17th Bled eCommerce Conference
eGlobal
Bled, Slovenia, June 21 - 23, 2004

Ontology-Based Analysis of e-Service Bundles for Networked Enterprises

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Abstract

Model-based approaches to developing multi-enterprise e-Business initiatives help involved enterprises understand the initiatives by creating a shared understanding as a basis for profitability assessment. Still, when developing a business model where multiple potential enterprises may participate in offering a service bundle, complexity increases, and the need arises for automated support for the selection of services to include in the service bundle, implying also a selection of partners to work with. To put it differently, given a set of potential services to include in a business model, we need tools to *configure* one or more feasible service bundles, and to reason about the pros and cons of service bundles. Then the business analysis can be completed by calculating profitability of these service bundles. The configuration process takes into consideration inherent dependencies between available services. Its output is a set of suggested service bundles, based on these dependencies as well as possibly other given requirements related to service properties as price, quality and more. In this paper we present a methodology for doing all the above. We discuss and exemplify theoretical fundaments for such a methodology, in the framework of an e-Business analysis.

1 Introduction

A consequence of the Internet's diffusion is that more and more enterprises jointly offer their e-Services as a *bundle* [Grönroos 2000, Lovelock 2001] to their customers. We view e-Services as normal, commercial services which can be ordered and/or fulfilled via the Internet to a certain extent. Various reasons exist for bundling e-Services. First, a bundle may present a more comprehensive offering that better fits customer demands. Second, a supplier may expect to earn more by selling a bundle rather than to sell the separate units [Choi 1997]. Third, a bundle may be offered for a cheaper price compared to the totalized price of the bundle's individual elements; for instance due to a better utilization of existing technical, human or information infrastructures. Finally, the Internet obviously plays an enabling role in offering multi-party e-Services. Many of such services are only possible with integrated software components on which such services rely.

A first step in developing a multi party bundled service offering is the design and assessment of a *business model*. Such a model shows the actors involved and what they exchange of economic value with each other. Developing a multi-enterprise business model is a very complicated task; as we have argued in [Gordijn 2003b], a *conceptual modeling* methodology for such an analysis helps stakeholders reach a better understanding of the business model, and enables them to assess the profitability of suggested business models. Conceptual models are described formally by an *ontology*. Ontologies are formal representations of a domain, and serve as an important tool in making domain knowledge machine-readable. [Borst 1997b] defines ontology as 'a formal specification of a shared conceptualization'. The *e^3-value* methodology [Gordijn 2001, Gordijn 2003a] – based on the *e^3-value* ontology – is an established multi-actor approach for developing e-Business models, taking into consideration the importance of *economic value* for all actors involved, and the intertwining of business *and* technology. When applied to the service industry we found that an *e^3-value* business model does not provide a logical framework for reasoning about how to *bundle services*. Such a business model cannot describe in detail the variety and complicate nature of potential service bundles. Nor does it handle inherent dependencies between multiple services, such as 'service X may not be offered without service Y'. This information is necessary in order to configure feasible service bundles and to point out differences between and redundancies among possible service bundles. Thus, we need extra information on services, to facilitate a complete business model analysis of service offerings. Consequently, we suggest using the *e^3-value* ontology with a service ontology that provides a conceptualization of special service characteristics, not present in a value ontology. Our service ontology, presented in [Baida 2003b, Baida 2004], provides a conceptualization of services, seen as components that require some inputs and provide some outcomes. Dependencies between services are also formalized, providing a mechanism for reasoning about which services must or may be part of a service bundle, and why. Using both ontologies together enables us to evaluate complex service offering scenarios. Our methodology includes the following steps:

1. Create an initial business model, using the *e^3-value* ontology. Elementary services can be identified in this model.
2. Model these services using the service ontology, and define feasible service bundles by applying the service ontology.
3. Reason about the identified service bundles, using knowledge modeled in the service ontology, and choose the preferred service bundles.
4. Use the *e^3-value* ontology to assess profitability of the chosen service bundles.

In the first step and in the last one we use a value ontology. The added value of using and applying the service ontology in steps two and three is that step four becomes feasible: only once interesting and feasible service bundles are identified, do we assess profitability.

