# $e^3$*alignment*: Exploring Inter-Organizational Alignment in Value Webs


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***Abstract*—In this paper we introduce the $e^3$*alignment* approach for inter-organizational alignment. With $e^3$*alignment* we create alignment between organizations operating in a value web - which is a set of organizations who jointly satisfy a customer need - by (1) focusing on the *interaction* between the organizations in the value web, (2) considering interaction from *four* different perspectives, and (3) utilizing conceptual *modeling techniques* for each perspective. By creating inter-organizational alignment between the actors in a value web $e^3$*alignment* ultimately contributes to a sustainable and profitable value web. To actually create alignment, $e^3$*alignment* iteratively takes three specific steps: (1) identification of alignment issues, (2) solution design, and (3) impact analysis. We tested $e^3$*alignment* on an industrial strength case study in the Spanish electricity industry.**


## I. Introduction

Recently, Chan and Reich [1] published an article summarizing and analyzing over 150 articles concerned with aligning business and IT in organizations. Among the directions for future research was "examining the process of alignment". Part of such a alignment process is the *exploration* phase in which alignment issues are elicited and (alternative) solutions are considered for improving alignment [2]. In computer science, this is often referred to as the *early requirements engineering phase*, in which the business context is analyzed to elicit business requirements, which ultimately are satisfied by information systems [3]. How to deal with business-IT alignment in such an early phase, characterized by limited availability of information about the case at hand, time constraints, and high uncertainty [4], is a research problem.

Additionally, companies are increasingly participating in *value webs*; these are sets of organizations which collaborate to jointly satisfy a complex customer need [5]. Most of the work identified by Chan and Reich [1] on business-IT alignment focuses just on alignment concerns within *single* organizations, while we argue that alignment issues may exist between *multiple* enterprises also. Interoperability between multi-enterprise information systems is an example of such an alignment issue. Therefore, dealing with alignment in a business network setting is another research problem.

To cope with the two aforementioned research problems, we introduce $e^3$*alignment* , which is part of the $e^3$*family* of business ontologies [6]. With $e^3$*alignment* , it is possible to explore a wide range of *inter-organizational alignment* issues concerning the *interaction* between organizations, and their information systems, in a value web, seen from *multiple perspectives*, and with the aid of *modeling techniques*. Such exploration should happen in a limited time frame, and with only limited information about the case at hand.

For organizations participating in a value web, we argue with $e^3$*alignment* that we need to focus on the *interaction* between these organizations to create alignment. We reason so, since one of the success factors of a value web is that *each* actor involved should be able to make a sustainable profit, and does so by interacting with the other organizations in the value web, e.g. by exchanging objects of economic value (see also section III-A).

The $e^3$*alignment* approach takes *four* different perspectives on interactions between organizations into account (see section III-B). Since there is no single type of interaction (e.g. information exchanges and economic value transfers are different kinds of interactions), we separate concerns by taking multiple perspectives on interactions between organizations in a value web. In other words: per perspective, $e^3$*alignment* focuses on one specific type of interaction. Separating concerns is well-known in the field of requirements engineering to deal with complex decision making processes (see [7]). In $e^3$*alignment* the following perspectives are taken on interaction: 1) a *strategic* perspective, to understand the strategic influence of organizations on other organizations; 2) a *value* perspective, to understand the things of economic value exchanged between the organizations in the value web; 3) a *process* perspective, to understand the order and activities behind the interactions; 4) an *IS* perspective, to understand the IT enabled exchange of information between organizations.

By focusing on interactions, $e^3$*alignment* takes an external view on alignment, also referred to as *inter-organizational alignment* [8] (see section III-D). Inter-organizational alignment is concerned with the coherence between actors in a value web. In contrast, an internal view on alignment, or *intra*-organizational alignment, focuses on the alignment within a single organization [8], which is the main concern of most traditional business-IT alignment frameworks (e.g. [9]). Inter-organizational alignment has two forms [8]: (1) alignment *within* one of these perspectives on interaction, and (2) alignment *between* two, or more, of the aforementioned perspectives on interaction. Alignment *within* a perspective is concerned with aligning interactions between actors as seen from a single perspective [8]. Alignment *between* perspectives is concerned with aligning multiple perspectives of the value web at hand [8], for instance between the value and IS perspective. Creating alignment, or *consistency*, between perspectives is well-known in the field of requirements engineering (see [7]).

Finally, with $e^3$*alignment* we reason that modeling techniques should be used in three iterative steps (see section IV): (1) identification of alignment issues, (2) alignment solution design, and (3) alignment impact analysis. To actually execute the process of alignment, $e^3$*alignment* utilizes light-weight, yet ontological well founded, modeling techniques (see section III-C). Utilizing modeling techniques enables us to create shared understanding among stakeholders [10], allows for traceability of changes over the perspectives [7], and closely resemble the way-of-working in information system design.

To understand the usability of $e^3$*alignment* - which we will reflect on in section V - we conduct an industrial strength case study of the Spanish electricity power system in which new technologies, resulting in new interactions between the actors, need to be integrated into the current system in a profitable way.

The paper is structured as follows: First, the case study is introduced. Second, the $e^3$*alignment* framework will be discussed. Hereafter, the modeling approaches as used in $e^3$*alignment* will be presented in more detail. Hereafter, the actual steps for alignment will be presented, and illustrated by means of the case study. The paper ends with lessons learned, in which we reflect on the practical usability of $e^3$*alignment* , to identify future research directions and to present conclusions.

## II. Case Study: Spanish Electricity Power System

We illustrate $e^3$*alignment* by an industrial strength case study in the field of electricity supply and consumption in the Spanish electricity industry. For this case study we have had interviews and discussion sessions with various organizations and research institutes involved in the Spanish electricity power system. All these parties are involved in the European FENIX project (see http://www.e3value.com/projects/ourprojects/fenix/).

### A. Distributed Energy Resources

Traditionally, electricity is produced in vast amounts by large power plants, in which fossil resources serve as the source of electricity. However, due to increasing $CO_2$ emissions and rising prices of fossil resources in combination with high electricity demands, nations across Europe - including Spain - are motivated to search and implement alternative sources of "green" electricity. Think of wind turbines, solar energy and, combined heating power installations (for example, heat produced by metal ovens is used to produce electricity). Such sources of energy are called Distributed Energy Resources (DER). Obviously, DERs need to be integrated into existing electricity power systems. This is however not only a technical and physical issue, in which electricity wires simply connect DERs with the rest of the system. To be economically feasible, it is necessary that "green" electricity is subsidized by governments, meaning that actually a second type of electricity is created, with its own price and valuation. Furthermore, since DERs are physically distributed over a geographical area, instead of centralized such as large nuclear power plants, the control and governance are quite different. Today, this control is operationalized and automated by means of information systems.

