



PRODUCT TRACKING AND TRACING WITH IOT AND BLOCKCHAIN

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Abstract

There is a pressing need for product tracking and tracing owing to globalized supply chains, diverse suppliers, risk of counterfeit products, and customer demand for in-depth visibility. This article discusses the limitations of existing track-and-trace technologies. It then examines how combining IoT and blockchain provides a mature way to digitally track and trace products by fully integrating supply chain applications with core ERP applications. The paper emphasizes how the combination of blockchain and IoT can integrate with backbone ERP and other systems, and shows how Infosys helps companies adopt business cases to solve these problems.

The Current State of Track and Trace

a) Background

In today's globalized economy, supply chains in every industry are expansive and complex. Products are designed by teams in one or more locations, manufactured at other locations, stored elsewhere, and sold everywhere. Goods and components pass through various countries, warehouses, weather conditions, handling methods, and storage situations before final products reach end consumers. The worldwide logistics industry accounted for 6% of GDP in 2017, or nearly \$4.8 trillion USD, according to Plunkett Research—which highlights its enormity and importance.

The use of high-tech materials and electronic components in modern products makes it essential to monitor the physical, climatic condition of manufacturing, and storage during transit and warehousing. For example, a paper published in the journal *Nature* showed that lithium ion batteries degrade faster when stored above room temperature (35°C). Such factors play an important role in the longevity and performance of products and, ultimately, in customer satisfaction. It is therefore vital that physical and operational factors affecting product performance and lifespan are identified and measured at every step in the supply chain. This is particularly significant for products that can have an immediate impact on human health, such as packaged foods, baby products, produce, medicines, meat, and medical devices.

b) Current track-and-trace solutions

Some companies provide track-and-trace solutions by using technologies such as data interfaces, electronic data interchange (EDI), B2B messaging and reports, bar codes, QR code, radio-



frequency identification (RFID), near-field communication (NFC), and global positioning system (GPS) devices. Such solutions often use a warehouse management system and RFID tags to ensure product traceability.

These tools have limited capabilities, including:

- They tend to be limited to logistics activities, such as identifying locations
- Some data is captured in nondigital formats, with no single authority to verify data integrity or accuracy
- Support for secure, multiparty information sharing is lacking

Most importantly, these tools fall short of providing the real-time, end-to-end visibility and transparency needed for all members of the supply chain during a product recall. Swiftly identifying and recalling products is critical to minimizing negative consequences, and without

visibility across a “system of systems,” conducting root cause and impact analyses becomes labor-intensive and error-prone.

Real-time visibility and transparency can be achieved in supply chains only through an integrated, end-to-end solution powered by the Internet of Things (IoT) and blockchain technology—a solution that gathers granular data at all stages of the supply chain and makes it accessible at any time to all supply chain members. Only then can track and trace be conducted quickly, efficiently, and accurately to adequately protect consumers and organizations.

c) Business challenges

Clearly, single integrated source data, the ability to track, trace, and verify products is fundamental as counterfeit products and contamination plague the marketplace. An integrated track-and-trace solution not only ensures supply chain efficiency, product safety, and sustained brand value,

but it also saves cost, time, and effort while helping companies adhere to regulatory requirements.

In industries where product safety is of the utmost importance, increasingly complex supply chains pose challenges for executing track and trace, despite regulatory efforts to ensure consumer safety.

i) Pharma supply chain

The Facts: Pharmaceutical Supply Chain

- 1 million people die every year from counterfeit drugs (WHO)
- 25% of vaccines reach their destination in a degraded condition due to incorrect shipping (AJOT)
- 20% of temperature-sensitive products are damaged during transport (AJOT)
- 30% of scrapped pharmaceuticals can be attributed to logistics issues alone (AJOT)

(Sources: World Health Organization, AJOT)

These numbers indicate that pharmaceutical supply chain safety is often measured only after the damage is done. To address counterfeiting, contamination, and degradation, the US Food and Drug Administration (FDA) in 2017 issued the Drug Supply Chain and Security Act (DSCSA), which outlines the steps manufacturers, distributors, dispensers (i.e., pharmacies), and third-party logistics providers must take to develop an electronic and interoperable system that tracks drugs at the unit-level throughout the drug supply chain. DSCSA further mandated serialization at the product and package levels for enhanced tracing.