We chose the *e³-value* ontology as a starting point, rather than another value ontology, due to its lightweight nature and because it is designed for modeling multi-enterprise scenarios. Other value ontologies either focus on a single enterprise [Uschold et al. 1998, Fox and Gruninger 1998] or lack the lightweight nature [Osterwalder and Pigneur 2002].

The contribution of this paper is in presenting and explaining this methodology for a multi-enterprise business analysis in the service sector so that the business model becomes clear to stakeholders, and the scope of the analysis is narrowed to a manageable level. We demonstrate it with examples from an extensive project we have been carrying out in the energy sector. The remainder of this paper is organized as follows. In Section 2 we present the energy domain, which will be used as a running example. Section 3 discusses the first step in our four-steps methodology. Sections 4 and 5 present an overview of the service ontology, and discuss steps two and three in our methodology. Section 6 discusses the last step of our methodology. Finally, in Section 7 we present our conclusions.

2 e-Services in the Energy Sector

In Europe, more and more final customers are able to choose a preferred electricity supplier. This is due to liberalization of the electricity industry, compared to the old days where energy supply was a government-controlled activity. Commercially, one of the disadvantages of the electricity product is that for power supply companies it is hard to distinguish themselves, due to the anonymous nature of this product: electricity from different suppliers is delivered according to the same standard and consumed through the same electricity socket in a customer's home. Consequently, companies face difficulties in competing with each other. One way to differentiate is to offer additional services such as Internet access, (software) application service provisioning and home comfort management. Most of these services can be ordered and provisioned via the Internet. Moreover suppliers can use existing infrastructure and/or available business processes to deploy such extra services (Internet via the electricity network is common technology), so bundling these services (e.g. with the traditional electricity product) can be done with relatively modest effort. The experience however shows that the bundling of services without sound logical fundaments of the bundles-configuration process and disregarding customers' demands may cause severe financial losses [Dagens Næringsliv 2001, Marthinussen 2002].

The study presented in this paper utilizes and exemplifies our service and value ontologies as well as existing work on configuration theory [Gruber 1996, Löckenhoff 1994, Borst 1997a, Borst 1997b], using a project we carried out for a Norwegian energy supplier. This supplier wishes to offer via a website bundles of electricity and other services, offered by other suppliers. The business idea is that given a list of predefined services, modeled based on the service ontology (see Section 4), customers can use a *Graphical User Interface* to define *online* a set of services (a service bundle) that meets their demands. The services are offered by several suppliers, thus a customer's choice of a service bundle implies also a choice of suppliers. In the present analysis suppliers analyze possible bundles that they can offer to their customers through a website. Also from the supplier's perspective, the choice of bundles to offer implies a choice of other suppliers to work with.

3 An *e³-value* model for Energy Services

A first step in creating a multi-enterprise business model is to understand the elementary services that are possible. In many cases, these services cannot be easily enumerated, simply because stakeholders do not have a clear view on such services. To this end, we have constructed an *e³-value* model (see Figure 1) that shows the services enterprises are offering to customers, as well as what they request in return. The construction of such a model involves eliciting services that exist in reality (or that stakeholders want to develop). The *e³-value* methodology has been discussed extensively elsewhere [Gordijn 2001, Gordijn 2003a], so we only present the model itself. Additionally, due to model complexity and lack of space, we only present a fraction of the model here. A tool to draw *e³-value* models, to check these, and to assess profitability based on such models can be obtained from http://www.cs.vu.nl/~gordijn/tools.htm.

First, Figure 1 shows a number of *actors*, in this case a final customer, and a number of enterprises offering a range of services (e.g. *TrønderEnergi Kraft AS*, and *Smartkonseptet*). All actors, except for the final customer, are partly or fully owned by a larger concern, or a *composite actor*, called *Trønder Energi*. Such a composite actor models that some legal enterprise consists of smaller profit & loss responsible enterprises.

