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Finding e-Service Offerings by Computer-Supported Customer Need Reasoning

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ABSTRACT

We outline a rigorous approach that models how companies can electronically offer packages of independent services (service bundles). Its objective is to support prospective Website visitors in defining and buying service bundles that fit their specific needs and demands. The various services in the bundle may be offered by different suppliers. To enable this scenario, it is necessary that software can reason about customer needs and available service offerings. Our approach for tackling this issue is based on recent advances in computer and information science, where information about a domain at hand is conceptualized and formalized using ontologies and subsequently represented in machine-interpretable form. The substantive part from our ontology derives from broadly accepted service management and marketing concepts from business studies literature. In earlier work, we concentrated on the service bundling process itself. In the present chapter, we discuss how to ensure that the created bundles indeed meet customer demands. Experience of Norwegian energy utilities shows that severe financial losses can be caused when companies offer service bundles without a solid foundation for the bundle-creation process and without an in-depth understanding of customer needs and demands. We use a running case example from the Norwegian energy sector to demonstrate how we put theory into practice.

Keywords: *conceptual model; electronic services; knowledge management; ontology theory; requirements engineering; service industry*

INTRODUCTION

More and more businesses nowadays offer their services via Internet, either parallel to or instead of the traditional physical channels. Statistics show an immense growth in the percentage of households with Internet access that actually shop online; from 27% in 1998 to nearly 50% in 2000 (Xue, Harker & Heim, 2003). Almost 30% of Internet users in the EU use online banking services, with the Nordic countries as leaders; nearly 65% of Internet users in Finland use online banking (Centeno, 2003). Airlines sell more and more tickets online instead of through traditional travel agencies; check-in is performed online rather than at the check-in counter in the airport. Companies as DHL and FedEx allow customers to follow their shipments through a so-called track-and-trace system. Governments are considering online voting. These are all examples showing the dominant and growing role and importance of e-services in a variety of industries.

Online service offerings introduce a new challenge, with which traditional service suppliers do not have to deal. It no longer is sufficient that only service personnel understands customers' needs; if a supplier wishes to offer customized services through an automated online process, software must be able to reason about these customer needs and about the possible service offerings satisfying such needs, so that the whole process can be provided online. The need for an automated process becomes even greater when a customer wants to buy a service bundle (Grönroos, 2000), a package of more elementary services, offered by multiple suppliers. Each supplier offers its added value, and together suppliers provide a complete answer for a customer need. In such a case, software should be able to decide whether and how to combine services of multiple suppliers into one service bundle.

Our study on creating customer-driven service bundles aims at this new challenge. We present a method for formalizing customer needs and available service offerings, and relate the two to each other. We do not directly address the problem of how to elicit and understand customer needs (although, as we will show, our method helps gain insights into these needs) but focus on the issues of conceptualizing and formalizing customer needs, such that software can configure service bundles satisfying customer needs.

Our research uses well-known and accepted knowledge, concepts, ideas, and terminology from business science literature (Grönroos, 2000; Kotler, 1988; Zeithaml, Parasuraman & Berry, 2001) to describe services from a supplier perspective as well as from a customer perspective. The idea is to conceptualize and formalize well-known business science concepts, not to invent new ones. Additionally, we use practices and ideas from computer science as a means to process this knowledge in order to enable automated support for the bundling process of customer-driven service bundles. One of these practices is the use of an ontology, which is a formal, shared conceptualization of something we assume to exist (Borst, 1997; Quine, 1961), in our case, needs and e-services. The unique contribution of this chapter is in the combination of well-known business science terminology on services with the modeling and conceptualization rigor of computer science.

The work presented in this chapter is not limited to e-services, but can be applied to traditional services as well. Nevertheless, our work is of much greater importance for e-services, since the realization of e-service offerings requires automating processes that may otherwise be performed in the minds of service personnel. For e-services realization, it is absolutely necessary that business knowledge is conceptualized, formalized, and made machine-readable and machine-processable. This is what we aim to achieve in our work.

Our method consists of three steps to be performed in advance, followed by one runtime step to be performed each time a customer wants to create a bundle for need satisfaction:

1. Identify and model customer needs and demands;
2. Identify and model available services;

3. Identify and model relations between needs/demands and available services;
4. Create service bundles out of available services, based on customer needs and demands.

Whereas our earlier work (Baida, Akkermans & Gordijn, 2003; Baida, Gordijn, Sæle, Morch & Akkermans, 2004; Akkermans et al., 2004) focused on steps 2 and 4 of the presented method, in the current chapter we present the whole method, and focus on steps 1 and 3.

In the remainder of this chapter we will use a case study in the energy domain to present our work. After introducing the energy domain, we discuss our research approach, followed by a discussion of a service ontology. We then present a four-step method for ensuring that e-services are demand-driven and discuss it using examples from the energy sector. Finally, we review related work, and present our conclusions.

CASE STUDY: BUNDLING ELECTRICITY SUPPLY WITH OTHER SERVICES

Electricity increasingly becomes a commodity product. Competing suppliers are offering electricity to end-customers, but the price per kWh is (nearly) the same. Additionally, it is delivered according to the same standard and consumed through the same electricity socket in a customer's home. Consequently, many suppliers are seeking competitive advantages by differentiating their product. One way to do so is to add complementary and additional services such as Internet access and home comfort management. In many cases, suppliers can use existing infrastructure and/or available business processes to deploy such extra services, so bundling these services can be done with relatively modest effort.

So, electric utilities in Norway started to offer so-called bundles via their Websites. One could observe a great variety of products and services, which were offered together with electricity retail contracts. Despite costly market campaigns, these offers, for the most part, were not appreciated by customers and failed. Experience has shown that the bundling of services without a sound understanding of the many requirements involved in the bundling process and the customer demands may cause severe financial losses. The need for such a solid and formal foundation necessary for a successful online process is the driving force behind our study in the energy sector.