ii) Food supply chain

The Facts: Food Supply Chain

- 48 million people in US become ill every year because of foodborne diseases
- More than 128,000 people in US are hospitalized every year due to foodborne diseases
- More than 3,000 people die every year in the US from foodborne diseases

(Source: Centers for Disease Control and Prevention)

This is an alarming public health burden—and one that is largely preventable. The FDA Food Safety Modernization Act (FSMA), introduced in 2011, aims to ensure food safety through prevention, inspection, compliance, and enhanced product tracing abilities—which includes tracking raw materials, ingredients, and packaging materials.

Producers, manufacturers, distributors, and retailers share responsibility for ensuring that only safe, authentic food reaches the end-consumer. However, as the number of parties involved in farm-to-fork provenance grows, so does the complexity of the supply chain—which can degrade supply chain transparency and make shared responsibility more difficult to enforce.

iii) Medical devices supply chain

The Facts: Medical Devices Supply Chain

- More than 201 million class I units were recalled in the first three quarters of 2018
- 21% of medical device recalls are due to software issues—the top cause of recalls for the past 3 years
- 51% of medical device recalls were nationwide in the third quarter of 2018

(Source: Stericycle Recall Index, Q3 2018)

Product recalls for medical devices and drugs are extremely complex because they often are sold across geographies. Tracing the product back from individual customers is time-consuming and expensive, and also is prone to errors—which poses a serious liability.

iv) Logistics management

The Facts: Logistics Management

- About 49.3 million tons of freight moved through the US transportation system each day in 2015 *(Bureau of Transportation Statistics)*
- About 71% of US freight (by weight) is moved by truck *(American Trucking Association)*
- 20 million shipping containers exist worldwide, making approximately 200 million trips a year *(BillieBox)*

The real time information of storage location, condition of storage, duration of storage, ownership, transit time statuses are key information specially when a product malfunctions. However, most logistics companies are unable to provide such granular visibility of product in transit when requested, due to unavailability of data. This poses additional challenges for manufacturers who lack such insights when undertaking root-cause analysis and trying to identify the cause and location of damage.

Moreover, last-mile information generally resides with logistics providers. This is critical information for all supply chain members as they contact customers and facilitate replacements or returns.

v) Manufacturing operations

The Facts: Manufacturing Operations

Each year, the automotive industry loses USD billions of dollars globally. Example in 2011 it is estimated \$b 12~45 billion globally is lost to counterfeit auto parts (Automotive Logistics, Global Banking)

10% of medical products and medicines are counterfeit and life-threatening (NPR)

By 2022, the total value of counterfeit goods in the world will be approximately USD \$1.9 trillion to 2.8 trillion.

(Frontier Economics, NPR, Automotivelogistics, Global Banking)

Manufacturers need effective product traceability to protect their reputations, maintain customer loyalty, streamline distribution, and minimize cost. It is also important for product recall and compliance. The use of product identification codes such as Global Trade Item Number (GTIN), International Article Number (EAN), or Universal Product Code (UPC) by manufacturers was the first step toward enabling product traceability.

In today's fast-changing business environment, manufacturing companies need more powerful technology to succeed. This is especially important because manufacturers are beginning to shift from merely selling products to using subscription-based models, and they need performance data on their user base to support the subscription model. While many companies are making efforts to leverage alerts, preventive maintenance, and reports, they continue to struggle due to a lack of transparency and real-time information availability.

d) A shifting approach to track and trace

The current state of track and trace has left organizations across industries struggling

with a lack of real-time capabilities, a lack of tamper-proof data, and data in nondigital formats. These limitations cost businesses billions of dollars.

As a result, there is a renewed focus on shifting away from time-consuming, report-based approaches to reliable mechanisms that enable real time transparent data-sharing among supply chain stakeholders.

The Current State of Track and Trace

a) A new paradigm for supply chain management: IoT and Blockchain

The combination of IoT and blockchain provides a powerful mechanism to gather, store, and share data with all supply chain partners—reliably and in real time.