### B. Balancing electricity supply and demand

A distinguishing characteristic of the electricity power system is that *always* the amount of electricity produced should equal the amount of electricity consumed.It is however not possible to know the exact demand on any given moment. Therefore, forecasts are made, with the aid of information systems, for both the demand and supply side. These forecasts are quite accurate, yet there are always deviances, meaning that the demand might be higher or lower than expected, or that deviations on the supply side occur. Continuously balancing the electricity power as supplied and as consumed is a business in its own right, and is crucial for the correct functioning of electricity power networks. We therefore introduce the most important actors playing a role in balancing supply and demand of electricity.

First, there are the *producers*, such as IBERDROLA in Spain, who produce electricity. Second, there are *suppliers*, such as ENDESA, who buy electricity from producers and sell electricity to customers. *Customers* are the third group and are those actors who consume electricity. Although households are also consumers, we focus in this case study on organizations who consume electricity in large volumes. Normally, suppliers and producers will have long term bilateral contracts, such that the suppliers can guarantee their electricity supply. However, suppliers cannot accurately predict the exact electricity demand for any given moment. Therefore suppliers also buy (or sell in the case of a surplus) electricity on a shorter time frame - up to a few hours - to better meet projections. The buying or selling electricity in a short time frame is done at an electricity market exchange, which is operated by a *market operator*. In Spain, the market Operator is *OMEL*. The electricity market operates on a day-a-head basis (d-1). So the day before actual production (d-1), suppliers and producers make offers and bids for electricity via special software. After the market operator has received all bids and offers, OMEL's information system determines the price of the electricity exchanged in that time frame. The market operator hereafter distributes schedules, using its information system, to both suppliers and producers, specifying how much electricity they should consume or produce. After the market price of electricity has been established and schedules have been provided by the market operator, a *market clearance* is given by OMEL.

The market operator does however only takes financial considerations into account. Technical considerations, such a stable voltage level, are considered by the *system operator*: REE in Spain. To this end OMEL and REE synchronize their databases after financial clearance. Hereafter, REE's information system determines if the technical integrity of the electricity power system is not compromised. If required, modifications to the schedules are made and producers and suppliers are informed, again with the aid of various information systems.

When the actual production schedules are executed and energy is consumed, there are still always deviations. Either the demand forecasts are incorrect or there is a supply problem, both causing "*imbalance*". When there is imbalance - detected by the system operator -, preselected producers are ordered to increase or decrease electricity production, typically within a few seconds. Therefore, the preselected producers keep reserve capacity, this unused capacity is referred to as "reserves". It is however possible that all available reserves are required. Therefore there are not only primary reserves, but also secondary reserves and tertiary reserves. The reserves differ in the time needed to switch them on or off (ranging from a few seconds to minutes). Reducing imbalance is however not free of charge, since producers have to be paid for keeping reserves and for producing extra electricity. Therefore, actors causing imbalance have to pay a penalty to the system operator for doing so.

*Case Study Problems.* Since various types of DERs exist (wind turbines, solar cells, etc.), and each has its specific alignment issues, we focus on a single type of DERs: (1) Combined Heat Power installations (CHP). CHPs use heat produced by for instance metal ovens to generate electricity. The three key problems of integrating CHPs into the existing Spanish electricity power system are: (1) how to "connect" CHPs to the current information systems? (2) How must organizations sell the electricity produced by a CHP, such that there is a reasonable return on investment? Here for instance we must take government subsidy into consideration. (3) How can it be avoided that CHPs cause an increase in imbalance?

## III. THE $e^3$*alignment* FRAMEWORK

We explore the electricity power case study by using our $e^3$*alignment* approach. To understand the philosophy behind $e^3$*alignment* we present the model in figure 1. The model shows the key features of $e^3$*alignment* :

- $e^3$*alignment* is concerned with creating alignment, or coherence, between organizations operating in a value web by focusing on the *interaction* between these organizations (see section III-A). In figure 1, these interactions are represented by the horizontal lines.
- $e^3$*alignment* takes four different perspectives on interaction between organizations: a strategic, value, process, and IS perspective (see section III-B). For each perspective there is a horizontal line in figure 1, representing the interaction considered by such a perspective.
- To understand and analyze each of the four perspectives on interaction, per perspective a conceptual modeling technique is utilized (see section III-C), as stated in the brackets per horizontal line in figure 1.
- Since we take multiple perspectives on interaction, $e^3$*alignment* creates alignment between organization *within* a single perspective (the horizontal arrows) and alignment *between* perspectives (the vertical arrows in figure 1). We explain the two types on alignment in more detail and with examples in section III-D.

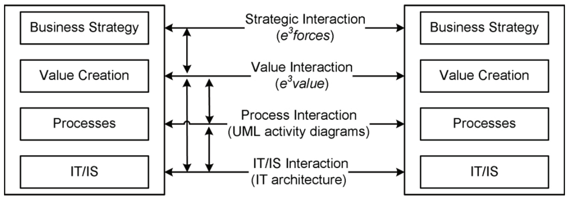



Fig. 1. The $e^3$*alignment* Framework

### A. Interaction Between Actors in Networks

Since organizations increasingly operate in value webs [5], $e^3$*alignment* takes a network perspective on alignment. In essence, a network is a number of nodes which are connected. In both the business and IT literature, nodes are often referred to as *actors* (e.g. [11], [12]). An actor can be a variety of things, an actor can be an organization, but also an actual person or even a piece of hardware [12].

A second key element of networks is the *interaction* between actors, which is the key focus of $e^3$*alignment* . Interaction between actors is represented in figure 1 by the horizontal lines. There is interaction between two actors if one actor somehow *influences* the other. In the case study at hand, examples of interactions between actors are the exchange of electricity, the payments for the electricity, but also the prediction of production/consumption and the clearance of the production schedules. In all these interactions, actors influence each other.

### B. Multiple Perspectives

As the case study demonstrates, *interaction* is a fairly generic construct. Furthermore, it has been dealt with in both business and IT literature. Interaction is expressed in business literature ranging from supply chain literature where objects of value are exchanged between actors (e.g. [11]) to strategic literature where actors influence each other on a strategic level (e.g. [13]). In IT literature, interaction is often considered from an information viewpoint where information is exchanged between actors (e.g. [12]) or a process viewpoint where the sequence of interactions is considered (e.g. [14]).

