DESIGNING SEMANTIC E-GOVERNMENT SERVICES DRIVEN BY USER REQUIREMENTS

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Abstract – *Designing the semantic structures for annotating e-government services is a critical challenge for administrations on the way to enter the Semantic Web. This article outlines a requirement-driven design approach that draws on information architecture and information quality concepts in relation to users' informational needs. We suggest a step-by-step design process that alerts the administrations to focus on the intended common understanding of citizens or businesses and administrations concerning the description of the service "interface," to analyze information demand and quality requirements for providing this description, and to determine the topics, terms and relations to be used for the description in order to fulfill these requirements. We claim that this design approach opens up the possibility for large-scale involvement of administrations and provides a crucial point of interception through defining informational requirements and thus creating benchmarks for subsequent activities in design and implementation.*

Keywords: *e-government, Semantic Web, service description, semantic annotation, semantic structures, requirement-driven design*

1 Introduction

For a number of years the "Semantic Web" has been discussed as a promising vision also for e-government, but what this exactly means in practice is not yet clear. Research is underway to explore the potentials of semantic technologies for e-government, however, practitioners are missing guidelines to design, develop, implement, and operate semantic e-government services (SeGS), i.e. electronic services enhanced by semantic annotations and/or mark-up.

In this paper, the focus is on the design of SeGS, specifically on the creation of the semantic structures to be implemented with the electronic service interface in order to bring out an (intended) added value for relating service providers and users. The research presented here is part of the Access-eGov project (see www.accessegov.org) that aims at improvements in finding, accessing and combining e-government services based on semantic technologies. The starting point (i.e. the basic underlying assumption) of our approach is that the design of the semantic structures should systematically follow requirements concerning the use of SeGS (in addition to a knowledge-driven design approach). The research question in focus is how to relate informational needs of service consumers to the design of specific semantic structures related to SeGS in order to trace this relation from the requirement analysis to the design. To answer this question we focus on the information architecture and required information quality of the service description as a boundary object [cf. 1] relating citizens/businesses and

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administrations. We use these constructs as stepping stones to suggest a general method for designing SeGS and identifying the administrations' contribution to a requirement-driven design approach.

In the remainder of the paper we first specify the design object, i.e. the semantic structures used for annotating e-government services, and recall the potentials of information architecture and information quality in order to meet the design challenge. Second, we combine the various elements and outline design approach exemplified by a case of marriage-related services. Finally, we discuss how the approach advances existing e-government research and practice and what should be primarily addressed in future research on designing SeGS.

2 Describing Semantics of e-Government Services

Services may be understood as single encounters or as unfolding relationships [4]. Within this paper we define services as social relations to recognize and satisfy situated needs of an individual or collective actor, based on an explicit or implicit agreement. In the end it is only the client who decides about successful satisfaction of his needs. We focus on the relationships in the government domain, i.e. between administrations as service providers offering services to citizens or businesses (i.e. service consumers) to fulfill their needs. One of the challenges of introducing computer support in the service domain lies in this situated and personalized relation between service provider and client. A service agreement can be facilitated through specifying the service's pre- and post-conditions [cf. 6] similar to the familiar concept of "design-by-contract" [9]: preconditions could include e.g. the case-based need, required information, documents, and fees. Post-conditions are the results of service performance, e.g. case-specific information, and certificate of approval.

We distinguish *traditional* (non-electronic) government services from *electronic* government services, although in practice we often find hybrid services, e.g. a form can be downloaded or an application may be filed, but the citizen still has to go to an administration office to complete the procedure. We define a traditional government service as a service whose interface consists exclusively of non-electronic elements, i.e. a traditional service neither requires nor provides any kind of electronic input or output (although the interface's *description* could be provided in electronic form). Traditional government services are often based on the exchange of paper forms and usually require some degree of personal interaction between the service provider and the service consumer. In contrast, we define an electronic government service as a service whose interface requires and/or provides input and/or output in electronic form. In case of an electronic service relationship, providers and consumers communicate through an electronic interface through which the service requests (statement of need) and service responses (fulfillment of need) are channeled.

Currently, research is under way exploring the potentials of semantic technologies for e-government (see e.g. EU projects such as SemanticGov, TerreGov, OntoGov, SmartGov). In simple words, the aim is to enable machines to process meaning associated with informational elements included in e-government services. Such kind of machine processing requires formalized semantic structures. To describe the design challenge more specifically, we define a *semantic* e-government service (SeGS) as an electronic service provided by administration of which its interface is formally described in a machine-readable way. The "semantic challenge" for e-government services then is how to choose concepts and their relations and how to formalize these in order to serve informational needs of citizens and businesses as users. The aim of this design task is that semantic structures (as result of the formalization):

- support informational needs during service processing as far as possible
- capture domain knowledge as far as necessary and feasible
- support technical implementation, e.g. can easily be used to describe web services (e.g. through WSMO, OWL-S)

"Semantic design" is not (yet) a concept elaborated in research. However, we do find numerous approaches to designing semantic structures in various fields such as information science, artificial intelligence and web design. Most approaches take the (knowledge about) a domain as the starting point for the creation of semantic structures. The result of this design strategy usually is some kind of knowledge model or nowadays *ontology* defining the "basic terms and relations comprising the vocabulary of a topic area as well as the rules for combining terms and relations to define extensions to the vocabulary" [10]. This kind of approach we call knowledge-driven or domain-driven design.

