medium of exchange
- Blockchain is the underlying technology which enables transactions to take place in a secure and trusted manner between pseudo-anonymous parties
- Anyone can participate in the bitcoin blockchain and ownership can be digitally transferred without the need for an intermediary
- Other digital currencies are available, including ether on the blockchain-based ethereum platform
- Bitcoin's price volatility, high liquidity as well as its role in enabling transactions to bypass trusted banks and financial institutions has led to criticism
- The creation or 'mining' of bitcoins is done through computers solving complex equations. Currently, it is heavily energy-intensive, requiring improvements in energy efficiency
- Whether bitcoin will be sustainable as a digital currency is yet to be known

Figure 3: What is bitcoin and how does it relate to blockchain technology?; **Source:** DHL

[1] https://www.computerworld.com/article/3249252/emerging-technology/blockchain-will-be-the-killer-app-for-supply-chain-management-in-2018.html
[2] https://www.marketsandmarkets.com/PressReleases/blockchain-technology.asp

1.2 How Blockchain Technology Works – An Overview of Key Features

Figure 4: A typical ledger from the 1950s detailing creditor payments; **Source:** Edinburgh City of Print

Blockchain technology does not introduce an entirely new paradigm. Rather, it builds on the old template of a ledger – something that is used to log transactions over a period of time (see figure 4).

Traditional ledgers are owned by one entity (such as a business, organization or group) and controlled by a designated administrator (for example, an accountant). This administrator can implement changes to the ledger without requiring consensus from all of the ledger's stakeholders.

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 the agreement of network participants and all changes to the distributed ledger are auditable. To illustrate how this operates, figure 5 shows a financial transaction recorded on a blockchain. A similar process can be used to trace other types of asset transfer, to commit new data to a blockchain, and to update data in a blockchain.

This 'mutualization of data' in a blockchain-based system is only possible with strong cryptographic techniques that make certain that copies are identical, transactions are not duplicated, and specific permissions are enforced to access stored data. Here, public and private keys are used to ensure confidentiality and privacy. In simple terms, a public key can be likened to the address of a physical mailbox, which is publicly known by senders. A private key is similar to the key or password required to unlock the mailbox; it is safeguarded at all times by the owner and must not be shared with third parties.

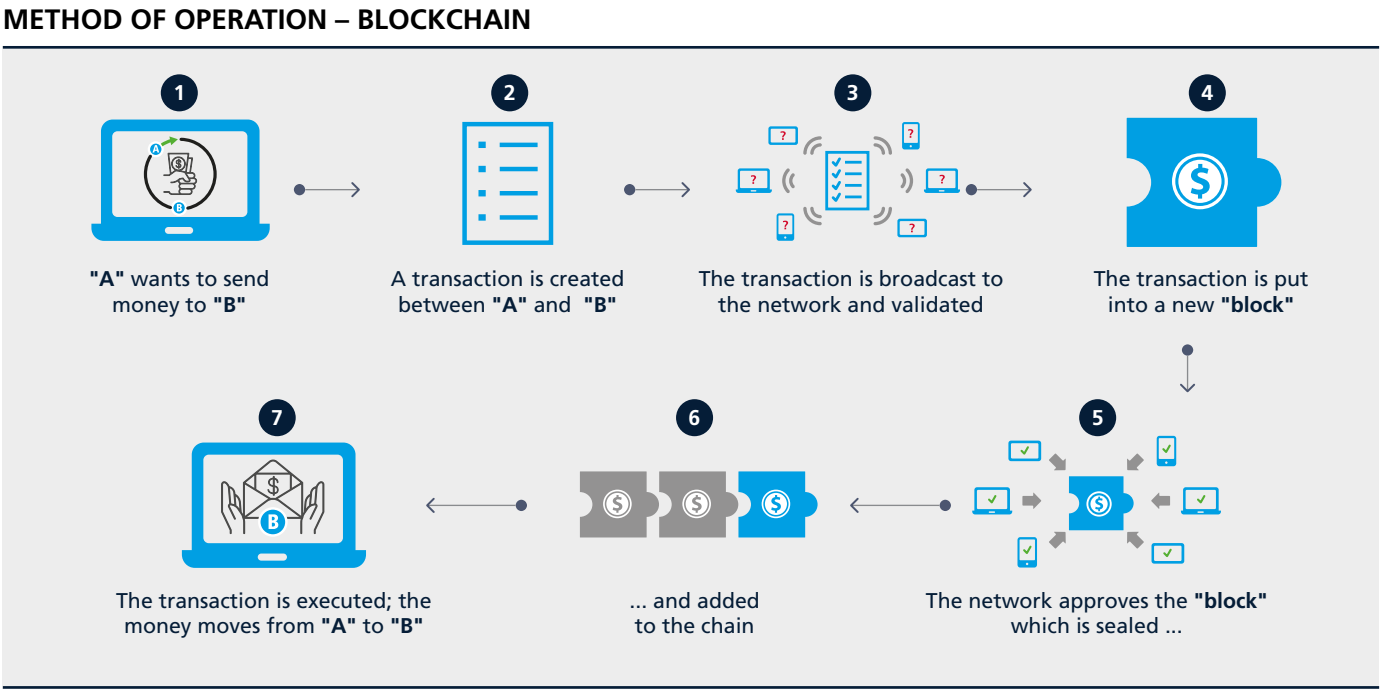
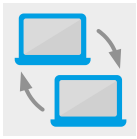


Figure 5: Illustration of a blockchain transaction; **Source:** DHL/Accenture

The transformative power of blockchain comes through the unique combination of its differentiating features and characteristics. Below is a summary of the four key features – these are data transparency, security, asset management and smart contracts.

1. Data transparency – Blockchain technology includes mechanisms to ensure stored records are accurate, tamper-evident, and from a verifiable source. Thus, instead of multiple parties maintaining (and altering) copies of their own dataset, now every stakeholder receives controlled access to a shared dataset creating a single source of truth. This gives confidence to everyone working with this data that they're using the most recent, accurate, and reliable dataset.

2. Security – Traditional ledgers typically provide a blanket layer of security which, once breached, allows access to all stored data. In a blockchain-based system, the security mechanisms make sure that individual transactions and messages are cryptographically signed.[3] This ensures essential security and effective risk management to tackle today's high risks of hacking, data manipulation, and data compromise.

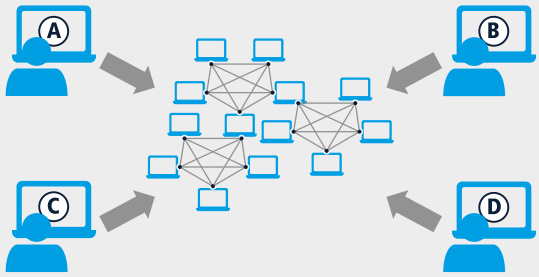


3. Asset management – Blockchain technology can be used to manage the ownership of digital assets and facilitate asset transfers. For example, it can be used to track the ownership of titles (e.g., land titles and diamond certificates) and rights (e.g., copyright and mineral rights). It can also be used to manage the digital twin of a physical object in the real world.

4. Smart contracts – Manual processes that are normally guided by legal contracts can be automated with a type of self-executing computer program called a smart contract. A smart contract is a component of a blockchain-based system that can automatically enforce stakeholder-agreed rules and process steps. Once launched, smart contracts are fully autonomous; when contract conditions are met, pre-specified and agreed actions occur automatically.

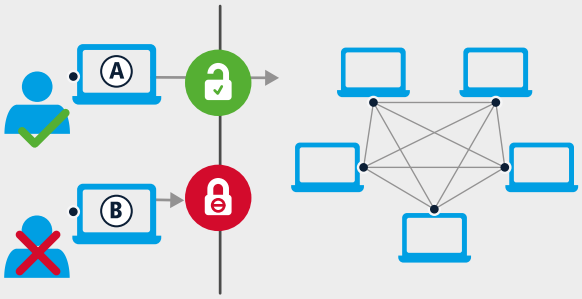
These capabilities can be deployed across two types of blockchain-based system: public permissionless blockchains where anyone can participate (e.g., the bitcoin network) and private permissioned blockchains where participants must be safelisted. Figure 6 shows the key differences between these two types of blockchain-based system.

