Early Identification of Potential Distributed Ledger Technology Business Cases Using e³value Models

Geert Poels[1][0000-0001-9247-6150], Fadime Kaya[2][0000-0002-7352-0387], Michaël Verdonck[1][0000-0002-1927-3151] and Jaap Gordijn[2][0000-0002-6401-3850]

[1] Faculty of Economics and Business Administration, Ghent University, Tweekerkenstraat 2, 9000 Gent, Belgium
{geert.poels, michael.verdonck}@ugent.be
[2] Department of Computer Science, Vrije Universiteit Amsterdam, De Boelelaan 1081, 1081 HV Amsterdam, The Netherlands
{fadime, jaap}@thevalueengineers.nl

Abstract. Many Distributed Ledger Technology (DLT) projects end prematurely without reaping benefits. Previous research has indicated a lack of sustainable business cases for many Blockchain projects. A successful project has a disruptive impact on the business ecosystem. The paper investigates how e³value modeling can contribute to identifying the potential success of DLT implementation. Using insights from a first DLT case-study, an abstract e³value model fragment is defined that indicates potential success. As a test, the e³value model fragment is subsequently applied to a second case-study that is currently being implemented as a DLT-based platform. The paper concludes by reflecting on how an e³value model can provide evidence of meeting the requirements for building a sustainable DLT business case.

Keywords: Blockchain, e³value modeling, Business case requirements.

1 Introduction

Distributed Ledger Technology (DLT) has emerged as a disruptive technology that could influence the mechanisms of enterprises and society in the years to come. DLT has been defined as a consensus of replicated, shared, and synchronized digital data geographically spread across multiple sites, countries, or institutions [1]. The inherent characteristics of DLT provide benefits such as transparency, robustness, auditability, and security, allowing certain industries to minimize their transaction costs as they become inherently safer, transparent and in some cases even faster [2], [3].

Despite its potential, a study by Deloitte showed that, as of October 2017, only 8 percent of more than 86,000 open-source DLT projects developed on GitHub were actively maintained with an average life span of only 1.2 years [4]. This entails that many resources are invested in DLT projects without reaping any benefits. This clearly indicates that there is a call for an early identification of potential success of a DLT project, in order to avoid wasting resources on projects which hold a weak business case [5].

We believe that conceptual modeling can contribute in analyzing and designing a sustainable DLT business case. Particularly, conceptual modeling techniques that take a business ecosystem perspective could indicate in an early stage of analysis whether the introduction of DLT will be disruptive in terms of impacting the composition of the ecosystem (e.g., removal of the middleman that acts as a trusted third party) [6].

The e^3value approach [7] is an enterprise modelling technique that has been positioned as an early Requirements Engineering (RE) technique for systems supporting business ecosystems. In a study of 65 MSc student projects on digital innovation, all cases of digital innovation through DLT (9 out of 65) were analyzed using e^3value models [8]. The students were free to choose amongst different enterprise modeling techniques, but they all choose e^3value modeling. This clearly demonstrates that a business ecosystem perspective when analyzing DLT cases is required.

This observation leads to the research question that we address in this paper: *How can an e^3value model identify a potential business case for DLT?* The goal of our research is to investigate whether an e^3value model can indicate whether a DLT project has the potential to build a sustainable business case. If no indications are present for a sustainable business case, then decision-makers might reject the idea of initiating a DLT project in order to save time and money.

We investigate this research question through modeling a Peer-to-Peer (P2P) electricity trading case. Blockchain solutions exist for smart grids that enable P2P electricity trading [9]. The insights from modeling this case are used to define an abstract e^3value model fragment that indicates a potential sustainable business case for DLT. We test the model fragment on a second case concerning image rights management.

Section 2 provides background information on requirements for successful DLT implementations aimed at disruptive business cases and e^3value as an early RE technique. Section 3 presents the first case-study (i.e., smart grid), its modeling using e^3value, the abstraction of the case-study insights in an e^3value model fragment indicating a potential DLT business case, and the proof-of-concept application on the second case (i.e., image rights management). Section 4 discusses our results so far and the limitations of the research. Finally, section 5 states our contribution and presents our future research.

