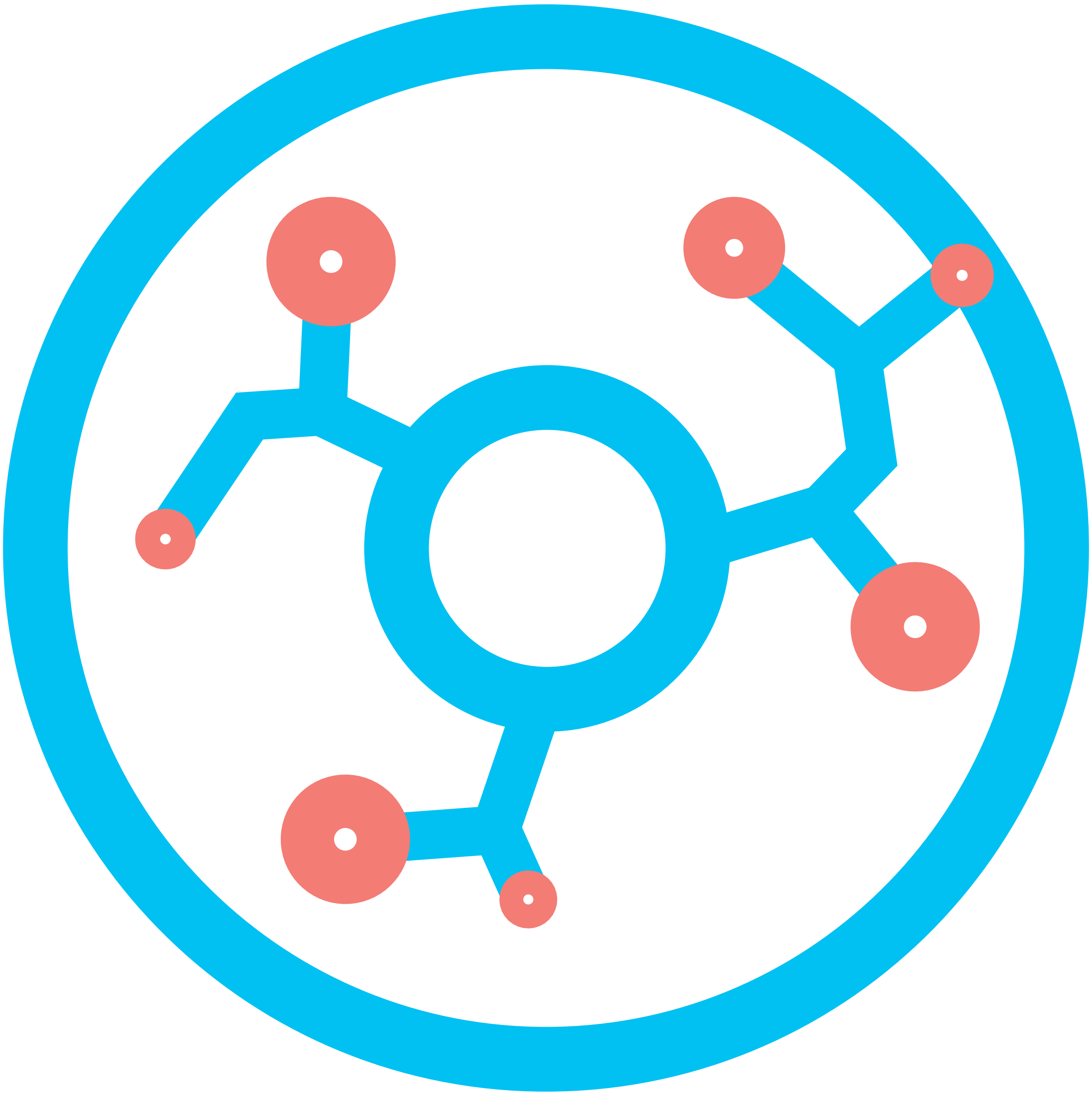
THE CIRCULAR SERVICE PLATFORM

A technical-administrative infrastructure for managing value in circular networks



NEDERLAND CIRCULAIR!

SUSTAINABLE FINANCE LAB

CIRCLE ECONOMY

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KEY TAKE AWAYS

1. In a circular economy, assets are no longer sold. Rather, the assets are collectively serviced by circular service (CISE) networks, comprising all stakeholders involved in keeping an asset functioning.

2. This requires unprecedented levels of cooperation and coordination, leading to often prohibitively high administrative costs and the need for trust and transparency in the network.

3. This Community of Practice used new technologies (distributed ledger technology (DLT), smart contracts and cryptocurrencies) to radically lower these costs and provide the called-for transparency

4. We piloted the case of Bundles - a circular company that provides its customers with 'clean laundry' per washing cycle – on a proof of concept DLT platform of Rabobank.

5. Our Circular Service (CISE) Platform functions as a decentralized digital administration system and adapts value management to circular ownership and incentive structures.

6. A Code of Conduct is provided that constitutes governance of the CISE Platform, and introduces a not-for-profit custodian holding all titles to all assets in the platform.

7. Before the CISE Platform can be brought to market, regulatory compliance needs to be ensured, privacy must be encompassed in the entire design, and technical issues need to be solved.

8. We invite anyone that wants to participate in the circular economy to join our network and engage with us in future developments.

EXECUTIVE SUMMARY

In a circular economy, assets are no longer sold. Rather, the assets are collectively maintained by a network of stakeholders involved in the ongoing functioning of the assets; the circular service (CISE) network. This shifts the responsibility for the functioning of an asset from the end-user to the network. Thus, stimulating the redesign of business processes to optimize the life-cycle performance of the asset.

A CISE network however requires unprecedented levels of cooperation and coordination between participants, leading to high administrative costs and the need for trust and transparency in the network. CISE networks are a totally different way of doing business, requiring different financial-, legal- and governance structures. Would it be possible for assets to be owned and procured by a network that creates value from them? Could this, simultaneously, reduce administrative costs? Could cashflows generated by the asset be redistributed to the network, leveraging the sharing of risks and returns?

COMMUNITY OF PRACTICE

These were the questions that prompted this Community of Practice (COP) - an interdisciplinary open learning space – to consider if new technologies might offer a solution. We looked into a range of recent technological developments and initiatives:

- Distributed ledger technology enables tracking and monitoring of transactions and the provenance of assets throughout their lifecycle in an adversarial environment.
- Smart contracts trigger automatic enforcement and execution of payment mechanisms that assure that everyone involved in the contract is compensated.
- Cryptocurrencies enable the transfer of micro transactions readily and securely

In this COP we have taken the first steps to put this theory into practice. Starting point was the proof of concept Sustainable Pay per Use (SPPU)-platform that Rabobank developed based on distributed ledger technology and smart contracts. This SPPU-platform fully automates the payment administration of assets that are offered in a pay-per-use proposition, such as cars (pay per km driven), and milk robots (pay per litre of milk).

We piloted Bundles – a circular company that provides its customers with 'clean laundry' - on Rabobank's platform. We further developed and adapted the platform to the evolving ownership and incentive structures in the circular economy.

THE PROPOSED CISE PLATFORM

Technology is not neutral, it needs to be carefully designed. The resulting CISE Platform functions as a decentralized digital administration system for circular service providers that supply a unit of service (e.g. clean laundry cycle). The CISE Platform

i. automatically charges the end-users for using an asset (e.g. per washing cycle), reducing the administrative burden and costs for circular entrepreneurs;

ii. automatically distributes the paid use fees to compensate network participants for servicing the asset. This enables service providers to engage with the assets, without a central party to coordinate;

iii. provides a transparent ledger containing information regarding revenues that are generated by a specific asset. This enables a clear division of rights and obligations regarding collateral and cashflows;

iv. allows for micropayments (smaller then €0,01) against low cost. This makes high volumes of transactions with small amounts affordable;

v. is open for anyone contributing to a circular economy, stimulating circular competition and lower prices;

vi. is community-owned and maintained by the CISE network participants. This allows the proceeds to be distributed amongst the CISE network rather than creating rents for the platform;

vii. allows all network participants, including end-users, to co-finance assets or innovations. Repayments are based on generated use fees, leading to new types of circular financial products.

CODE OF CONDUCT

The digital infrastructure relies on physical assets and external systems and agents, which requires legal structures to enforce decisions both within and outside the CISE Platform. The COP sketched the contours of these structures in a code of conduct. The Code of Conduct covers:

i. the constitution of the platform;

ii. the management, rights and obligations of the not-for-profit custodian holding all titles to all assets that are serviced on the platform;

iii. describes who is eligible to join, i.e. how the network can be accessed;

iv. rules on decision-making processes (e.g. voting schemes) regarding circular principles; circular investment opportunities, and changes to the code of conduct itself;

v. arrangements on the constitution and organizational governance of the CISE Platform.

FUTURE DEVELOPMENTS

Before the CISE Platform can be brought to market, a few key areas need to be addressed:

i. Regulatory engagement is a critical piece in future development of the CISE Platform, as many elements of the platform touch upon areas that are subject to regulation;

ii. The platform needs to be designed with privacy as a priority. Also, local and global data-protection regulations, such as GDPR, should be considered. This requires further research;

iii. A frictionless connection between euro's and claims on that euro's, represented in platform-tokens, is needed and requires further research and development.

iv. The platform needs to be piloted in other Product Markets to adapt the functionality to fit a broad range of assets.

JOIN THE NETWORK

Whereas the CISE Platform can be used to drive commercial circular activity in the future, the platform itself is not-for-profit and has no direct commercial interest. It functions as a flexible, open, and community-maintained facility, to be used by anyone that has the ambition to contribute to a circular economy. We believe that such a platform could be transformational to the circular economy, enabling CISE networks in a wide array of sectors. To realize this potential requires tremendous effort, dedication and cooperation. We have taken the first steps, but a long path still lies ahead. The support of many is crucial to its success. We invite anyone that is interested in being part of the circular economy to join our network and engage with us in future developments.

CONCLUSION AND FUTURE DEVELOPMENTS

ENABLE COLLABORATION BETWEEN VALUE CHAIN PARTICIPANTS

THIS REQUIRES:

	✓	Transparent and secure sharing of information between network participants collectively operating an asset
	✓	Transparent rights and obligations of network participants
Relies on tracking and tracing facility on the serviced asset	?	Transparency on performance of the serviced asset and generated cash flows
Not yet. Needs technical development (e.g. data partitioning) and regulatory compliance	✗	Privacy by design: transparency should be tailored to specific needs of participants and privacy must be encompassed in the entire platform
	✓	Allow for easy and open participation of circular entrepreneurs
	✓	Encourage lively debate on circular economy principles

FACILITATE AFFORDABLE PAYMENT ADMINISTRATION

	✓	Cheap, fast and secure payment solution for many small payments (micropayments)
	✓	Automatic execution and enforcement of contracts between all network participants
Requires implementation for connecting user with the asset (e.g. a QR-code)	?	Payment solution that allows for charging individual use of a shared asset

IMPROVE FINANCEABILITY OF ASSET

	✓	Allowing for flexible small investments to scale the circular asset pool
	✓	Solution for managing a complex division of ownership

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1 - THE COMMUNITY OF PRACTICE

A circular economy requires a different way of doing business. Business processes shift from companies that act episodically across the value chain, to circular service (CISE) networks that integrally connect life-cycle activities and optimize incentives inherently. Two elements are instrumental in reaching this outcome: (1) assets are being serviced and (2) this is done collectively.

As highlighted in a series of earlier reports, the collective servitization of assets come with significant coordination challenges, high administrative costs, particular financing needs and increasing complexity in division of ownership (FinanCE working group 2016; Fischer and Achterberg 2016; Achterberg and van Tilburg 2016; van Tilburg, Achterberg, and Boot 2018). Additionally, it requests trust and openness among value chain participants.

This paper discusses whether new financial information technologies might provide opportunities to address these challenges, thus radically enlarging the economic viability of CISE networks. To this end we address the following questions:

- Is it possible to own and procure assets by a network that create value from them?
- Could this simultaneously reduce costs and thus improve the circular business case?
- Can the asset rents that are generated by servicing circular assets be redistributed to the network?

In this Community of Practice (COP) - an interdisciplinary open learning space - consisting of Sustainable Finance Lab, Circle Economy, Nederland Circulair!, Bundles, Rabobank, Allen & Overy, ABN AMRO Bank, ING, DLL en Leystromem, we sought to answer these questions by drawing from a range of recent technological developments and initiatives: distributed ledger technology (of which blockchain technology is a subset) enables tracking and monitoring of incremental transactions and provenance of assets throughout its lifecycle. Smart contracts trigger automatic enforcement and execution of payment mechanisms that assures everyone involved in the contract is compensated. Cryptocurrency enables micro transactions.

In this COP we have taken the first steps to put theory into practice by developing the foundations necessary for a technical-administrative infrastructure, that adapts value management to the changing ownership and incentive structures in the circular economy. To this end, a circular enterprise and innovative payment solution were brought together. Bundles, a circular enterprise, that provides its customers with the service of 'clean laundry' but faces administrational and financial challenges. And a proof of concept DLT system that seeks to fully automate payment administration of equipment offered in a pay-per-use proposition, developed by Rabobank in a project called Sustainable Pay per Use (SPPU).

We think that the success of such a platform could be transformational to the circular economy. To make this a reality, however, tremendous effort, cooperation and resources is still required. Therefore, we hope that the CISE Platform, which we propose in this paper, will provide inspiration for others to innovate their businesses towards circularity.

This paper is structured as follows:

- Chapter 2 explains the why and how of circular service networks, leading to a 'design philosophy' (a circular wish list) that guides us through the subsequent chapters.
- Chapter 3 challenges the design philosophy from chapter 2 against distributed ledger technology (DLT), to build a case for or against the use of DLT systems for this particular purpose.
- Chapter 4 describes the functionality of the CISE Platform from the perspective of end-user and service provider, and presents the underlying legal- and financial structures.
- Chapter 5 enumerates the elements from our wish list that the CISE Platform provides, and what elements need further development or research.

2 - CIRCULAR SERVICE (CISE) NETWORKS

Before we dive into technological solutions and possible design choices, we formulate the goals we want to achieve. These reflections lead to a design philosophy, a circular technology wish list, that will guide us while exploring possible solutions in the subsequent chapters.

A key distinction of the circular economy is the need to consider the entire life-cycle of a resource. Resources must remain functioning at their highest potential for as long as possible, and must be re-entered into the system to create value again and again, from pre-use to post-use and back (see the Value Hills, Figure 1).

This requires a different way of doing business and thus different supporting mechanisms. Our perspective needs to be adjusted towards the resource itself from which the value is being created rather than towards fragmented business actors, acting episodically across the three phases of the Value Hill. A Circular Network integrally connects the activities in the three phases of the Value Hill and optimizes incentives inherently. This is summarized in Figure 2.

