Exploring Governance in a Decentralized Energy Trading Eco-System

Fadime Kaya

Jaap Gordijn

Roel Wieringa

Marc Makkes

EXPLORING GOVERNANCE IN A DECENTRALIZED ENERGY TRADING ECO-SYSTEM

FADIME KAYA[1,2], JAAP GORDIJN[1,3], ROEL WIERINGA[3] & MARC MAKKES[1]

[1] Vrije Universiteit, Amsterdam, The Netherlands, e-mail: f.kaya@vu.nl, j.gordijn@vu.nl, m.x.makkes@vu.nl
[2] Tymlez, Amsterdam, The Netherlands, e-mail: f.kaya@vu.nl,
[3] The Value Engineers, Amsterdam, The Netherlands, e-mail: j.gordijn@vu.nl, roel@thevalueengineers.nl

Abstract Increasingly, large tech firms dominate eco-systems. From a societal perspective this is not always beneficial since these companies behave as value extractors; they charge an unreasonable high fee for their services and they can do so because they are monopolists. A possible solution to this substantial power concentration can be decentralized eco-systems, e.g., enabled by blockchain technology, in which decision power is distributed fairly. However, this comes also with the requirement that such eco-systems need a decentralized governance model. This paper explores if such a governance model can be represented by conceptual models, in particular, e3value. We answer this question by designing a decentralized eco-system in the field of electricity supply, which enables peer to peer energy trading, and checking if important governance decisions, motivated by a systematic literature review, can be represented.

Keywords: governance, decentralization, energy trading, business models, eco-system.

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1 Introduction

Nearly every company and individual is part of at least one *eco-system*. Based on (Moore, 1996), we define an ecosystem as a collection of parties who work cooperatively and competitively to satisfy customer needs. Well known examples of eco-systems are Uber, Google, and Facebook. All these eco-systems are dominated by only one player.

Such eco-systems with a dominant player tend to do value extraction: Companies charge unreasonably high fees for providing services or goods, which is neither in the interest of, nor sustainable for society. To mitigate unfair value extraction, we propose the concept of *decentralized* eco-systems, which we define as a collection of parties who work cooperatively and competitively to satisfy customer needs, and in which decision power is fairly distributed over a (sub)set of parties in the eco-system.

Such decentralized eco-systems, specifically in the field of intensive information services, can be realized with Distributed Ledger (DLT) and Blockchain (BCT) Technology. The most well-known case of BCT is the Bitcoin, in which banks are disrupted by allowing customers and sellers to directly transact with each other, without a bank. In general, BCT enables decentralized business transactions between parties, without a powerful centralized party. However, governance of many BCT systems are poorly developed and is often an ad-hoc driven process. Bitcoin has some signs of a governance process, but the nodes play only a role at the very end of this process, namely by accepting or rejecting the revised Bitcoin protocol.

To enable a decentralized eco-system, the key question is: How to govern and design a decentralized eco-system? In a traditional eco-system, the focal company is governed hierarchically by its board of directors and control, shareholders, and ultimately the government. In decentralized eco-systems, governance evolves to a negotiation game between participants, rather than a hierarchical top-down decision process.

Based on our consultancy experience with decentralized business development projects we have seen that these projects usually do not have a sound governance system in place; in practice, the decentralized project is often driven and governed by one single enterprise, which is often also the technology provider. For decentralized eco-systems, this is not in line with the philosophy that decision power should be equally and fairly distributed over parties in the eco-system. Even the strongest supporters of adopting a decentralized eco-system have conceded that the biggest challenge is the design of distributed governance (Zachariadis, 2019) and consider decentralized governance is an emerging research field (Alves, 2017).

The specific research question in this paper is to what extent governance decisions can be represented by conceptual models, in particular, *e³value*. The goal of conceptual models is to precisely and unambiguously represent an artefact in reality with the aim for (automated) analysis. This is precisely our long-term research objective: We want to software-support the design and analysis of governance constructs, and we refer to this field as *computational governance*.

This paper is organized as follows. In Sec. 2 we briefly explain what we mean by BCT-enabled decentralized eco-systems, and we elaborate on the notion of 'governance'. Then we explain in Sec. 3 our research methodology, which is Exploratory Technical Action Research (ETAR). A crucial element in ETAR in the involvement in a real-life project, which in our case, is a project about decentralized enabled renewable energy trading (Sec. 4). Finally, Sec. 5 presents our conclusions.