In our study for an electricity supplier in Trondheim, Norway, we analyze possible service bundles that can be offered via the Web to customers who wish to buy electricity. The outcome of this study for our partner (the electricity supplier) are commercial viable service bundles that meet customers' demands. In Baida, Gordijn, Morch, Sæle, and Akkermans (2004), we have already presented these bundles; in this chapter, therefore, we focus on the aspect of customer demands.

NOTES ON RESEARCH METHOD AND DESIGN

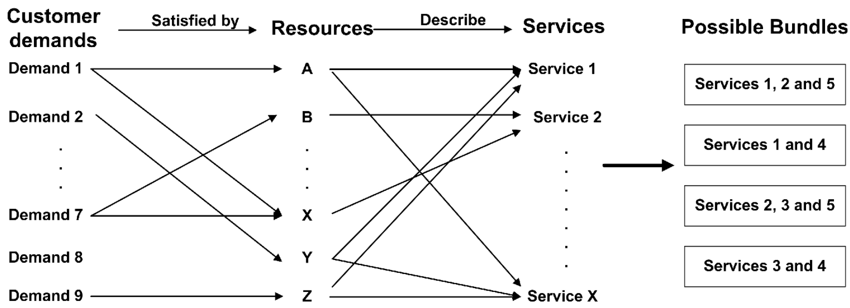
Our research approach represents a departure from traditional quantitative as well as qualitative modes of scientific research in information systems (IS) on several scores. First, the nature and role of theory; we employ formal ontology as a device for rigorous theory articulation. Ontologies are formal conceptualizations of a real-world domain such that they have a computational representation that is fit for automated reasoning. This work is much helped now that there are international standards such as RDF and OWL for knowledge representation on the Web (developed in the context of W3C's Semantic Web effort; OWL stands for Ontology Web Language and was finalized in February 2004). As theories, ontologies are formal (in a logical and/or knowledge-based inferencing sense) yet typically are not expressed in the variable and measure parlance of the common quantitative modes of social and business research (although, of course, this is not strictly excluded). So, usually, ontologies are formalized qualitative theories concerning conceptual structures shared by a community of practice in a domain.

Yet, this does not imply (at least not necessarily) that they are congruent with the interpretivist or naturalist perspectives common in qualitative research. Ontologies are intended to be reusable (this is the typical computer science term) (i.e., generalizable across other settings, contexts, and applications). Therefore, they formalize the agreed-upon (explicit or more often implicit) common understanding in a domain. For example, the ontology partly discussed in the present chapter only reflects and formalizes consensus aspects of service management and marketing as, for example, typically found in textbooks; it does not attempt to express the latest issues as debated in academic literature on services where there is no consensus, nor does it represent highly domain-specific or even organization-specific elements that one will undoubtedly encounter in any thick-description field empirical study. This implies a clear difference in the resulting theory from a strict interpretivist or naturalist perspective. Ontology is better seen as a model-based approach, whereby the quality and success of the model is assessed in terms of whether it is good enough to help in problem solving, as posed by the research goals. This notion of a model-based stance that is different from the standard fare in both quantitative and qualitative approaches has already been recognized and debated a long time ago in the knowledge systems literature (Ford & Bradshaw, 1993; Schreiber et al., 2000) and references therein.

Further, qualitative and quantitative approaches have in common that they (often tacitly) assume that scientific aims lie in (different forms of) explanation. In contrast, our ontology approach is more tailored toward problem solving and innovation in business and industry practice. Thus, its aim is closer to what Hevner et al. (2004) call design science in IS. We mention in passing that, based on previous research, engineering science, and industry experiences, we would take issue with some of these authors' proposed guidelines for academic quality design research, in particular design as a search process and as an (instantiated) artifact, but this is beyond the scope of the present chapter. But certainly in e-business and e-service research, where the field is in a constant state of change and emergence, research goals that go beyond observation, measurement, statistical-variable, or qualitative-interpretive explanation are of prime importance.

All this does have implications for the empirical and test/validation parts of research studies in IS. Ontologies can be tested by computer tooling, modeling, simulation, and analysis. This establishes what is sometimes called their computational adequacy and some aspects of their theoretical adequacy (soundness, consistency, completeness). Their empirical, epistemological adequacy can be tested by (as in our research) case studies in the field. Given the different nature and role of our approach to theory formation, such case studies do not sit well with the conventional typology

Figure 1. Serviguration: Configuring service bundles based on customer demands



of exploratory, descriptive, or explanatory case study. They serve a dual goal. On the one hand, they help validate (part of) generalizable ontological theory. To this extent, they might be viewed as tending toward being explanatory (although not necessarily in terms of causal explanation). On the other hand, however, they aim at helping to solve problems and achieve goals, as specifically perceived by our partners or clients in the study, which are, in the present case, not of an explanatory but of a business development and design nature. A consequence of this positioning of our empirical research is that case study design is not along the traditional lines of external-observer style empirical research but has much more in common with action research.