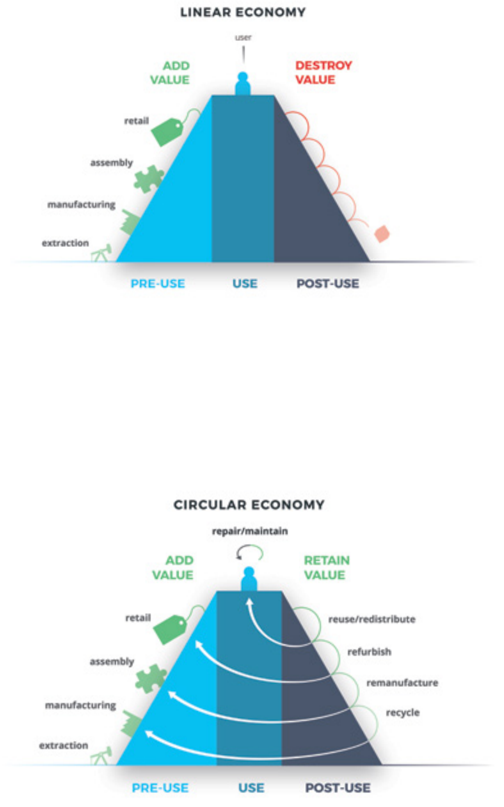


Figure 1 - The Value Hill. Source: Achterberg, Hinfelaar, and Bocken (2016)

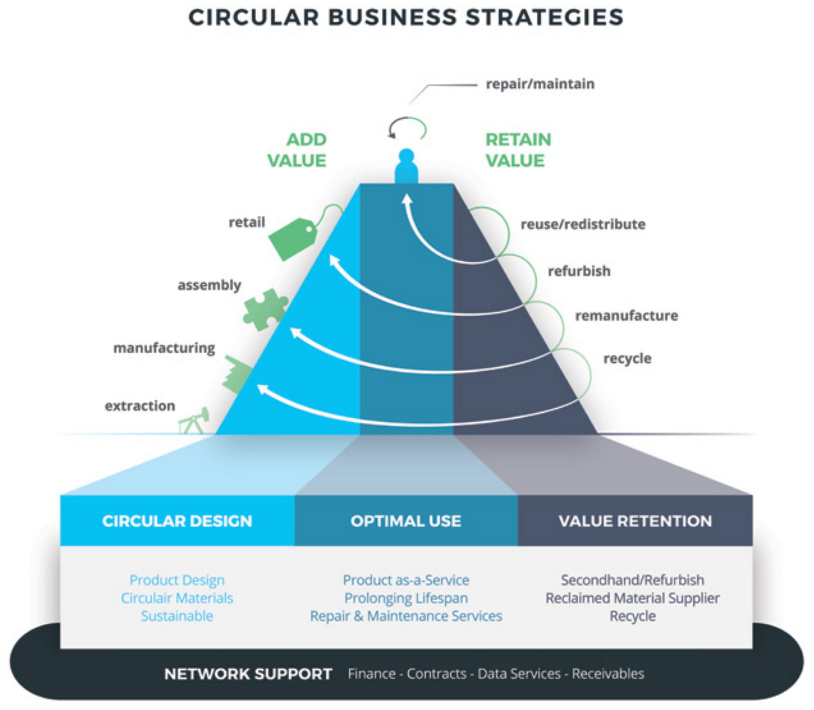


Figure 2 - Circular business strategies on the Value Hill. Source: Achterberg, Hinfelaar, and Bocken (2016)

IT IS ALL ABOUT ASSETS AND RELATIONSHIPS

Offering services around a product - rather than selling resources every step up the Value Hill - is deemed instrumental in translating circular products into attractive value propositions for all participants of a circular network (ING 2015; van Tilburg, Achterberg, and Boot 2018). Two elements are instrumental in reaching this outcome: (1) the assets are being serviced and (2) this is done collectively. This leads to the creation of circular service networks.

ASSETS ARE SERVICED

Firstly, offering services, rather than selling products, provides an incentive for sustainability. Eight different types of such so-called Product Service Systems (PSS) exist. In terms of environmental potential, result-oriented business models are the most promising, but also encounter the biggest challenges (Tukker 2004). In these business models the user buys the output of the product according to the unit of use (e.g. per washing cycle) or the result (e.g. clean laundry). The provider is, within the boundaries of contract terms, free as how to deliver the result. This incentivizes the provider to keep the asset functioning for as long as possible against the low possible cost, in other words optimize life-cycle performance.

I founded Bundles 5 years ago because I had the idea to start offering the best things as a service to prevent them ending up in landfill. We started with washing machines, dryers and dishwashers from Miele and connected them to the internet. This way we increase its value by smart maintenance and sustainable consumption. The question now is: how do we ensure that the value created with that asset is made transparent, that everyone is compensated according to their performance and that upsides and downsides can be shared? We hope to seduce asset manufacturers and consumable providers to start developing products that better fit this new story. Only then can product service propositions compete with the linear economy

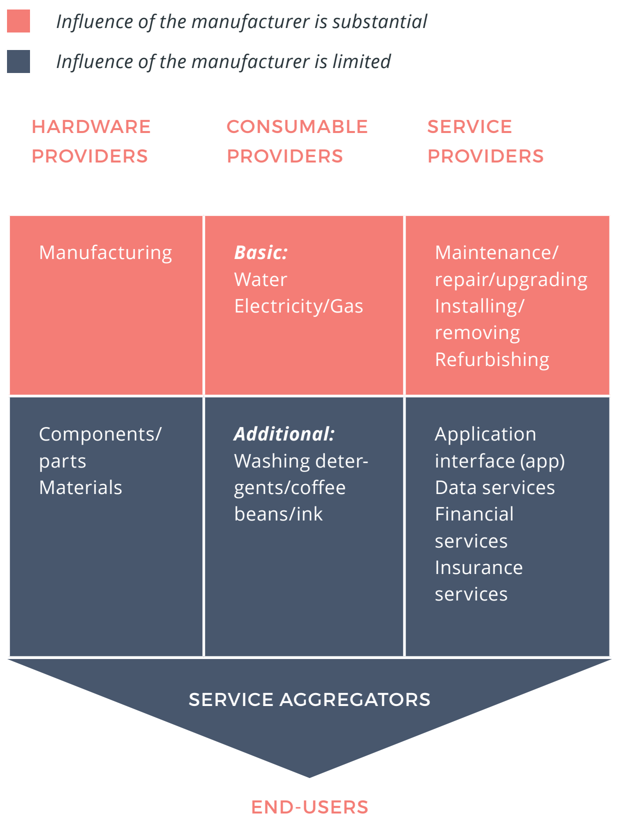
– Marcel Peters, CEO Bundles

Bundles washing proposition is a hybrid PSS model, providing its customers with a long-life washing machine and charging them a fixed fee for access to the asset (product lease) and a variable fee per washing cycle (pay-per-use). In some instances, assets are shared (product sharing). A device is attached to the washing machines which monitors its usage. Statistics gathered from the machine are displayed on the Wash-App, and translated into tips and insights to reduce the overall cost of doing laundry, including energy, water and detergent consumption. It also gives feedback on the effect of different sorting, dosing and programming schemes (advice). This way, not only the costs for the customer are reduced, but also the life of the machine is extended. Bundles is responsible for installation, maintenance and repair of the machine, but also replacement if the machine becomes outdated or broken. The time that a washing machine is out of order, is compensated for. This incentivizes Bundles to deliver excellent service.

SERVICE IS A COLLECTIVE EFFORT

Secondly, it is impossible to reach a circular state alone. A full-service proposition involves hardware-, consumable-, and service providers. Hardware providers are involved in the manufacturing process and provide components, parts and processes leading to an asset. A consumable could be either (i) necessary to operate the asset (e.g. electricity, gas or water) or (ii) that is provided additional to the asset (e.g. coffee beans or washing detergent). The one ideally situated to aggregate the services to the end-user is the one that has most influence on resource use, consumable use, ease of maintenance, repair and re-use of the asset.

To optimize life-cycle performance, the service aggregator (i.e. the one providing the stacked service to the end-user) heavily depends on its value chain. Better life-cycle guarantees can be negotiated, maybe even buy-back agreements, but the best way to align incentives is to compensate all value chain partners based on performance, i.e. unit of output or result. This would result in a collectively provided service by a network of service aggregators that provide part of the functioning of the asset (e.g. the motor, water pump, drum, etc.). A reduction of sales models in the value chain spreads the amount of upfront investments that are required over multiple service aggregators. This is illustrated in figure 3.



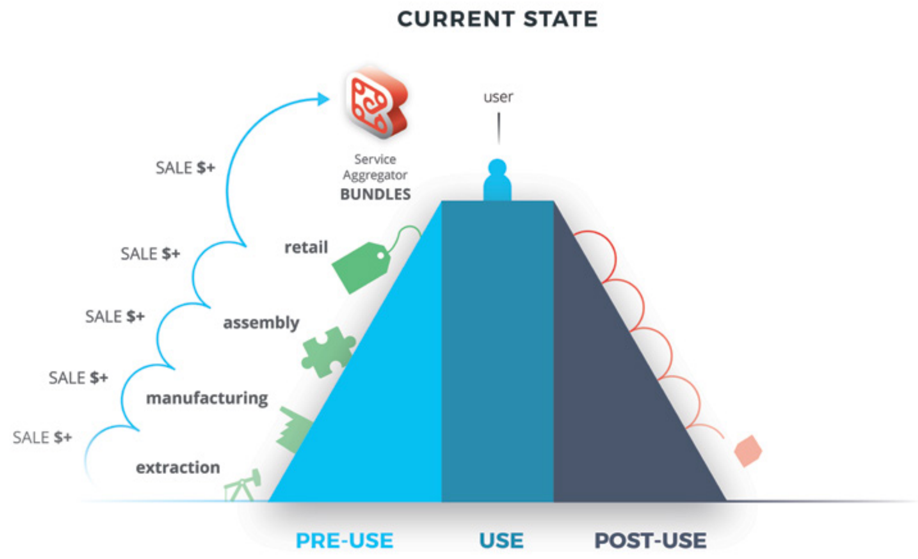


Figure 3 - Current situation Bundles on the Value Hill

FUTURE STATE

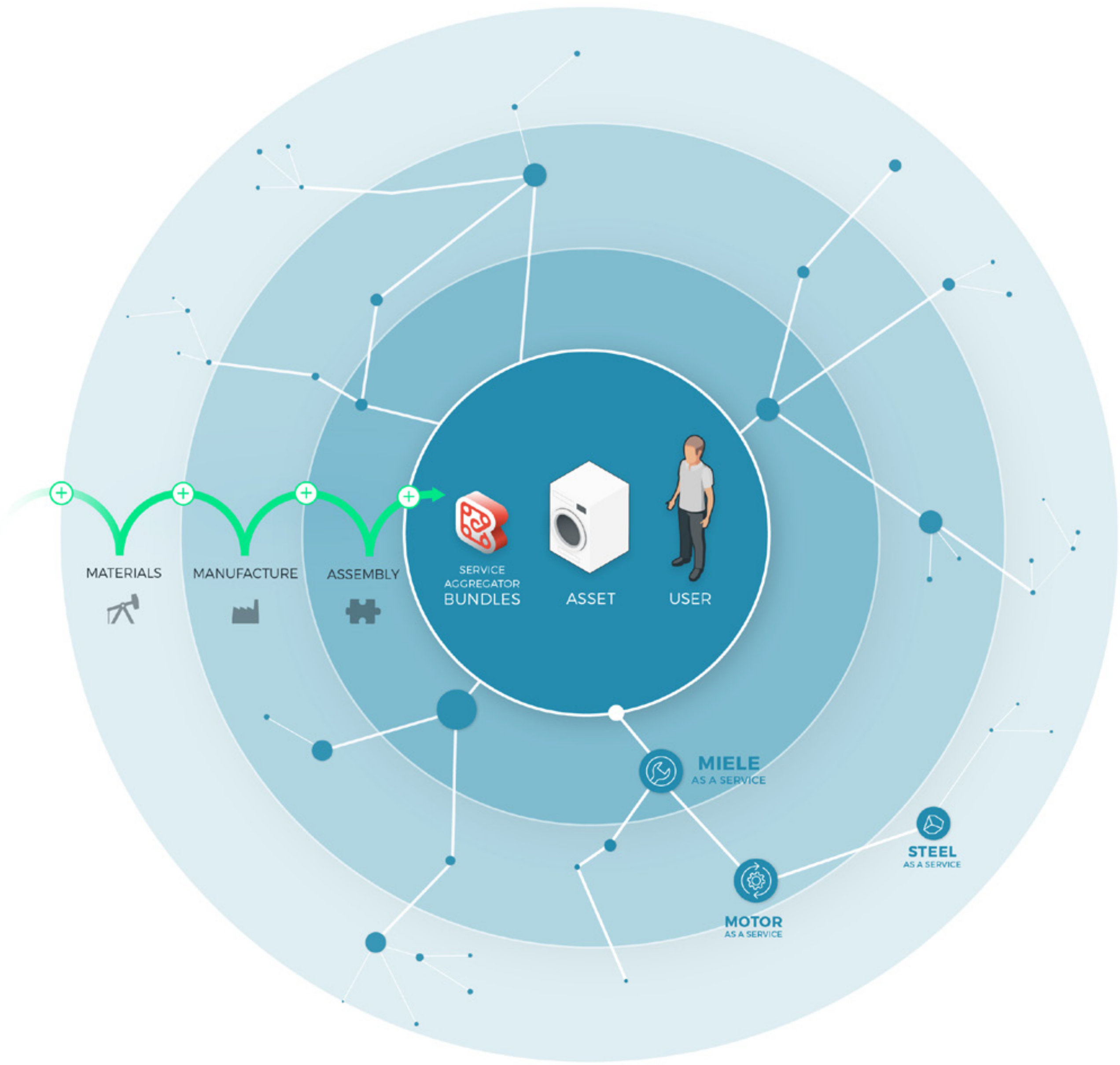


Figure 4 - From linear episodic sales to circular service (CISE) networks.

When all participants are integrated into the circular value proposition, life-cycle performance becomes a shared responsibility of all participants in the circular network and can be optimized. In such a system, an innovation at one point in the network benefits all participants directly. This creates leverage to share risks and benefits. However, this only works when all costs and services involved in operating an asset are shared and thus requests trust and openness in the network.

BUNDLES AS SERVICE AGGREGATOR

Currently, Bundles is the service aggregator and thus has limited influence on the design of the washing machine. However, the goal is to "seduce asset manufacturers and consumable providers to start developing products that better fit this new story." In the meantime, a combination of innovations in Bundles' business model have the potential for environmental impact. The product leasing element leads to a more frequent use of an environmentally friendly washing machine. With the pay-per-use element, efficient use of the washing machine is encouraged and the user makes more conscious use of the service (Tukker 2004). In a longitudinal study to assess whether consumption patterns of washing significantly changed after implementing a pay-per-use business model Nancy M. P. Bocken et al. (2018) found that the total number of washes and washing temperature decreased significantly. From the perspective of the provider, there is an incentive to improve product/service with life-cycle performance in mind.

The advice element might lead to more effective operated washing machines and the corresponding direct involvement with the customer might improve the risk of irresponsible behaviour due to non-ownership (Tukker 2004). Nancy M. P. Bocken et al. (2018) also found that consumers are generally unconscious about their use patterns and underestimate the number of washes and temperature with which they wash and "overestimate" the sustainability of their behaviour.

Lastly, in cases of product sharing leads to the more intensively usage and thus requires considerably fewer washing machines for the same client pool (Tukker 2004). This has the most impact on the pre-use (manufacturing) phase. Whereas the other aforementioned elements mostly impact the use phase.

WHY AREN'T WE THERE YET? HIGH ADMINISTRATIVE BURDEN

In a circular service model, relationships with clients are intended to be long-term and are shaped via contracts and agreements. This leads to increased costs for managing receivables (e.g. invoicing, credit checks), executing and enforcing contracts and tracking the performance of circulating assets and services. As the network grows, the complexity of administration does too. This requires a higher level of coordination between stakeholders: service providers, financiers, regulators and other supporting mechanisms.

BUNDLES' HIGH ADMINISTRATION COSTS

Currently, Bundles purchases all services, consumables and devices upfront and bundles them into a service pro-position for its customers. Bundles is managing its receivables and contracts, coordinates all services, administrates various legal entities necessary to execute its business. Bundles has high financing costs due to its specific finan-cing needs, that are not (yet) mainstream. This leads to high administration costs and limits his competitive power compared to linear equivalents. Moreover, Bundles has the ambition to offer variable pricing schemes to its customers, and thus increase the pay-per-use component in its offering, especially at sharing locations. By giving immediate feedback, charging the cus-tomers' digital wallet, and by offering lower prices to customers that show sustainable behaviour, costs can be saved and positive environmental impact can be created. Currently, this is not feasible, however, due to the high administration costs.

CASHFLOWS AND EVER-INCREASING BALANCE SHEET

Offering services around an asset rather than selling them, impacts cashflows: a high upfront investment (purchase of asset and consumables) is followed by small incremental income (use fees). Additionally, offering services around an asset changes ownership and responsibilities regarding the asset. Currently, this means that the service provider retains ownership of the asset, with an ever-growing balance sheet as a result. However, the more service providers would become involved in collectively providing the service, the more complex the division of ownership and responsibilities would become, and the more pressing the need for a shared repository and underlying governance.

DESIGN PHILOSOPHY

Circular service aggregators, such as Bundles, thus experience high administrative costs for managing receivables and coordinating services, as well as high capital pressure. This constraints Bundles' growth, but also limits realizing its ambitions: offering a broad range of pricing schemes to its customers and sharing risks and returns with value chain partners. Balancing these constraints with future ambitions, led to a design philosophy, summarized in. This wish list will guide us through the shop of technology design choices. We need an infrastructure that facilitates collaboration in CISE networks and scalable corresponding financial-, legal- and governance structures.