2 Background

2.1 Requirements for Sustainable DLT Business Cases

Gordijn et al. [5] explain that most DLT projects do not survive the proof-of-concept phase as they expose business cases for DLT that are not sufficiently disruptive in the sense that they do not aim at replacing the middleman by a DLT-based system, i.e., a Decentralized Autonomous Organization (DAO)[1]. A first requirement for a sustainable business case is affecting the business ecosystem by removing the party that has the power to prescribe rules and regulations over other parties. Basically, the only value

[1] The idea of a Decentralized Autonomous Organization is attributed to Vitalik Buterin, one of the initiators of the Ethereum project.

contributed to the ecosystem by such trusted third party is the intermediation of transactions between other parties. Removing the middleman is the most important reason to use DLT as this will disrupt the ecosystem (**requirement 1**).

As decentralization is expensive, two further requirements are elaborated [5]. First, the parties that need to share data or distributed computing should be peers in a market structure, meaning that these parties do not trust each other (**requirement 2**). Second, the transactional data stored should be immutable (**requirement 3**). Blockchain technology offers the capability to represent the full and immutable transaction history. Overall, we can say that a sustainable DLT business case requires transactional data storage and a computing environment in which trust, security and permanence are requirements, and in which the ecosystem is changed by replacing an intermediary (i.e., trusted third party) by a DAO.

2.2 Value-Based Requirements Engineering

The e³value modeling approach is a Value-Based Requirements Engineering (VBRE) technique [10]. VBRE techniques are early RE techniques, meaning that they are used early on in the process of eliciting, specifying and validating system requirements.

As an early RE technique, e³value modeling is used to analyze the business ecosystem in which a new IT system (e.g., a DLT-based system) is to be implemented. The analysis focuses on how an IT system will affect (i.e., enable, facilitate, automate, optimize, etc.) the creation and delivery of products/services within the ecosystem. The value model is subsequently operationalized by designing business processes and by developing a supporting IT system architecture.

Fig. 1 shows an e³value model. The electricity supplier is an *actor* that requests electricity (a *value object*) from producers (a *market segment*) and offers this electricity to consumers (another *market segment*). The *value exchanges* of electricity are reciprocated by *value exchanges* of money (another *value object*). To deliver the electricity to consumers (the *value activity* of electricity supplying), distribution and metering services (*value objects*) are needed. These services are delivered by the operator of the distribution system to which the consumers are connected (a *market segment*).

For more information on the syntax and semantics of e³value models we refer to [7].

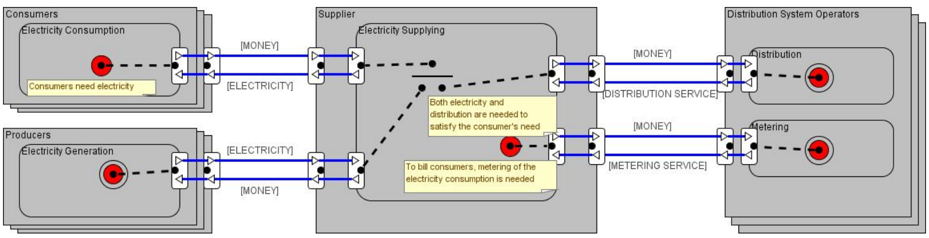

Fig. 1. Example e³value model

3 E[3]value Modeling of Potential DLT Business Cases

The DLT case that we explore is based on an analysis of the current and expected future Belgian electricity market [9]. In Belgium, a single transmission system operator (TSO) operates the high-voltage electricity transmission network and is responsible for grid balancing (i.e., equality of electricity injection and take-off). Belgium has eight regional distribution system operators (DSOs) that transmit electricity over medium- and low-voltage distribution systems to consumers. Producers generate electricity using different types of facilities and inject generated electricity into the high-voltage transmission system or directly into medium- and low-voltage distribution systems. Some consumers have evolved into prosumers which generate electricity for their own consumption (e.g., using solar panels), but which also inject excess production into the distribution system of the DSO of their region.

