Value-Based Requirements Engineering for Value Webs

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Abstract. Since the 1980s, requirements engineering (RE) for information systems has been performed in practice using techniques (rather than the full method) from Information Engineering (IE) such as business goal analysis, function– and process modeling, and cluster analysis. Recently, these techniques have been supplemented with portfolio management, which looks at sets of IT projects and offers fast quantitative decision-making about continuation of IT projects. Today's networked world, though, poses challenges to these techniques. A major drawback is their inability to adequately specify the requirements for IT systems used by businesses that provide services to each other in a value web. In this paper, we analyze this problem, and propose a solution by coupling IE and portfolio management with value-based RE techniques at the business network level. We show how these techniques interrelate, and illustrate our approach with a small example.

Keywords: value modeling, information systems planning, portfolio management, requirements engineering.

1 Introduction

Information Engineering (IE) arose in the 1970s out of the Business System Planning method of IBM [1] and was codified at the end of the 1980s by James Martin [2] and, less well-known, Clive Finkelstein [3]. Several businesses introduced their own version of IE [4,5]. All these approaches share a set of techniques, such as business goal analysis, data– function– and process modeling, and clustering, and they share a focus on what is now called enterprise architecture, the enterprise-wide set of information systems and their relationships, that should support business goals.

IE has several shortcomings, which we will analyze later. In response to these shortcomings companies have dropped the strict top-down *method* of IE, but

⋆ Supported by the Netherlands Organisation for Scientific Research (NWO), project 638.003.407, Value-based Business-IT Alignment (VITAL).

⋆⋆ Supported by the Netherlands Organisation for Scientific Research (NWO), project 632.000.000.05N01, Collaborative Alignment of cRoss-organizational ERP Systems (CARES).

P. Sawyer, B. Paech, and P. Heymans (Eds.): REFSQ 2007, LNCS 4542, pp. 116–128, 2007.

continued to use the *techniques* in IE. In the last few years, companies have also added quantitative decision-making tools to manage portfolios of IT investments, called portfolio management. Here, we want to discuss a particular kind of shortcoming to which an additional response is needed: Classical IE does not deal with IT used in value webs. By *values webs* we mean networks in which businesses provide e-services to each other or to consumers commercially, such as the provision of data storage capabilities, communication capabilities, information retrieval, multimedia access, etc. The main characteristic of a value web is a multi-actor business setting for satisfying specific customer needs. A classical IE technique such as business goal modeling will not suffice here, because there are many businesses with many, partly incompatible goals. And data– and process analysis at this level are inappropriate, because data and processes will be mostly confidential business resources, and besides, first the web of services needs to be designed. This calls for new techniques to identify requirements on IT in a value web. The techniques added to IE by Tagg and Freyberg to deal with networks still take the point of view of a single participant in the network [6] and do not deal with all the kinds of networks that have come into existence since then. In this paper we propose value-based RE techniques to deal with this. We will focus on the Information Systems Planning (ISP) task, which is the task that deals with defining an overall alignment between business and IT [7,8,9,10,11].

In section 2, we analyze the problems with IE in today's networked business environment. We argue in section 3 that classical IE techniques, supplemented with portfolio management and value-based RE techniques, suffice to tackle these problems. We illustrate this claim with a small example (section 4). Section 5 concludes the paper with a discussion of our results and of questions for further research.

2 Problems with Traditional ISP in Value Webs

A review of the literature [10,12,13,14] reveals several problems of ISP in value webs.

No Single Decision Point. Organizations are coordination mechanisms, in which there is ultimately a single point of management control [15]. Even though there are many different organizational structures, they share this hierarchical feature. Value webs, on the other hand, have no single point of control and are at least partly coordinated on a relational basis, where shared norms and mutual trust play a crucial role [16,17]. In addition to hierarchical and relational coordination, economic sociologists distinguish a third form of coordination, based on markets. Alstyne [18] and Miles & Snow [19] give convenient overviews. Salmela & Spil [14] and Wieringa [20] apply these ideas to IT support in value webs.