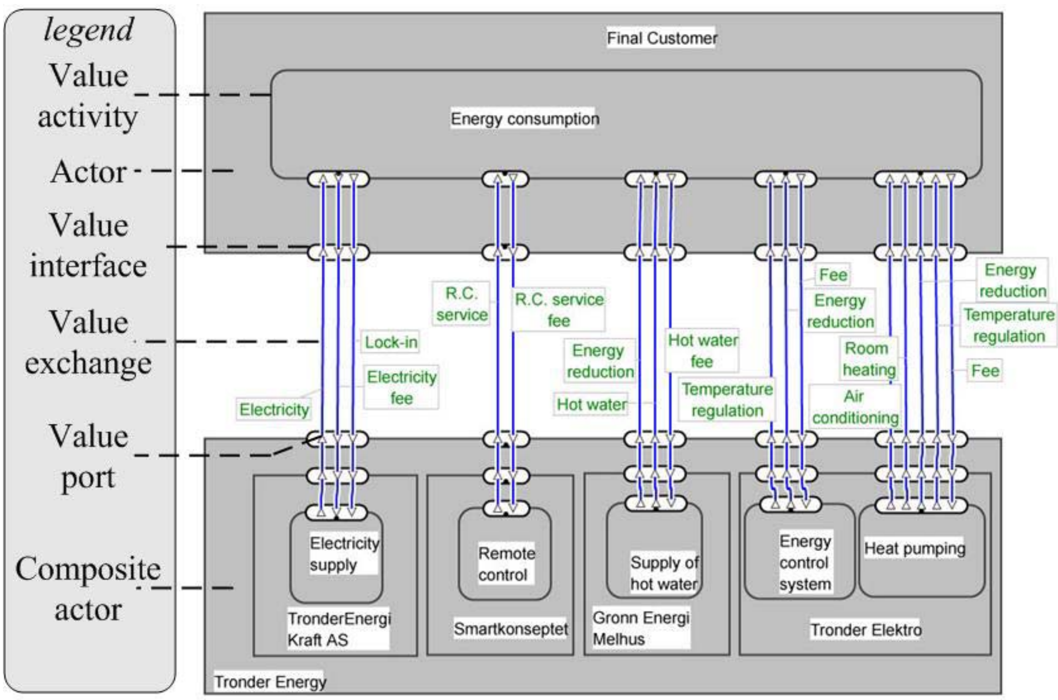

Figure 1 Initial value model for energy services. The legend is not part of the e³-value notation.

Actors exchange *objects of economic value* with each other, e.g. physical objects or fees. We model *only* things of economic value, and e.g. not information required for business processes. This ensures that stakeholders concentrate on understanding the values offered and requested, and nothing else. Examples of value objects in this case are *electricity*, the capability of *remote control* of devices such as heaters or coolers, and the capabilities for *energy consumption control* and *temperature regulation*. All fees are value objects too.

Value objects are offered and requested via *value ports*, depicted by arrows. The arrow shows whether a particular actor requests or delivers an object of value to or from its environment. Ports are grouped into *value interfaces*, depicted by small rounded boxes surrounding two or more value ports. Such a value interface fulfills two modeling purposes. First, a value interface models *economic reciprocity*. For instance, it says that electricity is delivered only if a fee is paid in return, and vice versa. Second, a value interface may represent *bundling* [Choi 1997], saying that two or more value objects are offered (or requested) only in combination. Figure 1 does deliberately not represent such a bundling case. In this paper, we discuss how to find such bundles for known elementary services (see Sections 4 and 5). Additionally, in Section 6 we show how to represent found bundles in *e^3-value* models.

Value ports are connected by *value exchanges*, represented by lines. Exchanges represent that actors are willing to exchange objects of value with each other.

Finally, rounded rectangles represent *value activities*. These are activities that are supposed to be profitable for at least one actor. The main rationale for such activities is to distinguish actors (enterprises) from what they are doing to make profit (value activities). The use of the *e^3-value* methodology in networked enterprise analysis has shown that the discussion on 'who does what' reflects an important business design decision.

The value model in Figure 1 represents actors, activities they perform, objects of value they offer and what they request in return. However, it does *not* show which meaningful bundles of value objects can be constructed. In a complex value model with many actors and value objects, finding these bundles is a far from trivial task. Moreover, the *e^3-value* ontology is not of help here, since it does not model *considerations* to bundle objects (or to exclude certain bundles); it can only model bundles *themselves*. To this end, we propose a service ontology that connects well to the *e^3-value* ontology, with the aim to assist in finding such bundles specifically for services.

