

IoT powered by Blockchain

How Blockchains facilitate the application of digital twins in IoT

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Background

By 2020, the amount of Internet of Things (IoT) devices will grow to over 20 billion. It is estimated that 4.5 billion of these devices will be implemented in Europe, of which 750 million will be in Germany. These interconnected devices will support millions of so-called “digital twins” with valuable data streams. Digital copies of physical objects or processes will constitute one fundamental pillar of intelligent digitalization and not only connect with each other, but provide a backbone for further related megatrends such as the Internet of Things (incl. use cases, e.g. connected home and smart cities) and Industry 4.0 (e.g. smart manufacturing).

Typically, IoT solutions can be categorized as Industrial IoT (IIoT) and Consumer IoT (CIoT). Until now, the focus was mainly on IIoT, and thus High Value Assets such as airplane turbines or windmills. However, similar to the internet, digital twins only unlock their true potential when they are used on a broad scale. They facilitate the digital transformation of the whole society and provide efficiency and transparency in several workplace and life areas. To achieve that, standardized infrastructures, open application programming interfaces (APIs) and collaborations among stakeholders are necessary.

Digital twins are virtual copies of physical objects or processes. They consist of IT components for status updates, connectivity, defined data structures and user interfaces that visualize relevant data.

Whether consumer business, manufacturing or automotive: Many sectors in Industry 4.0 scenarios have the potential to greatly benefit from digital twins and related business and product modelling.

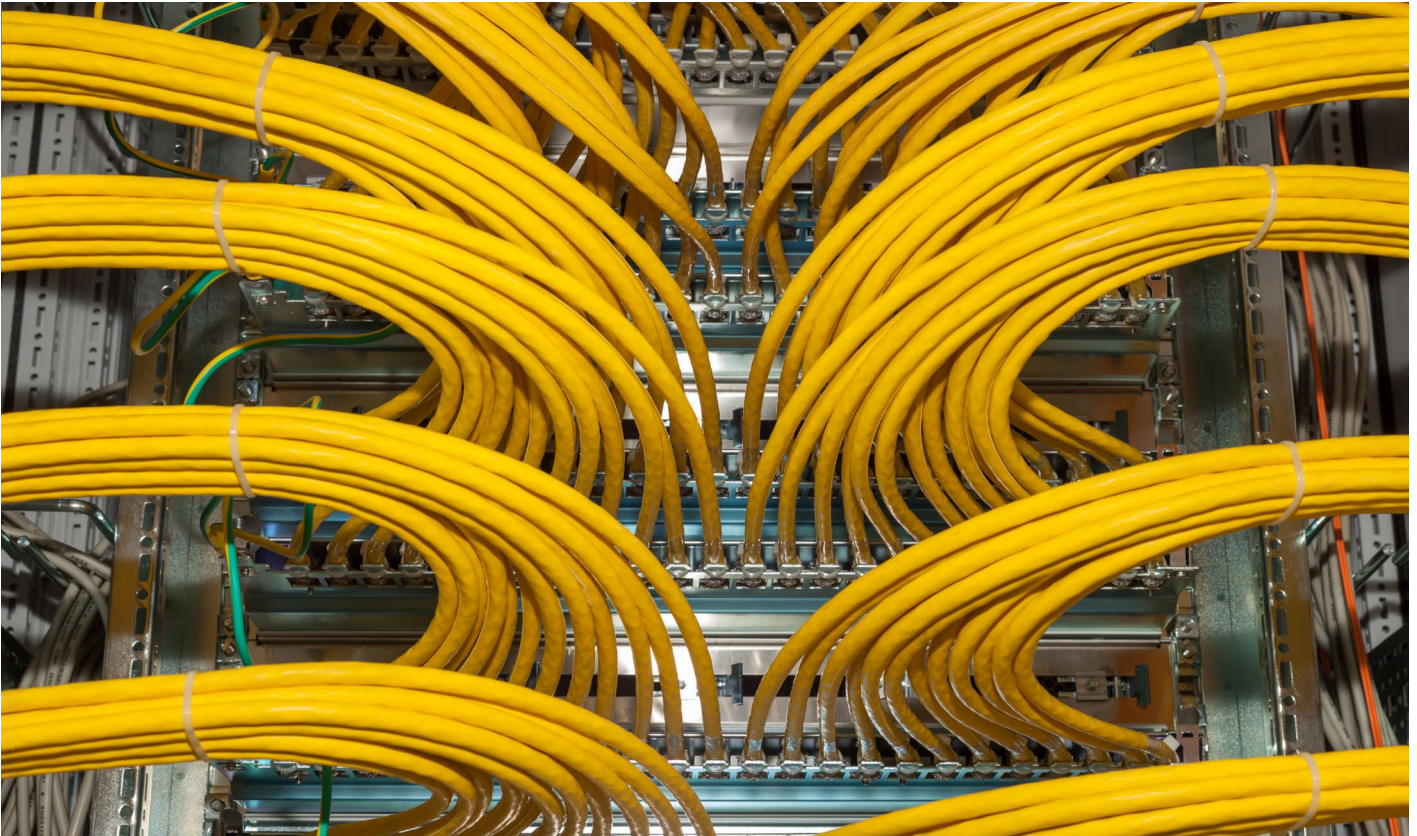
Blockchain technology appears today as potentially the most suitable and efficient way to generate, monitor and exchange digital twins. This evaluation roots in Blockchain's highly desirable attributes like auditability, security and immutability. Digital twins benefit from these features, as they allow the transmission of data and value of any kind over the internet without intermediaries and a high degree of transparency. Already, many small and large companies provide opportunities to store physical objects on Blockchains, calling them “tokenized assets” and making full use of the immutability and transparency Blockchains offer. The next step is to connect these digital twins with each other and with interested third parties. For this, a specialized distributed ledger platform that allows sharing information among digital twins is required. Consequently, this Point of View outlines such a platform's requirements, use cases and how stakeholders emerge as new leaders in their respective fields.

Distributed ledger technology (DLT) as an umbrella technology includes Blockchains. While other DLT solutions offer different advantages, this PoV focuses on Blockchain for comprehension reasons. Many attributes credited to Blockchains are also shared by other DLT.

About this Point of View (PoV):

Deloitte is publishing this PoV with RIDDLE&CODE - The Blockchain Interface Company, because hardware combined with Blockchain enables a unique perspective on the further development of the Internet of Things. RIDDLE&CODE provides innovative and secure Blockchain-enabled hardware solutions for digital twins that are directly linked to a Blockchain. Combined with the cross-functional advisory and analytics experience of Deloitte, new application and business models for IoT become possible.