IoT systems use open standards-based, connected sensors/devices to capture data automatically, without human intervention. In supply chains, IoT-connected sensors can help determine and verify the source of component materials and their regulatory compliance. In manufacturing lines, sensors can capture production metrics to monitor and record process quality and deviations. Sensors embedded in transported goods can monitor items and alert supply chain members to issues such as temperature deviations or product damage. At every stage of the supply chain, IoT-connected sensors provide data that paints a full picture of a product from raw materials to final delivery—and with sufficient granularity to conduct root-cause analyses, determine liability in case of an incident, and gain any number or type of insight. Better still, all data is digital and in real time—providing rich data for efficient, specific, and accurate track and trace capabilities.

When IoT data feeds into a blockchain, the data can be shared within a peer-to-peer network, distributed ledger or a cloud-based database. Each member

of a supply chain—including producers, suppliers, processors, distributors, and retailers—is a node in the blockchain network and can access all data within the blockchain at any time. The data feeds in continuously, and is validated, immutable, and secure. Smart contracts—self-executing scripts residing within the blockchain—integrate members and allow for proper, distributed, heavily automated workflows for information sharing, which mitigates trust issues arising from the absence of a third-party intermediary. This provides a fully transparent, single source of truth about the provenance of materials, production history, condition of items in transit (including temperature and location deviations), changes of custody and ownership, and last-mile delivery information—all in real time.

With the transparency of integrated IoT, blockchain, and supply chain management systems, enabled by the cloud, track and trace can be conducted digitally and in real time, with full visibility for all supply chain members.

Oracle's enterprise-grade platform offers mission-critical IoT applications for enterprise assets, production lines, transportation fleets, and mobile workers. These applications securely connect devices, analyze real-time and historical data, and integrate with back-end applications. With such capabilities, companies can extend their supply chain, ERP systems, and CX applications to the physical world and enable automation powered by intelligent, predictive algorithms. Oracle provides out-of-box agents that can be installed on any device or IoT gateway. These agents then connect physical devices with Oracle IoT Cloud Services using a secure communication mechanism. Oracle IoT Cloud also provides RESTful APIs, allowing information and operation professionals to build vertical-specific IoT solutions and integrate disparate enterprise IT systems.

Oracle Blockchain Cloud Service offers preconfigured blockchain code to optimize standard business processes, including ERP transactions. The enterprise-grade service leverages out-of-the-box validations that traditionally require third-party validation. As an Oracle-managed cloud platform, it is backed by 99.95% SLA availability with an in-built, highly available configuration, autonomous recovery agents, and continuous ledger back-up capabilities for multi-datacenter disaster recovery across availability domains. Oracle's blockchain platform integrates all underlying infrastructure dependencies, container lifecycle management, event services, identity management, REST proxy, and a number of operations and monitoring tools under a single console, thereby expediting the set-up and application development process. Figure 1 provides an overview of the Oracle blockchain architecture and how it interacts with Oracle Blockchain as a Service (BaaS), SaaS, PaaS, and on-premises ERP products

Oracle's blockchain solution with IoT is designed to meet the requirements of the pharmaceuticals industry, food suppliers, medical device makers, industrial manufacturers, and logistics service providers. Once information is securely shared with the other nodes/interested parties according to the smart contracts, actions can be initiated based on information that is accurate and indelible. Such a network is applicable across companies, ERPs (or any other system), and geographies