BUNDLES' CAPITAL PRESSURE

Bundles' growth is constrained by a lack of access to capital to purchase the assets in sufficient quantities to scale the business. This situation is aggravated by operating a use model, which leads to revenues being incremental and only available over an extended period. The funding need is based on many small sums (dependent on growth of the customer base), leading to high administration costs for the financier also. Financiers are therefore reluctant to finance these types of businesses. Bundles has the ambition to increasingly involve its value chain partners in its business model, and eventually aspires to share risks and returns with them.

CIRCULAR TECHNOLOGY WISH LIST

ENABLE COLLABORATION BETWEEN VALUE CHAIN PARTICIPANTS

THIS REQUIRES:

- [ ] Transparent and secure sharing of information between network participants collectively operating an asset
- [ ] Transparent rights and obligations of network participants
- [ ] Transparency on performance of the serviced asset and generated cash flows
- [ ] Privacy by design: transparency should be tailored to specific needs of participants and privacy must be encompassed in the entire platform
- [ ] Allow for easy and open participation of circular entrepreneurs
- [ ] Encourage lively debate on circular economy principles

FACILITATE AFFORDABLE PAYMENT ADMINISTRATION

- [ ] Cheap, fast and secure payment solution for many small payments (micropayments)
- [ ] Automatic execution and enforcement of contracts between all network participants
- [ ] Payment solution that allows for charging individual use of a shared asset

IMPROVE FINANCEABILITY OF ASSET

- [ ] Allowing for flexible small investments to scale the circular asset pool
- [ ] Solution for managing a complex division of ownership

3 - DISTRIBUTED LEDGER TECHNOLOGY (DLT) AS A SOLUTION?

What became apparent is the pressing need to solve the coordination problem that stems from the fact that the transition towards a circular economy is a collective process. It is not about individual companies, but about innovating the coordination of networks that revolve around assets and resources.

This prompted us to consider if developments in financial information technology that have occurred in recent years, which provide us with new functionality, might perhaps provide opportunities to address this coordination challenge from a different perspective.

Would it be possible to own and procure assets by a network that creates value from them? Could this simultaneously reduce cost of capital and of operations? Could (micro) rents that are generated at each transformation of the asset (e.g. washing cycle) be (re-) distributed to the network? These questions we sought to answer in this Community of Practice by drawing from a range of recent technological developments and initiatives. Distributed ledger technology (DLT), better known as blockchain - a specific subset of DLT - enables tracking and monitoring of incremental transactions and provenance of assets throughout its lifecycle in an adversarial environment (where participants don't trust each other ex-ante). Smart contracts trigger automatic enforcement and execution of payment mechanisms that assures everyone involved in the contract is compensated. Crypto- or virtual currency enable micro (less than €0,01) transactions. These processes are, in principle, technically possible. But practice still has to prove itself.

The right combination of technologies might provide a valuable element to grow and embed the circular economy and liberate circular entrepreneurs from large capital needs and ensuring a wider distribution of asset value by placing asset ownership and transfer with a wider crowd.

Both technology and circularity are in transition and not there yet. Businesses are getting themselves ready for a circular future, and technology need to be carefully designed to ensure circular impact and connection to reality. Therefore, as a community, we were challenged to balance the current possibilities with designing for the future.

For the purpose at hand, we are not providing detailed explanations of aforementioned technologies, as the internet overflows with very successful attempts. For ease of reading, however, we provide a short high-level brief, see box "Distributed Ledger Technology (DLT) 101" For a complete overview of definitions, we refer to Rauchs et al. (2018), as we have applied their framework that serves as a tool for examining and comparing DLT systems.

Before rushing towards designing our desired solution that solves all our problems, we take a moment here to consider whether aforementioned technologies actually fit our design philosophy. To do this, we have applied the framework of Mulligan et al. (2018) that guides us to answer the question whether blockchain is applicable to our use case. In this chapter we present the main topics of discussion that are relevant for our use case. We conclude with the outcome of the analysis.

DISTRIBUTED LEDGER TECHNOLOGY (DLT) 101

A popular way of describing distributed ledger technology is by comparing it with a Google spreadsheet. The spreadsheet, ledger, contains names, messages and events (transactions) between people. The ledger is protected by a combination of mathematics, smart code and cryptography, which makes it very difficult to cheat. Everyone may have a copy of the ledger. And anyone can add a transaction to the ledger, which automatically appears in all other copies of the ledger. These transactions can represent either the transfer of a digital asset of value, such as a token, or a way to link other information to a particular profile with a digital identity. Every transaction in a DLT system has a unique identity that is linked to a single entity who can exercise control over the information or asset from that transaction. The list of transactions is the chain and a set of changes to the list is a block. The ledger is designed so that any faulty transaction (e.g. due to insufficient balance, an incorrect password or malicious intentions) is automatically rejected by the ledger. But as soon as a transaction has been added, it is extremely hard to remove. To reverse a transaction, an opposite transaction needs to be added to undo the change without changing the history. The ledger is collectively maintained by a network of of linked computers that all run the same software. There is no central point of control. Users rely on algorithms, mathematics and software.

The first important DLT innovation was bitcoin, a peer-2-peer network for electronical transactions that is not dependent on mutual trust. It is a solution for the so-called 'double-spending' problem (not spending your money twice) that is solved by using the 'proof-of-work' (POW) consensus mechanism in combination with using blockchain for the registration of transactions. This makes it computationally expensive for hackers to corrupt the ledger. Participants are enabled to verify validity of transactions and blocks. Miners provide CPU-power to produce candidate blocks and are rewarded with bitcoin when the candidate block is accepted into the authorative ledger. The most important rules and incentives are captured in this POW consensus mechanism (Nakamoto 2009).

An important following innovation was the realization that by adapting the bitcoin source code the underlying technology could be separated from the bitcoin implementation and used for all sorts of mutual value exchange in the form of alternative payment systems and cryptocurrencies (Swan 2015). Different motives have been found to be engaged in these innovations. Some are purely opportunistic, others seek to distance themselves from the current financial system, and again others are interested in opportunities to self-organize in peer-2-peer collaboration and have a community network character like this Community of Practice (Scott 2016).

Another major invention following this was the introduction of the smart contract, also referred to as the 'derivative protocol'. This uses the programmability of money in, for example, loans, stocks, bonds, crowdfunding applications or other 'smart assets' that combine governance structures with payoff schemes (Swan 2015).

A major difference of using distributed ledger technology as opposed to the current way of organizing transactions (finance) is that the database in which all transactions between people are is maintained by a network of people, without losing the authenticity of transactions. In addition, tokens (representing currencies or other assets) can be "earmarked" and therefore can be tracked, sometimes referred to as digital cash.

It is my goal to put this story into practice by involving the parties that actually transition towards a circular economy. If you fail to address real challenges companies have, your efforts are useless.

– **Henk Kuipers,** Innovator at Rabobank

INTERMEDIARIES

We are redefining how business processes are delivered in a circular economy. For a DLT system to be an appropriate solution is the requirement to remove an intermediary (Mulligan et al. 2018). In the business context of circular service networks, it would be cheaper to collaborate directly with suppliers and end-users rather than acquire a bank to settle and clear high volumes of small (micro) transactions.

More importantly, the purpose of the CISE Platform is to prevent power concentration of a central party that accumulates the benefits of providing the infrastructure. We envision a neutral community-maintained infrastructure that aligns incentives for circularity. Commercial benefits are generated by circular business activity rather than the maintenance of the infrastructure. The goal of the platform is to minimize administration costs and enable the scalability of financial-, legal-, and management structures by providing these structures open source and preventing circular entrepreneurs to reinvent the wheel time and again.

It is not about removing intermediaries. Whether existing or new players take on the new roles that come up does not matter, as long as it brings a circular economy closer

– **Arnoud Boot,** professor of Corporate Finance and Financial Markets, University of Amsterdam

TRUSTED PARTIES

Two trusted third parties were identified as required for the use case. First of all, an exchange agent that provides financial services that provide withdrawal, deposit and exchange services between national currency and tokens is needed. As these are generally regulated institutions (currently provided by banks), more research in this area is needed on how regulators can be involved and how compliance can be ensured. Secondly, it is important to note that a cryptographically valid signature does not automatically provide proof that the owner of the corresponding private key has produced the signature.

Private keys can be stolen by attackers if they are not properly secured. Storing private keys securely can be a cumbersome task; key management is notoriously difficult and requires a certain level of technical proficiency, which is why it is often outsourced to third-party custodial services (Rauchs et al. 2018).

“Garbage in, garbage out”

– **Michael van den Berg,** DLT Requirements Engineer, ABN AMRO Bank

DIGITAL VERSUS PHYSICAL

The data produced in a circular service network reference exogenous objects, namely remotely monitored physical assets. This requires gateways to connect the digital platform to the external world, and thus are reliant on external agents (service providers) and existing legal structures to enforce decisions outside the platform (see section CODE OF CONDUCT).

Records also contain digital representations (tokens) of national currency, with which use fees are paid. This data, in our use case referencing washing events and virtual currency, can be successfully represented in a digital format. Only in very rare cases the state of stored data could be needed to be altered, leading to the need for restoring a previous version of the ledger.

SPEED & DATA REQUIREMENTS

DLT systems are unable to handle millisecond performance on transactions as of yet. As of April 2018, various forms of DLT carry between a two- and 10-minute processing time (Mulligan et al. 2018). The transactions in the CISE network doesn’t need to perform at millisecond speed. As we are used to invoicing on a monthly basis with a payment term of 30 or 60 days, being able to claim at your disposal in about 10 minutes is already a huge improvement.

It is currently not advisable to store non-transactional data on a DLT system as it heavily affects scalability of the system. In case of the CISE network, many data points can be stored locally. Transactional data needs to be in the right state in the whole network, and can be stored in a DLT system whereas additional data (e.g. pdf’s, images) can be stored locally. Any private information or any other data that may be in conflict with local and global data-protection regulations, such as GDPR, should separate from the data stored in the DLT system.

TRUST

DLT systems are disintermediating systems and delegates trust to the endpoints: end-users and service providers. In a CISE network users interact with the asset and pay for units of service used. Service providers (including network support providers, such as financiers, insurers) are compensated for their service from the generated asset rent. All participants thus write in the ledger any service units that has been delivered. Whether that is a payment for a unit of service (washing cycle), an upgrade or change of a component/part, an investment or any other relevant event.

Generally, the actors and entities interacting with the platform do not know and trust one another ex ante. End-users using a shared asset (e.g. washing machine) do not necessarily know each other, service providers among each other don’t know each other, especially not when situated in different Product Markets (e.g. washing machines and milk robots). Although the ambition of the platform is to have inherent aligned interests (by paying asset rents based on performance all actors benefit from longevity), profit driven entities might always have a motive to cheat.

The advantage of DLT is transparency, the disadvantage is transparency

- **Rob Guikers,** Innovation consultant at Rabobank

PRIVACY AND CIRCULARITY

Regarding decision-making processes on the platform (e.g. permissioning and engagement rules, changing functionality etc.) two issues stood out: 1) circularity and 2) privacy. To ensure circularity, a code of conduct is drafted, that states, amongst others, when initiatives are eligible to join the network, and how collective decisions are made (more details can be found in section CODE OF CONDUCT). Additionally, due to privacy regulation, such as GDPR, and ethical considerations certain data need to be kept private.

KEY CONSIDERATION AREAS

The previous considerations lead to the applicability of a private permissioned DLT system. That confirms the finding of Rauchs et al. (2018) that open systems with permissionless participation primarily record transfers of endogenous (native) resources and closed systems with more fine-grained permission levels typically reference external objects.

A few key consideration areas need to be considered when moving on developing and designing a CISE Platform:

- Regulatory engagement is a critical piece in future development of the CISE Platform, as many elements of the technical-administrative architecture we envision, touch upon areas that are subject to strict requirements from multiple regulators (e.g. banking, accountancy, data privacy);
- Any private information or any other data that may be in conflict with local and global data-protection regulations, such as GDPR, should be stored locally and not on the DLT system;
- As the digital system interacts with the physical world (assets and services), it is reliant on external agents and existing legal structures to enforce decisions outside the system;
- To ensure circularity, the platform requires legal structures and agreements that governs the platform including a democratically agreed code of conduct.

4 - THE CIRCULAR SERVICE (CISE) PLATFORM

SUMMARY

Name: The Circular Service (CISE) Platform

Purpose: Providing an infrastructure that unburdens circular service aggregators, such as Bundles, for (i) managing receivables and (ii) centrally coordinating services, (iii) enables offering a broad range of pricing schemes to end-users and (iv) the collective governance of a CISE network, leveraging the sharing of risks and returns in the network.

Network launch: Currently in pilot stage. Piloted are electric cars (pay-per-driven km), milk-robots and Bundles' pay-per-use washing machines.

Value proposition: Offered is a decentral digital payment platform for circular pay-per-use business models, that allow for micropayments (in virtual currency) and the automatic execution and enforcement of contracts (smart contracts), with the goal of unburdening service providers and enabling the collective governance of a circular network. The infrastructure is collectively owned and maintained by the service providers and network support providers (henceforth: the CISE network).

Technical summary: The CISE Platform is based on Quorum, an existing open-source codebase, and uses a raft-based consensus mechanism. The CISE network is semi-open as access is partially restricted, to ensure circularity. Members of the CISE network (i.e. service providers) are running full nodes, thus fully performing the functions and tasks available on the platform. Data is currently public, but methods that allow for a higher level of privacy are looked into. The CISE Platform is permissioned, as authorization to initiate transactions and record creation is restricted to the members of the CISE network. Incentives for maintaining the CISE Platform are both social as well as legal. There is a basis for trust and aligned incentives as every CISE network member wants the asset and the platform to function, as only then will it generate cashflow. All incentives that are not inherently aligned by the platform itself are governed through a Code of Conduct (incl. Joint Venture Agreement) that state the terms on how members of the CISE network cooperate and collaborate. On the CISE Platform, a transaction is initiated by a service provider that detects an event through a sensor detached to the asset that is being serviced (e.g. a washing cycle). This transaction triggers the execution of a smart contract that will charge the wallet with the price for the use of the unit service. Tokens are a digital representation of national currency, which is held in custody by gateways.

In this Chapter, we describe the functionality as well as the underlying foundations of the Circular Service (CISE) platform in its current form as initiated by the Rabobank as well as the future developments as developed and identified by the Community of Practice. We start with a description of the functionality of the CISE Platform from the perspective of the user, followed by the business (financial) perspective of service providers, regarding payment and contract handling. In the last two sections, we dive deeper into the underlying structures of the platform.

The Code of Conduct narrates who is eligible to join the network, the rights and obligations of CISE network participants and how circularity is ensured. The chapter details the technical architecture that underlies the functionality.

THE CUSTOMER JOURNEY

Using the CISE Platform changes little from the perspective of the end-user. In the online shop all circular subscriptions are displayed that are provided by the CISE network. Attached to the user account is a digital wallet with which the units of service can be paid. The balance in the wallet represent euro's, and are called micro-euro's, as it is possible to be charged a sum smaller than 1 euro cent, for example, to pay for a minute of lighting.