Some approaches to knowledge modeling and ontology development take aspects of the intended use situation into account [cf. 3] in order to guide the selection and formalization process, but none take the user requirement analysis as the starting point for design. In this paper we seek to explore the potentials of requirement-driven approaches in addition to knowledge-driven design of semantic structures. In particular, we focus on (1) information architecture (IA) and (2) information quality (IQ) as two concepts which both have been elaborated with the purpose of understanding (web) user requirements and informing the design and evaluation of web applications.

Information architecture (IA) is, in simple words, the structuring of information for a certain purpose. It serves as a link between the technical management of distributed data and strategic business objectives, bridging between business strategy, end user requirements and technical implementation (e.g. [2], p. 17). IA design does not start from domain modeling but from identifying what users (or providers) will consider valuable information. Rosenfeld and Morville [12] mention a number of IA components, e.g. categorization of information, labeling (including choice of terminology); additionally they mention invisible IA components such as controlled vocabularies and retrieval algorithms. The latter can be considered as semantic structures, which in an IA are often embedded in the site design, do not necessarily have to be made explicit nor isolated in separate formalized components. Developing an IA is an approach that, among other aspects, takes in informational needs as user requirements and delivers semantic structures incorporated in the technical implementation. The design decision, which of the user requirements will be served by the resulting IA (or not), and thus what information structure will be implemented, depends largely on the (business) objectives of the website operator, i.e. on the commitments towards information delivery.

IQ has been studied from various disciplinary perspectives such as Information Science and research in information systems, e-business and e-commerce. The discussion is quite diverse but the range of principle criteria do find some agreement among scholars (with differences mainly in emphasis) [7, 8, 13, 17]. Since IQ relates informational needs with the actual information delivered, it is a key for understanding also the requirements related to the specific use situation of SeGS. In order to trace this relation from the requirement analysis to the design we will build on the basic distinction (introduced by Lillrank [8]) between (1) information as an artifact and (2) information as deliverable: (1) Measuring the quality of information as an *artifact* presupposes pre-defined and shared understanding about the intended use of the information. The information producer is capable of ex ante evaluating the outcome (and improving the information delivered if needed). (2) Information as a

deliverable is much more difficult to formalize (ibid., p. 700). Here, measuring the quality of IQ can only be performed on the basis of an outcome negotiated between information providers and consumers (individuals or organizational entities).

Applying these concepts to a set of e-government services related to marriage, the aim is to demonstrate through this example how the IA development and IQ analysis help creating the semantic structures and how this approach may contribute to a new general method for designing SeGS driven by user requirements.

3 Designing Semantic Structures Step-by-step

By employing semantic technologies the EU-funded research project Access-eGov seeks to support semantic interoperability among e-government services across organizational, regional and linguistic borders. As far as feasible, available ontologies and standards shall be reused (e.g. GEA [11], GOVML [16], AGLS Metadata Set [14], IPSV/GCL and eGMS [15]). However within the project remains the challenge of semantically describing the e-government services in focus.

We demonstrate the applicability of a requirement-driven approach through an example of marriage-related services in Schleswig-Holstein (Germany) as one of the project's scheduled trials. While the design steps itself are generic, we show how the specifics of e-government are addressed through the reflection of the (to be established) shared understanding between administrations as service providers and citizens as service consumers. We first briefly introduce the situation of service provision and use from the administration's and citizen's point of view before describing the design approach.

3.1 Marriage-related Services in Schleswig-Holstein

The German administration views marriage mainly as the act of proving to the responsible civil registry office ("Standesamt") the identity of the future spouses and that there are no legal reasons preventing either of them from getting married. Once the couple has provided sufficient proof, they can schedule a date for the wedding ceremony with any register office in Germany. The specific documents that need to be presented as proof heavily depend on the individual circumstances of the couple. In the simplest case both partners need to present an identification card (or passport), a proof of registration, and a proof who their respective parents are ("Abstammungsurkunde" or a transcription from the family register).