PUBLIC VS. PRIVATE BLOCKCHAINS



PUBLIC, PERMISSIONLESS BLOCKCHAINS

- Anyone can join the network and submit transactions
- Anyone can contribute computing power to the network and broadcast network data
- All transactions are broadcast publicly



PRIVATE, PERMISSIONED BLOCKCHAINS

- Only safelisted (checked) participants can join the network
- Only safelisted (checked) participants can contribute computing power to the network and broadcast network data
- Access privileges determine the extent to which each safelisted participant can contribute data to the network and access data from the network

Figure 6: Key differences between public, permissionless blockchains and private, permissioned blockchains; **Source:** Accenture

[3] A cryptographic (digital) signature uses algorithms to sign data. One can imagine it as a sort of digital fingerprint placed on the data. This ensures data integrity: another person can verify the signature and can prove that the data originated from the signer and was not altered after it was signed.

Public, permissionless blockchains are open and therefore likely to spur faster innovation as they can be used by many parties and can gain network effects. However today, companies tend to adopt private permissioned blockchains as these support a closed ecosystem of participants with enterprise features such as strict access controls and privacy protections. Therefore, the choice between using public versus private blockchains should be determined by the individual needs of each blockchain implementation.

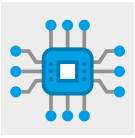
1.3 Key Challenges Facing Blockchain Technology Today

Blockchain has the potential to deliver vast savings by improving operational efficiency and generating value through new business models. However, as with many emerging technologies, considerable challenges must be overcome before blockchain can achieve mainstream adoption in all industries.

Gaining **industry adoption** is the most critical challenge and this will determine the success of blockchain technology in logistics. Being able to accurately and safely exchange information within a community is a key advantage of blockchain and stakeholders benefit the most when their community contains many relevant members. Therefore, similar to Facebook, the value of the community increases when it is adopted by a growing number of relevant stakeholders.

A powerful network effect is triggered in the supply chain when stakeholder adoption reaches a critical mass. As more and more supply chain stakeholders participate, blockchain becomes more valuable, evolving into an industry practice. However, it will be difficult at first to obtain stakeholder commitment because of differing levels of digital readiness and the initial requirement to recognize the mutual benefits of blockchain-based collaboration. This will be particularly tricky when there are legacy processes, regulations and laws governing various aspects of the business, as stakeholders will incur cost to migrate from legacy systems and integrate with new systems and practices.

Another challenge is the development of **standards and governance** of blockchain in each industry. There will probably be not just a single blockchain-based system in the logistics industry; instead, there will likely be multiple private permissioned blockchains due to the competitive nature of business. And of course in future there will be multiple public blockchains. Organizational bodies will be required to determine standards and agreements, especially in the context of interoperability between blockchains. To tackle this challenge, the first blockchain consortia are now beginning to emerge; for example, the Blockchain in Transport Alliance (BiTA) in the logistics industry.



It is necessary to make progress with blockchain **technology** itself in order to overcome current technical limitations. This is especially required for companies moving from a pilot implementation to full-scale deployment. For example, some blockchain implementations have been known to scale poorly and suffer from high latency although new innovations are being developed to address these scalability and performance issues. In some specific applications (such as large-scale, public cryptocurrency networks) there are issues with energy consumption and computing power requirements. These obstacles will need to be addressed for blockchain to reach maturity.

Organization and culture play a significant role in the success of digital transformation in any industry. Particularly with blockchain technology, this cannot be overlooked as its adoption will require a collaborative mindset to engage with a large number of stakeholders. Therefore, within organizations, a culture of embracing new opportunities from blockchain technology should be fostered. Managers, particularly those in IT functions, must gain blockchain expertise to proactively push organizational exploration and, if applicable, adoption of blockchain-based solutions.

Across organizations, stakeholders need to engage in shared governance, defining roles and answering key questions (e.g., on process transformation, development of the solution, active versus passive participation). Companies should therefore embrace concepts of collaboration and coopetition in order to derive the greatest benefits from a blockchain transformation.

While there are many hurdles to overcome, these challenges with blockchain are not insurmountable. Already this technology, despite its relative infancy, is showing promise across a wide range of industries including citizen services, retail, life sciences and healthcare, automotive, manufacturing, energy, and logistics. The next section explores today's most promising applications of blockchain.

2 BLOCKCHAIN EXAMPLES ACROSS INDUSTRIES

As blockchain technology matures, businesses in almost every industry are exploring how to capture new opportunities. This chapter reviews a selection of promising and disruptive examples of blockchain application and considers how these can inform future direction.

2.1 Citizen Services – Provisioning Digital Identities

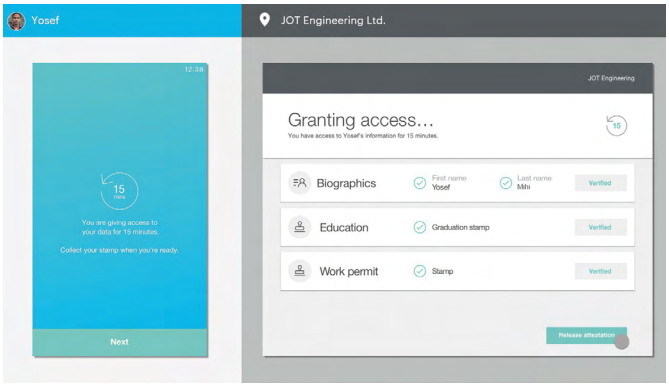


Figure 7: ID2020 – a global ID system using blockchain; **Source:** Microsoft/Accenture

Approximately one-sixth of the world's population cannot participate in political, economic and social life because they lack the most basic information: documented proof of their existence.[4]

Blockchain technology provides a tremendous opportunity to solve this challenge through the development of digital identity systems that are cryptographically secure. Governments and non-governmental organizations (NGOs) can use digital identities to provide a variety of citizen services and eliminate certificate forgery and identity theft.

ID2020, an organization affiliated with the United Nations, seeks to provide proof of identity to people without an official form of identification. In essence, ID2020 is using blockchain technology to provision global IDs – its system lets registered users control their personal data to share access and appropriate information without the worry of using or losing paper documentation. Blockchain enables system security and facilitates trusted transactions, allowing the people with digital IDs to access a wide range of activities, including education, healthcare, voting, banking, housing, and other social benefits.

The ID2020 prototype is designed to interoperate with existing identity systems so that personally identifiable information always resides "off chain". The system will deploy a breakthrough biometrics system to manage fingerprints, iris and other data. Coordinated with **Accenture** and **Microsoft**, the ID2020 alliance expects to move from prototype to implementation with the aim of supporting more than seven million refugees from 75 countries by 2020.[5]

2.2 Retail – Encouraging and Ensuring Ethical, Sustainable Consumption

Blockchain technology is being applied by retailers and consumer goods manufacturers to drive fair and responsible business. For example, it is empowering consumers by providing more information about how each item was produced, particularly identifying whether a product has been ethically and sustainably sourced.

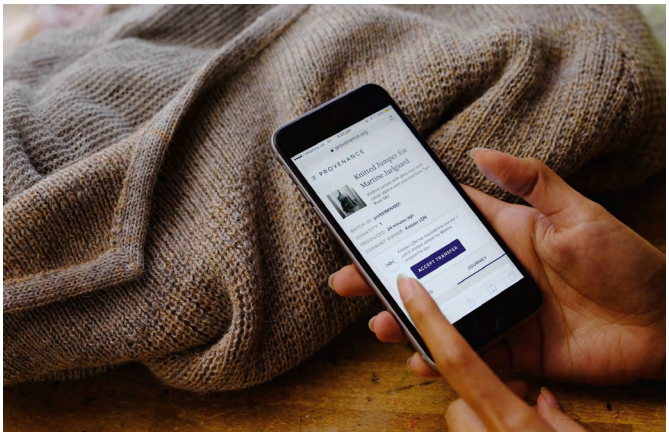


Figure 8: Increasing transparency in fashion supply chains; **Source:** Provenance

[4] http://id2020summit.org/
[5] https://newsroom.accenture.com/news/accenture-microsoft-create-blockchain-solution-to-support-id2020.htm

In the UK, the fashion designer **Martine Jarlgaard** is collaborating with **Provenance** and other partners in a pilot program that makes fashion supply chains fully transparent. This solution encourages and enables consumers and retailers to buy goods from fashion supply chains in which each stakeholder adheres to ethical and sustainable business practices. Users can look up a garment's supply chain history on the blockchain-based system by scanning its QR code or NFC-enabled label with a smartphone app. Building on this successful pilot program, Provenance is now working towards an open traceability protocol. This would allow anyone to track the place of origin for anything, from coffee beans to a roll of fabric, and hopefully accelerate the movement towards sustainable consumption.