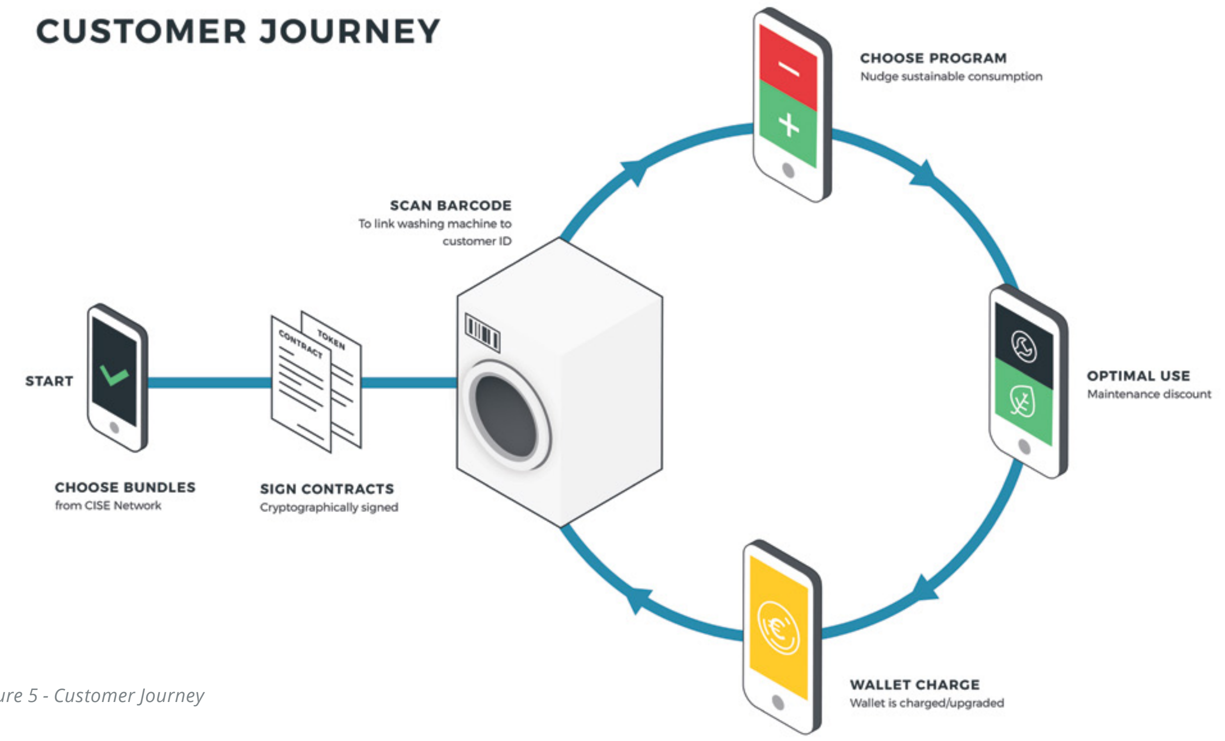


Figure 5 - Customer Journey

User contract and token contract are cryptographically signed

When a specific subscription is chosen, for example a pay-per-wash service like Bundles, the corresponding use contract (price and terms) and the token contract - that states the terms on which the wallet can be charged (e.g. direct debit) – are cryptographically signed.

User identity is connected to the used asset

The asset, the washing machine, can be accessed in a shared location or is delivered at home. The account of the customer needs to be connected to the asset through scanning a barcode (or other technology in place). When the appliance is used within a household, this only needs to happen once. In a shared location this needs to happen every time a use event happens.

Immediate charge allows for nudging towards sustainable consumption

Now the user can start consuming units of service, doing laundry, and the user's wallet is charged automatically. This enables direct feedback about the sustainability of the consumption (sustainable washing behavior), and nudging towards specific behavior such as washing during off-peak hours or small maintenance tasks by introducing discounts.

THE TOKEN JOURNEY

So, what happens with the tokens that were transferred by the customer, from their wallet, into the digital platform? What can service providers do with these tokens?

ASSET AS A SHOP

In the CISE Platform our perspective is shifted from the company towards the asset. Relationships are formed around the asset with the collective goal of operating that asset for as long as possible, at its highest value. In financial terms this means maintaining that asset to generate cash flow for as long as possible against the lowest possible cost, i.e. minimalizing needed resources.

Translating this to the current situation of Bundles, the washing machine becomes central to the offering. At the level of the washing machine, cash comes in through use fees and cash goes out to service providers that collectively offer the service of clean laundry. This is a combination of washing detergent, maintenance services, hardware and financing, and might also include insurance or other supporting services. This is illustrated in Figure 6.

RINGFENCING ASSETS AND CASH FLOWS

The ledger underlying the platform records all receivables that are generated on asset level. All generated cashflows thus can be separated (i.e. ringfenced), limiting income and recovery of investments to specific assets. Service providers, financiers and other actors that create value around the serviced asset are connected to the asset through smart contracts that execute payments to corresponding wallets. Tokens that represent receivables can be exchanged into national currency at any time or can be used to finance new assets or circular upgrades (e.g. a 'tech-refresh'). This enables the diversification of investments on asset level, having a portfolio of different asset types and risk profiles. Additionally, it aligns the incentives for sustainability not only between service providers, but includes financiers.

WHO CASHES ITS TOKENS FIRST?

We identified three payment schemes to compensate business actors.

1. Fixed percentage: Business actors can be paid out a fixed percentage of the use fee, for an indefinite amount of time for providing its part of the output (e.g. a working motor, functioning components/parts, a nice smell, et cetera). This shifts the risk for unforeseen maintenance or failures onto the provider of the indefinite service;

ASSET AS A SHOP

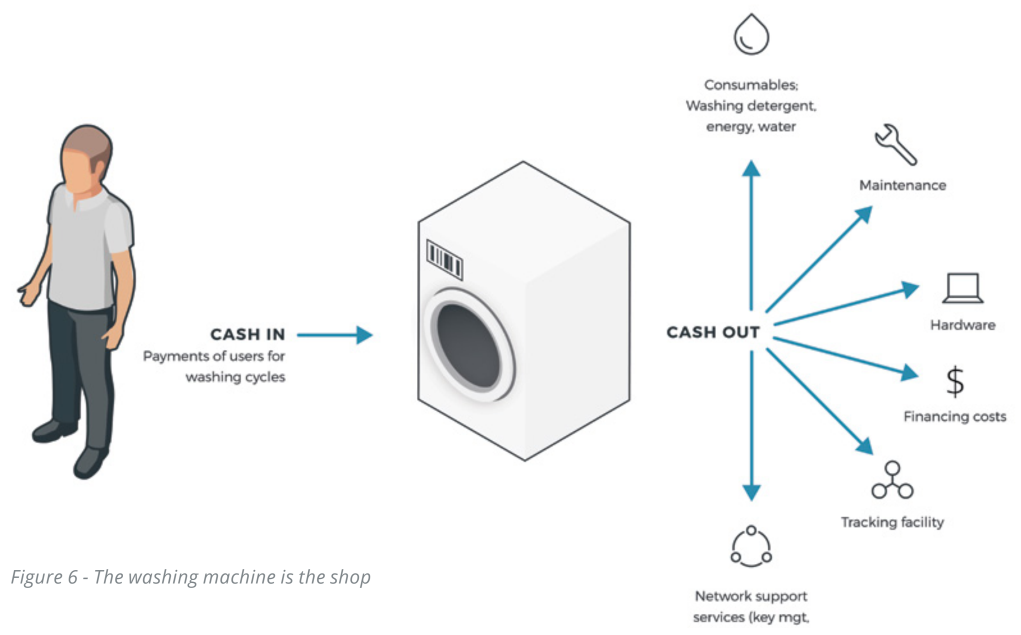


Figure 6 - The washing machine is the shop

2. Cost-plus: A cost-plus one-off service or circular improvement might be needed. To account for this, a fixed part of the use fee can be saved in a reserve. To use this reserve, value providers must reach consensus on how to the money is used, bearing circularity in mind;
3. Investment: Opportunities for a bigger "tech-refresh" might arise that improves the circularity of an asset drastically, but requires a larger investment. In these instances, the funding requirement can be broadcasted to the network and all CISE network participants can invest (this can be financiers, service providers or users). In case of investment, part of the use fee is disbursed to financiers until financial obligations are fulfilled.

There are many options to choose from, and ideal schemes need to be established based on the specific context of the service offering bearing circularity in mind. It is possible, for example, to combine 2 and 3 into one reserve and choose some sort of waterfall scheme, as to who is prioritized to be paid first. In Project Finance it is common to prioritize OPEX (operational expenditures) over CAPEX (capital expenditures), as without a working asset there is no cash flow at all. But there could also be reasons to prioritize the other way around, to reduce financing costs (i.e. interest) or choose an equal distribution. Or it could be designed a form of mutual credit that prioritizes smaller companies with a higher liquidity demand over larger mature companies that have bigger buffers and a less urgent need for liquid assets (i.e. cash).

The dynamics of the three payment schemes are illustrated in Figure 7, Figure 8 and Figure 9. In Figure 7 the balances of three types of service providers are displayed: a maintenance-, consumable- and device provider. All providers receive a use fee at every cycle and thus their balances keep growing at every cycle.

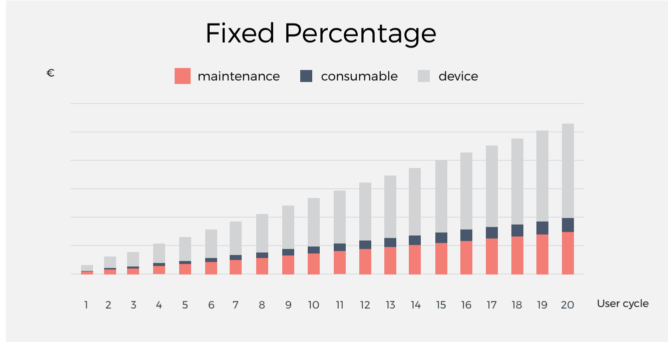


Figure 7 - Dynamics of fixed percentage payment scheme

The dynamics of the reserve are illustrated in Figure 8. At every use event, the reserve increases, until all participants agree to a one-off service or improvement. After payment of the one-off event, the same dynamic continues and the reserve keeps growing.

In the "linear" state we are in, not many entrepreneurs are ready to provide an indefinite service yet (taking the unforeseen maintenance risk themselves), there will be a definite need for one-off maintenance payments.

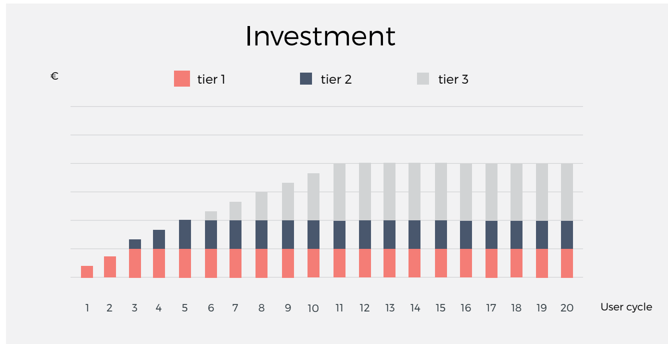


Figure 8 - Dynamics of reserve payment scheme.

A waterfall payment scheme for financiers is illustrated in Figure 9. Higher-tiered creditors receive interest and principal payments first, while the lower-tiered creditors receive principal payments only after the higher-tiered creditors are paid back in full.

An important difference of these schemes compared to current financial products is that repayments are based on performance of the asset, the unit of output. At every washing cycle, the financier is paid a percentage of the use fee until principle plus interest (or other financial agreement) is paid back. This creates an interesting hybrid of debt and equity. The amount that needs to be paid back are known (debt), but the payback period is performance-based (equity). The incentive of the financier is aligned with the incentives of the service providers, to maintain the asset to operate.

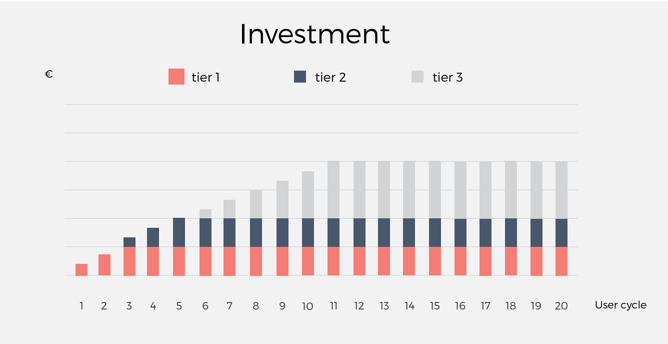


Figure 9 - Dynamics of waterfall finance payment scheme

Note that, the financier is paid directly out of the asset, rather than via a company changing credit risk profile.

TOKENS CAN BE CASHED ANY TIME

Tokens represent a receivable denominated in national currency. Tokens that are earned or deposited can be exchanged into national currency at any time. Alternatively, tokens can be used to finance new assets or tech-refreshes inside the platform.

CODE OF CONDUCT

This Chapter is authored by: Cees van Ginneken, Werner Runge (Allen & Overy)

1.1 INTRODUCTION

All participants of the CISE Platform are expected to work towards a circular economy. They should be rewarded for their efforts, but also be held accountable for their actions. The participants have a responsibility to keep resources circulating for a long as possible at its highest value and reduce the use of energy and reuse raw materials. The incentives in the platform are set up to keep the participants committed to these goals throughout the lifecycle of an asset.

Certain circular aspects, however, cannot yet translate into free economic incentives, and for these aspects, all participants must enter into an agreement regarding these topics. These are mainly topics that relate to the transition from the current economy to a circular economy. This document also includes arrangements on the constitution and organisational governance of the CISE Platform itself. We have named these the Codes of Conduct.

One characteristic of the CISE Platform is that it is an administrative tool which allows the participants to conclude their agreements in a cost effective and standardised way. This lowers the costs of doing business. The negotiation, conclusion of agreements, documentation and enforcement of these all happen on and by way of the platform. By standardising the agreements, the platform participants are ensured that circular economy criteria are adhered to. The CISE Platform will exist part on-chain and part off-chain. This results in a balance between software-defined rules that have to stay within strict protocol boundaries. Other rights and obligations can be broader.

Bankruptcy remote and ring-fenced custodian is introduced to the CISE Platform. This will be the only legal entity of the CISE Platform that will e.g. (i) hold all legal titles to the assets on which services are offered, (ii) enter into agreements with service providers and customers, and (iii) holds bank accounts in its name. The technological advances made allow us to create and operate an administration which registers the receivables of all the creditors to this custodian and of all debtors of this custodian. Each will only have a claim on that relates to the relevant assets they have invested in or provided services for. This is one of the advantages that will allow us to make available structured financing for smaller amounts (even at micro-payment level) due to the lowered costs involved by standardising and automating the financing arrangements.Below we have provided a conceptual framework for the Code of Conduct for the CISE Platform.

1.2 CONSTITUTION OF THE CISE PLATFORM

The CISE Platform has a layered structure. This provides a few key benefits. First, it allows the participants to interact only with relevant parties at each level. Second, that some rules are binding upon all participants, but some only to specific groups within the platform. Third, that the rules that govern different layers of the system can be easily amended. We have created the following layers for the CISE Platform:

CISE Platform-Layer	This layer contains the technological-administrative infrastructure on which the next layers are built.
Platform Support Layer	The participants that offer services which are offered in all different Product Markets are grouped together in this layer. These Network Support services are e.g. finance, insurance and key-management.
Product Market Layer	Each participant or group of participants can create a Product Market in which the service is offered. Multiple Product Markets can exist at the same time.
Asset Layer	The individual assets on which services can be offered by the service providers are placed in this final layer. Assets can relate to multiple Product Markets. Service providers form a small consortium around an asset and are collectively responsible for its lifecycle.

1.3 CISE PLATFORM LAYER

This layer of the network is the technological-administrative infrastructure of the CISE Platform. All participants use this fundamental layer. Particular points of interest that should be covered in this layer are:

a. The eligibility criteria for interested parties to join the CISE Platform.

b. A General Code of Conduct which covers at least:

- **I.** The obligation of a party to fulfil one of the four Value Hill strategies.
- **II.** The obligation of a party to reduce use of energy and reduce and reuse raw materials. (Circular design strategies; Optimal use strategies; Value recovery strategies; Network Support strategies)
- **III.** The obligation of a party to avoid the use of materials that cannot be recycled or absorbed by the earth's capacity (or bio-degradable).
- **IV.** The obligation of a party that offers its products or services in a linear for sales model to expose its true value.
- **V.** Commitments on how to handle data using the "privacy by design" approach.

c. Rules on how to make decisions that concern the platform as a whole (e.g. amending the General Code of Conduct).

d. The position, rights and obligations, and management of the ring-fenced custodian holding title to all assets in the platform.

e. Rules on payments/funding for the operating, maintenance and development costs of the CISE Platform.

1.4 NETWORK SUPPORT LAYER

This layer provides the services that are used by all participants. By creating a separate support layer, the various actors can create combined offerings of their services for the various Product Markets. This should stimulate collaboration and promote synergy in the offerings that are proposed.

