THINK TANK FOR INDUSTRIAL RESOURCE STRATEGIES

BLOCK CHAIN TECHNO LOGY

FOR INDUSTRIAL PRODUCTION AND THE DIGITAL CIRCULAR ECONOMY

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A sustainable, all-encompassing closed loop economy as envisaged in the European Circular Economy Action Plan hinges on the availability of data and information about natural resources and materials in all areas of product and service life cycles. In the process of industry's digital transformation, also known as Industry 4.0, an extensive body of digital data about processes and products is now available for the first time. It constitutes a so-called digital twin, which virtually replicates the real world.

As one of the leading industrial regions, Baden-Wuerttemberg is making extensive efforts to push ahead with digitalization and the digital transformation of its economy. I also hope that this process will play a significant role in achieving our environmental goals for the region. Our regional strategy for resource efficiency is therefore aimed at divorcing economic growth from the consumption of resources and turning Baden-Wuerttemberg into one of the country's most resource-efficient regions. Along with partners from industry, we have therefore founded the Industrial Resource Strategies THINK TANK.

I am therefore delighted that the THINK TANK's first publication focuses on the possibilities of blockchain and distributed ledger technology, which currently ranks as one of the most exciting and promising digital developments. In terms of industrial production and the circular economy, it unlocks process improvements, security and transparency in the supply of raw materials, the efficient use of products and better return of materials to the loop. Putting this into practice is one of the challenges that the THINK TANK aims to tackle.

Franz Untersteller, Member of the Landtag
Minister of the Environment, Climate Protection and the Energy Sector Baden-Wuerttemberg

Companies bear responsibility. They need to comply with environmental and sustainability standards and ensure that they are upheld and maintained across the supply and value chain, in which statutory regulations and ethical obligations apply. What has been lacking so far is a good, simple and at the same time, reliable means of communicating the underpinning data across the chain.

Every party has data, maintains them and maybe even passes them on. Employees spend days gathering information in answer to customer requests, which costs time and money and is unproductive.

This project is aimed at optimising the data and information flow between the various stakeholders along the supply and value chain. Digital technologies help the manufacturing industry to improve its processes while keeping its industrial secrets. We also identify opportunities for waste recycling. The circular economy and, in turn, resource efficiency would be strengthened.

We believe that blockchain technology can become a sustainable win-win solution for all stakeholders.

Thomas Mayer
Chief Executive Officer and Chairman,
VCI (German chemical industry association),
Baden-Wuerttemberg chapter
Chairman of the Advisory Board, Industrial Resource Strategies THINK TANK

Foreword

Connected thinking and digitalisation have made considerable advances in recent years. In the age of the internet of things and Industry 4.0, increasing digitalisation and the transformation processes related to it must also be viewed in terms of sustainability. The Industrial Resource Strategies THINK TANK, co-initiated by the regional government and industry, plays a key role in this endeavour. The role of this institution, the only one of its kind in Germany, and to which the LVI (Baden-Wuerttemberg Industrial Association) is a major contributor, is to provide politicians and industrial companies with scientific advice on raw material and resource efficiency issues. It will play a significant role in addressing the challenges of industrial transformation in terms of the supplying, availability and securing of raw materials and their transparency for the innovation hub of Baden-Wuerttemberg and beyond.

One of the first subjects the THINK TANK is addressing is blockchain technology for industrial production and the digital circular economy. As Germany's No. 1 innovation region, it is particularly important for Baden-Wuerttemberg to deploy this technology where it generates added value. Demonstrating its importance and drawing companies' attention to the opportunities it unlocks is therefore vital. The LVI advocates the responsible use of this technology, which can be deployed to enable our hidden champions and market leaders in Baden-Wuerttemberg's high tech community to continue shaping their business models along sustainable lines.

Wolfgang Wolf, Honorary Senator
Executive Board Member of the
Landesverband der Baden-Wuerttembergischen Industrie e. V.

Foreword

Access to raw materials, their efficient extraction, use and cycle management is essential to industry-driven economies. Raw material markets are coming under increasing pressure due to the growing world population, intensive technological developments and the advancing industrialisation of emerging countries. The path to an industrial society that husbands its resources must therefore be paved by a development that takes into account both the material needs of people and ecological and social consequences. Such an endeavour requires a concerted effort on the part of industry, science, politics and civil society. Towards this end, political and industrial partners founded the Industrial Resource Strategies THINK TANK in 2018, establishing it at the Karlsruhe Institute of Technology. As an independent pioneer addressing technological and strategic issues relating to resource efficiency, use and policies at national and international level, the Industrial Resource Strategies THINK TANK engages intensively with the deployment of new technologies to minimise resource consumption and maximise resource efficiency. One particularly innovative approach involves the use of digital technologies that unlock various opportunities to monitor data on raw materials throughout their life cycle (blockchain) and digitally display products during development (digital twins). Drawing on industrial practice and scientific insights, this book, entitled "Blockchain Technology for Industrial Production and the Digital Circular Economy" provides a comprehensive overview of the possibilities for applying blockchain technologies in the extraction, processing, use and cycle management of raw materials.

Prof. Dr. Thomas Hirth
Vice-President for Innovation and International Affairs, Karlsruhe Institute of Technology, and Spokesman of the Industrial Resource Strategies THINK TANK

Introduction

While blockchain is almost a buzzword, the term distributed ledgers is less familiar, and cryptotechnology fits in somewhere, too. Is it to be dismissed as just another hype? Revolutionary, disruptive, promising at the very least, only to be soon forgotten in our fast-paced times? Or, as some experts predict, the next big thing after the internet?

However you rate it, one thing is sure: the subject of blockchain attracts lively interest. Though reported on in many publications, few people actually understand it. Its relevance for every single one of us, its potential for industry, administration and not least, for society is grasped by even fewer. Anyone wishing to seriously engage with societal digital transformation, Industry 4.0, the internet of things (IoT), internet of services (IoS) or digital twins, must also tackle blockchain and all it entails.

This brochure aims to explore the use of blockchain and distributed ledger technology in relation to raw material and material flows and resources, from mining to smelting, production, use and recycling or disposal.

We look at existing substantial information flows and data along value chains and life cycles and make a bold attempt to provide an overview of emerging business models and a new stakeholder scenario.

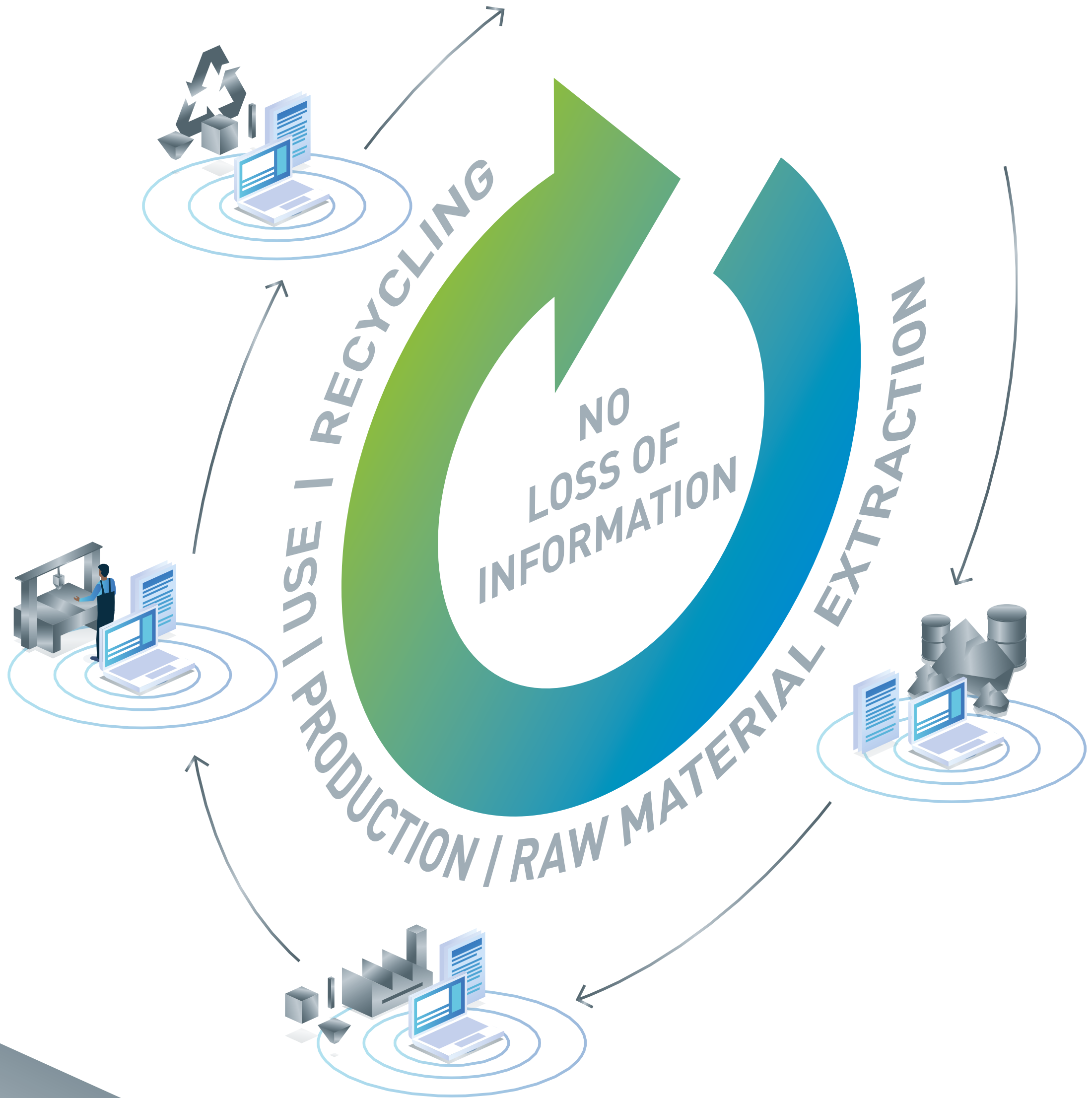
In an easily understandable manner, we aim to present the subject, spark your interest and stimulate ideas on how to use the opportunities unlocked by this technology. We look forward to receiving your feedback.

Dr. Christian Kuehne
Director
Industrial Resource Strategies THINK TANK

Blockchain – an innovative approach for the environment

Text: Prof. Dr. Mario Schmidt – Pforzheim University

Making optimum decisions



The following quotation, here in abridged form, is ascribed to British physicist Lord Kelvin: "If you cannot measure or express in numbers what you are speaking about, your knowledge is meagre and unsatisfactory; in your thoughts, you have scarcely advanced to the stage of science." Yet measuring alone is not satisfactory, either. Once harvested, data needs to reach points where it prompts action, such as decisions to buy on the part of consumers, adjustments in product design by product developers, changes in supply structures by purchasers, sorting and recycling waste flows by disposal companies, monitoring by enforcement authorities and so on.

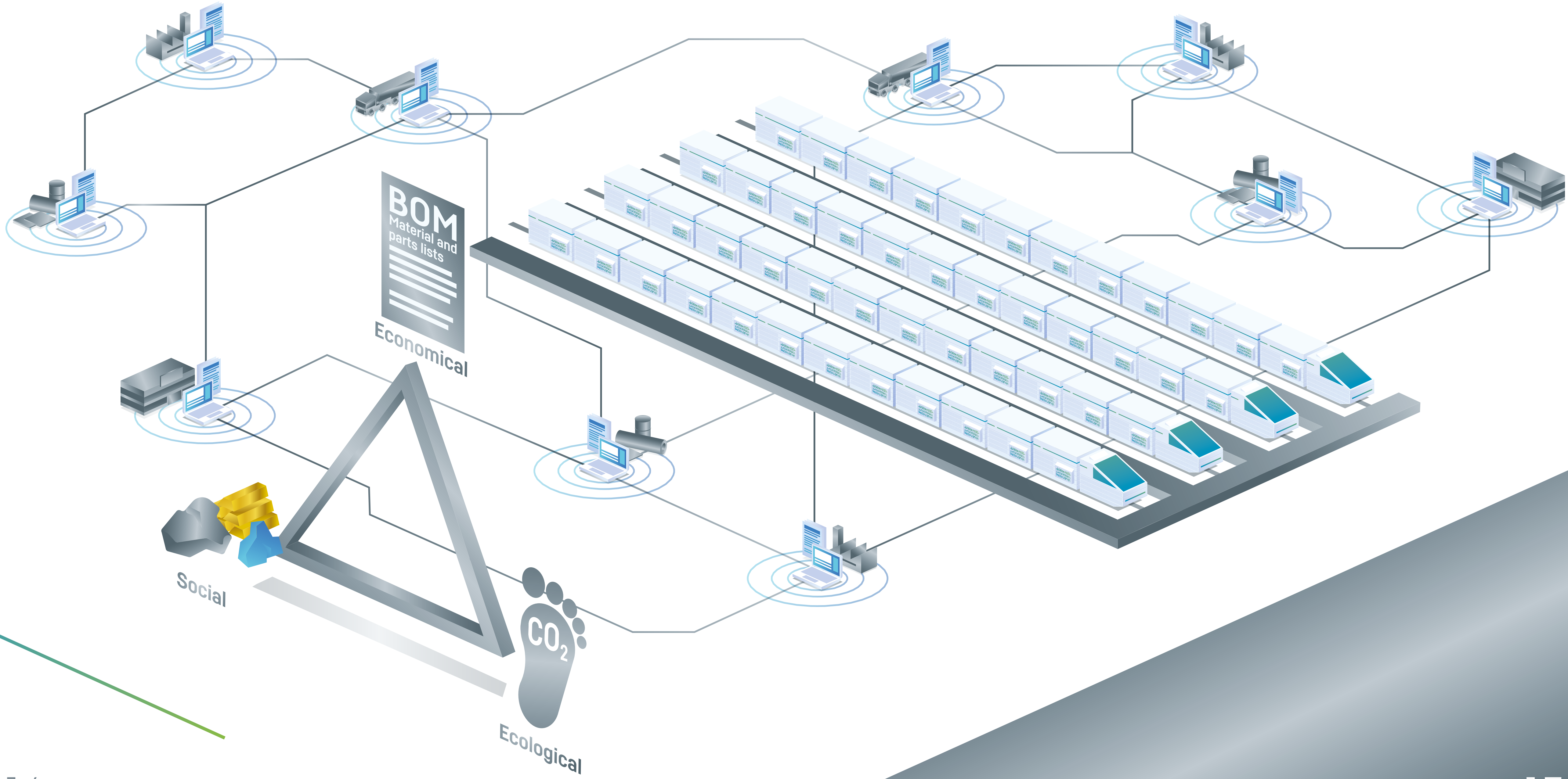
All these stakeholders are dependent on information that arises in a complex global production and consumption network. Dozens, sometimes hundreds or thousands of stakeholders are involved in each product and service. Today, an average car consists of up to 10,000 individual parts from different suppliers around the globe. They all know something about the product or service, but mostly only an inkling that is soon submerged in the confusion of global production networks. Manufacturers of finished products rarely have any idea of what is inside purchased parts, or how and in which environmental and social conditions they were produced.

This common ignorance and information loss results in sub-optimal decision-making on important matters: How best to dismantle end-of-life equipment? Which valuable materials might be re-used? Where are hazardous substances and environmental toxins concealed? What does the product's (social) life cycle assessment look like?

Current tools and methods available in the ICT sector can help to secure and pool this information and supply it in an appropriate form to those stakeholders who need it to make important decisions, or even to develop new business ideas. The aim is to reduce environmental impact, and to save and manage natural resources more sustainably. These goals, too, have long been globalised. The greenhouse-related emissions caused by a product can occur at production facilities anywhere in the world. The precarious social conditions related to the extraction of raw materials or the manufacture of products exist thousands of kilometres away from consumer markets. Even end-of-life electronic products from Europe are dismantled in Asia or Africa.

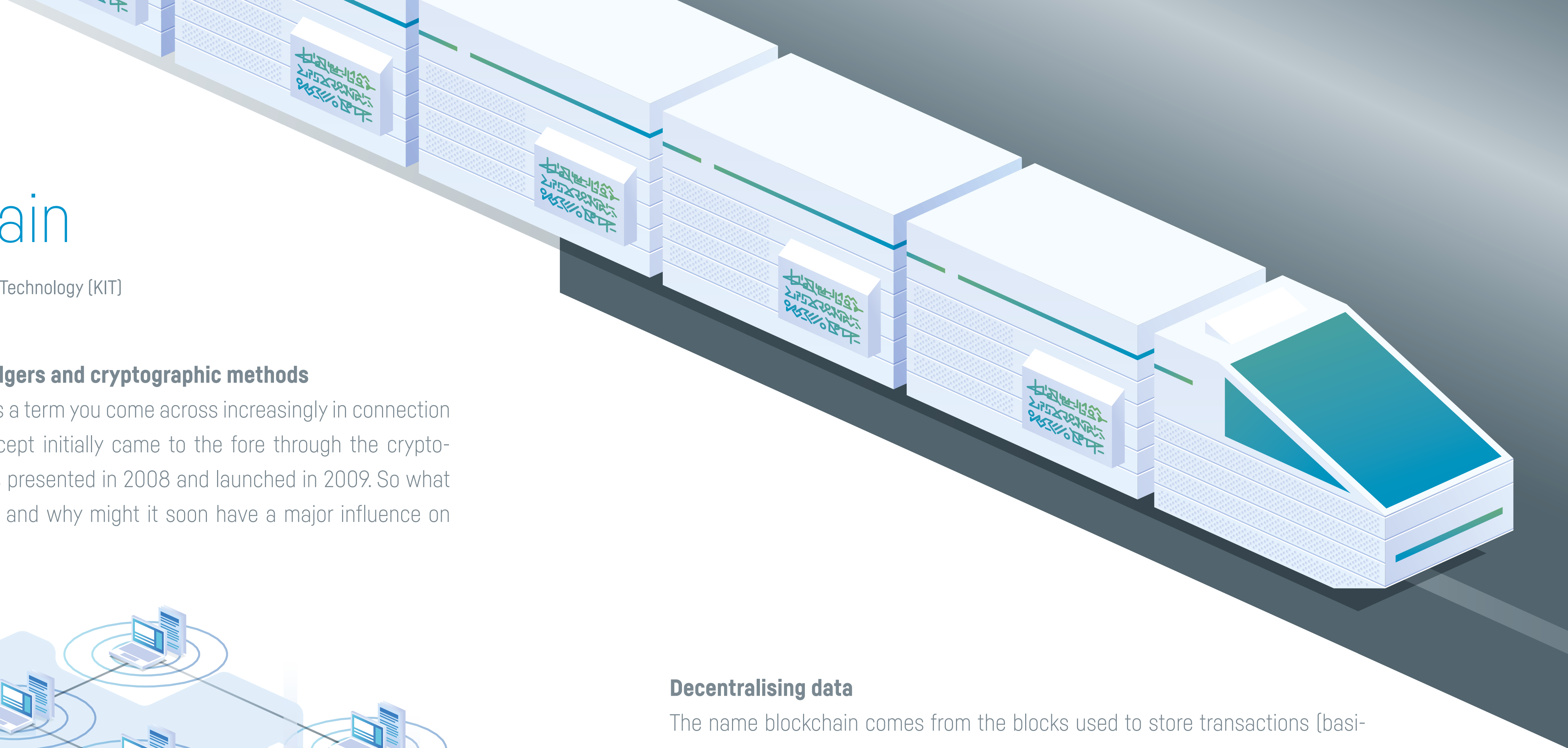
Sustainable blockchain solutions are aimed at the intelligent, targeted organisation of scattered knowledge which already exists in our global production and consumption network. On the one hand, stakeholders' legitimate interest in confidentiality must be observed where industrial secrets, formulas and sensitive supplier structures are concerned, and on the other, ecological transparency for the finished product is demanded. Not every piece of information is significant to every addressee, and access to some information should even be reserved for certain groups only. This calls for a system of graduated and reliable access rights, as well as a guarantee that the stored information is true and reliable. This precisely is the advantage of the innovative processes that underpin the blockchain idea.