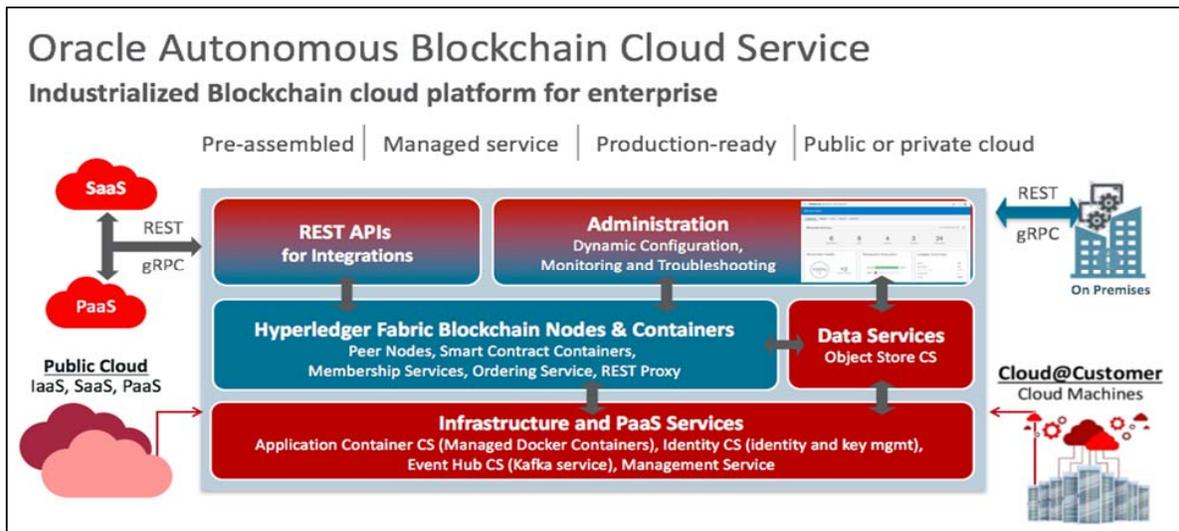


Fig 1: Overview of Oracle Blockchain Platform architecture (source Oracle [14])

Blockchain promotes trust between organizations by providing independent validation through a tamper-

resistant, peer-distributed ledger that eliminates the need for manual reconciliation or reports. It securely transfers and centrally shares

information with its members. Hosted on cloud, it is a managed platform and part of Oracle's innovative cloud application portfolio.

b) Mechanism of interaction – Blockchain and IoT for supply chains

The Oracle blockchain solution with IoT is designed to meet the requirements of the medical device manufacturing fraternity, industrial manufacturers, pharma supply chains, and logistics service providers. Blockchain and IOT offers new ways to automate business processes among your partners without setting up a complex and expensive centralized IT infrastructure. IOT and Blockchain combination is a new landscape that allows digital capture of data in different supply chain entities and share to a centralized ledger or any database on cloud. In this powerful combination, IoT tracks, monitors and transmits real-time data about an incident into a blockchain node.

This information is securely shared with the other nodes/interested parties according to the smart contracts. Then, actions can be initiated by the interested party

based on information that is accurate and indelible. Such a network is applicable across companies, ERPs (or any other system) and geographies.

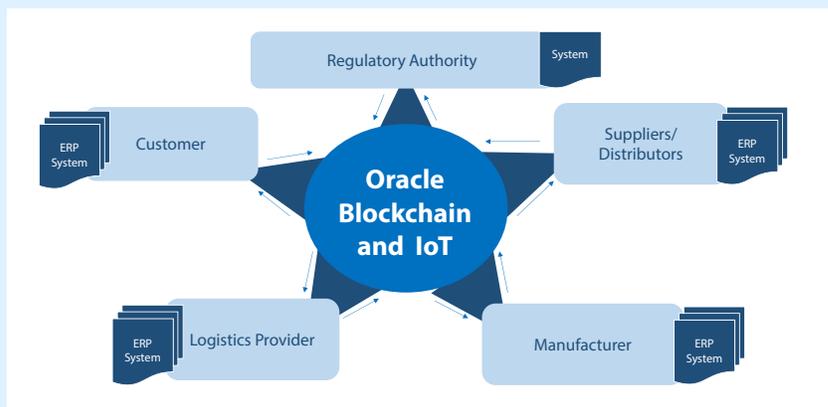


Fig 2: How Oracle blockchain and IoT can be central to all supply chain stakeholders (Source: Authors)

Generally, permissioned blockchains are the most suitable for such purposes. From a supply chain perspective, using permissioned blockchains raises three main considerations namely:

- Capturing supply chain events and passing these to the blockchain. Such events include functions like order booking, order shipping, ownership changes, etc.
- Capturing information from sensors and transmitting it to the blockchain ledger