Apart from the physical electricity transmission, there is buying and selling of electricity. Electricity is sold by suppliers at retail price to customers. These suppliers buy electricity at (the lower) wholesale price on electricity exchange markets, through the intermediation of Access Responsible Parties (ARPs) which, based on forecasting methods, match buy orders and sell orders such that for every quarter-hour, electricity injection and take-off are balanced for the grid access point they are responsible of.[2]

Fig. 2 shows an e[3]value model of the decentralized electricity market ecosystem. Indirectly, consumers and prosumers pay for transmission and distribution services via the bills paid to suppliers. Belgium is in the process of introducing digital meters, which allow suppliers (and other parties) to directly read electricity consumption and (in case of prosumers) production. This new type of meters, in the future accompanied by IoT-based sensors in electricity-consuming devices, offers the advantage of 'smart' metering, allowing households and firms to better control their consumption and (if applicable) production patterns as well as allowing ARPs to better forecast consumption and production. It is expected that suppliers compensate excess electricity generation by prosumers at an export tariff (see red *value exchange* in Fig. 2), which is higher than the wholesale price but lower than the retail price.

Smart metering allows introducing, in the future, smart grids which allow Peer-to-Peer (P2P) trading of electricity between prosumers and consumers, and hence promote the increased use of renewable energy sources and the increased consumption of locally generated electricity. A smart grid is a geographically bounded perimeter of the grid (i.e., a microgrid),[3] that is served by a same DSO, in which a new role, the aggregator (see Fig. 3), balances consumption and local production (i.e., by prosumers) and, in

[2] ARP is a role assumed by suppliers, producers, major consumers as well as electricity traders – in June 13, 2019 there were 87 ARPs providing balancing services to Elia, the Belgian TSO (https://www.elia.be/en/grid-data/lists-and-codes/list-of-arps). The models in this section abstract from the situation where an ARP fails in balancing, in which case the TSO needs to invoke (costly but effective) measures and charges the ARP an imbalance penalty fee.

[3] In principle, the microgrid can be virtual and not bound to a geographical area [9]. For our analysis, we assume that a microgrid falls within the perimeter of one DSO. As, for instance, the Flanders region in Belgium had more than 2.8 million households in 2018, with only 2 DSOs, this assumption will hold in almost all cases.

case of shortage or excess, trades electricity with suppliers or other parties in the role of ARP. The aggregator is responsible for metering (i.e., capturing information provided by the smart devices), billing, and balancing of the microgrid (i.e., the aggregator is the ARP for the microgrid).