Blockchain – like a locked train



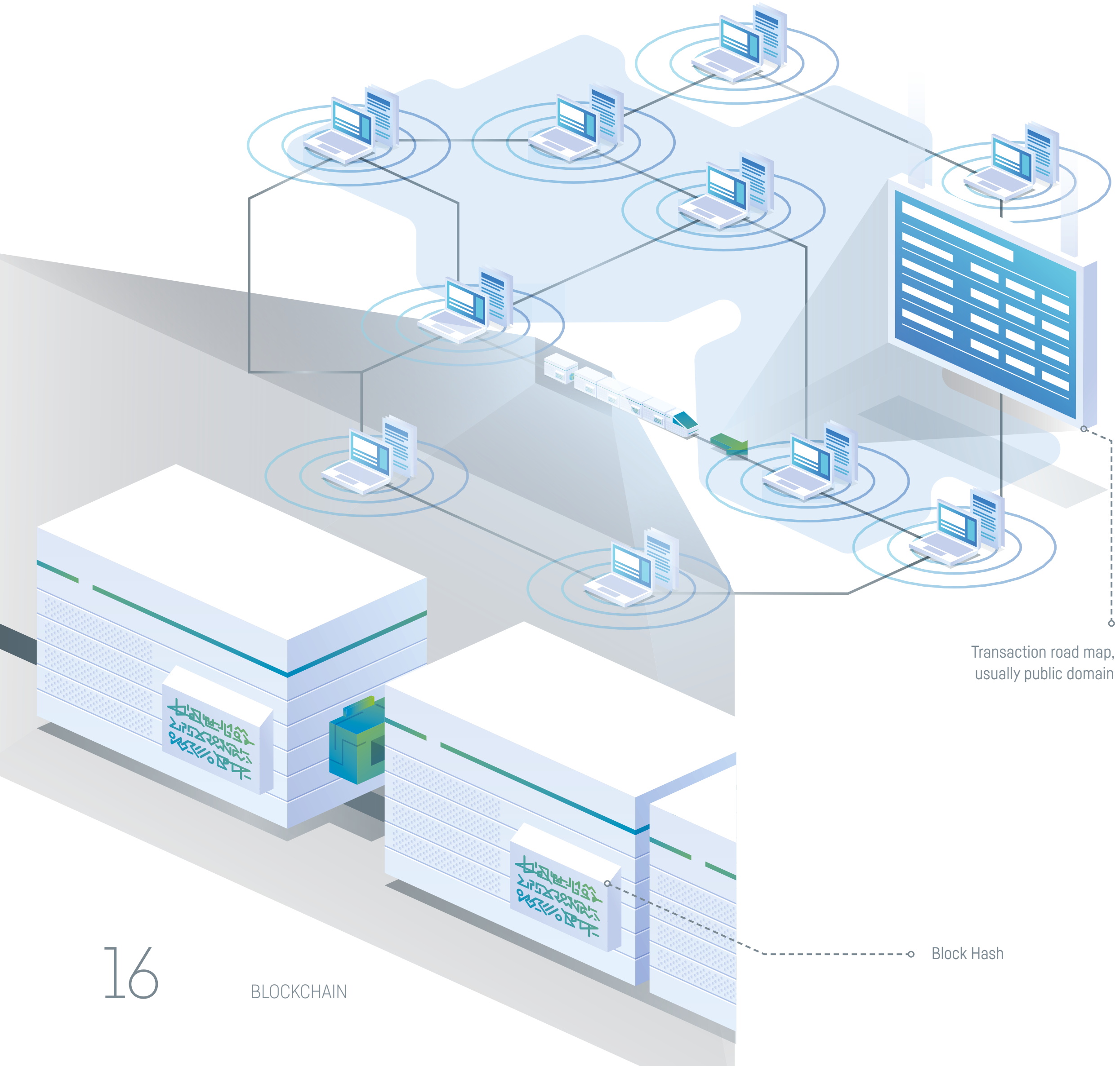
Blockchain – like a locked train

Text: Prof. Dr. Ali Sunyaev – Karlsruhe Institute of Technology (KIT)



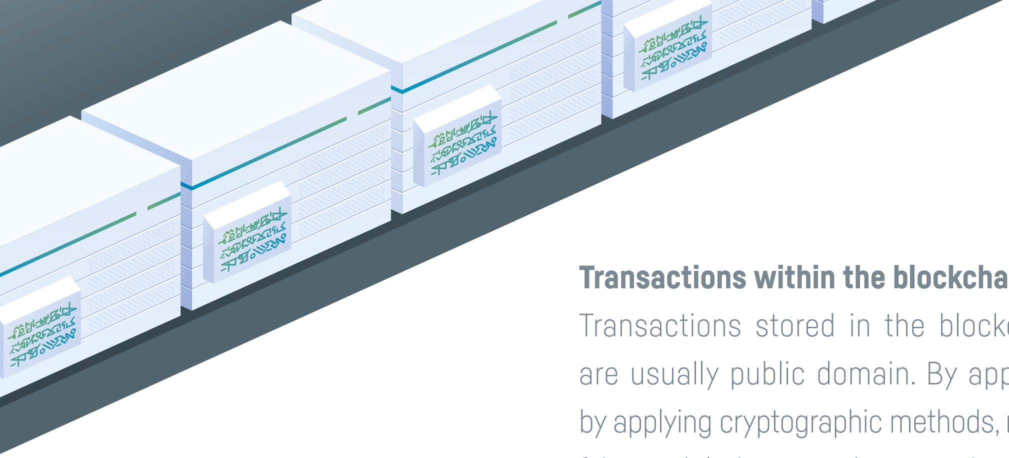
Blockchain, distributed ledgers and cryptographic methods

In recent years, blockchain is a term you come across increasingly in connection with digitalisation. The concept initially came to the fore through the crypto-currency Bitcoin, which was presented in 2008 and launched in 2009. So what is blockchain in actual fact, and why might it soon have a major influence on our daily lives?



Decentralising data

The name blockchain comes from the blocks used to store transactions (basically the documentation of data transfers, which can then be associated with assets) and which form a chain structure. This is a data storage concept that comes from distributed ledger technology (DLT). DLT is the underlying technology, the main purpose of which is to establish a consensus between nodes in a system, although nodes may be temporarily unavailable or some may even try to incorporate fraudulent or incorrect data, which are also referred to as Byzantine faults. In DLT, these issues were solved by using game theory concepts like the Byzantine Generals Problem. DLT is therefore considered as being Byzantine fault-tolerant. A decentralized digital infrastructure prevents dangers that occur in centralised infrastructures including, for example, what is technically called a single point of failure. Given the failure (point of failure) of a central system accessed by many other services and which are naturally strongly dependent on it, not only the system is affected, but all the other services as well. DLT eliminates dependency on a central unit.



Transactions within the blockchain

Transactions stored in the blockchain are usually public domain. By applying by applying cryptographic methods, modifying or deleting stored transactions at a later date is almost impossible. A single DLT transaction always contains the addresses of the sender and recipient, but also other original data, which has to be transmitted and provided in its uncorrupted state. Usually, every transaction has at least one predecessor and can have several successors that always have to be linked to the predecessor transaction. This chain can be used to trace the destinations of the individual data.

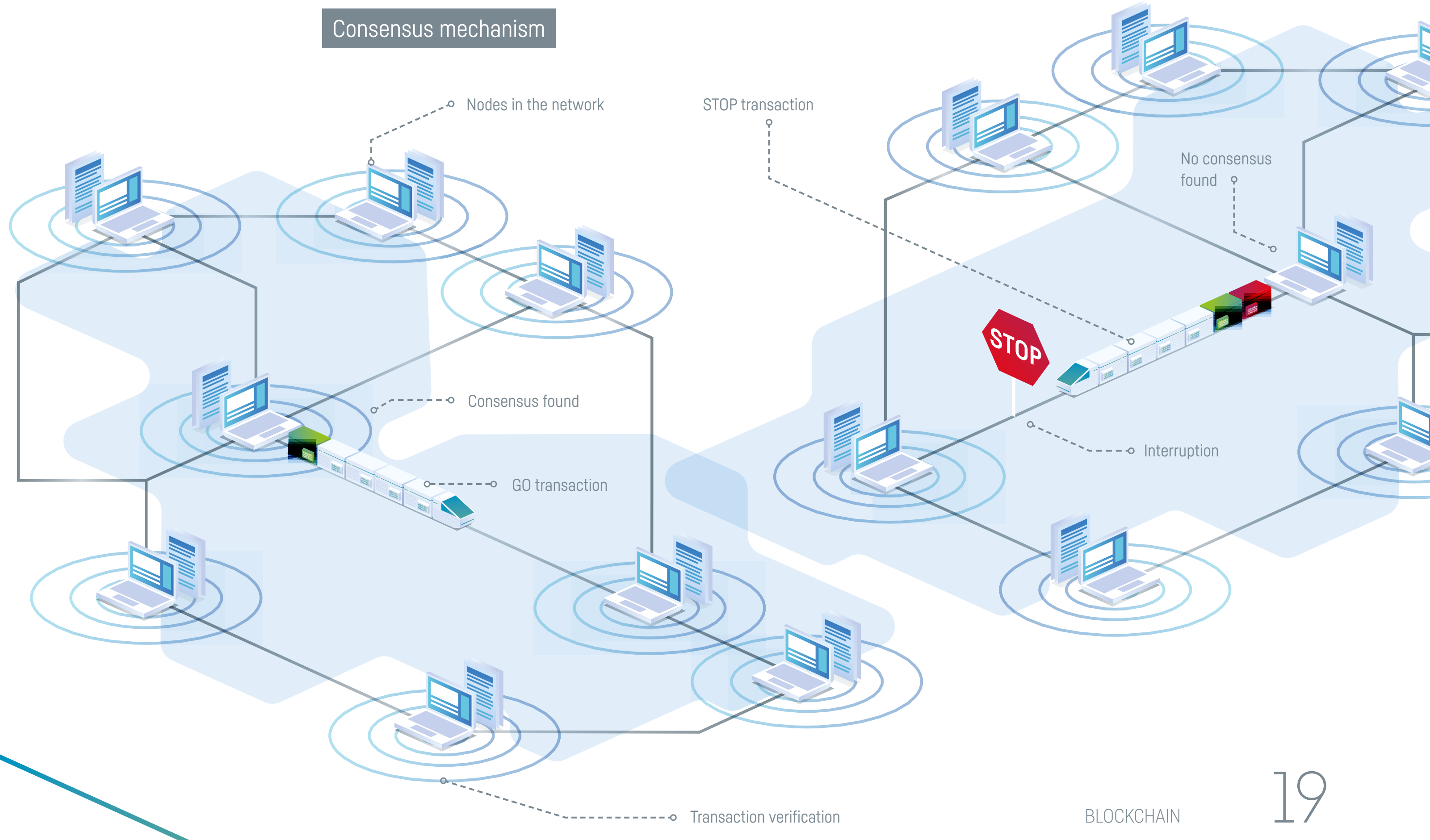
Transparency

Currently, many processes require the presence of a trusted third party or so-called intermediary. Intermediaries can also be found in technical areas, with providers of cloud platforms or social networks, whose behaviour is often not transparent to consumers. Users of services like Facebook, Google+ or Twitter have little chance of tracking which data are collected and how they are processed and stored. Blockchain technology makes controlling the use of their data easier for individuals and improves transparency. In this case, blockchain-based identity management should be used.

Data security: tamper-proof methods

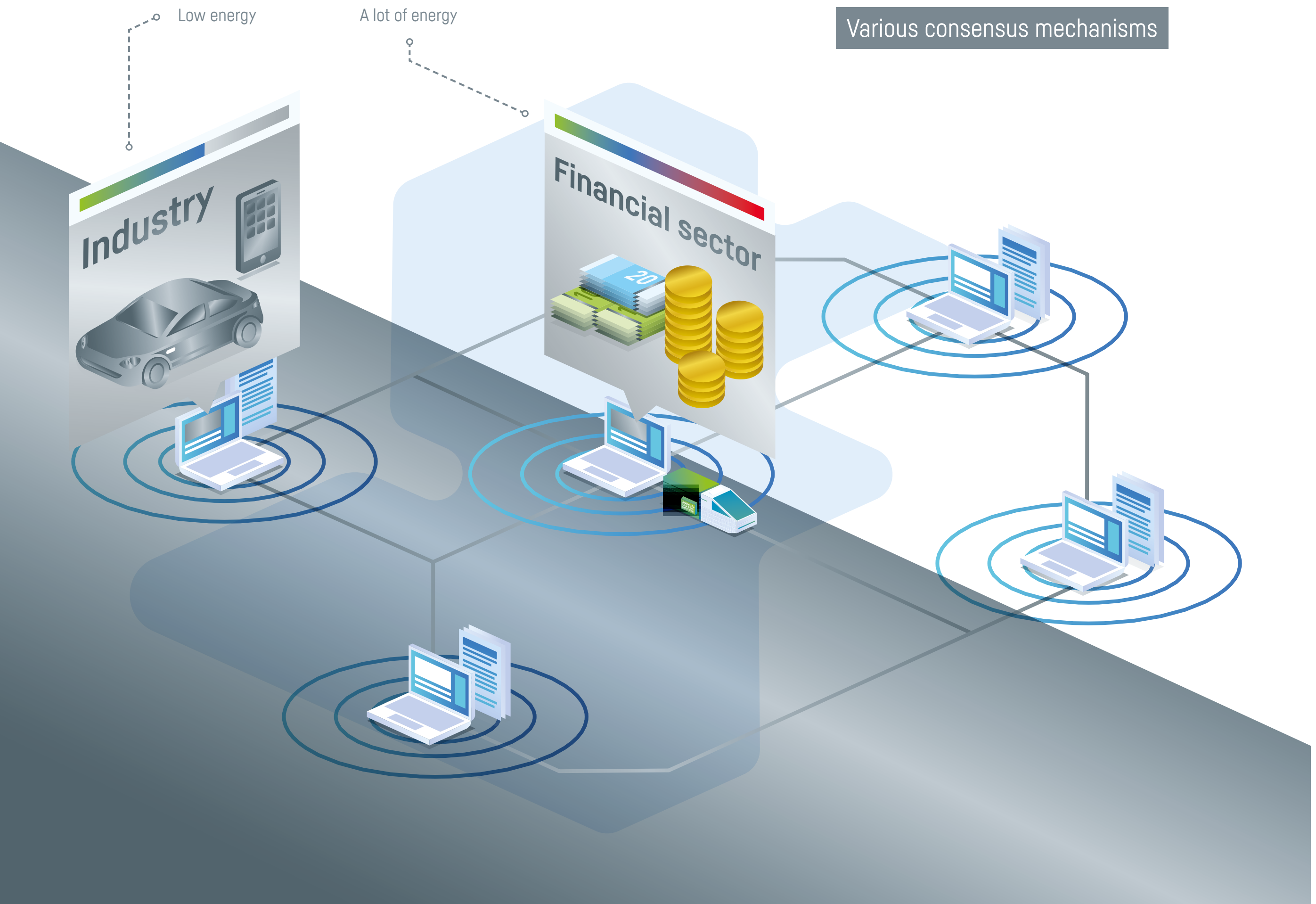
Each new transaction is forwarded to all computers in a node. Each of these nodes checks the validity of the transaction. Until 2008, checking was dogged by the unsolved problem of multiple forwarding of the same data (also known as the double spending problem) in a completely decentralised system without an intermediary (such as a bank). Blockchain has solved the double spending problem on a purely algorithmic level and eliminated the need for an intermediary. A vital element of this solution is the so-called consensus mechanism, which synchronises the various nodes to reach consistency in the distributed ledger. Currently the most common consensus mechanisms are based upon proof of work. In it, the nodes need to generate a random nonce that fulfils a specific requirement, a task that requires a huge amount of energy and computing power. The first node whose random nonce satisfies this requirement is rewarded for its efforts (energy and computing power).

Consensus mechanism



Mining is the term used in blockchain technology to describe participation of nodes in a consensus mechanism by guessing a nonce as a proof-of-work to propose the next block to be appended to the ledger. Participating in the consensus mechanism requires the use of certain resources (memory capacity, electricity and so forth). A monetary incentive, usually coins, is used to motivate users to take part in the consensus mechanism in return for expending resources.

Further consensus mechanisms are available which are considerably more efficient, in that they are significantly less time and power-consuming.



Various consensus mechanisms

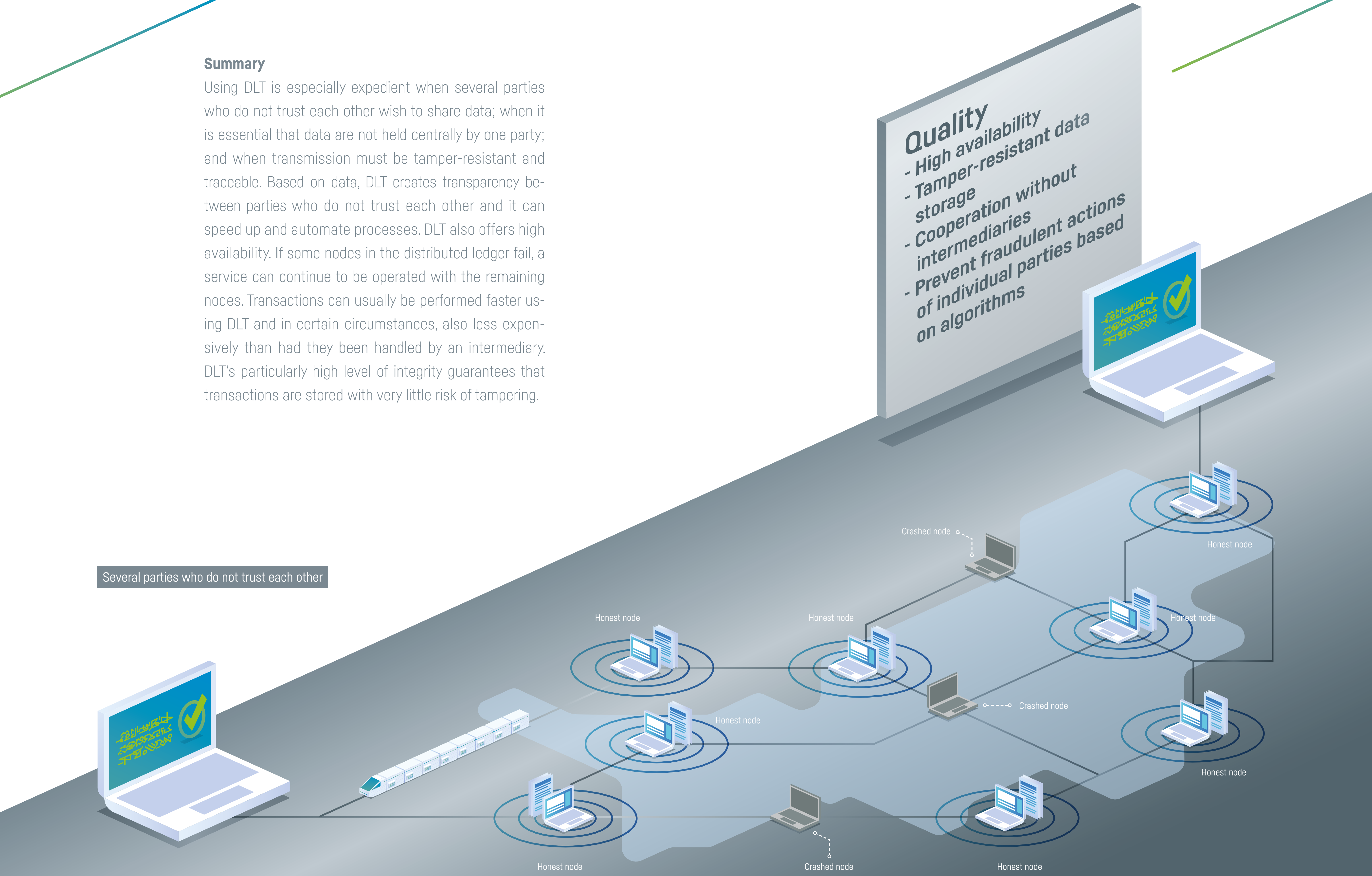
Data security: access protection

To secure assets stored on the blockchain from unauthorized use, public key cryptography is employed. Users must first confirm that they are entitled to access transaction data in order to make a transaction. Digital signatures are used in this case. Digital signatures are created using a private key and data set (a transaction, for example), which has to be signed. The digital signature is unique and can be verified via the user's public key. This way, it can be ensured that a digitally signed transaction was indeed created by a specific user.

The digital signature enables verification of which user is entitled to assign a successor to a transaction, or in other words, is allowed to pass on transaction data.

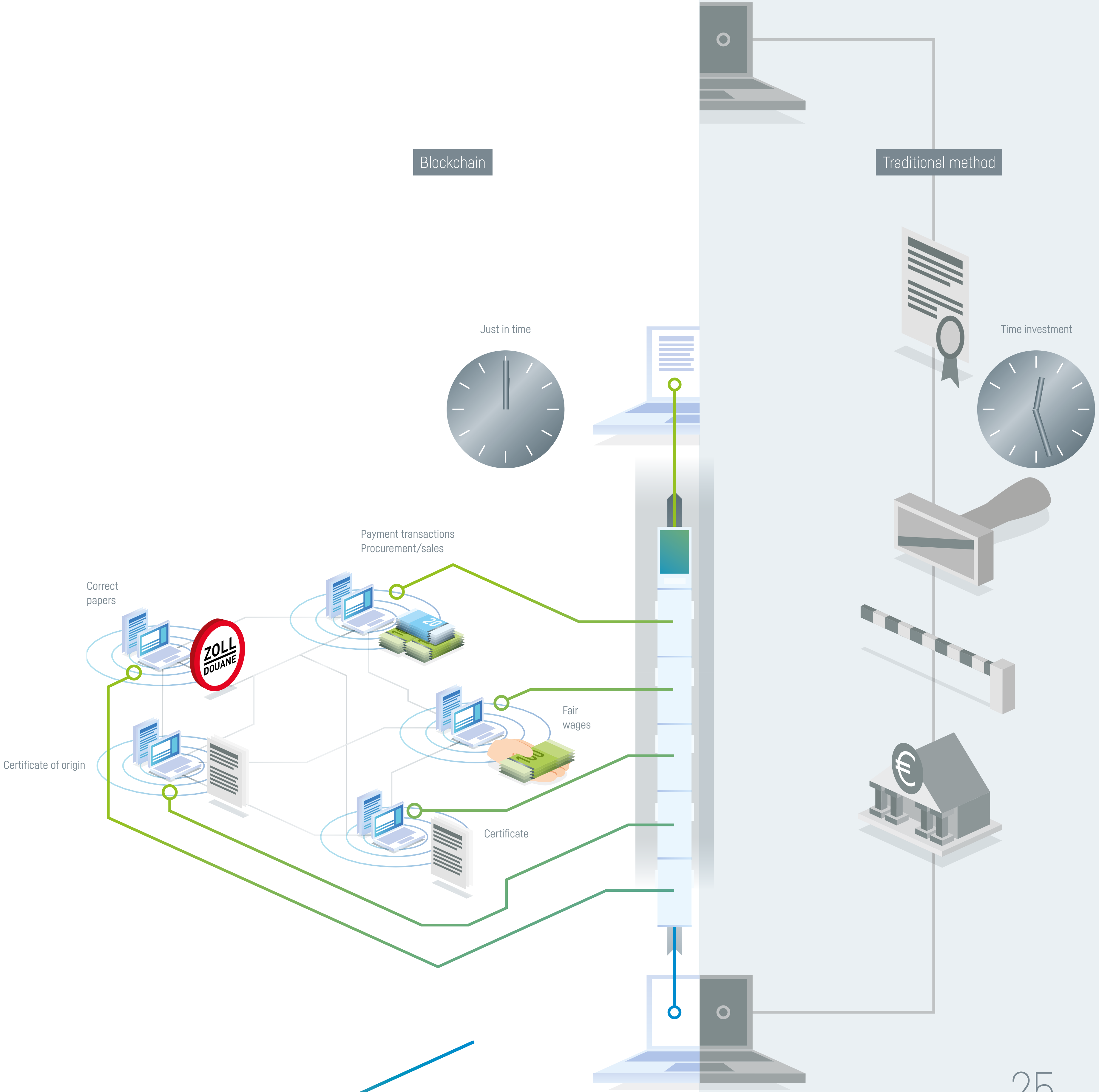
Summary

Using DLT is especially expedient when several parties who do not trust each other wish to share data; when it is essential that data are not held centrally by one party; and when transmission must be tamper-resistant and traceable. Based on data, DLT creates transparency between parties who do not trust each other and it can speed up and automate processes. DLT also offers high availability. If some nodes in the distributed ledger fail, a service can continue to be operated with the remaining nodes. Transactions can usually be performed faster using DLT and in certain circumstances, also less expensively than had they been handled by an intermediary. DLT's particularly high level of integrity guarantees that transactions are stored with very little risk of tampering.



