Early Requirements Determination for Networked Value Constellations: A Business Ontology Approach

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Abstract

Many enterprises organize themselves as networked value constellations to jointly deliver products and services. Such constellations are facilitated by recent advances in IT, specifically various Internet and Web technologies. Before embarking upon information systems design and dealing with the technical issues, we argue that it is first important to understand the constellation with its business goals and activities as an artifact itself. This analysis forms a part of the early requirements determination phase that particularly seeks to clarify the business requirements underlying information systems support. To this end, we propose an ontology-based approach called e^3*value* to represent and evaluate business models for networked enterprises from a value-creation perspective. In addition, the e^3*value* approach contains a stepwise design process, a set of evaluation methods, and a software tool that supports the business requirements modeling, analysis, and determination process. The different elements of the proposed approach are discussed and exemplified by an extensive industrial case study related to the development of online distributed power balancing services in the electricity sector.

Keywords: Networked value constellations, Business model design and evaluation, Interorganizational information systems, Design science, Ontology

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Contents

1 Introduction

Many enterprises are forming *networked value constellations* to jointly deliver products and services to their customers. Well-known established examples include networked business models in the computer industry, e.g. Cisco Systems (Tapscott et al. 2000) and Dell (Magretta 1998), but also in other industries networked value constellations are becoming commonplace. Such constellations are enabled by the adoption of Internet and Web technologies, protocol standards such as SOAP and WSDL, industrial interoperability agreements such as ebXML, and off-the-shelf distributed software components.

To design information systems support, the common practice is to first carry out a requirements analysis (Loucopoulos & Karakostas 1995), consisting of eliciting, representing and evaluating the software technical requirements for the IT artifacts at hand. Often, requirements determination is very much technical in nature, and as a result underplays the importance of the business and organizational considerations involved in information systems design and support. These considerations and their complexity are even more prominent in networked enterprises and interorganizational information systems. We therefore argue that it is important as part of the phase of early requirements determination to develop a detailed understanding of the value constellation *itself*, its networked value creation goals and activities, and of the business requirements this puts on information systems support. However, methodology for business requirements is much less developed compared to that for technical requirements determination.

The recent e-business history (Shama 2001) has clearly shown that developing such an understanding of a value constellation is not a simple task, witness the number of failed e-business initiatives. In addition to an assessment of the financial sustainability of a value constellation, a sound understanding is also important for designing interorganizational business processes that put the constellation into operation, as well as for developing supporting IT for such coordination processes. This early requirements determination focusing on business considerations frames and scopes the subsequent business process and information systems development activities.

This paper proposes a design theory for networked value constellations, consisting of various artifacts. First, we elaborate the elements that make up a networked value constellation, and conceptualize the notion of *economic value* creation and consumption in a *network* of enterprises. The resulting e^3*value* ontology provides a set of formal concepts, relationships and business rules, used to express business models for networked value constellations. The ontology is accompanied by a visual graphical representation for networked business models that facilitates shared understanding and communication with executive decision makers. In addition, the e^3*value* approach contains a stepwise design process, a set of evaluation methods, and a software tool that supports the business requirements modeling, analysis, and determination process. It includes a graphical editor, a model checker, and a software component capable of generating net value flow spreadsheets to assess economic sustainability on a per enterprise basis, and has for example been used for the industrial case studies reported in this paper.

This paper is structured as follows. In Section 2 we consider the theoretical background concerning business models for networked value constellations, early requirements determination, and ontologies. Next, we discuss in Section 3 the e^3*value* business ontology, illustrate it with a small example, and explain in general how business models can be designed and evaluated with it. The constructive use of the approach in practice is the subject of Section 4. We have developed, applied, and tested the approach in a series of real-life cases in the fields of telecommunication, IT, entertainment, healthcare, news provisioning, and banking. In this paper we exemplify our approach by an extensive industrial case study related to the development of online power balancing services in the electricity sector, based on decentralized and networked sustainable energy resources. Finally, in Section 5 we summarize a set of general theoretical principles involved in the design of business models for networked value constellations as they have emerged from our studies.

2 Theoretical background

The *e^3value* ontology-based approach for designing networked value constellations has its theoretical roots in three different areas. From a content point of view, our approach is based on research on business models for networked value constellations. From a design process point of view, *e^3value* employs techniques and ideas from requirements engineering, the discipline focusing on eliciting, representing and analyzing information system requirements. Finally, from the formal point of view, our theoretical framework is formulated as a formal ontology, which provides a rigorous method to express concepts, their properties, relationships and rules.

2.1 Business models for networked value constellations

2.1.1 Networked value constellations

Enterprises increasingly form networked value constellations, enabled by the diffusion of the Internet and other IT facilities to support cross-organizational coordination processes. A value constellation is defined as a set of actors (providers and customers) that *co-produce* value (Normann & Ramírez 1994). The associated products or offerings are understood as anything of value for a customer, created by a collection of activities which are possibly carried out by different actors, including customers themselves. In many cases these offerings have a bundled character, especially in service industries.

Whereas Normann & Ramírez (1994) see a constellation as a *web* of enterprises that co-produce value, Porter (1985) takes a *chain* perspective, also in the case of Internet business (Porter 2001). A value chain is pictured as a sequential lineair chain of suppliers with customers at the end. Each firm in the chain adds value to a product, until it reaches the customer. Although the value chain theory can be used to explain how value of a product increases along the chain, it does not clearly show who is involved in direct business interactions with whom. However, we consider this to be an important design question when developing business models for networked value constellations.

2.1.2 Business models

A significant amount of recent research has investigated the notion of (e-)business model for networked value constellations, although with quite different foci. General surveys are provided by Pateli & Giaglis (2004) and Osterwalder et al. (2005). Seddon et al. (2004) undertake to clarify the meaning of the term business model, especially in relation to Porter's conceptualizations of strategy. They see the business model concept as an abstraction of strategy, but argue that strategy typically focuses more on (external) competitive positioning, whereas business models focus more inward on firm activity systems, that is, on the mechanisms firms use to create value for their customers. They furthermore position the work of several researchers on business models within a space containing six different themes or dimensions characterizing recent business model research: definition, taxonomy, decomposition into components, availabity of methods for designing business models, for evaluation of business models, and guidelines for their change.

Several research efforts provide definitions of the notion of business model and its constitutive elements. Some research stresses the practical narrative aspects of the business model concept by very broadly defining it as "a story that explains how an enterprise works" (Magretta 2002). Weill & Vitale (2001) define the business model construct as: a description of the roles and relationships among a firm's consumers, customers, allies, and suppliers that identifies the major flows of products, information, and money, and the major benefits. Important aspects of a business model are the *valuable* flows and benefits for an enterprise. Similarly, Timmers (1999) defines a business model as: an architecture for the product, service and information flows, including a description of the various business actors and their roles, a description of the potential benefits for the various business actors, and the descriptions of sources of revenues.

Timmers (1999) also takes the flow of valuables as a starting point, but adds to that the notion of *multiple* business actors, effectively referring to a constellation that has to deliver a product or service, rather than taking a perspective of a *single* firm as Weill & Vitale (2001) do. A network perspective is also taken by Tapscott et al. (2000), by considering a business model as a business *web*, defined as: a set of contributors coming together to create value for customers and wealth for stakeholders in which each participant focuses on a limited set of core compentencies. Such an interpretation stresses that contributors (enterprises and final customers) are co-producing something of economic value, in line with Normann & Ramírez (1994).

Both the single actor and the multiple actor interpretations may be applicable in considering value constellations. A single actor perspective is useful for understanding the role and positioning of a specific actor *within* a constellation, whereas a multiple actor perspective is important to analyze whether the constellation *as a whole* creates value, and whether *all* enterprises that make up the constellation do so as well.

Another aspect that has been researched includes taxonomies categorizing various types of business models. Different classification criteria are proposed in the literature. Timmers (1999) classifies business models using functional integration and degree of innovation, Tapscott et al. (2000) employ economic control and value integration, whereas Kaplan & Sawhney (2000) use sourcing parameters.

Definitions and taxonomies of business models are useful to map out and globally organize the large space of possibilities. However, from a design science perspective, definitions and taxonomies are less useful. They do not provide sufficiently specific handles to actually represent and design a business model for a case at hand, nor do they tell how to make the next move in a large design space of possibilities (Simon 1996). Informal approaches proposing design representations of business models are proposed by Tapscott et al. (2000) and Weill & Vitale (2001). Some more rigorous proposals are based on ontologies and attempt to support (partly automated) reasoning about business models (Osterwalder & Pigneur 2004, Gordijn & Akkermans 2003). In view of the design complexity of business models for networked value constellations, design science support for reasoning — especially for the purpose of evaluation of proposed designs — is both a theoretical and practical need.

2.2 Early requirements determination

2.2.1 Designing artifacts

Design is both a process (set of activities) and a product (artifact) (Hevner et al. 2004). The design process consists of two parts: *build* and *evaluate*, and four different types of artifacts may be distinguished: *constructs* (providing a language for stating problems and solutions), *models* (to represent a real world situation using the constructs), *methods* (processes that provide guidance how to solve problems by searching the solution space, cf. (Simon 1996)), and *instantiations* (e.g., a working information system) (March & Smith 1995).

To arrive at an artifact, it is first of all necessary to develop a proper understanding of the problem space (Simon 1996) or the problem domain (Jackson 2001) and its context, before an information system can be successfully developed by an iterative design process of building and evaluating the artifact.

We note that the notion of design process can be recursively applied here; the organizational context of an information system can *itself* be seen as a designed artifact, the design of which is based on the strategic positioning of the firm and on the resources and competencies that it has. In this paper we will consider networked value constellations themselves as an artifact that is to be designed.

