Smarter end-to-end supply chains

Combining blockchain and NFC/RFID technologies

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The internationalization of flows has brought about more complexity in business management. Supply chains are now managed at a global scale, take outsourcing strategies into account and integrate wide product portfolios.

With more internal or external suppliers, and more products and raw materials coming from different locations, it is critical to build a smarter end-to-end system, more instrumented, interconnected and intelligent in order to identify, capture and share accurate product information at any stage of the product lifecycle.

Pairing blockchain technology with RFID/NFC solutions is a means of eliminating supply chain complexity and the inherent risks, making flows more transparent, more secure and automating administrative operations thanks to smart contracts. NFC technology indeed offers safe connection to data about the product's origin, certifications, and journey through the supply chain. This provides key benefits for all stakeholders from suppliers, to partners to customers. STMicroelectronics is one of the early pioneers of NFC/RFID technologies and has developed turnkey solutions using the ST25TV Type 5 NFC Tag ICs to address today's challenges in logistics management.

PROBLEM STATEMENT

Supply chain management complexity

Supply chains are at the core of business management and involve many parties. Indeed, a supply chain is a system of organizations, people, activities, information, and resources working together to create and move a product or service from supplier to customer. Natural resources, raw materials and components are transformed into a finished good during the process, and delivered to the end-customer.

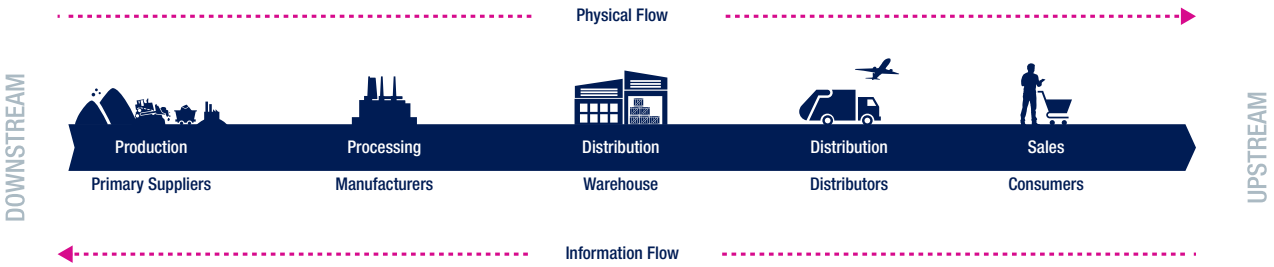


Figure 1 : Supply chain flows

Supply chain structures are often not linear, are integrated between various companies and require collaboration between them. Supply chain integration is a key factor of business performance and is therefore a major concern for firms.

Indeed, international supply chain management raises a certain number of concerns, among which:

- The challenges inherent to globalization and its drifts
- Cost containment and its fast-paced approach
- Risk reduction and its long-term performance

Figure 2 : supply chain concerns

Globalization and its drifts: individual product item tracking

Counterfeit products are introduced to the market from both unauthorized and authorized manufacturing sources because globalization and complex channels have lengthened the supply chain. Every step of the supply chain provides another opportunity for counterfeiters. The risk of purchasing counterfeit products on e-commerce platforms is clearly increasing: this is the so-called 'gray market.'

The International Trademark Association (INTA) and the International Chamber of Commerce commissioned a report indicating that counterfeiting and piracy could reach a value of $3.2 trillion by 2022. The Organization for Economic Cooperation and Development (OECD) estimates that the global loss of jobs due to counterfeit goods will amount to 4.2 to 5.2 million by 2022.

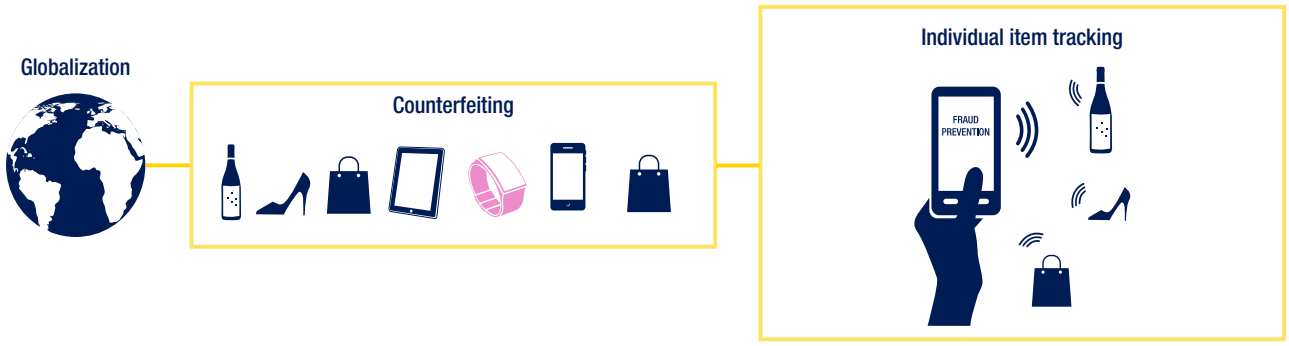


Figure 3 : Globalization - impact and solution

Secure individual item tracking or secure meta-data product association could be a means of fighting counterfeit production.