What is important for our purpose is that single enterprises, for which ISP was developed, are hierarchical. Even though there is a trend to flattening these structures [21], one will always find a central point of authority. Such a single decision point is (usually) absent in value webs. This can lead to conflicts of interest, which is a major hindrance for the systems planning process.

The underlying problem is that each actor in a value web is profit-and-loss responsible. Any actor will only participate if it expects this participation to be profitable. Each actor will make this decision for itself, but needs sufficient information about the network in order to enter negotiations with the other potential participants. This information must include information about who delivers which service to whom, and what is provided in return for this. Traditional ISP simply contains no techniques to do this kind of analysis. Yet this analysis is needed by each actor, first to decide whether to participate and second, to identify the services to be provided to other actors. Note that this is a management decision, but a decision that cannot be made in blissful ignorance of the IT infrastructure. In the value webs, which we consider, the services are delivered by the IT infrastructure, and a decision must be made whether this can be done in a way that is economically viable for each participating actor. Decisions about participating in a value web inextricably mix considerations of economic viability with considerations about IT infrastructure requirements.

Legacy Systems. Traditional ISP approaches stem from the 1970s and their main objective was to "computerize a company" [1] that previously was uncomputerized. Even in the network version of IE presented by Tagg and Freyberg [6], ISP ends with the identification of new IS's to be built. Legacy systems were no issue, because systems had to be built from scratch. However, nowadays legacy systems need to be considered and integrated. If possible, companies want to be able to reuse existing systems for new business opportunities, and therefore build underlying system architectures around these. Traditional ISP does not contain techniques to help make the decision to reuse or adapt a legacy system, or to acquire or develop a new system.

Speed of Change. The rapid spread of the use of the internet has led in the late 1990s to the so-called new economy boom. A large number of internet companies started up only to disappear a few years later. One of the reasons for this is the speed of change of the relevant market. Businesses in general and networked businesses in particular often need to adapt to given circumstances in the market. If they do not do this in adequate time, they run the risk of loosing their market position, i.e. they loose an eventual competitive advantage. The top-down approach, as implied in traditional ISP approaches is known to be very time consuming and and not flexible enough to allow for fast reaction. Often, IS designers/planners found themselves finishing their work only to find out that their results were no longer reflecting the actual situation of the company [22]. The speed of change that IS professionals today need to deal with is even higher, and therefore crucial for the ISP process. Traditional ISP does not contain guidelines for dealing with this speed of change.

No Global Modeling Possible. IE-like approaches to ISP require enterprise modeling be done from a global perspective. All core and supporting business processes and data flows are subjected to analysis, modeling, and documentation. Global modeling is difficult, resource-consuming, and problematic even for single companies. One reason for this was already given above: Companies often change at a speed higher than global modeling can take. In a value web, an additional reason for the impossibility of global modeling exists: The participating business actors will never make all information that is needed for a global model available, because much of this information is viewed as a corporate asset and is confidential. Yet ISP requires global models in order to make architecture decisions.

3 Solutions

Portfolio Management. A *portfolio* is a collection of assets of interest with some shared characteristics, and *portfolio management* is a method for managing these assets for value. Note that "the term portfolio management means a dozen different things to a dozen different people" [23]. In economic terms, the assets in a portfolio are viewed as investments. They can be financial assets, IT assets, real estate, or whatever else is of value to a company and needs to be managed as a whole. The essence of portfolio management is that the assets in a portfolio are considered as a whole, to check whether there are redundancies, lacunas, opportunities for synergy, etc. This naturally leads to the consideration of legacy systems: Systems that are already installed and used, and add value to the company right now. Portfolio management offers quantitative decision-making techniques, mostly based on the net present value of investments, to decide whether to add a required e-service to a current system or to a new system, and what the financial risk of each of these options is. Portfolio management has been proposed by McFarlan as an approach to managing IT investments more than 20 years ago [24], but in practice its actual use has taken on only in recent years [25].