(IoT function). This information includes storage conditions, weather conditions and any physical parameter that is relevant to the product or supply chain

- Storing information on the blockchain to be used when required and executing smart contracts based on this information

Smart contracts play a key role in the aligning stakeholders, permitting transactions and driving protocols. The information captured as a part of a supply

chain event or sensor data is contained in a block in the blockchain, which is copied to all participating nodes. The mechanism of interaction involves capturing and using supply chain information from various stakeholders for the benefit of the end customer and to improve product performance. Oracle Blockchain has features like 'channels' that help maintain confidentiality of transactions. At every stage of the supply chain process, information (event data or sensor data) is passed to the blockchain.

c) Putting IoT and blockchain to work together: A use case

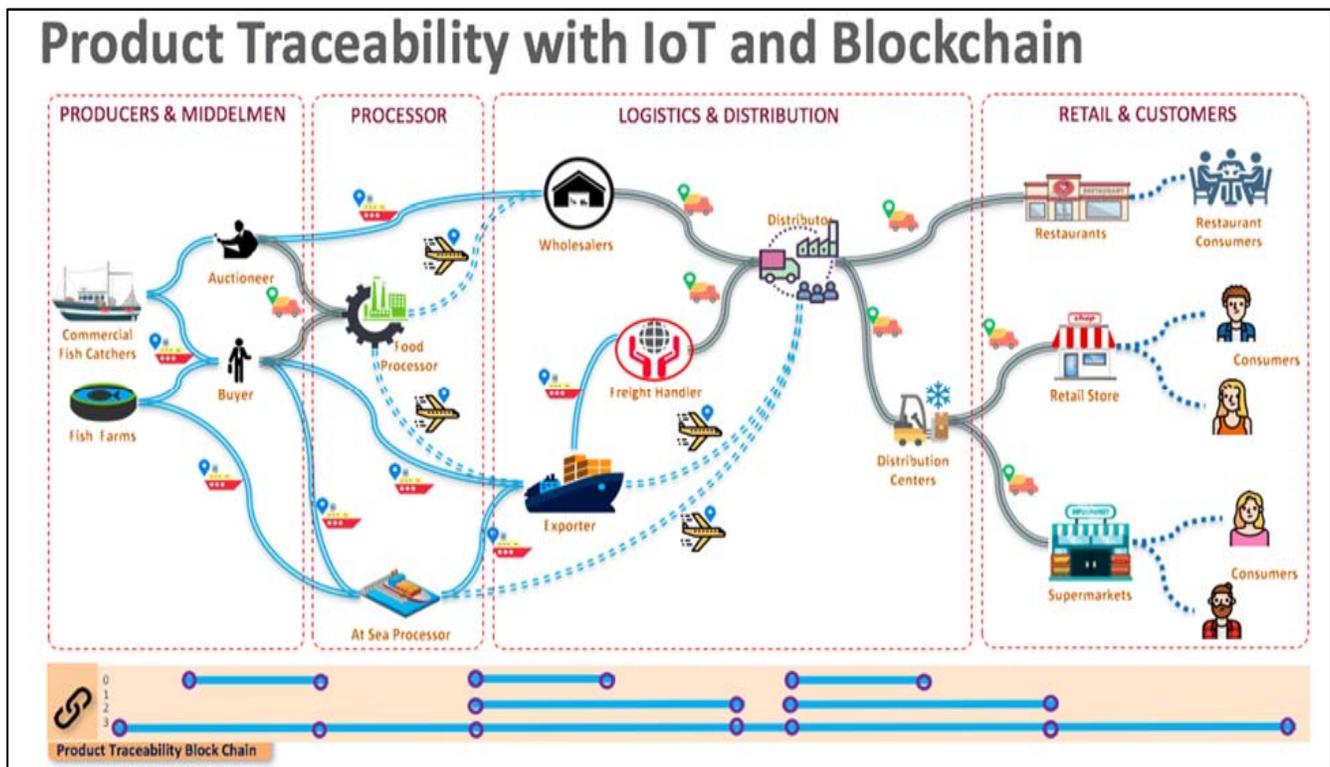


Figure 3 Food tracing and tracking using IoT and blockchain (Source: Oracle)

Figure 3 depicts how IoT and blockchain can be used to create a track-and-trace mechanism for the food industry—in this case, for fish distribution through a temperature-controlled supply chain. IoT

systems capture data right from the time the fish is caught through when it is served to customers. The data captured using IoT continuously feeds real-time and immutable data about

all transactions across the supply chain and into the blockchain network. Every node in the blockchain network can access this information at the click of a button.