4 A Service Model for Energy Services

The service ontology presented in [Baida 2003b, Baida 2003a, Baida 2004] describes formally a shared view on what services are with the aim to compose (or: configure) complex services out of more elementary services supplied by different enterprises. It is based on accepted terminology from the service literature [Zeithaml 1996, Grönroos 2000, Lovelock 2001, Kasper 1999, Kotler 1988 and more].

On a high level of abstraction, the service ontology embodies three interrelated top-level perspectives: *service value, service offering* and *service process*. The service value perspective describes a service from a customer's point of view in terms of a customer's needs and demands, his quality descriptors and his acceptable sacrifice, in return for obtaining the service (including price, but also intangible costs such as inconvenience costs and access time). The service offering perspective describes a service from a supplier's perspective; it provides a hierarchy of service components (service elements) and outcomes, as they are actually delivered by the service provider in order to satisfy customers' demands. The service process perspective describes how the service offering is put into operation in terms of business processes. In the rest of this section we will focus on the *service offering* perspective to describe available services.

As Figure 2 shows, **service elements** are the building blocks of a service bundle. They represent what a supplier offers to its customers, in supplier terminology. It is what the business literature defines as *service*, a business activity (performance) of mostly intangible nature [Grönroos 2000, Kotler 1988, Zeithaml 2001]. Elementary services result from our initial value model (see Figure 1). *Value activities* in the *e^3-value* ontology correspond to *service elements* in the service ontology. Additionally, *value objects* result in *resources* (see further).

A service element can be a composite concept; it can be decomposed into smaller service elements, as long as the smaller service elements can be offered to customers separately or by different suppliers. A **service bundle** is a set of one or more service elements that can be provisioned together, as a whole. We modeled numerous services that can be offered to customers in a bundle that includes energy supply: electricity supply, electricity transmission, hot water distribution (for room- and water-heating), broadband (Internet) access, IT-services, sales and installation of electrical appliances (heat pump and energy control system, to reduce energy consumption and to regulate temperature), and (temperature) remote control.