Possible applications

Current discussions focus on making it feasible for DLT to support business and government processes. On a larger scale, transmission of intellectual property to a distributed ledger might even be recorded and performed in real time. In supply chain management, DLT can be used to store data reliably with almost no risk of manipulation and to digitise transmission protocols. DLT-based documentation of this nature already enables checking of whether a raw material is a conflict mineral, for instance.



For more complex applications great store is set by smart contracts. These smart contracts contain machine-readable sets of rules that are stored on a distributed ledger with a fixed address. They can directly access data stored in the distributed ledger and request data from external services. Smart contracts let users define third-party access rights to their private data such as access to their medical records by doctors conducting medical examinations. DLT and smart contracts can also improve the security and transparency of communication between machines in the internet of things and access management on the machinesthemselves. In the future, for instance, electric cars might pay automatically for charging their batteries by using a cryptocurrency.

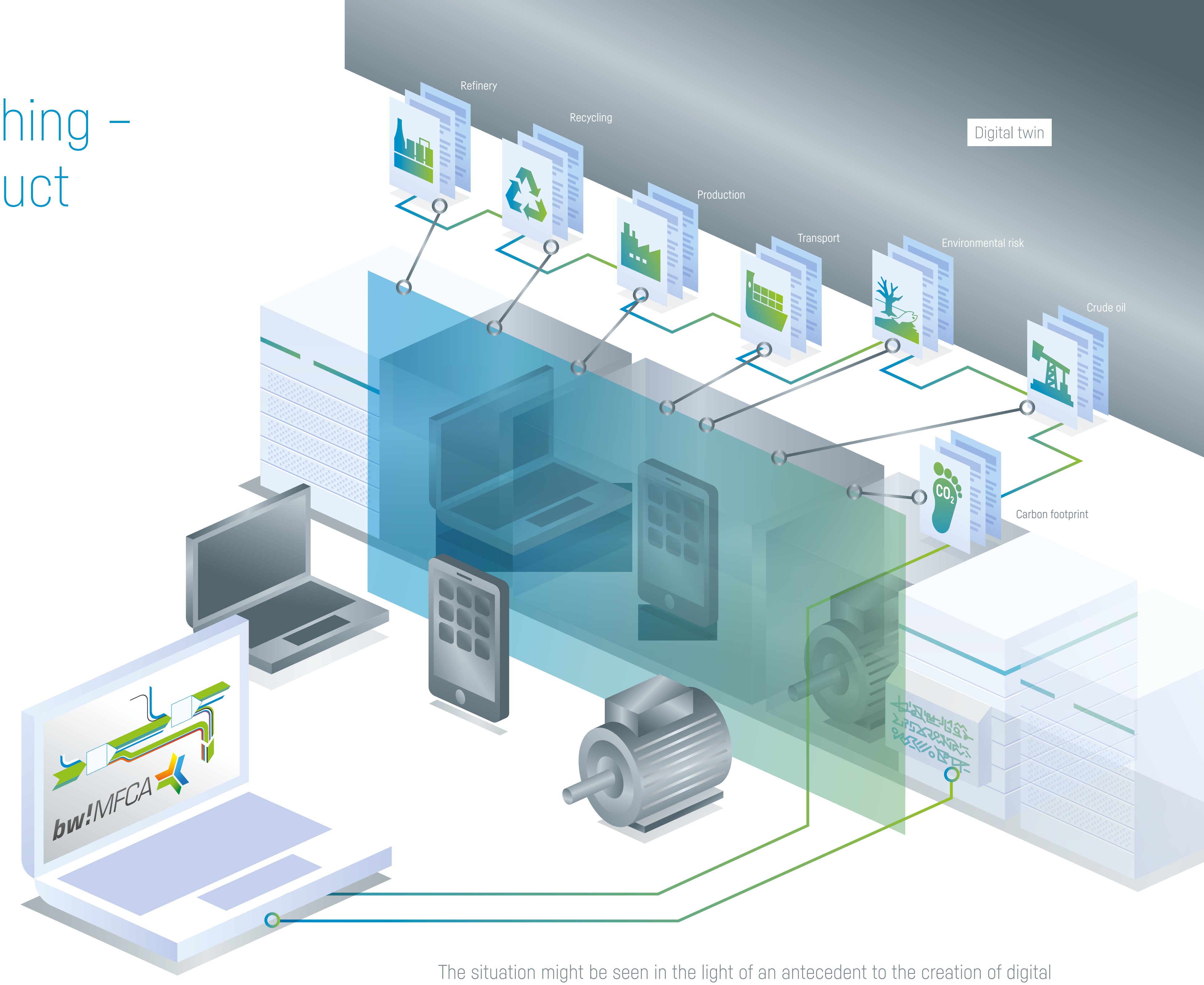
There are countless application areas and scenarios in which DLT (can) afford a promising contribution to the security and transparency of numerous systems. It is already clear today that in the near future DLT will prompt a significant structural change in existing processes and support us in our daily lives.

Digital twin of everything – the transparent product

Text: Prof. Dr. Mario Schmidt – Pforzheim University

The fears of becoming a transparent citizen is shared by many, which explains demands for perfected privacy to secure personal data and to protect them from misuse, but what about data relating to products? Don't they have to be protected, too? Shouldn't what they contain be kept secret, too, along with their history and origins?

The opposite applies and in some cases is already practised today. Product labels provide information about nutrients, the product's carbon footprint or toxic substances that they contain. They provide information on how to dispose of products. User manuals or assembly instructions are available in the internet for many products and can be retrieved via a QR code or serial number. Customers, also from the B2B sector, want as detailed information as possible on the items on which they are spending their money.



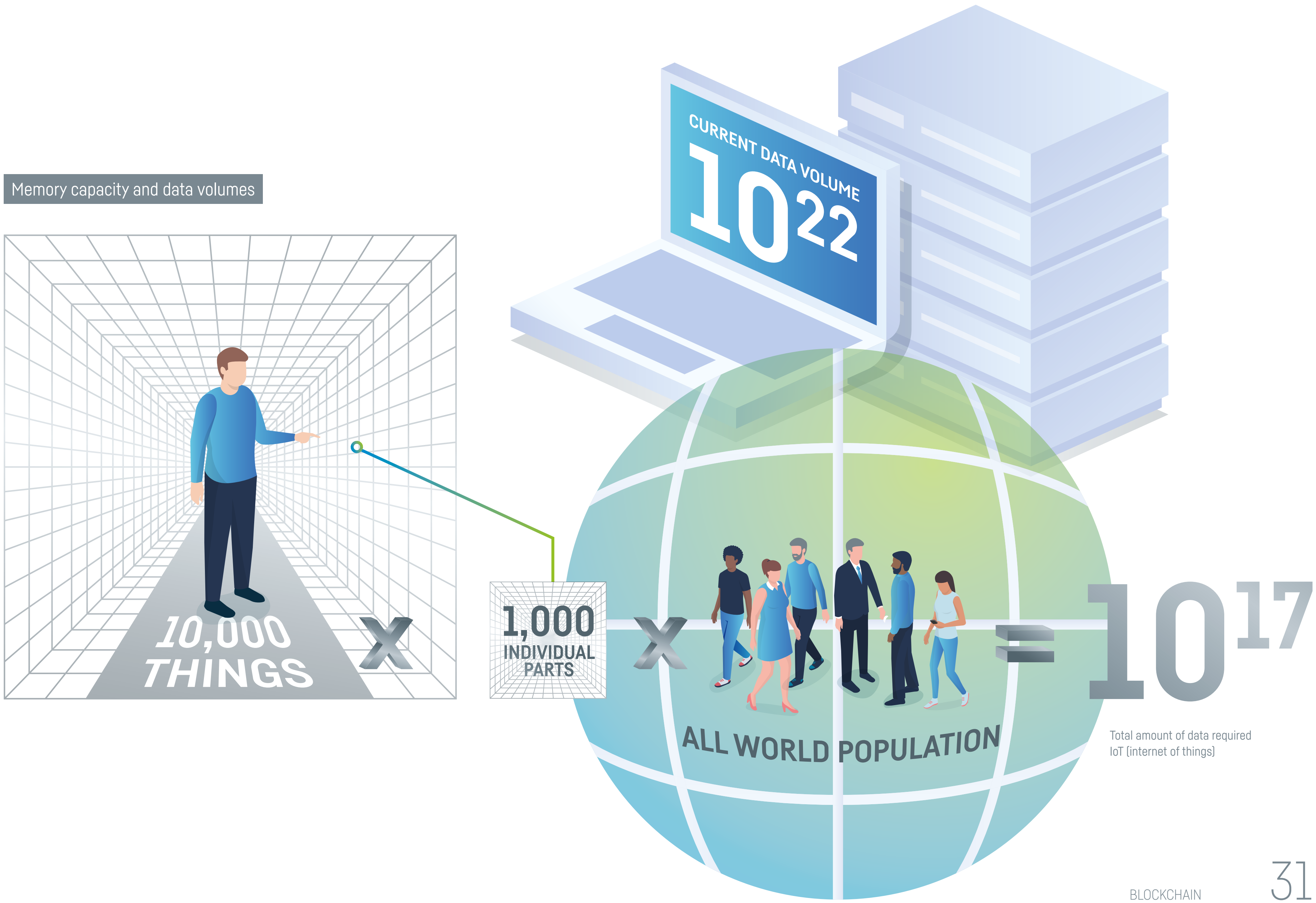
The situation might be seen in the light of an antecedent to the creation of digital twins for products. Information is available for products that is currently documented in different ways, on packaging, on the product itself, on enclosed information leaflets or in the internet. So why not pool all this information in a standard, straightforward system that is universally available online?

In this world, every product would have a digital twin with all the necessary product information. These twins would relate to product classes like the prototypes of products, or to product batches, in which the relevant manufacturing conditions are taken into account. You could even map individual products, in the case, say, of an expensive commodity or asset and collect and pass on the data relating to the product during its manufacturing and use stage. In doing so, better conclusions might be deduced for necessary repairs or proper disposal.

All of this is in the making, and already exists for a small number of specific products or use cases. The ICT processes underpinning blockchain however permit a uniform structure, standardisation of data formats and interfaces, extended functions like the control of access rights and thus ultimately, a reduction in transaction costs.

Ultimately, the amount of detail recorded in a digital twin is a matter of cost. Roughly estimated, the average European owns 10,000 things. If each of these things were to consist of 1,000 individual parts and we multiply this amount by the world population, we are talking about managing 10^{17} data sets. In 2017, worldwide memory capacity in the ICT sector was estimated at 10 zettabytes, which is 10^{22} or many more times what would be needed for a digital twin of everything, and available memory capacity continues to grow rapidly.

Memory capacity and data volumes



True data and confidential data

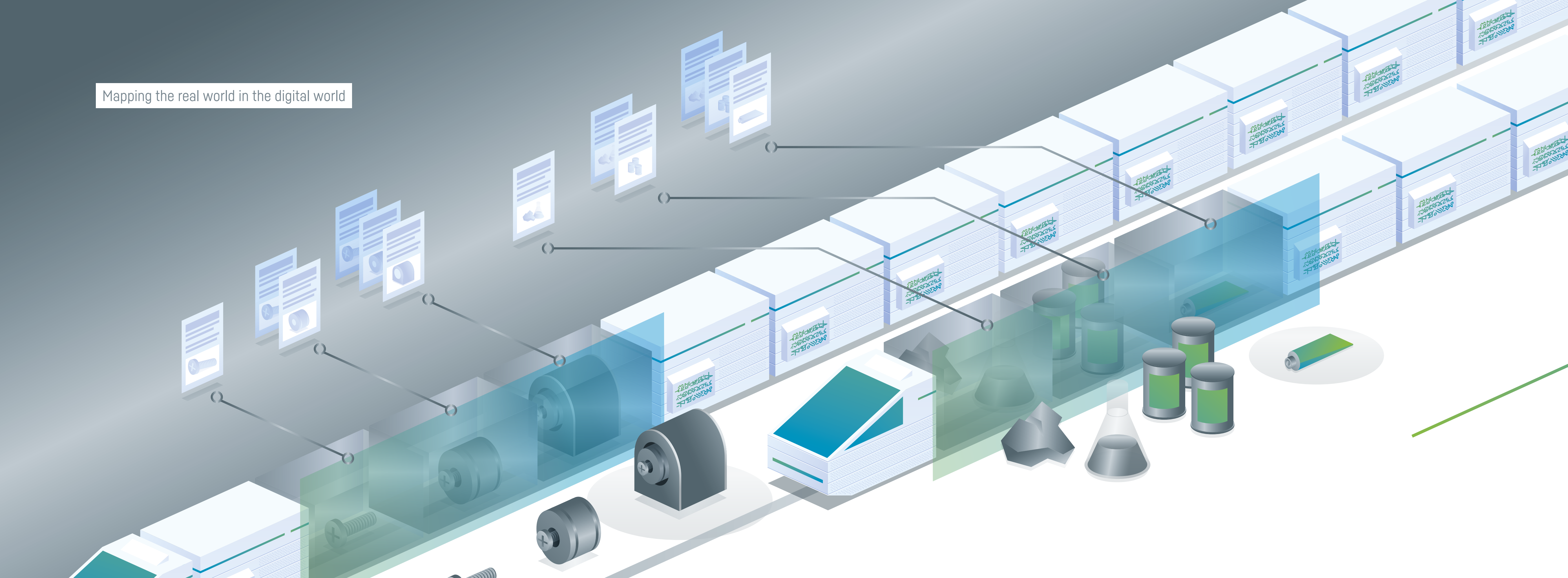
Text: Prof. Dr. Mario Schmidt – Pforzheim University

Data are sensitive assets. On the one hand, addressees doubt their veracity and whether they reflect the reality. In recent years in particular, and especially in connection with car emission data, this question has been rightly posed. On the other hand, the originators and senders of the data wonder what happen to them and whether they are not being misused. Both sides must be duly taken into account.

Verifying data that are collected, stored and passed on is a complex business irrespective of the system used. It starts as soon as you collect or create data, because later on in the data chain, you often no longer have the possibility of checking the veracity of data. Imagine a company, for example, that specifies the content of a certain substance in their product. The measurement must be quality assured, and yield a data set that complies with a fixed procedure so it can be passed on. Measurement, data creation and passing on must be subject to verification by an independent body by means of random checks, for instance. If necessary, the pertinence of the data set must be documented. Does it contain average values, for instance, what error tolerances are allowed, when did measurement take place etc. Corrupted data must not be passed on.

Verification is not part of the actual ICT process, nor can it be generalised, because it depends on the use case and the originator of the data. For instance, a producer in Asia must prove that the data they supply about compliance with the ban on child labour is true. This can be achieved by an appropriate certificate issued by a third-party body. The reliability of the data hinges on the trustworthiness and dependability of this body. If certificates can be purchased at will, the data are not reliable.

The problem of veracity in the creation of data applies in almost all areas. It is present in the technical, social and ecological conditions of production, compliance with regulations, the composition and contents of products. A sustainable blockchain is therefore not only a technical task, but it also requires the establishment of an organisational system to validate data that may even have to function at global level.



Transporting data along the data chain is thus an inherent remit of the ICT sector, or if you like, the blockchain. Encryption mechanisms and the control of access rights must ensure that data are not modified or corrupted when transmitted repeatedly. In this case, too, questions arise that cannot be solved at a purely digital level, but require specific agreements, standards and if necessary, audits as well. An easily solvable use case would be a supply chain in which a product, a screw, for instance, in semi-finished form, is used at various levels of complexity through to the finished product, but which still exists physically. That would be a typical situation in the manufacturing industry. The blockchain data set is then the equivalent of an exploded parts list and, in principle, the screw would be identifiable and traceable at any time.

However, if a new material is produced from various raw materials, the traceability of the raw materials used originally can no longer be guaranteed. This is a typical situation in the chemical or metal production industries, so questions as to what happens there arises: is legally sourced gold maybe mixed with illegally mined gold? The blockchain has a gap or break here, because mixing prevents clear item allocation. At this point, a suitable validation mechanism must again be deployed to consistently and faithfully link the information before and after mixing.

Finally, there is the question of who is allowed to use what data. A company, for instance, is willing to specify the composition of their primary products, but not the name or location of the supplier and their subcontractors. The contents (recipe) of a product should remain a secret to the customer, but not to a body who wants to inspect whether they include hazardous substances. Or should the contents (recipes) of individual parts be passed on, though always only specified for a unit, the product as a whole? IT can satisfy these requirements with a blockchain using encryption, access rights and appropriate aggregating algorithms.

Classification, labelling and declaration of substances and mixtures

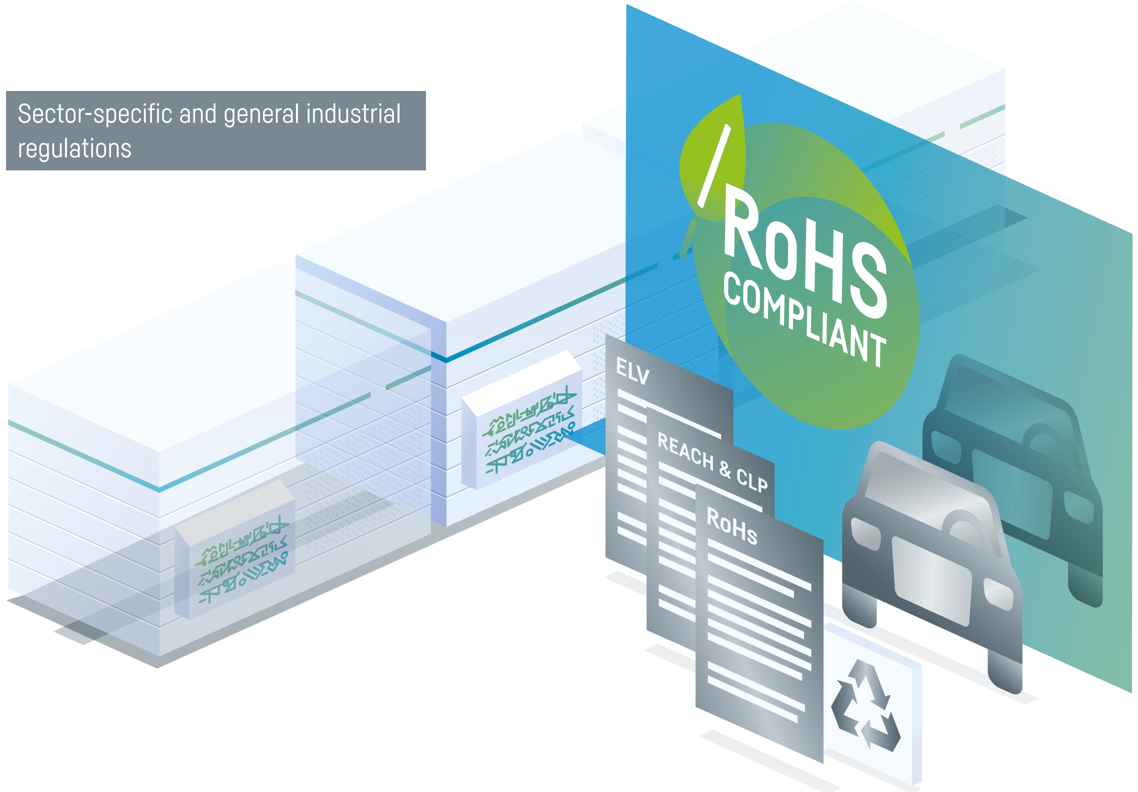
Text: Dr. Ruediger Herpich – LANXESS Deutschland GmbH

The substances and mixtures produced in the chemical industry are often not finished products. For the most part, they serve as starting materials or raw materials for chemical reactions and conversions within the industry, or they are used and chemically converted in downstream industries. This makes it difficult to pass on information across the entire supply chain which is required for the legal assessment of a substance or compound at any time.

Legal basis: the EU regulations on chemicals

Since 2007, the REACH Regulation 1907/2006/EC has governed the registration, assessment, approval and restriction of chemicals within the EU. Their marketing has since been subject to the specification of toxicological and ecotoxicological data. The registration and approval processes are complemented by CLP Regulation 1272/2008/EC which sets out the classification, labelling and packaging of substances and mixtures. The safety data sheet, similar to the patient information leaflet enclosed with medication, for chemicals traded on the market, pools all this information (including the classification of hazardous substances in line with the German Water Management Act). The information can be passed on within the supply chain in this way.

However, most of the substances and mixtures are no longer subject to chemical reactions as they are passed along in the supply chain. Specialty chemicals companies, in particular, manufacture substances and chemical mixtures that are used to improve product qualities as components or additives practically as they are. They are supplied, for instance, to manufacturers of paints, varnishes, plastic, rubber products, textiles, oil products and all kinds of finished goods manufacturers. This group of chemicals stands out with its especially wide diversity of substances and mixtures and comparatively small production and consumption quantities.