Infosys: Expertise in Designing Integrated IoT and Blockchain Solutions

Infosys provides a suite of offerings to help clients adopt and integrate IoT and

blockchain networks for greater value realization. It leverages proven expertise in other technology areas such as analytics and cloud to complement blockchain solutions, thereby amplifying its value. Infosys offers Blockchain-Incubation-as-a-Service, which

uses a Design Thinking-led assessment to identify use cases, assess technologies, and enable rapid prototyping. This approach ensures constant collaboration with clients during their blockchain adoption journeys. Figure 4 depicts.

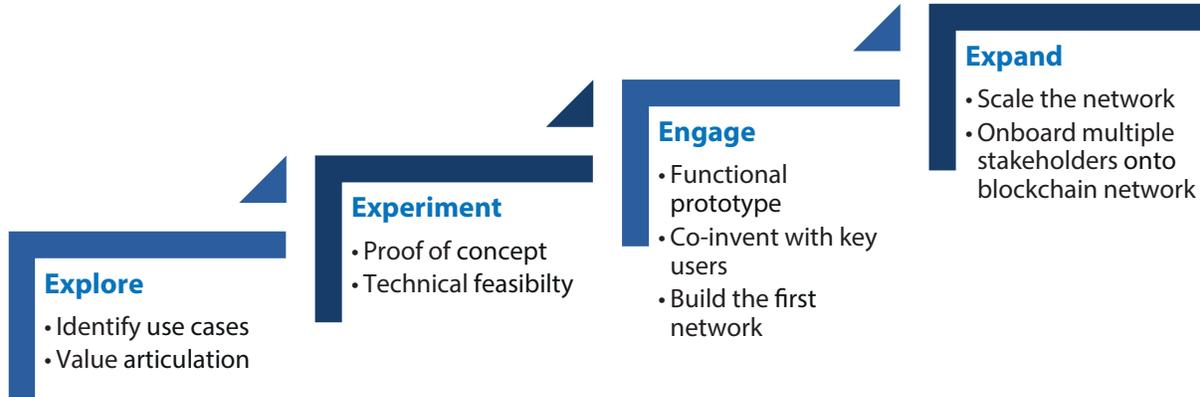


Figure 4: Infosys Blockchain Incubation-as-a-Service approach (Source: Infosys/ Authors)

Infosys blockchain services includes technology advisory, consulting, development, integration, and testing services. Infosys offers industry-specific business case development for adopting blockchain along with relevant solutions for integrating blockchain with enterprise applications like Oracle ERP Cloud. Our Blockchain Assessment Framework analyzes the need for blockchain and

ideates and prototypes the right solutions.

Infosys offers easily deployable solutions for enterprises that gather data from sensors to provide actionable business insights as a part of IoT solutions. Infosys enables customers with IoT by leveraging

the Industrie 4.0 Maturity Index. As a pioneering expert in this field, Infosys defines and implements optimal Industrial

Internet of Things (IIoT) roadmaps; builds smart, connected products that helps customer create new revenue streams; and creates new vertical industry solutions and platforms that harness the power of machine learning and advanced analytics to help customers become more efficient and competitive. The offerings in the area of IoT are integrated to deliver and manage solutions.