We have split the services in the commercial and non-profit services.

a. Commercial

The following services could be eligible to be offered in this layer and create offerings that are accessible to all Product Markets: financing, insurance, legal, accountancy, and tax. This list can be amended over time to include e.g. internet connectivity providers or utility companies.

b. Non-profit

Specialised institutions, such as academia who research circular economy are eligible to join this layer. They can support participants in various Product Markets in creating their circular service solutions or provide expert knowledge on circular principles and trade-offs.

1.5 PRODUCT MARKET LAYER

This layer contains all the various Product Markets. Service providers that want to create a Product Market can create one in this layer. Each product market must have its own Specific Code of Conduct. This Specific Code of Conduct the service providers agree on a level of circular economical behaviour that should be adhered to by all those who are active in the market.

The service providers can work together with the non-profit institutions of the Network Support Layer to provide contributions to the knowledgebase on circular economy of the CISE Platform. These can contain guidelines on how to solve financial, operational and maintenance challenges. Specific points of interest that should be covered are:

a. Fixed fee versus cost-plus options for maintenance contracts;

b. Availability versus pay-per-use;

c. Shared responsibility to keep the asset operational;

d. Strategic decisions on maintenance, upgrading, refurbishing, re-manufacturing;

a. Setting up models for governance:

- **i.** one-euro-one-vote;
- **ii.** unanimous decisions;
- **iii.** specialist decisions,

b. Challenging the information asymmetry, free riding and common pool problems.

These contributions can improve the chances of other entrepreneurs starting to behave in a more circular economical way.

1.6 ASSET LAYER

The individual assets on which services can be offered by the service providers are placed in this asset layer. These assets can be related to multiple Product Markets. Service providers form a small consortium around an asset and are together responsible for its lifecycle.

Each asset is ring-fenced from all other assets. This results in a structured non-recourse financing of an asset. I.e, the only source payment of receivables in respect of any specific asset originates only from the cash flow generated by that specific asset that was financed for this purpose. This creates incentives that are aligned for all service provides that are together in a consortium around a specific asset. They are all in it together.

The asset layer must also introduce some sort of governance. This mostly relates to voting methods relating to operating and maintenance choices, such a tech refresh or update of an asset that come up.

TECHNICAL DETAILS

In this paper, we have focussed primarily on the functionality of the CISE Platform: what the technology needs to achieve, why, and how that translates into the use of the platform from different perspectives, i.e. the end-user, service providers, network support providers and the underlying legal- and financial structures.

Although technology is only a tool to reach a desired outcome, central to the functionality of the CISE Platform are the underlying technological design- and configuration choices. This section, provides a high-level explanation of the technical details that enable the CISE Platform to function. For further inquiry, the interested reader, is referred to the Annex 1.

In order to examine the traits, features and design requirements of the CISE Platform, we used the framework as developed by Rauchs et al. (2018). This framework is built up of three layers:

1. The protocol layer consists of software, the codebase and rules with which can be engaged with this software.
2. The network layer brings the protocol layer to life, by the network of independent servers and storage that participate in protocol-defined operations.
3. The data layer, is the shared database with special properties that is created by multi-party consensus. This layer entails the core functionality of the platform. The construction and maintenance of the data layer is enabled by the protocol and network layer.

In terms of hierarchy between the layers, protocol changes can overrule data semantics (data layer) and transaction processing decisions (network layer). Transaction processing (network layer) can censor/reverse data (data layer).

Every DLT system makes trade-offs in accordance to their objectives and their security, trust and threat models. In this section we set out, the main trade-offs, and choices that were made in the design of the CISE Platform, given the current state of technology and our formulated design philosophy. We also discuss prospects of future developments in both technology as well as circularity. Some properties of the CISE Platform might not be fully functional yet, and therefore sometimes sub-optimal choices have been made for implementation reasons.

A NOTE ON DECENTRALISATION

Decentralisation versus centralisation is among the most discussed trade-offs in DLT systems. Rauchs et al. (2018) found that many different, but related, concepts are associated with decentralisation: the removal of entities with which actors traditionally must interact or the ambition of diluting power. In the context of DLT systems, decentralisation is also often associated with data replication among many different machines. The recurring theme being whether the system has processes and institutions which allow free and open participation and encourage vibrant debate, rather than relegating decision-making or system management to a fixed set of entities (Rauchs et al. 2018).

Decentralisation indicates whether the system has processes and institutions which allow free and open participation and encourage vibrant debate

Decentralization is not a binary property, however. It is a combination and interaction of design choices in various layers of the system. In order to avoid single-party control, the DLT system needs to have sufficient decentralization in all areas (Rauchs et al. 2018). However, decentralization comes with a cost, among which, scaling limitations, low throughput, slow confirmation speed, high energy costs, poor user experience. Generally, the more centralized the system, the faster, cheaper, and more efficiently it runs (Rauchs et al. 2018).

CISE PROTOCOL LAYER

The CISE network uses an existing framework, a Quorum-based codebase, which is itself a fork of Ethereum. The codebase is open source, which means that network participants may decide to fork the project (i.e. 'copy-paste' the codebase) and create an alternative system which is based on similar premises. Quorum is initially used for its high compatibility with Ethereum, and the resulting ease of use for smart contracts. Besides that, Quorum is able to implement multiple consensus mechanisms and allows for private transactions. It uses a raft-based consensus mechanism, which is particularly useful for network settings where there is a certain level of trust, enable the scaling of our transaction volumes.

In the alteration component a governance aspect is included about how collective decisions are made and how the results of these are incorporated. This can be either on-chain (as an explicit part of the protocol), or off-chain. Changes to the protocol layer (codebase) are voted upon by record producers (validators). Everyone has the right to propose changes to the codebase; a formal decision-making process is in place.

The CISE Platform depends for its functionality on external systems that are depicted in Figure 10.

INTERSYSTEM DEPENDENCIES

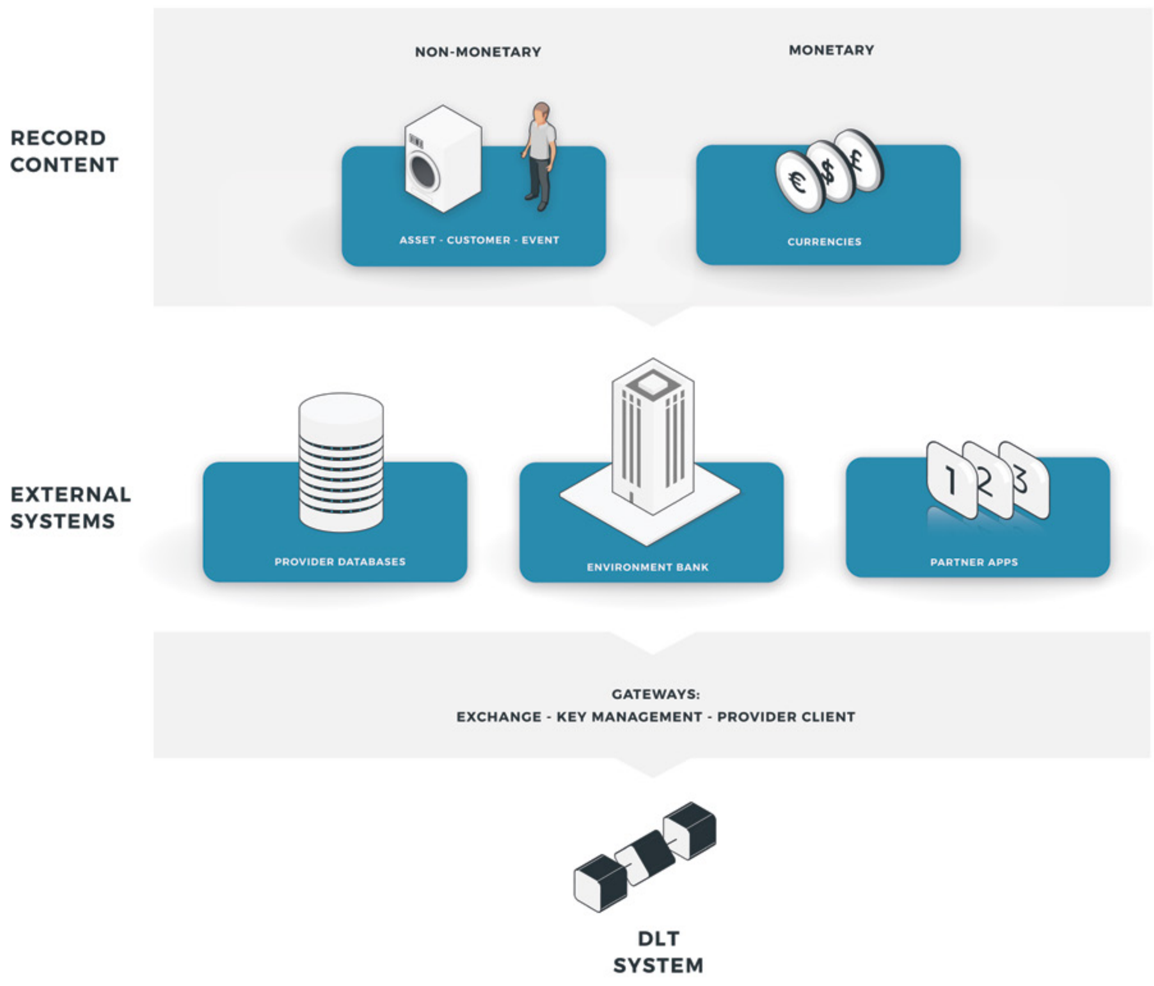


Figure 10 - Intersystem dependencies CISE Platform. Adapted from Rauchs et al. (2018)

CISE NETWORK LAYER

A DLT system is composed of actors that perform various roles. In this context, an actor is any entity or individual that is either directly or indirectly interacting with a DLT system. Actors can be grouped together into four key categories according to the role they play in the system. One entity can take the roles of multiple actors simultaneously and operate on more than one layer. Similarly, a specific role can be performed by multiple actors at the same time (Rauchs et al. 2018). The actors in the CISE network are specified in Table 3

DEVELOPERS	ADMINISTRATORS
Write and review code underlying the technological building blocks **Core Protocol:** All service providers and network support providers are part of the network that collectively maintain the core protocol. **Client:** 1) platform client for service providers to connect with the platform and 2) exchange client that provides payment services (deposit, withdrawal), exchange between euro's/tokens, and user registration services (KYC) **Application:** apps for users, providers, exchanges, event store, etc. **External Systems:** - Virtual currency exchange - Key manager (signing transactions) - Backend of service providers (event data) - event store (contract cache)	*Control access to the codebase and decide to add, remove and amend code to change platform rules (i.e. governance)* **Consortium (the CISE network)** Every service/support provider takes on the role of administrator. However, a CISE network member can choose to (partially) outsource this. Kaleido, for example, offers node management services.
GATEWAYS	**PARTICIPANTS**
Provide interfaces to the platform acting as a bridge between the platform and the external world **Gatekeeper** CISE network grants participants access. Governance rules yet need to be established. Oracle There is no oracle yet. Every service provider is its own oracle transmitting external event data (e.g. washing events) to DLT system **Custodian** This is a challenge as the goal is to make transactions cheap. The way Ethereum prevents attacks is to make participants pay in GAS, and thus make it expensive to attack the system. So, at the moment the incentive to "not-sabotage" the platform is that it will sabotage their own services/products. Thus, there are some trust requirements between members of the CISE network **Exchange** Exchange can be any player that the client trusts with its money and facilitates purchase/sale of tokens. **Issuer** Infrastructure tokens are issued when purchased through the deposit of traditional specie (e.g euro's) and represents a receivable denominated innational currency. Tokens will be earmarked according to the exchange that issued (e.g. ING tokens, ABN tokens, etcetera)	*The network consists of interconnected participants* **Auditor** All CISE network members (service/support providers) check validity of transactions and records (full/full-validating nodes) **Record Producer** All CISE network members produce/submit candidate records (e.g. "blocks") **Lightweight Client** At the moment not necessary. In the future, when devices themselves will directly communicate to the network (IOT methods), then lightweight clients/wallets become necessary. **End-User** User of the devices (e.g. buying washing cycles). Requires gateways: an exchange (wallet) and key manager (can be same actor).

Table 3 - Actors in the CISE Network

The CISE network is semi-open. Access is partially restricted, to make sure the goal of stimulating circularity is guaranteed. Prospective participants need to apply. Access will be granted via on-chain or off-chain voting by the existing network participants. Competition is stimulated, but linear market offerings are barred.

Participants of the CISE network (i.e. Service Providers and Network Support Providers) are running full nodes, thus fully performing the functions and tasks available: receiving, validating, storing and broadcasting transactions and records to the DLT system and performs independent validation. The external assets and end-users are connected to a full node via an Application programming interface (API).

Data is public, broadcast to all nodes (universal data diffusion), i.e. public, and seeks convergence towards a single shared set of records (global consensus). However, for the CISE Platform, methods of data partitioning and multi-channel data diffusion are looked into, to prevent nodes from storing and processing data that is of little interest to them (better scaling), but also to ringfence data in partitions that are only accessible for authorized participants to guarantee a higher level, and more granular level of privacy.

The authorization to initiate transactions is restricted to the participants (the service- and network support providers). Record creation is also restricted to the CISE network (i.e. permissioned). Incentives for maintaining the CISE Platform are both social as well as legal. As we are working with a permissioned network of service providers and network support providers that seek to collaborate, there is a basis for trust and aligned incentives. Every CISE network member wants the asset to function, as only then will it generate cashflow. Therefore, all CISE network members want the CISE Platform to work. All incentives that are not inherently aligned by the platform itself are governed through a Joint Venture Agreement (incl. Code of Conduct) that state the terms on how members of the CISE network cooperate and collaborate.

There is a popular belief that records stored on a DLT system are 'immutable' and can never be reversed. However, this is not necessarily the case: DLT systems provide different degrees of transaction finality depending on the system design. This means that a confirmed (and executed) transaction may be subject to reversal. In the CISE Platform, raft is responsible for reaching consensus on which blocks should be accepted into the chain. In general, there is one CISE network member that is assigned as record creator. In the rare case that there is conflict, the first created block wins. This chain extension logic is deterministic: once a block has been added it is permanent.[1]

CISE DATA LAYER

The data layer, described the core functionality of the platform. In the CISE Platform, a transaction is initiated by a service provider that detects an event through a sensor detached to the asset that is being serviced (e.g. a washing cycle). This transaction triggers the execution of that smart contract that will charge the wallet of the user of the service. Smart contracts as deployed on the CISE Platform can be seen as a set of business rules that refer to general terms and conditions, stated in the use contract offering. The smart contract enforces the execution and stores corresponding information in the ledger.

1 https://github.com/jpmorganchase/quorum/blob/master/docs/raft.md

A contract on the CISE Platform generally consists of a user_product, which comprises of a product (washing program + detergent), a device (a specific washing machine), provided by a specific service provider, and with corresponding costs (productcosts).

In the CISE Platform exogenous variables are kept track of (e.g. washing cycles, maintenance events, pricing schemes) that are generated by exogenous systems (i.e. service providers). Additionally, records also generate tokens (IOUs) that are issued by gateways (i.e. exchanges) and function as a digital representation of national currency, which is held in custody by gateways. Transactions that reference national currency held in external systems, require external agents and off-chain processes to enforce transfers in the 'real world'.