2.2.2 Early requirements

Eliciting, representing, and analyzing an IT problem domain has been extensively studied by the Requirements Engineering (RE) discipline. RE is seen as a form of iterative design, in which a cyclic process is distinguished of problem investigation, solution design, solution implementation, solution validation, implementation use, and implementation evaluation (Wieringa et al. 2006). Wieringa (2005) points to two different interpretations of requirements: requirements as *solution specifications* (cf. the IEEE-830 standard for solution specifications to be implemented as software components), and requirements as *problem descriptions* (e.g, using problem framing methods as proposed in (Jackson 2001)).

The latter interpretation (that we also employ in the present paper) has a strong focus on the context aspects of IT artifacts. They are investigated in the phase of early requirements determination that aims at developing a conceptual understanding of the *why* questions surrounding information systems (Mylopoulos 1992), as opposed to the later requirements phase that contributes to constructing information system solution specifications and concentrates on the technical *how-to* issues.

Early requirements determination has been extensively researched in the *i** approach (Yu 1997, Gordijn et al. 2006), which models the intentions of organizations in the form of goals, as well as the interorganizational dependencies that exist between these goals. This approach also aims to find design alternatives, by considering the hierarchy of all sub-goals that may help satisfy the original goal. Other goal modeling approaches are TROPOS (Giorgini et al. 2004) and KAOS (Van Lamsweerde et al. 1998); these have a more technical and less organizational flavor than the *i** approach. An approach closely related to considering multi-enterprise goals is the work of Tillquist et al. (2002), who propose Dependency Network Diagrams (DNDs) rooted in resource dependency theory. A DND models that in order to achieve a goal, a role (taken on by an individual or organization) is dependent on the achievement of other goals by other roles.

Only a few design-oriented research studies on early requirements determination in the context of business models for networked value constellations have been carried out. As described earlier, analysis of business model research considers a framework of six dimensions of investigation: definition, taxonomies, components, design, evaluation, and change of business models (Seddon et al. 2004). The dimensions of 'design' and 'evaluation' are the closest and most important ones with respect to the design science notions of iterative build and evaluate processes (Hevner et al. 2004). Seddon et al. (2004) refer to three widely-cited approaches that score high on the dimensions of design and evaluation: Linder & Cantrell (2000), Weill & Vitale (2001), and Gordijn & Akkermans (2003).

Linder & Cantrell (2000) introduce 'operating business models' that intend to show the core logic of creating value by graphically representing revenue sources and value propositions in an informal way. The 'business schematics' approach of Weill & Vitale (2001) is an informal graphical technique to represent business models, from a single-actor perspective. A firm of interest is chosen, and for this firm, suppliers and customers are shown; money, product, and information flows are all represented within a single business model diagram. These authors also identify 'atomic' business models, which can be viewed as a kind of design patterns for business models, quite analogous to the software design patterns of Gamma et al. (1995). A rigorous ontology-based design approach for IT-enabled networked business models is proposed by Gordijn & Akkermans (2003). The latter approach is further developed in the present paper.

2.3 Ontologies

Ontologies have gradually emerged as a foundation for advanced information systems since circa 1990. Initially, they were first of all investigated to supply more rigorous principles and methods for the conceptual modeling of various kinds of information systems (Gruber 1993, Wand & Weber 1990). In recent years, they have in addition become prominent as a technology that assists in making knowledge explicit and sharable over the World Wide Web, has been incorporated into corresponding W3C recommended standards, and popularized by W3C chair Tim Berners-Lee and others (Berners-Lee et al. 2001). Ontology-based modeling also underlies the research discussed in the present paper.

2.3.1 Ontology and philosophy: on what there is

The notion of ontology has a very long history. Ontology is an active branch of philosophy, where it stands for the general theory 'on what there is' (the title of a famous essay on ontology by the 20th century philosopher Quine (Quine 1961)). It dates back to Aristotle (especially his Metaphysics) and medieval Scholastic philosophy; the term ontology itself, as denoting general metaphysics or the study of being 'as such', was introduced in the early 17th century by the German Scholastic philosopher Glocenius (Burkhardt & Smith 1991).

Present-day formal ontology has undergone a strong influence of two related but distinct strands of thought that became prominent in the early 20th century: (i) the methodological extension of ontology as a result of the modern development of formal logic and mathematics; (ii) an extension of the subject matter of ontology to very abstract notions such as object (or thing), property, state of affairs, relation, part and whole, connectedness, et cetera. Both these elements have also impacted ontology as it exists in Information Systems research.

In this connection, it is further relevant to mention the position of the philosopher Quine who sees ontological questions as being on a par with questions of natural science (Quine 1961). His ‘naturalized epistemology’ is summarized in the slogans “what exists is what can be quantified over” and “to be is to be the value of a variable”. What exists is what is presupposed in our scientific theories about the world; and an ontological commitment then is the collection of things that must be assumed to exist in order for our theories to be true.

2.3.2 Ontology and Information Systems: systematic conceptualization

Ontology has gradually established itself as a foundational approach to Information Systems over the past two decades. In the IS context, the notion of ontology has a somewhat different meaning than in philosophy and it goes with a different scientific practice, with elements of both continuity and change.

The informal intuition behind employing ontologies in IS is the design objective to come to information systems that act as being closer to the real world of their stakeholders (Wand & Weber 1990), and that correspondingly display more intelligent behavior in their interaction with users. An information system should ideally have some kind of ‘understanding’ of how humans look at the world we live and act in. To this end, the IS should have some grasp of the concepts we employ in order to perform useful tasks in a domain, of the properties these concepts have, and how they relate to one another.

The formal specifications of those real world-related concepts, properties, relationships, facts and rules, in other words, of ‘the things that exist’ in a domain (hence the name) are called ontologies. The specifications that together make up an ontology constitute a formal model of how stakeholders conceptualize a part of the real world or domain they are interested and acting in. This character of formal and systematic conceptualization gives ontologies their relevance as a foundational principle underlying information systems (Guarino (1998), esp. pp. 3-15).

In an IS context, ontologies are thus generally defined as explicit and formal specifications of a shared conceptualization for some domain of interest (Gruber 1993). The term *shared* refers to an agreement within a community of interest or practice over the description (i.e., conceptualization) of the domain, while *formal* indicates that the representation of this agreement is in some sort of computer-processable format. Note the rather open notion of a domain conceptualization in the definition: ontology research makes no claim about the nature of the knowledge to be modelled (Mika & Akkermans 2004).

Accordingly, there are various kinds of IS ontologies that can be categorized in terms of different levels of generality. At the highest level of generality, we have top-level or upper ontologies (Sowa 1995). They attempt to formalize highly generic notions such as object, property, taxonomy (Welty & Guarino 2001), relationship (Wand et al. 1999), as they occur in information systems. This research shows a strong continuity with the formal ontology tradion in philosophy mentioned above. Some practical examples of recent IS formal ontology research are online available as results of collaborative standardization efforts, see e.g. IEEE Upper Ontology work at `http://suo.ieee.org/SUO/SUMO/`, and some ontology engineering patterns of the W3C Semantic Web Best Practices & Deployment Working Group, `http://www.w3.org/2001/sw/BestPractices/Overview.html`.

At the lowest level of generality, there are the application ontologies. They are best characterized as conceptual models underlying specific application systems. In many instances, they are relatively simple, sometimes ad-hoc, metadata annotations and taxonomies that focus on optimizing the practical usability of systems, often at the cost of their generality. Recent research in IS ontology has focused here on providing methods to validate and improve such conceptual models of applications (Guarino & Welty 2002, Shanks et al. 2003).

In-between, at an intermediate level of generality, we have ontologies representing, with a term borrowed from sociology (Becker 1998), *middle-range theories*. This kind of ontologies may be viewed as close in spirit to Quine's naturalized epistemology and definition of ontological commitment refered to above. Middle-range ontologies are concerned with precise definitions of concepts within a domain, discipline or similar broad subject area. They are less universal than the top-level ontologies, but as domain theories they have a much wider applicability than the situations, contexts, systems or cases from which they actually originate.

Recent examples in business research are found in Currie (2004), who presents several studies of researchers investigating e-business model ontologies and taxonomies, and in Osterwalder et al. (2005) who present an ontologically informed discussion of what the precise meaning is of the business model concept. The e^3*value* ontology discussed in this paper is also an example of ontology as middle-range theory.

2.3.3 Ontologies as elements of design science

In contrast to the tradition in philosophy, in information systems the focus of ontologies is not on theoretical claims about what generally exists in the world, but on how the world is being conceptualized by various agents. If these conceptualizations are, empirically or practically, found to be common across many agents, they can be formally specified as ontologies that thus express a shared basis for communication and understanding. In addition these ontologies can, if represented in a computer-processable format, be implemented as intelligent IS system components.

Accordingly, ontologies are IT artifacts in the design science sense (Hevner et al. 2004) in two distinct ways: (i) as conceptualizations of how stakeholders model their world (the human and social aspect); (ii) as IS instantiations intended for computer-based reasoning (the machine aspect). As depicted in Figure 1, ontologies have a *dual* reference. It is important not to conflate the two, even though in Computer Science much of the research attention regarding ontologies has been paid to the language and computer representations in which ontologies

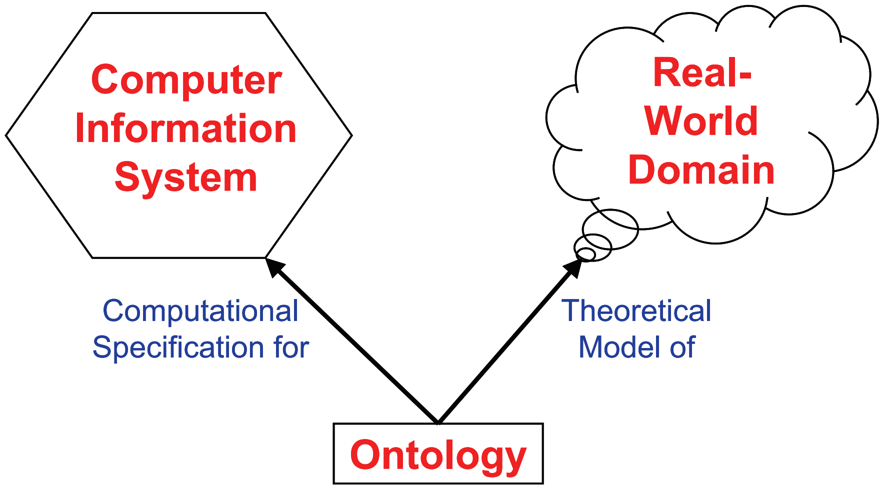

Figure 1: The conceptualization triangle and the dual reference of ontologies.

are cast. However, ontologies are not simply technical specs referencing a computational implementation (like conventional IS or database schemas), but they have an explicit real-world *content or substantive reference* as well (Akkermans et al. 2004, Evermann & Wand 2005, Guarino & Musen 2005). From the IS perspective, we argue that this substantive character of ontologies is the aspect that is leading.