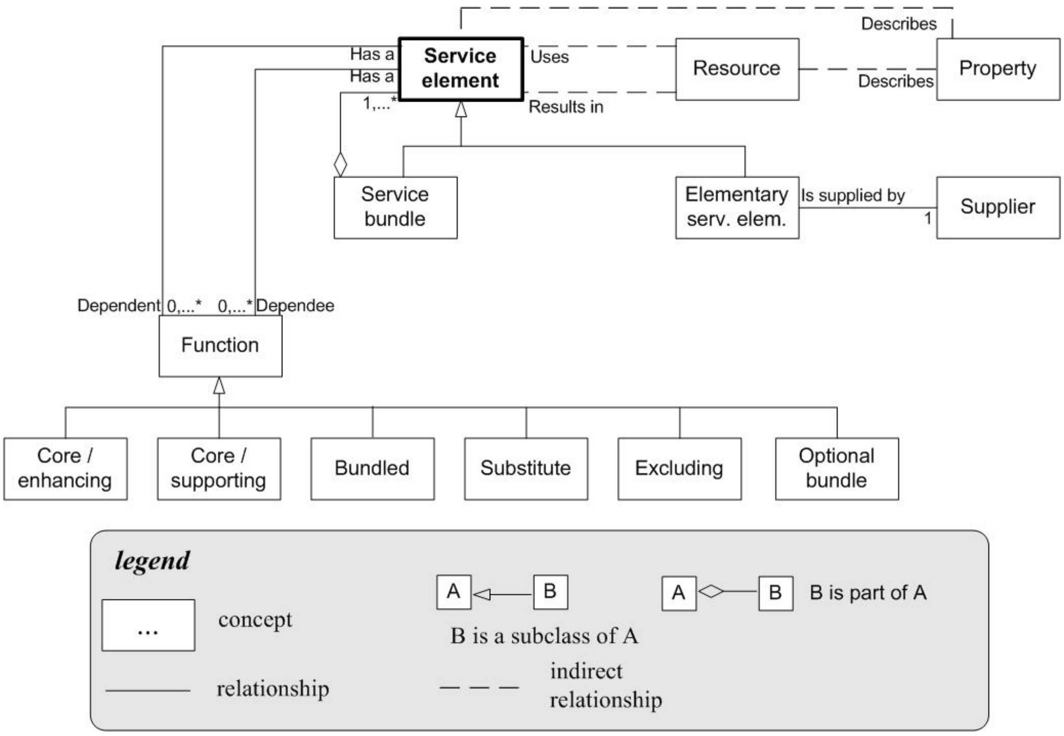

Figure 2 Service offering perspective of the service ontology

Resources are either pre-requisites for the provisioning of some service element (*service inputs*), or the results of a service element (*service outcomes*). Very often the outcomes of a service reflect the customer benefits from a service. Resources may be of several types: physical goods, human resources, monetary resources, capability resources (the ability to do something, which is of value to an involved party) and more.

Functions are relationships that define dependencies between two service elements. They represent business-related constraints on how these service elements may or may not be bundled. For every pair of services A and B, a function between A and B determines whether A may be provisioned separately of B, whether B can be provisioned instead of A and whether A and B may (or must) be provisioned together. A thorough discussion on *functions* can be found in [Baida 2004]. Examples are the *core/supporting* function, *core/enhancing* function, *substitute* function and *excluding* function.

Figure 3 is a partial visualization of two service elements: *electricity supply* and *heat pumping*. The symbols 'OB' mark functions between the involved service elements: *Optional Bundle*. This function can be interpreted as 'two services may be provisioned separately or together; there is business logic in bundling them, but they may also be provisioned independently.' A tool to make such visualizations can be obtained from http://www.cs.vu.nl/~ziv/tool.

The 'base' e^3-*value* model did not consider dependencies between different service elements, making development of financial calculations for the model very time-consuming due to the multitude of possible solutions; the task of selecting feasible bundles becomes very demanding. The service ontology was applied to resolve this problem, narrowing the scope of our primary business model by:

1. A very large number of service bundles could theoretically be created using all given services. The service ontology identified those bundles that are feasible and are driven by business logic, omitting all other theoretically possible bundles (step two in our methodology)
2. Providing knowledge on services, to facilitate a reasoning about a choice between the feasible bundles (step three in our methodology)

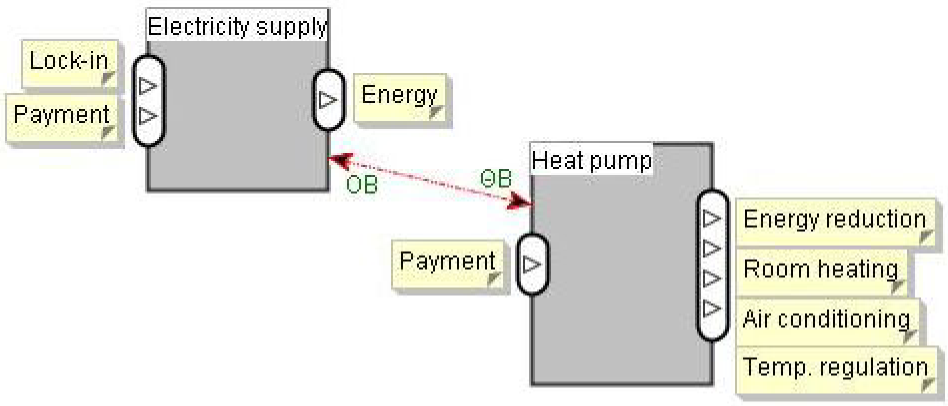

Figure 3 Example service elements: electricity supply and heat pumping. *Service Inputs* are shown on the left side of a service element, and *Service Outcomes* are shown on the right side thereof

By applying *functions* between service elements, we generated a set of all feasible service bundles, omitting infeasible bundles and bundles that have no business logic (in a supplier's eye). Examples of feasible bundles are:

1. Electricity supply and heat pumping
2. Electricity supply and hot water
3. Electricity supply, energy control system and remote control

No dependency (*function*) exists between *heat pumping* and *hot water*, because there is no business logic behind a bundle that includes only these two services (a heat pump reduces electricity consumption, but when hot water replaces all the use of electricity for heating, there is no electricity consumption to reduce). Consequently the bundle of *heat pumping* and *hot water* is irrelevant, and was not generated as feasible. On the other hand, since a function between *remote control* and *energy control systems* requires that *remote control* is not sold without *energy control systems*, all possible bundles with *remote control* but without *energy control systems* are invalid, and were not generated as feasible.