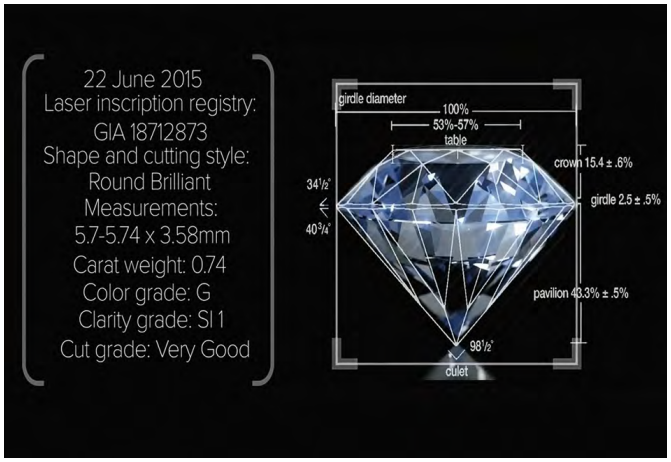


Figure 9: Ethical sourcing of diamonds using blockchain; **Source:** Altoros/Everledger

Another example of ethical sourcing is from **Everledger** in the UK. Everledger is developing a blockchain-based system to provide secured proof of origin and ethical sourcing for high-value goods such as diamonds, wine, and even fine art. It uses blockchain to store a digital record for millions of precious goods. For diamonds, this system would replace the flawed paper-based certification process currently used by diamond suppliers, intermediaries and buyers. Unlike paper records which may be forged or lost, blockchain records are permanent. Everledger achieves this by creating a digital thumb-print for each individual diamond. This digital thumb-print contains unique identifiers that consist of over 40 metadata points, the diamond's four Cs (color, clarity, cut, and carat weight) as well as the certificate number which can be laser inscribed on the physical diamond if required. This thumb-print is then made visible and stored with all participants on the blockchain-based system.[6]

2.3 Life Sciences and Healthcare – Enabling a Single Source of Truth

When data is stored on a blockchain-based system, stakeholders gain controlled access to a single source of truth for the most current and reliable dataset. In the life sciences and healthcare industry, where data is often stored in silos and data security is paramount, blockchain has huge potential to be deployed privately and securely. The wide range of applications include clinical trial results, health records management, infectious disease reporting, insurance policies, pharmaceuticals serialization, track and trace, vaccination histories, and many more.

The **United States Food and Drug Administration (FDA)** is exploring the use of blockchain to share and audit electronic medical records, clinical trial results, and health data. By doing so, difficult-to-access data can be securely managed on one blockchain platform shared among stakeholders, driving transparency as well as unlocking potential new efficiency gains. In October 2017, this work expanded to assist the United States **Centers for Disease Control and Prevention (CDC)** in testing a blockchain-based platform for health surveillance. This solution aims to enable more efficient management of data during a health crisis. The CDC is expected to move from the prototyping phase to application deployment during 2018.

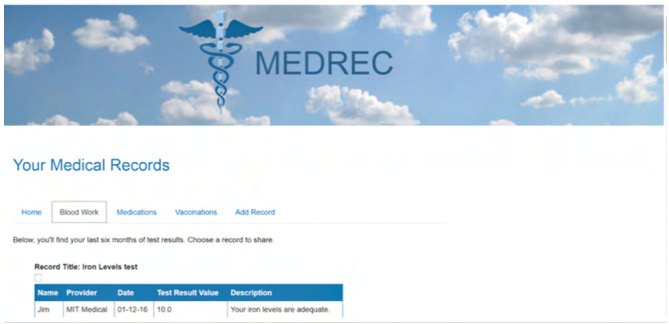


Figure 10: Revolutionizing medical records through a single source of truth; **Source:** MIT Media Lab

Other projects are building towards a vision of individual patients controlling their own healthcare data. All of a patient's data from each of their healthcare providers and pharmacies could be stored, and the patient could choose to share (or not share) this data with specific healthcare providers. A prototype system by **MIT Media Lab** called MedRec is getting close to realizing this vision with a blockchain-based system to keep track of each patient's medication.

[6] https://www.altoros.com/blog/a-close-look-at-everledger-how-blockchain-secures-luxury-goods/

2.4 Automotive and Manufacturing – Managing Physical Assets with Blockchain

Some of the excitement surrounding blockchain technology in the automotive and manufacturing industries is to do with its application in digital twins.

A digital twin is a dynamic, digital representation of a physical asset which enables companies to track its past, current and future performance throughout the asset's lifecycle. The asset, for example a vehicle or spare part, sends performance data and events directly to its digital twin, even as it moves from the hands of the manufacturer to the dealer and ultimately the new owner. Blockchain can be used to securely document everything related to the asset.

Figure 11: Documenting all aspects of a vehicle using blockchain; **Source:** Dassault Systèmes

Groupe Renault is experimenting with storing the digital twin of its vehicles on a blockchain-based system which would provide a single source of truth for each vehicle's maintenance data. In July 2017, the company released a prototype that was created in collaboration with **Microsoft** and **VISEO** – it uses blockchain to connect each new vehicle's maintenance events to the vehicle's digital twin. This data is fully traceable and visible to authorized parties such as the vehicle owner. As the digital twin is fully transferable on the blockchain-based system, each vehicle's maintenance history remains connected to the vehicle even when there is a change of vehicle ownership – a very useful and practical data management service that automotive companies can provide to their customers.

For a different reason, **Bosch** and a German certification authority, **TÜV Rheinland**, are also experimenting with digital twins of vehicles. These organizations aim to prevent illegal odometer manipulation. In Germany, one of Europe's largest used car markets, it is estimated that every third car has been subject to illegal odometer manipulation. The fraudulent increase in value per car is estimated to be USD $3,700 alone, which in Germany means almost $7.5 billion in fraud every year.[7]

Figure 12: Eliminating illegal odometer manipulation; **Source:** TÜV

To solve this challenge, the partners created a blockchain-based system with an in-car connector to regularly record the distances travelled by each vehicle which acts as an ongoing, tamper-evident record of odometer readings. Here, the recorded data on a distributed blockchain network makes it obvious if an odometer is manipulated. This use case shows how manufacturers can increase data credibility and protect public safety; it also has value for regulators, fleet owners and drivers who need access to trusted data on used vehicles.

In future, the entire automotive industry could collaborate on a single blockchain-based platform to store the digital twin of every vehicle, including important events and status updates. This would allow, for example, maintenance data and odometer readings to be stored together as a comprehensive record. Of course, to become reality this would necessitate industry-wide collaboration.

[7] https://www.adac.de/sp/rechtsservice/_mmm/pdf/2014-04-Rechtliche-Beurteilung-der-Tachomanipulation_199025.pdf