Cost containment and its day-to-day fast-paced approach: unified ability to react

Focusing solely on conventional design techniques of supply chains is no longer sufficient: supply chains must now cope with quickly shifting cost structures and other operational fundamentals. As the demand for rapid responses to changing market needs continues to grow, agility and cost-effectiveness in supply chains become key benefits.

Manufacturers, in that sense, need to manage logistics, knowing where and when products need to be, in order to meet demand or sudden demand changes across the globe.

Figure 4 : Costs - impact and solution

Their unified ability to react could be an answer to the day-to-day fast-paced market.

Risk reduction and its sustainable performance: auditable cross-chain quality

Supply chain risks are usually associated with the day-to-day management of supply chains, and are addressed using principles such as safety stock and safety lead time or overtime. As risk occurrence becomes potentially more expensive, effective risk management is all the more important. Supply chains which set up good practices in risk management can mitigate risks and claim advantages from these capabilities. These benefits increase when practiced across the whole supply chain and become a key strategic competitive advantage.

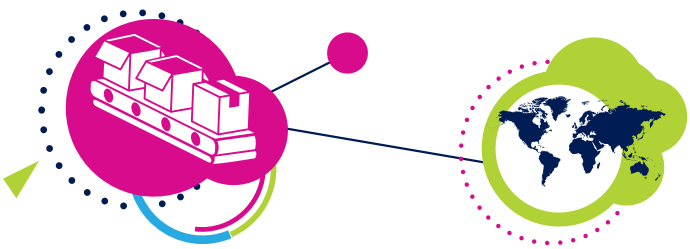
Indeed, poor supply chain management can lead to undesirable results: the most straight-forward examples of disruptions or undesirable outcomes can be easily found in specific industries, such as the food, pharmaceutical or automotive industries, which tackle public health or consumer product safety. Lack of visibility on the process at stake significantly increases the risks of waste, losses, delays and reduced quality.

Nowadays, weak technical systems, which are not fully digitized or show a lack of interoperability, take a toll on rapid response times and efficient flows of information, leading to safety issues and important recalls.

Figure 5 : Recalls and units by sector

Figure 6 : Risks - impact and solution

By implementing technologies that can increase reliable visibility and interoperability into the supply chain, manufacturers can more easily collaborate and communicate with suppliers and facilitate audits and controls.



The growing complexity, the decreasing access to information and the greater need for higher product quality in a shorter time and at a lower cost illustrate today's global supply chain landscape.

BLOCKCHAIN TECHNOLOGY AS A TRUSTED FACILITATOR

As the world begins to work differently with Internet of Things (IoT) technologies and its smarter objects, smarter supply chains, assisted by digital and physical infrastructures, are emerging: objects can communicate and collaborate directly, without human intervention. Entire systems can be connected, not just supply chains with other supply chains, but also with transportation systems and financial markets.

With so much built-in intelligence, stakeholders' abilities in supply chain management can shift from decision support to decision delegation and, ultimately, have a predictive capability. Up to now, operational activities, such as the tracing and tracking of goods, are already implemented in smart supply chains. Blockchain technology is as a game-changing technology, which takes smart supply chains one step further.

With its unique capabilities and benefits, blockchain technology unlocks new potential for traditional databases and current architectures.

Overall, blockchain technology can verify the authenticity and the quality of a physical asset with a cost-efficient and simple two-party-only concept, in creating reliable end-to-end visibility. This contributes to company success as well as customer satisfaction and is based on its four pillars, 'security, transparency, trust and speed', which are valuable capabilities for the digital world.

There is true potential in blockchain technology that traditional infrastructures have not yet fully accomplished.

TO GO FURTHER...

Blockchain technology technically relies on the core idea of the Distributed Ledger Technology (DLT), which is a growing list of records that is stored into a ledger and continuously updated. These records are known as 'blocks', and they are all intrinsically linked and secured thanks to cryptography: a series of these blocks form a 'chain' — hence the name 'blockchain'.