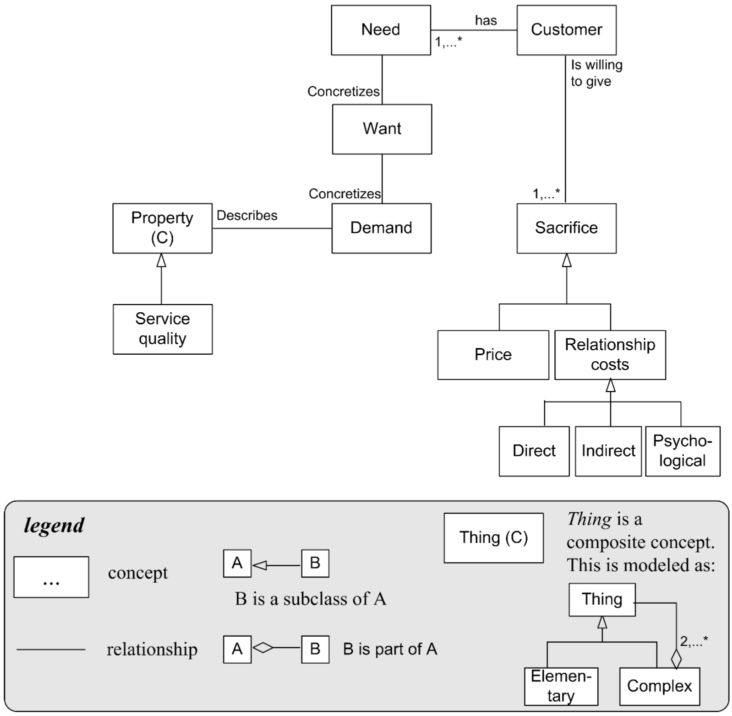
FROM CUSTOMER NEEDS TO E-SERVICES

In this chapter, we present a four-step approach (see Figure 1) to find alternative bundles of e-services that satisfy customer needs. In short, with the help of business experts from the energy sector, we first elicit customer needs and demands, and then describe available services. Since customer demands are satisfied by providing some customer value, we identify relations between demands and outcomes of services (resources, as we call them), that reflect a customer's benefits from a service. When searching for possible services or service bundles that satisfy customer needs, demands (described possibly by subjective quality criteria) are used as selection criteria for resources (benefits, described by objective quality criteria). Resources, in turn, are descriptors of services. Hence, selecting specific demands implies not only selecting certain resources but also certain services that must or can be part of a bundle. Then, based on business knowledge on the inherent dependencies between services (Baida et al., 2004), other services may be included in bundles, or substituting services may be suggested as solutions. The causal chain, from needs and demands through resources to services, ensures that the offered service bundles will, indeed, meet customer needs.

Formalizing Business Knowledge Using a Service Ontology

We formalize business knowledge on services using a service ontology (Baida et al., 2003). On a high level of abstraction, our service ontology embodies three inter-

Figure 2. Service sub-ontology representing the service customer value perspective



related top-level viewpoints or perspectives: service value, service offering, and service process.

The service value perspective (see Figure 2) captures knowledge about adding value. It represents a customer viewpoint on value creation by expressing customer needs, expectations, and experiences, and is driven by a customer's desire to buy a certain service of a certain, often vaguely defined quality, in return for a certain sacrifice (including price, but also intangible costs such as inconvenience, costs, and access time).

The service offering perspective, in contrast, represents the supply-side viewpoint; it provides a hierarchy of service components (a core service and supplementary services) and outcomes, as they are actually delivered by the service provider in order to satisfy customers' needs.

The service process perspective encapsulates knowledge about putting the service offering into operation in terms of business processes. In contrast to the usual production process of physical goods, customers often take active part in the service production process.

The service value perspective and the service offering perspective are relevant for the present discussion and will, therefore, be presented in the following subsections.

Service Value Perspective

The sub-ontology representing the service value (customer) perspective is sketched in Figure 2.

Needs and Demands. The starting point for the discipline of marketing, whether it refers to services or not, lies in the human needs and wants (Kotler, 1988). The term *need* refers to what humans need and want (to buy) and is quite straightforward. A formal definition is given by Kotler (1988), who distinguishes needs, wants, and demands:

- A human need is a state of felt deprivation of some basic satisfaction.
- Wants are desires for specific satisfiers of these deeper needs.
- Demands are wants for specific products that are backed up by an ability and willingness to buy them.

Needs are often vague; the need for financial security, for example, can be interpreted in many ways. Customers concretize their needs by transforming them into wants and demands, based, for example, on their exposure to existing services and to marketing campaigns. In many cases, when a customer is interested in some service, he or she has already transformed needs into wants and demands. As a matter of fact, the customer already has a solution in mind for his or her need (e.g., indoor comfort [need]; lighting [want]; energy supply [demand]).

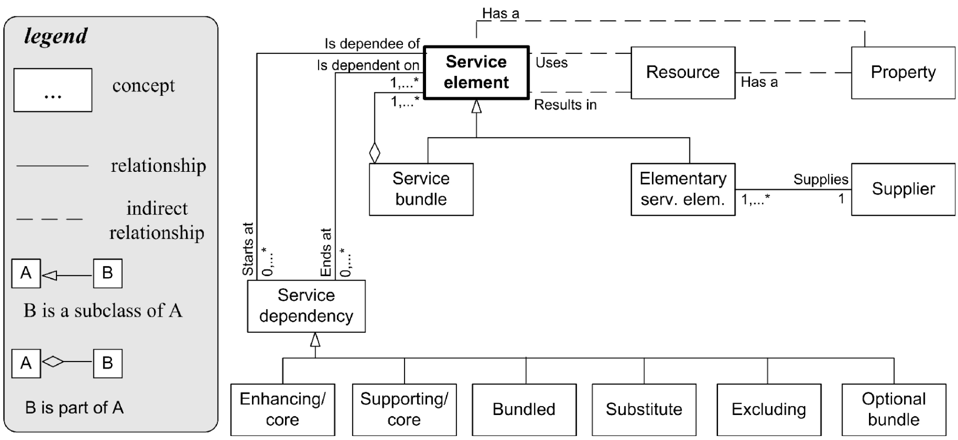
Service Quality. Service quality is the degree and direction of the discrepancy between a customer's expectations and the perception of the service (Bigné, Martínez & Miquel, 1997). Customer expectations embrace several different elements, including desired service, predicted service, and a zone of tolerance that falls between the desired and adequate service levels (Berry & Parasuraman, 1991). Expectations are based on word-of-mouth communications, personal needs, past experiences, and external communications from service providers (Zeithaml et al., 2001). At least two widely accepted generic methods for defining service quality exist: that of the Nordic school (Grönroos, 2000) and that of the North American school (SERVQUAL) (Zeithaml et al., 2001). Nevertheless, quality definition is domain- and market-specific (e.g., high level of reliability, highly individualized service, and fancy conference location). Next to quality description, other criteria also may play a role (e.g., location, where the service should be provided; time, when the service should be provided; etc.). For this reason, we have introduced the concept *property* in our ontology. Service quality, technically speaking, is a property of a customer demand. In the rest of this chapter, whenever we use the term *desired quality*, we refer also to other properties.