Within the paradigm of design as search (Simon 1996), the role of ontologies has been extensively investigated. Particularly Motta & Zdrahal (1998) describe in detail how ontologies are able to methodically exploit the knowledge about a domain, so as to structure and reduce the search space, thus leading to more effective problem solving. Other sophisticated examples of this approach, combining and integrating the use of top-level and middle-range ontologies, are found in physical systems engineering (Borst et al. 1997). An example of the same approach in business-related systems is discussed in Akkermans et al. (2004) who show how ontologies provide a rigorous foundation for constructing service bundles that satisfy stated customer needs and business constraints and requirements.

2.3.4 Business ontologies

Ontologies have been developed for an extremely wide range of domains. Also in the business domain several ontologies have been developed. Probably the oldest ontology for business purposes is REA (Resource-Event-Agent) (McCarthy 1982, Geerts & McCarthy 2002) which formalizes accounting systems and theories.

Other ontologies focus on the generic description of enterprise structures with an emphasis on business processes and their integration. Examples are the MIT Process Handbook of Malone et al. (1999), the Edinburgh Enterprise Ontology (Uschold et al. 1998), and the Toronto Virtual Enterprise (TOVE) ontologies (Gruninger et al. 2000). Contentwise, these ontologies cover similar ground, but they display (intentional) differences in their degree of formalization and so put different weights on the human vs. computer roles in ontology use. The MIT process handbook contains specialization hierarchies (i.e. taxonomies) of business processes that first of all are intended for human selection and use, while the TOVE ontologies aim for the highest possible degree of automation.

In the central topic area of the present paper, business models (as contrasted with business processes), Osterwalder & Pigneur (2004) outline a general ontological characterization of the business model concept. It has four main components — infrastructure management, product innovation, customer relationship, financial aspects — to represent the what, who, how, and how much aspects of a firm.

In the present work, we also focus on the concept of business models, but aiming at and emphasizing two specific scientific contributions: (1) a rigorous approach to the *design and evaluation* of business models (as also noted by Seddon et al. (2004)), and (2) doing so not from a single-enterprise view (as in the research cited above), but inherently from the perspective of *business networks* as the carrier of IT-enabled value propositions.

3 e^3*value* : A formal ontology for designing and evaluating networked value constellations

3.1 Ontology design choices

The aim of the e^3*value* ontology is threefold. First, it provides support for the conceptualization and design of business models for networked value constellations such that each participant in the constellation has a shared understanding of it. This is not easy to achieve, because typically a wide range of stakeholders are involved, and these stakeholders come from different enterprises, with different backgrounds, and employing different terminologies (Gordijn & Akkermans 2003). In other words, the aim of the e^3*value* approach is that participants in a value web tell the same story (Magretta 2002).

Second, the aim is to be able to evaluate a business model for its financial sustainability. Apart from story telling, understanding expected profit and loss numbers is an important purpose of the explication of business models (Magretta 2002).

Third, the purpose of business modeling is the *scoping* for the subsequent design of business processes and supporting information systems for the value constellation. The e^3*value* representation of a business model serves as a statement of the IS context requirements that are to be supported by the system.

To this end, a number of design choices have been made in developing the ontology:

- It is a lightweight ontology, meaning that the ontology contains only a limited number of concepts and relationships. As a result, the ontology can be easily understood and explained. Also, creating a business model using the ontology can be done within a reasonably short timeframe, which is a requirement given time-to-market considerations.
- To represent instantiations of the ontology (i.e., particular business models), a graphical syntax has been developed (Gordijn & Akkermans

2001*a*), with software tool support (that is freely available from http://www.e3value.com). For business modelling, a graphical representation is considered to be an important feature so as to enhance communication with business stakeholders (Osterwalder et al. 2005).

- From a content point of view, the ontology sole focus is on the creation, distribution, and consumption of economic value in a network of enterprises and consumers. We do so to separate concerns: our experience is that designing a networked value constellation in terms of value transfers between the parties is a significant and complex task in its own right. Taking on other perspectives and tasks at the same time (such as business process inputs/outputs or information/data flows, as some previously discussed informal business modelling approaches do) unnecessarily complicates the issues at hand, and hinders executive desicion making. Such a design strategy is known as 'separation of concerns' (Nuseibeh et al. 1994).

- The e^3*value* ontology should be sufficiently formal from the computational point of view to support automated analysis and evaluation of proposed business model designs. As demonstrated later on, the e^3*value* model allows for computer-supported reasoning about the financial sustainability by generating the net value flows for each participant involved in the form of a spreadsheet analysis. The e^3*value* ontology is available as a UML class diagram, RDF/Schema implementation, Prolog rule base, and Java-programmed design workbench (see http://www.e3value.com/).

3.2 Key concepts of the ontology

Figure 2 presents the key concepts of the e^3*value* ontology to represent business actors that create and transfer economic value to and from each other, in the form of a UML class diagram. Below, these concepts are explained, and adstructed with a small illustrative example, see Figure 3.

Actor: An actor is perceived by its environment as an economically independent

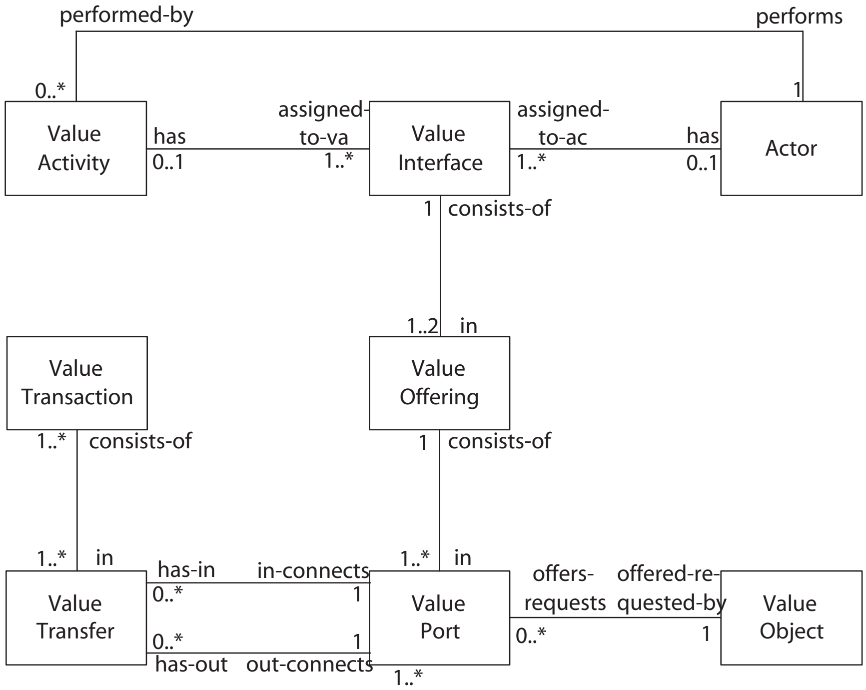

Figure 2: UML diagram showing the key concepts of the *e*^{3}*value* ontology and their relationships.

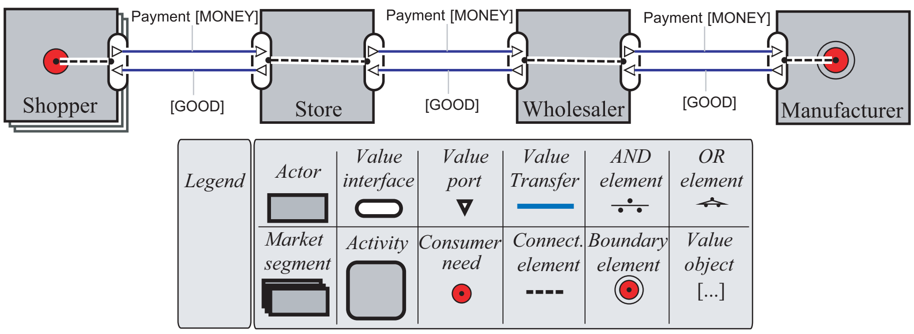

Figure 3: *e*^{3}*value* business model illustration: a shopper buying goods from a shop.

(and often also legal) entity. Enterprises and end-consumers are examples of actors. A profit and loss responsible business unit, which can be seen as economically independent is an actor, although such a unit does not need to be a legal entity. Economic independence refers to the ability of an actor to be profitable over time (in the case of an enterprise), or to increase value for themselves (in the case of end-consumers). For a sound and viable value constellation, we require that each actor can be profitable or can increase value. A 'Store', 'Wholesaler' and 'Manufacturer' are all examples of actors.

Value Object: Actors exchange value objects. A value object is a service, a good, money, or even an experience, which is of economic value for at least one of the actors. Its purpose is to satisfy a particular need, or to be used to produce other value objects. In the example, we distinguish two value objects: 'Money' and 'Good'.