2 Governance of decentralized eco-systems

To understand governance and its layers, we revise the generic *control* paradigm of Blumenthal (see e.g., (Bemelmans, 1994) and (Leeuw, de, 1973)) to arrive at a more specific *governance paradigm* (see Fig. 1). We distinguish three governance systems: (1) the *governed* system (operations of a company) that has to obey to rules set by the governing system (e.g. the management of that same company), (2) the *governing* system that monitors and steers the governed system, and (3) the *meta* governing system that controls the governing system (e.g. the government of a country).

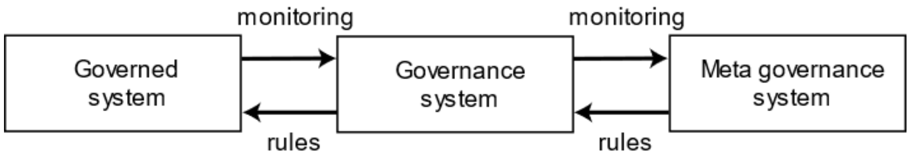

Figure 1: The governance paradigm

The rules are *normative*, e.g., the governed system should comply with these rules. (Re)design of rules is based on the monitoring of the governed system. The governed system performs *value-adding operations*, such as providing a video stream to customers in return for money (in the case of e.g. Netflix). The meta-governance system prescribes the rules for making rules (by the governance system). This implies that the governance system is a governed system at the same time. It is important that we understand *the system* as in system's theory: A system consists of entities with relationships. In our work (see also the next section), the governed system is a *decentralized network* of enterprises (e.g., a networked value constellation (Normann & Ramírez, 1993) or an eco-system (Moore, 1996)).

3 Exploratory Technical Action Research

We are interested in how to design governance for decentralized eco-systems and to what extent the governance of such eco-systems can be expressed in an *e*^{3}*value* model. Often, 'decentralized governance' is considered *ex-post*, that is when governance is already in place and up for evaluation. In contrast, we study the topic *ex-ante*, e.g., as a topic of design, cf. (Erbguth & Morin, 2018). Concretely, we do so by means of a project about renewable energy that facilitates peer-to-peer energy trading. We have been actively involved in this project. We use Exploratory Technical Action Research (ETAR), following the TAR approach, which is often used in the field of Design Sciences (Wieringa, 2014). ETAR comprises the following activities: (1) problem analysis, (2) treatment design, (3) treatment, and (4) treatment analysis. The notion of 'exploratory' emphasizes that we use TAR to first *understand* decentralized governance better, which might be followed by one or more TAR engagements with the field with the goal of theory formation and evaluation of the validity of the theory.

4 Governance for peer-to-peer energy trading

4.1 Project background

We have been working on energy transition towards renewable energy project that facilitates peer-to-peer energy trading. In The Netherlands, private citizens who have photo-voltaic (PV) cells, currently may subtract the generated electricity from the consumed electricity and only pay for the net amount of consumed electricity. Effectively, the owner receives the electricity price for sold electricity that should be paid normally, if he buys electricity (in The Netherlands about 0,20 Euro/KWh). During day-time, when the sun shines, the owner may generate more electricity than he needs and sells the surplus to the net. At night, the opposite happens. Consequently, the electricity grid functions as a kind of *store*: if the PV cell owner has a surplus, it can be delivered to the grid, and if he has a shortage, he can obtain electricity from the net, and the owner pays only for the net energy bought measured over one year.

This storage is offered free of charge, while for the large scale electricity suppliers and power generators who provice this service, it is not free at all. Due to physical constraints, the amount of electricity generated in a grid should at all times equal the amount of electricity consumed. The large electricity suppliers and generators are responsible for keeping this balance, and they do so by switching on and off generators and loads if demand and supply requires that. Obviously, this flexibility does not come for free, and therefore large electricity providers complain about the attractive arrangements for private owners of PV cells.

As a result, the Dutch government has decided to depreciate the current arrangement gradually. In the new situation, owners of PV cells *directly* receive a fee if they deliver to the grid. This fee is expected to be substantially lower than the 0.20 Euro/KWh mentioned earlier (e.g. 0.06 Euro/KWh). The same happens if electricity needs to be bought. It is not allowed anymore to settle generated and consumed electricity over the period of one year.