Portfolio management solves the problem of incorporating *legacy systems* into an architecture because it provides quantitative decision-making techniques to decide whether to add a required e-service to a legacy system or to a new system. It takes a company-wide, global view but does not require the design of enterprise-wide data– process– and function models. The information needed to make this decision is mostly of a financial nature, and it is feasible to acquire this on an enterprise-wide basis before the information is out of date. So when practiced on an ongoing basis, portfolio management also answers the problem of *speed of change*, because it represents a direct link to the applications and therefore offers bigger flexibility than given by traditional time-consuming ISP approaches.

Portfolio management is however practiced on a company level, not on a value web level. It does not provide techniques to deal with the lack of a single decision point in a network, nor with the needs to make global, network-level ISP models. To deal with these problems, we need to turn to other techniques, discussed next.

Value Web Design. To design a value web, we must chart all business actors (including consumers) that form a value web, and specify what is exchanged with whom, and against which reciprocal exchange. We follow the e^3-*value* method introduced by Gordijn & Akkermans [26,27,28].[1] In this method, a value web

[1] See also `http://www.e3value.com/`

is represented by a graph, called a *value model,* in which the nodes represent economic actors and the arrows represent transfers of value objects. A *value object* is money, goods, services or other intangibles (such as "a trustworthy image") offered by an actor to other actors. Because each actor in the value web is an economic actor, it expects some value object in return. The goal of designing a value web is to ensure that each actor can participate in an economically viable way. To provide quantitative decision support, e^3*-value* offers two techniques, namely (a) the *net value flow* and (b) the *discounted net present cash flow* (DNPC) technique. Using these techniques, each actor can estimate (based on revenues, expenses and investments) its income (net value flow) and discount it to its present value.

Most of the transfers of value objects in the cases we are concerned with, are e-services (or parts of e-services). A service is defined to be a "provider/client interaction that creates and captures value" [29]. An e-service is a service delivered over an electronic network. In our research they are usually digital objects of value to the receiver of the value object, such as data storage services, data retrieval services, multimedia content, communication, etc. Once the participating actors agreed on a value web design, each actor can map the services it offers to or consumes from other actors in this web to its own internal IT infrastructure. The value model is thus a source of functional requirements on current (legacy) or new IT systems. Additionally, the value model is a source for quality requirements, such as scalability, interoperability, or flexibility, because the value model (and its accompanying techniques for assessing economic sustainability) tells us how often certain transactions will occur, with which systems a given IT system must interoperate, and what changes we can expect in the time period considered by the value web. We make this more concrete through an example in Sec. 4.

First, we explain why e^3*-value* can solve the remaining two problems with traditional ISP, the lack of single decision point and the impossible requirement of ISP to make global models. By its very design, e^3*-value* charts the different decision points in a value web and thereby supports negotiation of these economic actors in the design of the value web. As far as a value web is actually a web of services, provider/client identification indicates the decision points. Each economic actor in the web is profit-and-loss responsible and the value web uses the language understood by all economic actors: Money, or more generally, economic value. So e^3*-value* techniques help solve the problem that there is *no single decision point.*

Secondly, e^3*-value* does require us to make one global model. This is a model at a very high level of aggregation that contains just enough information for the different businesses to decide whether and how to participate in the value web. Once an actor decided to participate, it can derive functional and nonfunctional requirements from the value model and this can serve as the input to an ISP process inside each actor. And inside each actor, global data–, function– and process models need not be made; they only need to be made of the IT assets required to participate in this particular value web. So using e^3*-value* avoids the *global modeling problem* of ISP.