Value Port: A value port is the outlet an actor uses to provide or request value objects to or from its environment which consists of other actors. It interconnects actors so that they are able to transfer value objects. A value object flowing into or out of an actor port denotes a change of ownership of a physical object, the experiencing of a service outcome (in-flowing), or the provisioning of a service outcome (out-flowing). A port abstracts away from how objects are produced or consumed by business processes: the focus is just on the fact that an actor provides or requests things of economic value. The port concept as an abstraction to reduce complexity stems from technical systems theory, cf. (Borst et al. 1997).

Value Offering: A value offering models what an actor offers to (an out-going offering) or requests from (an in-going offering) its environment. A value offering consists of equally directed ports of the same actor, and implies that either all ports in that offering transfer value objects, or none at all. It is used to model various kinds of *bundling* (Stremersch & Tellis 2002, Choi et al. 1997): the notion that some value objects are only offered or requested in combination.

Value Interface: Actors may have one or more value interfaces. A value interface groups precisely one in-going and one out-going value offering, thereby expressing the mechanism of economic reciprocity. Economic reciprocity as a principle refers to rationally acting actors: 'one good turn deserves another'. We assume that actors are only willing to offer objects to someone else, if they receive adequate compensation (i.e. other value objects) in return. So, with the value interface, we can model that an actor is willing to offer something of value to its environment but requests something in return, whereas a value offering models that objects can only be requested or delivered in combination.

The transfer of value objects is atomic at the level of the value interface. Either all ports in a value interface (via value offerings) each precisely transfer one value object instance, or none at all. This ensures that if actors offer something of value to other actors, they get something in return they want. How this is ensured is a matter of a robust business process design, of trust and associated control mechanisms (see e.g. Gordijn & Tan (2005)), legal agreements, or sometimes use of technology, but this is abstracted away from by the e^3*value* ontology. Also, we note that a value interface and value offering do not model in which (time) order value object are transfered; it is only modeled *that* they are transfered. As seen in the model example of Figure 3, each value interface consists of precisely one in-going and one out-going offering, while each offering consists of precisely one (by definition equally directed) value port. These are all important generic principles and business rules inherent in the ontology that formally constrain and support the modeling and design of value networks.

Value Transfer: A value transfer is used to connect two value ports with each other. It shows which actors are willing to transfer value objects with each other. Value transfers can be labeled with a name, such as 'payment' and the value object transfered (e.g. 'Money').

Market Segment: A market segment is defined as a concept that breaks a market (consisting of actors) into parts that share common properties (Kotler 2006). We employ the notion of market segment to show that a number of actors assign economic value to objects in the same way, and thus from a modeling perspective can be dealt with as a whole. In the example, 'Shopper' is an example of a market segment.

Value Activity: A value activity is a task performed by an actor (or market segment) that potentially results in a positive net cash flow (if the actor is an enterprise), or that potentially contributes to an increase of utility. An important issue in value constellation design is the assignment of value activities to actors. This assignment is an important design decision in modeling value constellations. So, one of the employed modeling principles in the ontology is the *separation* of *activities* from performing *actors*. Therefore, we are interested in the collection of operational and potentially profitable activities which can be assigned as a whole to actors; such a collection is termed a value activity. Value activities can be decomposed into smaller activities, but a general rule is that a value activity is potentially profitable. Thus, not all business processes (e.g. overhead activities) are value activities, and so business modeling is not the same as business process modeling. This also gives a decomposition stop rule in modeling constellations from a value-creation perspective.

Partnership: In value constellations, it is quite common that enterprises decide to form partnerships (Davidow & Malone 1992, Tapscott et al. 2000). From an ontological perspective, a partnership groups already existing value interfaces of actors or market segments, stating that these actors offer/request value objects of these interfaces jointly as if these interfaces were just one interface. To represent this grouping, a partnership has its own value interface(s) to its environment.

With this ontology, we are able to represent actors in a value constellation, as well as what they transfer of value with each other.

3.3 Construction of scenarios to support evaluation

Actors are related to each other by stating the appropriate value transfers between ports in value interfaces, which in turn belong to a specific actor. However, value interfaces of the same actor should also be related, if we want to be able to reason about a net value flow for all actors in the constellation. This is enabled by the construction of operational scenarios.

To this end, we introduce dependency and connection elements that relate intra-actor value interfaces. Together they form dependency paths, which enable to state operational scenarios that explain that transfers via one interface depend on transfers via another interface of the same actor. These operational scenarios provide a formal handle for (partly automated) reasoning on the basis of the ontology, in particular about the net value flows within a constellation. But these operational scenarios are also an important channel for managerial communication, since they appear to be a very useful mechanism for story telling (Carroll & Rosson 1992, Magretta 2002).

The scenario constructs are the following, and are visualized in Figure 3.

Consumer need: A consumer need is a state of felt deprivation of some basic satisfaction (Kotler 2006). Actors or market segments may have needs. In the example of Figure 3, the Shopper has a need for a particular good.

Connection element: Connection elements relate dependency elements, being consumer needs, boundary elements, AND/OR elements (see below), or value interfaces. To satisfy a consumer need, an actor needs to obtain one or more value objects via one of its value interfaces. For instance, the shopper obtains a good via its value interface. Alternatively, actors may obtain value object in order to offer value objects to someone else. In the example, the Store must obtain a good from the Wholesaler in order to be able to provide a good to the Shopper.

Boundary element: An important modeling decision is in fact when to stop modeling. In value constellations, such a decision boils down to stating when not to include value transfers anymore. This design decision is modeled by boundary elements. In the example, it is stated that we do not consider anymore which value transfers the Manufacturer has to do in order to produce goods.

AND/OR element: A consumer need, value interface, and boundary element can be directly related by a connection element, but in practice more complicated structures occur (as also shown in the industrial case study later on, see section 4). By using AND/OR elements it is possible to state that, given a consumer need, an actor can choose from different value interfaces (and thus different value objects) to satisfy a need. This provides a mechanism to express forking scenario paths.

Using these scenario constructs, it is possible to represent the dependency paths between various kinds of actors in their value transfers to ultimately satisfy consumer needs. The resulting e^3*value* model has however no notion of time-ordering as in process modelling techniques, such as UML activity diagrams or Petri nets: scenario dependency paths may constrain but do not themselves express any temporal ordering of value transfers. This is an explicit design decision we have taken with respect to the ontology in order to reduce modeling complexity.

3.4 Design process steps and guidelines

In designing an e^3*value* model, it is assumed that an initial business idea is present. This idea can be elicited by having brainstorm workshops, reasoning about strategic positioning (Porter 2001), or by other approaches. Experience with a range of application studies shows that design of a IT-enabled networked business model is usefully done according to a set of typical subsequent phases.

3.4.1 Eliciting and representing a baseline business model

Operational scenario identification. Business model construction starts with the identification of operational scenarios. Initially, these are described by short sentences, denoting the product, service, or experience desired by a customer. It is our experience that it is hard to find these scenarios and to articulate them well in a first step. Consequently, designing a business model is an iterative process: a few cycles are usually needed for stakeholders to define scenarios accurately.

In practice we have experienced that many stakeholders tend to describe an idea by outlining the business processes supporting a business idea. This may tend to shift the focus away from the value creation aspects and so introduces the risk that promising value propositions are overlooked. Consequently we emphasize the business *value* aspect rather than the business *process* aspect.

Actor identification. Next, a list of actors is created, initially based on the actors initiating the idea, and the (end)-consumers they have in mind. After a number of cycles, it may appear that some actors have been removed or added to this list, caused by a better understanding of the needed kind of actors for the idea at hand. Actors are labeled by their company name (named actors), or by the role they play (non-named actors, such as in the case of end-consumers).

Additionally, we distinguish *environmental* actors. These are actors needed to let a business model work, but they do not belong to the core actors that are of interest to model and evaluate the financial sustainability. Environmental actors thus occur in a value constellation for the sake of model completeness.

Value object identification. The criterion used for distinguishing value objects is that a value object must be of economic value for at least one actor. Furthermore, such an actor must be willing to transfer the object in return for another object (Ramsay 2005). Thus, a value object does not need to be of value for both actors transfering the object. This is motivated by the observation that valuation of objects depends largely on an individual actor (Holbrook 1999), and consequently not both actors have to assign economic value to an object.

We use three guidelines to find value objects: (1) analysis of the business idea and of the scenarios, (2) application of the principle of economic reciprocity, and (3) consideration of causally related value objects. First, the business idea and scenarios provide triggers for the identification of value objects. If at least one value object is found, stakeholders can be asked for reciprocal value objects. It is our experience that for nearly each found value object at least one reciprocal value object can be elicited. We also search for causally related value objects. To be able to offer a value object to its environment, it is likely that an actor must obtain other objects in a causal chain (for example, in a trading chain objects that are sold must also be bought).

Grouping value ports into value offerings and interfaces. In this step, value ports are grouped into value offerings. The grouping of value ports into a value offering represents the design decision that the transfer of objects via these ports can only be done in combination.

A value offering is of use for representing a number of situations. First, some objects may be only of value for an actor if they are obtained in combination. In-ports transfering such objects then form an ingoing offering. Second, actors may decide to offer objects only in combination to their environment. Ports offering such objects then form an outgoing offering. An example of an outgoing offering is the case of mixed bundling. This refers to the mechanism that an actor wants to offer value objects in combination rather than separately, supposingly because different products sold in combination yield more profit than sold separately (Choi et al. 1997).

Subsequently, found value offerings of an actor are grouped into value interfaces. This models the principle of economic reciprocity. Consequently, the reciprocity heuristic we used previously to identify value objects can also be used to group value offerings into a value interface. It is our experience that in nearly all cases, a value interface consists of two offerings in opposite directions. The direction of an offering is equal to the direction of its ports. The reason for this guideline is that a rational actor only is willing to exchange an object o_{out}, if it obtains another object o_{in} in return. Moreover, it must assign to object o_{in} a higher economic value or utility than to object o_{out}.