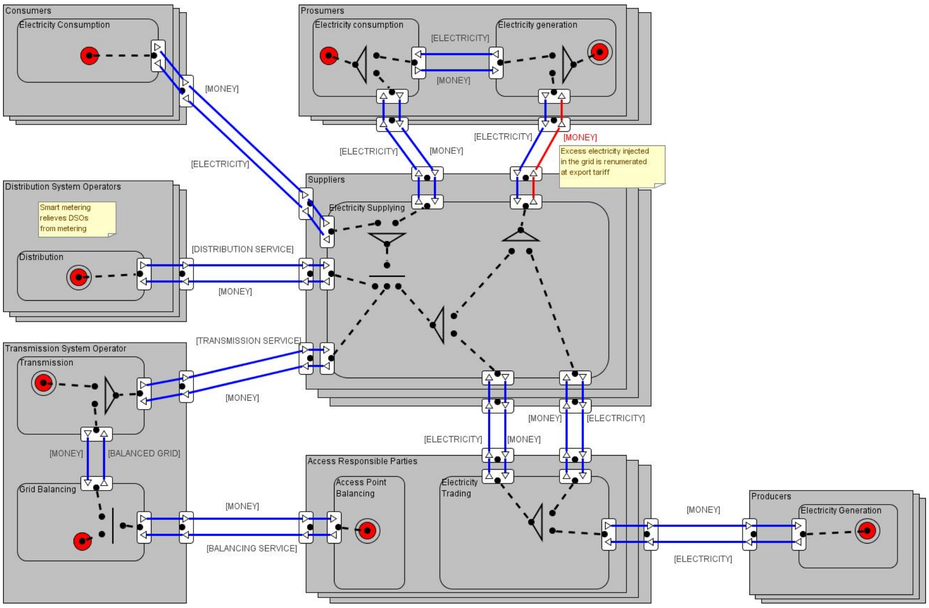

Fig. 2. Decentralized electricity market with smart metering

It is expected that in a smart grid ecosystem, the price paid for excess local electricity produced is higher than the export tariff, hence stimulating more consumers to become prosumers. However, if the aggregator of a microgrid is an economic independent entity (i.e., an e^{3}value *actor*), then the costs (i.e., variable, fixed and investment) of hosting the P2P market (i.e., an e^{3}value *value activity*) need to be covered by the difference of incoming and outgoing cashflows, while this difference must also allow for a certain profit margin in order to convince parties to assume the aggregator role.[4] This means that microgrids will only be viable if they have some minimum scale, which contradicts the objective of stimulating consumption of locally produced electricity. Replacing the aggregator by a DAO is therefore an economical option to reduce the scale of microgrids and realize the objective of increasing the consumption of locally produced electricity. Hence the idea of implementing a DLT-based system to perform the hosting the P2P market *value activity*.

---

[4] Given that the aggregator is a role, which can be played by another party (e.g., a supplier, a large industrial prosumer), it can also be modelled as a *value activity* of that other party. This doesn't affect our analysis as value activities need to be profitable or provide utility for the actors performing them.

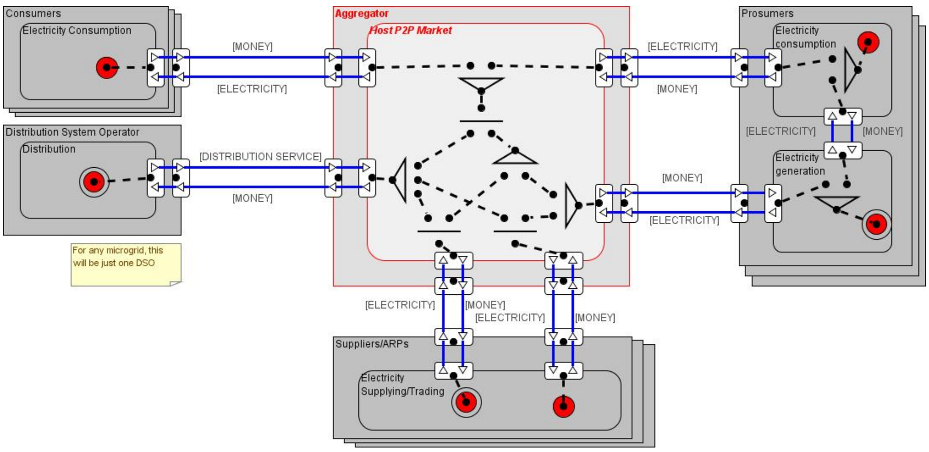

Fig. 3. Smart grid ecosystem with aggregator

In the smart grid ecosystem, the aggregator is a middleman between consumers, prosumers and suppliers. Within the microgrid, consumers and prosumers participate as peers in the electricity market. The aggregator is needed as trusted third party that intermediates between these consumers and the local producers (i.e., prosumers) of electricity. Also, there is a need to keep track of how much electricity is consumed (by consumers and prosumers) and how much electricity is produced (by prosumers) and, for the working of a fair market mechanism, this measuring (i.e., metering) must be accurate and reliable. Further, the aggregator trades electricity with suppliers and/or ARPs and distributes the expenses and revenues fairly amongst consumers and prosumers. Consequently, the suppliers and ARPs also participate as peers in the microgrid electricity market, without assuming a seller dominant position as in the current situation (Fig. 2), which is the disruption caused by the introduction of smart grids. Finally, the contracting of the DSO service is fully handled by the aggregator, who shares costs amongst consumers and prosumers.