Since various conceptualizations of interaction exist to address various stakeholder concerns, $e^3$*alignment* separates these concerns by taking different perspectives on interaction. Each perspective analyzes a different type of interaction between organizations. Separating concerns in also well known in the IS field of requirements engineering (e.g. [7]). The benefit of separating concerns is that (large) complex issues are reduced in more comprehensible issues, making it easier to focus on the key elements. To cover the wide range of interactions between actors in a network, four different types of interaction are considered in $e^3$*alignment* (see the horizontal arrows in figure 1):

1) The *Business Strategy* perspective, which considers how other organizations influence the *strategic position* of an organization. This type of interaction is taken into consideration in $e^3$*alignment* , since it shows how organizations influence each other on the long term. For example, think of the strategic influence of DER's on traditional monopolistic positions of large energy producers, since now other organizations can start producing electricity (e.g. energy producers thus loose their monopolistic position).
2) The *Value Creation* perspective, which considers how value is created by the *value web* in which the organization operates. This type of interaction is taken into consideration since it shows the things of economic value exchanged between actors in a network to ultimately be able to meet a customer need. Consider for instance, the exchange (i.e. interaction) between two actors trading "green" electricity in return for subsidized payments.
3) The *Process* perspective, which considers the cross-organizational *coordination processes* to support the value creation. This type of interaction is taken into consideration in $e^3$*alignment* since this view on interactions shows the actual physical transfer of objects and takes "time" into consideration, such that the activities behind the interactions and sequence of interactions can be considered. Think of the order of activities to successfully execute an electricity market.
4) The *IT/IS* perspective, which considers information systems and technologies used to interact with the environment to *exchange information*. This type of interaction is taken into consideration since it will enable us to shows which part of the exchange of objects (e.g. information) is facilitated by information technology. For example, information systems facilitate the exchange of production/consumption schedules between suppliers and OMEL.

Although each perspective takes a different viewpoint, they all view the same phenomenon: interaction between actors in a value web [8]. Note that we, in contrast to other multi-perspective approaches (e.g. [7]), have specified the perspectives to be analyzed beforehand, since now stakeholders can directly focus on concerns regarding the alignment, instead of first determining the relevant perspectives.

Although in many cases all the four perspectives are considered relevant for inter-organizational alignment, we do not believe that all perspectives are always required. Field experience has shown that stakeholders are often more concerned with a subset of the viewpoints, rather than with all four. For example, in the presented case study stakeholders are mainly concerned with the value and IS perspective. Their interest is not with the strategically implications of implementing CHPs, nor is it with redesigning processes to control CHPs. Their first and main concern - which is dealt with during the exploration phase - is to determine how a technical solution (e.g. the IS architecture) could be made financially feasible. To this end, we only consider the IS perspective and value perspective for the case study at hand.

### *C. Modeling Techniques*

For each type of interaction, a modeling technique is given (between brackets in figure 1). To be able to execute the process of business-IT alignment, $e^3$*alignment* departs from traditional alignment frameworks by actually introducing techniques and methods for creating alignment. The $e^3$*alignment* approach considers for each type of interaction a specific modeling technique. For instance, for the value perspective we utilize the modeling technique $e^3$*value* (see [15]). The benefit of utilizing known modeling techniques is that we can easily create more shared understanding over various aspects of the value web at hand [10]. In addition, we can trace changes over the four perspectives to better understand the consequences of design choices within one of the perspectives [7]. Finally, by choosing this model-based approach, we closely resemble the way-of-working in information system design, so the models developed provide a suitable starting point for further design and implement ion of the information systems needed to enable the value web.

Since we focus on the value perspective and IS perspective in this paper, we do not discuss the modeling techniques for the business strategy perspective (see e.g. [2]) and process perspective (see e.g. [14]).

*1) IS Perspective - IS Architectures:* There is a substantial amount of literature on modeling information system architectures (see e.g. [16]). In terms of languages there is the UML [12] as an industry standard. In addition, design approaches such as TOGAF [17] are becoming increasingly popular. The aforementioned approaches are however rather comprehensive and therefore time consuming to apply during the exploration of inter-organizational alignment. Therefore, a notation which is easy and traceable, but also provides a suitable starting point for further IS development (such as TOGAF), is needed. To this end, we use (high level) IS architectures. Specifically, we are interested in identifying three aspects: 1) what key technologies are needed, since new technologies lead to modification in the other perspectives (see also section III-D2), 2) which (sub)-information systems or data-stores are required, and 3) how do the information systems interact with their environment; what information is exchanged between actors. These three aspects show the big picture of how information systems technically realize the value web under investigation. Furthermore, based on our field experience, if one of these three aspects of the IS architecture changes, chances are high that the value creation and strategic position will also change. For instance, we will see in the case at hand that when the metering system is changed, new

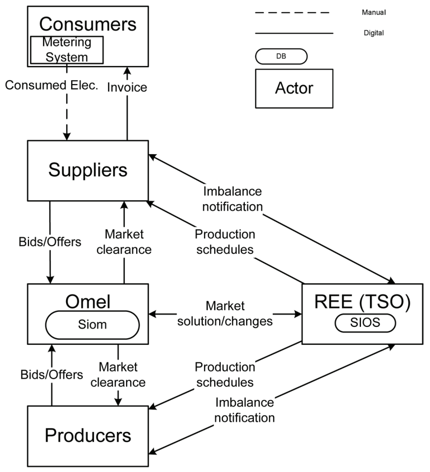



Fig. 2. IT Architecture current situation

information about electricity consumption and/or production will become available, which is of value for certain actors.

So, for the value web under investigation we model the actors' information systems and data stores with squares and rounded squares. Subsequently, we model, via simple arrows, which information is exchanged between various actors in the value web. For these actors we also model which (sub)-information systems and data stores they require to interact with the other actors in the value web. Technologies needed to enable the information exchanges are also included (textual), since the selected components reflect important technology choices.

We provide an IS architecture in figure 2 for the case at hand (such a view on the information systems was actually already used by various actors in the case study). The model shows that a "metering system" informs Suppliers with the amount of electricity consumed by Consumers. In addition, the model shows that Suppliers send their sell/buy bids to OMEL. Furthermore, OMEL clears the market and information is sent back to Suppliers. In addition, OMEL en REE synchronize their databases (market solution, requests and changes, etc). Finally, REE informs the Suppliers of the production schedules which are now also technical approved. There is also an information exchange between Suppliers and Consumers; Suppliers manually determine the consumption of electricity produced and send out invoices.

*2) Value perspective - $e^3$value:* To model the value perspective on value webs we use the $e^3$*value* modeling technique [15]. The $e^3$*value* approach provides modeling constructs for representing and analyzing organizations exchanging things of economic value with each other. We provide an $e^3$*value* model for the current Spanish electricity power system to explain the various constructs (see figure 3). Note that we do not explain the value model itself, which we will do later, at this point we only explain the constructs used in $e^3$*value* .