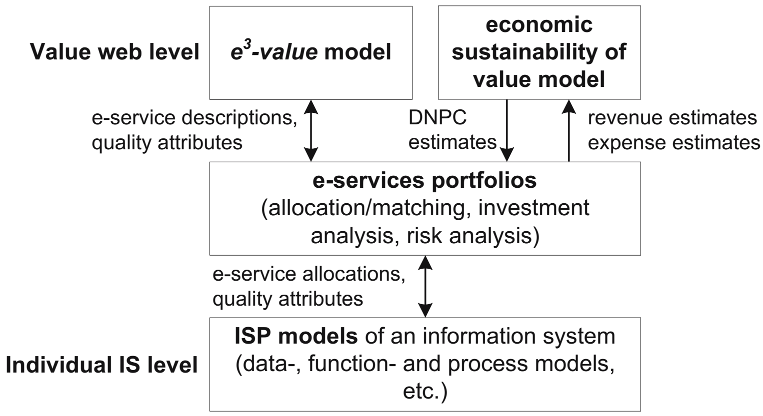

Fig. 1. Relationships among the different techniques

Relationships among the techniques. Figure 1 shows the relationships among the techniques that we propose. Value models provide information about required e-services to be provided by a business actor in the value web, which need to be allocated to information systems (IS) in an IT portfolio. The DNPC technique provides estimates of net present value of value flows in the web. That can be used by portfolio analysts to make estimates of a business actor's expenses needed to provide or consume the e-services in the period considered by the value model. This leads to improved DNPC estimates, which can be used to improve the investment analysis, etc.

Once the required e-services and their quality attributes are allocated to IS, the business actor can identify requirements for individual IS in the portfolio, and elaborate these using traditional ISP techniques. Note that e-services and their quality attributes flow along bidirectional arrows. This is because portfolio analysis can lead an actor to a decision to change its offered or consumed e-services in the value model, and that modeling of an individual IS can lead to improved understanding of the feasibility and expected income or expenses generated by offering or consuming an e-service.

Note that in portfolio management, we take the point of view of an arbitrary actor in the value web, who wants to find a way to manage its IT portfolio in such a way that participation in the value web is estimated to be profitable. At the value web level, by contrast, we assume a model of the value web that is shared by all actors in the web.

4 Example

To illustrate our approach, we apply it to a small example.

Case description. Consider a small telecom company named TwenteConnect, that serves a regional market. The company has been providing so far only fixed land-line services. They did not sell any hardware components such as cell phones to their customers. Now, TwenteConnect wants to expand to the area of mobile phone services, again in the same region. Their expansion plan says that before starting to target private clientele, they will run a test phase with corporate clients. The goal is to provide the local police and the staff of the local hospital with mobile phone connections.