Crypto hardware takes IoT and digital twins a step further and thus makes an integrated ecosystem possible. Our collaboration seeks to create awareness of new possibilities and trigger the imagination of entrepreneurs and investors.



An Introduction

Digital Twins

Currently, a great deal of movement from different industries towards digital twins can be observed. While there appears to be a general consensus as to the importance and potential of digital twins, there currently is no universal standard or generally adopted definition of what exactly a digital twin is.

Fundamental requirements of the IoT ecosystem are IT components and connectivity. A physical object's status is mirrored into a digital twin, which in return provides digital surveillance and manipulation capabilities of their counterparts in the physical world. Furthermore, relationships and communications between digital twins can be set up.

Not only do they store and transmit data, they also enable analytics solutions and play a major role in services like predictive modeling. This becomes especially evident when looking at smart cities, which combine many application areas of IoT and digital twins.

Mapping real assets to their digital twins typically requires a combination of the following four key characteristics:

1. IT components that transmit a status or data package
2. Connectivity in form of bandwidth
3. Defined data structures that handle basic analytics
4. User interfaces to visualize relevant data

One definition of digital twins: Digital twins are virtual replicas of physical objects or systems; a pre-existing necessity is the Internet of Things.

Blockchain Technology

Blockchain technology's core component is a technological protocol that enables data to be exchanged among multiple parties within a network. It does so without the need for intermediaries, as network participants interact with encrypted identities (anonymously) and directly with each other using peer-to-peer communication. Each transaction is then added to an immutable transaction chain and distributed to all network nodes.

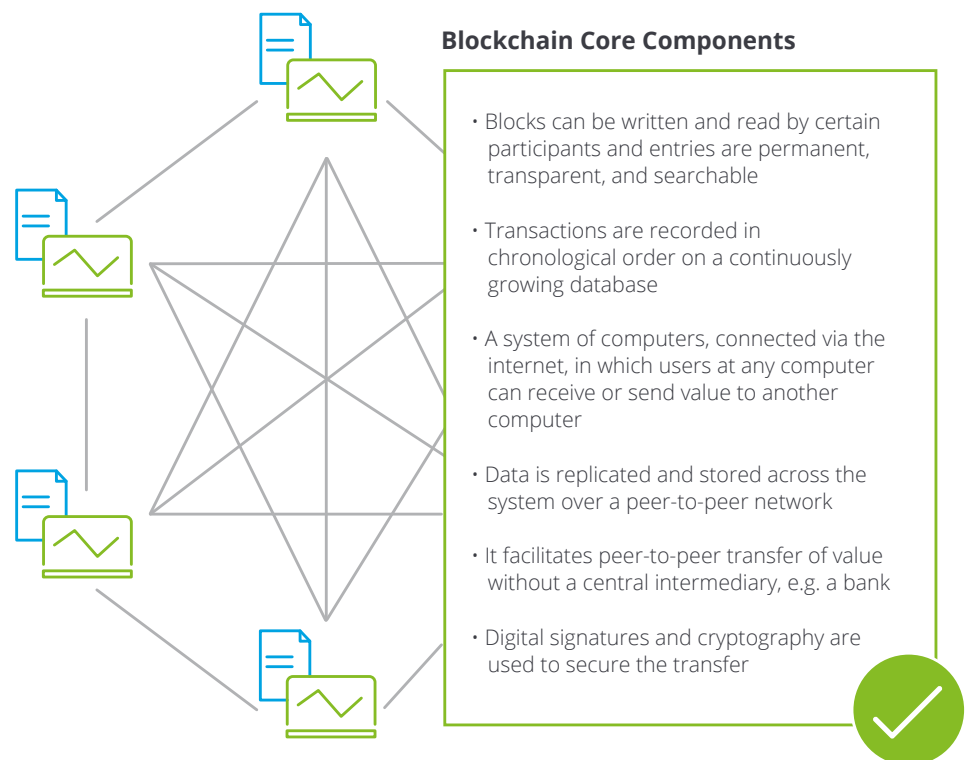
Though this definition might sound complicated at first, it explains why Blockchain technology generates interest at a level similar to the first commercial use of the internet.

Blockchain technology is expected to offer tremendous potential for bringing radical changes in a broad range of industries, business models and operating processes such as payment, accounting and auditing. In view of the technical complexity and lack of acceptance of these far-reaching changes in the private, public and commercial sectors, this new technology, like many disruptive technologies before, will catch on gradually with an expected increase of pace over time. It is therefore less of a question of whether Blockchain will establish itself, but rather when and in which areas. The current focus of Blockchain technology is primarily on using the Blockchain to validate, execute and store transactions, which is why its development has been mainly driven by the financial industry and is now spreading across further markets.

However, the transformational impact of Blockchains is far-reaching and affects a multitude of levels within and outside companies; including business processes, regulatory frameworks, technological soft- and hardware developments and the formation of new business models. The successful use of this technology leads to its combination with established and new technological trends with the aim of creating new entrepreneurial value.

Enhancing established processes with Blockchain technology opens new opportunities to create transparency between unknown participants and also to improve security on a global scale. This can be achieved by end-to-end encryption within a network of distributed ledgers in which every transaction needs to be approved by the majority of the network. Though different concepts like Proof of Work (PoW) and Proof of Stake (PoS) exist, the core idea remains the same: Manipulation and

Fig. 1 – Blockchain technology; a decentralized, distributed ledger that provides a way for information to be recorded, shared and maintained by a community.



“Unlike the internet alone, Blockchains are distributed, not centralized; open, not hidden; inclusive, not exclusive; immutable, not alterable; and secure. Blockchain gives us unprecedented capabilities to create and trade value in society.”

World Economic Forum (2017)

fraudulent behavior by a single entity becoming increasingly difficult as the network grows in terms of users because of mutual verification among users.

For example, the consensus mechanism based on majority approval and Proof of Work is one key aspect why the probability of manipulation and fraud committed by a single entity decreases with an increase of users, as checking for correctness is easy, but calculating it is not. Therefore, a large distributed system makes it difficult to control more than 50% of validating participants, practically eliminating the chance of a hostile takeover of a properly set-up Blockchain network.