Comparing this case to the three requirements for a sustainable DLT business case [5] (see sub-section 2.1), we observe the following:

- **Requirement 1 – removing the middleman**. The aggregator is clearly a middleman. In a perfect balanced ecosystem, the consumers and prosumers would exchange electricity for money directly, but due to periodic imbalances and the need of a physical electricity distribution network, the services of an intermediary come in handy;
- **Requirement 2 – market structure**. In the smart grid ecosystem, consumers, prosumers and suppliers are peers. They do not need to trust each other, because the aggregator is a third party that establishes trust in the ecosystem;
- **Requirement 3 – immutable transaction history**. A traceable, secure and transparent account of ‘who consumes and who produces what amount of electricity when’ is needed for performing P2P market hosting.

The question we address in this paper is how to visually find evidence of the fulfillment of these requirements in the e^{3}value model. Analyzing Fig. 3, we find

- An *actor* (aggregator) that is connected to *market segments* (consumers, prosumers, suppliers/ARPs);
- A *value object* (electricity) that is exchanged with these *market segments* and that flows in and out of the intermediating *actor*, without being altered by the *value activity* performed by this actor;
- Some evidence of the service provided by the *value activity* performed by the intermediating *actor* – here a *value object* (distribution service) that is obtained from outside and that is needed (as evidenced by the *AND-gates*)[5] for the *value transactions* with the *market segments*;
- Reciprocal *value exchanges* of money with the *market segments* – the money flows in exchange for electricity can be valuated differently for different *value transactions*, allowing the intermediating *actor* to cover costs (and possible realize profits).

If we now abstract from the particular case, the e^{3}value model of Fig. 4 is obtained where the above observations are translated into an abstract value model fragment. The model shows an *actor*, referred to as intermediating actor, that passes on a *value object*, referred to as the focal value object, from one *market segment* to another,[6] without altering this *value object*. The *value exchanges* of this *value object* are reciprocated with money flows. The *value activity* of the actor that performs the work to pass on the focal value object, referred to as intermediating actor's primary value activity, obtains a *value object* from another *actor* (or *market segment*) which is needed to perform the work required to pass on the focal value object.

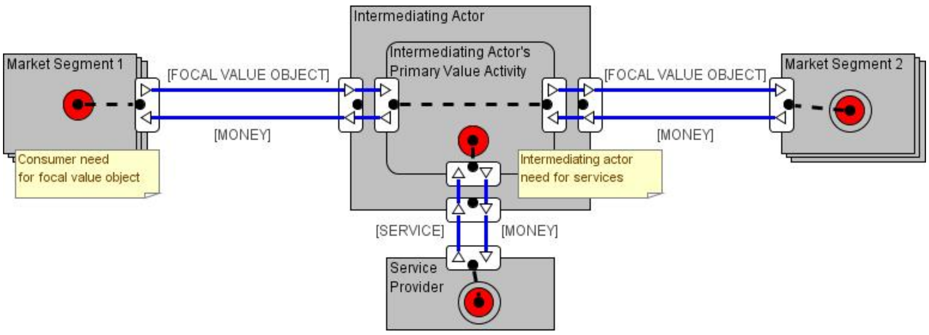

Fig. 4. Early indications of a potential DLT business case

To test the e^{3}value model fragment and at the same time demonstrate its use, we applied it to the case of KodakOne (https://kodakone.com), which is a joint initiative of Eastman Kodak and WENN Digital to establish an online platform where professional and amateur photographers sell licenses for using their images to interested parties.

---

[5] Alternatively, the value model can show a *start signal* inside the Host P2P market *value activity* that indicates the need for distribution services.

[6] A second *market segment* is strictly not needed as the focal *value object* can be passed on to another *actor* within the same *market segment* via another *value transaction*.

Fig. 5 shows the envisioned business ecosystem enabled by DLT. KodakOne connects image providers and image users, allowing them to sell and buy the right to use an image. If not done before, the copyright of the image is registered with the US Copyright Office. These activities are performed by WENN Digital. KodakOne operates under the Kodak brand for which the license is obtained from Kodak Eastman. WENN Digital also performs a number of other value activities which are outside the scope of our analysis (e.g., AI-based web crawling to detect copyright infringement, image cataloguing and searching).