2.5 Energy – Eliminating Marketplace Inefficiencies

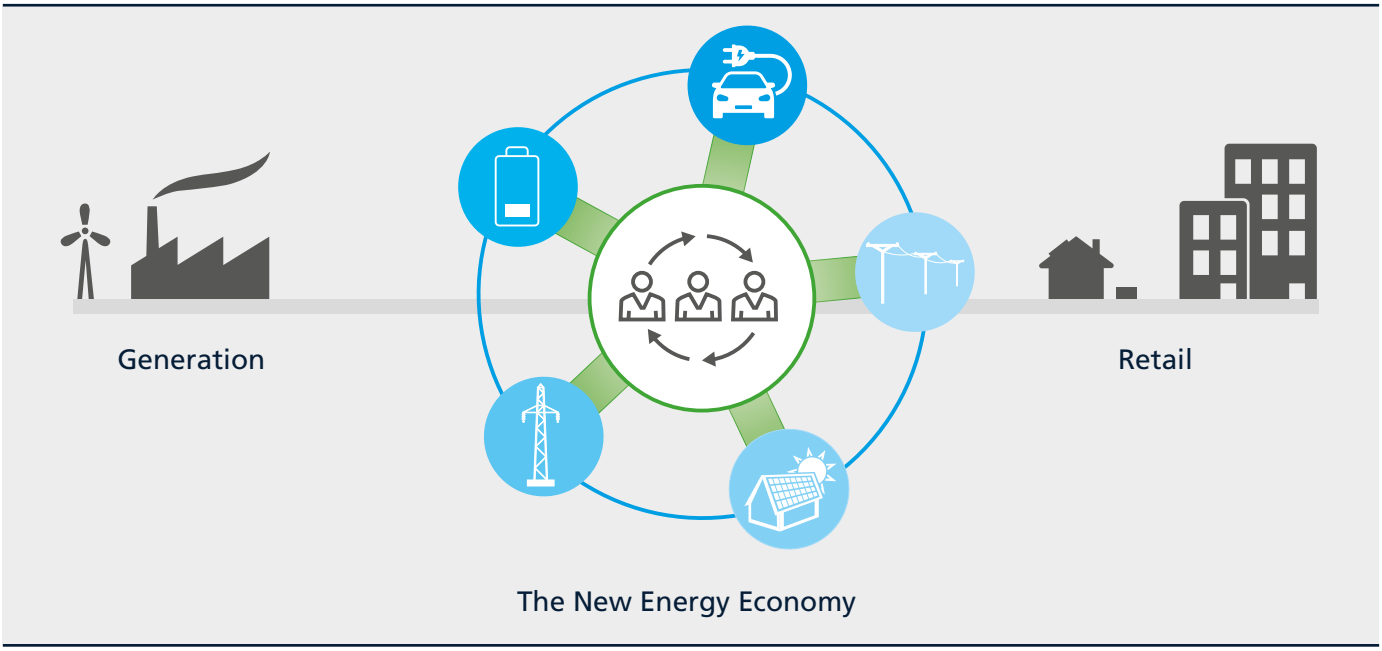


Figure 13: New energy marketplaces based on blockchain; **Source:** Power Ledger

The energy industry is likely to find many uses for blockchain technology. Transformational examples include enabling the operation of self-managing utility grids and facilitating peer-to-peer energy exchanges – individual households could sell surplus energy (self-generated by solar panels) to their neighbors. In addition, there are many near-term examples of process improvements that could help energy companies to run more efficiently and save money.

Power Ledger, an Australian startup, has created a local marketplace to sell surplus renewable energy through cryptocurrencies (see figure 13). The blockchain-based system enables the sale of surplus energy generated at residential and commercial developments connected to existing electricity distribution networks, or within microgrids. This empowers renewable energy asset owners to decide who they want to sell their surplus energy to and at what price, and allows for each unit of electricity to be securely tracked from the point of generation to the point of consumption.

From local to cross-border trading, **BP**, **Eni Trading & Shipping**, and **Wien Energie** completed a European energy trading pilot program in mid-2017 using a proprietary blockchain development platform from **BTL Group** in Canada. This pilot used blockchain technology to streamline cross-border trading and back-office processes such as confirmations, actualizations, invoice generation, settlement, auditing, reporting, and regulatory compliance across the energy trade lifecycle. BTL Group now aims to create a live, commercial version of an energy trading solution that will reveal significant cost savings applicable to numerous areas of the energy sector.

It's clear that companies in almost every industry are starting to unlock greater efficiencies and new business models using blockchain. They're doing so by leveraging many of the key capabilities of this technology including data transparency, security, asset management, and smart contracts – all of which can be widely used in logistics. The next chapter explores the ways in which blockchain technology is already benefitting the logistics industry and investigates how it could shape logistics in the near future.

3 BLOCKCHAIN IN LOGISTICS

3.1 Unlocking Value in Logistics

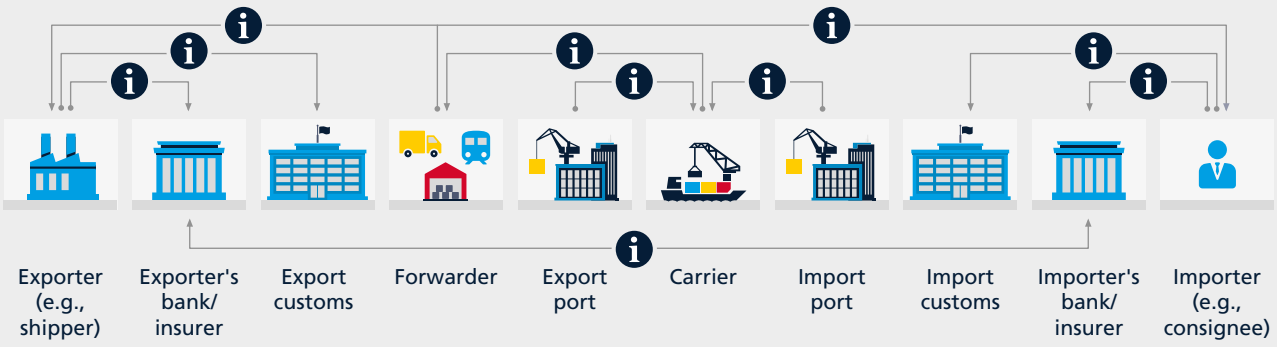


Figure 14: The information flow in international trade is complex, involves many parties, and is documentation heavy; **Source:** Accenture

Achieving excellence in logistics involves working collaboratively with others to optimize the flow of physical goods as well as the complex flow of information and financial transactions (see figure 14).

But today there is a significant amount of trapped value in logistics, largely stemming from the fragmented and competitive nature of the logistics industry. For example, in the US alone, it is estimated that there are over 500,000 individual trucking companies.[8] With such a huge number of stakeholders involved in the supply chain, this often creates low transparency, unstandardized processes, data silos and diverse levels of technology adoption.

Many parts of the logistics value chain are also bound to manual processes mandated by regulatory authorities. For example, companies must oftentimes rely on manual data entry and paper-based documentation to adhere to customs processes. All this makes it difficult to track the provenance of goods and the status of shipments as they move along the supply chain, causing friction in global trade. Blockchain can potentially help to overcome these frictions in logistics and realize substantial gains in logistics process efficiency. This technology can also enable data transparency and access among relevant supply chain stakeholders, creating a single source of truth. In addition, the trust that is required between stakeholders to share information is enhanced by the intrinsic security mechanisms of blockchain technology.

Furthermore, blockchain can achieve cost savings by powering leaner, more automated, and error-free processes. As well as adding visibility and predictability to logistics operations, it can accelerate the physical flow of goods. Provenance tracking of goods can enable responsible and sustainable supply chains at scale and help to tackle product counterfeiting. Additionally, blockchain-based solutions offer potential for new logistics services and more innovative business models.

This chapter explores some of the most prominent use cases for blockchain in the areas of global trade logistics, supply chain transparency and traceability, and commercial processes in logistics (see figure 15 on next page). The final part of this chapter outlines the key success factors for industry adoption of the technology.

[8] http://www.usspecial.com/how-many-trucking-companies-in-the-usa/

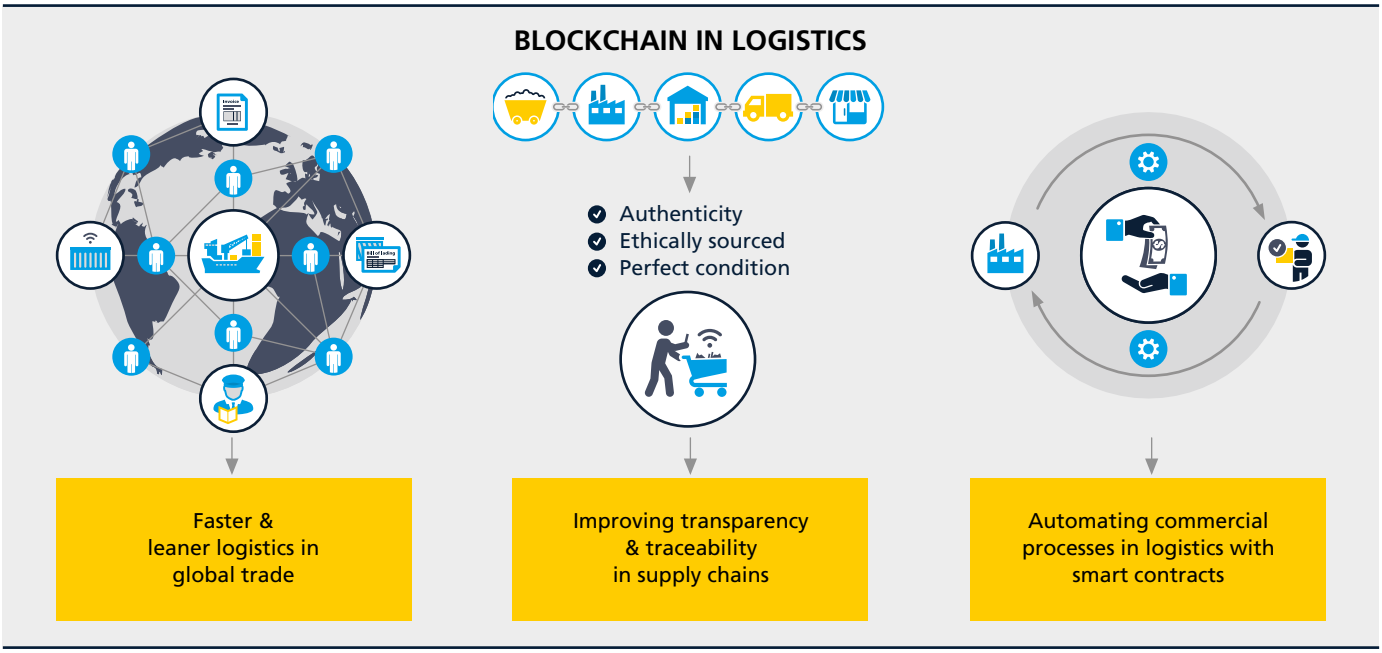


Figure 15: Key blockchain use cases in logistics; **Source:** DHL

3.2 Faster and Leaner Logistics in Global Trade

Figure 16: Blockchain can streamline the global movement of freight; **Source:** Maersk

Logistics is often considered the lifeblood of the modern world, with an estimated 90% of world trade carried out by the international shipping industry every year.[9] But the logistics behind global trade is highly complex as it involves many parties often with conflicting interests and priorities as well as the use of different systems to track shipments. Therefore, achieving new efficiencies in trade logistics is likely to have significant impact on the global economy. According to one estimate from the World Economic Forum, reducing supply chain barriers to trade could increase global gross domestic product (GDP) by nearly 5% and global trade by 15%.[10]

Blockchain technology can help alleviate many of the frictions in global trade logistics including procurement, transportation management, track and trace, customs collaboration, and trade finance.