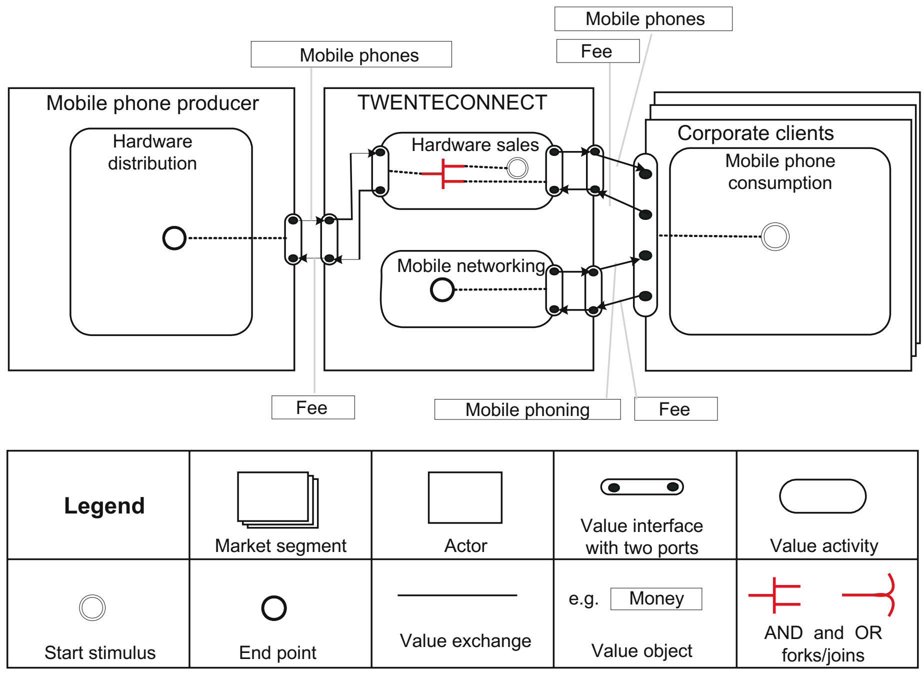

Fig. 2. The "TwenteConnect Mobile Phoning" - Example

Suppose, the mobile operation infrastructure is already settled and the company has all it that should be provided to the corporate clients. TwenteConnect relies on a collaboration with a well-known mobile phone producer, whereby the producer's mobile phones are (i) bought by TwenteConnect at markdown prices, (ii) bundled with communication services (calling cards, voice mail, wireless web access, SMS) and corporate-client-specific rate plans, and (iii) offered as a value proposition to a corporate client. Suppose the regional police service and the general management of the local hospital opt to TwenteConnect value proposition, then TwenteConnect will devise a specific fee-to-be-charged schemas on annual basis for each of these clients and - in return, each client will receive a customizable package of mobile communication services and staff members' phones.

Value model. Figure 2 shows an e^3*-value* model of the value web. The following symbols are used. An *actor* is a participant in the value web and an independent, rational economic entity. In our example, the mobile phone producer and TwenteConnect are actors. A *market segment* is a group of actors that share the same needs. Actors exchange *value objects* with each other. A value object is anything that is of value for at least one actor, such as money, a service, a product, or an experience. e^3*-value* principle of economic reciprocity is hereby assumed, so that a transfer of a value object is always coupled to a reciprocal value transfer. Value objects are transferred through *value ports*. *Value interfaces* are groupings of value ports. A *value exchange* between two actors, then, connects two value ports with each other and represents an atomic trade of value objects between value ports. *Value activities* can be assigned to actors and represent a collection of operational activities, which must yield profit. To show which value exchanges are needed to fulfil a consumer need, we can draw a *scenario path,*, which is a set of connected line segments that starts with a circle with a double line (representing the occurrence of a the consumer need) and ends in single lined circle (representing the boundary of our model). *AND/OR* elements can be used for merging and splitting parts of a scenario path.

Figure 2 shows that Corporate clients buy a package from TwenteConnect in one atomic exchange (because it is one value interface), consisting of hardware and mobile networking. TwenteConnect buys the hardware from a mobile phone producer.

Assessing economic sustainability of a value web. As far as a value web is a network of profit-and-loss responsible businesses (or business units), each of them has the goal to act in a profitable way. We already mentioned that we use two techniques ensuring viable participation of the actors in a value web. Coming back to our business case, we want to evaluate whether the test phase promisses a (positive) net value flow for TwenteConnect. We consider that the local hospital has a need of 20 and the police has a need of 80 mobile phone connections and mobile phones, so in complete 100. For each mobile phone TwenteConnect has to pay 40 Euros to the mobile phone producer (100*40€=4.000€), but sells it for 1 Euro to its corporate clients (100*1€=100€). TwenteConnect sells the connectivity as a monthly mobile phone flatrate for 15 Euros (100*15€=1.500€/month). If we consider the time-period of one year we can assume to get a net income of 14.100€(-4.000€+18.100€=14.100€). Note that the second year will differ in such a way that the income will be even 18.000€, because everybody from the police and hospital already has a mobile phone and we assume two years of average usage of such hardware.