*Actors* are perceived by their environment as economically independent entities, meaning that actors can take economic decisions on their own. OMEL and REE are examples of actors. *Value objects* are services, goods, money, or information, which are of economic value for at least one of the actors. Value objects are exchanged by actors. *Value ports* are used by actors to provide or request value objects to or from other actors. *Value interfaces*, owned by actors, group value ports and show economic reciprocity. Actors are only willing to offer objects to someone else, if they receive adequate compensation in return. Either all ports in a value interface each precisely exchange one value object or none at all. So, in the example, electricity can only be obtained for money and vice versa. *Value transfers* are used to connect two value ports with each other. It represents one or more potential trades of value objects. In the example, the transfer of "electricity" and "money" are both examples of value transfers. *Value transactions* group all value transfers that should happen, or none should happen at all. In most cases, value transactions can be derived from how value transfers connect ports in interfaces. *Value activities* are performed by actors. These activities are assumed to yield profits. *Dependency paths* consists of *consumer needs*, *connections*, *dependency elements* and *dependency boundaries* and are used to reason about the number of value transfers. A consumer need is satisfied by exchanging value objects (via one or more interfaces). A connection relates a consumer need to a value interface, or relates various value interfaces of a same actor internally. In the example, by following the path we can see that, to satisfy the need of consumers, the producers ultimately has to provide electricity.

### D. Inter-organizational Alignment

As introduced earlier, two types of inter-organizational alignment are considered in $e^3$*alignment* : alignment *within* a perspective and alignment *between* perspectives.

*1) Alignment within a perspective:* This type of alignment is concerned with the alignment between organizations [8] as seen from a single perspective (the horizontal arrows in figure 1). The various interactions an organization has with other actors in the value web, as seen from a single perspective, need to be properly aligned, since otherwise the network will not be able to function properly, thereby influencing the success of the organizations.

A clear example of inter-organizational alignment *within* a perspectives is the construction of price for electricity produced by DERs (see annotation (e) in figure 3). In addition to the price a supplier is willing to pay for the electricity, the government provides subsidies on electricity produced to stimulate the build of DERs. Since this is mainly a financial issue, such a problem is dealt with in the value perspective. An organization installing DER provides "green" electricity, which is of value for the government. The government provides subsidies, which is of value for the organization installing the DER. For this exchange of value objects, there must be coherence (i.e. alignment) between both parties on the construction of the subsidy. The subsidy must be sufficient enough to stimulate installing DER. yet the costs of the

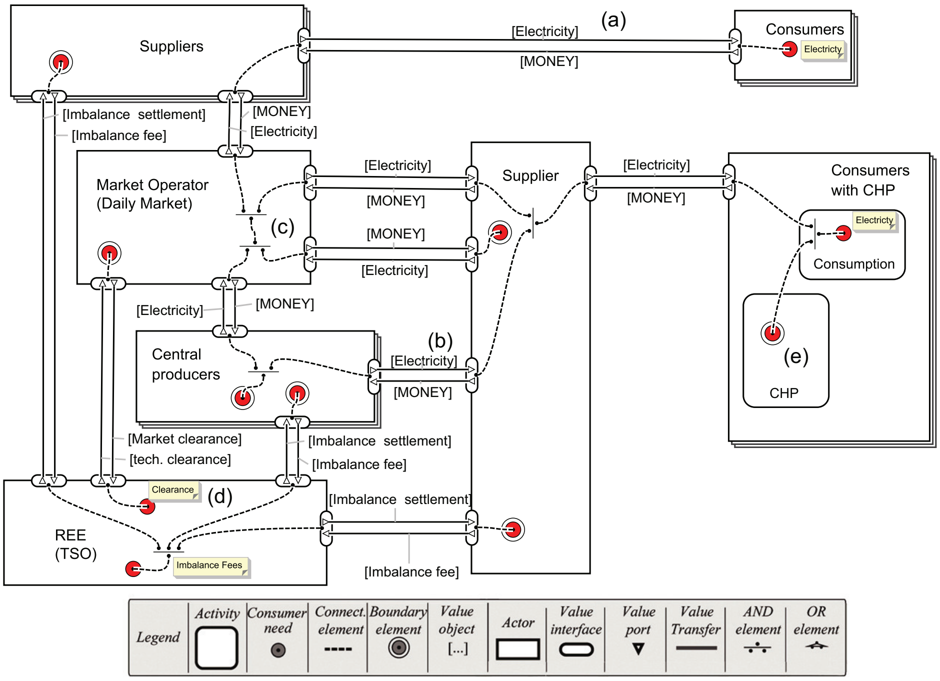



Fig. 3. $e^3$*value* model: CHP integrated

subsidy for the government must however be realistic; thus *alignment* has to be created (this issues is discussed in more detail in section IV-K).

*2) Alignment between perspectives:* Inter-organizational alignment *between* perspectives is concerned with the alignment between two or more perspectives for the entire value web (the vertical arrows in the figure 1). Since $e^3$*alignment* takes multiple perspectives on the value web at hand and each of the perspectives must be a correct representation of the value web, the various perspectives need to be consistent (i.e. aligned) [7].

In the case at hand, we only consider the value perspective and IS perspective. Subsequently, both perspectives need to be aligned. However to be able to do so, we need to understand the mutual influences between interactions as seen from the value perspective and interactions as seen from the IS perspective. Two main influences can be distinguished: "*structure of interactions*" and "*technologies*".

*a) Structure of interactions:* With the structure of interactions we mean the overall composition of actors and their interactions. For instance, the structure can be centralized (actors interact via one central actor) or decentralized (interaction is more on a bilateral basis). Our field experience and case studies have shown that if the structure of the value web changes, the IS structure follows a similar pattern and vica versa.

For the case study at hand, if some conditions are met (e.g. minimal volume, financial guaranties, etc.), organizations with a CHP are allowed to trade their electricity at OMEL. There is thus a relationship between each organization and OMEL, both in the value perspective (e.g. exchanging electricity for money) and IS perspective (e.g. exchange of offers and clearances). In other words, both the electricity and information regarding the electricity are centralized at OMEL. However, organizations with a CHP could use an intermediate to trade their electricity at OMEL (this reduces overhead costs). In such a case, the intermediate "buys" the electricity produced by CHPs and sells it at OMEL. Thus now the electricity is centralized at the intermediate, which is seen in the value perspective. However for the intermediate to be able to do so the intermediate needs to know the offers from each organization, furthermore this actor needs to distribute the production schedules across the organizations participating. In other words, not only is the electricity now centralized at the intermediate, all information concerning the value transfers is centralized at the intermediate also. The IS structure thus take a similar structure as the value structure. Note that adjusting the IS structure to the value structure is a clear example of inter-organizational alignment between perspectives.