With over 50,000 merchant ships[11] involved in the global shipping industry and multiple customs authorities regulating the passage of freight, a major area of focus for efficiency gains is ocean freight. Blockchain technology has huge potential to optimize the cost as well as time associated with trade documentation and administrative processing for ocean freight shipments. One example that highlights the complexities behind ocean freight today is the estimate that a simple shipment of refrigerated goods from East Africa to Europe can go through nearly 30 people and organizations, with more than 200 different interactions and communications among these parties.[12]

[9] http://www.ics-shipping.org/shipping-facts/shipping-and-world-trade
[10] http://www3.weforum.org/docs/WEF_SCT_EnablingTrade_Report_2013.pdf
[11] http://www.ics-shipping.org/shipping-facts/key-facts
[12] https://www-03.ibm.com/press/us/en/pressrelease/51712.wss

To unlock efficiency in ocean freight, **Maersk** and **IBM** have started a venture to establish a global blockchain-based system for digitizing trade workflows and end-to-end shipment tracking (see figure 17). The system allows each stakeholder in the supply chain to view the progress of goods through the supply chain, understanding where a container is in transit. Stakeholders can also see the status of customs documents, and can view bills of lading and other data. Blockchain technology ensures secure data exchange and a tamper-proof repository for this documentation.

The two companies expect this solution to track tens of millions of shipping containers annually. It has the potential to significantly reduce delays and fraud, which could lead to billions of dollars in savings in the logistics industry.[13]

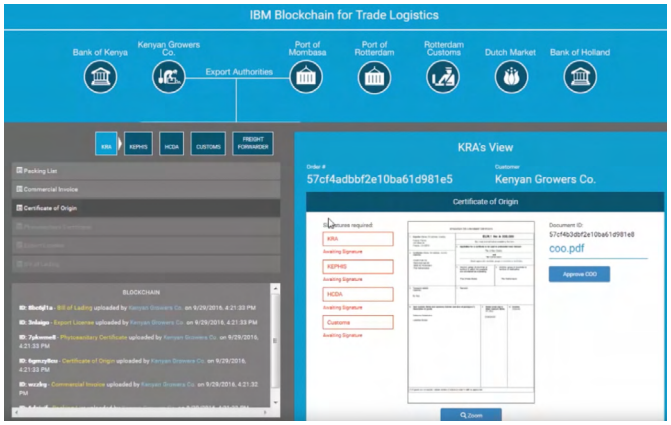


Figure 17: Digitalizing global trade logistics; **Source:** Maersk/IBM

Ocean carrier company **ZIM** has conducted a pilot to digitize the actual bill of lading, often hailed as a 'holy grail' application in logistics. The bill of lading is one of the most important documents in ocean shipping, and it acts as a receipt and a contract for the goods being shipped. The information stored on a bill of lading is critical as it contains all necessary details such as the shipment description, quantity and destination, as well as how the goods must be handled and billed. During the trial of a blockchain-based system developed by **Wave**, ZIM and pilot participants issued, transferred, and received original electronic documents successfully through the decentralized network.

The containers, shipped from China to Canada, were delivered to the importers (i.e., consignees) without a problem.[14] Although still in pilot phase, industry adoption of a digital bill of lading would be significant. It could greatly support supply chains in reducing costs, enabling error-free documentation and fast transfer of original documents.

Accenture is developing a blockchain-based system also focused on replacing the traditional bill of lading as well as facilitating a single source of truth for all supply chain stakeholders for freight inquiries up to issuance of trade documents. Here, a decentralized network connects all parties in the supply chain and enables direct communication, eliminating the need to go through central entities and rely on intermediaries. According to Adriana Diener, Global Freight & Logistics Lead at Accenture, the proven value of this project is surpassing expectations: "Using blockchain to replace the traditional bill of lading documentation to ship goods will drive millions of dollars in process efficiency and operational cost reduction benefits across the supply chain for multiple parties in the trade ecosystem including shippers, consignees, carriers, forwarders, ports, customs agencies, banks, and insurance companies".

3.3 Improving Transparency and Traceability in Supply Chains

Many projects are underway using blockchain technology to improve supply chain transparency and monitor provenance. These initiatives amass data about how goods are made, where they come from, and how they are managed; this information is stored in the blockchain-based system. This means that the data becomes permanent and easily shared, giving supply chain players more comprehensive track-and-trace capabilities than ever before. Companies can use this information to provide proof of legitimacy for products in pharmaceutical shipments, for example, and proof of authenticity for luxury goods. These initiatives also deliver consumer benefits – people can find out more about the products they are buying, for example, whether a product has been ethically sourced, is an original item, and has been preserved in the correct conditions.

[13] https://www-03.ibm.com/press/us/en/photo/51717.wss
[14] http://www.zim.com/newsandpress/recentnews/pages/zim-block-chain-technology.aspx

SPOTLIGHT: FIGHTING COUNTERFEIT PHARMACEUTICAL GOODS THROUGH BLOCKCHAIN

One key application is the use of blockchain technology to combat a major challenge in the world today: the counterfeiting of drugs and false medication. According to Interpol, around 1 million people each year die from counterfeit drugs[15], 50% of pharmaceutical products sold through rogue websites are considered fake, and up to 30% of pharmaceutical products sold in emerging markets are counterfeit.[16] To answer this challenge, **DHL** and **Accenture** are driving a blockchain-based serialization project providing sophisticated track-and-trace capabilities to the pharmaceutical industry (see figure 18).

Pharmaceutical serialization is the process of assigning a unique identity (e.g., a serial number) to each sealable unit, which is then linked to critical information about the product's origin, batch number, and expiration date. Serialization effectively enables a unit to be tracked at virtually any moment, and traced to its location at any stage of its lifecycle. A key serialization challenge is maintaining traceability and transparency especially when these units are repackaged or aggregated from unit to case to pallet for logistics purposes and then disaggregated back down to unit level for consumption.

The DHL/Accenture proof-of-concept was established to overcome this and other challenges by demonstrating the effectiveness of blockchain technology in product verification. The aim is to show that pharmaceutical products have come from legitimate manufacturers, are not counterfeit, and have been correctly handled throughout their journey from origin to consumer.

Most importantly, this initiative proves how end customers can verify the legitimacy and integrity of pharmaceutical products, especially compliance with handling requirements. This not only reassures the end customer at the point of purchase that their medicines are genuine and in perfect condition, but has potentially life-saving implications.

To achieve this, the partners have established a blockchain-based track-and-trace serialization prototype comprising a global network of nodes across six geographies. The system comprehensively documents each step that a pharmaceutical product takes on its way to the store shelf and eventually the consumer (see figure 19 on next page). The prototype was a lab performance simulation that demonstrated how blockchain technology could handle volumes of more than 7 billion unique pharmaceutical serial numbers and over 1,500 transactions per second.

The project illustrated how blockchain can be used to capture all logistics activities relating to an item of medication – from production to purchase – and ensure this information is made secure, transparent, and immediately available. "Our proof of concept demonstrated the opportunities blockchain presents in the fight against counterfeit pharmaceutical goods. Together with our partners we are actively refining the solution as well as working with key industry stakeholders to operationalize the concept" states Keith Turner, CIO Chief Development Office at DHL Supply Chain.