Sector-specific regulations and commercial requirements

Apart from chemicals legislation, other additional and also substance-related provisions apply which may impose bans or restrictions. In some cases, downstream industries have very specific regulations of their own with which they have to comply, such as the End-of-Life Vehicles Directive (2000/53/EG ELV) in the automotive sector, the electrical and electronic equipment directive (2011/65/EU RoHS) in the electrical and electronic industry or regulations of the Federal Institute for Risk Assessment (BfR) for companies that manufacture articles intended for contact with food or drinking water. So-called conflict minerals and their traceability are of particular interest in mechanical, electrical and electronic apparatus engineering. In addition, companies in the automotive engineering sector demand compliance not only with substance bans and restriction in line with statutory provisions, but also with commercial agreements in relation to quality assurance.

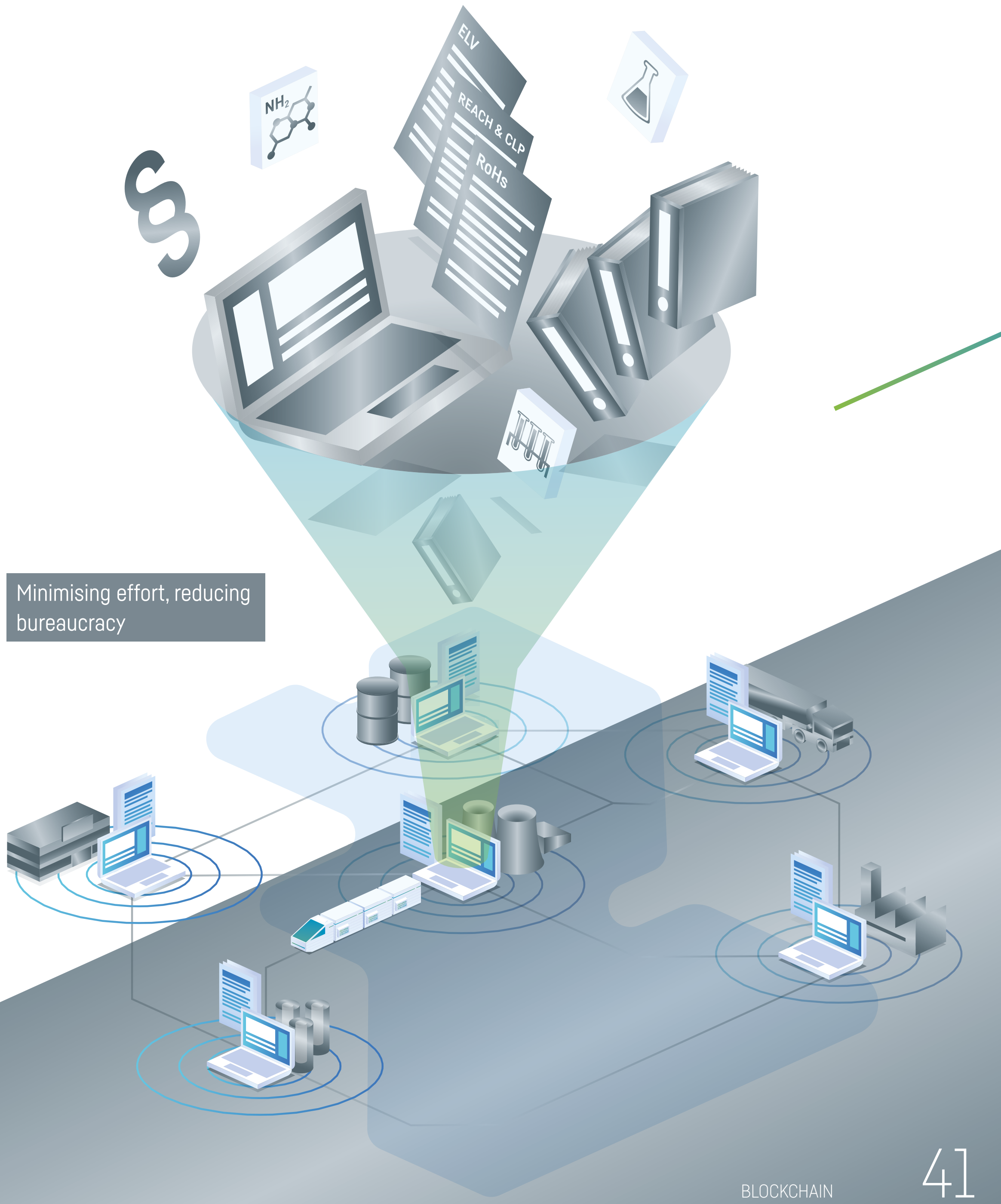
Against this background, the safety data sheet as “information leaflet” for customers in the chemical industry, though useful, is far from being exhaustive. There are far more classification characteristics for individual substances and product components across the supply chain over and beyond the registration status, rating and labelling.

Blockchain: transparent and confidential at the same time

A blockchain approach across the supply chain, in which the individual substances are flagged or electronically marked throughout the material cycle, is ideally suited to both satisfy the confidentiality demands of the chemical manufacturers while taking into account restrictions in use. The relevant legal assessments for materials that are not modified in the material cycle can be retrieved at every stage in the loop. This applies both to the status of a substance (or also mixture components) in relation to a standard (REACH , 850/2004/EG “POP”) and to classifications to critical or hazardous substance groups (SVHC, CMR, PBT, vPvB etc.). The recipe and composition data of products have to be itemised anonymously in substances – without reference to product or company – in order to protect the know-how of the chemical companies. In theory, such electronic substance marking can also be applied to foreign trade regulations on substances.

Currently, information relevant to foreign trade regulations is usually company-specific and non-standardised as it is passed on along the supply chain. It is often transmitted manually or semi-automated, on request by declarations (in letter form), occasionally signed or not, in the form of in-house certificates, sent via fax or email through to undocumented confirmations over the phone.

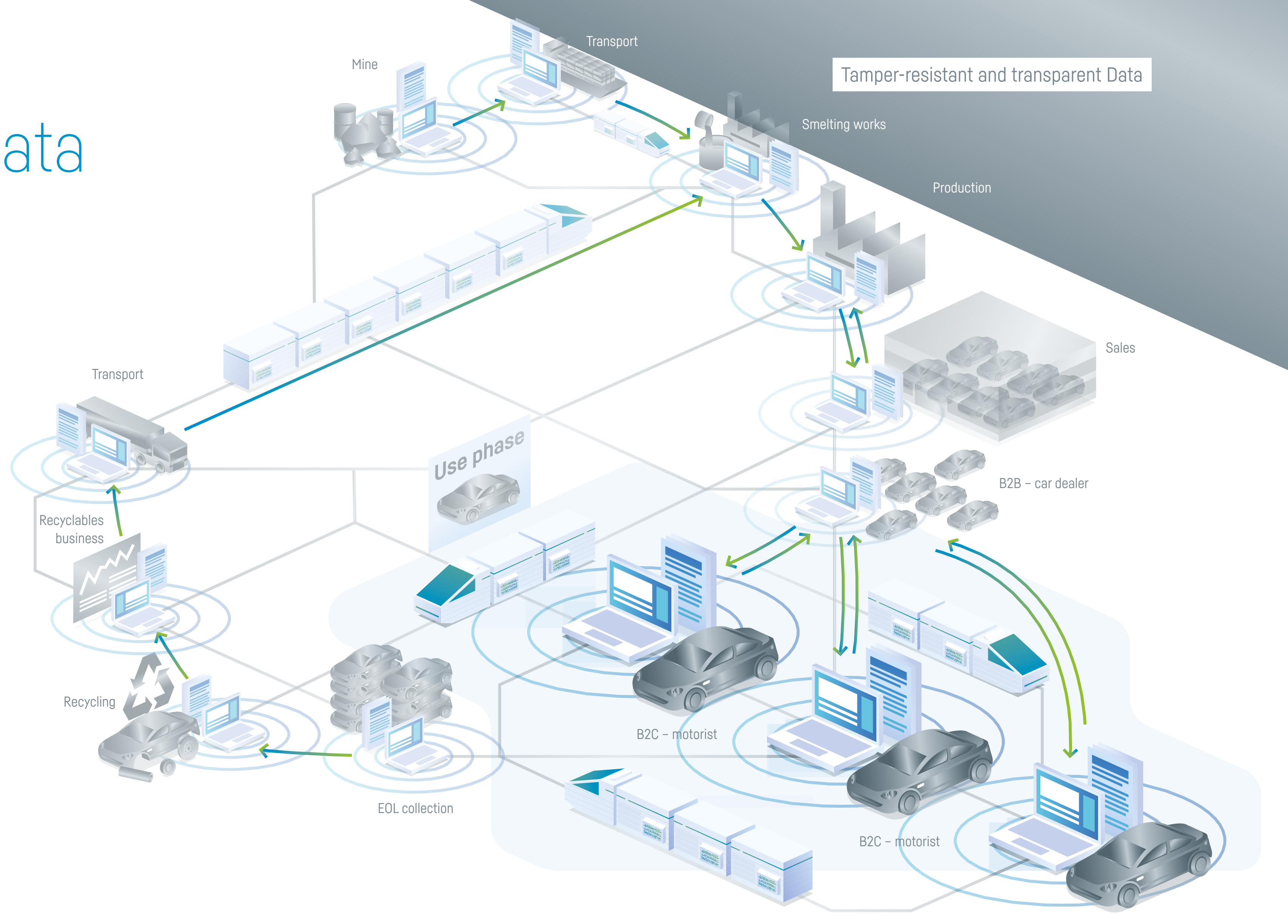
Electronic mapping of substance-related regulatory information for stakeholders within the supply chain unlocks the opportunity for the chemical industry to significantly reduce its administrative and documentation workload in communicating the status of individual substances in relation to legal areas outside chemicals legislation. At the same time, downstream industries can be provided quickly and easily with the information and documentation they need on the individual substances in a transparent format.



Minimising effort, reducing bureaucracy

Blockchain technology for data availability in the use phase

Text: Dr. Christian Kuehne – Ministry for the Environment, Climate Protection and the Energy Sector, Baden-Wuerttemberg



Looking at the life cycle of a product you will find that a fair amount of data is available from the mine to the smelting works and production. In the future, this body of information will be even more extensive and reliable through digitisation and the introduction of Industry 4.0. A great deal of information is also available about the recycling of end-of-life (EOL) products.

Currently, the widest gap is formed during the product's use phase. While in the B2B sector data are to some extent exchanged with service companies or the manufacturer, when it comes to private users there is a reluctance to share usage data with companies. With the circular economy in mind, you also find that no targeted forwarding of data collected during a product life cycle to recyclers is envisaged after the use phase. Retro feedback, the flow of information in the opposite direction back to the designer, is not envisaged at all.

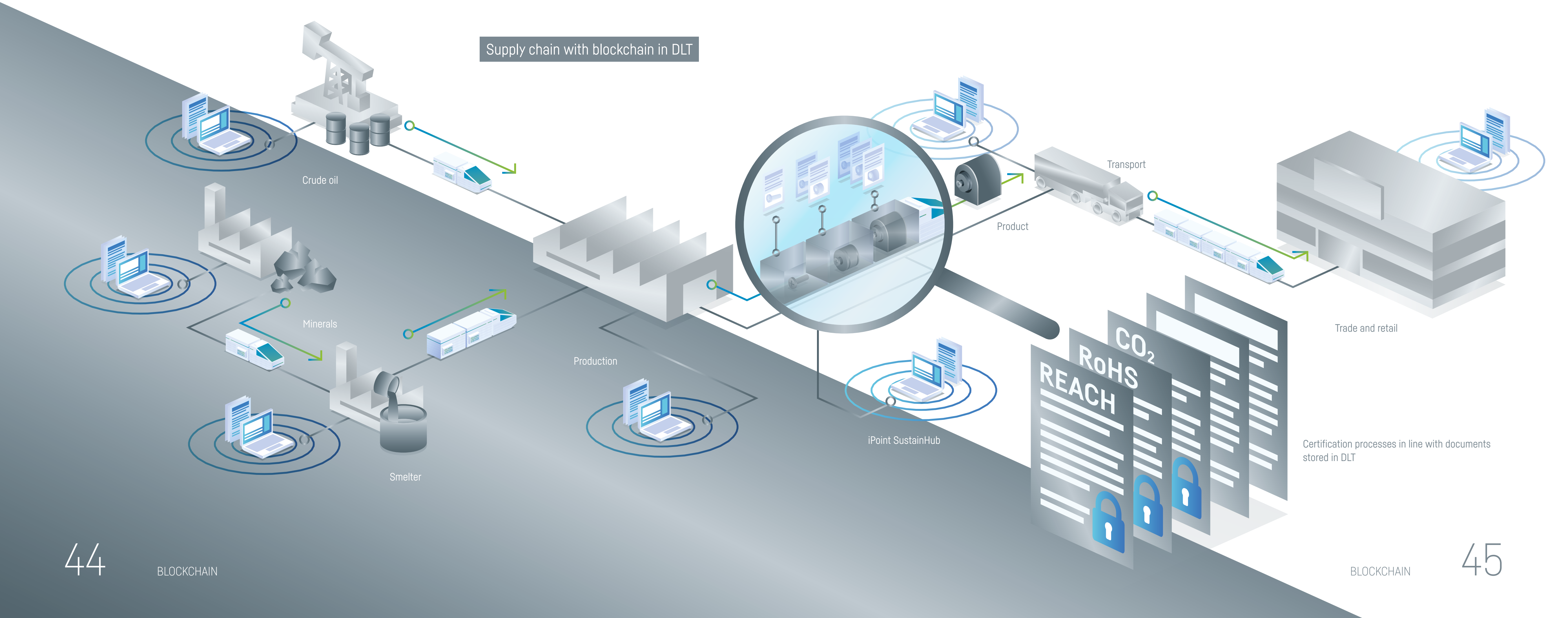
Blockchain technology could break down existing reservations and help with data availability, resulting in many benefits for those involved. It would be easier to set up a circular economy. Information from the use phase would enable the continuous adjustment of products in line with the actual use and real requirements. Take electric cars, for instance. The type of battery could be readjusted to best suit the driving style of motorists such as long-distance drivers, sporty drivers or city drivers covering short distances. Preventive maintenance and, in turn, a longer product life cycle could be enabled. The info gap to recyclers would then be closed, because they would know far in advance what and how many EOL products would be coming their way. They could plan in the long term and optimise processes. With suitable business models and reward systems for users who provide data, the blockchain model with its consensus mechanisms and security can truly pave the way to a genuine digital circular economy.

Making data traceable and tamper-proof

Text: Andreas Schiffleitner – iPoint Group

In commercial enterprises, business units with separate processes and systems abound. That is why there are experts whose job it is to take care of transferring data from one system to the other. Intermediaries are also needed to validate and verify these transactions. This is a difficult enough job even for one company, but it gets a lot more complicated when dealing with whole supply chains. This is especially true of all small and medium-sized suppliers who usually make up the supply chains in the manufacturing industry.

Supply chains need to be completely transparent for material to be tracked. Supply chain players are also required to disclose specific data such as information relating to the composition of components. On the other hand, they are reluctant to disclose data relating to business relationships and other sensitive information as this involves data confidentiality and intellectual property aspects.



Customers of this supplier must be able to understand and follow how the supplier controls his processes. Based on the information available to them, they assess whether the supplier is credible and in a position to obtain all the necessary information from their suppliers and sub-suppliers. In the automotive sector, the supply chain usually goes back seven to 13 stages to the material source. Currently, it therefore takes around six months until all supply chain data are available. If something is changed, like a new material being used in production, it is a long time before this information trickles down through all stages of the supply chain.

Traceable and valid

Using blockchain technology offers many advantages in the tracking of materials. One of the most important aspects is that it can guarantee the integrity and consistency of data during further transmission so that users can trust it. In the case of so-called conflict minerals, the following question arises: who can check the first link in the upstream supply chain – the mine – and confirm where the data come from and whether the source is trustworthy? One of the main strengths of the blockchain is that data and transactions can be traced back to the source. However, it can only be as reliable as the source information. For this reason, standard terms and metrics must be agreed before the blockchain is implemented.

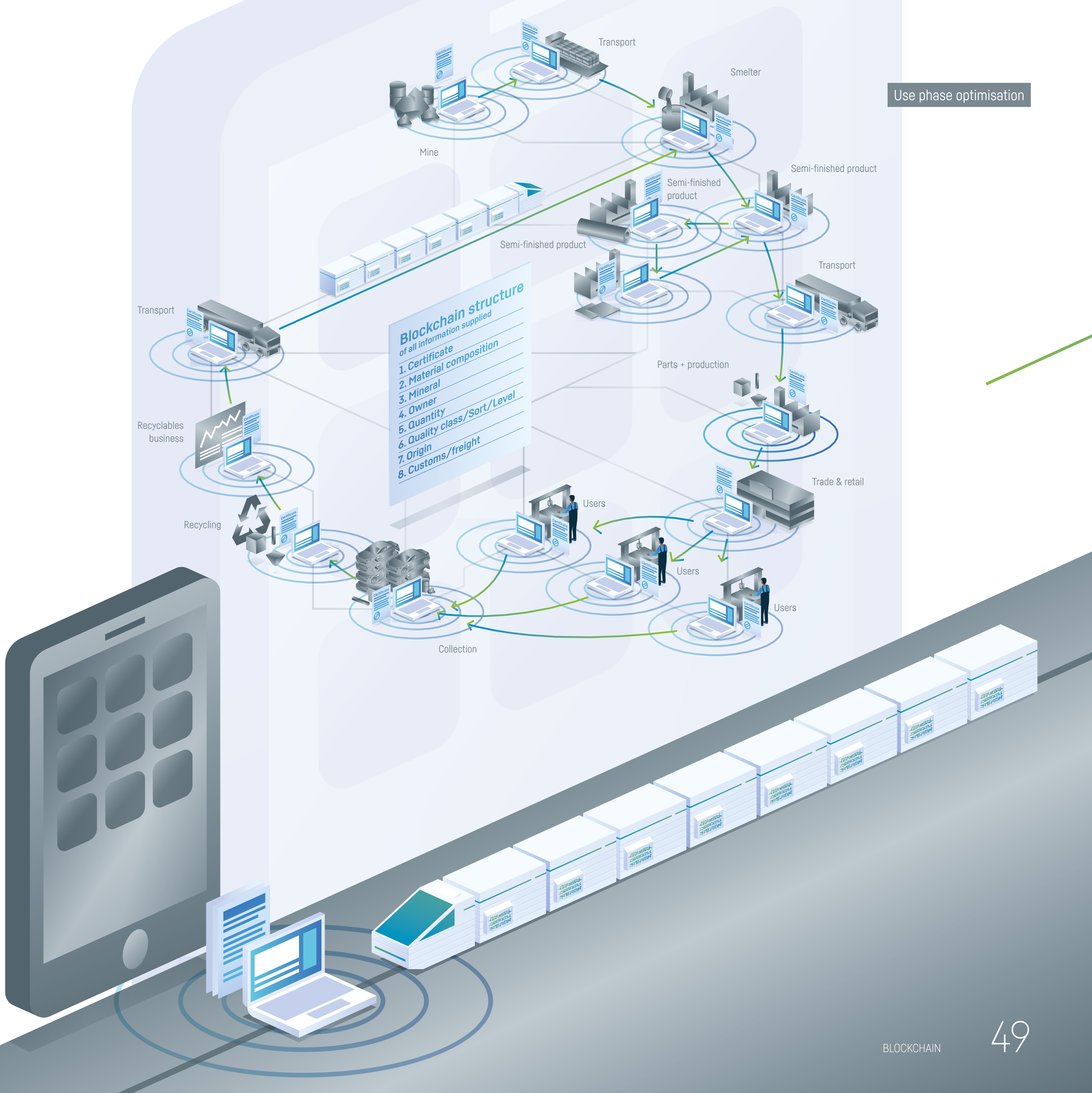
Another aspect is the increasing customisation of products and the increasing speed at which data are collected. For the more individualised products there are on the market, the more important it will be to exchange data as quickly as possible. The blockchain is superior in this case: data need only be sent to one data container – the user's own. This lets each user call up just the information they need for their processes. The physical distribution of a customised product must be accompanied by the necessary compliance information. This way, a user can check whether a product is REACH or RoHS-compliant, while another user can find out more about the product composition, and yet a third user may get information about its carbon footprint, process flows, production etc.

Blockchain can also speed up delivery. Depending on the level of trust and the smart contract concluded by the contracting parties, each company can determine and control how its data packet should be visible in the supply chain. These are just a few of the challenges and opportunities unlocked by blockchain technology in relation to material traceability.

Digital twins in the digital circular economy

Text: Joerg Walden and Martina Prox, iPoint Group

Digital twins are the basis for artificial intelligence, machine learning and analysing large data volumes (big data) to create digital simulation models that are updated in real time abreast of changes in the corresponding physical objects. The possibility of satisfying the need for information about natural resources and raw materials across long and complex value chains is particularly important for the digital circular economy. Digital twins can integrate the specific composition, origin of all resources, raw materials and components in a clearly identifiable manner. The physical object can thus carry information about its proper, secure handling in the production process, during use and also for subsequent recycling in the highly connected industrial environment.



Use phase optimisation

It is particularly interesting for the digital circular economy if such product information is already available at a very early stage of the product development process and can be simulated throughout its entire life cycle. Constant availability of the necessary information on compliance, sustainability, use and recycling generates a wide variety of benefits: risks can be minimised, the ecological, social and economic benefits optimised and ultimately, a sustainable world secured for future generations.

IIoT – Industrial internet of things

The key to a truly circular economy is the internet of things (IoT), the Industrial internet of things (IIOT) and know-how about the all-pervasive connectivity as a new infrastructure paired with technology convergence that blur the boundaries between the physical and virtual worlds. Consistent digital anticipative models are needed across the entire system life cycle to implement this approach at a high level of automation, while at the same time tapping the sustainability potentials of new business models. Digital twins can be used to efficiently develop products before use and to continuously improve them as part of a smart system through to material recycling.