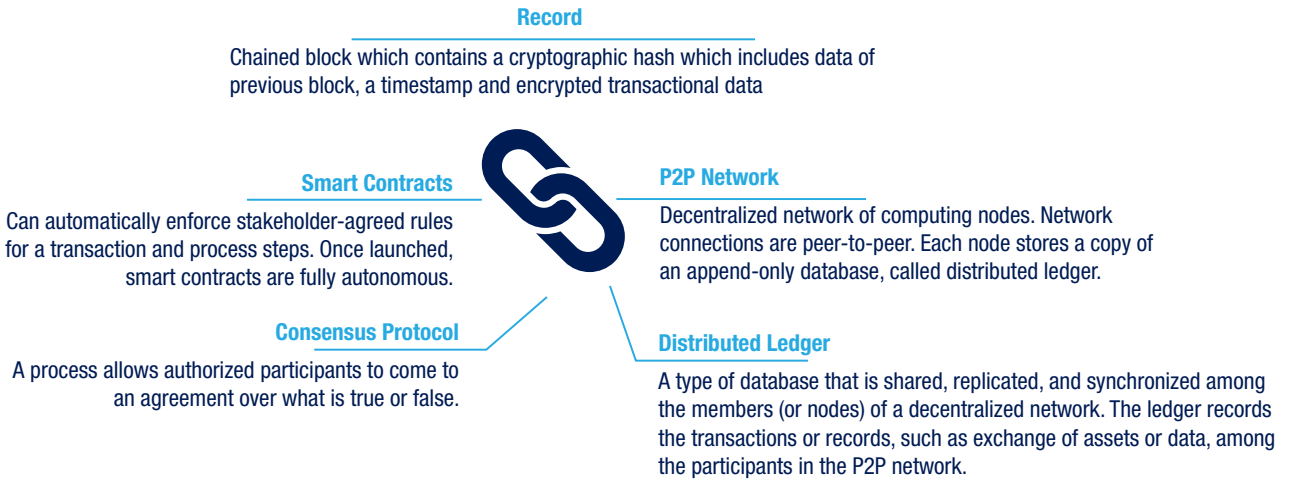


Figure 7 : Blockchain Components

A record or a block is a major component of blockchain technology: each block contains what is known as a cryptographic hash which includes data from the previous block, a timestamp, and the transactional data.

A record or a transaction data can be a financial exchange or the record of an event such as a hand-off in a chain of custody, the completion of a task, or even a temperature reading at a specific time and place or any specific information linked to an item or product.

Records can be accessed thanks to private keys by the owner of that record and with public keys by participants with whom they want to share information. The system is intended to enable the user to have full control of the data while allowing participants to gain access to trusted information: it is a huge database that can be safely shared among an important number of people. They can include all their data but decide on what they would like to share.

Thanks to its design, the blockchain is entirely resistant to any data modification and cannot be tampered with or edited in any way. The blockchain is typically managed by a Peer-to-Peer (P2P) network which collectively adheres to a particular protocol that manages inter-node communication and validates new blocks. Once recorded, the data in each block is unable to be modified afterwards without altering the internal shape of the subsequent blocks, which would require the agreement of the network majority.

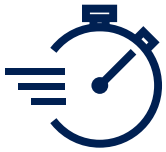
In other words, blockchain technology creates a secure transaction ledger database that records and stores every transaction which occurred in a network of decentralized computers, essentially eliminating the need for 'trusted' third parties such as payment processors. Thus, blockchain technology offers the possibility for extremely low-cost payments to be made between buyers and sellers of produce and/or related services such as transportation. Both sides of transactions are executed simultaneously.

Blockchains can automatically run smart contracts and computer programs embedded in them, when certain events happen or pre-defined conditions are met. While traditional databases can also provide automated execution, smart contracts inherently provide transparency for all parties to see exactly what the rules of automation are.

Blockchains can be 'permission-less' or open to the public, where anyone can join and remain anonymous by design or can operate in 'permissioned' mode. Permissioned blockchains allow users to control accesses and permitted actions are performed only by identifiable participants. Once identity and roles have been defined, participants join the private network, which is closed and non-visible to non-participants. Supply chains may opt for permissioned blockchains because one of the advantages of this mode is the greater granularity in privacy and security that businesses need.

Blockchains provide other features that benefit supply chains: blockchain is cutting-edge database technology. Hosted in a cloud-based environment, conventional databases are likely to become bottlenecks as the amount of data they collect increases - blockchains can remedy this thanks to their distributed nature.

Supply chains that implement a blockchain mechanism could reshape the supply process and eliminate an entire layer of complexity from the global system. Making the supply chain more transparent and automating administrative operations would add considerable business value and could provide many benefits for the company.