*b) Technologies:* Technologies used in the IS partially determine the actors and value transfers in the value web, since new technologies often result in new processes or new sources of information (which might be valuable).

For instance in the case at hand there is traditionally one meter per organization, which obviously only measures the amount of electricity consumed. However if an organization installs a CHP, then electricity is also produced (see annotation (e) in figure 3), which also has to be measured, thus a new metering system is needed. A new metering system is seen as a new technology and should be dealt with in the IS perspective. The new metering system generates new information (about the amount of electricity produced). Since now the actual amount of electricity produced is known, the electricity produced by a CHP can be sold, which leads to a new value transfer. A new value transfer means modifications to the value perspective. Thus a new technology in the IS perspective, leads to modifications in the value perspective.

In addition, traditionally a person had to physically check the amount of electricity produced. Yet nowadays more advanced metering systems exist, which communicate via the Internet to inform supplier about the electricity consumed/produced. Yet to realize such an advanced metering system, aid from an Internet Service Provider (ISP) is needed who facilitates the exchange of information. Obviously, the ISP needs to be paid for this service, indicating that a new actor is needed in the value model. To ensure that the value perspective and IS perspective are consistent, the new actors and interactions have to be included in both the value and IS perspective.

Note that both examples are concerned with inter-organizational alignment between perspectives.

## IV. $e^3$*alignment* : ALIGNMENT STEPS

### A. Exploration Phase

So far, we have presented a framework for multiple-perspective alignment of organizations participating in a value web. We now introduce how this framework can actually be used to address alignment issues.

Our interest in inter-organizational alignment in value webs concerns the *exploration* of *innovation* in these webs. For the case study, such an innovation is the DER/CHP device. In the exploration phase, solution directions have to be found about the integration and utilization such a CHP device in the value web, or in other words, the electricity network. Usually, these found 'solution directions' are at a fairly high abstraction level, which need to be more detailed after the exploration phase. The $e^3$*alignment* approach concentrates on the exploration phase only. Deciding about such solution directions in the early exploration phase brings the risk of being "locked in", meaning that your are stuck to a certain solution path, whilst superior paths may exist [18]. Such may happen often, since the exploration phase is characterized by an inherent fundamental uncertainty [18], limited time, and often little information is available also [4]. For instance, in the case at hand there is pressure from the government to implement CHPs and other DERs as soon as possible (i.e. limited time span). In addition, it is not possible to predict how many organizations will install DER, or what the exact amount of electricity produced by DERs will be (i.e. limited information).

Therefore, a *broad range* of options should be considered in the exploration phase, at a reasonable high abstraction level, to avoid getting "locked-in". With $e^3$*alignment* , this is precisely what we aim to reach.

### B. Engineering Cycle

To deal with the uncertainty and the variety of the alternative solution paths, a structured way is needed to *explore* alignment issues. The steps in $e^3$*alignment* are based on the more generic engineering cycle as explained by Wieringa et al. [19]. Three main steps are considered in $e^3$*alignment* : (1) Alignment Problem Investigation, in which the exact nature of the alignment problem is explored; (2) Alignment Solution Design, in which various alternative solutions for the alignment problem are considered and explored. To be able to consider the total set of solutions, it is important that there is "openness" to alternative paths (i.e. solutions) [18]; (3) Alignment Solution Validation, in which the impact of the solution is explored. The validation of a solution may lead to new or refined problems. Not only does thinking about the problem lead to better understanding of the problem (e.g. problem refinement), but also since one innovation often leads to other innovations, each with its own problems [18].

### C. Step 0: Motivation for Alignment

Before actually starting analyzing one of the four perspectives considered in $e^3$*alignment* , we need to determine which one to start with. For this reason, we need to understand the main driving force behind the alignment analysis process. In our case studies, we have found two dominant forces, namely (1) process innovation, and (2) product innovation.

*1) Process Innovation:* According to classic business-IT alignment frameworks, organizations should strive for alignment to improve their performance [1]. Such organizational improvement is often referred to as organizational "*process innovation*" [4], [20]. *Process innovation*, in the broadest sense, can be seen as innovation on the business side of the organization, ranging from process redesign to changing the entire business structure [4]. Would such be the motivation for alignment, then the first step would be to explore the process perspective to identify alignment issues within the process perspective.

*2) Product Innovation:* The second motivation for alignment is "*product innovation*", which starts with a technological invention. An invention is the first occurrence of an idea for a new product or service [18], which nowadays is often information technology driven. Commercialization of inventions results in "product innovation" [4]. To commercialize the invention, the invention must not only be technically realized (i.e. created), the commercialization of the product must be realistic (i.e. a proper business plan) [15]. However, in many cases it is unavoidably to cooperate with other organizations to commercialize an invention cf. [5]. For the case at hand, operating CHP devices requires cooperation of electricity suppliers, the market operator, etc. Therefore, the organization commercializing the invention needs to be aligned with the organizations on which it depends ([9], [8]. Would such be the motive for alignment, then the first step would be to explore how the new product creates value, since the product need to be commercialized (e.g. create value).

*Innovation and the case study.* In the Spanish electricity case study, the motivation to analyze alignment is primarily *product innovation*, since a new technology needs to be commercialized (i.e. profitably integrated into the current system). A DER/CHP device is an emerging technology, which needs to be commercialized. For a CHP, this means that the CHP needs not only to be technically integrated in electricity power system, but also needs to be financially (i.e profitable) sustainable. Therefore, the first step is to understand how the integration of a CHP leads to be value creation within the value perspective.

### *D. Step 1: Identify Alignment Problems*

Following the engineering cycle of Wieringa et al. [19], the first step is *problem identification*. For $e^3$*alignment* , this step is concerned with eliciting inter-organizational alignment problems, both *within* the perspectives and *between* the perspectives.

*1) Within a Perspective:* Since CHPs are a product innovation, we start with modeling the value perspective. In figure 3 the $e^3$*value* model for the Spanish Electricity System is presented. The figure shows the earlier discussed actors, such as OMEL, REE, producers, etc. In addition, there is a second group of consumers: "Consumers with CHP". This market segment does not only consume electricity, it also produces electricity, by operating a CHP device.

The $e^3$*value* model shows that consumers obtain electricity from suppliers in exchange for money (a). In addition, the model shows that suppliers acquire electricity from producers (e.g. bilateral contracts) and from the electricity market controlled by OMEL (b). Both producers and suppliers sell electricity to the market (c). Supplier can do so when they expect to have bought a surplus of electricity and therefore try to resell their overcapacity. The model finally shows that REE (TSO) collects money from producers and suppliers for causing imbalance (d). If we focus on the "Consumers with CHP" then the main difference with normal consumers is that these consumers also produce electricity (e). In the $e^3$*value* model this is represented by a value activity in which a CHP produces electricity.