High tech takes givens to the next level

Text: Uwe Koethner – Robert Bosch GmbH

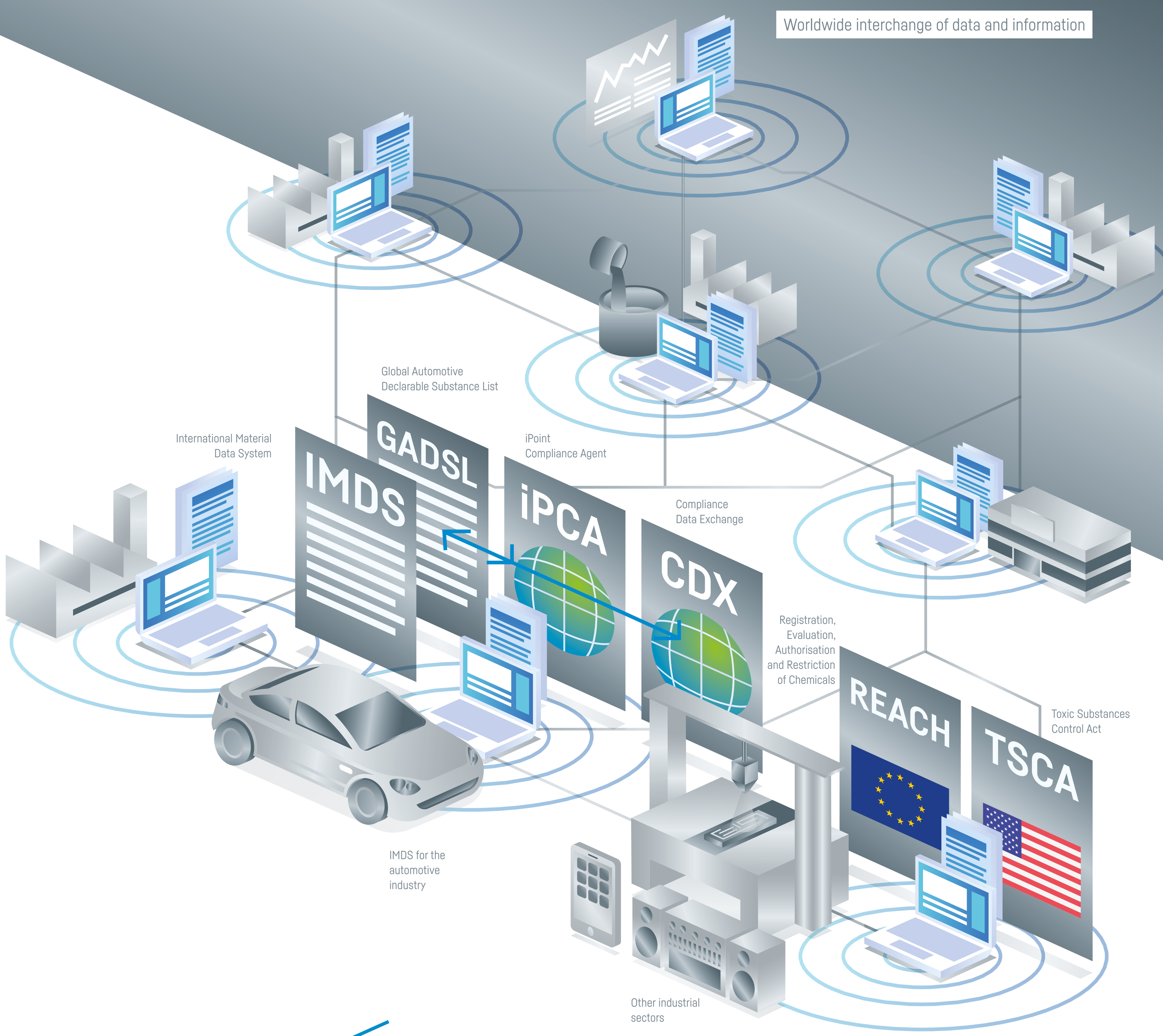
The challenge today consists of tackling the growing number of material compliance regulations worldwide and the demand for a sustainable approach to physical material. If they are to comply with the law and practice sustainability, stakeholders need reliable and secure material-product life cycle data which they can provide specifically to fellow stakeholders.

A lot has been achieved. The first regulations on material recycling and materials were introduced in the automotive sector. In the EU, recycling end-of-life vehicles was the hot topic of the 1990s, resulting in the 2000s in the End-of-Life Vehicles Directive, aimed at increasing recycling rates. Bans on certain contents were put in place in 2003. The IMDS (International Material Data System) was introduced to collect data. The system stores the material composition of parts and products in a standardised form and can pass the information onto car manufacturers in the supply chain. This standardisation approach is enhanced by the GADSL (Global Automotive Declarable Substance List), which sets out automotive industry requirements.

Further regulations ensued, both for specific industries such as electrical and electronic goods, ships and so forth, but also cross-industry requirements like the EU REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) Directive and the US TSCA (Toxic Substances Control Act). These regulations raise the requirement bar for any relevant material data. Today, the motto "no data, no market" is widely implemented, and manufacturers must comply with specific material bans, use restrictions and customer information obligations.

An in-house system can improve efficiency, quality and speed, for instance by enabling electronic communication with suppliers and customers. Limit value requirements need to be translated into inspection criteria so that products and their composition can be run through automated parts list-based checks. The aim is to avoid increased cost, also on the part of suppliers, in the face of tighter requirements.

However, to achieve sustainable material use, further efforts are needed at cross-industry level. A key aspect is IT system-neutral data interchange to let users of different IT solutions share in the cross-industry interchange of data. General access to public-domain material data with no know-how content in a universally readable format would be a help. This also applies to requirements on the part of legislators



and customers. Easy data accessibility and availability and an appropriate degree of user friendliness are important to enable a lot of companies to participate. Targeted data releases for specific addressees, for compliance audit purposes, for instance, repair or material recycling, without involving data duplication, would go a long way to improving efficiency. It should be possible to release selected data and to make it available so that efforts need not be duplicated.

Standardisation, data security, maximum efficiency and quality are crucial for companies. New participants in the interchange of data should also be able to enjoy these services.

Blockchain brings transparency to raw material supply chains

Text: Maroye Marinkovic and Joerg Walden, iPoint Group

Efficiency, speed and low costs are some of the potential benefits of using blockchain for supply chain management. Blockchain technology offers two further benefits for mineral and metal supply chains: traceability and transparency.

Legislation and public control are the two main reasons for the growing demand for greater traceability and transparency in the supply chain of certain raw materials from conflict-affected and high-risk areas – so-called conflict minerals. iPoint-systems, a leading provider of conflict minerals compliance solutions for more than 50.000 companies, considers distributed ledger technology to be potentially transformative in the areas of sustainability and compliance. In addition to current, declaration-based compliance reporting, a supply-chain-wide distributed ledger lets stakeholders control the entire chain of custody from mining to selling the finished product to the consumer and beyond, to end-of-life recycling.

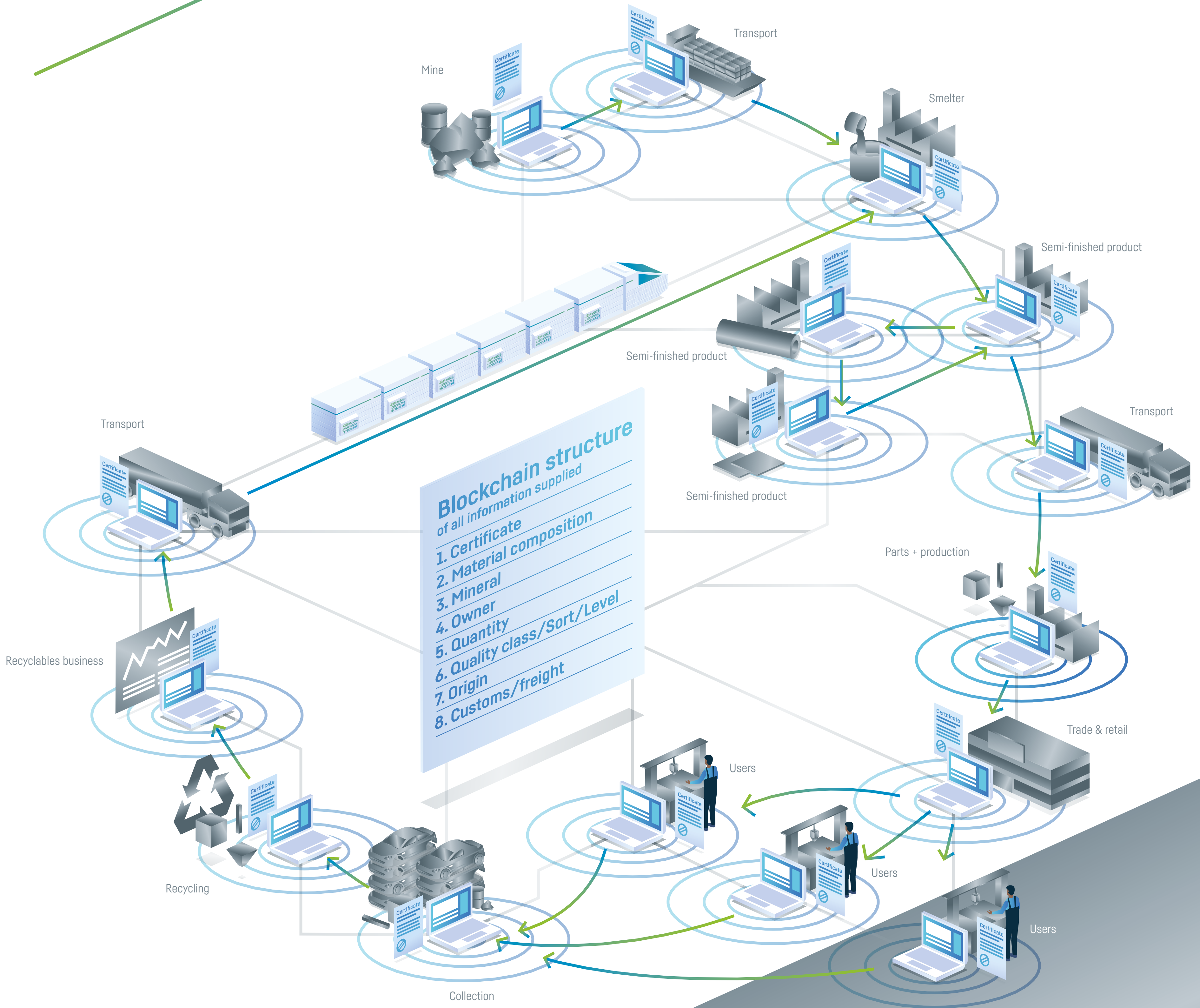
At the end of 2018, the Responsible Minerals Initiative (RMI) published a set of guidelines[1] outlining a potential blockchain model from the mine to the market. It is aimed at defining terms, concepts and basic data attributes required for identifying the players in the mineral supply chain taking part in a blockchain-based chain of custody solution. In such a system, in which many parties are integrated into a common, incorruptible ledger, and in which transactions are both time-stamped and immutable, irregularities and anomalies can be quickly detected, and problematic areas in the supply chain identified.

[1] www.responsiblemineralsinitiative.org/media/docs/RMI%20Blockchain%20Guidelines%20-%20FINAL%20-%2012%20December%202018.pdf

As goods pass the various stages in the supply chain, information is collected about the product, place of transfer, identity and compliance with responsible production standards. Based on a pre-agreed consensus, the blockchain can validate data from various sources (IoT, GPS, smartphones, manual entries etc.) at any time. This combination not only forges a resilient chain of custody solution, but also, thanks to the immutability of the blockchain, a tamper-proof verification of origin and proof of responsible production.

If new blocks are added to the old ones, each new block is "sealed" by encryption to all the preceding blocks. It is therefore impossible to tamper with historical data without breaching blockchain consensus rules. The series of additional blocks can be viewed as a “digital” fingerprint for each batch of raw materials or minerals, so that downstream users can see exactly what proportion of the material comes from which mine and whether it was sourced responsibly.

Different organisations have different interests and drivers. In mineral supply chains, some stakeholders are keen to improve speed, efficiency and costs, while others are motivated to improve transparency and traceability because they wish to address social and ecological issues.



Blockchain as a tool to improve supply chain management – the example of SustainBlock

Text: Dr. Katie Boehme and Maroye Marinkovic – iPoint Group

Can a tamper-proof ledger, distributed across multiple entities, help us improve supply chain management? The findings of current analyses by well-known large accounting firms are encouraging. Blockchain lets companies digitalise and optimise supply chain operations – from raw material sourcing to recycling – so that many inefficient and time-consuming steps will be eliminated.

Most corporate blockchain initiatives are currently at the proof of concept phase, though some companies are already conducting pilots. Many of these projects are in the area of supply chain management which shows that this area is currently regarded as one of the most promising use cases for blockchain technology. Track and trace blockchain use cases are a boon to the supply chain-centric business model of the engineering SMEs and car manufacturers who are so typical of the German industrial scene. This is also borne out by the Deloitte blockchain survey published in 2018[1]. It revealed that the supply chain was the application area most frequently cited by the more than 1,000 executives interviewed currently engaged in it.

Moreover, the majority of the respondents (84%) believe that the blockchain will one day achieve mainstream adoption. The survey also found that in Germany the major interest in track and trace approaches to verify the origin of goods and raw materials is sustainability-driven.

A current use case is SustainBlock, a project that could link in more than 50,000 users of the iPoint compliance and sustainability platform SustainHub with its conflict minerals data acquisition and reporting app to the blockchain. Headed by iPoint, the project aims to create a blockchain-based system for tracing certain raw materials from conflict-affected and high-risk areas across the entire supply chain. Conflict raw materials include tin, tantalum, tungsten, their ores and gold. Cobalt is another focus of responsible sourcing programmes. SustainBlock is currently engaged with one conflict mineral from the mines in the African Great Lakes Region.

[1] Deloitte: Breaking blockchain open. Deloitte's 2018 global blockchain survey. Download (PDF): www2.deloitte.com/content/dam/Deloitte/us/Documents/financial-services/us-fsi-2018-global-blockchain-survey-report.pdf

SustainBlock is a cooperation project comprising several partners. It is headed by the software and consulting company iPoint-systems which specialises in global sustainability solutions for downstream supply chain players. Together with partners specialised in the upstream sector, iPoint aims to set up a traceability process across the entire supply chain from the mine to the OEM. End user accountability for the upstream due diligence[1] process can thus be evidenced by careful risk assessment. Traceability and data reporting are blockchain-based in a distributed network so that downstream supply chain players and end users can access reliable, verified information across all relevant stages of the supply chain.

Auditing and verification is carried out at the very beginning of the supply chain, during prospecting, by the upstream project partners. They specialise in the mineral supply chains of conflict-affected and high-risk areas and collect data locally, directly and in real time at audited mines and feed them into the blockchain. The partners use a marking and scan-based tracking system, which ensures data reconciliation before the raw materials are exported. Each shipment includes dashboards with data pertaining to the raw materials extracted, such as weight and mine of origin, as well as socio-demographic data like the age and gender of miners, working hours, education, etc. By ensuring full traceability of raw materials from start to finish, the solution can also help to make it more difficult for "black sheep" and unethical sources to enter the market. Ethically correct, sustainable practices and conduct across supply chains can be supported in this way. Moreover, it can be safely assumed that this transparency will pave the way for international investment capital and thus continuously improve local living and working conditions.

The SustainBlock project is funded by the European Partnership for Responsible Minerals (EPRM). Find out more at www.sustainblock.org.

[1] In line with OECD guidelines due diligence includes: 1) Identifying actual and potential adverse impacts; 2) Seeking to prevent and mitigate adverse impacts; 3) Accounting how companies have addressed adverse impacts through a) tracking and b) communication on results;" See OECD (2017), Responsible business conduct for institutional investors: Key considerations for due diligence under the OECD Guidelines for Multinational Enterprises. https://mneguidelines.oecd.org/RBC-for-Institutional-Investors.pdf

Data traceability and use cases – from mining to the finished product, with a focus on conflict minerals

Text: Andreas Schiffleitner and Sebastian Galindo – iPoint Group

From the mine to the smelting works

Laws have been developed at international level to counter forces that illegally exploit raw material supply chains. These forces control the sourcing and trading of raw materials from mines, finance violent conflicts, systematically committing human rights breaches in the process and thus contribute to the unleashing of humanitarian emergencies in the conflict-affected and high-risk in question. These laws cover minerals (ores and concentrates) that contain tin, tantalum or tungsten, as well as gold, and other metals that contain or consist of tin, tantalum, tungsten or gold. The term "conflict minerals" or "conflict raw materials" has become established in this context, along with the abbreviation 3TG for tin, tantalum, tungsten and gold.

Currently, such legislation means that access to international conflict-free mineral markets is governed by compliance with guidance issued by the OECD. This "Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas" must be complied with by upstream suppliers, that is by the players in the "supply chain from the extraction sites to the smelters and refiners"[1].

[1] Regulation (EU) 2017/821 of the European Parliament and of the Council of 17 May 2017 laying down supply chain due diligence obligations for Union importers of tin, tantalum, tungsten, their ores and gold from conflict and high-risk areas, Article 2, j. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32017R0821

Upstream supply chain due diligence is subject to the following problems:

> Due diligence costs from the upstream supply chain, that is the expenses arising out of diligence and risk assessment to meet downstream expectations are passed on in full by midstream operators to the mining communities (in the form of a discount on the world market price).
> Compliance checkbox exporters and traders (companies that do not check the content, but only the existence of documents) who engage in high-risk transactions thus have an incentive not to source from the affected regions – which can have disastrous economic consequences for the inhabitants of these regions.
> Investing in mines is hampered by opaque local trading that is further damaged by unreliable data collection and data reporting systems.
> Data collected at local level by various organisations and are available in theory, but they are centralised and are not used enough by international stakeholders.

Current practice of copy and pasting reports

CMRT = Conflict Minerals Reporting Template

> The wealth of information available on certain mining communities is not used to tackle the challenges that are not yet covered by existing regulations.
> The process of recording smelters absorbs and blurs data in advance so much that systematic challenges like the structure of cooperatives or the role of government agents and associations remain largely unknown or are misunderstood.

Economic operators downstream from smelters and refineries, that is, the other players in the metal supply chain leading "to the final product"[2], are directly affected by the legislation on conflict minerals. Their brand value and reputation hinges on their fulfilment of social responsibilities. Downstream demands for further efforts to achieve transparency in sourcing from Central Africa have prompted many smelters and refineries to simply leave the region.

End-user access to reliable upstream due diligence data should permit a more extensive assessment of the impact of due diligence at local level and should unlock new possibilities for the sustainable funding of local transparency and community engagement processes.

[2] Regulation (EU) 2017/821 of the European Parliament and of the Council of 17 May 2017 laying down supply chain due diligence obligations for Union importers of tin, tantalum, tungsten, their ores and gold from conflict and high-risk areas, Article 2, k. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32017R0821

From smelter to semi-finished product to component to final product

Conflict minerals pose companies with significant challenges alone due to the barely manageable range of products which contain the 3TG. Annual reporting obligations and long and complex supply and distribution chains require high manpower resources. Depending on the industry, the supply chain to the material source comprises more than a dozen stages. This complexity means that when something changes in the supply chain or product composition, it initially goes undetected because information on conflict minerals is typically only requested once a year.

An inadequate grasp of the requirements and incomplete definitions, even in the relevant US law, the Dodd-Frank Act, further complicate the matter. Furthermore, the standard reporting template, the Conflict Minerals Reporting Template (CMRT), is Excel-based and not overly resilient. In addition, there are around 600 relevant smelters around the globe, however, due to lack of clarity in the entries, 2,000 or so are actually reported. These quality problems are also the highest risk factor. The lack of proper identification of smelters or faulty of smelters means that some high-risk smelters are not detected and it becomes impossible to track the origin of certain goods throughout the supply chain. Companies thus lose options for action to ensure that such high-risk smelters and mines are removed from the supply chain.

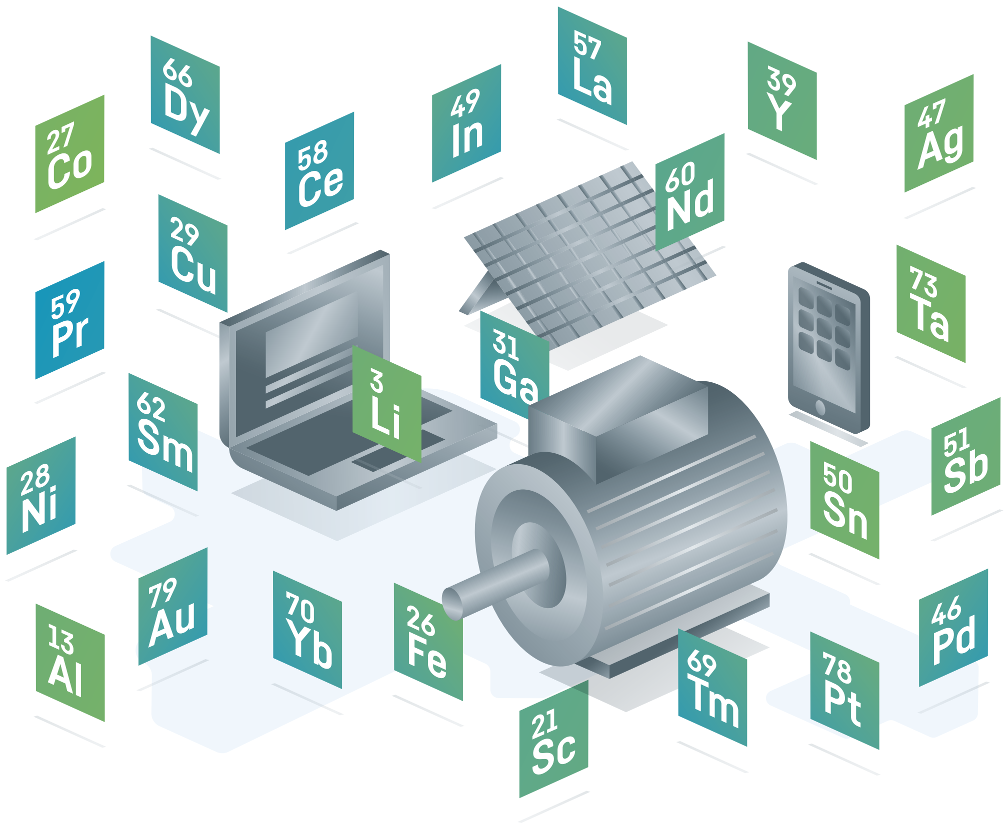
With the exception of the economic operators at the beginning and end of the supply chain, the mines and finished product manufacturers, every party in the supply chain is both a data supplier and recipient. Each of these companies must therefore expend the same amount of effort to practice due diligence, even though the same data (smelter information) are always being passed on. The one-time verification of the integrity and incorruptibility of data could minimise these efforts with applications like SustainBlock.