Identification of dependencies. As part of the construction of operational scenarios, as discussed above, dependency paths show which value objects need to be transfered as a result of a customer need. To satisfy this need, an actor must transfer objects of value via a value interface, which we show by connecting the need with a connection element to a dependency element, such as a value interface. If the actor can choose from more than one value interface for need satisfaction, the need is connected via an OR fork to these value interfaces. The transfer of value objects via an actor's value interface always implies transfers via a value interface of another actor. This results in a continuation of the scenario by using connection and dependency elements again. If no transfers are needed anymore, the scenario stops, which is indicated by a boundary element.

3.4.2 De- and reconstructing the baseline model to find design alternatives

In practice, many variations of a baseline business model can be conceived of. Business model deconstruction and reconstruction intends to find such design variations in a structured way. It is inspired by work of Tapscott et al. (2000), Evans & Wurster (2000), and Timmers (1999). It is beyond the scope of this paper to discuss this process in detail; Gordijn & Akkermans (2001*b*) discuss how it is systematically done on the basis of the e^3*value* approach.

3.4.3 Evolution of business models

Business models may change over time (Seddon et al. 2004). To understand the envisioned evolution of a business model over time, it may be useful to consider a sequence of business models, each representing a particular period in time. This sequence can be used to express differences in stages, e.g. early adoption vs. mature markets, where financial and market parameters used in business model evaluation are very different.

3.5 Evaluation of networked business models

A baseline business model (and its alternatives) should be evaluated to assess its appropriateness as a design. The e^3*value* approach incorporates several different methods of evaluation.

3.5.1 Ontology-based business rule checking

A designed business model should be consistent with the formal constraints and rules embedded in the e^3*value* ontology. As an example, some essential rules are:

- *Economic reciprocity:* Each value interface must have precisely one in-going value offering and precisely one out-going value offering. Additionally, each value offering must at least have one value port. This rule is used to check if there are no 'free rides' in the business model.
- *Completeness of bundles:* For each offering, *all* ports should be connected to ports of other offerings via a value transfer. As the notion of bundling implies that objects can only be obtained in combination, all bundled ports should transfer values.
- *No self-sale:* Ports of offering of an actor *a* should connect to ports of an actor *b* via a value transfer, and actor *a* should not be equal to actor *b*. In fact, there is a transitive version of this rule that prohibits such self-connections via a third actor. This rule represents that is makes no sense to sell an object to yourself and keeps out unwanted cycles in the model (that may be hidden from the eye in larger and more complex value network models).

3.5.2 Sustainability evaluation

If an e^3*value* model is supplied with numerical values estimating important financial parameters, it is possible to automatically generate *net value flow sheets* and on this basis assess the predicted sustainability of a business model. In Figure 3 for example, the number of shoppers, the number of consumer needs per considered timeframe, and the assigned economic value to objects are key variables to evaluate. Based on the number of needs, the number of required value transfers can be counted. If we additionally know the value of the objects transfered, we may calculate the net value flow, by subtracting the total value of out-going flows from the total value of the in-going flows.

For the assignment of economic value to objects, we employ a separation principle that distinguishes objects representing *money* (or some other monetary good) from all other objects that are of value, but are not money. All these objects are ultimately expressed in terms of monetary units to perform the net value flow calculations, but money objects are valued in a shared 'objective' way (as everyone observes a same amount of monetary units if a certain amount of money is transferred), whereas all other objects are valued subjectively (as everyone may assign a different utility to one and the same value object if transferred (Holbrook 1999)).

For Figure 3, Table 1 gives a simple illustrative net value flow sheet for the Store actor. Such sheets are generated for each actor in the constellation. A central rule that applies to this form of evaluation is that *each* actor should have a positive net value flow for a business model to be sustainable. The software tool support we have developed for the e^3*value* ontology is capable to calculate the Net Present Value (NPV) of the net value flows for all participating actors; it automatically generates the associated spreadsheets. It can also do this for a sequence of business models, so that evolutionary changes of a business model are covered as well by the e^3*value* approach.

3.5.3 Sensitivity evaluation

Commonly, the actual numbers themselves of the net value flows are of limited use for stakeholders, because the underlying estimates or predictions of parameter values may not be very reliable. Therefore additional methods of evaluation are needed beyond the sustainability evaluation discussed above. It is therefore useful is to do a sensitivity analysis of essential parameters in the model, resulting in a better understanding of the business model at hand. Sensitivity evaluation tests the robustness of a designed business model against varying conditions or future events. To do so, we employ evolutionary, or what-if, scenarios, as extensively dis-

Value Interface	**Value Port**	**Value Transfer**	**Occurrences**	**Valuation**	**Economic Value**	**Total**
MONEY, GOOD			100,000		-9,000,000	
	out: MONEY	Payment: MONEY	100,000	90	-9,000,000	
	in: GOOD	(all transfers)	100,000	n.a.	n.a.	
GOOD, MONEY			100,000		10,000,000	
	out: GOOD	(all transfers)	100,000	n.a.	n.a.	
	in: MONEY	Payment: MONEY	100,000	100	10,000,000	
total for actor						1,000,000

Table 1: Net value flow sheet for the ‘Store’ actor.

cussed by Van der Heijden (1996). To elicit such scenarios, we distinguish three kinds: (1) scenarios that capture foreseen changes in the structure of the business model (e.g. occurrence of new or leaving actors), (2) scenarios that capture foreseen changes in the way economic value is calculated for objects transfered (e.g. major changes in pricing models), and (3) scenarios that capture foreseen changes in the number of consumer needs per timeframe (major changes in the size of market segments).

The e^3*value* business ontology approach, with the discussed rules, guidelines, and methods for design and evaluation of networked business models, has been applied to a variety of business and industry problems in different sectors. The next Section discusses an extensive industrial case example showing in full the use and utility of the approach.

4 Designing and Evaluating Business Models for Energy Network Services

In this section we discuss some case studies carried out in collaboration with the power industry, especially targeted at IT-enabled innovation concerned with novel distributed energy network services.

4.1 Industrial Context

Electrical power networks are an infrastructure that is critical to the economic and social functioning of societies and nations everywhere. Continuing security of supply is therefore crucial. The many major blackouts that have occurred in recent years in different parts of the world show that this is a pressing problem also today.

4.1.1 Industry structure changes

In many countries, particularly in Europe and North America, the power industry is undergoing fundamental changes. For a long time, utilities for electricity generation, transmission, and distribution were often regional monopolies. Governments have since the early 1990's set up new regulatory frameworks that introduced various forms of market liberalization and competition. In a development reminiscent of the telecommunications industry, power companies have begun to compete for their customers and market share, and customers increasingly have a free choice of supplier. The emergence of a liberalized market environment has forced enterprises in the power industry and utility sector to carefully rethink their business model.

Business models in the power industry are not only changing as a result of ongoing market liberalization. Technology developments have their influence as well. New energy technologies, labeled as Distributed Energy Resources, are vigorously entering the market. They include various forms of distributed power generation: local renewable generation (solar, wind, biomass, fuel cells) and local combined heat-power production (CHP). They also envisage end-customer power consumption processes (called ‘loads’ in the industry) to take on more active roles in the management of energy networks, where they used to be treated as fully passive end points for supply. Thus, both production and consumption network end nodes tend to become more prominent and active, leading to the need for more decentralized and bottom-up forms of real-time control of the energy network. This need is (independently) increased as an outcome of market liberalization: it technically necessitates that different enterprises share and utilize the same power grid infrastructures in order to supply their services to their customers.

This is in stark contrast to the traditional highly top-down view of managing energy networks, from power plant generation, high-voltage transmission, to low-voltage distribution to end customers. This top-down thinking is very much entrenched in the culture as well as the technology of the industry. Energy networks have to control forceful physical phenomena involving voltage, current, and frequency variables. This is in clear contrast to computer networks that only handle signals (data, information) which essentially carry negligible power.

4.1.2 IT-enabled innovative business models

Overall, a combination of business, technology, and policy factors is driving the power and utility sector towards developing more flexible and distributed forms of control, but this goes with increased complexity in network management and security of supply. Dealing with these problems is inconceivable without the extensive exploitation of advanced IT.

First, IT is essential in establishing connectivity between a large variety of grid devices, both big and small power production resources, electricity network nodes, and local loads (i.e. consumption nodes). On top of this connectivity, many new IT techniques in hardware and, even more, in software help make energy networks more intelligent and self-managing (we will outline some of these developments more concretely later in this section). This provides new technical foundations for distant control of highly distributed networks on an increasingly large scale.

Second, IT provides new technical and business opportunities for real-time interaction between suppliers, distributors, and customers in the power grid. Here, Internet and Web are the most eye-catching developments that lie at the basis of interactivity. Timely and high-quality information on the status of the grid is becoming much more easily accessible for all stakeholders. Beyond monitoring, Internet and Web enable new electronic services based on two-way communication between suppliers and customers. Automated demand response (the industry term for managing power networks by using demand change triggers from end customers), balancing services that help maintain the match between power demand and supply in real time, and market-based dynamic pricing, buying and selling of power are all emerging applications and innovations that are enabled by IT.

Corresponding IS design issues, especially in the phase of early requirements determination, are set in the context as described above. Both technical and business requirements play an important role here, and moreover they are strongly interrelated. Achieving more decentralized ways for information, coordination, and control of the energy network, maintaining its security of supply, and finding new ways of serving its customers will require significant investments in IT and IS. Apart from clarifying the technical requirements, it is therefore crucial to develop early insights to help answer the central managerial question "What is the business case?" for proposed IT and IS developments. Thus, clarifying the associated business model issues as part of early IS requirements determination is the focus of the ontology and methodology proposed in this paper.