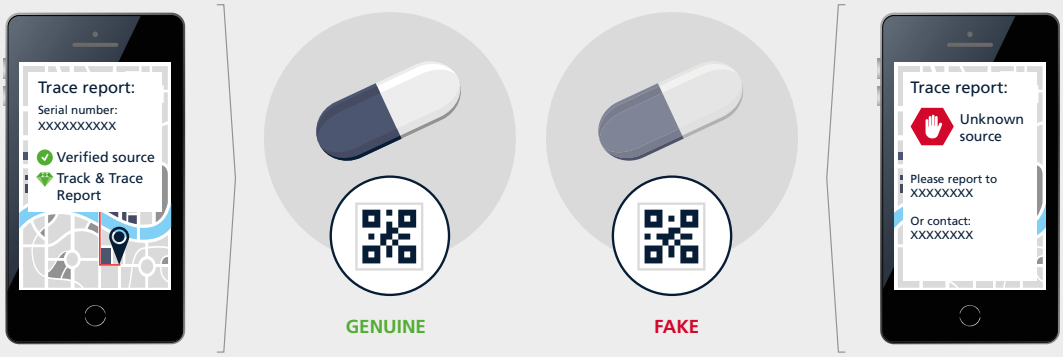


Figure 18: Blockchain can be used to ensure product integrity; **Source:** DHL

[15] http://www.who.int/mediacentre/news/releases/2006/pr69/en/
[16] https://www.insightcrime.org/news/brief/counterfeit-drugs-kill-1-million-annually-interpol/

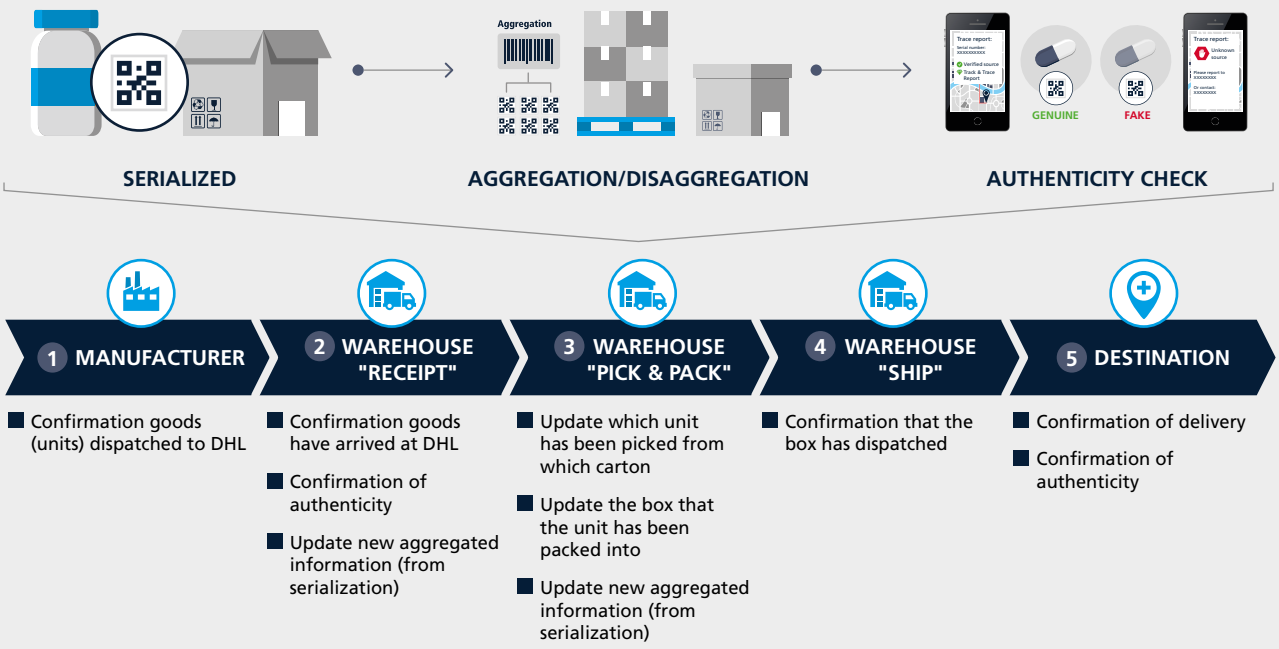


Figure 19: Simplified example of how a blockchain-based track-and-trace system can be used to monitor pharmaceutical goods from manufacturer to end user; **Source:** Accenture/DHL

In the consumer goods and retail industry, companies like **Unilever** and **Wal-Mart** are exploring the use of blockchain technology to improve supply chain transparency and to track provenance. Wal-Mart is focusing specifically on food tracking, traceability, and safety (see figure 20).

Together with partners, Wal-Mart has conducted a blockchain test designed to trace the origin and care of food products such as pork from China and mangoes from Mexico. To begin with, this initiative documented the producer of each specified food product so that Wal-Mart can easily address any case of contamination, should this arise. Secondly, the test put mechanisms in place to identify and rectify the improper care of food throughout the journey from farm to store. For example, since meat shipments must not rise above a certain temperature, the test took temperature data from sensors attached to the food products and committed this data to the blockchain-based system. From there, automated quality assurance processes notified relevant parties in the event of suboptimal transport conditions. Since launching this test, Wal-Mart has also announced the creation of a Blockchain Food Safety Alliance, an extensive partnership to apply tracking, traceability, and safety benefits to food supply chains in China.[17]

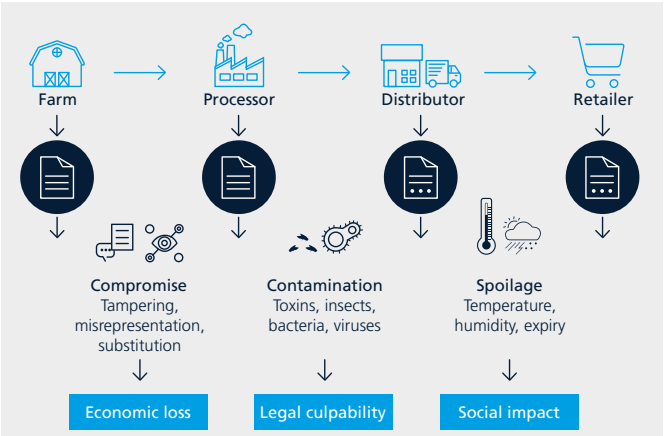


Figure 20: An example of using blockchain to increase safety and reveal product provenance in food supply chains; **Source:** IBM

Moving forward, a key requirement for track-and-trace applications will be to adopt more secure and intelligent forms of digital identity for each physical product – moving from the provision of a passive barcode or serial number to, for example, enabling interactivity with the use of Internet of Things (IoT) sensors. Smart devices can be securely tied to or embedded in the physical product to autonomously record and transmit data about item condition including temperature variation, to ensure product integrity, as well as any evidence of product tampering.

[17] https://www-03.ibm.com/press/us/en/pressrelease/53487.wss

3.4 Automating Commercial Processes in Logistics with Smart Contracts

Current industry estimates indicate that 10% of all freight invoices contain inaccurate data which leads to disputes as well as many other process inefficiencies in the logistics industry.[18] This problem is so prevalent that in the oil and energy industry alone, Accenture expects that at least 5% in annual freight spend could be reduced through improved invoice accuracy and reduction of overpayments.[19]

Blockchain has the significant potential to increase efficiency along the entire logistics and settlement process including trade finance and help to resolve disputes in the logistics industry. As digitized documents and real-time shipment data become embedded in blockchain-based systems, this information can be used to enable smart contracts (see figure 21). These contracts can automate commercial processes the moment that agreed conditions are met.