To mitigate the decrease in revenue for private owners of PV cells, we have designed an innovative, peer-to-peer business model for energy trading. If a private owner has a surplus of energy, he first sells it to another private owner. In case of shortage, owners buy electricity first from their peers. In case all participating owners have sufficient electricity, the surplus can be sold to the electricity market, as proposed by the government. In case of a shortage, owners buy electricity from the electricity market.

4.2 Problem analysis

The problem at hand is how to design governance in a decentralized eco-system. In Design Science, the notion of artefacts is key. We express artefacts in terms of conceptual models (Brodie, Mylopoulos, & Schmidt, 2012). These models allow for a better and shared understanding of the domain at hand and facilitates automated proof of correctness of models and computer-assisted analysis of the domain at hand (e.g., compliance with governance rules set by law). We want to understand whether model-based artefacts can assist in designing and understanding governance in decentralized eco-systems.

4.3 Treatment design: Governance artefacts

One of the first questions in terms of Design Science (Hevner et al., 2004) is what the actual design artefacts are. Without having the intention to be complete, based on our previous experience with eco-system design projects, and inspired on (Wieringa, Engelsman, Gordijn, & Ionita, 2019), we propose at least the following artefacts:

- **The strategy artefact:** Identifies the participants (as governing parties), rule, regulation, and lawmakers (as governing parties), their capabilities, and the services and products offered and requested. It provides a high-level blueprint of the eco-system at hand. Such models can be expressed by e.g., the UML Business Motivation Model (BMM) (BMM 2015) or i* to represent the strategic intent of stakeholders (Yu, 1997).
- **The business model artefact:** Puts into operation the strategy of the eco-system, in terms of flows of valuable objects. It also addresses economic reciprocity. Such models can be represented by e.g., *e³value* (Gordijn &

Akkermans, 2018), the Resource Event Agent (REA) ontology (Geerts, Mccarthy, Andersen, Dunn, & Smith David, 1999), and the Value Delivery Modeling Language (VDML) (VDML 2018).

- **The business process & data artefacts:** These artefacts represent the processes, time-ordering of activities, the performance of these by resources, and interaction between activities, in terms of message flows. Also expressed is a domain model of the relevant entities, relationships, and properties. There are many possibilities to represent these artefacts, we refer here to the Business Process and Model Notation (BPMN) (BPMN 2013) and the Unified Modelling Language (UML), more specifically class diagrams (Seidl, Scholz, Huemer, & Kappel, 2015).
- **The IT artefact:** This artefact encloses a number of sub-artefacts, e.g., the relevant views of the UML (Seidl et al., 2015), such as class-, activity, state transition- and deployment models. The focus is on embodying the previous artefacts into IT components.

These artefacts become governance artefacts as soon as they are prescriptive, meaning that they set the rules for the partipants. All these artefacts can play that role.

Designing all artefacts is a significant amount of work that exceeds the reporting space in this paper. Therefore, we concentrate on the business model artefact. The strategy artefact was already known when we entered the project, namely cost reduction for PV cell owners as soon as the new energy regulation starts. The other artefacts follow once there is agreement about the business model.

4.4 Treatment: A peer-to-peer energy business model expressing governance decisions

The project consortium consists of an energy certification body, a research institute, and a BCT platform provider. To express the business model, we require a language and we have chosen for the *e³value* methodology (Gordijn & Akkermans, 2018). This a tractable and teachable method for business development specifically designed for eco-systems. Note that the traditional energy infrastructure is hierarchically and centrally orchestrated, therefore it does not provide decentralized governance for the case at hand. Consequenty, a new governance model is needed.

In figure 2, we model the business model for the peer-to-peer energy trading ecosystem, expressed as an *e³value* model. The model is the outcome of several workshops with stakeholders but is simplified (some parties are left out) to allow for a compact presentation in this paper. Prosumers are *market segments* because there are many of them (e.g. households). Prosumers own PV cells and likely batteries (e.g., in their electric cars) to store electricity temporally. A market segment is a set of homegenous *actors*. Actors are also economically independent parties, such as the Cooperation and the Electricity Trader. The Cooperation aggregates electricity power from Prosumers and can, therefore, negotiate a better deal with the Trader. In the same way, the Trader delivers electricity against favourable conditions to Prosumers via the Cooperation if there is not enough electricity generated by the Prosumers themselves. As can be seen from the model, the Prosumer uses first energy ('consume' value activity) from its own PC cells and/or batteries.