4.2 Elicitation Methodology

Based on the e^3*value* business ontology approach discussed in the previous section, several business ideas and opportunities for new business models in the area of Distributed Energy Resources (DER) have been investigated. The studies were carried out partly by a university research team led by the present authors and, for the most part, by different research partners within the power and energy industry itself. Studies according to the same research design were carried out in different countries (UK, Spain, Norway, Sweden, Netherlands). In this paper, we mainly discuss results of the latter study.

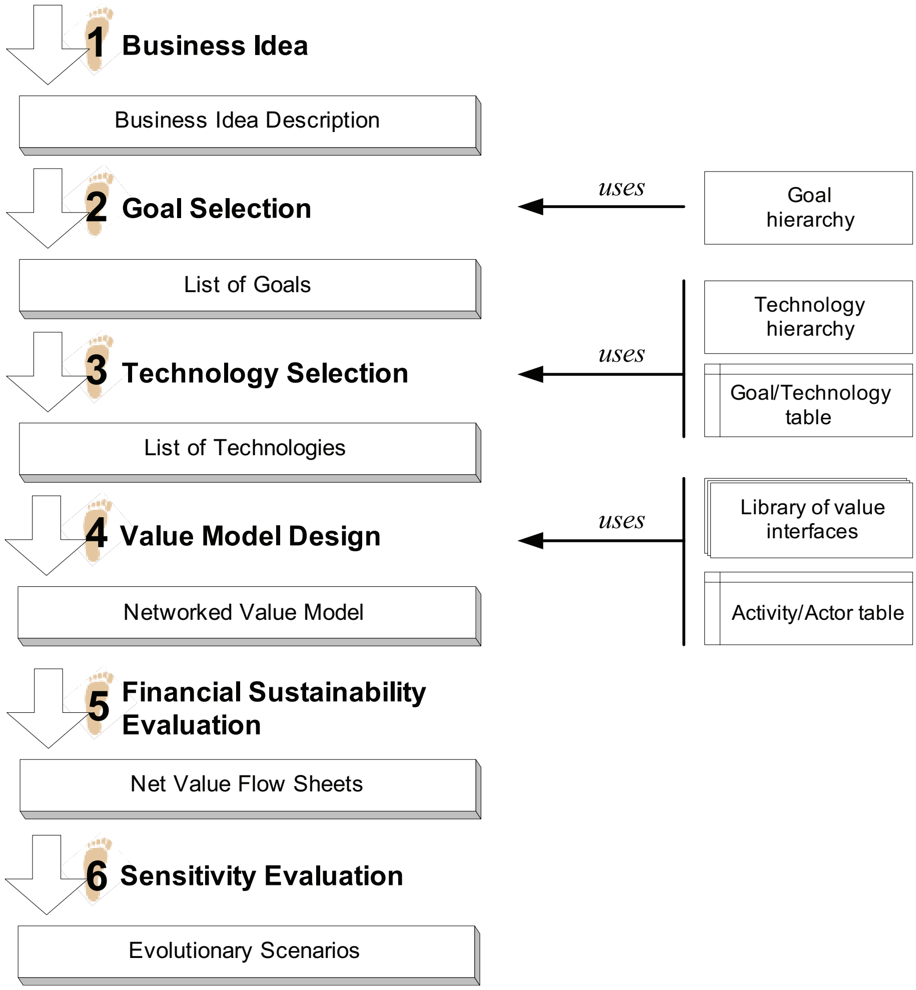

Figure 4: Elicitation methodology used for business model design and evaluation.

To clarify early business requirements, a process of elicitation is needed that starts from initial business ideas and subsequently details them and evaluates their consequences. The methodology used for this process is depicted in Figure 4, and consists of a series of steps to be performed by business developers. It is a specialization of the design process discussed in Section 3.4. Parts of this process were done in the form of short workshops and interviews with executives, while the more detailed modeling and evaluation activities were carried out as desk studies by industry researchers, business developers or strategy analysts. The latter are usefully supported by the developed e^3*value* tool for business modeling, whereas communication with managers is clearly facilitated by the visual diagram format (cf. Figure 3) of the networked business models. The major steps in this process are as follows.

Step 1: Business Idea Description. Stakeholders are asked to concisely state their business idea. In workshops we employed a description template to state the idea in structured natural language. This template covers (1) a one-liner presenting the essentials of the idea, (2) a statement of scope (e.g. for DER the region is of importance), (3) the core business processes that are required for the idea, (4) the main enterprises (actors) involved, (5) potential DER and IT equipment/components that may be required for the idea, (6) the ownership of equipment (DER ideas often require investments), and (7) regulatory incentives (as some ideas lean on subsidy schemes).

Step 2: Goal Selection. In this step, stakeholders representing various enterprises are asked to specify the goals a particular DER business idea may serve. To aid the goal specification process, we have constructed two taxonomies of long-term strategic goals and short-term operational goals, respectively. In each case study, our research partners have selected strategic goals from the predefined taxonomy, and the lists of goals per stakeholder were then used to negotiate goals in case of conflicts. There are in this industry sector strategic goals such as environmental ones that relate to society in general (e.g. reduction of greenhouse gas emissions such as CO_2); often governments promote such goals. Operational short-term goals contribute to reaching strategic goals, such as Market development (M), Environment (E) or Quality and efficiency of supply (QE).

Step 3: Technology Selection. Understanding goals is important to select suitable DER technology and to construct a value model. To help stakeholders with technology selection, we developed two predefined tables to select from. The first table is an industry-specific taxonomic hierarchy of DER technologies and their characteristics, the second is a score matrix whether and to what extent specific technologies assist in reaching listed goals. This step is clearly industry-specific and must be driven by domain experts, although we believe that technology characterization tables and goal-technology matrices are practical instruments of wider applicability.

Step 4: Value Model Design. To construct a value model, stakeholders decided what value activities should be carried out for a specific DER business idea. Additionally, value interfaces of activities are stated. These interfaces may be compared to wall outlets for electric power: they state what a particular activity or actor offers of economic value to other actors. Our methodology supported this step of constructing a value model by providing modeling guidelines as well as libraries of predefined value activities and value interfaces specific to the DER domain. To assist in the allocation of value activities to actors, we developed a matrix of frequently occurring assignments. For example, some assignments of activities can be fixed by regulatory frameworks (often stated by country law) to a specific actor. For instance, a long distance electricity Transport activity is in some countries legally assigned to one specific actor, usually called the Transmission System Operator (TSO). This step is of crucial importance in clarifying business requirements related to a value proposition, as it clarifies in detail which actors are involved for what activity and what their mutual relationships are. The e^3*value* modeling tool is helpful here in checking whether the value model is well-formed, i.e., complies with the set of business rules that underlie the ontology, and by giving corresponding modeling suggestions in the style of a CASE tool.

Step 5: Financial sustainability evaluation. To assess the financial sustainability of a business idea, net value flow estimates based upon the value model from the previous step are calculated by means of a spreadsheet approach. First, the important operational scenarios are identified; they may derive from the business process narratives produced in Step 1. Stakeholders then decide on valuation functions for value objects representing money (often fees). For example, a pricing formula has to be given, e.g. the price per kWh for electricity. If we estimate these valuation functions, as well as other variables in the model, the e^3*value* tool automatically calculates all net cash flows for each actor involved (the tool generates Excel spread sheet results on a per actor basis). In a network of actors, such calculations are way too complex to be handled manually. This part of the evaluation shows whether the actors benefit from a business model, under assumed normal operating conditions.

Step 6: Sensitivity Evaluation. Many financial parameters in a business model are difficult to estimate or are expected to change. So, a final step is to identify possible future events that may influence the business case positively or negatively, and evaluate this influence by means of financial parameter sensitivity analysis. The basis for this part of the evaluation are what-if or evolutionary scenarios, in a way similar to scenario-based strategic decision making (Van der Heijden 1996). Such events may influence valuations or even the structure of the value model itself. Evolutionary scenarios considered in the DER business model studies often relate to changing regulations, changing fuel prices, and exhausting fossil fuels in different rates than expected. We have experienced that 'playing' with the financial parameters to test the robustness of a business model against a range of possible future conditions is of much more value to stakeholders then relying on the numbers themselves. It can be seen as the *stress testing* of a business model idea; if it passes these tests, it helps to convince managers of the potential of the idea and increases their confidence that it will actually work.

4.3 Representation: Distributed Balancing Services

Figure 5 presents a DER business model that has been developed in one of our industry case studies. Specifically, it is the design result of Step 4 of the above-discussed elicitation methodology, and it formalizes a networked business idea regarding *distributed balancing services* (DBS).