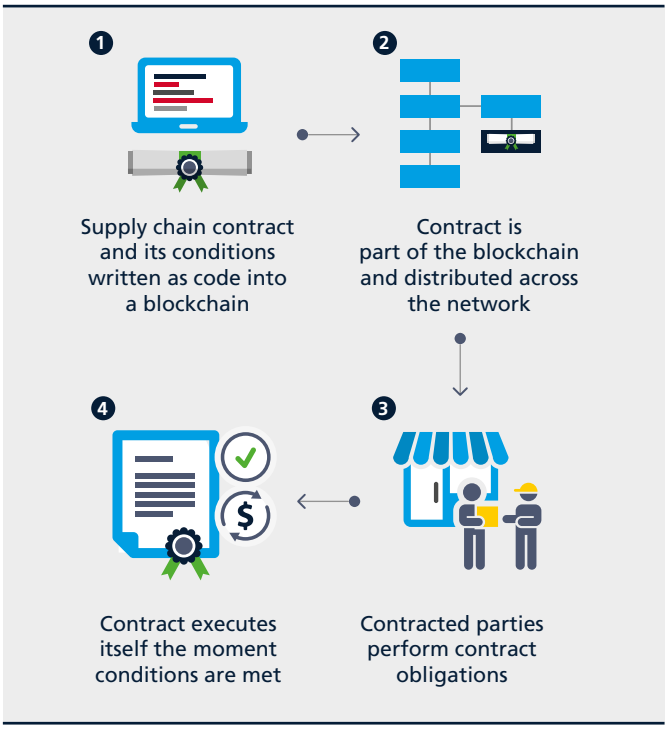


Figure 21: How smart contracts could work in the logistics industry; **Source:** DHL

One of the first startups to pursue such smart contract applications in the logistics industry is **ShipChain**. ShipChain is an early-stage company which has designed a comprehensive blockchain-based system to track and trace a product from the moment it leaves the factory to final delivery at the customer's doorstep. The system is designed to encompass all methods of freight and there are plans to include an open API architecture that can integrate with existing freight management software. All relevant supply chain information is recorded in an immutable blockchain-based database that can execute smart contracts once the conditions have been met (for example, as soon as the driver transmits confirmation of successful delivery). A key element to automating the settlement process is through ShipChain's digital currency called "SHIP tokens". Participants of ShipChain's platform purchase these tokens in order to pay for freight and settle transactions on the platform.

In this use case, blockchain in combination with the Internet of Things (IoT) in the logistics industry will enable even smarter logistics contracts in future. For example, on delivery a connected pallet will be able to automatically transmit confirmation and the time of delivery as well as the condition of the goods to the blockchain-based system. The system can then automatically verify the delivery, check whether the goods were delivered as per agreed conditions (e.g., temperature, humidity, tilt) and release correct payments to the appropriate parties, greatly increasing efficiency as well as integrity. Blockchain can further be used in the context of IoT to automate machine-to-machine payments (e.g., connected machines negotiating and executing price based on the logistics activities performed).

Another example of smart contracts in the logistics industry is the digitization of letters of credit (L/C) in order to accelerate the preparation and execution of a standard paper-based L/C – a process which currently tends to take from a few days to a few weeks.

[18] https://www.inttra.com/assets/documents/ced97146-272c-436e-8c54-131313915625.pdf
[19] https://www.accenture.com/us-en/blogs/blogs-blockchain-can-drive-saving

The **Bank of America Merrill Lynch (BofAML)**, **HSBC** and the **Infocomm Development Authority of Singapore (IDA)** have developed a prototype to bring the paper-intensive L/C process onto a blockchain. The system essentially enables the sharing of information between exporters, importers and their respective banks on a secure block-chain-based platform. This allows trade deals to be executed automatically through a series of digital smart contracts. In the trial, each of the four parties involved in an L/C transaction could visualize data in real time on a mobile tablet and see the next actions to be performed.

In a joint statement, the consortium partners state that the proof of concept shows potential to streamline the manual processing of import/export documentation, improve security by reducing errors, increase convenience for all parties through mobile interaction and make companies' working capital more predictable. The partners now plan to conduct further testing on the concept's commercial application with selected partners, such as companies and shippers.[20]

Startups are also working in this space with one example being **Libelli**. This company is developing a solution to essentially act as an escrow agent between any seller and any buyer to create a smart contract, bypassing the need for buyers and sellers to engage banks and eliminating the paperwork traditionally associated with L/C. The company aims to provide transparency to all stakeholders during the process, and claims that the automation of this commercial process reduces L/C time-to-execution down to a few minutes, with costs ten times lower than currently charged by banks.[21]

Other functions that could be automated include outsourced transportation management, normative compliance, route planning, delivery scheduling, fleet management, freight forwarding, and connectivity with business partners.

Figure 22: A digital letter of credit reduces time, cost and complexity in logistics; **Source:** Shutterstock

[20] http://www.about.hsbc.com.sg/-/media/singapore/en/press-releases/160810-blockchain-letter-of-credit.pdf
[21] www.libelli.com

3.5 Getting Started with Blockchain in Logistics

Once a company understands and recognizes the potential of blockchain technology to drive efficiency and value, the next step is to establish a roadmap for application. This should start from a willingness to collaborate, and involve building blockchain knowledge and capabilities with focus on driving value for all stakeholders. There are three main success factors for every blockchain initiative:

Success factor #1: Create a culture of collaboration

When a company agrees to work with blockchain technology, it is signing up for an intensely collaborative endeavor. This is because a huge part involves facilitating trusted collaboration between multiple parties including both public and private entities of all kinds – government agencies, industrial organizations, regulators, partners, and even competitors.

Taking the example of the highly competitive financial services industry, collaboration platforms have been created for competitors to work together researching the application of blockchain technology. Although competitor collaboration might seem counterintuitive, economies of scale impact the value of blockchain. When more parties agree to use a single blockchain solution, more value is created for each participating organization. That's why right now several blockchain consortia are emerging in the logistics industry.

Success factor #2: Build up blockchain knowledge and capabilities

Knowledge and capabilities enable organizations to identify and realize the value of new operating models. So it is essential to provide empowering partner organizations and individual contributors with the time, tools, and resources they need to successfully contribute to each blockchain project. These contributors must be able to liaise effectively within the blockchain ecosystem and with relevant technology players, implementation partners, and associations.

Success factor #3: Focus on value and engage with stakeholders on blockchain opportunities

By participating in blockchain-based prototypes, stakeholders are able to prove and understand the business value of a new initiative, as well as establish technical feasibility. It is important to set realistic expectations and acknowledge that blockchain technology remains in an early phase of the software maturity lifecycle. It has yet to be applied at scale. Realizing the full value of this technology depends on collaboration with the entire stakeholder ecosystem, and participants must be ready for this.

When identifying promising blockchain use cases, companies should scrutinize each idea to establish its dependency on blockchain technology. This process can be facilitated by the decision tree illustrated in figure 23.

SIMPLIFIED BLOCKCHAIN DECISION TREE

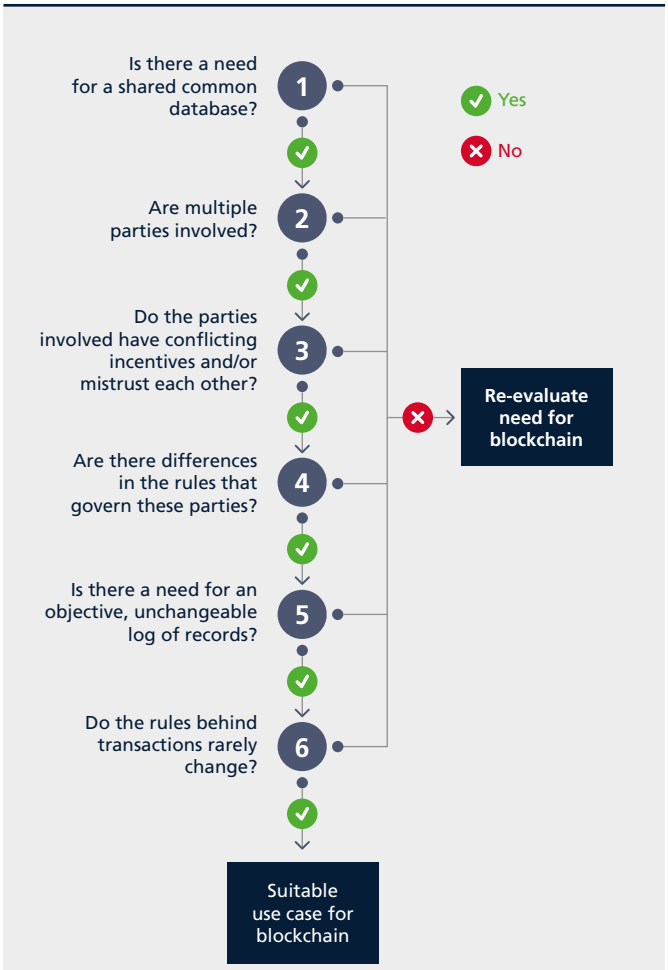


Figure 23: Simplified decision tree for identifying blockchain use cases; **Source:** Adapted from Verified ICOs

To get started with an idea and bring it to a scalable solution, companies can follow the steps shown in figure 24. The design-and-plan phase builds toward a prototype for the proof of concept. During the proof-of-concept phase, stakeholders should learn all the nuances of using blockchain technology in the proposed application. In the pilot phase, stakeholders should test the application on a small scale while completing a high-level assessment of roll out at scale. It is imperative to include all stakeholders in this pilot phase so this step involves a shift of perspective – from achieving success with an internal solution to now onboarding multiple parties and testing the solution across a network.