Sacrifice. The customer's long-term sacrifice includes the price of the service as well as relationship costs. These can be direct (e.g., investment in office space, additional equipment), indirect (related to the amount of time and resources that the customer has to devote to maintaining the relationship), or psychological costs (lack of trust in a service provider; unpleasant sensory experiences such as noise) (Grönroos, 2000) (e.g., time spent waiting to be served, travel costs, switching costs from one supplier to another).

Service Offering Perspective

The service offering supplier perspective, lengthily discussed in Baida et al. (2004), describes how a business intends to add value (see Figure 3). It is centered on the concept of **service element**, which is what the service marketing literature defines as business activities, deeds and performances of a mostly intangible nature

Figure 3. Service sub-ontology representing the service supplier perspective



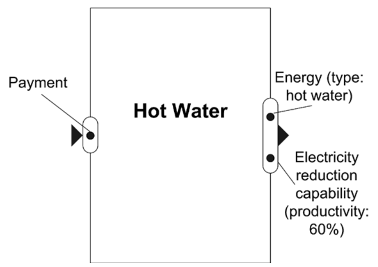
(Grönroos, 2000; Kasper, Helsdingen & de Vries Jr., 1999; Kotler, 1988; Zeithaml et al., 2001). In order to facilitate the service bundling (configuration) process, we describe the business essence of a service with constructs from configuration theory (Baida et al., 2004).

A service element is a business activity that involves the exchange of values between the actors involved. Hence, it requires a set of *service inputs*, and results in the availability of a set of *service outcomes*. Very often, the outcomes of a service reflect the customer benefits from a service, whereas the customer sacrifice is expressed as service inputs (e.g., payment). Service inputs and service outcomes are referred to as **resources**. Resources are described using objective, measurable parameters. For example, the service element *broadband Internet access* for household customers has an outcome resource *broadband Internet capability* with properties *download speed* and *upload speed*, specified in Kbps. Hence, the resource description provides the objective and measurable benefit of a service; this objective benefit may be interpreted differently by customers who have differing expectations and quality perceptions, leading to their subjective value perceptions of the same service.

Service elements can be offered as a bundle and thus form a complex service element. To facilitate automated reasoning about bundling, the **service dependency** is used; it is a relation between service elements. For instance, a substitute function between elements A and B represents that service element B is a substitute service for service A.

Figure 4 is an example service element from our energy study—the supply of hot water. The service is described by its resources. One service input is required to provide this service (payment), and it results in the availability of two service outcomes (energy of type hot water, and a reduction capability of 60% of electricity consumption). Hot water is used for room heating as well as tap water. There is a geographical constraint for this service, because hot water can only be delivered to customers in an area where the infrastruc-

Figure 4. Example service element: hot water



ture for transporting the hot water (pipelines) is available.

Relating the Service Value and Service Offering Perspectives

The process of service configuration—serviguration—(Baida et al., 2003) spans both perspectives: service value and service offering. Serviguration is the process of defining bundles of service elements (a supply-side description of services, part of the service offering perspective) that satisfy the customer description of his desired service (service value perspective). Serviguration (see Figure 1) can be split into two subprocesses: (1) transformation process between the customer description of the requested service (service value perspective) and the supplier's terms for describing the service; and (2) defining zero or more bundles of service elements (service offering perspective) that satisfy this supplier description of the requested service and, thus, also the customer description of his or her requested service. Whereas our earlier work concentrated on the second subprocess (Baida et al., 2004), the present chapter concentrates more on the first subprocess. It requires that (1) customer needs, wants, and demands (service value perspective) and available services (service offering perspective) are modeled and expressed in a machine-readable way and that (2) needs, wants, and demands are modeled and mapped with concepts of the service offering perspective. The latter will be the input for the actual configuration process, resulting in service bundles.

STEP 1: IDENTIFY AND MODEL CUSTOMER NEEDS AND DEMANDS

Understanding customer needs has been acknowledged by service marketing and service management researchers as an important early phase in business initiatives (Aschmoneit & Heitmann, 2002; Kotler, 1988; Mentzer, Rutner & Matsuno, 1997; Teare, 1998). But also in the field of Requirements Engineering (RE), a subdiscipline of computer science, significant effort has been put into understanding stakeholder needs to be satisfied by information systems (Liu & Yu, 2001; Mylopoulos, Chung & Yu, 1999; Mylopoulos, Chung, Liao, Wang & Yu, 2001; Sharp & Galal, 1999; van Lamsweerde, 2000). A specific contribution of RE is Goal Oriented Requirements Engineering (GORE). In GORE, needs are called goals, and formal and semi-formal modeling techniques are used to model goals and relations between these. We employ these techniques to represent and to reason about needs. The advantage of doing so is that this enables us to reuse existing mechanisms for reasoning about such needs.

In the first step of our method, we identify and model customer needs. Needs identification has been studied by marketing researchers (Kärkkäinen & Elfvengren, 2002; Kotler, 1988; McCullough, 2002; Murthi & Sarkar, 2003; Reynolds & Gutman, 1988; Teare, 1998), and is beyond the scope of our study. Instead, we con-

Figure 5. Customer needs, wants, and demands for the energy utility TrønderEnergi

Customer's Needs	Customer's Wants	Customer's Demands
Indoor Comfort	Lighting (II,I) Home services (cooling, washing, etc.) (H) Comfort temperature (II,I)	Energy supply (II,I) Hot tap water (II,I) Room heating (H, I) Air conditioning (II,I)
	Energy regulation for budget-control (II,I)	Energy regulation for budget control (II,I) with different characteristics (manual / automated, on site regulation / location-independent)
	Temperature regulation for increased comfort (H,I)	Temperature regulation (H,I) with different characteristics (manual / automated, on-site regulation / location independent)
Social contacts and recreation (H) Business contacts (I)	Communication (II,I)	Telephone line (II,I) Mobile phone (H,I) Internet (broadband) (H,I)
Safety (II,I)	Increased security (II,I) Reduced insurance premium (II)	Safety check of electrical installation (H) Internal control of electrical installation (I)
IT support for business (I)	IT-services (I)	ASP-services (I) Hardware (I) Software (I)

sider customer needs to be known in advance by domain experts. We then use need hierarchies to model these needs in accordance with our service ontology (needs, wants, and demands). Figure 5 presents our hierarchy of needs, wants, and demands for the energy utility at hand. The notations H/I refer to the customer type: household or industrial. As can be seen from Figure 5, some demands relate to concrete services (e.g., a demand for a mobile phone line), while others are more abstract when a customer does not necessarily know which service can satisfy his or her need, or when a diversity of solutions exits (e.g., the demand *temperature regulation* does not specify a concrete service; it can be satisfied by a variety of services).