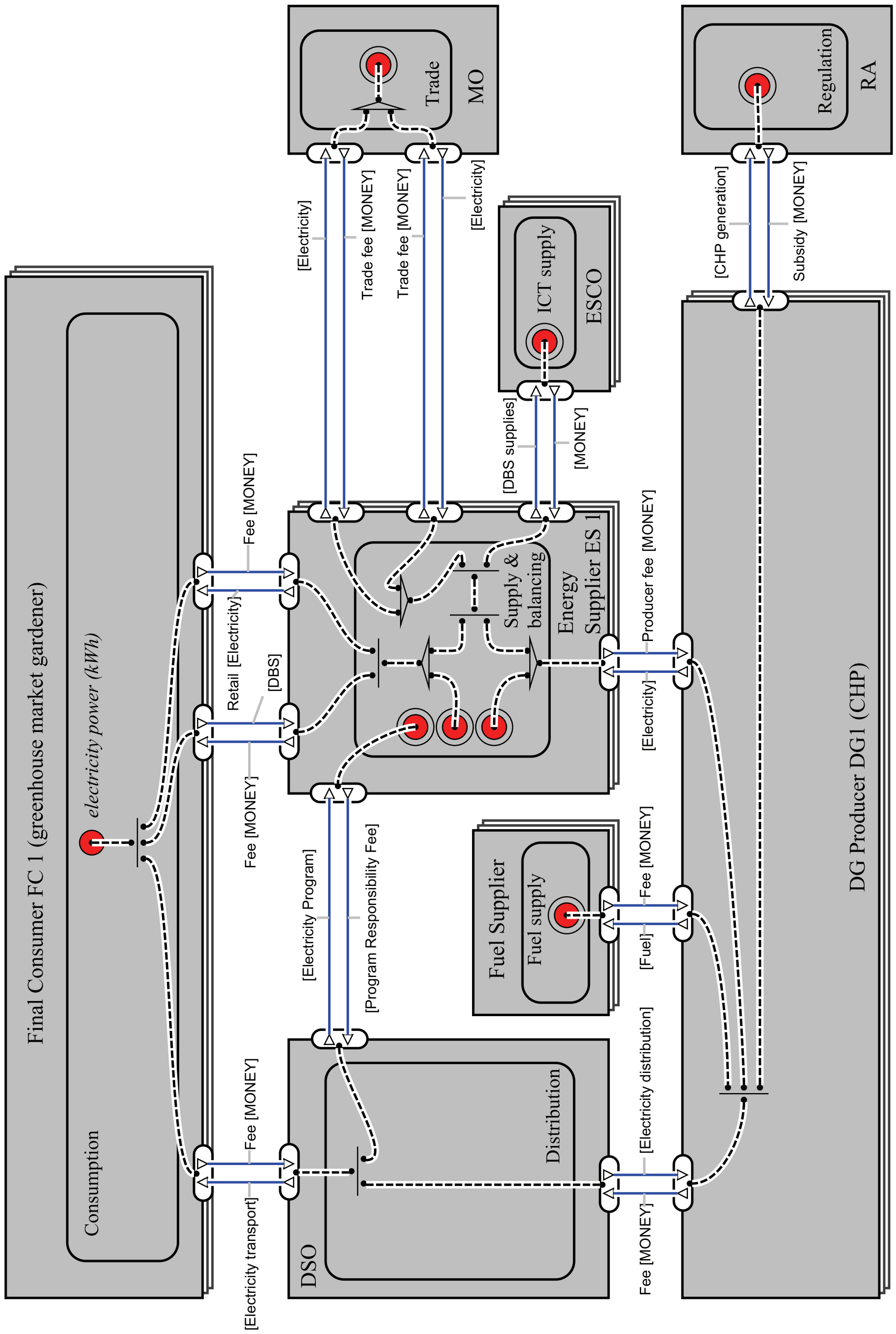

Figure 5: DER business model for distributed power balancing services, as generated by the e^3*value* approach and tool.

Informally the business idea can be stated as follows. One of the important issues in energy network management is to ensure the real-time power balance, i.e. the property that power supply always matches demand at each point in the network. If this is not the case, voltage drops and frequency changes may occur that, if they become too big, lead to a collapse of the network and potentially to blackouts. A traditional method to provide the network service of power balancing is to have reserve power generation capacity available that can be switched on or off on a short notice as needed. However, a general effect observed in all countries that have embarked upon market liberalization, is that investments in reserve power generation have strongly decreased. Typically, reserve power generation installations require an investment time horizon of twenty to fifty years. Given the market uncertainty over such long periods, there appears to be no incentive to invest in such capacity in a market-driven environment. Reductions in generation capacity investments lead to a greater risk of power grid disturbances and demand-supply mismatches. In addition, stagnation of reserve capacity ultimately leads to high peak prices and strong fluctuations on the power exchange markets.

Peaks and fluctuations in power prices open the door for alternative solutions. One is to use IT-enabled clusters of Distributed Energy Resources for such energy management services. By properly controlling DER resources, it is technically possible to counterbalance deviations of the real-time power balance realization from the day-ahead power planning. From the business point of view, significant price fluctuations suggest that there is an attractive business case for using DER resources for such distributed power balancing services. An additional competitive advantage of distributed balancing services by DER resources is that additional investment is needed only for control and not for production or storage.

There are several market segments where such distributed balancing services might be applied. The one considered in the e^3*value* business model of Figure 5 are greenhouse gardeners in the flower production and agricultural sectors. In the Netherlands, a relatively large percentage of power is generated by combined heat and power (CHP) installations in the agricultural sector. Other sectors of interest are large cold storages (as exist in the food industry and meat factories) and large office buildings. In all these cases there is a substantial heat buffer capacity that gives a significant time span for flexibility in control, by switching on/off production and sales of locally generated electricity. IT and information systems are essential in achieving these flexible and fine-grained forms of local control for power balancing services, and to realize this over large numbers of interconnected DER devices.

Figure 5 shows the network relationships in value creation through distributed balancing services between the different actors, for the market segment of greenhouse gardeners. Similar models have been developed for other market segments. The Figure, that has been generated by the e^3*value* support tool, shows quite convincingly that the multi-actor relationships in a business model are quite intricate. Experience shows that the design of networked business models at this level of complexity is very difficult to handle by manual and natural-language means only. Instead, our formal business ontology approach adds precision and rigor, while the associated tooling makes it possible to deal with very sophisticated business models and networks, and still succeeds in keeping them understandable and communicable to relevant managers.

4.4 Evaluation

As pointed out, peaks and fluctuations in the power prices suggest that there may be an attractive financial case for the business model expressed in Figure 5. A clear indication of these price fluctuations is given in Figure 6 which shows the power imbalance prices in the Netherlands over the whole year 2003 as a function of the hour of the day. This is one of the financial input parameters in the net value flow calculations that are performed to evaluate the business model of Figure 5.

The first part of the evaluation of the DER business model for distributed balancing services is based on operational scenarios. This corresponds to the Step 5 activities in the above-mentioned elicitation process. In the present case, the business processes and interactions on an hourly and daily basis between the energy supplier and the gardeners are looked at in more detail. An example of the evaluation results for this operational scenario is given in Figure 7. In the Summer

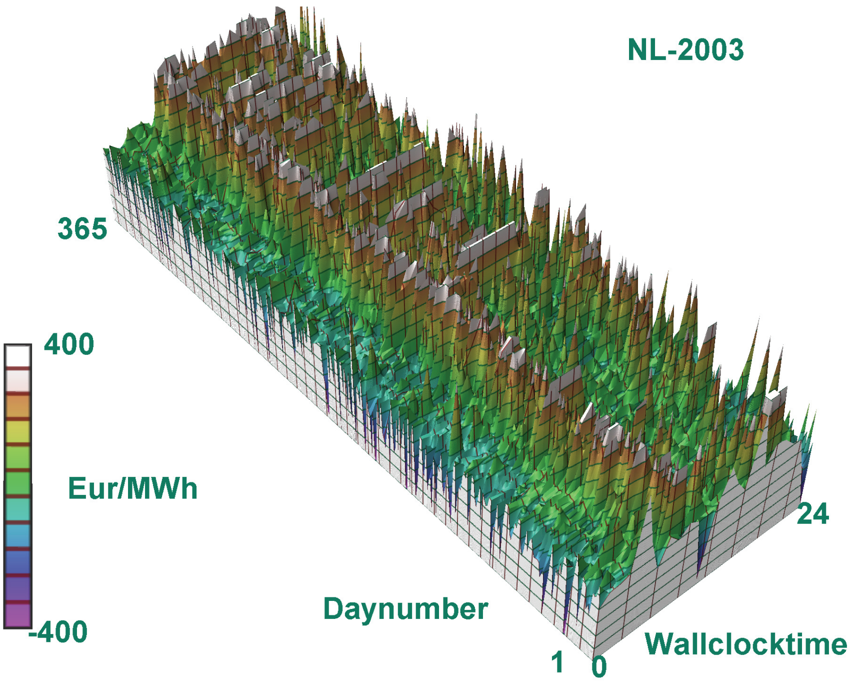

Figure 6: Imbalance price fluctations for power over the year 2003 in the Netherlands.

period, the energy supplier could in principle produce 24 hours a day and sell it to the Amsterdam power exchange market APX, but as the Figure shows, this would not deliver an optimal profit. The optimum production period according to the operational scenario evaluation lies between 9:00 and 19:00 h.

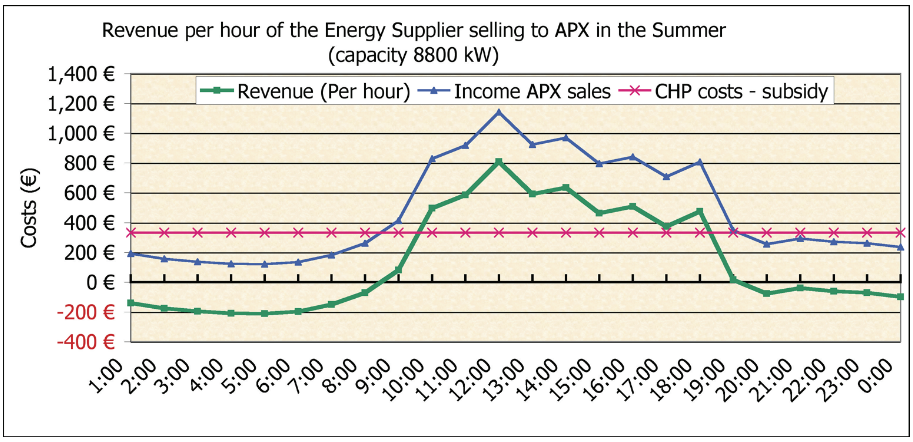

Figure 7: Example of financial sustainability evaluation of the DER business model for distributed power balancing services.