Raw material transparency – locating recyclables inside products

Text: Prof. Dr. Mario Schmidt – Pforzheim University

Worldwide demand for raw materials continues to rise unabated. The trend towards product specialisation and miniaturisation, and more importantly, the development of high tech products is resulting in an increasing need for chemical elements and materials, also exotic ones, which up to a couple of years ago were widely unknown. A common smartphone contains more than 50 different metals, albeit only in minute amounts. Though the metal content of

Full information about business-strategic raw materials



copper, gold, silver and palladium in a single device is worth less than one euro, once multiplied by the 1.4 billion smartphones sold annually worldwide in 2016, it adds up to 9,000 tonnes of copper, 15 tonnes of silver, 24 tonnes of gold and around 3 tonnes of palladium with a metal value of just over one billion euros. Other metals are also inside, such as tantalum, gallium, indium and rare earth elements. While of little material value, they are vital from a technical point of view. Modern technologies in the energy turnaround also need such exotic materials: neodymium for permanent magnets in wind farm facilities and electric motors, indium and gallium for photovoltaic cells, cobalt and lithium in rechargeable batteries.

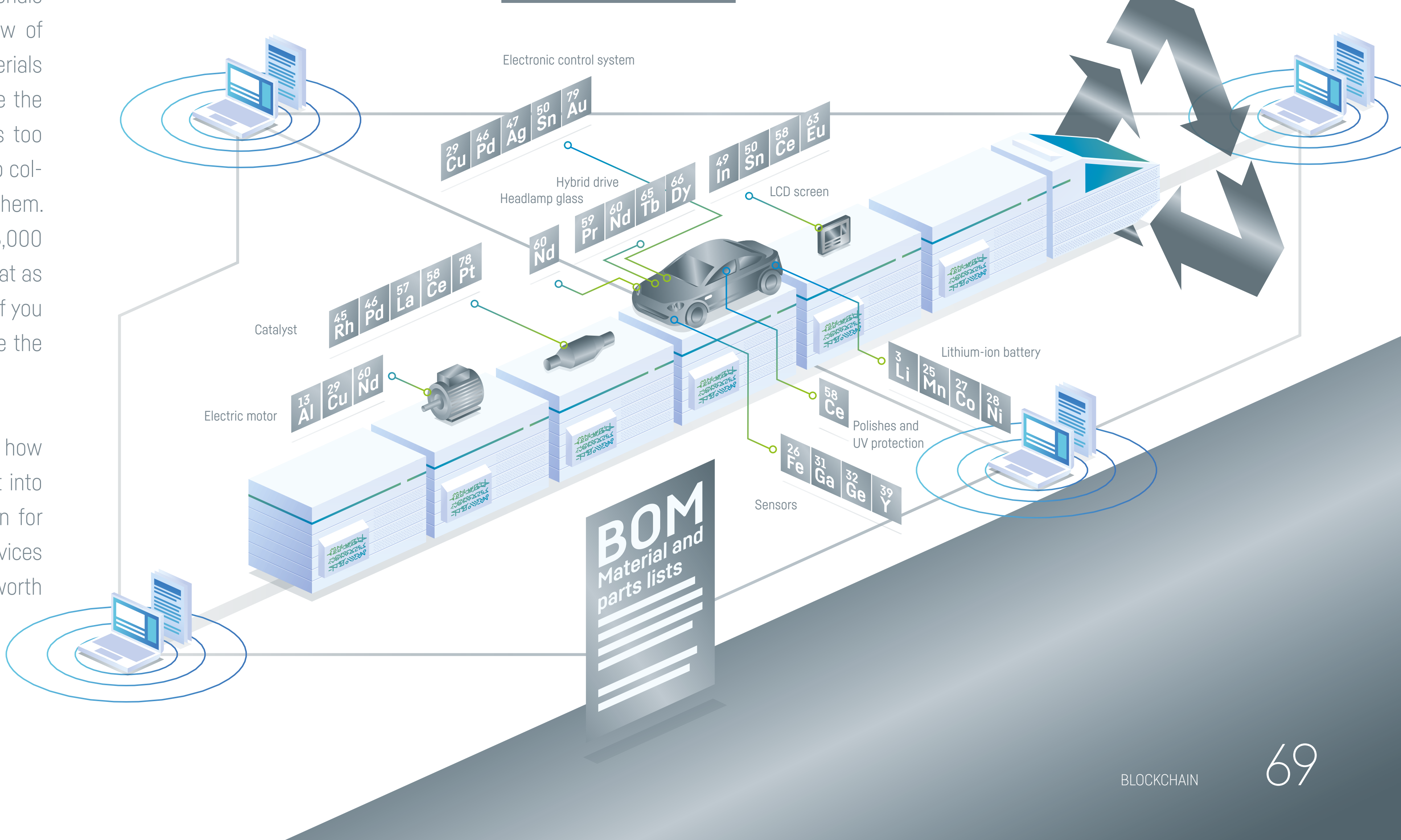
In the future, industry will need to recycle more of these materials to ensure their continued supply and ensure a steady flow of high-quality and innovative products. Yet at present, raw materials are largely lost at the end of a product's life cycle, because the effort involved in collecting and recycling them still costs too much. The challenge is twofold. On the one hand, you have to collect products selectively and build up large quantities of them. A tonne of smartphones has a metal value of more than 6,000 euros. And on the other, the parts have to be separated so that as many different raw materials as possible can be recovered. If you want to recycle tantalum, for instance, you need to separate the capacitors from the computer chips or the boards.

This example shows that recycling is about knowing where, how much and in what form the different raw materials are built into the product. This information is usually not available, even for high-quality products. Sophisticated analyses of individual devices can yield this information afterwards, but it is usually not worth the effort.

It would be simpler to obtain the data from the manufacturers and their suppliers. When disassembling devices, recycling companies would need to be able to access databases explaining the easiest way to dismantle devices, and specifying the location and quantities of the desired raw materials. Consequently, recycling could become profitable for many raw materials, primary resources could be saved and pollution prevented.

The automotive industry already has the makings of just such a database. For years now, the International Material Data System (IMDS) has been used to supply information about the material and chemical composition of components and semi-finished products.

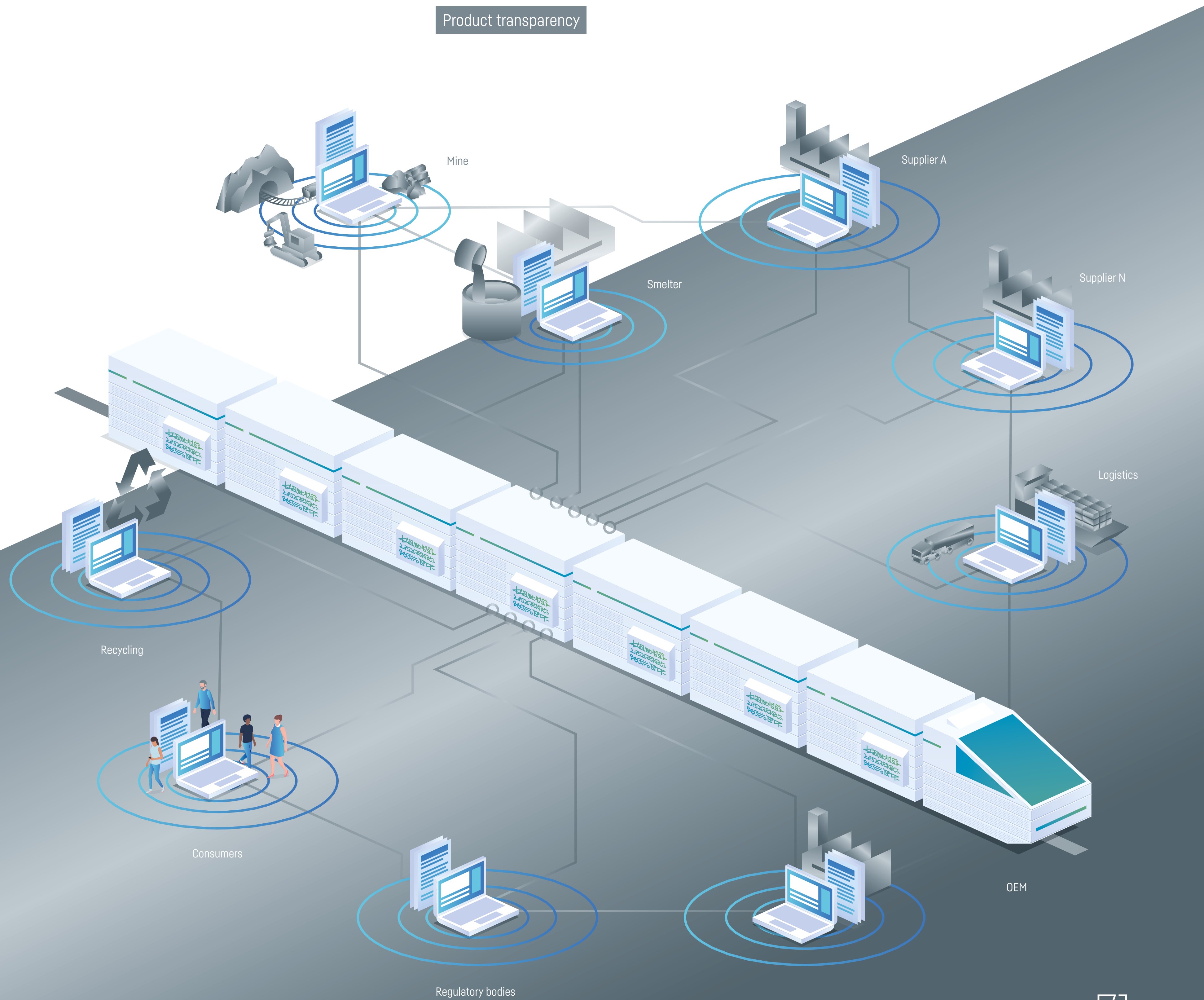
Full data for the material loop

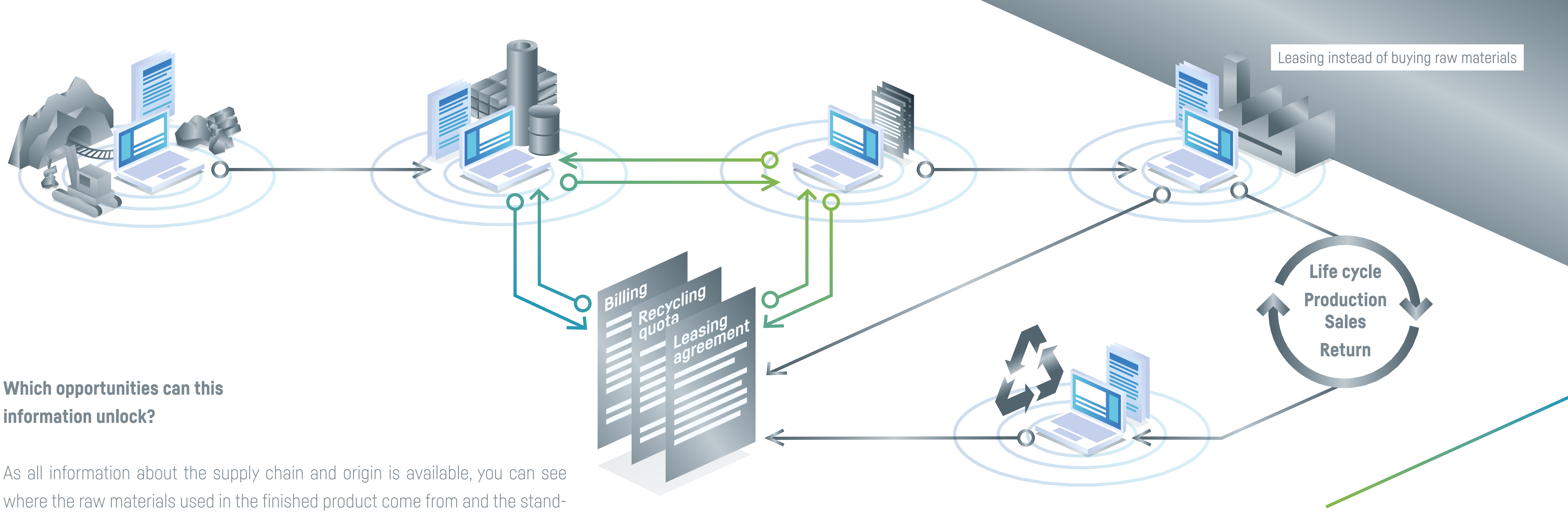


How can blockchain support sustainable business models?

Text: Joerg Walden and Gunther Walden – iPoint Group

Let's assume we already had a digital twin with verified information about all the raw materials used in the final product and supply chain components in a blockchain. At every step, information about the origin of the materials and components, not to mention that of all their predecessors, would be documented.





Which opportunities can this information unlock?

As all information about the supply chain and origin is available, you can see where the raw materials used in the finished product come from and the standards by which the mines were certified. Responsible raw material sourcing also includes the environmental and social conditions involved in mining.

The information can also be used to prove that the product and its components do actually come from the brand owner and are not fake products.

Using this information, the “raw material value” of the products, based on current raw material prices, can be calculated. With this knowledge, an OEM can make the consumer a buy back proposal towards the end of the product’s life cycle and offer them a discount on the purchase of a new product.

If this concept is developed in line with the XaaS (Everything as a Service) model, companies will offer the use of raw materials as a service instead of selling them. This business model, which works well with the circular economy, can create an additional incentive for suppliers and OEMs to design components and products that can be dismantled and recycled far more efficiently (urban mining).

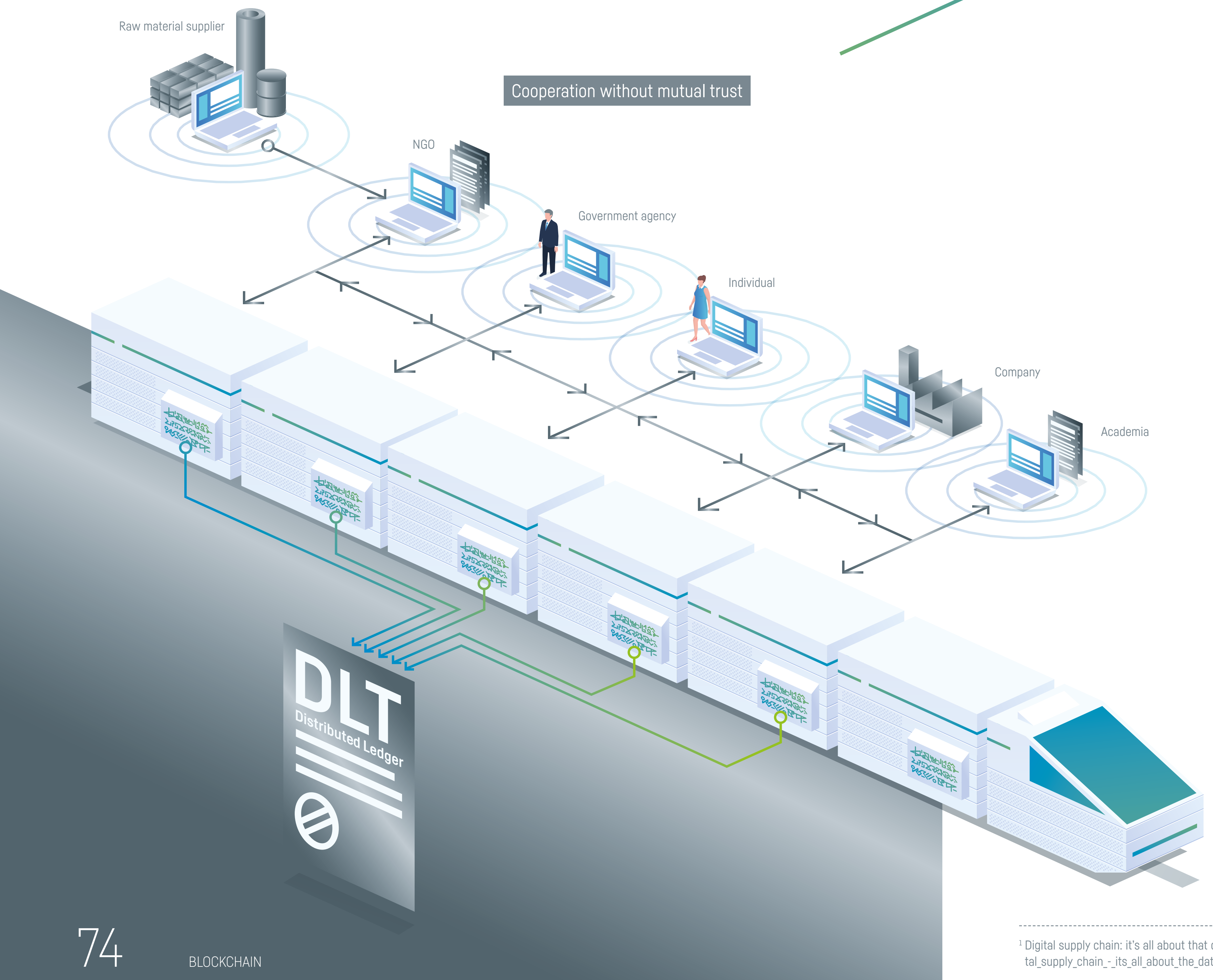
With detailed blockchain information, companies and supervisory bodies can automatically check whether a product complies with local regulations for the use of specific materials or certifications that are required in the country to which the product is delivered.

New legislation restricting certain materials or their use e.g., because they are potentially hazardous or damaging, can be easily enforced, even if products containing these materials are already in the supply chain or are even in the possession of the consumer.

It will, of course, take some time before a consensus is reached among the suppliers, OEMs, partners and supervisory bodies as to which data should be accessible and which should be confidential and not passed on to all stakeholders. However, this is a purely organisational issue; blockchain technology offers suitable solutions to provide appropriate degrees of information confidentiality.

Blockchain as catalyst for collaboration and coopetition

Joerg Walden and Maroye Marinkovic – iPoint Group



Companies are investing in blockchain across all sectors – hoping to automate the supply chain, minimise risks and improve speed, efficiency and costs. Whatever the drivers, whatever the interests of the individual parties, blockchain is a coordination and cooperation technology which demands a collaborative approach. Many of the blockchain initiatives springing up today in almost all industry sectors take the form of consortia and partnerships. They often bring together start-ups, NGOs, government agencies, companies and academia, who work together to solve problems that go beyond their own interests, and that may exceed their capacities as single entities. In exchange for the availability of much more accurate and useful data in a shared blockchain, according to Paul Brody from Ernst & Young, we will accept that our competitors know from whom we are buying and how some of the processes work in our supply chain.[1] The global blockchain survey conducted in 2018 by Deloitte revealed that the vast majority (74%) of the more than 1,000 executive respondents is either participating in or likely to become a member of such a blockchain consortium. Consortia are set to retain their high relevance in the near future as a valuable resource for companies to learn about and develop blockchain applications.

Distributed ledgers are business-to-business workflow tools. So blockchain pratically demands collaboration to set standards, build and develop infrastructures and carry out transactions. These consortia form the mechanism through which companies, government agencies and governments interested in blockchain collaborate. In the opinion of Chris Butler, president and co-founder of the cryptocurrency platform URAllowance, blockchain could foster collaboration between rival companies.[2] This type of collaboration is called "coopetiton", a new term combining "cooperation" and "competition".

[1] Digital supply chain: it's all about that data. EY 2016. https://www.ey.com/Publication/vwLUAssets/Digital_supply_chain_-_its_all_about_the_data/$FILE/EY-digital-supply-chain-its-all-about-that-data-final.pdf

Consortia will play a key role in the commercialisation of blockchain technology in every industry. Deloitte experts have predicted that another dozen or so will be set up by 2020. Not all of them will go into business, which is accepted by those members who are more interested in the learning process at this stage.[3]

In view of the fact that successful commercialisation is highly likely, though still a few years away, we are confident that now is the best time to learn, engage with the topic and collaborate to shape the future Internet of Value.

The iPoint blockchain innovation hub CircularTree advocates the use of blockchain technology with a circular mindset[4]. It focuses on satisfying needs, while prioritising efficiency and energy saving, including minimising waste, fraud, corruption and negative effects on health, safety and the environment. Like the circular economy, blockchain solutions call for collaborative design thinking.