For the couple, marriage usually is an important and emotionally involved step. From their point of view the legal act of marriage is provided as a service to them for which they (the couple) may choose a date and possibly a special location. The couple is not likely to be aware of the legal requirements and the necessary documents. Though they may not be aware of the specific requirements one can expect that the couple has some prior knowledge about what the legal act of marriage involves (from talking to friends) and how to interact with an administration in general (from personal experience, for example, paying taxes).

Thus, the couple will have some idea how to reach their goal of getting married. They will expect that they have to fill out some forms, present some required documents, make appointments and maybe do other things. Based on this general idea they will look for more detailed information. Their informational need at this point may include the need for

- general information on marriage which provides an overview of the necessary procedures etc.
- specific, case-based information on marriage, for example, between a German citizen and a foreigner
- information on special locations for the wedding ceremony, for example, on a ship or in a lighthouse, and on special dates (e.g. Sundays)
- contact information, including opening hours, of a nearby office that is responsible for marriage in their case
- a list of the required documents for their own special circumstances

In addition to their informational needs the couple will also want to make an appointment with the responsible register office, get the required documents, provide the required documents to the officer, fix a date for the wedding ceremony, and, finally, get married. The main services that administrations offer with respect to marriage are

- to provide information on how to get married (mainly legal restrictions, required documents, steps to do)
- to offer to schedule an appointment for a wedding at a certain location (usually the register office)
- to perform the official wedding ceremony, effectively marrying the couple

The gap between information needs and today's service provision is significant. The threefold responsibility—for the law, specific regulations and local requirements—and the lack of jurisdiction over the register offices (they are under communal jurisdiction) makes it difficult for the state to provide helpful, case-based information about marriage to citizens on the state's website. Even when electronic services are available, they are currently not integrated with (information about) non-electronic services.

3.2 Designing SeGS: the Example of Marriage Services

A shared understanding between service providers (administrations) and service consumers (citizens) cannot be presupposed ex ante. Service providers describe services based on the services' inputs, outputs and other attributes, while service consumers will locate services based their own needs and goals. To this end, others have suggested representing citizens' needs (or goals) separately from service descriptions (e.g. [11]). Using both aspects to describe services provides a common semantic ground for service providers and service consumers while letting each group keep their own focus. In this sense, the service descriptions serve as boundary objects between the different communities of practice [cf. 1].

To design semantic structures based on the user's needs and ultimately put them to technical use in a software system, we propose the following sequence of steps (see table 1). Each step is characterized as a specific task with brief description as well as input and output of each task, respectively. The case of services related to marriage in Schleswig-Holstein is used as an example for illustrating the application of the approach.

If, for example, details on relevant documents are considered to be an informational need, then hierarchy relations may be used to define one or more hierarchy of concepts: The two concrete document types "certificate of ancestry" and "certified transcript of family register" (as described above) both serve the same purpose of proving one's ancestry. This could be ex-

Task	*Description*	*Input & output (exemplified by: marriage in Schleswig-Holstein)*
1. Identify informational needs	Analyzing prior knowledge of citizens and the diversity of informational needs of different groups of citizens	INPUT: none OUTPUT: list of user groups' informational needs E.g. all citizens may expect a case-based list of required documents needed for scheduling a date for their marriage, but people who have been married before may not require a detailed description of the overall procedure.
2. Identify required IQ	Informational needs of each user group are analyzed with respect to required IQ properties: scope, relevance etc. Needs can be determined by understanding information as an artifact and/or as a deliverable	INPUT: List of user groups' informational needs OUTPUT: List of requirements concerning information provision by service providers E.g. information as an artefact: the marriage law with its minimal IQ attributes official publication, latest version, applying to the service provider's region. E.g. information as deliverable: which documents are required depends on individual circumstances? These must be negotiated between service provider and consumer, for example, each future spouse will need one of two documents: either a certified transcript from the family register or certificate of ancestry. The latter will only be accepted if no family register exists, i.e. in case the parents were not married or married outside Germany.
3. Create glossary of topics & terms	A glossary is created that contains all relevant topics and terms needed for describing the services in question; each entry provides a short description of the topics and the corresponding informational needs	INPUT: List of requirements concerning information provision by service providers OUTPUT: Glossary of important terms and topics in relation to given services E.g. an entry "Schedule appointment for marriage" should clearly distinguish between inputs (and preconditions) and outputs (and postconditions); the documents needed to schedule the appointment (i.e. input, e.g. the certified transcript of family register) should each have their own entries in which any applicable case-based preconditions should be explained
4. Create controlled vocabulary	Based on the glossary a controlled vocabulary is created: each service and general topic to be described should be represented by a main term and possibly additional related terms.	INPUT: Glossary of important terms and topics; list of informational requirements OUTPUT: List of preferred terms (controlled vocabulary) for all services and general topics from the glossary, including inputs, outputs and other attributes for each term E.g. the service "schedule appointment for marriage" may be represented by the term *Schedule Marriage* with including terms for the representation inputs (the case-based list of required documents), outputs (the appointment); other terms may come from the list of informational needs and user groups, for example, a list of laws that apply or a general description of the process of scheduling an appointment for marriage.
5. Group & relate terms	Relating all items of the controlled vocabulary through defined relations	INPUT: List of preferred terms (controlled vocabulary) OUTPUT: A set of relations that relates the terms of the controlled vocabulary with each other in a meaningful way The terms from the flat list of the controlled vocabulary are already (informally) grouped into services and their respective inputs, outputs etc. By defining a set of relations (e.g. "is-input", "is-output", "is-reference-to-law" etc.) the terms will be formally arranged into groups of concepts.