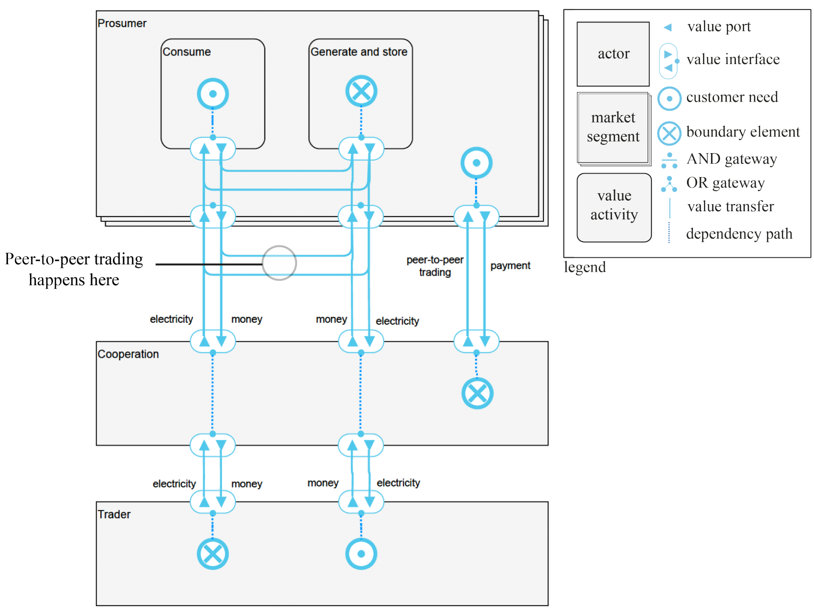

Figure 2: Peer-to-Peer Energy trading

Similarly, if the Trader generates more electricity than it requires, it first stores the energy in a battery component. If there is still a surplus of electricity, the Prosumer sells electricity to other Prosumers: the peers. The same happens if a Prosumer consumes more than it can obtain from its PC cells or batteries; then, it first obtains electricity from other Prosumers. To be attractive to all parties, the peer-to-peer electricity price should be higher than the price the Trader would pay while buying (so more than 0.06 Euro/KWh) but lower than the price the Trader charge while selling (so lower than 0.20 Euro/KWh). This gives sufficient price negotiations between Prosumers (peers). This represents the *peer-to-peer* trading. Furthermore, the Cooperation provides a service to the Prosumers, namely an IT-enabled energy trading platform. Part of the service is (dis)aggregation of electricity to the trader, to sell a surplus of electricity of the Prosumers, or to buy electricity for the Prosumers in case the Prosumer do no have sufficient electricity himself. This way, the Cooperation ensures that at all time the supply and demand of electricity are in balance, which is a requirement for the electricity grid.

4.5 Treatment analysis: Governance decisions in the peer-to-peer business model

In terms of treatment analysis, the question is whether a business model represents governance decisions adequately. In (Alves, 2017), a number of governance mechanisms have been identified based on a systematic literature review of 63 studies on governance for eco-systems. The study of (Alves, 2017) focuses on eco-systems with one dominant actor, which differs from a decentralized eco-system. However, we consider the study as an useful starting point because most of these mechanisms are also applicable to decentralized eco-systems.

In (Alves, 2017), three classes of governance mechanisms are identified that can be used to design governance in eco-systems: (1) value creation, (2) coordination of players, and (3) organizational openness & control. Each class of governance mechanism has subclasses (see below). We use these governance mechanisms to evaluate per governance mechanisms to what extent our *e^3value* model for peer-to-peer energy trading (see Fig. 2) represents the governance decisions.

Value creation evalution based on our *e³value* model.

The value creation aspect considers how value is created and distributed.