Customer requirements for services are decomposed into three different categories: (1) needs, wants, and demands; (2) desired quality; and (3) acceptable sacrifice.

Demands often describe the functionality of a desired solution, whereas the desired quality prescribes the expected performance-level of a service. Hence, the desired quality describes a certain level that applies to demands. The acceptable sacrifice captures the price, switching costs, psychological costs, and more to be paid for satisfaction of a need.

Need Hierarchies

In GORE, links between goals capture situations where goals positively or negatively support other goals (van Lamsweerde, 2001). We call such related goals a goal hierarchy. In need hierarchies, this is being done using graphs, where a high-level need can be concretized by a set of lower-level needs (wants or demands) by using AND/OR graph structures. An AND structure means that all lower-level demands must be satisfied to satisfy the higher-level need. An OR structure means that any, or a combination of the lower-level demands, can be satisfied to satisfy the higher-level need. Weaker links exist for situations in which there is no clear-cut criterion for the satisfaction of a need: *A* contributes positively to *B*, and *A* contributes negatively to *B*. By using links to refine need hierarchies, it becomes possible to reason about needs. The leftmost part of Figure 6 shows how this is done.

Our experience from the energy study shows that the use of refinement structures requires adding a context dimension, since customer needs differ per customer (or customer type), and, thus, the refinement changes per customer. For example, as can be seen in Figure 5, the customer want for *communication* can be refined to three demands: (regular) telephone line, mobile phone line, and Internet access. Whereas one type of customer may require only a regular phone line, another may want Internet access and a mobile phone line and no regular phone line. Knowledge relevant for matching needs with service offerings is thus encapsulated in demands rather than in higher-level needs or wants. Consequently, reasoning on need satisfaction (i.e., which service can satisfy a customer want for communication) should be done on the level of customer demands rather than on the level of (more abstract) customer wants or needs. Note that quality criteria also typically describe demands; wants or needs are often too abstract to be described by some well-defined desired quality criteria.

STEP 2: IDENTIFY AND MODEL AVAILABLE SERVICES

In step two of our method, we use the service offering perspective of the presented service ontology to model available services of suppliers. We describe services by their resources—their required inputs and their outcomes. Our study of the energy domain involves a group of financially independent enterprises that provide a variety of services. Together with domain experts, we investigated and modeled services, including electricity supply, electricity transmission through a high voltage network, hot water supply (for room heating and tap water), energy control (for controlling the temperature; that is, to lower the temperature during the night and to switch appliances on and off), temperature remote control, broadband Internet access, ASP (Application Service Provider) services, and more. A detailed description of this step can be found in Baida et al. (2004). For our current discussion, we will provide a shorter summary.

When a customer searches for a service or a service bundle to buy through a Website, he is, in fact, not interested in the service itself but in the value that the service presents. This principle was acknowledged (Holbrook, 1999; Kotler, 1988), and can be traced back in the acknowledgment of how important customer value is in e-service offerings. The customer value of a service is reflected very often by the benefits of the service. Benefits often are expressed as the service outcomes (Kasper et al., 1999). The term *benefit* has to be understood in a broad sense; a benefit may also be negative. For example, some services require customers to perform some of the work by themselves (e.g., self-service restaurants). Also, payment—a sacrifice in terms of the service ontology—is seen as a negative benefit. Thus, the benefits of a service reflect not only the positive value of a service (from a customer's perspective), but also the negative value thereof. We describe benefits with resources. A service thus is described by its resources—its required service inputs and its produced service outcomes. Example resources are energy (of type hot water or electricity), air conditioning, and payments. Since resources represent a supplier perspective on services, they are described in objective terms rather than as a customer perceives them to be—subjective. Consequently, they are not influenced by contextual information as customer type or by customer expectations. The objective description is necessary in order to compare services, calculate prices, and provide specifications of the delivered service. Every resource is described by generic attributes (i.e., name and type) and possibly domain specific properties (to describe a state, productivity, speed, etc.). Accordingly, the quality level of a service is described by the properties of the resources associated with the service.

In other words, resources specify not only the functional benefits of a service (e.g., ability to surf on the Internet), but also an objective description of its quality (e.g., download speed). Consequently, a list of resources—including required positive benefits and acceptable negative benefits—can be used as requirements for service selection when bundling (configuring) elementary services into a value-adding service bundle. To summarize, since resources (inputs and outcomes) describe the customer benefits of a service, they will be used for the selection of services to include in a service bundle.

The use of resources to select services can be manifested by the following example. Both the service electricity supply and the service hot water have an outcome: energy. However, the *service electricity supply* provides an energy resource with the property *type: electricity*, whereas the service *hot water* provides an energy resource with the property *type: hot water*. These are, in fact, two different resources. Suppose now that a customer is interested in energy. A reasoning engine—software that can use business logics and business rules to derive solutions suitable for customers—will then look for services with the outcome resource *energy* (without specifying the resource properties). If a variety of *electricity supply* and *hot water* services are available (possibly provided by different suppliers), each of them will have the outcome *energy*, so each of them will be a suitable solution. If, on the other hand, the property *type: electricity* also is specified, any of the *electricity supply* services (but not the *hot water* services) may be (part of) a solution.