*2) IS perspective:* Secondly, we describe the system from an IS perspective, the aim is here to illustrate the information which is exchanged between the various actors and what the sources of these information are (e.g. metering devices or databases). Including sources of information and technologies is however not obligatory, since the main focus is on interaction (i.e. information exchange). To represent the information exchanges we use (high level) IT architectures. The IS architecture for the case at hand was already discussed in section III-C, and constructed by the case study partners themselves; subsequently the IS architecture can be found in figure 2.

*Alignment Problem Identification.* There is an alignment issue between "Consumers with CHP" and "Supplier". Currently, "Consumers with CHP" can only consume the electricity itself. Although this saves the organization money, since less electricity needs to be obtained from the supplier, "Consumers with CHP" can not sell the electricity produced by a CHP. However, "Consumers with CHP" would like to have such an interaction (e.g. sell the electricity produced) with "Supplier", since then they can sell the electricity at a higher price. The fact that the "Consumer with CHP" cannot interact as it would like to, indicates that there is not correct alignment.

*3) Alignment between perspectives:* At first sight, we have not found any alignment issues between the value and IS perspective (which was already discussed in section III-C1). Therefore, and due to space limitations, we do not elaborate on this for now.

### *E. Step 2: Designing alignment solutions*

At this point an alignment problem has been identified (e.g. electricity produced by a CHP can not be sold). Following the engineering cycle of Wieringa et al. [19], the next step is to design solutions which solve the problems at hand. To solve the alignment issue identified within the value perspective in the previous section, two solutions are considered, according to the domain experts.

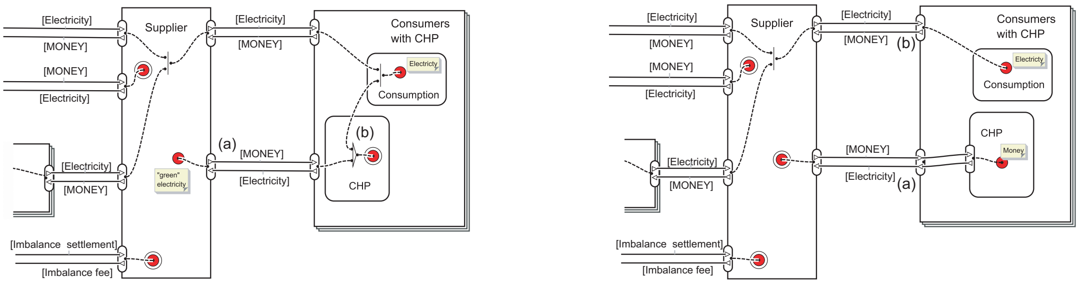
*1) Solution 1: Sell surplus:* The first solution is that the "Consumer with CHP" sells the *surplus* of electricity produced by the CHP (see figure 4(a)). In this case the "Consumer with CHP" only sells the electricity which it does not use itself (in case the CHP production is higher than the organization's consumption). In figure 4(a) this is represented by value transfer (a), in which electricity is sold to a Supplier, and the OR-port (b), which shows that the CHP either provides electricity to the organization itself or to the supplier (when there is a surplus). It is important to understand that the valuation of the electricity offered by the "Consumers with CHP" to the Supplier does no longer have to equal the price of electricity bought. This is because there is now an actual transfer of electricity, in return for money, between the Supplier and "Consumers with CHP", which was not found in figure 3.

*2) Solution 2: Sell All:* The second solution is to sell *all* electricity produced by the CHP to the Supplier. In this case the "Consumer with CHP" does not use the electricity produced by the CHP, it only sells it. This is modeled in figure 4(b), where there is no dependency between value transfers (a) and (b) anymore. The difference with figure 4(a) is that now value transfers (a) and (b) can occur simultaneously, while in figure 4(a) this cannot. Again, the valuation of the electricity provided by the "Consumers with CHP" to the Supplier does not have to equal the price of electricity bought.

### *F. Step 3: Analyzing impact*

The last step is to analyze the impact of the solutions designed. This analysis may lead to new alignment problems or refinement of existing alignment problems [19]. For the case at hand, the solutions suggest modifications to the value perspective. The question is whether there is now proper alignment within the value perspective *and* whether there is proper alignment between the value and IS perspective.

*1) Alignment within perspectives:* We concentrate now on the value perspective: The question is whether there is




(a) Only sell surplus of electricity

(b) Sell all electricity produced

Fig. 4. *$e^3$value* model: Designed solutions

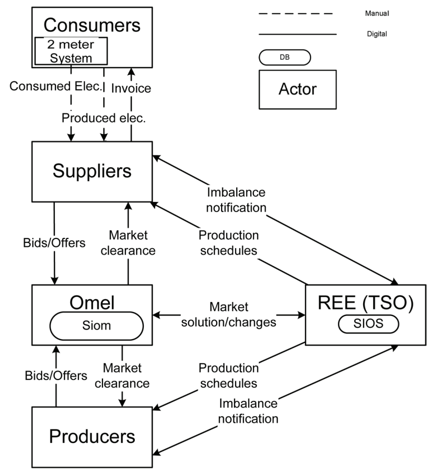



Fig. 5. IT Architecture: 2 meter system

alignment between the various actors within the value perspective. Although the “Consumers with CHP” can now sell the electricity to the “Supplier”, “Consumers with CHP” only receive what the “Supplier” is willing to pay. Obviously, the maximum the “Supplier” is willing to pay is the market price, since otherwise the Supplier would have acquired the electricity cheaper (e.g. at OMEL for the market price). So, there is an alignment issue between the “Consumers with CHP” and “Supplier”. The price offered by “Supplier” for the electricity produced by a CHP is insufficient for the “Consumers with CHP”, since at that price operating the CHP is not economically sustainable (in other words: the return on investment is too long). So there still remains an inter-organizational alignment issue within the value perspective; “Consumers with CHP” want a higher price for CHP produced electricity then “Supplier” is willing to pay.

*2) Alignment between perspectives:* We now consider whether the value perspective and IS perspectives are still aligned, now that the value perspective has been modified. While analyzing the models, it can be seen that for both options (“sell surplus” and “sell all”), there is an information source needed, which tells how much electricity is produced (either the total volume or just the surplus, depending on the chosen solution.). Currently there is no such source of information. Therefore it is not possible, with the current IS architecture, to execute value transfer (a) in both figure 4(a) and 4(b). In other words: there is incorrect alignment between the value perspective and IS perspective.