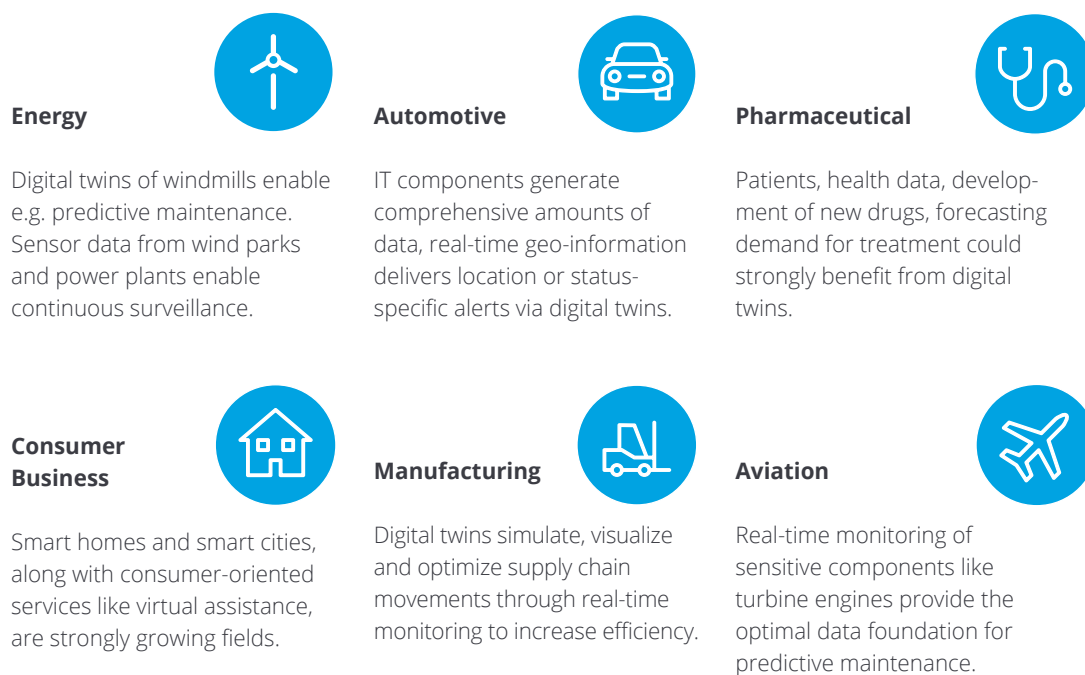
Application Areas along Industries and Functions

Similar to the internet and its users, the IoT ecosystem's beneficial character increases with a growing digital twin population.

While so far mostly High Value Assets, such as airplane turbines or windmills, have been subject to this development, with increasing digitization more generally available objects and machines will populate digital twin solutions.

Whether consumer business, manufacturing or automotive: Many sectors in Industry 4.0 scenarios have the potential to greatly benefit from digital twins and related business and product modelling.

Fig. 2 – Industry examples of digital twins



Drilling further down from broad industry examples, specific opportunities and use cases can be identified:

1. Track and Trace:

Digital twins are stored within the IoT ecosystem to enable tracking of both the location of a shipped item and the circumstances under which the shipment took place. Based on automatized processes, IT component data can immediately trigger insurance payments or freight settlements if agreed-upon contract arrangements as specified in smart contracts are not met (e.g. temperature too low/high) and result in quality decay of the shipped goods.

2. Proof of Provenance:

By adding crypto hardware components to physical goods and storing related metadata as a kind of "certificate of trusted origin", digital twins in combination with crypto hardware can act as a measure against product piracy. The same approach is valid for official documents enhanced by crypto tags to prove their authenticity. Similar to traditional seals, crypto tags act like "smart" seals: When they are broken or removed, the document loses its "smart" functions and turns invalid.

3. Digital Lineage / Secondary Market Certificates:

Adding crypto hardware to goods enables a secondary market for collector's items or goods of high value, ranging from the art market to spare parts for cars.

4. Peer-to-Peer Trading:

Peer-to-Peer (P2P) describes the mechanism that allows two or more network participants in a decentralized platform to interact with each other directly, without the need for an intermediary third party. P2P trading based on information provided by digital twins greatly improves the communication between participants because it creates transparency by transmitting data like production, consumption and storage availability information directly from the digital twin to the intended party and thus circumvents human error or inefficiencies. Without the need for intermediaries and with increased trustworthiness of the supplied data through digital twins, P2P trading is significantly improved.

5. Network / Machine Integrity:

By adding Blockchain hardware to physical network components, e.g. IT components for critical infrastructure, the object itself can be monitored and it can be guaranteed that all data and manufacturing components are verifiable. This is especially important for predictive maintenance modeling.

6. ID Management / Access Control:

On an individual level, personal data can be stored as a digital twin while still represented in the physical world by an ID card – and thus complete transparency can be achieved in terms of who is entitled to access a certain building, documents or machines.

The implementation of digital twins in the previously mentioned scenarios (and many more) enables efficiency gains and new business models. However, there are still many challenges to overcome. Privacy and security flaws within the system, for instance, could lead to hijacked digital twins, or changed characteristics of e.g. ownership or other value fields. The initial investment required to adequately address these issues and the system's implementation needs to be surpassed by improved efficiency, security or new business model opportunities.

While an underdeveloped infrastructure compromises the idea of real-time information, it can be improved over time. On the other hand, trust in the system requires immutability of the data from day one. This requires a platform that (1) is safe from hacking, (2) combines accessibility from different locations and by various participants, and (3) includes proven reliability mechanisms.

What defines a "smart contract"?

A smart contract is a piece of code implemented in the Blockchain that is executed automatically once pre-defined conditions are fulfilled.



Excursus: Smart City

Smart cities combine the Internet of Things with almost every aspect of life, and with recent developments in mind, smart cities will become a reality in the near future. Investments by Bill Gates near Phoenix, Arizona, NEOM in the Middle East or development plans for Hangzhou in China, show a universal interest all over the world.

While numerous examples from every aspect of life, including education, health and safety can be cited, particularly the concept of smart mobility and energy as well as smart retail & logistics come to mind when thinking of the combination of IoT and digital twins. With an ever-increasing

urban population, congestion and pollution become a major concern for both residents and governments and therefore demand innovative technical solutions.

The City of Los Angeles is working on an automated traffic surveillance and control system, which is scheduled for 2018 and uses IT components in roads and vehicles that provide accurate data with which to anticipate and reduce traffic congestion and pollution. Smart parking, on the other hand, focuses on real-time information provided by drivers in regards to available parking spots, which are represented as digital twins. An example of a smart parking

solution can be found in Barcelona, where a fully operational system is also scheduled for 2018.