TRANSACTION PROCESSING

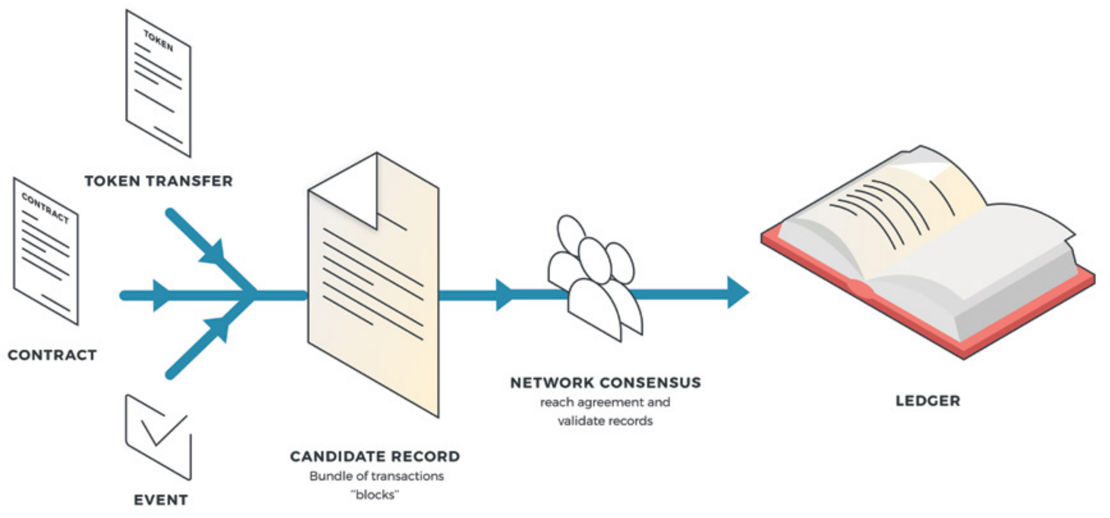


Figure 11 - From washing event to authoritative record in the ledger

ITERATE AND REVISIT

An important element to a system design is to iterate and revisit all areas and reassess the questions at transition points in a system's life cycle. This has been a process of intentional design from the start and iterative reassessment will ensure that the CISE Platform continues to achieve the desired circular impact. Meanwhile preventing unintended consequences as much as possible (Lapointe and Lara Fishbane 2018).

5 - CONCLUSION AND FUTURE DEVELOPMENTS

ENABLE COLLABORATION BETWEEN VALUE CHAIN PARTICIPANTS

THIS REQUIRES:

- ✓ Transparent and secure sharing of information between network participants collectively operating an asset
- ✓ Transparent rights and obligations of network participants
- ? Transparency on performance of the serviced asset and generated cash flows — Relies on tracking and tracing facility on the serviced asset
- ✗ Privacy by design: transparency should be tailored to specific needs of participants and privacy must be encompassed in the entire platform — Not yet. Needs technical development (e.g. data partitioning) and regulatory compliance
- ✓ Allow for easy and open participation of circular entrepreneurs
- ✓ Encourage lively debate on circular economy principles

FACILITATE AFFORDABLE PAYMENT ADMINISTRATION

- ✓ Cheap, fast and secure payment solution for many small payments (micropayments)
- ✓ Automatic execution and enforcement of contracts between all network participants
- ? Payment solution that allows for charging individual use of a shared asset — Requires implementation for connecting user with the asset (e.g. a QR-code)

IMPROVE FINANCEABILITY OF ASSET

- ✓ Allowing for flexible small investments to scale the circular asset pool
- ✓ Solution for managing a complex division of ownership

FUTURE DEVELOPMENTS

A big challenge in this project was the balancing of the current state of technology and businesses processes with that which we envision for the future. Multiple key areas still need to be addressed in future development of the platform. We provide here the main issues:

- Regulatory engagement is a critical piece in future development of the CISE Platform, as many elements of the technical-administrative architecture we envision, touch upon areas that are subject to strict requirements from multiple regulators (e.g. banking, accountancy, data privacy);
- Any private information or any other data that may be in conflict with local and global data-protection regulations, such as GDPR, should be stored locally and not on the DLT system;
- As the digital system interacts with the physical world (assets and services), it is reliant on external agents and existing legal structures to enforce decisions outside the system. We sketched the contours of a governance structure in the code of conduct, but these need to be specified and tailored to specific circular, business and technical contexts;
- A frictionless connection between euro's and claims on that euro's (represented in micro-euro's in the platform) is needed and requires further research and development.
- The platform needs to be piloted in other Product Markets and business contexts to adapt the functionality to fit a broad range of circular assets.
- What the effect of the CISE Platform is for sectors as accountancy and tax authority are still an open question

GLOSSARY

ADMINISTRATOR	Actors that controls access to the core codebase repository and can decide to add, remove and amend code to change system rules. An administrator is often considerably involved in the governance process.
CANDIDATE RECORD	A record that has not yet been propagated to the network and thus not been subject to network consensus.
CENSORSHIP RESISTANCE	Inability of a single party or cartel to unilaterally perform any of the following: 1) change rules of the system; 2) block or censor transactions; and 3) seize accounts and/or freeze balances.
CIRCULAR NETWORK	A circular network integrally connects the activities in the three phases of the Value Hill, i.e. pre-use, use and post-use and optimizes incentives inherently.
CIRCULAR SERVICE (CISE) NETWORK	The network of service providers and network support providers that collectively provide circular services on the CISE Platform.
CIRCULAR SERVICE (CISE) PLATFORM	The CISE Platform as proposed in this paper brings together communities of circular service providers, network support providers and end-users to meet and interact. It offers automated micro transactions and the automatic execution and enforcement of use contracts, with the goal of unburdening service providers and enabling the collective governance of a circular network. The platform is collectively owned and maintained by the service providers and network support providers.
CONSENSUS ALGORITHM	A set of rules and processes used by the network to reach agreement and validate records.
CRYPTOGRAPHIC HASH FUNCTION	A cryptographic hash function is a hash function which takes an input (or 'message') and returns a fixed-size alphanumeric string. The string is called the 'hash value'. The ideal hash function has three main properties: **1.** 1. It is extremely easy to calculate a hash for any given data. **2.** 2. It is extremely computationally difficult to calculate an alphanumeric text that has a given hash. **3.** 3. It is extremely unlikely that two slightly different messages will have the same hash.
DEVELOPER	Actor that writes and reviews code that underlies the technological building blocks of a DLT system and its connected system(s). A developer can be professionally employed or participating as volunteer contributor.

DLT SYSTEM	A system of electronic records that (i) enables a network of independent participants to establish a consensus around (ii) the authoritative ordering of cryptographically validated ('signed') transactions. These records are made (iii) persistent by replicating the data across multiple nodes, and (iv) tamper-evident by linking them by cryptographic hashes. (v) The shared result of the reconciliation/ consensus process - the 'ledger' - serves as the authoritative version for these records
ENDOGENOUS REFERENCE	Data which can be created and transferred solely through the means of the system and has meaning within the system. Enforcement is automatically performed by the system.
EXOGENOUS REFERENCE	Data that refers to some real-world condition and needs to be incorporated from the outside. This generally requires a gateway to make the connection to the external system and enforce decisions outside the DLT system.
FORK	The event of a DLT system splitting into two or more networks. A fork can occur when two or more record producers publish a valid set of records at roughly the same time, as a part of an attack (e.g. 51% attack) or when a DLT system protocol change is attempted (such a fork is 'hard' if all users are required to upgrade, otherwise it is 'soft').
GATEWAY	Actor that provides interfaces to the system by acting as a bridge between the system and the external world.
INDEPENDENT VALIDATION	Ability of the system to enable each participant to independently verify the state of their transactions and integrity of the system.
JOURNAL	The set of records held by a node, although not necessarily consistent with the consensus of other nodes. Journals are partial, provisional, and heterogeneous: they may or may not contain all the same records.
LEDGER	The authoritative set of records collectively held by a substantial proportion of network participants at any point in time, such that records are unlikely to be erased or amended (i.e. 'final').
LOG	An unordered set of valid transactions held by a node, which have not yet been incorporated into a formal record subject to network consensus rules (i.e. 'unconfirmed' transactions). Also called mempool.
MULTI-PARTY CONSENSUS	Ability of the system to enable independent parties to come to agreement on a shared set of records without requiring a central authority.
NATIVE ASSETS	The primary digital asset(s), if any, specified in the protocol that are typically used to regulate record production, pay transaction fees on the network, conduct 'monetary policy', or align incentives.

NETWORK	Interconnected actors and processes that implement the protocol.
NETWORK SUPPORT PROVIDERS	All actors that provide products or services that enable the offering of a collective circular service proposition
NODE	A network participant communicating with peers over a shared communication channel.
OFF-CHAIN	Interactions, actions, and processes that occur outside of the formal system boundaries.
ON-CHAIN	Interactions, actions, and processes that occur within the system (i.e. at the system level) and are reflected in the data layer.
PARTICIPANT	Actor interconnected with other participants in the network and communicating by passing messages among each other.
PROTOCOL	Set of software-defined rules that determine how the system operates.
RECORD	A bundle of transaction data which has been subject to network consensus rules and is part of the global ledger.
SERVICE PROVIDER	In this paper, a service provider indicates a company or set of business actors that offer a service around a circular asset.
SHARED RECORDKEEPING	The ability of the system to enable multiple parties to collectively create, maintain, and update a shared set of records.
SMART CONTRACT	A computer script that, when triggered by a particular message, is executed by the system. When the code is capable of operating as all parties intend, the deterministic nature of the execution reduces the level of trust required for individual participants to interact with each other. They are commonly referred to as smart contracts due to the scripts' ability to replace certain fiduciary relationships, such as custody and escrow, with code. However, they are not autonomous or adaptive ('smart'), nor contracts in a legal sense - rather, they can be the technological means of implementing a contract or agreement.
TOKEN CONTRACT	A token contract states the terms how tokens can be deposited, charged and exchanged. These are shaped between anyone using a wallet in the CISE Platform and the exchange agent of their choice.
TRANSACTION	Any proposed change to the ledger; despite the connotation, a transaction need not be economic (value-transferring) in nature. Transactions can be unconfirmed (not included in the ledger) or confirmed (part of the ledger).

TRANSACTION FINALITY	Determines when a confirmed record can be considered 'final' (i.e. not reversible). Finality can be probabilistic (e.g. PoW-based systems that are computationally impractical to revert) or explicit (e.g. systems that incorporate 'checkpoints' that must appear in every transaction history). Finalised records are considered permanently settled, whereas records that have been produced but which are feasible to revert are referred to as provisionally settled.
TRANSACTION PROCESSING	The set of processes that specifies the mechanism of updating the ledger: (i) which participants have the right to update the the shared set of authoritative records (permissionless vs. permissioned) and (ii) how participants reach agreement over implementing these updates. Also called mining.
USE CONTRACT	A set of business rules that refer to general terms and conditions on which a circular service is offered to the end-user. A use contract consists of a userproduct, which comprises of a product, a device and is provided by a specific service provider, and has corresponding costs productcosts.
VALIDATION	The set of processes required to ensure that actors independently arrive at the same conclusion with regard to the state of the ledger. This includes verifying the validity of unconfirmed transactions, verifying record proposals, and auditing the state of the system.
WALLET	A software program capable of storing and managing public and private key pairs used to store and transfer digital assets.

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ANNEX 1: TECHNICAL DETAILS CIRCULAR SERVICE (CISE) PLATFORM

In this Chapter, we describe the architecture underlying the Circular Service (CISE) platform in its current form as initiated by the Rabobank as well as the future developments as identified by the Community of Practice. In order to examine the traits, features and design requirements of the CISE Platform, we use the framework as developed by Rauchs et al. (2018) for consistency of terminology and concepts.

SUMMARY

Name: The Circular Service (CISE) Platform

Purpose: Providing an infrastructure that unburdens circular service aggregators, such as Bundles, for (i) managing receivables and (ii) centrally coordinating services, (iii) enables offering a broad range of pricing schemes to end-users and (iv) the collective governance of a CISE network, leveraging the sharing of risks and returns in the network.

Network launch: Currently in pilot stage. Piloted are electric cars (pay-per-driven km), milk-robots and Bundles' pay-per-use washing machines.

Value proposition: Offered is a decentral digital payment platform for circular pay-per-use business models, that allow for micropayments (in virtual currency) and the automatic execution and enforcement of contracts (smart contracts), with the goal of unburdening service providers and enabling the collective governance of a circular network. The infrastructure is collectively owned and maintained by the service providers and network support providers (henceforth: the CISE network).

Technical summary: The CISE Platform is based on Quorum, an existing open-source codebase, and uses a raft-based consensus mechanism. The CISE network is semi-open as access is partially restricted, to ensure circularity. Members of the CISE network (i.e. service providers) are running full nodes, thus fully performing the functions and tasks available on the platform. Data is currently public, but methods that allow for a higher level of privacy are looked into. The CISE Platform is permissioned, as authorization to initiate transactions and record creation is restricted to the members of the CISE network. Incentives for maintaining the CISE Platform are both social as well as legal. There is a basis for trust and aligned incentives as every CISE network member wants the asset and the platform to function, as only then will it generate cashflow. All incentives that are not inherently aligned by the platform itself are governed through a Code of Conduct (incl. Joint Venture Agreement) that state the terms on how members of the CISE network cooperate and collaborate. On the CISE Platform, a transaction is initiated by a service provider that detects an event through a sensor detached to the asset that is being serviced (e.g. a washing cycle). This transaction triggers the execution of a smart contract that will charge the wallet with the price for the use of the unit service. Tokens are a digital representation of national currency, which is held in custody by gateways.

The framework is built up of three layers:

1. The protocol layer consists of software, the codebase and rules in which can be engaged with this software.
2. The network layer brings the protocol layer to life, by the network of independent servers and storage that participate in protocol-defined operations. The servers and storage are not owned by a single entity, but by the network of participants, that not necessarily know or trust one another ex ante, but contribute resources to the network in exchange for value gained from participating.
3. The data layer, is the shared database with special properties that is created by multi-party consensus. This layer entails the core functionality of the platform. The construction and maintenance of the data layer is enabled by the protocol and network layer.

In terms of hierarchy between the layers, protocol changes can overrule data semantics (data layer) and transaction processing decisions (network layer). Transaction processing (network layer) can censor/reverse data (data layer) (Rauchs et al. 2018).

Some properties in the CISE network might not be fully functional yet, and therefore sometimes sub-optimal choices have been made for reasons of implementation.

DLT CRITERIA

Three years ago, the first smart contracts for an IoT pay per use model were set up by Rabobank. To this end, an environment was sought that is stable, quick and easy to configure, and which allows for private transactions. Eris (later Monax and now Hyperledger Burrow) was a first choice at that time. Because of the developments that Burrow did that diverged from the purpose at hand, the framework of Quorum was chosen to work with. The main reasons for that were the strong link with the Ethereum basic implementation, relatively simple configuration and the possibility of private transactions. In addition, Quorum has a consensus mechanism (raft) that can handle the volumes of transactions that we expect in the short run.

Meanwhile, Hyperledger Fabric and Corda are developing to such extent that they can be considered as alternatives. In the first instance Fabric, because of the large community around it and the support of many parties, and then Corda because of the strong support for financial contracts and the possibilities for closed transactions. No definitive choice has been made, however, at this point in time. An advantage of Ethereum as a basis is the extensive support and knowledge in the market. Currently, the Ethereum Alliance is focussing on interoperability between permissioned and public networks, which is, we believe, an important direction for the future to develop. Lastly, the developments of Parity with regard to Polkadot and Substrate, we find interesting and follow closely as these developments would make it possible to connect multiple DLT networks with each other. That enables us to work towards a set of specialist chains that can jointly solve our issues.

What remains a challenge, however, is the functionality of the necessary smart contracts in the CISE Platform, that can become quite complex. There are several DLT systems or hashgraphs that can implement micropayments very well, but, if we want to "program" complex conditions into them, most will drop out quickly (think of Iota, for example). If we would have better interoperability between the different solutions in the future, "best of breed" solutions would be a good alternative to a single solution.

Quorum Blockchain
QUORUM

Developed by J.P. Morgan, Quorum is an enterprise-focused, permissioned blockchain infrastructure specifically designed for financial use cases. Quorum is built off Go Ethereum, the base code for the Ethereum blockchain. It functions very similarly to Ethereum, but with four major distinctions: network and peer permissions management, increased transaction and contract privacy, voting-based consensus mechanisms, and higher performance.

Quorum's permissioned chain is a consortium blockchain and is meant to be implemented between participants that are pre-approved by a designated authority. In case of the CISE network the permissioning is merely based on circularity principles. Eventually, however, incentives in the CISE Platform should be inherently circular, leaving the permissioning redundant. Smart Contracts on Quorum can either be public (i.e. visible and executable by all participants in the CISE network) or private to one or more network participants.

Raft-based consensus mechanism

A raft-based consensus mechanism is an alternative to Ethereum's default proof-of-work. This is useful for consortium settings where byzantine fault tolerance is not a requirement, and there is a desire for faster blocktimes and transaction finality (the absence of forking.)

Raft-based consensus works with a so-called leader. The leader validates transactions and creates records (i.e. blocks). When a leader disappears, another leader is chosen. For the CISE Platform we are looking into methods to circulate "leadership" among participants.