Blockchain Key Benefits	
	Cost effectiveness: reduce a firm's annual shipping costs by 2 to 5%. Blockchain technology offers real-time traceability, thus simplifying the transfer of ownership, goods and payments, reduces performance irregularities between contracted terms and improves planning capabilities and risk management.
	**Offer authenticity, responsiveness and quality assurance:** recording the actions taken to manage the flow of goods allows blockchain participants to identify root causes, verify the data and quickly take the required actions.
	Decrease fraud and theft: any changes brought to documents in blockchain records are tracked and securely saved which helps blockchain participants to confirm their authenticity.
	Simplify control and audits: blockchain technology not only allows companies to make sure their data is accurate and highly traceable, it also helps them gather documents in one comprehensive system without help from regulators.
	Foster interoperability of systems: blockchain technology consolidates data in a single platform, thus easing the integration of different services without divulging too much proprietary information to third parties and disclosing information on a need-to-know basis, to the right people and at the right time.
	Enhance the potential of IoT technologies: blockchain promotes the implementation of IoT scenarios which were extremely difficult to consider without it.

WHEN BLOCKCHAIN TECHNOLOGY MEETS NFC TECHNOLOGY: DIGITAL PAIRING

The world is already full of connected devices—and more are coming. IoT technology is converting offline or physical objects into online assets: IoT can also be referred as the 'Internet of Objects'. The IoT is a network of objects integrated with radio frequency identification chips. In 2017, according to Gartner analysts, there were an estimated 8.4 billion IoT devices. By 2020 that number could exceed 20 billion, and by 2030 there could be more than 500 billion. The vast and growing IoT universe of connected devices extends far beyond just smartphones and private houses. In fact, IoT is spreading everywhere and is applied to an industrial scale from virtual assistants to self-driving cars to healthcare, in a way people can hardly imagine.

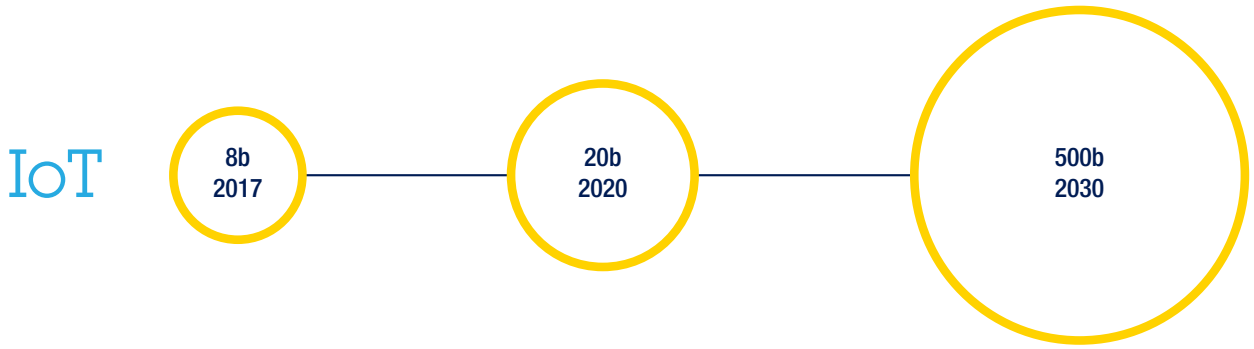


Figure 8 : IoT forecast

NFC/RFID is implemented as a subset of IoT:

- RFID technology (Radio-Frequency Identification) primarily operates at three frequency ranges: Low Frequency (LF), from 125 to 134 kHz, High Frequency (HF) at 13,56 MHz and Ultra-High Frequency (UHF) from 856 to 960 MHz. It is defined as the technology which suits automatic identification, asset tracking and supply chain management best, but there are many other applications of RFID in everyday lives.
- NFC technology (Near Field Communication) is fast, intuitive and already widely used in the mobile industry. It only operates at a High Frequency rate (13.56 MHz) similarly to some HF RFID devices. Because it is generally more secure than other wireless communication technologies, NFC technology is a widely adopted protocol for mobile wallets or other payment applications, such as Apple Pay or Android Pay, recently launched around the world. However, NFC-enabled technology extends beyond financial transactions and offers exciting opportunities to both consumers and advertisers though user engagement and user experience applications. These NFC-enabled devices are poised for explosive growth in the years ahead: Cisco research estimates that 80% of the global population will be mobile users by 2024 and today, Android phones and iOS phones are already equipped with NFC technology and amount to 70% and 28% of the mobile market respectively.