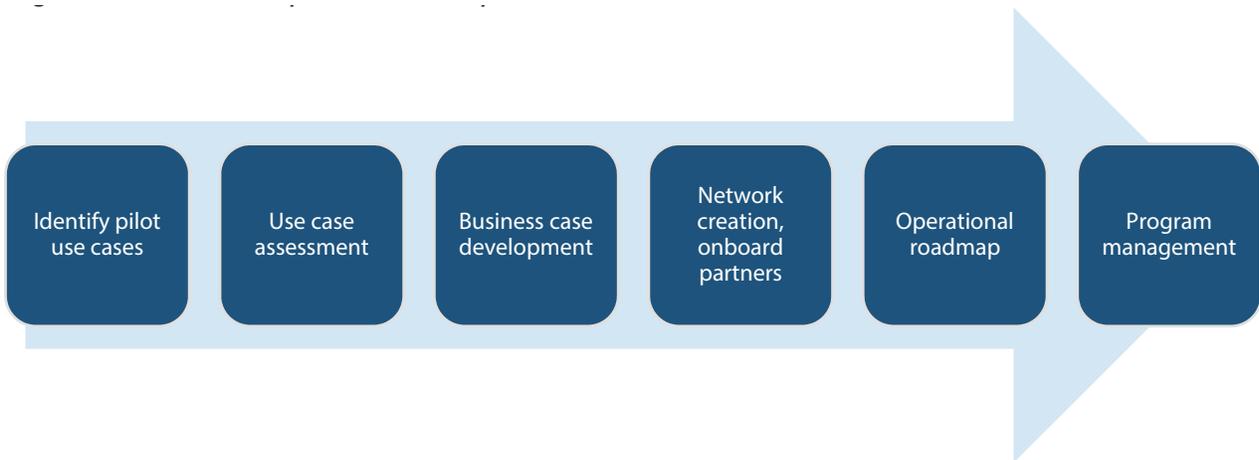


Figure 5: Blockchain implementation process (Source: Infosys/ Author)

Conclusion

From a system perspective, the combination of blockchain and the Internet of Things is both reliable and impregnable while being comprehensive enough to accommodate all supply chain needs. It offers a mature track and trace technical solution to improve compliance and assist with other tasks such as product recalls, returns, etc. More importantly, it simplifies the process of searching for, acquiring, and gathering data

across complex supply chains by using a distributed yet centralized system. The use cases and capabilities of these powerful technologies underscore the value of digital adoption in improving tracing and tracking.

Best-of-breed track and trace solutions can help manufacturers and suppliers improve preventive maintenance, root cause analysis, service levels, and product performance, thereby enhancing customer satisfaction and cementing customer loyalty



About the author



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Dr. Arnab focuses in bringing business and technology together through his researches, solutions and publications. He has more than 17 years of experience in consulting, business and product development in the domain of Manufacturing, Hi-tech and Distribution. Currently, he is a Principal Consultant and consults in the Supply chain area for Enterprise Management and Blockchain. His research interests include information technology and blockchain applications in supply chain management. He has extensive publications in the area of reverse supply chain, lean/agile/leagile initiatives, theory of constraints, supply chain transformations and humanitarian logistics.



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Murali Venkatesh has worked with strategic Big-5 management consulting, led consulting practice, and product development for various sectors such as Financial, Hi-Tech, Energy and Supply Chain over 25 years. He is a Director of Emerging Technologies, designing future use cases where customers can take advantage for Oracle products (ERP, SCM, HCM, etc.) integrated with latest technologies such as Artificial Intelligence, Machine Learning, Blockchain, Chat Bots, and Internet of Things. He helps guide customers and partners around the world in applying these emerging technologies to a broad range of business challenges, supporting discovery and sharing best practices, deployment models, and integration architecture to facilitate rapid experimentation and production-ready results.

Additional Resources

Oracle IoT Cloud Service

1. <https://www.oracle.com/solutions/internet-of-things/>
2. <https://cloud.oracle.com/IOT-apps>
3. <https://www.infosys.com/engineering-services/service-offerings/internet-of-things/>

Oracle Blockchain Cloud Service

1. <https://www.oracle.com/cloud/blockchain/>
2. https://cloud.oracle.com/en_US/blockchain
3. <https://www.infosys.com/blockchain/#block-chain/3>

For further discussion on getting started with this solution and process methodology, please contact oracle_mktg@infosys.com or arnab_banerjee08@infosys.com

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