The second part of the business model evaluation, corresponding to Step 6 of the elicitation methodology, is the identification and analysis of what-if or evolutionary scenarios, which consider possible future events that positively or negatively influence the business case. In the investigated situation, several factors affect the revenues of the energy supplier, such as the gas price, the APX market spot price, as well as possible government subsidy schemes. So, a sensitivity analysis is carried out to better understand these factors, and to find out how they influence the sustainability of the DER business model. The Table of Figure 8 presents the estimated profitability for all core actors, under different what-if scenarios. In the first row the base scenario of one hour production per day is shown. The second row shows the alternative scenario of a 30% increase of the gas price, followed by one assuming 30% lower market prices; finally the scenario is considered that deals with the cut-off of any subsidies. Although there are changes, the evaluation shows that there is a business case for all core actors that is robust against significant changes in external financial parameters.

Net Value Flow Analysis				
	Turnover	**Profit**	**Profit**	**Profit**
Scenario	Energy Supplier	Energy Supplier	Gardener (33%)	ESCO
Base Scenario	203,490	82,338	67,152	54,000
30% increase of gas price	166,860	57,796	55,064	54,000
30% decrease of APX price	142,443	41,437	47,006	54,000
No CHP subsidy	183,141	68,704	60,437	54,000

Figure 8: Example of the evaluation of what-if or evolutionary scenarios for the business model case of distributed balancing services.

Thus, the business idea of Distributed Balancing Services for greenhouse market gardeners using an (existing) CHP installation co-managed by the energy supplier is a profitable one for all core actors. Important influencing factors are the spot prices during the seasons and the fees for the market participants. Gas prices, possible subsidies, and the initial IT investments appear to have less influence. An interesting general conclusion is that the business case for distributed balancing services does not depend on environmental subsidy schemes, even though environmental goals are strategically important, as was identified in Steps 2 and 3. This business model design and evaluation study has been repeated for other market segments and situations, with similar results (Gordijn & Akkermans 2006).

4.5 Implementation and Further Steps

The discussed business models for distributed power balancing services are enabled by IT, as discussed above in the section on industry context. The business model therefore needs to be instantiated in terms of distributed information systems that establish the needed connectivity between DER devices and provide the flexible and distributed information management, coordination and control underlying real-time balancing services.

The information system is based on electronic markets as first proposed in (Ygge & Akkermans 1996). A commercial aggregation of DER devices (represented by the market segment in the DER business model) acts as a ‘virtual power plant' but run in fully decentralized ways. Technically, DER devices are represented by software agents that participate and negotiate on a market with the goal to optimize their production and consumption of power. This optimization is driven by a combination of functional and financial incentives such as the goal to reduce imbalances in the power system. Formally, the information system for power balancing services is based on distributed algorithmic approaches (Cheng & Wellman 1998, Gustavsson 1999) that implement microeconomic market theories of general equilibrium (Mas-Colell et al. 1995). Special distributed algorithms were developed that are very efficient in terms of market convergence for large numbers of market participants, and the market outcomes provide the setpoint parameters for predictive model-based optimal control. This special integration of computational market and control theories (Ygge & Akkermans 1999) provides the formal foundation of the information systems performing distributed balancing services.

Both business models and associated information system instantiations have gone through several iterations. Also, special measures were taken to communicate novel business and IS concepts clearly to industry experts and managers. This included a management game for electronic power market negotiations and dynamic pricing, that for example was played at a plenary session of an international conference of the power industry. Furthermore, distributed balancing services have been tested through several field experiments. One example is shown in Figure 9. It shows a commercial cluster of different DER devices spread over distances of about 200 kilometers in different parts of the Netherlands. In this case, the power imbalances are created by the intermittent and fluctuating production of the wind turbine parks. They are counteracted in real time by other, more controllable and flexible, DER devices of both a residential and industrial nature (for example, the cold store is associated with a meat factory), via the agent-based electronic market that is the heart of the information system called the PowerMatcher (Kok et al. 2006).

The results of this field experiment convincingly demonstrate a highly significant reduction in power imbalances: on average a 45% imbalance reduction over

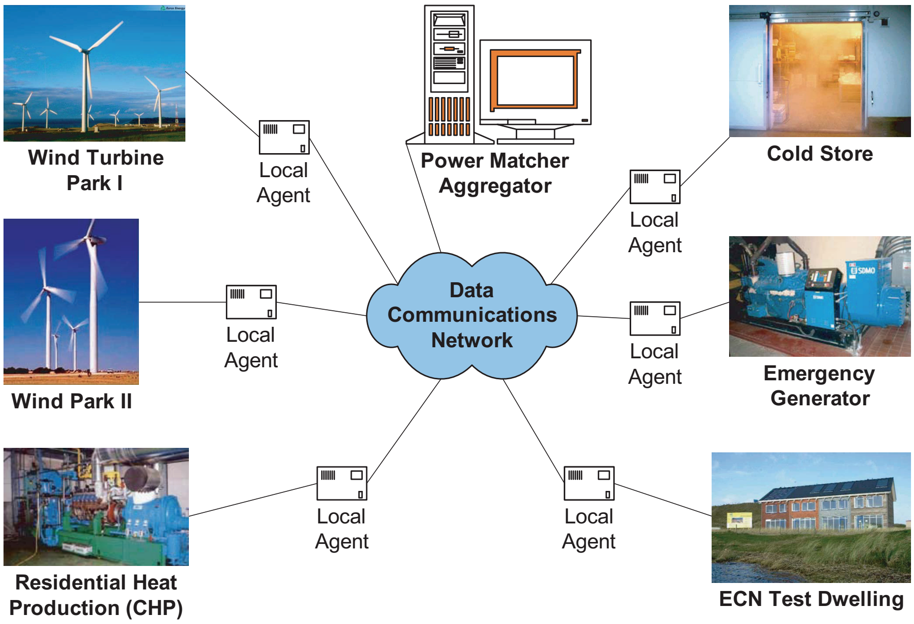

Figure 9: Set-up of one of the field experiments for distributed balancing services.

a period of nearly nine months for this specific (fixed) DER cluster was achieved. The evaluation of the experimental results also shows that if the DER aggregation itself would be made dynamic, by adding additional DER devices on the fly to the commercial portfolio as the need arises, performance indices close to 100% can be achieved. Further detailed scenario and financial evaluations based on the e^3*value* business ontology approach are in progress. In sum, strong evidence has been established both from the value model evaluation and from the technical IS performance for the attractiveness of the DER business model for distributed power balancing services.

5 Conclusions

We have investigated in this paper the design of networked value constellations. We specifically argued that, preceding IS technical design, an organizational and economic understanding of a networked value constellation forms the basis for the design and evaluation of its business model and its multi-actor relationships.

This analysis forms a part of the early requirements determination phase that particularly seeks to clarify the business requirements underlying information systems support from a value creation standpoint. It contributes to a *shared* understanding of the constellation at hand from a managerial perspective, and enables to 'tell the story' and explain it through operational and evolutionary business scenarios. The constellation can be evaluated for a set of *desired properties*, including economic sustainability, reciprocity of value transfers, and completeness of offerings. The agreed business model for the constellation then *scopes* the design activity of supporting information systems.

To develop this understanding, we have proposed a set of related artifacts: a formal yet lightweight *ontology* that allows for the representation and analysis of a business *model* for a networked constellation in a principled and structured way; a design process *methodology* helping the business analyst in iteratively eliciting and evaluating such a business model; and a software *design tool* supporting visualization, communication and reasoning about a designed business model.

Our ontology-based approach offers, in our view, a number of general scientific contributions to design science research. The e^3*value* ontology itself embodies in a formally rigorous way a set of important design science principles discussed in this paper. Specifically, some of these are:

Economic reciprocity: Actors transfer objects of value, only if they can obtain objects with higher (subjective) utility in return.

Separation of activity and performing actor: In a business model, value adding activities and actors are fully separate entities. In fact, the assignment of value activities to actors is an important design degree of freedom in the construction of networked business models.

Separation of money and other value objects: Value creation in a sustainable way is the focus of business models. To reason about this, a clear difference should be made between money and other value objects, as the assignment of value or utility to these objects is actor-dependent and needs to be characterized carefully in business design studies.

Separation of concerns: The e^3*value* ontology aims to provide a theoretical model how economic value is created, distributed and consumed in a network, and is not directly concerned with, for example, supporting business processes and corresponding IT technical design. This separation of concerns facilitates executive communication and decision making by a focus on the value issues, and contributes to problem solving by decomposition (Simon 1996).

Also with respect to the development of ontologies and theoretical models in general, there a number of principles emerging from our research, in particular:

Minimality of ontological constructs: Many ontologies tend to easily become very large. This also applies to several business ontologies cited in this paper. However, too many constructs result in intractable ontologies that obscure shared understanding and communication. For design, it is important to focus on the essentials. This is why separation principles as outlined above are important. For ontologies as a mechanism for conceptualization and theory formation, we suggest that parsimony of concepts is a useful evaluation criterion that we have also applied to the e^3*value* and other ontologies (cf. Figure 2). In other words, Occam's razor — entities should not be multiplied beyond necessity — (cf. (Sober 1981)) provides a good design guideline.

Visual communication: To be usable for a managerial audience, business ontologies and models are to be cast in understandable visual and graphical formats. Formality and computer processability are useful features to have for analysis purposes, but their complexity must be kept under the hood and hidden from the eye. The current state of the art makes it possible to achieve this, although the principle is often violated. The commonplace phrase that a picture says more than thousand words indeed applies here.

Actionable ontologies: Ontologies are commonly interpreted as representations that formalize a concept in a static way. We have learned that there is no useful ontology however without an associated dynamic methodology that tells how to come to conclusions based on reasoning with the ontology. In the present case, the *e*^{3}*value* ontology goes with methods that have specifically been developed for evaluation, such as net value flow analysis in a network of actors. Generally, ontologies as a foundation for IS have to embody actionable knowledge and display implementable validity (Argyris 2004).

As discussed in this paper, the theoretical and design principles embodied in the *e*^{3}*value* approach have proven their practical utility and validity in a range of case studies and applications carried out in collaboration with industrial research partners in several different sectors.

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