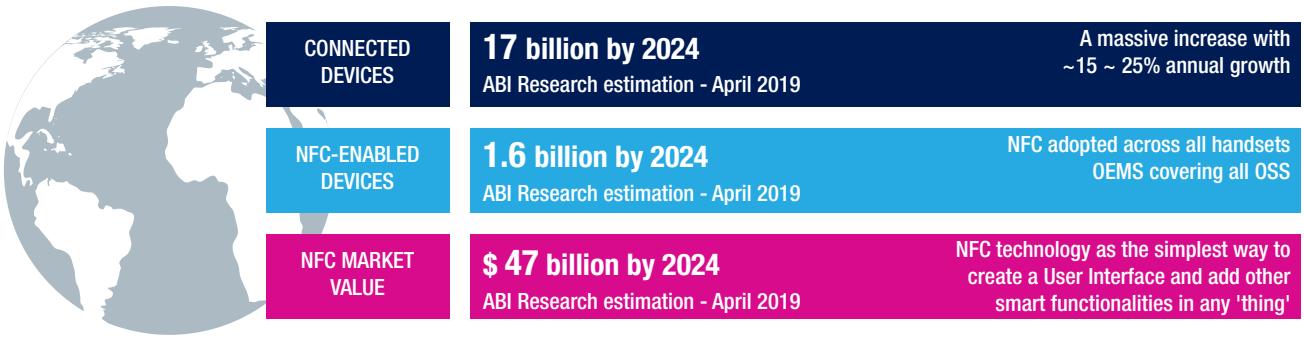


Figure 9 : NFC-enabled technology - Trends

These advanced NFC-enabled devices can detect and read information stored on NFC-compatible or RFID-passive devices, such as those embedded in labels or smart posters. Those passive NFC/RFID devices, such as Tags, are attached to an object or item, temporary connected to a network and able to receive instructions to adapt their behavior.
They are becoming smaller, cheaper, and more flexible. They can even be embedded in paper and plastic, making the product's microscopic electronic devices part of the material itself.

Linking it back to modern supply chains, IoT is an umbrella term for a variety of tracking and monitoring solutions using open standards-based connected sensors. Asset monitoring, fleet monitoring, worker safety monitoring, and manufacturing production monitoring are among the most common use cases for IoT today.

Merging IoT devices and blockchain together creates a reliable, concrete and permanent channel to collect, communicate and aggregate data from real-world objects and allows 'smart' machines to record and present information in an understandable way. This network will allow interconnected devices to interact with their environment and make decisions without any human intervention.

Figure 10 : IoT and Blockchain Channel

However, the potential applications of blockchain-based supply chain platforms, while implementing NFC/RFID technology, are more diverse.

Blockchain and NFC/RFID will help mitigate supply chain entropy, while enhancing visibility and transparency far beyond the supply chain. It is undoubted that the usage of RFID technology has revolutionized supply chain management strategies and the way information is passed upstream and downstream in supply chains. Upstream stakeholders include customers (distributors, retailers) and end-users of the product/service. Downstream stakeholders include suppliers (component suppliers, other tier suppliers), sub-contractors, raw material providers and farmers/growers.

User Experience

The adoption of RFID technology has not really taken off beyond the point of sale. One area where RFIDs could not really take off is at the consumer point. Indeed, in practice, there is no scalable technical solution using traditional infrastructure which can enable this.
However, NFC technology will change with the increasing number of NFC-enabled devices such as smartphones, since consumers will want to benefit from lower costs and faster transaction speed. Combining this with blockchain technology, scalable and promising solutions become possible.
Embedded in almost every smartphone, NFC allows end-users to link up to data about the product's origin, certifications, and journey through the supply chain. Consumers can use the 'Internet of Things' to gather information about the provenance and the quality of the item, not just at the generic level of the item category or type, but for a specific physical item, identified by a unique digital ID.

In the same way paper labels are used to identify goods, a technological tag can be used in two ways.
Indeed, it can store data directly, and in some cases, can even be updated in a secure manner, as the item moves through the supply chain. This new digital label, with its protectable memory density which spans up to 64 Kbits, holds much more data than conventional bar codes do.

Furthermore, tags can simply hold a unique identifier, pre-programmed and assigned by the chip manufacturer, which acts as a pointer to a vast amount of web-based supporting data. Conventional QR-code technology can address this option but is less reliable than NFC technology. Readability of the barcode depends on factors such as lighting, viewing angle and clarity of the image (label without scoring or other damages). These conditions can be hard to meet without manual and human interventions.

NFC is an entry point to secured transaction ledger for a specific object tracked in a blockchain. It enables a permissioned user to see the immutable history of the physical object. With NFC and blockchain technologies, a given object suddenly becomes much more than its physical item because its entire history, from creation to current instant, is stored and available.

Anti-counterfeiting

Using NFC/RFID technology with its local authentication processes together with blockchain technology, can extend blockchain capabilities on the agreement on validity of a given record and may provide a multi-layered defense against well-known risks which can occur in supply chain management, such as counterfeiting. This NFC technology does not require special abilities or features, such as processors (to perform cryptographic operations), or inaccessible memory. It only uses low-cost NFC devices, which are powered by NFC mobile phones or industrial readers. Indeed, the tag comprises an antenna and a small chip and as this passive device has no internal power supply and no radio transmitter, the electromagnetic energy is sent by the reader. To overcome the counterfeiting issues which arise in supply chains, a decentralized supply chain that exploits blockchain technology and NFC/RFID technology, stands out as a suitable platform to establish countermeasures against common counterfeiting attacks from authorized manufacturing.