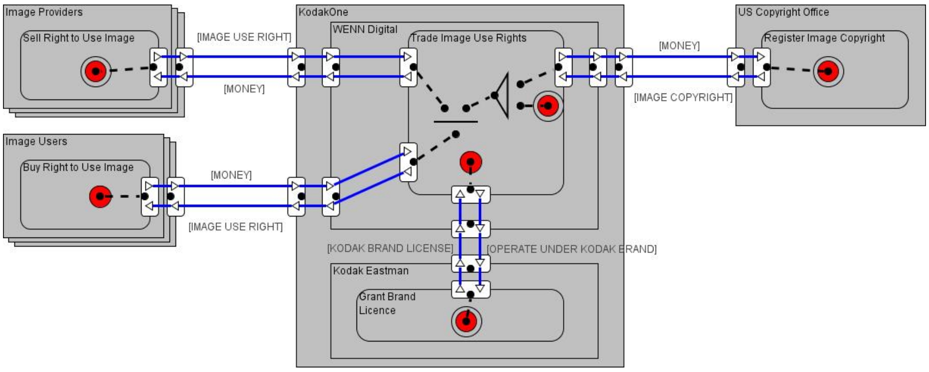

Fig. 5. KodakOne ecosystem for trading image rights

If we compare Fig. 5 to Fig. 4, then we discover an *actor* (WENN Digital) that passes on a *value object* (image use right) from one *market segment* (image providers) to another *market segment* (image users), without altering the *value object*. The *value exchanges* of image use rights are reciprocated with money flows and the primary *value activity* of the intermediating actor (trade image use rights) needs other *value objects* (image copyright, Kodak brand license) to perform the work. Hence, a potential business case for implementing the trading of image use rights using DLT is identified.

In reality, the online image use rights trading platform has being implemented using blockchain technology and a digital currency, the KodakCoin, was introduced for buying image use rights. KodakOne was launched in June 2019.

4 Discussion

Further research is required to investigate whether the e^{3}value model fragment shown in Fig. 4 effectively suggests potential DLT business cases. The fulfillment of **requirement 1** seems to be indicated by an *actor* that passes on a *value object* from one party to another where these *value exchanges* are reciprocated by *value exchanges* of money. Further, this *actor* has a *value activity* that needs to perform some work for passing on the *value object*, as evidenced by the sourcing of at least one other *value object*. We acknowledge that work performed by an intermediating actor's primary value activity might not always be visible in the e3value model. We assume, however, that for performing work, resources are needed which need to be sourced from another value activity performed by the same actor or from other actors or market segments. Whether such sourcing is visible depends of course on the level of granularity at which the intermediating actor's primary value activity is modelled.

The parties that exchange the focal value object with the intermediating actor are modelled as *market segments*. Each individual *actor* in a *market segment* ascribes the same value to the *value objects* that are exchanged, which signifies that the parties represented through these *market segments* are peers. The mere existence of the intermediating actor in the business ecosystem might indicate a lack of trust between these peers, which is exactly what is expressed in **requirement 2**.

Regarding **requirement 3** we admit that the granularity level of an e^{3}value model does not allow representing requirements regarding the storage of transactional data, hence the fulfillment of this requirement cannot be concluded based on an analysis of an e^{3}value model.

We also acknowledge three other types of limitations. First, the early identification of potential DLT business cases is performed visually. This allows for a 'quick and dirty' analysis, however, the e^{3}value approach also permits to quantify different model elements. Adding information on, for instance, cardinalities of *market segments*, occurrences of *value transactions*, valuation of *value objects*, and adding variable, fixed and investment costs to *value activities*, allows performing a net cash flow analysis to evaluate the viability of a business ecosystem. We did not yet explore how this aspect of the e^{3}value approach can be used to identify DLT business cases.

Second, our approach only identifies DLT business cases based on the removal of the middleman, which involves a disruptive application of DLT – not in the least for the trusted third party that acts as middleman. The approach therefore strongly relies on the requirements for such cases stated in [5]. There are other use cases for DLT, which might not be disruptive but still offer benefits in terms of increased security, traceability or efficiency. For instance, blockchain-based coordination systems have been implemented for executing message-based collaborative processes. For identifying such cases a business process model is more interesting than a value model which is time-agnostic and does not show the exchange of messages that are needed for choreographing an ecosystem's value activities and included processes.