For both scenarios, one can visualize how digital twins, perhaps first as traffic lights, then as street segments and finally as cars and parking spots, accurately replicate the real-world environment. Digital twins emerge from digital objects and allow status updates e.g. on location, utilization or temperature in near real-time. This kind of transparency is highly beneficial to emerging IoT ecosystems which typically focus on increasing efficiency and optimization.

What is meant by “smart city”? A city is smart when investments in (i) human and social capital, (ii) traditional infrastructure and (iii) disruptive technologies fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance.*

Enabling IoT with Blockchain Technology

As previously mentioned, the security of a platform that handles digital twins as well as high-value data is an important issue: Blockchain technology combines security from hackers through its built-in encryption features, and simultaneously creates transparency of the data history as a Blockchain block is considered immutable. Thus, contributors (1) are able to trace back past transactions, (2) are secure from hacking through encryption and the absence from a single point of failure due to the distributed nature of the network. As these features – security and trust – are essential to building an ecosystem and attracting stakeholders who are set to interact with each other on a common platform, it is worth looking into the framework model illustrating their relationships.

Blockchain-User Interaction Model

The expected potential of digital twins today is limited by an extremely fragmented IoT ecosystem. A universally adopted distributed ledger platform could help overcome this fragmentation. Blockchains constitute a multi-sided platform, which serves as a transaction platform for a diverse set of parties (data providers & data users), creating transparency and "injecting trust" in the systems and their participants. Blockchain technology resolves one crucial obstacle: interacting only in fragmented IoT ecosystems.

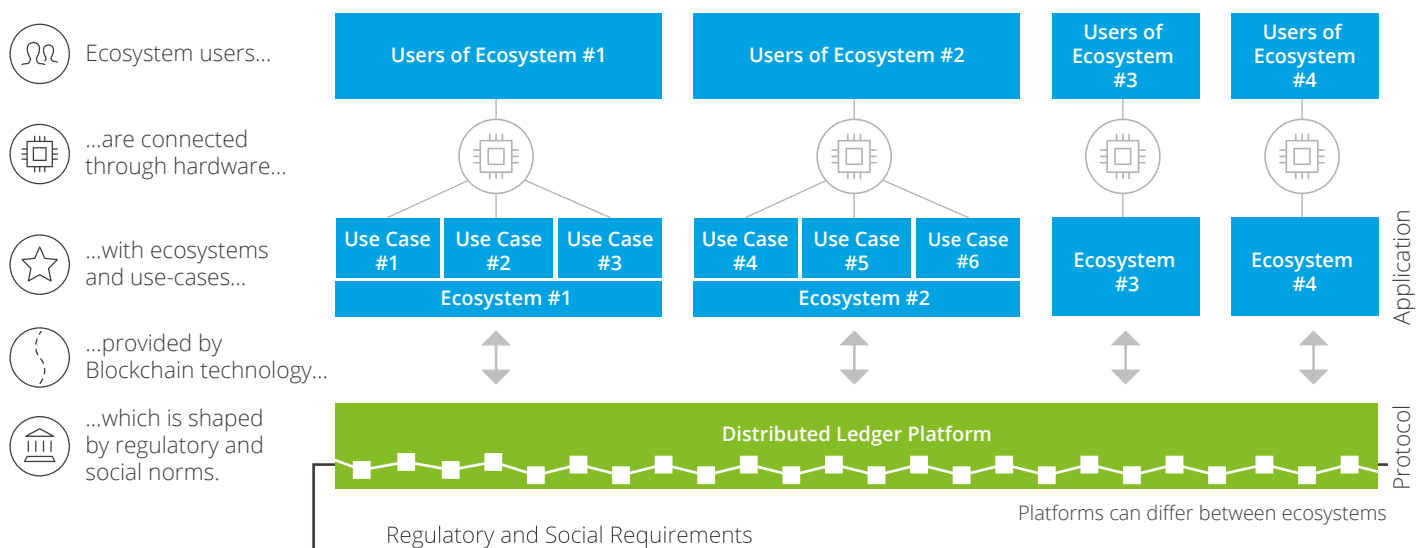
Figure 3 highlights how ecosystems and sub-ecosystems build upon a mutually used distributed ledger platform. It illustrates how the Blockchain-User Interaction

Model unites core components of IoT with Blockchain technology.

Within the application level, a variety of IT components from various ecosystems deliver data related to physical objects and / or real processes and feed their respective digital twins through use case specific APIs.

However, users from Ecosystem #1 are not limited to interacting only with their original ecosystem. By using a compatible protocol and sharing a distributed ledger platform, users may access all connected applications. This is possible due to Blockchain technology, which allows digital twins to be "tokenized" and equipped with smart contracts. Interested parties, such as Big Data companies, may access this data and feed

Fig. 3 – Blockchain-User Interaction Model





it into new, potentially real-time, business models. Using tokens and smart contracts allows different users to decide on individual parameters in terms of pricing, usage or further distribution rights.

Only a user-friendly and efficient platform with an adequate infrastructure provides the necessary convenience and incentive to attract multi-stakeholder interactions. Blockchain is the backbone of such a system. It functions without the need for intermediaries due its peer-to-peer and smart contract capabilities. Further, trust among stakeholders is not a requirement because Blockchain technology offers encryption features and complete traceability of every block.

The Blockchain-User Interaction Model introduces the four major stakeholders, users, regulatory authorities, and technology and infrastructure companies. The foundation of the model is the mutually used platform, populated by users with digital twins, which are accessed for further processing of information. Regulatory and social requirements lay the groundwork for rules on how this platform and ecosystem are to be used. In particular, how smart contracts are enforced or settled if doubts arise and litigations follow can only be solved by involving regulatory authorities. The exchange of data and value using digital twins requires commonly accepted standards, set by globally acting companies, esteemed as authorities in the domain of global protocols.

These standards need to be developed in harmony with users, regulatory authorities and infrastructure providers. The latter are also tasked with providing the necessary bandwidth to meet the increase in user demand for data transmissions within and across ecosystems. By adding Blockchain hardware, such as a microchip, it can be guaranteed that digital twins are created in the chip's secure environment and are stored with cryptographic security. This is necessary in order for multiple parties with non-aligned interests to interact based on the common belief that the data stored in the commonly used Blockchain repository can be trusted. Smart contract-based obligations, e.g. transactions of data and / or physical assets, can therefore be settled due to mutual trust in the Blockchain.