[2] David Drake: Will Blockchain Technology Boost Collaboration Among Corporates? June 15, 2018. https://www.equities.com/news/will-blockchain-technology-boost-collaboration-among-corporates

[3] Peter Gratzke, David Schatsky, Eric Piscini: Banding together for blockchain. Does it make sense for your company to join a consortium? Deloitte, August 16, 2017. https://www2.deloitte.com/insights/us/en/focus/signals-for-strategists/emergence-of-blockchain-consortia.html

[4] Blockchain for Circular Supply Chain. https://www.ipoint-systems.com/blog/blockchain-for-circular-supply-chain

Blockchain in the circular economy – improving recycling

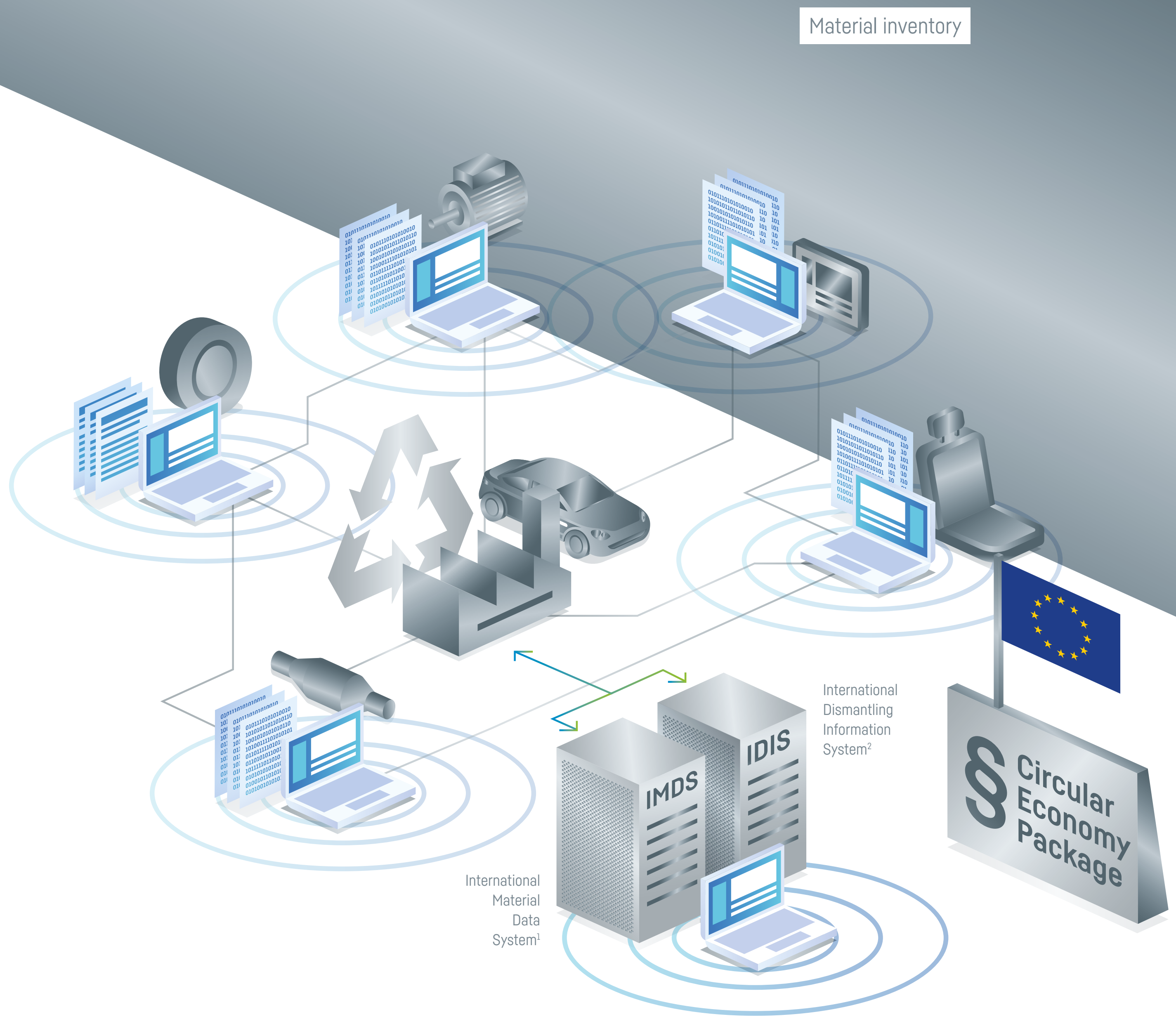
Text: Dr. Dipl.-Chem. Beate Kummer – Scholz Recycling GmbH
Dr. Christian Hagelueken – Umicore AG & Co. KG

Using blockchain technology and increasing digitalisation in waste and recycling industry processes is associated with several advantages. Besides mass products or mass raw materials, there is a growing emphasis on the recycling of rare and critical raw materials (precious metals, lithium, cobalt, rare earths) in compliance with quality assurance requirements. Even for material-heavy consumer products such as cars and electronic devices recycling is still rudimentary, which is also a consequence of lack of information and opaque material flows. Many issues from the past could be resolved in the future with blockchain technologies:

Which hazardous and precious materials can be found in the products and their main components? Where are these particularly resource-relevant parts built into the product and how can they best be separated from it? Where are (mobile) products located at the end of their service life and how can they be reliably steered into high-quality collection and recycling chains? How is waste transported through the recycling chain to the final recycling process, how can the illegal export of end-of-life products be better controlled? Which components and raw materials have actually been recovered and recycled to be used in new products?

The EU Circular Economy Package requires much greater efforts by industry to close loops. For, in the case of complex end-of-life products, the physical loop only works if, differently to what is frequently the case today, these products are actually recorded comprehensively and fed into the most suitable high-quality recycling processes in the recycling chain.

Blockchain offers the chance of more transparency across the supply chain through to the creation of material inventories for intermediate and finished products. Hundreds of suppliers are involved, for example, in putting a car on the market today, and in doing so pollution restrictions (different requirements around the globe) and other manufacturer-specific requirements in respect of equipment, energy efficiency, convenience, autonomous driving and safety need to be taken into account. Over time, these requirements have changed substantially, resulting in similar major changes in the product material mix. Recyclable material and hazardous substance contents also vary greatly from one model, one manufacturer to the next. At the end of the product's life, dismantling and recycling companies are then called upon to ensure parts recycling and as high a standard of reuse as possible. To some extent, companies engaged in recycling old vehicles use existing databases like IMDS or IDIS. However, they tend to hold only patchy information on rare and critical raw materials. Usually, experience is relied upon and familiar parts that can be accessed at a reasonable cost are deinstalled and recycled. With blockchain, a material inventory can be created with the necessary information for all stakeholders. Research projects can be promptly initiated when new parts/material groups are added. Due availability of such information is important, especially in view of new vehicle concepts like electric cars, for which many rare and critical metals and innovative components are used, to develop adapted, cost and performance-optimised spare parts and recycling schemes.



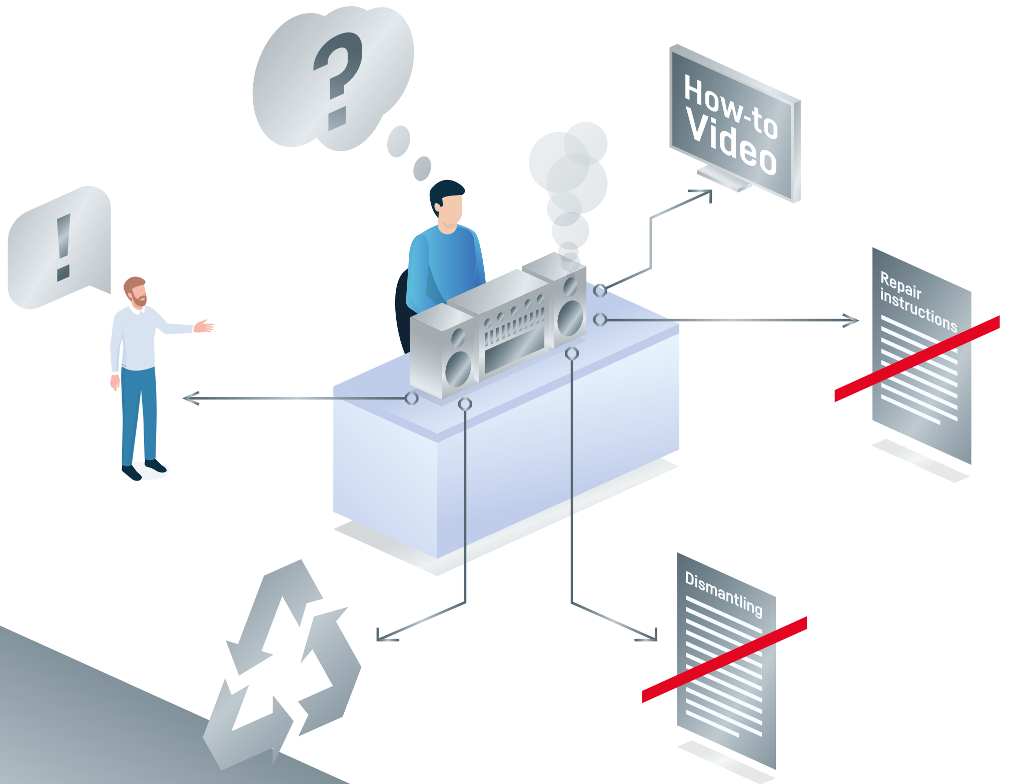
[1] IMDS (International Material Data System) is a global standardised data exchange and management system for material data in the automotive industry.
[2] IDIS (International Dismantling Information System) is an information database for the efficient recovery of end-of-life vehicles that is updated regularly. IDIS enables the identification of processed materials, contains information about material composition and detailed dismantling instructions.

Pooling dismantling know-how – don't bin It, fix it

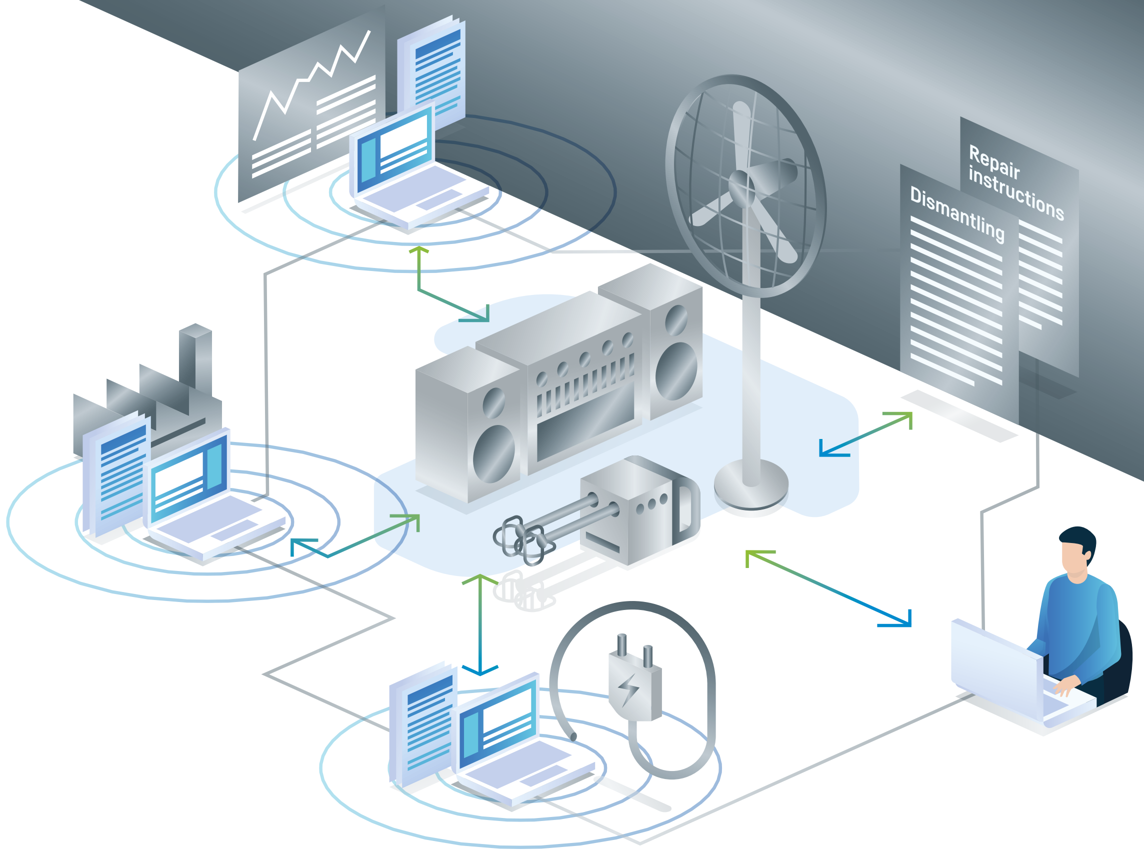
Text: Dr. Torsten Zeller – CUTEC Clausthal Environmental Technology Research Centre

Defective small electrical appliances are usually disposed of at once. Ideally, valuable recycling products should be separated from the waste in a crushing and sorting process. Small electric appliances are usually not repaired in Germany, nor are components with a high content of valuable material recycled. This is due to the relatively high cost of dismantling, which is not offset by potential returns.

Fix it or bin it



Knowledge management for everyone

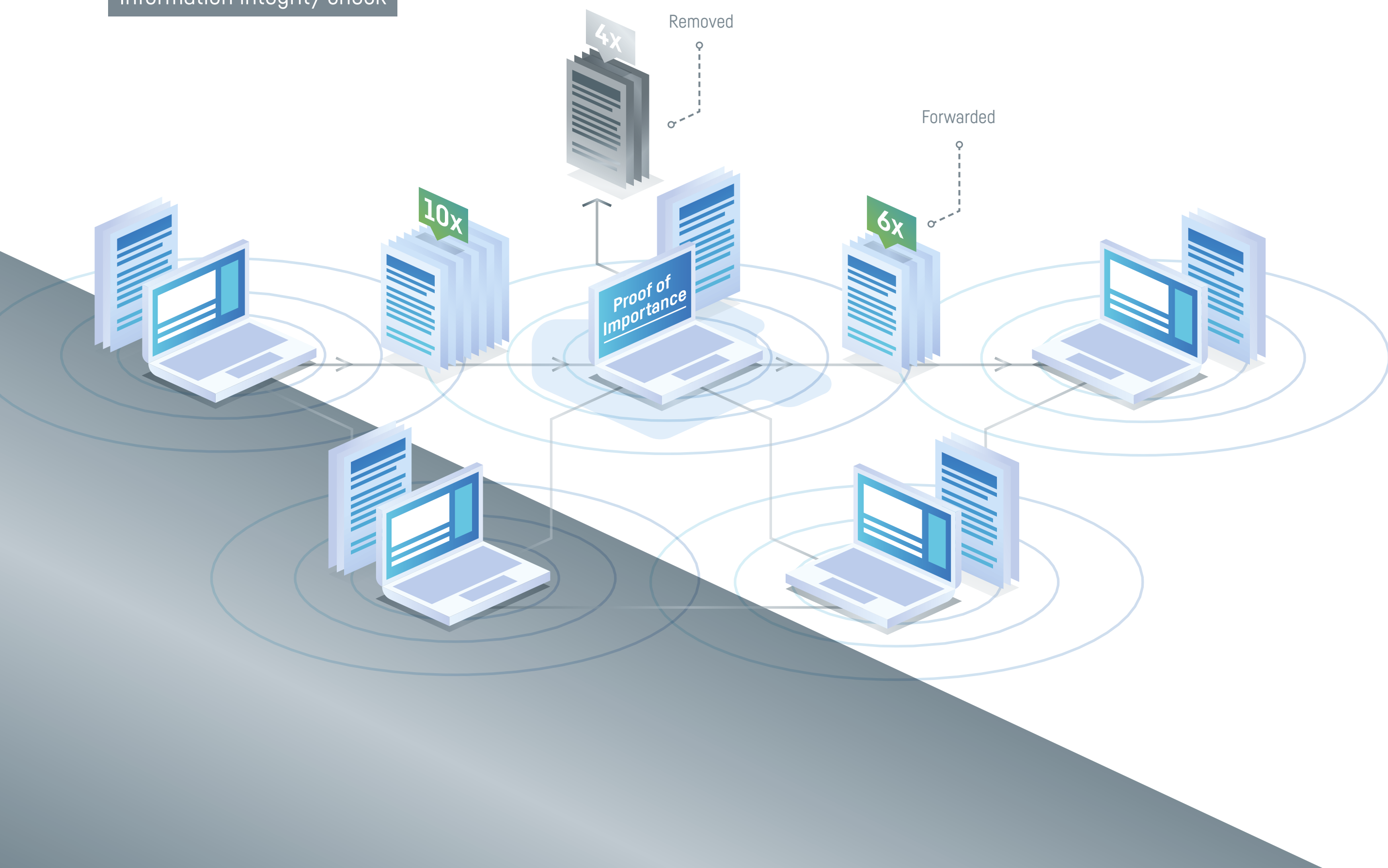


Dismantling is complex. On the one hand, there are design constraints, such as permanently glued joints, on the other, there is a lack of good instructions. However, interest in repairing small electrical goods is growing, shown by the 600 or so repair cafés in Germany alone. So a lot of expertise is out there, but it is scattered and not organised. Know-how and information are mainly passed on by "How-to" videos on social platforms. Blockchain technology could play an important role in this area. It could be used to set up a comprehensive information management system that pools and rates expertise and makes it accessible to users. Using the consensus principle, blockchain can develop best practice dismantling guides to show users the best way to repair their devices.

There are various approaches to finding a consensus. The commonly used proof-of-work approach is energy-intensive and therefore not expedient in terms of resource efficiency. Adapted mechanisms like proof-of-stake or proof-of-importance can be used instead to guarantee a high standard of quality by weighting stakeholders' input in relation to the their activity, filtering out spams and avoiding manipulation. These blockchain technology versions also provide the incentive of stakeholders being able to participate in this form of information management.

Higher involvement – higher repair rates – higher level of resource efficiency.

Information integrity check



Optimising recycling flows and transparency across real product and material flows

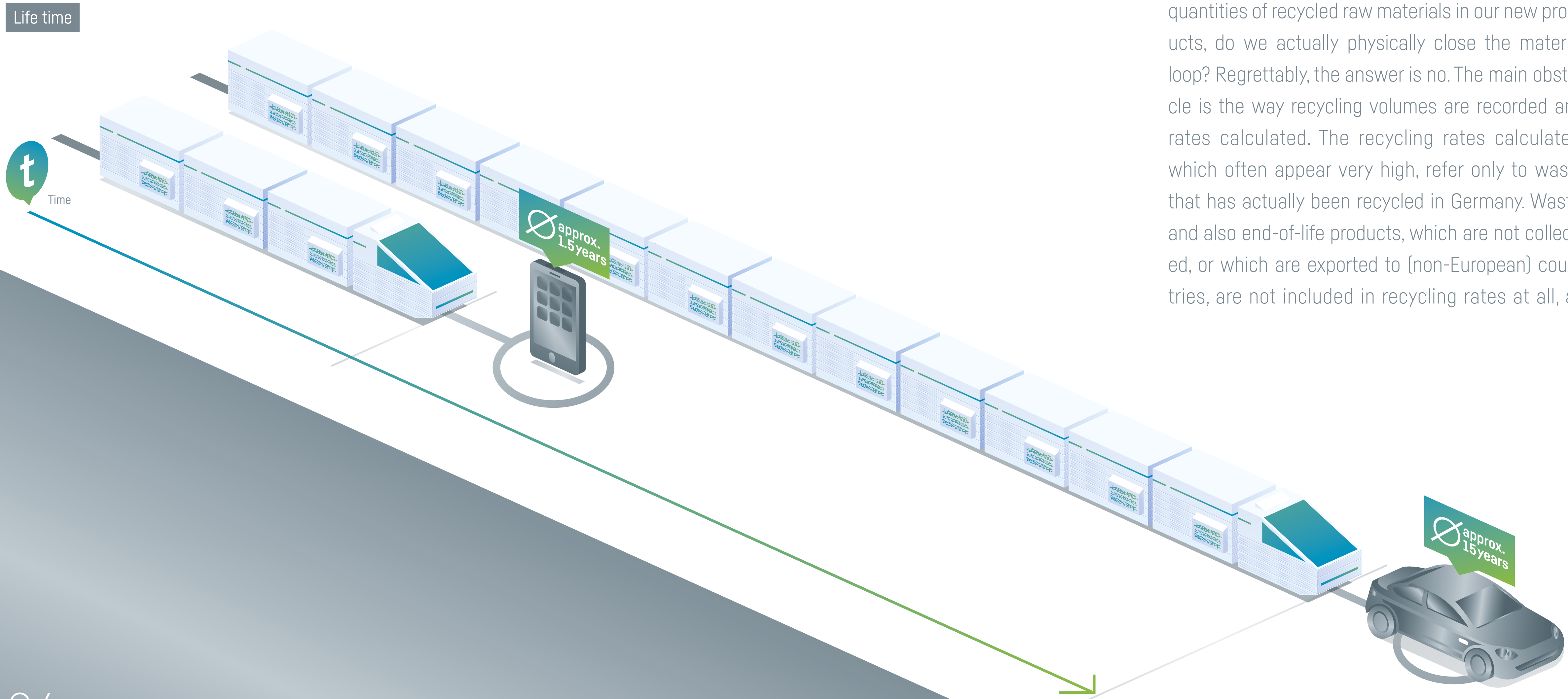
Text: Dr. Dipl.-Chem. Beate Kummer – Scholz Recycling GmbH
Dr. Christian Hagelueken – Umicore AG & Co. KG

In order to improve tracking of material flows of long-life products (such as cars, which have a lifespan of 15 to 16 years), products with shorter life cycles like mobile phones (1.5 years), or even packaging (single use), labels or unique identification numbers must be issued. With cars, this idea has long been implemented through the FIN1 system. Based on unique identification and corresponding registration, a product can be tracked across its life cycle to end of life and necessary deregistration or sign-off. At this juncture, it is important that a national independent body (such as the German Kraftfahrtbundesamt fuer Fahrzeuge and EAR, the national register for waste electric equipment including mobile phones) be responsible for (de)registration.