5 Business Analysis Using the Service Ontology

In step three of our methodology we reason about all theoretically feasible service bundles, and make a choice about preferred bundles. Our reasoning is based on the assumption that a supplier wishes to offer service bundles that satisfy its customer needs and demands. These are modeled in the *service value* perspective of our service ontology. We modeled them and linked customer demands to available services and service outcomes (see Figure 4). These links have the form of *'IF demand-X THEN service outcome-Y'* and *'IF service outcome-Y THEN service element-Z'*, reflecting a logical correlation: service element Z provides service outcome (resource) Y, which can satisfy demand X. Demands and resources can be described by quality criteria, such as productivity, availability and more.

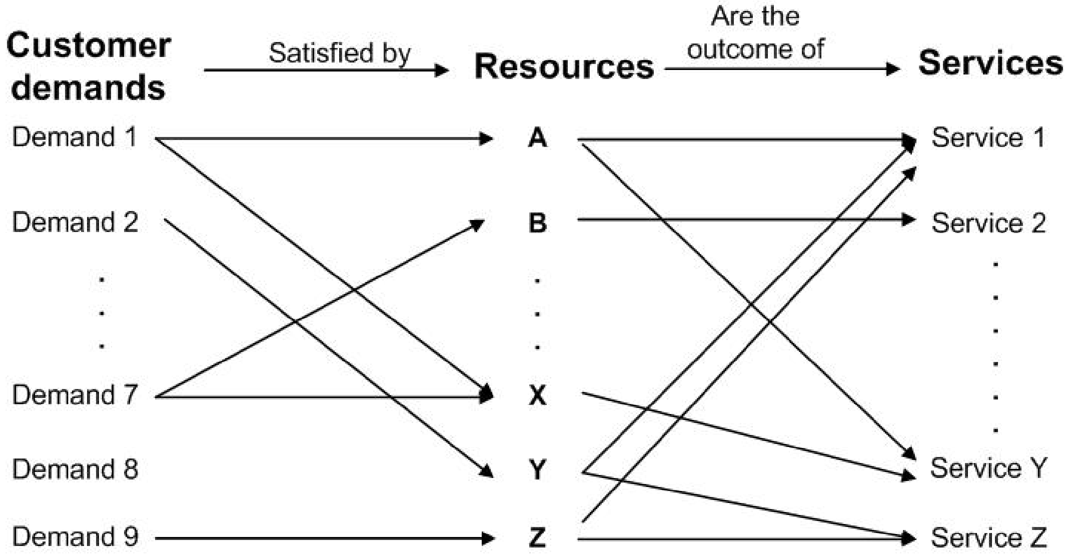

Figure 4 Linking customer demands to services and their outcomes

Applying these links resulted in sets of feasible service bundles per customer demand. In other words, we identified which bundles satisfy the same customer demands. Based on knowledge that the service ontology provides, business developers can then reason about these bundles. Some of them may appear to be redundant (because they compete with each other on satisfying the same customer demands). Others may be suitable only in certain circumstances (certain areas or customer types), as we will show in our running example. When suppliers reason about a choice of one or more bundles to offer, they actually make a choice of partners to work with.

To satisfy customer demand for *energy supply* a bundle may theoretically include almost any combination of the following services: *electricity supply, heat pumping* and *hot water* (as well as other obligatory services that we do not discuss here). However, the service ontology provides extra tools to narrow the scope of our analysis:

- *Hot water* (replacing part of the electricity consumption, for a lower price) is available in a limited geographic area only; hence, different service offerings are possible in different areas.
- Customers would prefer bundling *electricity supply* with *hot water* to bundling *electricity supply* with *heat pumping* due to a lower price. Consequently, where the *hot water* service is available, offering *electricity supply* with *heat pumping* may be less attractive.