General Requirements and their Benefits

Enabling the Internet of Things with Blockchain technology is an endeavor that requires both financial and human resource commitments from all participating stakeholders. As the value of Blockchains flourishes the most when many stakeholders, even competitors in the same industry, collaborate and build a shared platform, the creation of common ecosystems is of the utmost importance. In general, the following prerequisites must be met:

- The willingness of companies to collaborate, despite different interests, to set up a value-creating platform and to establish market power
- The integration of the Blockchain platform in business processes, including preparing both employees and customers
- Hardware to connect users and company processes with the newly established distributed ledger protocol
- Infrastructure that ensures smooth communication between devices and backs up the decentralized Blockchain platform
- The right choice of platform protocol (e.g. Ethereum, EOS, NEO etc.) and the technical re-alignment towards use cases (e.g. closed vs. open platform)
- Legal regulations that allow the use and facilitation of Blockchain platforms in the respective industry

Crypto-enabled hardware is highly innovative and ecosystem partners will face serious challenges. The further analysis focuses on the following three core require-

ments: (1) the external formation of the ecosystem, (2) the internal realignment of processes and (3) hardware solutions. In addition to this, there are other important aspects, such as application programming interfaces, legal frameworks and protocol standards. Though important, they will not be addressed specifically, as they are the products of, not actors within, participating ecosystem partners.

External Formation of Ecosystem

In order to establish international standards in a global market economy, ecosystem partners are required to function as leaders within their respective markets. The necessity is rooted in the fact that the development of standards requires experience, financial commitment and the authority to convince competitors to adopt a developed standard. Examples in other industries where the formation of an ecosystem took place are e-mobility, car sharing and the insurance industry. Within any ecosystem, different stakeholders collaborate and thus they need to be represented among initial ecosystem partners. For example, without the supporting legislation, no such platform will be used for transactions, and data sharing might not even be legal. Neither corporations nor consumers would take advantage of such a system as long as issues remain unresolved. Consequently and most importantly, initial ecosystem partners are not just fundamentally required, but also have a trendsetting effect and thus are expected to easily attract and convince new participants to join the network.

If the ecosystem is established, all ecosystem partners will reap significant advantages from that collaboration, for example:

- Users and companies will enjoy an increased availability of higher-quality data
- Technology providers will face an increased demand in soft- and hardware to allow the monitoring of information flows
- Infrastructure providers will have the opportunity to increase bandwidth and furthermore establish new business models
- Regulatory institutions will generate new tax revenue streams through taxable transactions provided by participants

Internal Realignment of Processes

Although the commitment of stakeholders to invest in a Blockchain platform is key, it takes further effort to integrate the functionalities into existing operations. This includes but is not limited to transforming current internal processes and business models to be in alignment with the approach of handling data within those new ecosystems.

Ultimately, the parties involved drive developments, either individually or collectively. Blockchain and IoT are still relatively new and thus a lot still needs to be learned: Training courses, workshops and additional support will help to smooth the transformation and strengthen these new approaches at every level inside and outside the company, with vertical integration being a key component.



Finally, transforming a business to support an IoT-powered ecosystem, especially in its early stages, will eventually lead to difficulties that need to be overcome. Any business ought to be aware of the need for cross-functional competences and that generating and sharing lessons is essential at this stage.

If companies succeed in implementing IoT-based Blockchain solutions in their corporations and within their business processes, they will have built the foundation for further, long-term advantages, for example:

- The ability to use the existing platform for further use cases
- Build on the established collaboration with industry participants and also align and simplify contract management processes between stakeholders

Hardware Solutions

Whether IT components and data can be trusted is an important question when developing integrated hard- and software solutions. It is important to ensure only correct data points from trusted sources are entered into the system.

The available solutions require that the same algorithm works with, but is not limited to:

- Near Field Communication (NFC) inlays
- Ultra High Frequency (UHF) transponders
- Radio-Frequency Identification (RFID) labels
- Extended microcontrollers
- Field Programmable Gate Array (FPGA) designs
- Application-Specific Integrated Circuit (ASIC) designs
- IoT gateways & end nodes
- IT component networks and networked servers

The core element is the combination of a crypto accelerator and an active NFC/UHF/RFID transponder. By attaching crypto hardware, which is directly linked to a Blockchain solution, to physical goods, its trusted digital twin allows for secure data transfer, repository and storage solutions. With this, the provenance of any physical good as well as measurements and the history of its usage can be proved and certified. In the future, advances in storage capability will enable applications and wallet functionality to be stored on tags. This could turn any physical object into a wallet and open up new business opportunities, e.g. in the field of autonomous cars.

Interaction with crypto tags is possible via mobile application and NFC. By only using short range NFC communication and its induction energy, an additional level of security is added to the system. Larger files would not be stored directly on the Blockchain but referenced by using hash links. This increases scalability and performance while reducing costs without compromising on user experience. On the other hand, longer distances and higher throughput can be adjusted by using UHF/RFID tags rather than NFC.

Summarized, new hardware solutions offer:

- High flexibility through global standards in microcontroller architecture
- New business model opportunities through universal implementation possibilities
- Use case-specific modifications for higher security (through NFC) or long range communication (through UHF/RFID)
- Unexhausted hardware development allows for further storage improvements and thus extended utility

To allow easier visualization of this abstract model, the opportunities referred to above can be rolled out into tangible examples.

Pilot Projects: Illustrating Further Opportunities

Since 2017, a sharp increase in interest among companies from core industries in developing digital twin concepts that are directly connected to a Blockchain can be observed. To illustrate the broad range of pilot projects and opportunities in this area, two examples will be introduced.

Example 1: Energy Metering The Underlying Issue:

While the new generation of smart meters allows tracking of the energy produced and used by consumers, mechanical meters are still very common. The incompatibility problem among distributors and suppliers can be observed e.g. in the United King-

dom, where no clear standards for smart meters exist. This issue results in hardware losing its "smart" functionality when changing distributor or supplier.