There are five minimal criteria for a system to be labelled a DLT system as identified by Rauchs et al. (2018). The CISE Platform – currently based on Quorum - satisfies most of them. Only, independent validation is not always covered, but that is something that can be developed at a later stage. Find details in Table 4.

DLT CRITERIA	DEFINITION	CISE PLATFORM
SHARED RECORD KEEPING	Enable multiple parties to collectively create, maintain, and update a shared set of authoritative records (the 'ledger').	Service providers create, maintain and update the shared ledger with use transactions, i.e. execution of smart contracts and corresponding payments. The resulting event data can be used by multiple service providers to optimize their services (maintenance, consumable supplies, etc).
MULTI-PARTY CONSENSUS	Enable all parties to come to agreement on a shared set of records **i.** If permissionless, without relying a single party or side-agreements,and in the absence of ex ante trusted relationships between parties; and **ii.** If permissioned, through record producers who have been approved and bound by some form contract or other agreement.	Raft-based consensus mechanism on Quorum for reasons of speed and scalability. As we are working with a permissioned network with service providers that want to collaborate. Therefore, there is already a basis for trust. The real need is for transparency and audibility. In the future, however, the ideal is to move towards a real byzantine fault tolerance (BFT) model. But these are too slow for the purpose at hand, at the moment.
INDEPENDENT VALIDATION	enable each participant to independently verify the state of their transactions and integrity of the system.	This is not always the case with raft-based consensus. As the leader would be producing the records, whereas in independent validation instances, any participant should be able to produce records. In combination with *Lightning Network*[2] or *Raiden*[3] this would be possible, to have validation speed at the same time. Waited is for developments in technology that improve on the combination of speed and system integrity.
TAMPER EVIDENCE	allow each participant to detect non-consensual changes applied to records trivially.	Tamper Evidence is a basic mechanism of the platform.
TAMPER RESISTANCE	make it hard for a single party to unilaterally change past records (i.e. transaction history).	Raft consensus does not protect us from bad actors directly. At this moment the emphasis is on speed and transaction finality (the absence of forks). Since we are in a closed environment it would be easily detected that transactions are reversed (which will take a lot of work anyway). To facilitate this, block-hashes are also secured in separate storage.

Table 4 - Minimal DLT criteria Adapted from Rauchs et al.(2018)

2 *https://lightning.network/*
3 *https://raiden.network/*

ACTORS

A DLT system is composed of actors that perform various roles. In this context, an actor is any entity or individual that is either directly or indirectly interacting with a DLT system.Actors can be grouped together into four key categories according to the role they play in the system (Figure 12). One entity can take the roles of multiple actors simultaneously and operate on more than one layer. Similarly, a specific role can be performed by multiple actors at the same time (Rauchs et al. 2018). For the CISE network, these types of actors and roles are specified in Table 3.

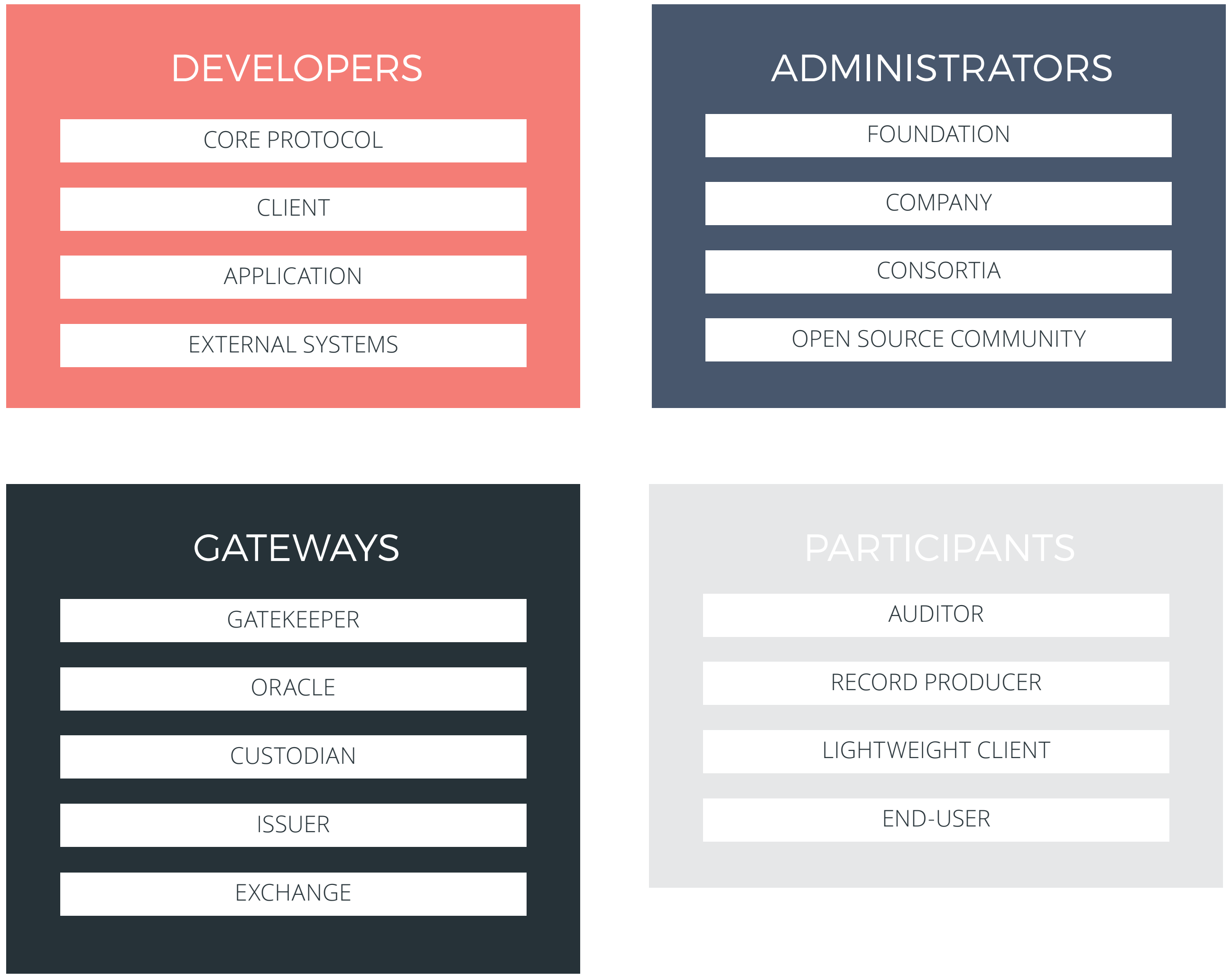

Figure 12 - Types of Actors as found in DLT systems by Rauchs et al. (2018)

DEVELOPERS *Write and review code underlying the technological building blocks* **Core Protocol:** All service providers and network support providers are part of the network that collectively maintain the core protocol. **Client:** 1) platform client for service providers to connect with the platform and 2) exchange client that provides payment services (deposit, withdrawal), exchange between euro's/tokens, and user registration services (KYC) **Application:** apps for users, providers, exchanges, event store, etc. **External Systems:** - Virtual currency exchange - Key manager (signing transactions) - Backend of service providers (event data) - event store (contract cache)	**ADMINISTRATORS** *Control access to the codebase and decide to add, remove and amend code to change platform rules (i.e. governance)* **Consortium (the CISE network)** Every service/support provider takes on the role of administrator. However, a CISE network member can choose to (partially) outsource this. Kaleido, for example, offers node management services.
GATEWAYS *Provide interfaces to the platform acting as a bridge between the platform and the external world* **Gatekeeper** CISE network grants participants access. Governance rules yet need to be established. Oracle There is no oracle yet. Every service provider is its own oracle transmitting external event data (e.g. washing events) to DLT system **Custodian** This is a challenge as the goal is to make transactions cheap. The way Ethereum prevents attacks is to make participants pay in GAS, and thus make it expensive to attack the system. So, at the moment the incentive to "not-sabotage" the platform is that it will sabotage their own services/products. Thus, there are some trust requirements between members of the CISE network **Exchange** Exchange can be any player that the client trusts with its money and facilitates purchase/sale of tokens. **Issuer** Infrastructure tokens are issued when purchased through the deposit of traditional specie (e.g euro's) and represents a receivable denominated innational currency. Tokens will be earmarked according to the exchange that issued (e.g. ING tokens, ABN tokens, etcetera)	**PARTICIPANTS** *The network consists of interconnected participants* **Auditor** All CISE network members (service/support providers) check validity of transactions and records (full/full-validating nodes) **Record Producer** All CISE network members produce/submit candidate records (e.g. "blocks") **Lightweight Client** At the moment not necessary. In the future, when devices themselves will directly communicate to the network (IOT methods), then lightweight clients/wallets become necessary. **End-User** User of the devices (e.g. buying washing cycles). Requires gateways: an exchange (wallet) and key manager (can be same actor).

Table 5 - Various actors and roles in the CISE network. Adapted from Rauchs et al. (2018)

PROTOCOL LAYER

The protocol layer is a set of software-defined rules that determine how the system operates. Initial code base and architecture specifying the rules of engagement within the system.

GENESIS

How is the platform linked to other external systems? There are, in principle, no dependencies on other systems. The CISE Platform requires, however, inputs from external sources. The platform is able to persist and function even if external data is not received, although it will depend on gateways or interfaces to asset data pertaining to the events regarding the serviced assets. In the example of the washing machine, if the exchange is off, the machine will still operate and exchange tokens. But the payment transaction will take place at a later stage.

Therefore, we call the platform self-sufficient. "A self-sufficient DLT system has all of the components necessary for its continued operation incorporated into its basic architecture, and the system itself is sufficient to enable the core functionality. Such systems do not depend on other systems for their operation, apart from the wider Internet infrastructure (e.g. reliance on TCP/IP or similar protocols and the underlying network infrastructure). Other examples are open systems such as the Bitcoin and Ethereum main nets as well as permissioned systems such as the NASDAQ Linq blockchain" (Rauchs et al. 2018). In the future, the CISE Platform could move towards an Interfacing system, but only if we deem the total breakdown of the DLT a possibility.

"An interfacing DLT system is a system that 'opportunistically' employs core functionality provided by another DLT system but which could easily be reconfigured to use another 'base-layer' DLT system if needed/desired. This means that if one system ceased to exist, the interfacing system would be able to survive for at least some time on its own and may be able to continue operating by exploiting the functions of an alternative 'base layer' DLT. The long-term survival of an interfacing system depends on the continued existence of at least one 'base-layer' DLT system, and a collapse of a base-layer system may cause significant disruption to the interfacing system. Examples include 'layer-2' solutions such as the Lightning Network based on Bitcoin and the Raiden Network based on Ethereum. These systems are commonly designed to improve the scalability and functionality of the base layer, without compromising network decentralisation or security" (Rauchs et al. 2018). The intersystem dependencies in the CISE Platform are shown in Figure 10.

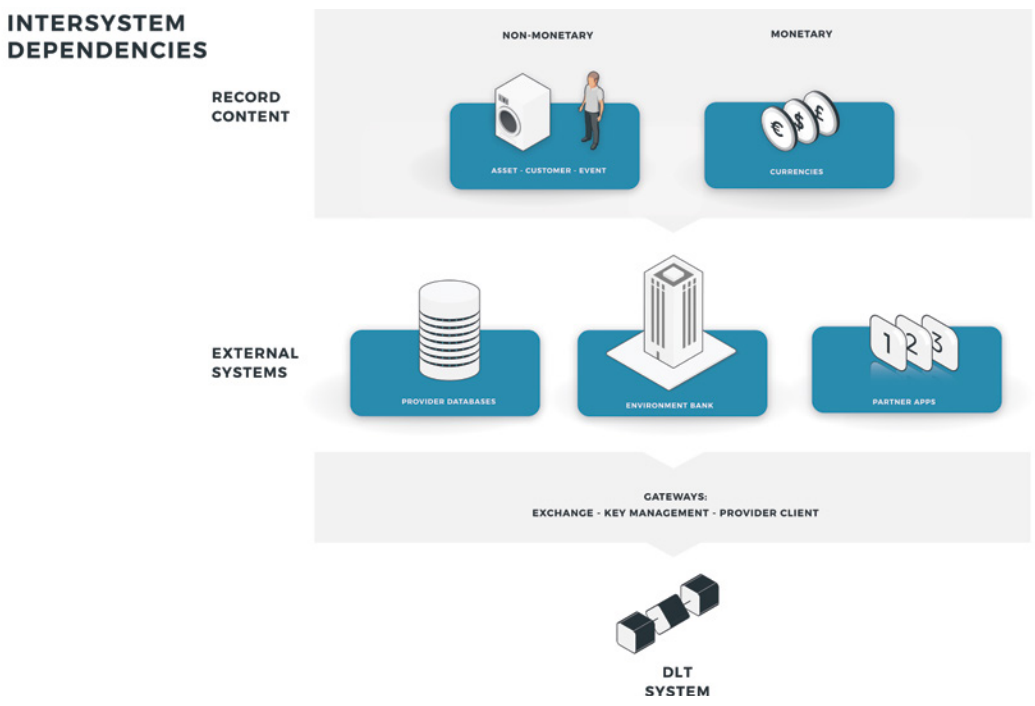

Figure 10 - Intersystem dependencies CISE Platform. Adapted from Rauchs et al. (2018)

CODEBASE GENERATION

How the protocol is generated are set out in Table 6

LENSE	CONFIGURATION	CISE NETWORK CONFIGURATION
CODEBASE	- Existing Framework - New/from scratch	The CISE Platform uses an existing framework, a Quorum-based codebase, which is itself a fork of Ethereum. See paragraph DLT criteria.
OPENNESS	- Open-source - Closed-source	The codebase is open source, which means that network participants may decide to fork the project (i.e. 'copy-paste' the codebase) and create an alternative platform which is based on similar premises.

Table 6 - Codebase generation. Adapted from Rauchs et al. (2018)

Rule initiation

Rule initiation refers to defining the ruleset upon which the DLT system will operate. This process can be performed by different actors and is specific to a particular DLT system. The CISE network formally joins forces to collaboratively develop and manage the platform. Protocol changes are voted upon by record producers (validators). It is an open source community, in which everyone has the right to propose changes to the codebase; a formal decision-making process is in place for that.

ALTERATION

In the alteration component a governance aspect is included about how collective decisions are made and how the results of these are incorporated. This can be either on-chain (as an explicit part of the protocol, or off-chain. Off-chain rules are set out in Section CODE OF CONDUCT. A diverse set supplemental on-chain voting schemes have been developed for DLT systems, ranging from barometers of community sentiment to enforceable referenda (Rauchs et al. 2018).

Protocol governance

Protocol governance is about how decision- and implementation processes are created. For the CISE network, we tend towards a democratic/plutocratic protocol governance process, in which protocol change proposals are voted on by network participants. This can be done on-chain.

It is an open platform, anyone is allowed to propose changes. How the funding for the development will be realised is not clear as of yet. At the moment, the development is done by a corporation, but the network continuity, will be done differently. The CISE network itself will fund development of the platform. This development itself is governed by all network members. Further development or support/maintenance could be allocated by number of contracts active per member. Participants implement changes individually by choosing to run a specific instance of a client software (rather than software being pushed to clients). If a participant does not want to incorporate changes, i.e. choose to run other software, this may result in network splits. That means that the split part of the network need to set up their own network, which also required bringing exchanges and other network support providers to the new network.

NETWORK LAYER

"The network layer brings the protocol layer to life, by the network of independent servers and storage that participate in protocol-defined operations. The servers and storage are not owned by a single entity, but by the network of participants, that not necessarily know or trust one another ex-ante, but contribute resources to the network in exchange for value gained from participating" (Rauchs et al. 2018).

Communications Component

Open versus Closed: network access

The CISE network is semi-open. Access is partially restricted, to make sure the goal of stimulating circularity is guaranteed. Prospective participants need to apply. Access will be granted via on-chain or off-chain voting by the existing network participants. Competition is stimulated, but linear market offerings are barred. The exact criteria that will allow this, need to be specified. Two goals in setting these governance rules are (1) stimulating circularity/sustainability and (2) dynamic and flexible membership, easy entering.