- Revenue model. The revenue model shows how each actor earns money. In the *e³value* model, this is shown by means of value transfers. In the peer-to-peer energy trading case, a Prosumer pays a lower price for electricity than the fee a Trader would charge.
- Attract and maintain partners. The electricity case has a close resemblance to the idea of partnering. Effectively, partners (the Prosumers) team up to provide each other electricity and act as one to the electricity market if there is a surplus of shortage in electricity. This partnership can not easily be observed in the *e³value* model, because in *e³value*, a partnership has a different meaning, namely two or more actors offering or requesting objects of value together as one proposition.
- Stimulate co-investments and share costs. Each Prosumer has to invest in technology to participate in the eco-system. Although not visible in the graphical model, this can be represented to quantify the model, which is a standard feature of the *e³value* method. For shared-costs, all Prosumers contribute to the financial sustainability of the Cooperation. This can be seen from the value transfer "peer-to-peer trading".

Coordination of players evalution based on our *e³value* model.

Parties in an eco-system should work together in a harmonized way.

- Roles and responsibilities. A governance decision is to have a cooperation and not only Prosumers. A truly peer-to-peer system would not have a cooperation. However, the Cooperation represents all Prosumers, and these should have a say in the decision making processes of the cooperation. The *e³value* model does not represent this, e.g., does not model that a party is represented by some other party for decision making. This could be an extension of the *e³value* language (see e.g., (Sarkar & Gordijn, 2018) for a proposal on how to do this). Furthermore, value activities can represent the roles of actors. The model presents only value activities to distinguish between the consumption of electricity and the generation and storage of electricity. This is needed to represent that buyers first 'buy' electricity from themselves before buying electricity from their peers or

Cooperation. Value activities could be added to the other actors to emphasize the roles they take.

- Effective communication channels. The peer-to-peer electricity trading eco-system is supported by information technology, more specifically BCT, to avoid the emergence of a central party. Communication is not represented by an *e³value* model; other artefacts must be developed to represent this.
- Conflict management. In any eco-system, conflicts can arise, and in peer-to-peer eco-system there is no centralized party that can resolve conflicts. Conflict management is a topic by itself, it can be seen as a commercial service (then it would be visible in the *e³value* model), but also as an inter-organizational business process, and hence be modelled by a business process artefact.
- Manage resources, risk, and expectations. Resources (e.g., a capacity to perform activities) can be seen by the value activities as assigned to actors. Risks and expectations can be analyzed by the *e³value* model by quantifying it and then performing what-if analyses.

Organizational openness and control evalution based on our *e³value* model.

Eco-systems can be open (or closed) to their environment, e.g., of actors that may participate. Control refers to the actor(s) who orchestrate the eco-system.

- Autonomy. In this case, autonomy would refer to the decision power of actors in their own right. In the case of normal electricity consumption, the consumer buys electricity from a large supplier and has no decision power . For the peer-to-peer electricity case, decision power is with the cooperation. These processes can not be seen by the *e³value* model.
- Distribution of power. The peer-to-peer electricity case distributes power equally over the Prosumers. This can be seen from the *e³value* model. Prosumers are depicted as the same kind of actor, and consequently, their need for electricity is the same, as it is for generating electricity. Since Prosumers are part of a market segment, they assign economic value to electricity in the same way. Quantification would illustrate that Prosumers earn and spend the same amount of money.
- Architectural decisions. The eco-system at hand requires an IT architecture, to allow for interoperability between all parties. This is not illustrated by the *e³value* model.

5 Conclusion

The question raised at the beginning of the paper is to what extent an *e³value* model can present governance decisions. Concerning value creation, we have learned that *e³value* represents decisions regarding the revenue model. However, partnering of Prosumers can not really be represented in *e³value*, the notion of partnership needs to be revisited, e.g., by introducing different kinds of partnerships. Investments and cost-sharing can be represented if the model is quantified. Coordination of players seems to be more a business process design issue than a business (value) model concern. Roles and responsibilities can be partly represented by value activities; risk and expectations by running what-if scenarios, which is a standard functionality of the *e³value* toolset. An *e³value* model can partly visualize organizational openness and control. Autonomy regarding the decision process can not easily be seen; the distribution of power can be spotted in various ways. Architectural decisions require IT modeling techniques, but also a commitment to standards to ensure inter-operability. As a final remark, although an *e³value* model can represent some aspects of governance decisions, the design process for *e³value* is focused on *business development*: understanding the required eco-system, performing a financial sustainability assessment and fraud analysis. The other layers of the eco-system should be designed and analysed as well (such as control, ICT and powergrid layer). For future research we plan to extend the peer-to-peer *e³value* model and to model the other layers of decentralized governance as well.

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