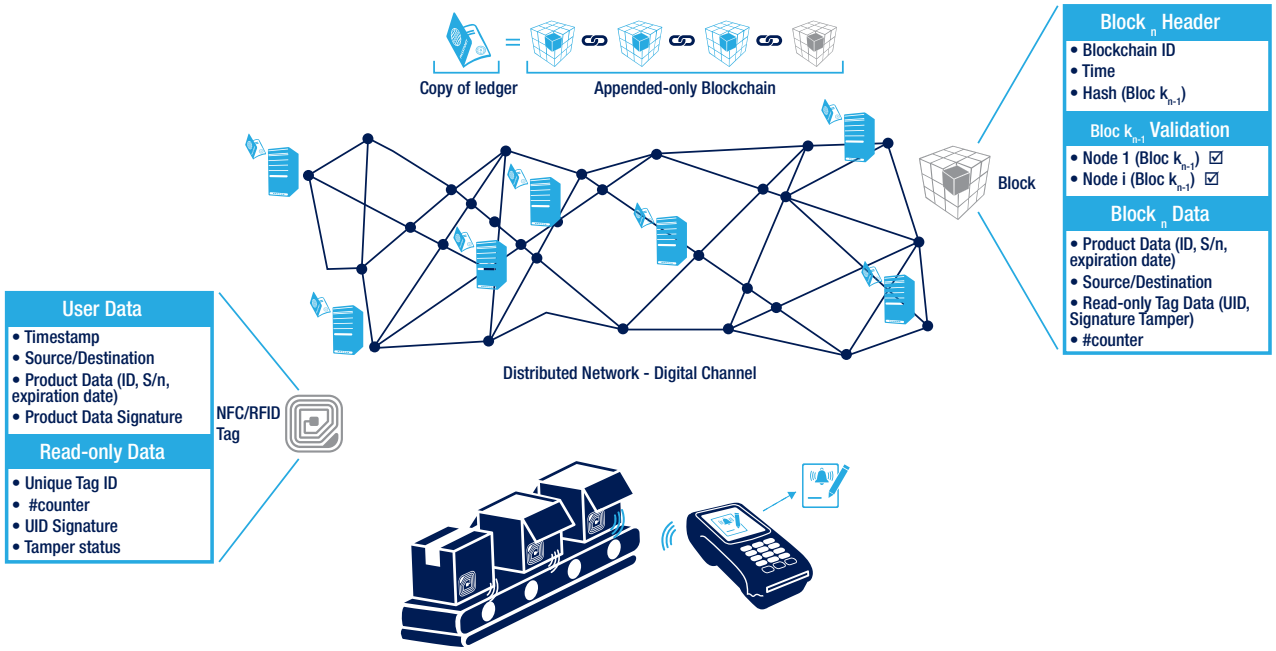
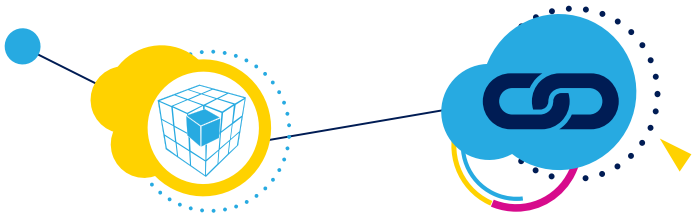


Figure 11 : Physical and Digital Channels



Blockchain technology is ideal for dealing with counterfeits because of its ability to create unique identities for items. By using NFC/RFID technology, supply chains can create a robust link between the physical object and its digital life on the blockchain. This one-to-one link outlines absolute transparency and trust in the authenticity of goods. Thanks to blockchain & NFC technologies, consumers can have more information on the product they purchased and retailers can gain efficiency and reliability in the management of supply chain flows.

TO GO FURTHER...

From a technical point of view, blockchain technology is a distributed ledger that contains chained blocks, each of which is made up of several transactions. These blocks are validated by the authorized nodes/participants of the peer-to-peer network, globally and transparently, to guarantee security.

A blockchain-based supply chain would authenticate each product/item and detect counterfeit goods without the need for a centralized authentication server. Instead, it would involve the nodes in the authentication process by using blockchain benefits.

The product manufacturer creates the genesis block, in other words, the first block of the chain, and creates the information structure with the product's details and digitally signs this artefact and the tag's unique identifier with its private key in order to produce a data digital signature. Thus the genesis block and tag, attached to the product are populated with product's details and the data signature. The genesis block is then broadcasted to all the nodes in the supply chain.