Why Blockchain is a Good Solution:

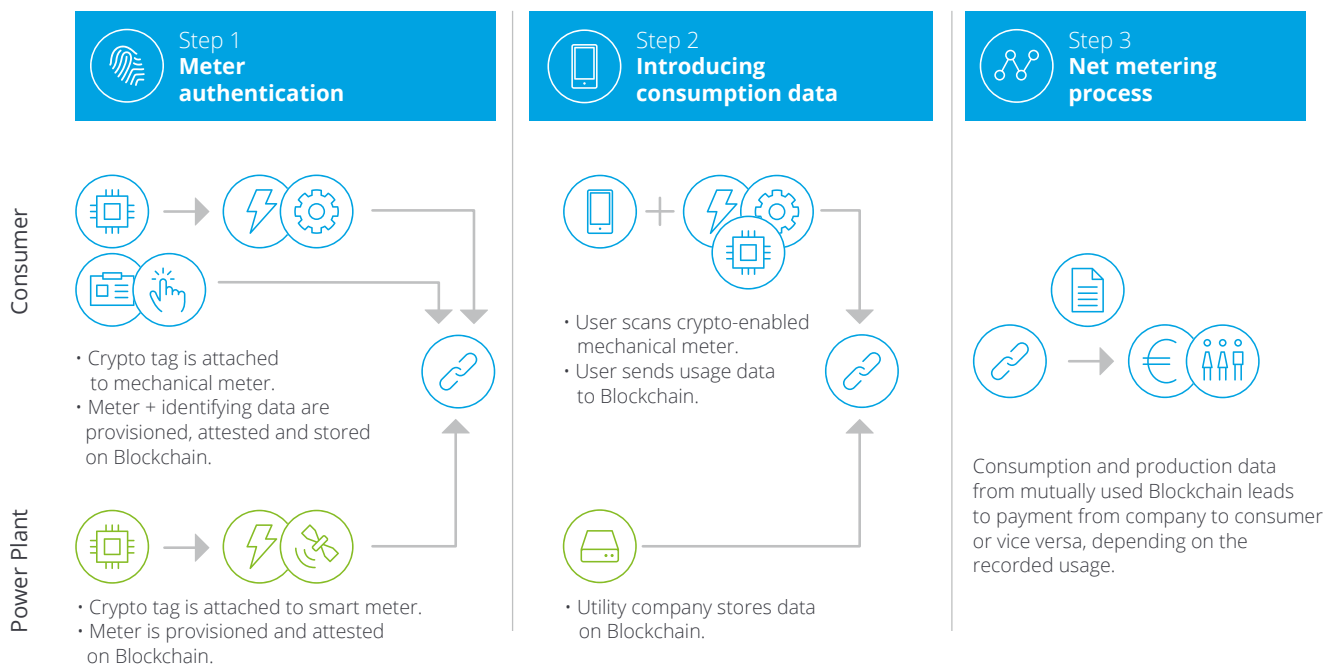
As a distributed ledger, the storage of energy production/consumption data and distribution fees in the Blockchain allows to bring trust and transparency to those settlement processes. Additionally, with an infrastructure of distributed nodes in the network, this solution can help to mitigate the risk of having a central server authority that would act as a single point of failure. Figure 4 shows two connected activity streams for consumers and power plant as an example chain of events when imple-

menting crypto tags as energy metering solution.

Solution Approach & Benefits:

Depending on consumer behavior, production and consumption of energy might fluctuate significantly and adequate information management is not always put in place. Transparency about how much energy was consumed and information accuracy can be improved with crypto tags. Non-removable, sealed crypto tags verify a meter's integrity (untampered nature), and thus create trust in the consumption data provided. Via NFC, the owner, previously authorized via biometric authentication, is able to access the tag data and upload consumption information.

Fig. 4 – Energy metering example



By using this set-up, both utility companies and energy customers can be provided with a secure, cost-effective and scalable solution, enabling them to:

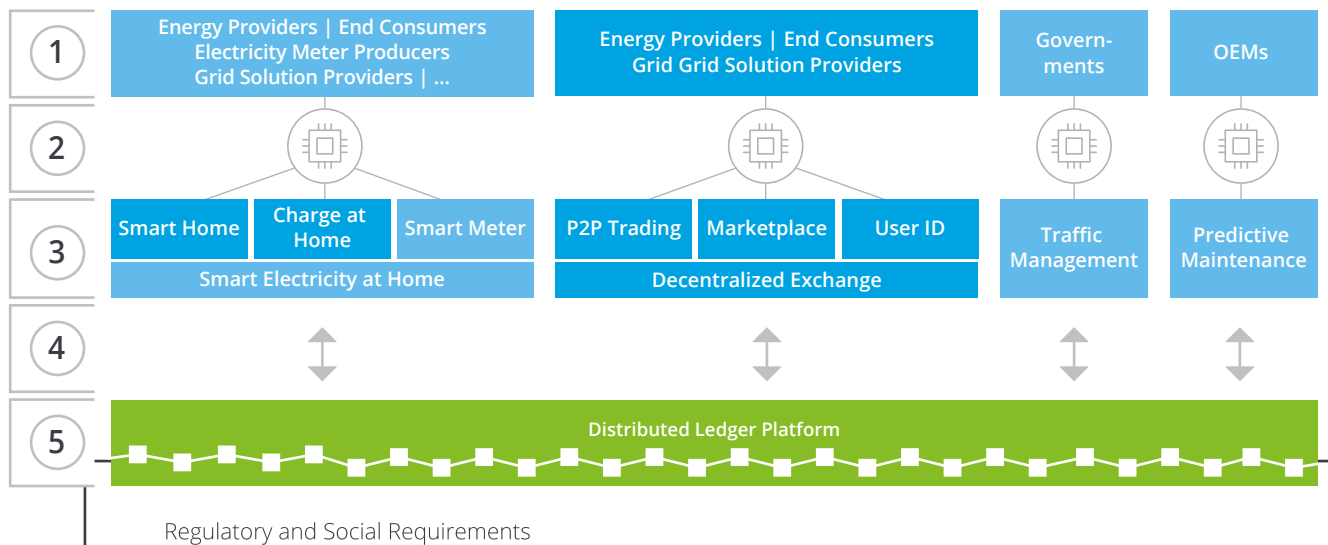
1. Bring together the digital identity of the meter, customers and their smartphones for efficient billing
2. Track data via Blockchain traceability and easily generate awareness of energy consumption
3. Demonstrate the benefits and thus increase the incentive to upgrade legacy IT systems

Using the energy metering use case as an example, the Blockchain-User Interaction Model can be applied as seen in figure 5.

For energy metering and consumer services in general, an industry-specific framework establishes fundamental rights among stakeholders, in this case the protection of consumer data. The infrastructure, specifically used distributed ledger protocol, heavily depends on the requirements of certain use cases. For energy metering, a protocol that combines the use of smart contracts with a large network and open adaption policy is required.