The stakeholders decided to choose the second solution, namely to sell *all* electricity produced, since this option leads to the highest revenues for “Consumers with CHP”. The revenues for the second solution are higher since with this solution *all* electricity produced by the CHP is sold at a higher price, instead of only the surplus. Therefore, we now focus on selling all produced CHP electricity only.

### *G. Next Iteration - Step 1: Identify Problems*

Now, the first alignment cycle is completed, but two new alignment problems have been identified: (1) There is no source of information for the amount of electricity produced by a CHP within the IS perspective; (2) The price received for the electricity produced by “Consumers with CHP” is insufficient. Therefore, we iterate over the alignment problem/solution/analysis cycle again.

### *H. Step 2: Design Solutions*

To find solutions for the identified alignment solutions, we have again consulted the stakeholders. After a session, they proposed the following alternative solutions:

*1) Solution: Install a two-meter system:* To align the IS perspective with the value perspective, the stakeholders propose to include a two-meter system in the IS architecture. The two-meter system measures both the total amount of electricity *consumed* by an organization, and total amount of electricity *produced* by the CHP of that same organization. Within the IS architecture this is a simple, but crucial, modification, as it requires substantial investments in a two-meter (smart) system for *all* “Consumers with CHP”. Since the old meter system is replaced by a two-meter system, an additional source of information is present (the second meter). Although the source is located within the “Consumers with CHP”, the information is transferred to the Supplier, so that the Supplier can determine the amount of money, which must be paid to the “Consumers with CHP”.

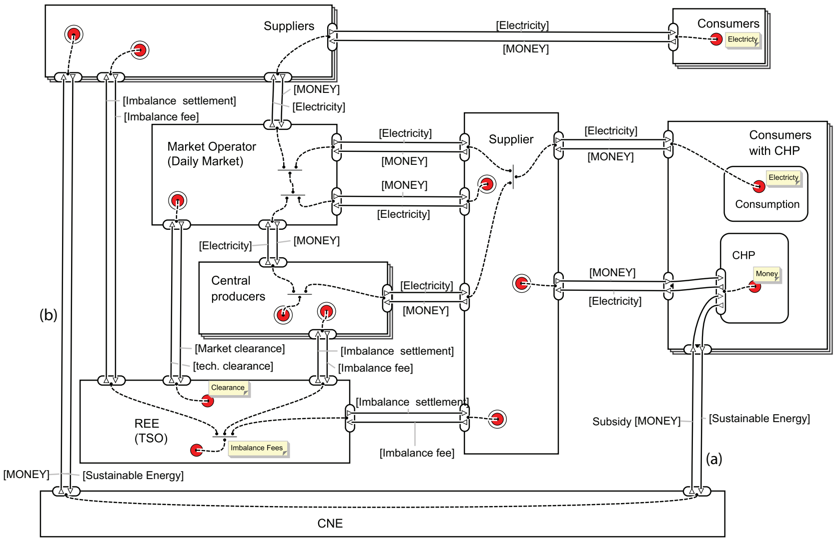



Fig. 6. $e^3$*value* model: CNE included

*2) Solution: Subsidy by a new Actor:* The second alignment problem identified was: The price offered by "Supplier" for the electricity produced by a CHP is insufficient for "Consumers with a CHP' 'to operate the CHP in an economically sustainable way. Again, we consulted the stakeholders, who come up with a solution.

The proposed solution is to subsidize generation of CHP-generated electricity. To that end, we introduce a new actor: CNE. This actor will provide subsidy for the CHP electricity produced and sold by "Consumers with CHP". CNE is a new actor in the Spanish electricity power system (see figure 6), since none of the current actors can provide the subsidy. CNE is concerned with *acquiring* funding for subsidies (value transfer (b)) and *paying* subsidies to "Consumers with CHP" (value transfer (a)).

Note that the addition of CNE spawns-off an additional inter-organizational alignment issue concerning the value perspective. Namely, CNE needs to get funding from someone, which is another alignment issues, since it requires additional interactions. To solve this issue, a new problem/solution/impact cycle is needed. However, we skip this cycle due to space limitations and directly show the solution (see figure 6 (b)).

### I. Step 3: Analyze impact

*1) Alignment within perspectives:* At this point we need to analyze if there is alignment within the value perspective and within IS perspective, since both perspectives have been modified. Due to space limitation we focus on the value perspective. As proposed, "Consumers with CHP" now get subsidy from CNE for electricity produced, which solves the alignment issue that "Consumers with CHP" do not receive enough money. However, the exact configuration of the subsidy is unclear (e.g. how is the subsidy calculated?). So the interaction between CNE and "Consumers with CHP" (figure 6 (a)) is still not properly aligned. This is a good example of an inter-organizational alignment problem isolated to one perspective.

*2) Alignment between perspectives:* The question is whether the value and IS perspective are still aligned now that the value perspective has been modified. Although the two-meter system in the IS perspective solves the original alignment problem (no information source for electricity produced), a new alignment issue emerges. In the value model a new actor is introduced, namely CNE. For CNE to perform its task (provide subsidy), CNE's information system needs to be connected to the other information systems in the electricity power system. Such a connection is needed to inform CNE about the amount of produced CHP-electricity, for which the subsidy is given. This means that CNE also needs to be included in the IS perspective, which is currently not the case. Therefore, there exists still an alignment issue between the value and the IS perspective.

### J. Next Iteration - Step 1: Identify Problems

Now the second alignment cycle is completed, but two new problems have been identified: (1) There is no valuation of the subsidy for electricity produced with CHPs within the value perspective; (2) CNE's information system is not connected to the information systems of the Spanish electricity power system, so data about the amount of CHP-generated electricity, needed to determine the subsidy, cannot be exchanged.

### K. Step 2: Design Solutions

After consulting the stakeholders about the previously mentioned alignment problems, the stakeholders came up with the following solutions:

*1) Valuation of subsidy:* The problem is here to decide about a subsidy scheme, which encourages parties to install CHP devices. Two solutions are considered for the valuation of subsidy; the subsidy itself is represented as the value transfer

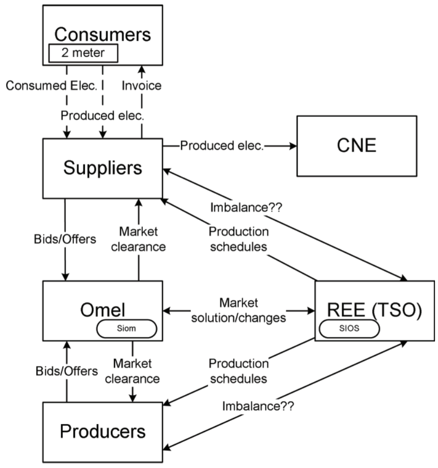



Fig. 7. IT Architecture: CNE included

between CNE and "Consumers with CHP": (1) The first option is to get a *fixed* price for "CHP-generated electricity". This price is calculated by summing the market price for "normal electricity", for that moment and the subsidy for renewable (CHP) electricity. The market price of electricity is however variable, since OMEL calculates the market price of electricity six times in a day. Therefore, in order to have a constant price for "CHP-electricity", the subsidy must also be variable. (2) The second option is to get a *fixed* subsidy option added to the *variable* market price for "normal electricity". In this case the total amount of money received for CHP-electricity is variable.