Third and most obvious, our approach identifies the ***potential*** for a DLT business case. After such identification, additional analyses need to be performed before the business case of implementing DLT is proven. For instance, the work performed in the intermediary actor's primary value activity needs to be automated using smart contracts, which requires an investigation of the technical feasibility of a DLT solution. Also, the specific type of DLT needs to be decided on, with respect to data structure (e.g., blockchain, non-block DLT, directed acyclic graph), network (e.g., Ethereum, IOTA, Hedera HashGraph), degree of privacy/publicness of the data, permissionless/permissioned, etc. Apart from such technical questions, also legal, governance, financial and sustainability aspects need to be considered. It is our position, however, that these aspects are not worth investigating if the potential for a DLT business case is not shown, which is exactly what our approach aims to accomplish.

5 Conclusion

The e^3value model fragment that we abstracted from the P2P electricity trading case is a first attempt at defining an e^3value model pattern for early identification of sustainable DLT business cases. As a proof-of-concept, we demonstrated the use of the model fragment regarding the online image rights trading platform KodakOne, which has been implemented using blockchain technology.

Patterns were popularized in software engineering as proven solutions to reoccurring problems, where a common heuristic to qualify a solution as a pattern are three occurrences. Hence, we cannot claim to have established the model fragment as a pattern yet. In future research, we will investigate additional cases of disruptive DLT implementation (i.e., replacing the middleman) and other proven or promising applications of DLT in order to refine our current solution, possibly extend it for other types of DLT use, evaluate it as a pattern, and design a method for verifying the occurrence of the pattern in e^3value models. Regarding the immutable transaction history and other requirements that might pop up in our further research (e.g., for other types of DLT use), we will identify the information that is needed to assess these requirements and investigate how it can be modelled, possibly using other modeling languages than e^3value.

References

1. Ølnes, S., Ubacht, J., Janssen, M.: Blockchain in government: Benefits and implications of distributed ledger technology for information sharing. Government Information Quarterly (34) 3, 355-364 (2017).
2. Greenspan, G.: Ending the bitcoin vs blockchain debate (2015). https://www.multichain.com/blog/2015/07/bitcoin-vs-blockchain-debate/
3. Christidis, K., Devetsikiotis, M.: Blockchains and Smart Contracts for the Internet of Things. IEEE Access 4, 2292-2303 (2016).
4. Trujillo, J.L., Fromhart, S., Srinivas, V.: Evolution of blockchain technology. Insights from the GitHub platform. Deloitte Insights (2017).
5. Gordijn, J., Wieringa, R.J., Ionita, D., Kaya, F.: Towards a sustainable blockchain use case. Presented at the 13th International Workshop on Value Modelling and Business Ontologies (VMBO 2019). https://vmbo2019.blogs.dsv.su.se/files/2019/02/GordijnEtAl.pdf.
6. Wieringa R.J., Engelsman, W., Gordijn, J., Ionita D.: A Business Ecosystem Architecture Modeling Framework. Accepted for the 21st IEEE Conference on Business Informatics (CBI 2019). https://research.e3value.com/docs/bibtex/pdf/TEAM%20CBI%202019.pdf.
7. Gordijn, J., Akkermans, H.: Value Webs. Understanding e-Business Innovation. The Value Engineers, Soest, The Netherlands (2018).
8. Poels, G.: Enterprise Modelling of Digital Innovation in Strategies, Services and Processes. Accepted for the BPM 2019 1st Workshop on Value and Quality of Enterprise Modelling (VEnMo 2019).
9. Degraeve, H., Nys, J.: The Potential of Peer-to-Peer Trading and Blockchain Technology in a Decentralized Energy Network. A Value-Based Analysis. Unpublished Master Dissertation, Ghent University (2018). http://www.mis.ugent.be/wp-content/uploads/2019/06/JornNys-FMEBENDA341-746856-1528185345-Degraeve_Nys_2018.pdf.
10. Gordijn, J., Akkermans, H.: Designing and evaluating e-business models. IEEE Intelligent Systems 16(4), 11-17 (2001).