6. Design an ontology	Fixing the meaning of the terms and their relations in a formal way; verifying that formal meaning reflects informal description in the glossary (and *vice versa)*	INPUT: Controlled vocabulary and relations
		OUTPUT: One or more formal ontologies that fix the formal meaning of the terms defined in the glossary
		E.g. the hierarchy of aforementioned document types could be represented in an ontology of documents (using WSML) as follows:
		`concept ancestry_proof`
		`  concept certificate_of_ancestry`
		`    subConceptOf ancestry_proof`
		`  concept family_register_transcript`
		`    subConceptOf ancestry_proof`

7. Implement semantics	Use of the above constructs for service description and operation (e.g. creating *service profiles* in WSMO)	INPUT: The formal ontologies
		OUPUT: e.g. WSMO *service profiles*.
		A sample (partial) WSMO service profile for the marriage appointment service is presented below. It defines a single input for the service which must be of the type `ancestry_proof` (see above):
		`importsOntology`
		`_"http://accessegov.org/documentsOntology"`
		`capability MarriageAppointmentCapability`
		`  precondition`
		`    definedBy`
		`      ?proof_of_ancestry memberOf`
		`        ancestry_proof`

Table 1. *Step-by-step process towards designing semantic structures for e-government services*

pressed by introducing an abstract document type "ancestry proof" and relating the two concrete document types by an "is-a"-relation. Doing so will arrange the three document types into a simple class-hierarchy. If, for example, certain details on documents (like "is required") are deemed to be relevant only under certain case-based circumstances (i.e. the information cannot be considered as an artifact), then the conceptualization must be enriched by "business rules" describing the relation between the document's relevance and various types of premarital status of the service user in order to automatically manage the dialogue between citizens as information seekers and administration as information provider.

4 Discussion

In the previous section a requirement-driven design approach has been outlined that draws on research concerning information quality and information architecture in relation to users' informational needs. It is presented as a rather straightforward approach, formulated in imperative mode. It should be stated clearly that the application of this approach has only started, and an evaluation of the actual use of the newly annotated services will be available only after one or two years (after the two trials, respectively) which certainly will give rise to revisiting and refining the approach introduced here.

However, the step-by-step process itself is not considered to be the main result of this paper. Rather, the aim is to demonstrate that, first, requirement-driven design of semantic structures is possible based on already developed constructs and approaches in the area of IA and IQ, and, second, administrations have a critical contribution in this design process: The approach outlined here alerts the administrations to

1. focus on the intended common understanding of citizens/businesses and administrations concerning the description of the service "interface,"
2. analyze information demand and quality requirements for providing this description,
3. determine the topics, terms and relations to be used for the description in order to fulfill these requirements

All of the three above tasks belong to the responsibility of the administrations, and this responsibility cannot be delegated to e.g. IT service providers. Since every service (in principle) deserves an analysis as outlined above, the approach calls for more resources than a knowledge-driven or domain-driven approach performed by selected experts. But in contrast to such top-down approaches, the design approach presented here opens up the possibility for large-scale involvement of administrations (as far as they are interested in framing future service relations) and provides a crucial point of interception. That is, while it might appear as yet an additional burden for administrations, defining the informational requirements creates benchmarks for subsequent activities in design and implementation.

The above identification of administrations' tasks in the requirement-driven design process is considered to advance the e-government research and practice in terms of clarifying critical design objects, design tasks related to SeGS and responsibility of the actors involved. However, additional research effort is necessary to explore further the success factors (and barriers) of service providers and consumers in developing a common understanding of the e-government service "interface." In particular we should strive to know: What is exactly needed to make citizens and businesses understand how to (electronically) relate with administrations? How can this be captured by semantic structures as the basis for computer support? How can administrations be aided in setting these requirements?

Within the Access-eGov project answers to the above questions will have to be provided in order to assist e.g. the Schleswig-Holstein government in proceeding with developing service annotations, i.e. with designing their SeGS. However, as in the years to come many administrations will address the semantic challenge, the theoretical basis for such kind of design tasks still needs to be further developed and consolidated.

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