Furthermore, to address the time value of money, we can use DNPC. Take the first time-period were we already calculated an undiscounted net value flow of 14.100€. By discounting it, let's say with an interest rate of 5%, we have a value at the start of the first period of just 13.428,57€. If we discount the net value flow for the second year ($18.000/1.05^2$), the value will at the start of the first time-period be just 16.326.53€, instead of the previously calculated net value flow of 18.000€. The DNPC approach also allows to include expenses for investments. Suppose TwenteConnect needs to make an investment for a software piece amounting to 3525€, for realizing the business case. In terms of the DNPC this is called an upfront investment, where a special time-period 0 has to be introduced. Table 1 compares the (undiscounted) net value flow calculations with the DNPC for the two mentioned years (period 1 and 2) with an upfront investment period 0 to include the investment.

Table 1. Comparing evaluation approaches: net value flow vs. DNPC

Period	Revenues	Expenses	Investments	Net value flow	DNPC
0			3.525	-3.525	-3.525
1	18.100	4.000		14.100	13.428,57
2	18.000			18.000	16.326,53
Total				**28.575**	**26.230,10**

Identification and allocation of e-services. As an example, consider the interaction between TwenteConnect and the mobile phone producer. As represented by the start stimulus inside the value activity Hardware Sales in TwenteConnect, whenever TwenteConnect needs to restock on mobile phones, it buys them from the mobile phone producer. This requires IT support for ordering, purchasing and payment. The set of transfers of value objects between TwenteConnect and the mobile phone producer are showing the interaction, and are thus representing an e-service in our web of services. TwenteConnect will need to decide whether to develop this support from scratch, or to adapt an existing (legacy) system, or to acquire an IT product from the market to provide this support. If the support is developed from scratch, TwenteConnect may decide to do the development in-house or to outsource it. If the IT support is acquired on a market, TwenteConnect has to decide whether to buy a COTS (commercial-off-the-shelf) package or to buy the required IT-service from a third party.

These decisions are made in the context of a current portfolio of IT systems (figure 1) and in the context of what the mobile phone producer is willing to implement in *its* value interface to TwenteConnect. This leads to a mutual adjustment process in which everything can change:

- TwenteConnect as well as the mobile phone producer may have to change their decisions regarding IT support for the purchasing function, because each may have to adapt to what the other is willing to do;
- The value model may change because third parties may get involved (e.g. an IT supplier or an outsourcing party);
- The DNPC computations may change because each of the possible decisions about IT support influences initial as well as recurring expenses.

IT requirements are just one factor in this process of mutual adjustment (alignment) of IT, value model, value analysis, investment analysis, and business processes.

Classical ISP techniques such as context diagrams and data models (figure 1) can be used in all cases to document the integration with the chosen solution with other IT of TwenteConnect. Only if TwenteConnect decides to build the required IT support itself, will these techniques be used to document the design of the required IT systems.

IT investment calculations. In portfolio management, the decisions how to provide the required e-services will be made financially, using classic investment analysis techniques [30,31]. For example, as part of a particular solution, additional hardware and software may have to be bought and maintained, maintenance may have to be bought, etc. Each of the possible solutions will have to be evaluated using a particular investment computation. Different computations are possible [31]. For instance, consider again our initial investment of 3525 €. Given this item of information, we could calculate the length of time required to recoup the investment. This is called the *payback period* and would be in our case just three months. More in line with value modeling would be to use net present value methods, in particular to use the DNPC computations already done as part of the value web design. The choice of investment analysis technique is actually up to each business actor; but in combination with e^3-*value* , a discounted evaluation technique should be used. Each solution option has a particular set of expenses associated with it, that are fed into the DNPC computations at the value modeling level (figure 1), which leads to updated net present value estimates that can then be used to analyze this investment in the context of their current IT portfolio.