Let us now take a new customer demand into consideration: *temperature regulation*, for indoor comfort. The following service elements satisfy this demand for commercial customers: *heat pumping, energy control system and remote control*. Also here the service ontology provides extra information for our business analysis:

1. *Manual and location-dependent*[1] (only on-site) temperature regulation requires the following service elements: *electricity supply* and *heat pumping*. If a customer already consumes these services for his energy supply, manual energy regulation is available with no extra costs.
2. *Automated and location-dependent* (only on-site) temperature regulation requires the following service elements: *electricity supply* and *energy control system*.
3. *Automated and location-independent* (via a website) temperature regulation requires the following service elements: *electricity supply, energy control system* and *remote control.*

Suppliers may then decide whether they want to offer all three services, or whether they want to profile themselves as en e-Energy supplier, and supply only the online temperature regulation version. If *electrical appliances* and *remote control* are offered by different companies, this implies also a choice of partners to work with. Although all three bundles satisfy the same customer demands, as we have seen they are essentially different due to their properties. For our example let us assume that the choice was made to supply the first and the third of these bundles.

6 The *e³-value* Model Revisited

In the last step of our methodology we develop business models for the chosen bundles, followed by a profitability assessment of these bundles. Profitability assessment is not shown here (see for a detailed explanation [Gordijn 2003a]), but only how found bundles can be fed back into an *e³-value* model. All feasible bundles that were not chosen in step three are discarded, so their profitability need not be assessed. Chosen bundles can be shown in a revised *e³-value* model (see Figure 5). In this case we restrict ourselves to bundle 3 as explained in the previous section. A customer *demand* as identified in the service ontology, e.g. *automated, location independent temperature regulation*, is represented by an *e³-value start stimulus*. Such a stimulus shows the consumer demand, and connects to one or more value interfaces of the actor that has such a demand. The actor then exchanges objects of economic value to satisfy the demand via one of the connected value interfaces. In our case, the demand is connected to three interfaces via an AND-fork, saying that in order to satisfy the need, the actor must exchange objects via *all* three interfaces. Information elicited by using the service ontology was very useful when calculating profitability of the chosen bundles. For example: in the initial *e³-value* model it was difficult to define some value exchanges, because we had to make assumptions, e.g., about the demand. The service ontology-based model allows us to verify the existing financial formulas and create the missing ones because it includes more details. Take for example the bundle that includes *electricity supply* and *heat pumping*: we can make a better assessment of electricity consumption (and thus the costs) during winter and summer for a given customer, because this information is modeled using the service ontology (consumption will be reduced during the winter and increased during the summer). We can derive very realistic figures, based on the composition of the bundle.
A found bundle in the previous section is represented in Figure 5 as a value interface for the composite actor *Trønder Energi* that bundles ports exchanging a *remote control service, electricity*, and *energy control*. Additionally, the reciprocal value objects (fees, lock-in) are also shown in the value interface. Note that a value interface exactly models bundling: it is only possible to obtain the bundled

[1] Manual/automated and location-dependent/independent are descriptors of resources.

services *in combination*, in return for the sacrifice stated. Other bundles found can be modeled similarly. In the project carried out, step two generated dozens of feasible bundles, based on seven elementary services. In step three we chose only a subset thereof for profitability assessment. These bundles are not shown here for reasons of brevity.

7 Conclusions

Developing a multi-actor business model for *e-Service bundles* involves various potential partners, each offering a number of services; only a subset of these services has to be selected for a business model. However, why choose for one service or another? Assessing profitability of all possible scenarios is often undesired, because it is a very time consuming task. In this paper we have presented an ontology-based methodology to tackle this problem. Our methodology provides a means to conduct automated reasoning on the selection of one service or another for a service bundle, eventually resulting in one or more feasible service bundles that satisfy certain customer demands. When multiple feasible service bundles satisfy the same customer needs, it is important to be able to reason about differences between the bundles, to make a decision about one or more bundles, reflecting one or more business models to develop. Since we choose only a subset of the feasible bundles, our business model will have a much narrower scope than a model that takes all possible partners (and services) into consideration, and does not enable reasoning about bundles. The service ontology was applied to resolve the complexity problem of a business analysis in the energy sector by narrowing the scope of our primary business model. Consequently, less effort has to be put into profitability assessment.