Channels

Service Providers and Network Support Providers are running a full node, thus fully performing the functions and tasks available on the platform: receiving, validating, storing and broadcasting transactions and records to the DLT system and performs independent validation. The external assets and end-users are connected to a full node via an Application programming interface (API). At this moment there are no lightweight nodes, but as soon as assets become smarter, assets themselves could become lightweight nodes, performing basic tasks such as creating transactions without fully validating the DLT system state. It still would require connecting to a full node for receiving information of the system.

Public versus Private: data broadcast

How data is shared and exchanged

Currently, data is broadcasted to all nodes (universal data diffusion), i.e. public, and seeks convergence towards a single shared set of records (global consensus). But there are reasons to look into another way of diffusing data (multi-channel data diffusion) so that it is only shared between a subset of nodes directly involved in a specific operation/transaction (local consensus). This way, effectively, a private sub-network is created (e.g. around a washing machine or in a product market). This concept is commonly referred to as partitioning. Multi-channel diffusion prevents nodes from storing and processing data that is of little interest to them, and can theoretically lead to better scaling. Hyperledger fabric, for example, uses data partitioning, which allow for the ringfencing of data in partitions that are only accessible for authorized participants.

Unrestricted versus restricted: transaction initiation

The authorization to initiate transactions are restricted to the CISE network (the service- and network support providers).[4]

Transaction Processing Component

How are transactions processed? In other words, what is the set of actions required to add an unconfirmed transaction to the shared set of authoritative records? In other words, how is the ledger updated?

4 *Gas is the execution fee for every operation made on ethereum. Its price is expressed in ether and it's decided by the miners, which can refuse to process transaction with less than a certain gas price. To get gas you simply need to add ether to your account (https://ethereum.stackexchange.com/questions/3/what-is-meant-by-the-term-gas).*

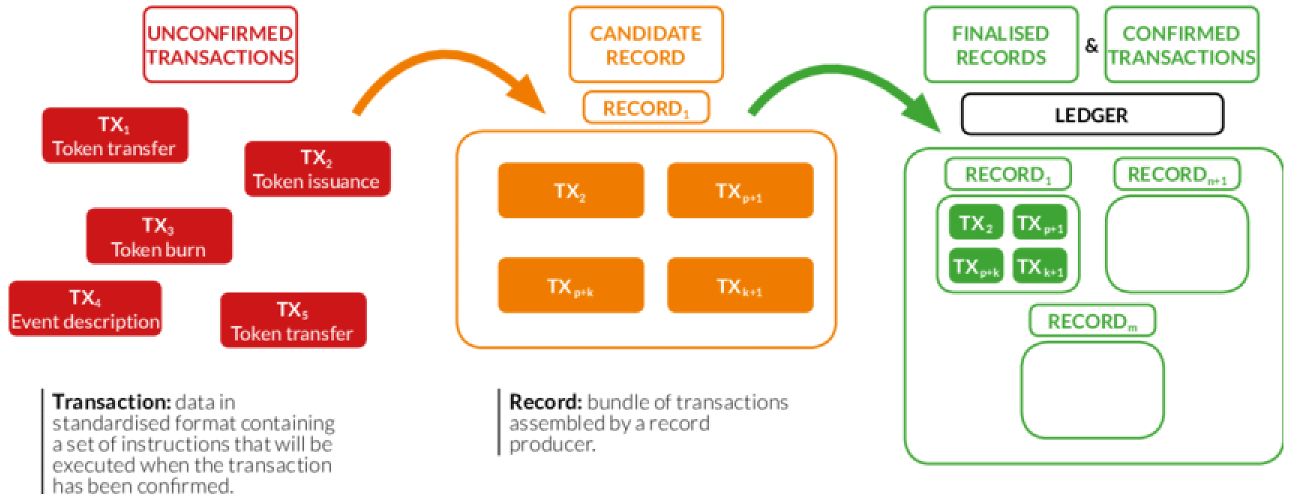

Figure 13 Conceptualizing Transaction Processing in a DLT System. Source: Rauchs et al. (2018)

"In a DLT system, a transaction is an authorised attempt - cryptographically signed by the initiator using a private key - to change the state of the accumulated records (i.e. a 'state transition'). Transactions generally contain a set of instructions (e.g. issuance of a token, transfer of a token, update balances, redemption of a token, description of an event." (Rauchs et al. 2018)

The extent transaction data has been accepted:

1. Transactions: unconfirmed proposed change to the ledger (event), need not be value-transferring
2. Log (mempool): unordered set of valid transactions held by a node
3. Record: transaction data has been subject to network consensus rules
4. Journal: set of records held by a node, not necessarily the same for all nodes
5. Ledger: authoritative set of records collectively held by a significant proportion of network participants (unlikely to be erased or amended, i.e. final) – the state of the system – convergence of synchronized individual journals.

Permissioned versus permissionless: record proposal

Permissioned or permissionless refers to which participants have the right to update set authoritative records. The consensus mechanism refers to how agreement is reached on implementing these updates (Rauchs et al. 2018). In the CISE Platform, record creation is restricted to a subset of participants (i.e. permissioned), based on membership of the CISE network. Validator nodes select unconfirmed transactions from their mempool and bundle them together into a candidate block. Raft-based consensus mechanism to reach agreement.

Conflict resolution mechanism

How disputes regarding competing or conflicting versions of valid records being resolved depend on consensus mechanism and is in the case of CISE Platform according to the raft-based consensus mechanism, in which the first block wins, and competing blocks are discarded.

Incentivised Transaction Processing

Incentivised Transaction Processing regards the implicit and explicit incentives in the system to encourage record producers to engage in transaction processing by creating and proposing records. Incentives can be Monetary, Legal, Social and can be either expressed directly by protocol rules (e.g. block rewards in native asset) or by external factors (e.g. contractual agreements established between participants). Open systems such as Bitcoin tend to be secured via economic incentive designs that make use of an endogenous network resource (native asset) as an economic coordination mechanism to align incentives (Rauchs et al. 2018).

	INTRINSIC	EXTRINSIC
MONETARY	Block rewards (subsidy + transaction fees)	Paid services (fees)
NON-MONETARY	Required for transaction creation	Contractual obligations, reputation, etc.

There are both social incentives as well as legal incentives in the CISE network. As we are working with a permissioned network with service providers that want to collaborate there is a basis for trust and an aligned incentive, that everyone wants the asset to work, because only an operating asset will generate cashflow. Therefore, all service providers want the network to work.

In addition, there will be governance in terms of a Joint Venture Agreement on conortium level, which states the way and on what terms participants in the network cooperate and collaborate.

Validation Component

The validation component states the actions undertaken by each auditor, such as verifying whether transactions and records conform to protocol rules (i.e. are valid and non-conflicting), and when transactions are considered final ('immutable').

Transaction & record validation

Transaction and record validation refer to the process of verifying whether an individual transaction (e.g. a washing event and corresponding token exchange) or record complies with the protocol rules before relaying it to other actors. Verified is whether the transaction is properly formatted, has a valid signature, and does not conflict with any other transaction.

Public transactions and private transactions are handled differently. Public transactions are executed in the standard Ethereum way.[5] Private transactions, however, are not executed per standard Ethereum: prior to the sender's node propagating the transaction to the rest of the network, it replaces the original transaction payload with a hash of the encrypted Payload that it receives from Constellation[6], the "privacy engine" of Quorum. Participants that are party to the transaction will be able to replace the hash with the actual payload via their constellation instance, whilst those participants that are not party will only see the hash[7].

Transaction finality

There is a popular belief that records stored on a DLT system are 'immutable' and can never be reversed. However, this is not necessarily the case: DLT systems provide different degrees of transaction finality depending on the system design. This means that a confirmed (and executed) transaction may be subject to reversal! In the CISE network, Raft is responsible for reaching consensus on which blocks should be accepted into the chain. "In the simplest possible scenario, every subsequent block that passes through Raft becomes the new head of the chain. However, there are rare scenarios in which we can encounter a new block that has passed through Raft that we cannot crown as the new head of the chain.

The most common case where this can occur is during leadership changes. The leader can be thought of as a recommendation or proxy for who should mint -- and it is generally true that there is only a single minter -- but we do not rely on the maximum of one concurrent minter for correctness. During such a transition it's possible that two nodes are both minting for a short period of time. In this scenario there will be a race, the first block that successfully extends the chain will win, and the loser of the race will be ignored. This chain extension logic is deterministic: the same exact behavior will occur on every single node in the cluster, keeping the DLT system in sync. There cannot be forks in the Raft setting. Once a block has been added as the new head of the chain, it is done so for the entire cluster, and it is permanent".[8]

For an overview of how transactions are processed generally in DLT systems, refer to Figure 14.

FINALITY	PROBABILISTIC	EXPLICIT
PROVISIONAL	In theory always; practically, a time window determined by network conditions	Short time window determined by protocol
FINALISED	In theory never; practically, after a certain block depth	After a specific block depth determined by protocol

Table 9 - Transaction finality. Source: Rauchs et al. (2018)

5 *https://github.com/ethereum/wiki/wiki/JavaScript-API#web3ethsendtransaction*

6 *https://github.com/jpmorganchase/constellation*

7 *For details on how Consensus is achieved in light of this, please refer to https://github.com/jpmorganchase/quorum/wiki/Quorum-Consensus.*

8 *https://github.com/jpmorganchase/quorum/blob/master/docs/raft.md*

DATA LAYER

In this layer, the core of the functionality of the platform is described.

Operations Component

The operations component describes what operations are performed on data to produce an emergent ledger: processes that govern how and which data is used in the creation of new records, modification of existing records, and the execution of code (including smart contracts).

Input

Inputs in the CISE network are a combination of internal (previous outputs, such as account balances and smart contracts) and external sources (exchange, off-chain events of service providers). A transaction is initiated by a service provider (information provider) that detects an event through a sensor detached to the asset that is being serviced (e.g. a washing cycle). This transaction triggers the execution of charging the wallet of the end-user.

TYPES	CONFIGURATIONS	DESCRIPTION
INTERNAL SOURCES	Transactions	A set of cryptographically-authenticated instructions to modify the state of the ledger.
	Records	Bundle of transactions that have been added to the shared set of authoritative records (global ledger).
	Automated executables	Programs that exist inside the system (or on another DLT system that interfaces with the focal system) which are allowed to trigger phenomena once a predetermined condition is verified.
EXTERNAL SOURCES	Sensors	Physical devices that are able to broadcast specific information to selected systems (e.g. RFID chips).
	Information providers	Entities that collect and organise data which are allowed to interact with selected systems (e.g. a price API).
HYBRID SOURCES	Generalised state channels	A transaction type that allows users to run programs outside the DLT system, with each state transition representing a private 'counterfactual'. At any time, the final state can be relayed to the DLT system.

Table 10 - Types of data sources. Source: Rauchs et al. (2018)

Smart Contracts

The CISE Platform supports general-purpose on-chain computations (via an integrated virtual machine) that can be used to design and run complex agreements and programs directly 'on-chain' (expressive). These are at the moment automatically executed at the network level by all validating nodes (global data diffusion), but investigated is to move towards multi-channel data diffusion, where only those involved in that particular agreement execute. However, complex computations are minimized, as keeping computations as simple as possible have better scaling possibilities and a higher security.

Smart contracts as deployed in the CISE network can be seen as a set of business rules that refer to general terms and conditions, stated in the product-service offering. The smart contract enforces the execution and stores event information in the ledger. The components that are specified in every contract are depicted in Figure 15. In the example of Bundles, an end-user belongs to an exchange where euro's can be exchanged for CISE tokens. The user, uses a UserProduct, which comprises of a product (the aggregation of multiple services stacked into a ruleset), using a device (the physical representation), provided by a service provider, and with corresponding costs (ProductCosts).

Locus of Execution

The CISE network uses the Ethereum virtual machine (Quorum) that allows for complex computations on-chain and thus is capable of performing an open-ended range of operations.

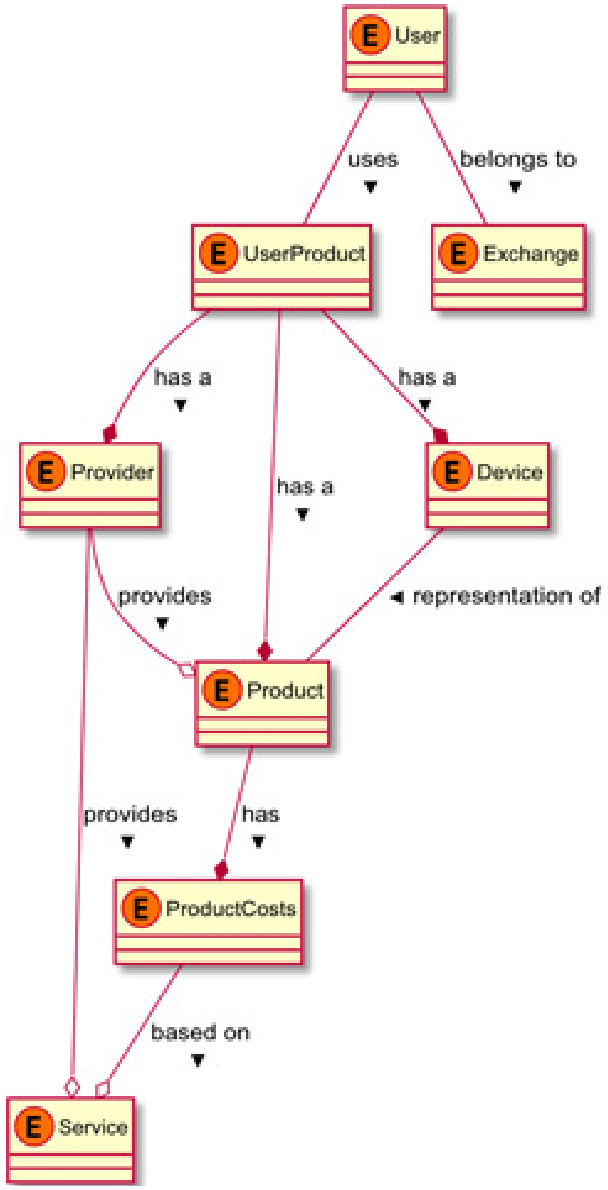

Figure 14 - CISE product-service contracts components

Journal component

The content of stored records

In the example of the pay-per-wash example, the exogenous recorded data is referencing a Site ID (location of the washing machine), Sensor ID (referencing the asset itself), timestamp, the type of service that is provided (washing cycle, programme used, washing detergent used), Customer ID (wallet needs to be charged), Contract "IDs" contracts of all services (device, consumable, maintenance) and corresponding prices, i.e. distribution of payment (e.g. financier, detergent provider, asset providers).

Types of reference

Records may reference an internal object (e.g. native assets, previous states, account balances or smart contracts) or something external to the platform (e.g. a physical items tracked across a supply chain). As soon as the records reference exogenous objects, enforcement becomes dependent on external agents. All types of reference are set out in Table 11

TYPES	DESCRIPTION
Endogenous	Refers to data or digital assets that exclusively exist within the boundaries of the system and do not require a connection to external systems. Decisions can be automatically enforced by the system as the data and/or assets are intrinsic to the system. For example, native assets such as ETH and associated dApp tokens are endogenous references of the Ethereum system.
Exogenous	Records referencing data that is exclusively extrinsic to the system and thus requires gateways for connecting to the external world and enforcing transactions. Recordkeeping only systems are an example of this type in that they only record events or facts occurring externally.
Hybrid	Digital assets that share both endogenous (i.e. exclusively exist within the boundaries of the system) and exogenous characteristics (i.e. have some link to the external world). Hybrid can also refer to systems that support both endogenous and exogenous references.
Self-referential	Pieces of code (e.g. smart contracts) that do not reference endogenous or exogenous variables, although they may require information about internal or external variables.

Table 11- Types of references. Source: Rauchs et al. (2018)

In the CISE Platform exogenous variables are kept track of (e.g. washing cycles, maintenance events, pricing schemes) that are generated by exogenous systems (i.e. service providers). Additionally, records also generate tokens (IOUs) that are issued by gateways (i.e. exchanges) and function as a digital representation of national currency, which is held in custody by gateways. Transactions that reference national currency held in external systems, require external agents and off-chain processes to enforce transfers in the 'real world'.

Therefore, in the CISE network, external agents must be trusted. Enforcement relies on existing legal and socio-economic structures or other arrangements outside the platform. This will be further explored in Section CODE OF CONDUCT.