5 Discussion and Further Research

Summary. Information systems planning (ISP) deals with defining an overall alignment between business and IT. Traditional ISP has a 1970s background and assumes a single point of decision making, ignores legacy systems, and assumes a time-consuming top-down approach in which global enterprise models are made. These assumptions fail in modern networked businesses. Portfolio management has come into use to deal with the problem of legacy systems and with the current, high speed of change of business development. In this paper, we proposed using value modeling to deal with the absence of a single decision point, and with the problem that in a value web, no global ISP-like models can be made. We proposed a scheme for relating all these different techniques, and illustrated our approach with an example.

The role of ISP. In our approach, value modeling and portfolio management are used as a front end to traditional ISP. Value modeling proposes and analyzes possible business models for actors in a value web, where a "business model" is "a way of doing business" for each actor. Portfolio management can be used by a business actor in the network to map the IT services required by participating in the value web, to its internal IT systems. ISP serves two purposes in our approach. The first purpose of ISP is to document and maintain an enterprise-wide IT architecture. When used for this purpose, ISP provides techniques such as context modeling, data modeling and process modeling that allows business architects, IT architects and requirements engineers to specify how particular IT systems fit into the overall architecture of a business actor. Where portfolio management techniques focus on monetary aspects of integrating an IT system into a portfolio, ISP techniques focus on architectural and semantic issues involved in integrating an IT system into the set of all IT systems of a business.

The second purpose of using ISP is relevant when a particular IT system is built rather than acquired on a market. In this case, ISP techniques will be used in the classic ISP-way to specify the functional and non-functional requirements of a new system.

The role of requirements engineering. Figure 1 is actually a model of how to perform business-IT alignment in a networked context. It presents a particular view on how to perform RE in such a context. We view all activities in the diagram as RE activities: Value modeling and DNPC analysis identify the e-services offered and consumed by actors in the value web, portfolio models map the services offered and consumed by one actor onto the internal IT systems of this actor, and ISP tells us how these services are allocated to individual systems and are integrated into the overall IT architecture. In this context, RE comes in many variants:

- adjusting e-services identified in the value model to the capabilities offered by current legacy systems, or to possible new systems, or to COTS packages, or to the capabilities offered by a third party;
- adjusting legacy systems, possible new systems, COTS, or third party services to the requirements imposed by the value model;
- adjusting the requirements of IT systems to the capabilities of the systems of partners to be interfaced with;
- adjusting the requirements of IT systems to what is economically profitable according to investment analysis;
- updating the investment analysis to what is required by the e-services identified in the value model.

Clearly, we cannot claim that the above list is complete. It, though, provides enough evidence indicating that it is not realistic to define a single RE method that suits all the cases. Instead, what seems achievable is the definition of a set of techniques, each one being a good fit to some cases and not to others. Our future research will be focussed on the design of some of those techniques.

Future research. Our future research will be case-study-oriented, in which we will perform pilot studies for organizations wishing to participate in a value web. Our first case will concern distributed balancing services in an electricity network [32]. Other cases will be acquired through our business partners in the VITAL project.[2]

In these studies, we will focus on the alignment of functional and non-functional requirements for e-services. We are interested in further investigating a number of

[2] See `http://www.vital-project.org/`

questions: What properties of an e-service can we actually derive from a value model? Which nonfunctional attributes can be derived from a value model and its DNPC computations, and how much design freedom does the IT architect have regarding some of these attributes? How do we trade off different options for a portfolio to realize functional or nonfunctional attributes? What is the minimum information a business actor in a value web must release in order for other actors to be able to make their design decisions? Do all actors need one, shared value model or can they work with incomplete models?

These are actually design questions, and therefore our studies will not be strictly empirical case studies, in which the researcher refrains from interfering with the subject of study. Instead we anticipate action research studies, in which the researcher joins the subject of study in order to improve the case, learn from this and transfer some of this knowledge to the subject of study. We will report on the result of our action research in the future.

Acknowledgments. This paper benefited from our discussion with the other researchers of the VITAL project team.

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