During the authentication process, as the product travels throughout the supply chain, the associated blockchain gets updated each time it leaves a node and moves to the next by adding new blocks to it.
When a node receives a product, 2 types of authentication are performed:

- Local authentication, processed by the local node, which compares and detects mismatch between information in the previous block of the blockchain and the tag's internal data.
- Global authentication, processed by all nodes, which validates the new block with a verification of the well-chained and appropriate order of blocks.

Local authentication is processed using internal and persistent tag data resources at first, and can be summarized as followed:

- Detection of 'cloning attacks' without requiring the NFC/RFID tag to perform any cryptographic operation, such as signing or encrypting a challenge.
  For this detection, Data such as Product ID and its associated read-only Tag ID are verified on both sides –Tag content and Blockchain content. The Tag ID, which is pre-programmed into the tag and assigned by the chip manufacturer, is in some cases pre-signed by the manufacturer too. This read-only and unique digital signature acts as an electronic certificate of authenticity. This eliminates fake Tag IDs.
- Detection of 'modification attacks' on information presented into the chained record.
  For this detection, product integrity can be detected by data and its associated digital signature in user memory. This process computes a digital signature with the tag data and the new signature is invalid if any product's detail is modified, such as the product's expiration date.
- Detection of 'tampering attacks' on the outer packaging (seal integrity).
  Product integrity can be detected by a tamper detect feature which produces a report on the state of the package seal at any time.
- Detection of 'label reapplication attacks' in which a counterfeiter removes the legitimate label from a genuine product and reapplies it to a counterfeit or expired product.
  For this detection, a hardware counter, automatically incremented, read-only and not adjustable, tracks how many times a tag has been accessed in the supply chain.

KEY BENEFITS FOR STAKEHOLDERS

With such a huge number of stakeholders involved in the supply chain, blockchains can potentially foster data transparency and accessibility among relevant supply chain stakeholders. This creates a single source of truth and provides particular key benefits for each stakeholders:

Producers/Suppliers: reduce downtime and improve efficiency and productivity levels
The suppliers stand to benefit from real-time data on the requirements of the seller. They are able to generate reports on the fly, as to what is necessary and what needs to be prioritized. Reports are based on inventory flows from partners across the supply chain or based on the smart and predictive business analytics. Additionally, the detection of any supply chain disruptions will allow companies to quickly react.

Logistics: increase accountability and mitigate risk.
These new technologies will help increase accountability and efficiency in tracking product movement and reduce the risk of waste, loss and spoilage, in speeding up delivery.

Retailers: enrich the downstream relationship with customers.
Sellers are able to accurately assess the timelines for the supply of materials and share precise information in a seamless manner with suppliers, partners and customers.

Partners: create new forms of competition and foster agility.
Supply chain actors can keep track of flows, ensure their well-functioning, and provide additional assistance whenever necessary. With public records and transactions, partners will be able to see competitors' rates and levels of service: transparency in contract negotiations forces supply chain middlemen to reduce fees and surcharges lower than they might be otherwise.

Control agencies: facilitate audits and increase reactivity
With an immutable blockchain audit log, organizations can more quickly and properly resolve supply chain disputes or make sure operational systems are being properly implemented and executed. Smart contracts can be negotiated between partners in a supply chain, which allow them to agree on sourcing, environmental conditions, and delivery timeline. If certain conditions are violated, smart contracts can for instance trigger product recalls or stop the production, to avoid that affected products reach customers.

Brand: improving brand management and tackle counterfeiting
The reputation of brand names can be improved, while also providing new and unique services, communicating pertinent product information and making the supply chain more transparent and accessible to consumers. Beyond the product or the packaging themselves, brands can start selling a global experience with digital labels though videos and promotional offers in multiple languages.

Consumers: address public safety concerns and consumer perception
The consumers can track and trace the origins of the product and goods, as well as learn more details about the products or services they are purchasing.

These new technologies can unveil new ways of managing supply chain dynamics, in a larger number of industries and for more purposes. Their role will be as important for supply chain infrastructure as they will be for marketing.

ST25TV SERIES NFC TAGS: A BLOCKCHAIN-READY ECOSYSTEM

STMicroelectronics is one of the early pioneers of NFC/RFID technologies and offers a wide range of products and solutions covering many applications in everyday lives as well as rich development ecosystem.

Thanks to its broad product portfolio, ST covers most NFC/RFID applications including:

- smart things applications, by enabling peer-to-peer data exchange with gaming accessories or by increasing customer engagement while protecting against counterfeit, grey markets or unauthorized distribution.
- smart home and cities applications through access control or Bluetooth/Wi-Fi pairing methods and seamless user interface approach
- smart industries, by interacting with products at any stage of the manufacturing chain, even after packaging, by accessing diagnostics and maintenance information or monitoring troubleshoots and adjusting equipment parameters.