From an $e^3$*value* model perspective (see Fig. 6), such choices are reflected by changing the pricing formulas for the generated CHP electricity.

*2) Aligning the value and IS perspective:* Remember that in the previous step, a second alignment problem was identified: The actor CNE, present in the $e^3$*value* model is not yet present in the IS model, while interactions between the CNE's information system and other actors are necessary in order to provide subsidies. Therefore, the IS perspective has to be modified by including CNE's system and interactions with the other information systems (see figure 7). The CNE acquires information from the "Consumers with CHP" on how much electricity is produced from the two-meter system.

### L. Step 3: Analyze impact

At this point we should analyze the impact of the proposed changes on the alignment within the value and IS perspectives themselves, and between the value and IS perspective mutually. We actually performed six additional cycles of problem identification, solution design, and impact analysis. Due to lack of space, we can not discuss all these iterations in detail and instead present a few salient details. For instance, "Consumers with CHP" can sell their electricity directly at OMEL to get the market price for the electricity produced (sidestepping the supplier). A consequence would however be that "Consumers with CHP" have to pay imbalance fees as soon as the CHP causes imbalance, as normally such fees are covered by the supplier. To reduce the imbalance fees, a number of possibilities can be considered, such as "electricity power aggregators" and "virtual power plants", each with their own, and different, IS architecture.

## V. Lesson Learned

### A. Modeling Techniques

We started this paper with the claim is that we can explore alignment problems for cases of networked enterprise, find solutions, and understand the impact of these solutions, all with only limited information, by utilizing various modeling techniques. The case study as presented supports that claim. The various modeling techniques helped us in eliciting which actors were relevant and what type of interaction was relevant for that specific perspective. For instance, $e^3$*value* assisted in showing a clear view of value transfers within a value web. But more importantly, we only needed a few sessions with stakeholders to create a correct $e^3$*value* model. The $e^3$*value* model could hereafter be used to analyze alignment internally to the value perspective. Since in previous research we already analyzed the possible relationships between the modeling techniques (see e.g. [2], [14]), it was possible to trace changes over the model. One the claimed benefits of using modeling techniques (see [7]). Since such changes are traceable, it is relative easy to adjust a perspective to an other perspective (i.e. create inter-organizational alignment between perspectives). For instance, as we saw in the case, when the new actor CNE was included in the value perspective, CNE also needed to be included in the IS perspective.

### B. Four Perspectives on Interaction

The second claim is that we need to consider at least four types of interactions to properly consider a wide range of concerns relevant for creating alignment within a value web. As indicated one of the problems of an exploration phase is getting stuck to a single solution path, which might have large negative implications later. By considering four perspectives we cover the areas where alignment issues can occur. Although we presented only two perspectives for the case at hand (the value and IS perspectives), in reality, we had to develop the strategic and process perspectives also, and thus explore the full range of perspectives. For instance, we mentioned that a new actor (CNE) had to be introduced to distribute subsidies. The inter-organizational alignment issue here was to find a party who could *execute* these processes (e.g. could one of the existing actors perform the processes?). For this, the process perspective had to be analyzed. Due to space limitations this side step to the process perspective is not included. Second, by considering the four perspectives, we also found solutions which are viable over multiple perspectives. For instance, a solution should not only be viable in the value perspective, but that same solution must also be realized by the information systems, as shown by the IS perspective. For example, selling CHP produced electricity at OMEL (value perspective) is only realistic if the information systems can be adjusted to cope with trading at OMEL (IS perspective).

### C. Focus on Interaction

The last claim is that we need to focus on *interaction* between actors to create alignment, both within a perspective and between perspectives. Since we operate in the field of *inter*-organizational alignment, it is unavoidable to consider the interaction between actors. By focusing on interactions we implicitly also considered the *actors* interacting. Thus our claim is actually that we need to focus on actors - seen as black boxes - and their interaction. As was the situation in our case study. To integrate CHPs into the electricity power system, the interactions between actors had to be adjusted to create proper alignment and additional interactions (and actors) were identified. For example, subsidy needed to be transferred too organizations with a CHP by a new actor (CNE), such that installing the CHP became financially feasible. In addition, the valuation of this interaction (i.e. the exchange of subsidy for electricity) needed to be aligned, meaning that coherence, or agreement, had to be created between CNE and the organization with the CHP.

## VI. Related Work

A focus on inter-organizational alignment via multiple perspectives is also found in [21]. However, in comparison to $e^3$*alignment* , only the value ("management"), process ("administration") and IS ("IT") perspective are considered, strategic implications are not considered. Furthermore, a top-down approach, starting with the value perspective, is taken into account, while in $e^3$*alignment* each perspective can be the starting point for inter-organizational alignment.

Another related early phase requirements approach is TROPOS [22]. However, TROPOS focuses on software development and less on the business-IT alignment. Furthermore, TROPOS mainly takes "actor goals" into account and for instance does not consider value creation.

## VII. Conclusion

In this paper we have introduced the $e^3$*alignment* approach, which is concerned with creating alignment between organizations operating in a value web by (1) focusing on the *interaction* between these organizations, (2) considering interaction from *four* different perspectives, and (3) where for each perspective a conceptual *modeling techniques* is utilized. Since $e^3$*alignment* take multiple perspectives on interaction, $e^3$*alignment* creates alignment between organizations *within* a single perspective and alignment *between* perspectives. To actually create alignment, $e^3$*alignment* iteratively takes three specific steps: (1) identification of alignment issues, (2) solution design, and (3) impact analysis. The case study performed supports the claims made with $e^3$*alignment* . The case study showed that we need to focus on interaction between actors to create a sustainable value web. Furthermore by considering four perspectives we covered all areas where alignment issues might occur *and* where viable solutions could be found. Finally by using modeling techniques we were able to create alignment between the actors in the value web with limited information and in a short time span. However, more research on $e^3$*alignment* is needed. Not only should $e^3$*alignment* be tested in additional case studies to create more external validity, the relationships between the various perspectives are also area of future research.

## Acknowledgment

The authors would like to thank Labein (ES) and ECN (NL), and especially C. Madina and K. Kok, for introduction and access to the Spanish electricity system. This research is partly funded by the EU project FENIX.

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