We created a prototype software tool for modeling services in accordance with the presented service ontology. The tool (available at www.cs.vu.nl/~ziv/tool) presents a user-friendly graphical user interface that hides the technical details of the underlying service ontology. Once services are visually modeled by the user, the tool is capable of creating a service-ontology-based machine-readable version of the model using the RDFS-W3C standard[1] . This is an XML-based standard used for describing information; it adds a layer of semantics to information, and it is suitable for reasoning with ontologies over the Web.

STEP 3: IDENTIFY AND MODEL RELATIONS BETWEEN NEEDS/ DEMANDS AND AVAILABLE SERVICES

Yet, the ultimate goal of buying services is satisfying some higher-level, customer-dependent goal(s) rather than objective benefits. These goals create the need for specific benefits. They are captured by customer needs, wants, and demands.

Thus, in order to ensure that a service satisfies a customer demand, we need to link demands to resources, as shown on the left side of Figure 1. Resources, in turn, are related to services.

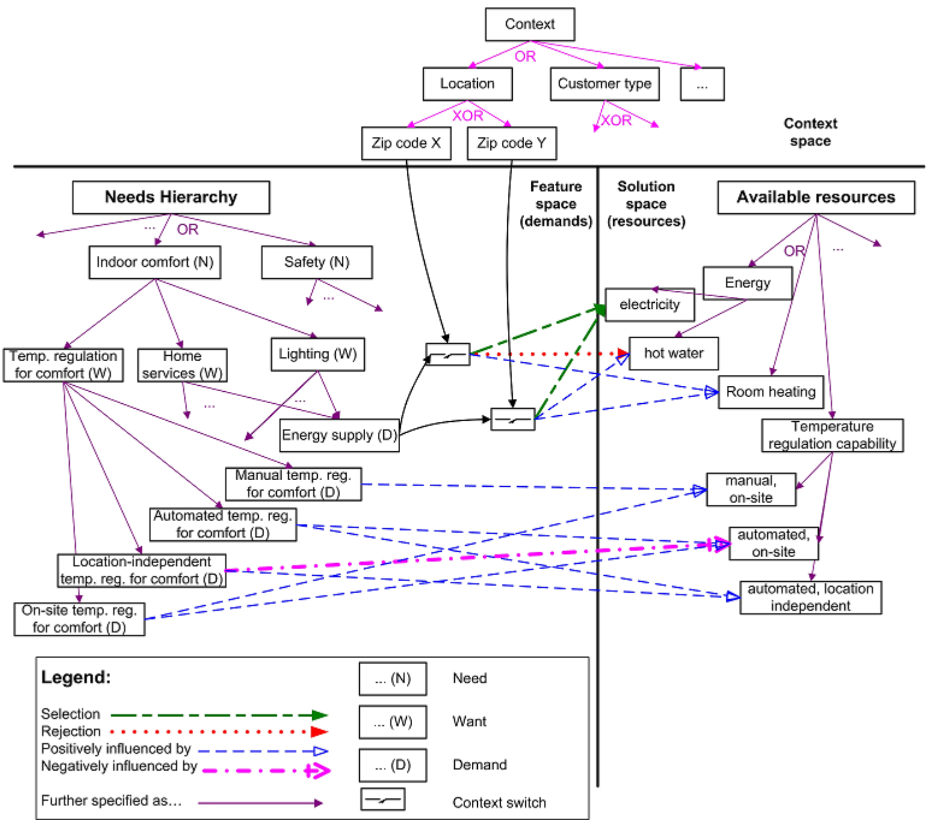
To this end, we use another requirements engineering technique; namely, feature-solution graphs (de Bruin & van Vliet, 2001, 2002; de Bruin, van Vliet & Baida, 2002). A link between customer demands (the satisfaction of which is the goal of the e-service offering) and resources of services (descriptors of available services, or solutions) can be viewed as a system of rules of the form "if a particular situation X is encountered, then select solution Y" (referred to as *production rules* in the artificial intelligence field). In de Bruin and van Vliet (2001, 2002) and de Bruin et al. (2002), the use of context-aware feature-solution graphs is suggested to model the same rules. The suggested graph captures and documents context-sensitive business knowledge so that it becomes possible to reason about feasible solutions and the demands (requirements) they support. A feature-solution graph (adapted to our case) includes three spaces, all organized in hierarchies, as explained previously:

1. **Feature Space.** Describes what is desired by the user. In our case, these are customer demands.
2. **Solution Space.** Contains the services decomposition into resources that are required for or produced by available services.
3. **Context Space.** Contextual information relevant for the domain (e.g., customer types, geographic restrictions).

Links between elements of the feature space (demands) and elements of the solution space (resources) may have the semantics of selection (if demand *A* is requested, select resource *B*), rejection (if demand *A* is requested, then do not select resource *B*), or weaker relations (positively influenced by or negatively influenced by). An example FS-graph, adapted for our case, can be found in Figure 6. For visualization reasons, we explicitly mention the type of hierarchy (AND/OR/XOR) only in a few places. Note the context space, where context information as location or the type of customer may influence the behavior of a relation (for a thorough discussion on context spaces see De Bruin et al., 2002). The hierarchy uses AND/OR/XOR structures. As explained before, an AND structure means that all lower-level elements (demands or resources) must be satisfied in order to satisfy the higher-level element. An OR structure means that any, or a combination of the lower-level elements, can be satisfied in order to satisfy the higher-level element. A XOR structure means that any, but not more than one, of the lower-level elements can be satisfied to satisfy the higher-level element.

In step one of our method, we identified and modeled customer need hierarchies using the service value perspective of our service ontology. These now will be considered as features. In step two, we used the service offering perspective of our service ontology to model available services described by resources. The latter now will be considered as solutions. In the third step of our method, we define links between demands (features) and resources (solutions), as can be seen in Figure 6. These links have the advantage that they easily can be formalized by logical and programming constructs, making it possible to do a systematic analysis of customer needs and their corresponding solutions (available services) and to automate the reasoning for the selection of resources (and thus, services) to meet certain customer demands.