There is no form of standard nationwide vehicle (de)registration, because it falls under the responsibility of regional transport authorities which so far have no digital network to connect them. Change of ownership on the sale of a vehicle is not registered either, nor final deregistration or off road notification. Online deregistration via a unique number would enable tracking of the vehicle

[1] In the wake of international standardisation, the former chassis number has been replaced by the vehicle identification number (VIN). The VIN is the internationally standardised 17-digit serial number by which a vehicle can be clearly identified. It consists of a manufacturer ID (world manufacturer identifier) such as W0L for Opel and Vauxhall, WDB for Daimler AG, WVW for Volkswagen, WF0 for Ford (Germany) or VF7 for Citroën, a manufacturer-specific code and a serial number usually based on the year of construction.

and its whereabouts. This would significantly alleviate the current situation of a high volume of end-of-life vehicles every year being classed “of unknown whereabouts”. It might be worth considering fitting new vehicles and products (like smartphones) with a compulsory identifier in the form of a RFID chip or other tracers that enable clear identification and quality-assured recycling using automated sorting processes.

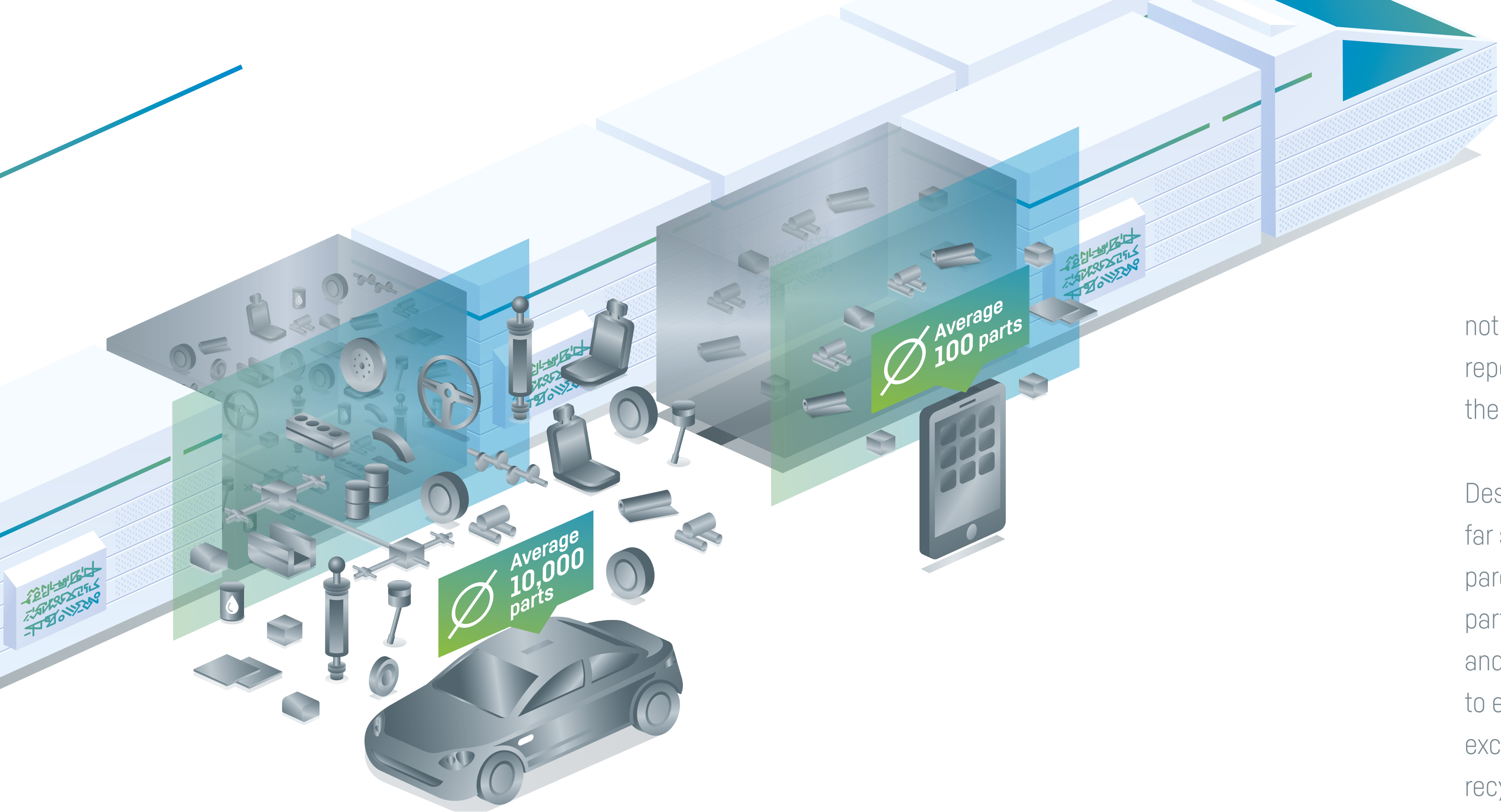


[1] See also www.polysecure.eu

Monitoring (material-related) real recycling volumes and rates

Text: Dr. Dipl.-Chem. Beate Kummer – Scholz Recycling GmbH
Dr. Christian Hagelueken – Umicore AG & Co. KG

Germany is often reported in the press as being the world champion in recycling. But is it true? Is the German recycling system as good as its name? More importantly, does it mean that we already use large quantities of recycled raw materials in our new products, do we actually physically close the material loop? Regrettably, the answer is no. The main obstacle is the way recycling volumes are recorded and rates calculated. The recycling rates calculated, which often appear very high, refer only to waste that has actually been recycled in Germany. Waste, and also end-of-life products, which are not collected, or which are exported to (non-European) countries, are not included in recycling rates at all, as



shown by the example of end-of-life cars. In Germany, around 3 million vehicles are deregistered every year, but only around 0.5 million are recycled in Germany (and the rate is based solely on this figure). We at least know what happens to around 2–2.5 million of the rest, but that still leaves a substantial gap of almost 800,000 end-of-life vehicles every year "of unknown whereabouts" in Germany, and several million in the EU, (Oeko-Institut, 2018)[4] and it can be assumed that a very large proportion of them are not recycled properly. The raw materials in these vehicles, especially the rare and critical metals, are lost and the loop is not closed. The same goes for old electrical appliances, most of which are not properly recorded either or which disappear into dark channels (see reports in the media about electrical scrap in Ghana/West Africa and the current documentary "Welcome to Sodom", 2018).

Despite ambitious recycling laws the reality of their enforcement falls far short of expectations, and this is mainly the result of a lack of transparency in the real product and material flows. We must aim to track particularly raw material-relevant products like cars, electronic goods and batteries across their service life and on reaching its end, not only to ensure that they are (somehow) "recycled", but that they are handled exclusively by high-quality recycling companies along the logistics and recycling chain until they reach their ultimate recycling point. Only such companies can ensure that components and raw materials are reused and recycled to an optimum extent within a feasible technical and financial framework in compliance with ecological and social standards.

The vision is one of establishing such transparency across real material flows along an optimised recycling route by using product and component identification features and tools like blockchain, and doing so reliably, with no risk of corruption, and easily, so that stakeholders are spared extra administrative work. Such a system could also more or less automatically provide documentation of product inventories, recycling quantities and actual recycling rates.

[4] Oekoinstitut, 2018, Assessment of the Implementation of Directive 2000/53/EU on end-of-life vehicles (the ELV Directive) with emphasis on the end of life vehicles of unknown whereabouts. EU Commission.

Life cycle assessments and climate footprints

Text: Prof. Dr. Mario Schmidt – Pforzheim University

What is the environmental impact of a product or service, such as shipping, for instance? Which is greener, Product A or Product B? How and where is it easiest to improve a product's life cycle assessment?

These are simple questions, but the answers are anything but. The product's entire "journey through life" has to be taken into account, from raw material extraction to manufacture, use by the end consumer and disposal or recycling.

All processes involving pollution need to be taken into consideration, thus wherever electricity is used or any shipping indirectly causes emissions from power stations, vehicles or oil refineries.

These analyses are called life cycle assessments (LCAs) They are internationally standardised in line with ISO 14040 and cover various environmental effects such as impact on the climate, the hole in the ozone layer, waters, biological diversity and so forth. If an analyse is confined to climate impact, the term carbon footprint is used.

The challenge posed by LCAs and carbon footprints is how to track a product's journey, before point of sale, thus before the use phase, or in other words, the product supply chain. Data would be needed from every supplier about the pollution they have caused, directly by manufacturing a product or calculated proportionally to the product. They must also pass on their upstream supplier data relating to the eco baggage carried by all the materials and semi-finished goods required for their product. A data structure linking one supplier to the next is thus created, starting with the extraction of the raw material from nature and any environmental impact caused during the product journey.

In practice though, it is a problem that defies solution or involves a huge amount of research, which makes life cycle assessments very expensive. Manufacturers of finished products seldom have a full picture of the whole supply chain, contact being limited to their direct supplier. Often, suppliers are reluctant or downright unable to provide their own or upstream supplier data. This is why currently, even in professional software solutions like Umberto, life cycle assessments are based on generalised data, which means that if aluminium is used in a manufacturing process and comes from China, a generic data set is calculated for Chinese aluminium, for which, for instance, Chinese electricity generated by coal-fired power stations is used. So although this LCA comes relatively close to the real thing, it is rarely the exact match for the specific product.

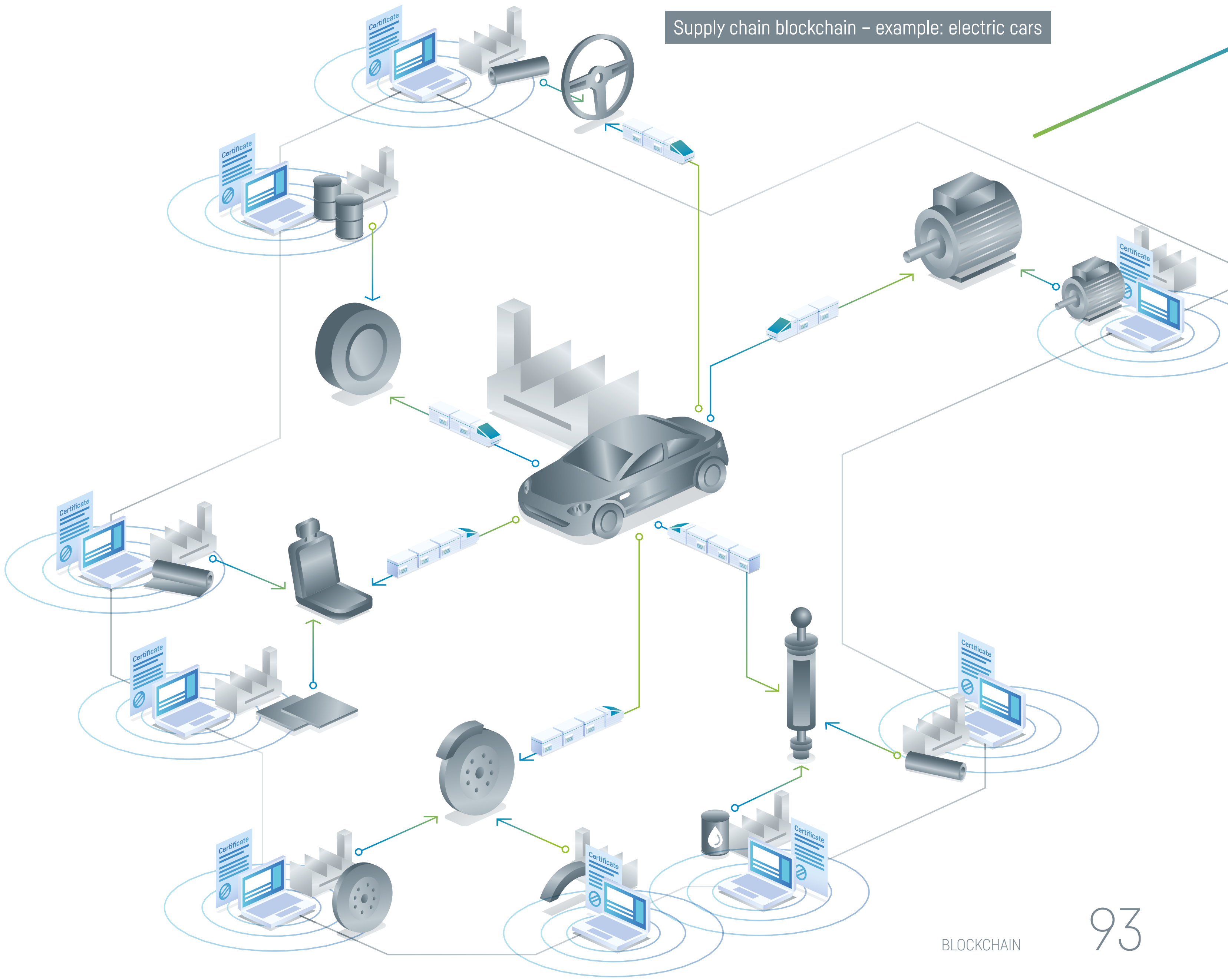
Traditional supply chain

Generally, life cycle assessments are created once for a prototype or a classic product proponent. In many cases, this is sufficient. However, if the supplier structure changes over time, and the aluminium is no longer bought from China, but from a supplier in Norway, the life cycle assessment will change, too. Supplier changes are common, especially for fast-moving products in the food and consumer goods sector. So when the potato supplier changes, so does the carbon footprint of the bag with the crisps. It ought to be corrected, but isn't.

Taking into account the use and disposal phases of a product is even more complicated. You need exact usage data: How often and how long is the product used? Does it use a lot of electricity or some other fuel? Is it used a second or third time round? How is it disposed of? These data are usually determined by market analyses or plausible assumptions. Again, they do not refer to a single product, but to a class of products, such as all vacuum cleaners of the same type, used in conditions typical for the market.

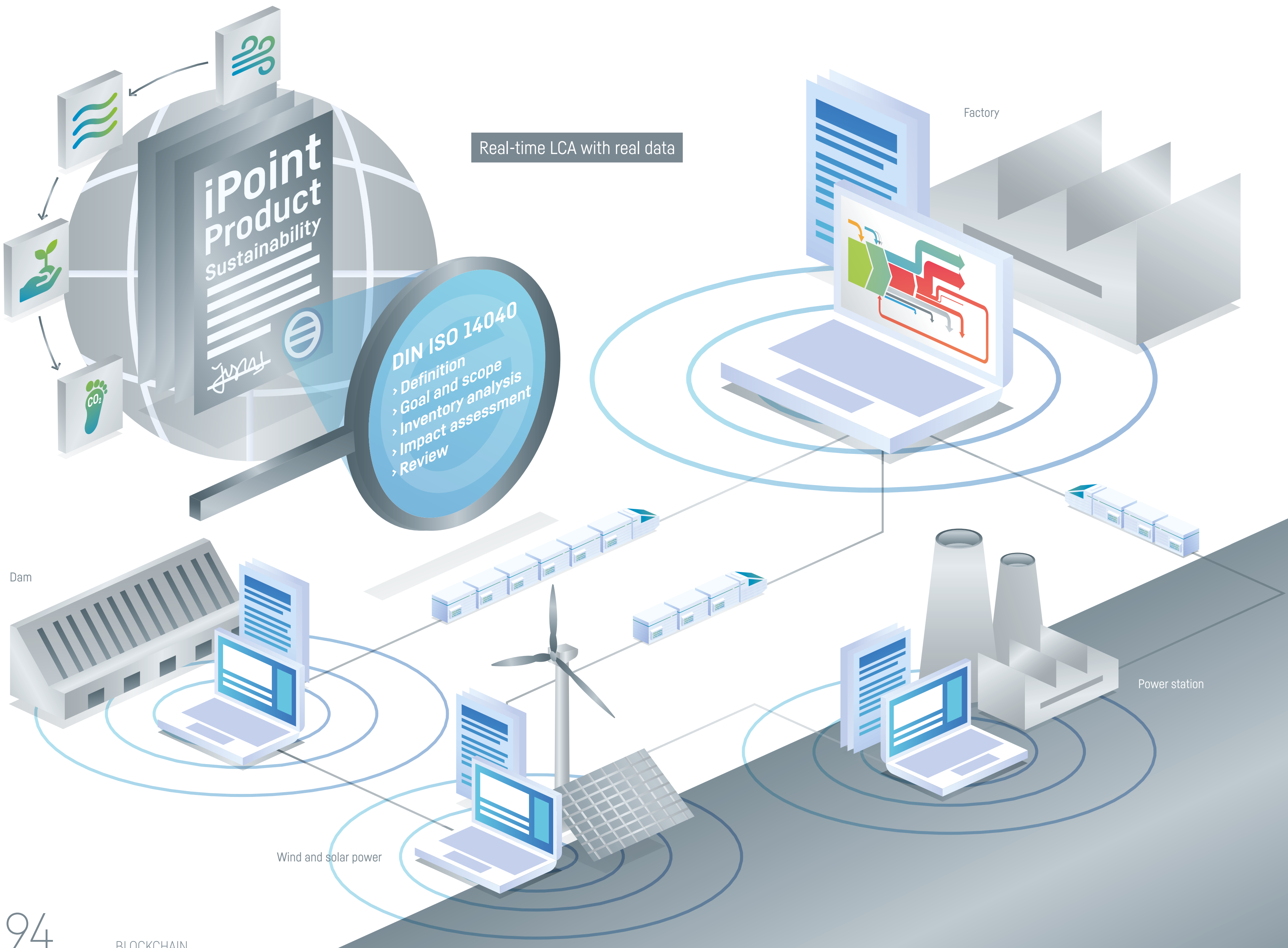
A blockchain could revolutionise life cycle assessments and carbon footprints. Firstly, the actual environmental impact across the product life cycle could be recorded, and then passed along to the next player in the chain without the question of trust arising. Suppliers could retain their anonymity, while still allowing exact tracking of a product's carbon footprint. Secondly, the assessment could be tailored precisely to one individual product, thus taking into account whether it has been reworked several times, its factory or country of origin, where the necessary electricity was supplied and so forth. Did the milk for the yogurt you've just bought come from your area or from far away? Only then would absolute product transparency be achieved for the consumer buying a product, echoing the old saying "What you see is what you get" or rephrased to match a carbon footprint label on the product "What you see is what it did".

If it were possible to also record the usage phase, in anonymised form, of course, valuable information could be gained for the downstream disposal phase or future product developments. The same data could also be transferred seamlessly to another application, namely the control of recycling flows and processes with individual product data.



Optimising value creation ecologically and economically

Text: Martina Prox – iPoint Group



Widespread use of life cycle assessments (LCAs) can help us to make decisions when buying new production machinery, for instance, or implementing new product concepts or selecting materials. The discussion about using LCA more widely, however, is overshadowed by major obstacles – issues like cost of procuring data and their reliability, currentness and quality. At the same time, increasing digitalisation of processes and product developments lead to the generation of even more data. Digital twins already contain information about contents, technical functionality, origin and proper handling of materials, semi-finished and finished goods. This can be complemented by information on the amount of energy consumed at every stage in the value chain, climate impact and other environmental effects. iPoint's Product Sustainability solution integrates the relevant information relating to the environmental effects of each value chain stage and to make it readily available at all times for analyses and as an aid to decision-making.

In some sectors, the law demands that goods can only be placed on the market if all the contents of every part and component are fully declared. Platforms, like the iPoint SustainHub with more than 55,000 registered users, are already available for collecting and managing relevant information across the supply chain. They keep all important data about compliance and sustainability readily available. Established platforms, processes and structures like this can easily be used for other kinds of information such as the impact of a component on the climate. They can also be used for other sectors in which stakeholders committing themselves voluntarily to achieve more transparency in the supply chain might result in a similar demand for information and solutions as statutory requirements in other industries (such as the automotive and electronic industry).

If digitalisation can improve the general availability of sustainability data in the supply chain, then the use of blockchain can ensure that these data are transmitted without being modified or corrupted. Manufacturers and consumers alike can trust these data. Moreover, Blockchain deployment would enable improvements to be made without having to threaten sanctions as was the case up to now. How so? If information is passed on in one direction, money flows can be sent in the other direction, back to the original supplier of the material and information, and the sanction system would give way to a reward system. The legitimate protection of trade secrets, which often stands in the way of information transparency today, would be ensured through the use of blockchain technology.

Index of abbreviations

3TG	Conflict minerals: tin, tantalum, tungsten and gold
B2B	Business-to-business
B2C	Business-to-customer
BEV	Battery electric vehicle
BfR	Bundesinstitut fuer Risikobewertung (Federal Institute for Risk Assessment)
BOM	Bill of materials
CDX	Compliance data exchange
CLP	Classification, labelling and packaging
CMR	Cancerogen mutagen reprotoxic
CMRT	Conflict Minerals Reporting Template
DLT	Distributed ledger technology
EAR	Elektro-Altgeräte Register, Waste Electrical and Electronic Equipment (WEEE) Register
ELV	End-of-life vehicles
EOL	End of life
EPRM	European Partnership for Responsible Minerals
EU	European Union
GADSL	Global Automotive Declarable Substance List
GPS	Global Positioning System
ICT	Information and communication technology
IDIS	International Dismantling Information System
IIoT	Industrial internet of things
IMDS	International Material Data System
IoS	Internet of services
IoT	Internet of things
iPCA	iPoint Compliance Agent
IT	Information technology
LCA	Life cycle assessment
LCD	Liquid crystal display
NGO	Non-governmental organisation
OECD	Organisation for Economic Co-operation and Development
OEM	Original equipment manufacturer
PBT	Persistent, bioaccumulative and toxic substances
POP	Persistent Organic Pollutants
QR-Code	Quick response code
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RFID	Radio frequency identification
RoHS	Restriction of Hazardous Substances
SCM	Supply chain management
SVHC	Substances of very high concern
TSCA	Toxic Substances Control Act
UV	Ultraviolet
vPvB	very persistent and very bioaccumulative

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MINISTRY OF THE ENVIRONMENT, CLIMATE PROTECTION AND THE ENERGY SECTOR

THINK TANK
FOR INDUSTRIAL
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Blockchain Technology for Industrial Production and the Digital Circular Economy