Using application programming interfaces allows for convenient monitoring of energy flows and metering statistics, smart contract agreements and payment options. As figure 5 shows, the connected but separated levels serve different stakeholders and address different requirements.

Fig. 5 – Blockchain-User Interaction Model illustrated with energy metering use case



Detailed Parameters

- | | | |
|--|--|--|
| <p>1 Users</p> <p>Participants using the application, e.g.</p> <ul style="list-style-type: none"> • Energy providers • End consumers • Electricity meter producers • Grid solution providers | <p>2 Connecting Hardware</p> <p>Hardware allowing the application, e.g.</p> <ul style="list-style-type: none"> • Electricity meter • Grids • Crypto tags | <p>3 Applications</p> <p>Established applications with added value, e.g.</p> <ul style="list-style-type: none"> • Smart metering solution to increase transparency and convenience and to establish trust • Built up through smart contracts and mutual agreements among participants |
| <p>4 Infrastructure</p> <p>Chosen protocols as foundation, e.g.</p> <ul style="list-style-type: none"> • Ethereum, EOS, NEO, or other Blockchain protocols • Choice of protocol dependent on use case • Also includes underlying hardware, e.g. servers (mainly as storage, not for communication) | <p>5 Framework</p> <p>Industry-specific regulations, e.g.</p> <ul style="list-style-type: none"> • Consumer data protection | |

Example 2: Logistics

The Underlying Issue:

Many industries suffer from workflows that can neither guarantee (data) efficiency nor transparency, and international supply chains are only one example of an industry that can and will have to benefit from new digital technology innovations.

Apart from securing freight and freight containers, the associated documents such as ownership certificates or bills of lading are also an area that can potentially gain a lot from the use of Blockchain technology. The concept of digital twins can solve two of the most fundamental problems:

1. Ensure that paper documents cannot be forged and can be tracked digitally
2. Enable single freight item packaging to be sealed, allowing for the same level of traceability for single items as for whole containers or pallets along the whole supply chain

Why Blockchain is a Good Solution:

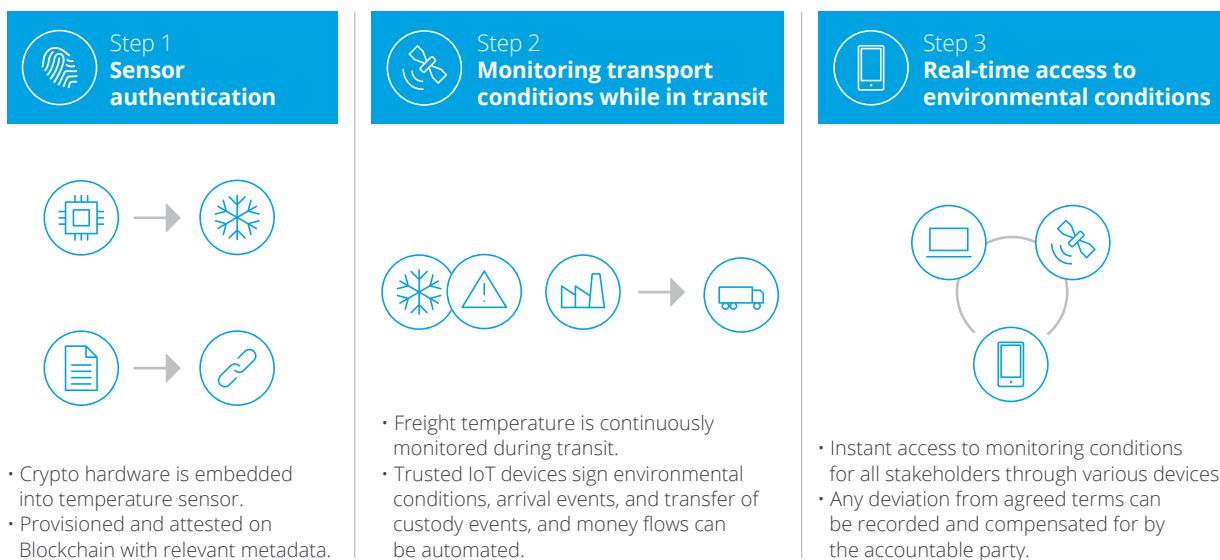
Supply chains can be taken to a higher security level and turned into a trusted and leveled data playing field by the use of digital freight twins and Blockchain technology, which can also benefit from additional and powerful functions such as automated settlements. International shipping logistics may be required to secure either the shipped goods or their packaging.

Blockchain-connected freight containers and related sensors will create a system that is immutable, offers complete traceability and can be equipped with smart contracts to automate processes such as payment executions, e.g. for clearing customs. Combined with crypto-enabled hardware, Blockchain increases security significantly at all levels of supply chains.

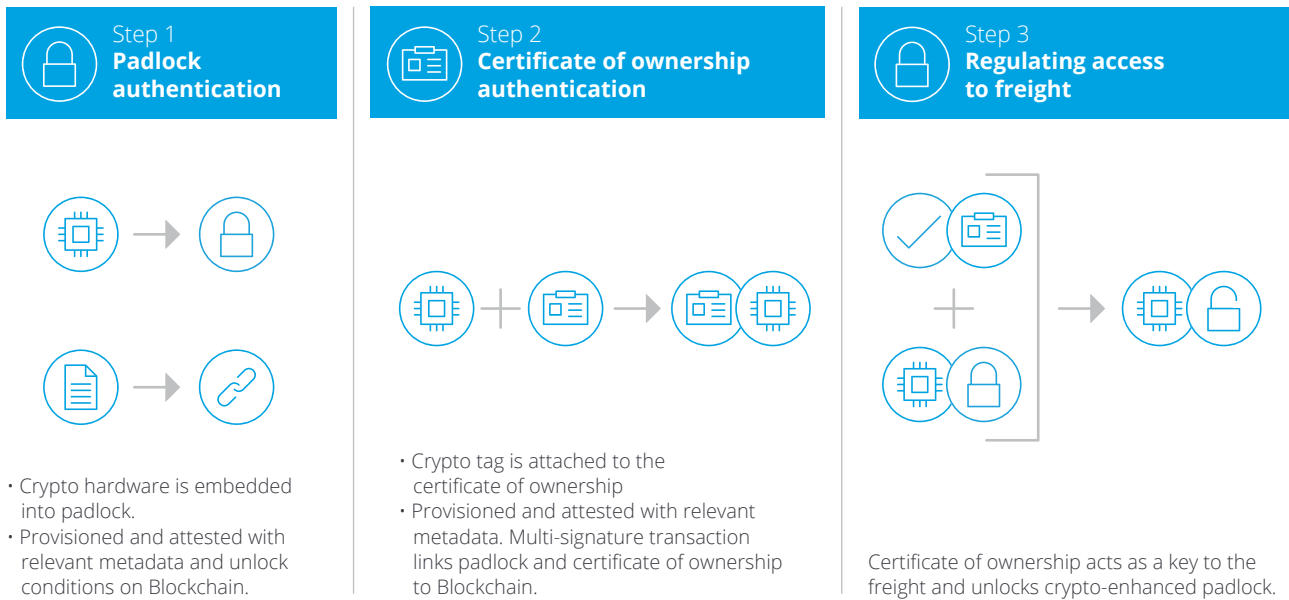
Solution Approach & Benefits:

Using widely adopted technology (e.g. smartphones), adding new soft- and hardware, smart contracts and crypto locks, and releasing all of this in an ever-growing industry, i.e. logistics, will have a huge impact in terms of an increase in efficiency, security, convenience and reliability. By embedding Blockchain hardware into IT components and sensors inside the cargo or into the lock at the door of a shipping container, both the transport conditions and the legitimate access to the freight can be monitored and restricted. At the same time, on the administrative side, the paper workflow can be digitized and corresponding data be made available on the Blockchain.

Fig. 6 – Logistics example 1



Opportunity in securing & blockchainifying all assets of a supply chain: the item itself, its container and related documents on paper.

Fig. 7 – Logistics example 2

Additionally, the level of reliability and security along the transport value chain can be increased by using digital twins to monitor environmental transport conditions and access restrictions based on IDs that are embedded into documents, locks or other physical objects. Only previously authorized parties, e.g. holders of the original freight paper, may then be entitled to open a crypto lock and gain access to the container. This could even be taken to a point that the container can only be opened at a specific GPS position or within a certain period of time. Authentication takes place via smartphone and NFC, which are secure and convenient for users. After unlocking the shipping container, the freight status can be checked and by accepting the delivery, the digital twin changes ownership automatically and smart contracts trigger payments.

Constant monitoring capabilities help to optimize usage of limited resources like cargo space, energy and time. Even a small percentage cost reduction can save

billions in a multi-trillion industry. The end consumer benefits by receiving a delivery that is secured by a seal-like crypto tag and being assured that the provenance of the delivered goods is as intended and the item is unchanged.

The use of different radio transmission standards also helps to manage different stages of a typical supply chain: Blockchain hardware “labels” that work with UHF tags will support rapid data input in warehouse or loading situations, while NFC-enabled crypto tags (seals) will do their job directly on the package or inside paper documents, and can add an additional security aspect since they require physical proximity. The fact that both types of crypto tags can fully work with energy harvesting and do not rely on external power supplies underlines the fact that Blockchain technology is ready for industrial use also on the hardware level.

Conclusion

Both the Internet of Things and digital twins have been around for some time and have become business realities in various industries, e.g. for predictive maintenance in the production environment.

Until recently, implementation faced high technical and economical limitations. As the number of IoT devices grew, these limitations became less relevant, yet for the digital twin paradigm, an underlying platform was still missing. Once this is established, use cases like proof of provenance, track and trace and identity management can be realized, new business models developed and the information value loop fully leveraged.

An IoT ecosystem further allows companies to share, use, buy and sell digital twins and data using provisioned IT components, middleware and analytics.

Distributed ledger technology combines immutability, transparency and security for ecosystem participants. However, setting up this initial platform poses several challenges: Companies aiming to introduce, for example, secure and transparent tracking and tracing tools need to invest in this technology both financially and strategically. New competences need to be built up within an organization, both for hardware and software aspects.

As the added value of Blockchain platforms increases exponentially with the amount of participants, first-movers will embrace the challenge of stakeholder management. This challenge is the deciding factor in the decision-making process on building such a platform and determines who can fully take advantage of this opportunity. Potential gains are not limited to increased transparency, security and efficiency. As mentioned, by attaching a crypto chip, any physical object can be turned into a market place. This transaction capability that every

physical object can be linked to in the back-end is the pre-requisite to empower new business potential:

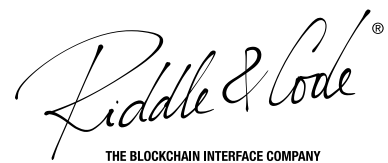
- A new role for banks to act as “custodians” of the new asset class of tokens – allowing for decentralized ownership models such as fractional ownership of physical objects of value
- In the IoT and smart city sphere, digital twins are the backbone of identity required for identity management business concepts
- Within supply chain management and logistics, digital twins support the transition from fixed ownership to flexible on-demand models for equipment

In order to assess the impact of this upcoming paradigm shift, companies have to be aware of their position within this ecosystem and how they want to contribute: Are they data providers or interested in acquiring data? What Blockchain infrastructure is required in order to achieve the desired level of cross-industry efficiency for them? Do they have the technical capabilities to provide adequate hard- and software or can they outsource this and mainly focus on establishing a Blockchain-based ecosystem? Industries and companies have yet to define how to adapt and embrace the challenge and new business opportunities.

As this Point of View shows, IoT enables digital twins and by leveraging Blockchain and understanding the prerequisites and operational challenges of implementing these technologies, companies can start building their future business strategies. Not only will existing processes be more efficient, but also currently unknown business models will emerge and re-shape global industries.

blockchain INSTITUTE

The Blockchain Institute in Germany is a cross-functional entity within Deloitte that focuses on innovative solutions based on distributed ledger technology. The institute covers all industries and is tightly connected to the EMEA and Global Deloitte Blockchain teams. It combines the firm's technological, industry and strategic knowledge to collaborate with a wide range of clients and partners, including technology providers and startups, universities, industry players and regulatory institutions.



RIDDLE&CODE is Europe's leading company for Blockchain interface solutions, specialized in innovative, cryptography-enhanced hardware devices combined with perfectly tailored software solutions. Its hard- and software stacks enable companies to master the challenges of our digital society such as machine identity, product provenance and supply chain management. Based in Austria, RIDDLE&CODE is currently one of only a few companies world-wide to have succeeded in combining Blockchain/cryptography at both software and hardware level. The company was recognized with various awards for its technology. RIDDLE&CODE is founding member of the Trusted IoT Alliance aiming to create a secure, scalable, interoperable, and trusted IoT ecosystem.

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