Figure 6. Partial FS-graph of the energy study



STEP 4: CREATE SERVICE BUNDLES

The process of ensuring customer value of service offerings is termed *serviguration* (Baida et al., 2003) and sketched in Figure 1. First, customer demands and acceptable sacrifices are mapped to possible service benefits (referred to as resources). These describe available services. They are then used as a trigger for the service bundling process, resulting in zero or more sets of services that provide the required customer benefits, within the limitations of the acceptable sacrifice. Customer benefits, therefore, are criteria (or requirements) for the service configuration process. Each benefit can be related to some higher-level need or demand of a customer. The process of creating service bundles, based on a given set of available services and on a set of requirements expressed in resources, is discussed at length in Akkermans et al. (2004) and Baida et al. (2004) and is beyond the scope of this chapter. For the current discussion, it suffices to say that we use research on configuration theory from the field of knowledge engineering. By describing services in a way that corresponds with existing configuration ontologies, we simplify the bundling process to a configuration task, for which a wealth of research exists (Borst, Akkermans & Top, 1997;

Borst, 1997; Gruber, Olsen, & Runkel, 1996; Schreiber et al., 2000; Stefik, 1995).

To automate the process of service bundling (or configuration), we use a configuration software tool developed by our partner Fundacion LABEIN in Bilbao, Spain. The configuration tool uses service models created by the service modeling tool (see step 2) to create service bundles based on a given set of requirements. The created service bundles are then imported back to the service tool, where they are visualized to enhance user friendliness.

LESSONS LEARNED FROM THE ELECTRICITY SUPPLY CASE STUDY

Needs Can Be Expressed Using Goal-Hierarchies

The lesson falls into two parts.

First, we can use goal-hierarchies to represent needs. This is important because we then can utilize existing knowledge about goal-reasoning.

Second, need-hierarchies are of use during elicitation of other needs. Domain experts provided us with an initial list of identified customer needs. By asking the question *why*, requirements engineers elicit more abstract goals than those first identified in order to find out other important subgoals of the more abstract goal that were overlooked in the first place (van Lamsweerde, 2000). Our eventual need hierarchy (see Figure 5) evolved from the initial one by applying two methods: asking the question *why* about existing needs, and also asking the question *why* about existing solutions (available services and their provided resources or results). We found that both techniques help identify new needs as well as concretize vaguely defined customer needs. Furthermore, asking the question *why* about existing needs helps understand the granularity of needs; it helps define whether a need should indeed be seen as a need, or actually is a more concrete want or demand.

Positive-Influenced Relations Occur the Most

As argued and demonstrated in de Bruin et al. (2002) and Baida, de Bruin, and Gordijn (2003), the FS-graphs approach enables reasoning about solutions systematically by capturing knowledge about the relation between system requirements (features) and available solutions. This is done using four relations (selection, rejection, or weaker relations *positively influenced* by *or negatively influenced* by), as well as by the context-space where one can specify that a specific relation behaves differently in differing contexts.

We applied the FS-graphs approach to energy services, considering customer demands (described by quality descriptors, but not including acceptable sacrifice) as features, and available resource classes rather than specific occurrences of resources, as solutions. The reason to do so is that if a resource with some characteristics is a good solution, any resource that has these characteristics is a possible solution. For example, suppose a resource *energy* with property *energy type: electricity* fulfills a customer's demand; there may be multiple resources of this type supplied by multiple suppliers, and possibly further specified by other properties. Any of them may be a good solution.

We found that the positively influenced by relation plays the main role in our case, whereas other relations occur much less. Once we add also acceptable sacrifices (i.e., price) to the graph, we will receive a richer FS-graph, in which the rejection relation and the negatively influenced by relation will occur much more often (a low acceptable sacrifice will disqualify expensive solutions).

The FS-graphs approach, using goal hierarchies, has shown to be an effective approach for making customer needs explicit; it enables a reasoning about the relation between specific customer demands (which sometimes do not have clear-cut satisfaction criteria) and parameters of possible solutions (i.e., resources of available services).

Service Ontology Allows for Reasoning on Inconsistencies and Bundles

Relations, as specified by the FS-graph, can cause inconsistencies, for example, in a situation in which a customer specifies conflicting quality criteria for a demand (e.g., a top quality, low-budget service). Handling such inconsistencies (referred to as *conflict resolution*) must be performed during the reasoning process. We perform conflict resolution, as discussed in Baida et al. (2003) and de Bruin et al. (2002).

From a business perspective, reasoning on potential service bundles is of most interest. For example, (1) some services require other supporting services; (2) other services may have substitutes that also provide a good solution for a customer; (3) suppliers may prefer to bundle specific services for better utilization of existing infrastructure, and so forth. All these business rules can be expressed in a computer-interpretable way, so that software can implement them. We have built a prototype software tool that does exactly this kind of reasoning. Now that we have a set of required resources, we have to create bundles of services that offer these resources. Any of the required resources may be offered by multiple services, so typically more than one service or service bundle will include these resources and, hence, fulfill the customer's demands. This last process—service configuration—is discussed thoroughly (Baida et al., 2004) and includes the already mentioned business rules. The service configuration process implements production rules of the type *if service X is part of the bundle, include also service Y, services X and Y may not be part of the same bundle*, and so forth.