By continuously analyzing global trends in its B2B ecosystems, ST helps customers shape their future and solve complex challenges, such as global supply chain complexity. B2B ecosystems include several ST key-partners gathering system-solution integrators, tag converters, raw material experts or inlay makers. ST is also able to deliver turnkey solutions to ease and solve the most complex design challenges.
The ST25TV series delivers state-of-the-art Radio Frequency (RF) performance and offers key-enablers, required by the blockchain-based supply chain platform to enrich blockchain technology.

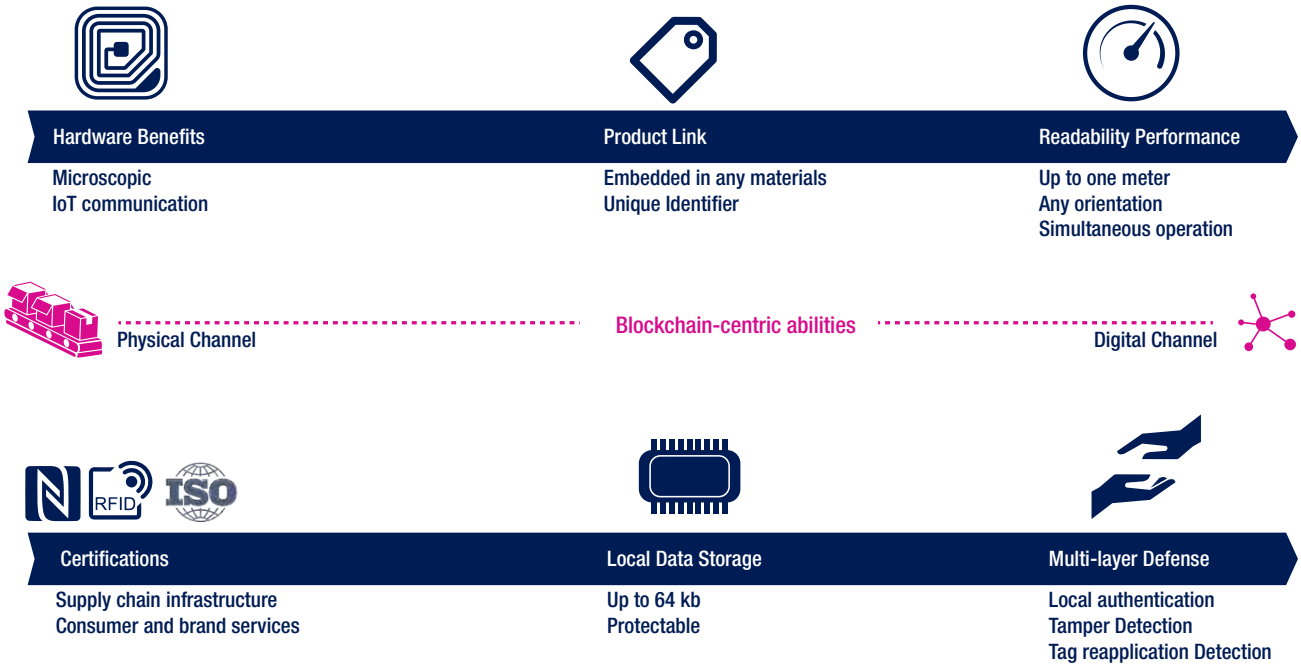


Figure 12 : ST25TV tag ICs

ST25TV Type 5 Tag chips are certified by the NFC Forum and abide by ISO/IEC 15693 RFID specifications. They operate at 13.56 MHz, include highly reliable memory density which spans 512 bits to 64 Kbits and store product or item information which is retrieved at power up at any stage of the end-to-end supply chain. They hold Unique Identifier and Trust25 Digital signature, assigned at EWS stage and include counter, data protection and Tamper detect features, providing multi-layer defense against counterfeiting.

ST25TV RFID capabilities used by supply chains, can be automatically bridged with NFC capabilities, with their built-in NFC Data Exchange Format (NDEF) support. ST25TV tags are easier to tap and read by consumers, therefore improving the user experience designed by each brand. Brands and manufacturers now have access to smaller NFC tag labels and stickers, which are safer and easier to install for enhanced engagement with their customers.

The ST25TV Type 5 Tag ICs series brings intuitive connectivity, flexibility, configurability, convenience and security, achieving the new challenges of the modern supply chain.

For more information, visit www.st.com

Smarter end-to-end supply chains

Combining blockchain and NFC/RFID technologies

Globalization has brought about new challenges for companies regarding cost structure, flexibility and risk management. Considering the number of parties involved in supply chain flows, transparency has become an essential parameter in identifying bottlenecks and potential issues. Blockchain technology paired with NFC/RFID solutions, such as the ST25TV Type 5 Tag chips, offers a solution to improve reliability, accountability and effectiveness in dealing with supply chain flows.

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