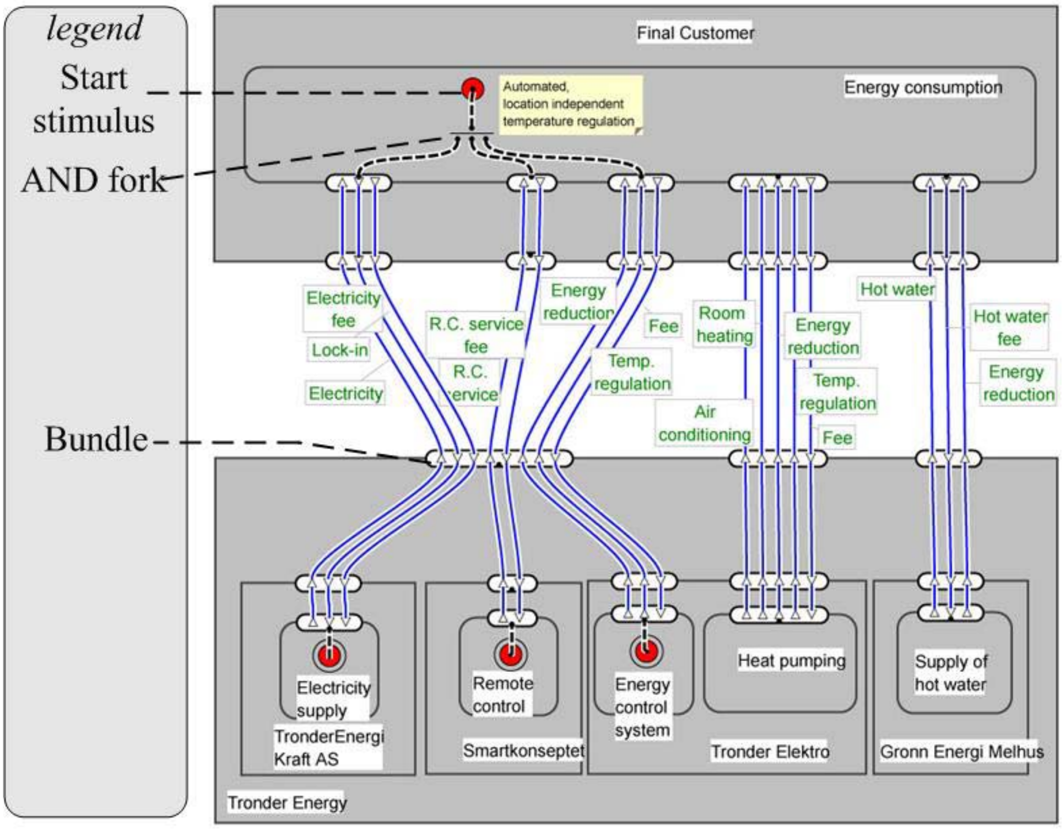

Figure 5 A revised e^3-*value* model, reflecting bundling decisions

In our present study an energy supplier wishes to bundle electricity supply with other services, provided by a number of suppliers. The questions at hand are with which other services to bundle *electricity supply*, and whether the resulting business model(s) will be profitable. Even with a limited set of available services, the number of possible bundles can get very high. We started with an initial business model, where a set of available services was identified, with which a very large number of bundles could be defined; assessing profitability for all service bundles would cost too much time. No mechanism was available for selecting bundles. By applying the service ontology in the energy domain, we managed to reduce the task complexity:

1. The number of service bundles for which profitability needs to be assessed was reduced by formalizing and applying dependencies between services, serving as rules for service bundling, or service *configuration*.
2. Knowledge on services was made available, to facilitate a reasoning about a choice between the feasible bundles
3. Information on costs of and demand for services helps make a sound profitability assessment

Acknowledgements
This work has been partially supported by the European Commission, as project No. IST-2001-33144 OBELIX (Ontology-Based ELectronic Integration of compleX products and value chains).

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