RELATED RESEARCH

When our method is used by marketing personnel for developing (e-)service offerings, the use of our service ontology can be complemented by the means-end theory, which provides an even more abstract view on service offerings. The means-end theory (Gutman, 1982; Zeithaml, 1988) uses relations between customer values and product/service attributes and benefits in order to explain customer behavior and his or her preference for one product/service or another. A means-end chain is a model that seeks to explain how a product or service selection facilitates the achievement of desired states (Gutman, 1982); customers seek means to achieve their ends (goals). The means-end theory uses a hierarchical model to describe this customer goal-oriented behavior. The model consists of three linked concepts: values, benefits/consequences, and (product/service) attributes. The hierarchy is created by linking values to underlying benefits and attributes. In their studies, Gutman (1982), Herrmann, Huber, and Braunstein (2000), and Mentzer et al. (1997) present examples of means-end chain models in different sectors: the railway sector, the automobile industry, and the beverages industry. Examples are provided for values, benefits, and attributes (the three elements of a means-end chain model ordered in a decreasing level of abstraction). We have presented in this chapter a need hierarchy with needs, wants, and demands (ordered in a decreasing level of abstraction). Comparing these three studies with ours, we can make the following observations about relations between the means-end theory and the service ontology:

1. Values in the means-end theory either can be terminal or instrumental. Terminal values are more abstract than any concept in the service ontology; instrumental values correspond to needs in the service ontology.
2. Benefits/consequences in the means-end theory correspond to wants and needs in the service ontology.
3. Attributes in the means-end theory either can be abstract or concrete. Abstract attributes correspond to wants in the service ontology; concrete attributes correspond to demands in the service ontology.

The existence of a similar and equivalent structure (hierarchy) and concepts make it possible to incorporate the use of our method and ontology with means-end chain models by marketing departments. The added value that our method presents in this context is twofold:

1. Value hierarchies, as in the means-end theory, define relations between values, benefits, and attributes. By adding AND/OR/XOR refinements to hierarchies, we enable a much more detailed and useful analysis of these relations. For example, an OR refinement implies that any low-level element (e.g., demand or attribute) can satisfy a higher-level element (e.g., want or benefit). Consequently, it may not be necessary for a service provider to implement all lower-level attributes. Such knowledge cannot be inferred from means-end hierarchies in their traditional form.
2. The means-end theory does not consider the possible solutions for a customer's demands. Customer needs are refined to the degree of desired product attributes, but these are not linked further to any elements that provide these attributes. The service ontology, on the other hand, includes both customer needs and available solutions. By using our method and ontology, it becomes possible to relate not only product attributes, but also possible solutions (available or future service offerings) to a customer's needs and values. This can be used for any marketing analysis, but it is of greatest importance for e-service offerings, because they require that all elements of the process (from customer needs to actual solutions) be linked so that information systems can reason about the process and provide a customer with a suitable solution for his or her needs.

In addition, Herrmann et al. (2000) argued that the means-end theory needs to be complemented with a means to transform customer needs to more concrete, implementation-related measurements. They suggested combining the means-end theory with quality function deployment (QFD). Their approach is similar to ours in that both approaches facilitate a transformation process from vaguely defined customer needs to concrete measurements. The approaches differ, however, in their goals. Whereas Herrmann et al. (2000) use the transformation to investigate how the business process of a firm can be improved (and thus link product/service design and part features with production processes), our approach is targeted at finding good solutions (service offerings) for a set of customer demands. We remain on the level of product/service design and part features, and not on the level of business processes.

CONCLUSION AND FUTURE WORK

In this chapter, we have proposed an ontology for understanding customer needs for e-services. Using this ontology, it is possible to reason about possible service-bundles that satisfy needs. The bottom line of the energy study was that the analysis performed made it possible for the energy utility involved to define service bundles for specific groups of customers in such a way that bundles fit the demands of their respective customers. Furthermore, it helped understand which service bundles should not be offered to specific groups of customers, because they do not satisfy the demands of these customers well enough, or because other bundles can satisfy the same demands better. For example: to satisfy a customer demand for energy supply, a bundle theoretically may include combinations of the following services: electricity supply, heat pumping, and hot water. However, customers would prefer bundling electricity supply with hot water to bundling electricity supply with heat pumping due to a lower price. If there had not been a geographical limitation on the supply of hot water, the bundle electricity supply and heat pumping would not have been of interest at all. Another example is the customer demand of temperature regulation for indoor comfort. The following service elements result in benefits (resources) that satisfy this demand for industrial customers: heat pumping, energy control system, and remote control. However, given the desired quality criteria for this demand (automated vs. manual, location-independent vs. on-site), different combinations of these (and other) services need to be offered.

Knowledge and expertise from business science, information science, and computer science have been intertwined in our research to solve the problem at hand. We spilt the process into a customer perspective (step one of our method), a supplier perspective (step two of our method), and a transformation process between the two (step three of our method). By expressing both perspectives using a formal ontology, also expressible in a machine-interpretable language (RDF), we facilitate checking business knowledge for consistency, using it for reasoning by software, and performing a systematic analysis of the domain.

The method presented in this chapter uses conceptual modeling and formalizing techniques, widely accepted in computer science and information science, and applies them to concepts from business science. In spite of the elusive nature of important business concepts such as quality, benefit, and value, it is possible to derive concrete parameters out of more abstract ones by using several layers between the two. Abstract notions can be transformed to somewhat less abstract notions; these can then be transformed or mapped to even more concrete notions. The QFD approach uses this technique, and so do means-end hierarchies and requirements engineering goal hierarchies. However, both QFD and means-end models have a limited perspective: supplier's solution and customer needs, respectively. Our method, on the other hand, connects both perspectives using FS-graphs. The two perspectives must be related in order to allow an automated process that finds a solution for a specific high-level need.

By applying our approach for the Norwegian Energy sector, we managed to elicit business knowledge and to formalize it in such a way that it can be expressed in computer-interpretable terms. The service offering perspective was implemented in a software tool. Using our service ontology as its fundaments, the tool is capable of creating bundles of services, when requirements are specified in terms of resources. In the present chapter, we have shown how we derive such requirements: by adding an earlier step in which we formalize customer demands and mapping them into available resources. Our service ontology includes a perspective dedicated to these demands: the service value perspective.

The service ontology includes the notion of quality criteria to describe customer demands. Demands, however, are subjective and context-sensitive. A wealth of research exists within business science about service quality (Grönroos, 2000; Zeithaml et al., 2001). The service ontology includes constructs for modeling the quality related to demands and to services. So far, the available constructs have proven to be suitable and sufficient. Future research can be directed at incorporating existing service quality models (e.g., SERVQUAL) (Zeithaml et al., 2001) into the service ontology.

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ENDNOTES

1 http://www.w3.org/TR/rdf-schema/

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