The final stage in a blockchain implementation involves scaling the solution and realizing comprehensive benefits. This requires a significant transformation of business processes across not just internal parties but also multiple stakeholders, including business partners and even competitors. Therefore, solution success depends heavily on stakeholder uptake and acceptance. The success of the project hinges on everyone adjusting their business practices and full leveraging the blockchain implementation. Stakeholder participation is arguably the most critical success factor in blockchain adoption.

GETTING STARTED WITH BLOCKCHAIN

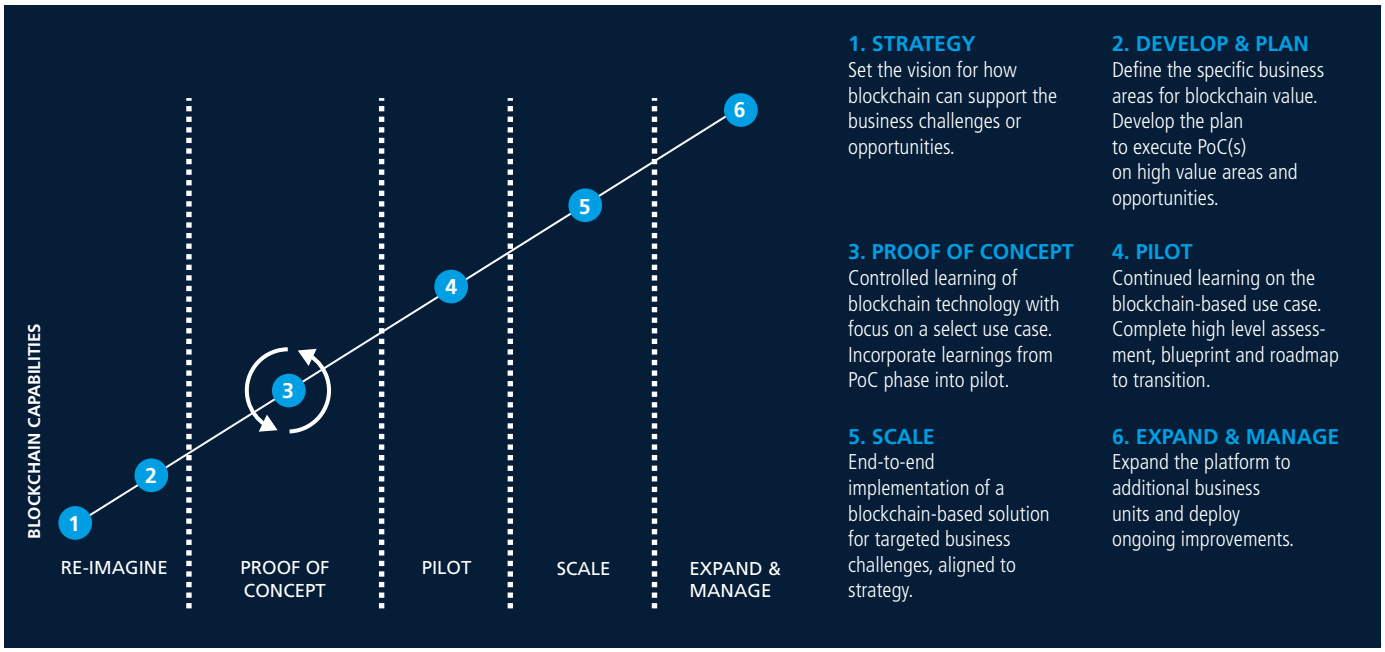


Figure 24: The steps for a blockchain implementation; **Source:** Accenture

CONCLUSION AND OUTLOOK

Blockchain technology is emerging from its first deployments in cryptocurrency and is now likely to have significant impact across almost all industries. Like a pebble dropped into a lake, the ripples from this technology are beginning to expand outwards in all directions including the logistics industry, where blockchain promises to make business processes more efficient and facilitate innovative new services and business models.

Already many projects are underway to apply blockchain technology to global logistics, adding value by boosting supply chain transparency and automating administrative operations. In future we can anticipate blockchain technology will intersect with other innovations to amplify impact. Imagine how the physical flow of goods can be more effectively orchestrated and synced with information and financial flows when blockchain is combined with the IoT, artificial intelligence, robotics and more.

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.

Despite all the hype surrounding blockchain today, we believe that the logistics industry needs to leverage new technologies and embrace ways of rethinking old processes in the digital era. While there are still many challenges to overcome, we invite you to explore with us the opportunities that blockchain presents. By joining forces, we can create the right foundations for successful industry adoption of blockchain and we can ultimately unlock new value in logistics.

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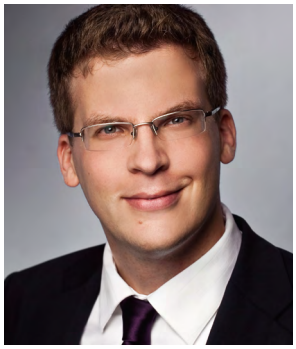

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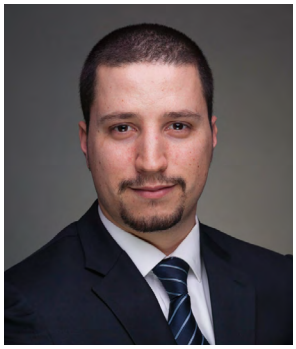

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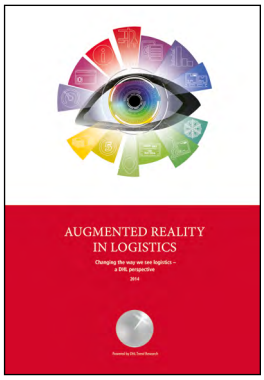

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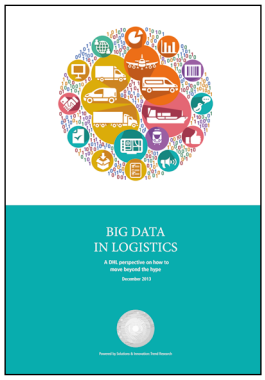

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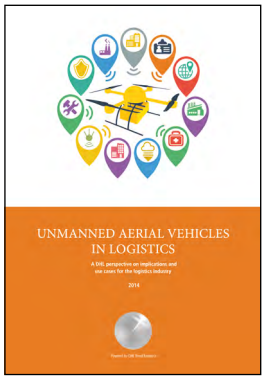

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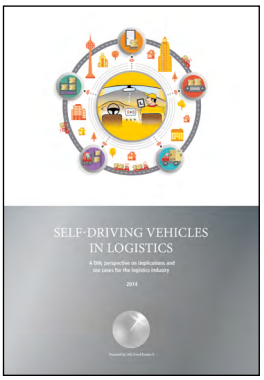

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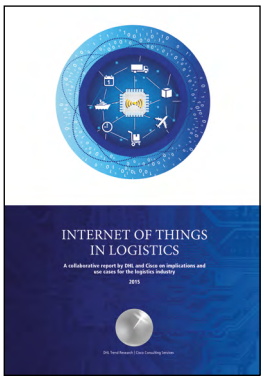
INTERNET OF THINGS IN LOGISTICS



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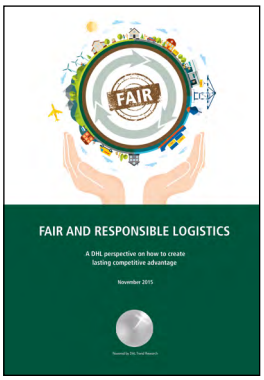
FAIR AND RESPONSIBLE LOGISTICS



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OMNI-CHANNEL LOGISTICS

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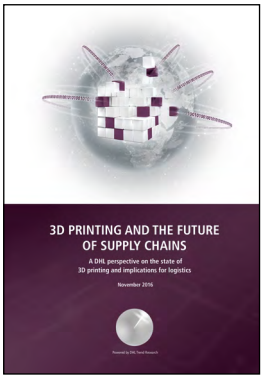
ROBOTICS IN LOGISTICS

www.dhl.com/robots

3D PRINTING AND THE FUTURE OF SUPPLY CHAINS



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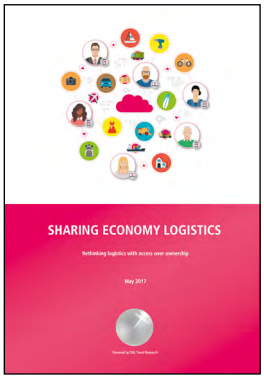
SHARING ECONOMY LOGISTICS



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FOR MORE INFORMATION

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