Semantic Web Technologies for Information Management within e-Government Services

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Abstract

This article examines a case of developing a prototype for an ontology-driven e-government application based on Semantic Web technologies in order to learn more about how to interrelate systems development with the tasks of information and knowledge management related to e-government service provision. The focus of evaluation is set by analyzing the information management challenges specific to the administrative domain and by the need for taking into account the increased granularity of informational resources and the manifold semantic differences in dealing with those resources.

Following the different tasks and problems within the development process the authors identify what appeared to be critical issues: requirements analysis, choice and mastering of Semantic Web technologies, representation of ontology and informational resources, creating interfaces for users and other services. Based on the project analysis, the article concludes by suggesting an agenda for the cooperation of administrative information managers and systems developers as a prerequisite for successful Semantic Web projects in e-government.

1. Introduction

As e-government services become more and more complex, administrations need to improve their management capabilities. One of the main tasks is information management: an interdisciplinary field which draws on and combines skills and resources from librarianship and information science, information technology, records management, archives and general management. Its focus is on information as a resource irrespective of the physical form in which it occurs, for example books and articles, data stored on local or remote computers, microforms, audio-visual media, etc. – sometimes even the information in people's heads. The following information management challenges are specific to the administrative domain:

- an immense variety of actors and processes producing informational output, each of these relevant for a particular context of administrative work or service
- widespread concerns for privacy and security related to the ownership of personal and/or case-based data
- high expectations regarding accuracy, transparency and accountability of information processing
- availability of identical informational resources for several services and different channels (e.g. call center)
- implementation of (new) seamless, personalized services for citizens and other clients

The main incentive for administrations to advance in information management is that they want and need to improve efficiency (e.g. by reducing effort for information collection and editing) and quality (e.g. in terms of accuracy, scope, personalization, interoperability) of their e-government service provision. On one hand, e-government services are only a small part of the administrative performance requiring a professional information management. On the other hand, this section is unique as it calls for the most advanced approaches to support a distributed, cross-organizational and completely IT/internet-based information management.

The above challenges are strongly related to the management of informational resources and the administrative knowledge on how to organize these resources. This article employs a systems development perspective to support these activities: what kind of information technology and which direction of systems development are appropriate to enable the next steps in information and knowledge management needed for e-government services?

The article is organized as follows: firstly, Semantic Web concepts and technologies are taken into consideration which are likely to be used in meeting the (new) challenges of managing informational resources within e-government service provision. Secondly, the paper examines a case of developing a prototype for an ontology-driven e-government application to support personalized services within the web-based citizen information service of the City of Hamburg. Following the different tasks and problems within the development process we identify what appeared to be critical issues in interrelating systems development and information management. For each of those issues, the specific problems are described, requirements for cooperation with the administration are pointed out, and the role of an information manager is highlighted as a means to link the systems development with the information management. Finally, based on the project analysis, we suggest an agenda for the cooperation of administrative information managers and systems developers as prerequisite for successful Semantic Web projects in e-government.

2. Semantic Web for e-government

Provision and use of e-government services span across borders of given organizations and corporate infrastructures. Because of the heterogeneity of IT infrastructures in administration and the tendency to operate closed systems and networks, information management within e-government services cannot rely on integrated systems. Therefore, this paper focuses on internet technologies and in particular on the potentials of Semantic Web technologies.

This section discusses the relevance of Semantic Web technologies for e-government services by outlining their technical potentials, their relation to information and knowledge management and the path of adoption in e-government research and development.

2.1 Semantic Web technologies

The term "Semantic Web" was coined by Tim Berners-Lee et al. [3] referring to a "Web for machines" as opposed to a web to be read by humans. The core issue is to annotate documents or other informational resources with 'semantic markup' which is not interpreted for display but serves as an expression of document content to be automatically processed by agents and other IT components.

One of the core assumptions of Semantic Web is that information on the web is available in modularized form: "information in the information space is in the abstract chunked into addressable things known as resources." [2] In the technical architecture, resources have unique identifiers such as a Uniform Resource Identifier (URI; http://www.w3.org/Addressing/). In principle, anything with a URI could be an informational resource. In many cases on the current Web, the informational resources at stake can be regarded as 'documents.' Technically, it is possible to also refer to a particular part of or view of a resource. E.g. a hypertext link defining the other end of the link has two parts: the identifier of the document as a whole, and then (optionally) a hash sign "#" and a string ('fragment identifier') representing the view of the object required. With the technical options almost unlimited, granularity becomes an issue for information resource design (see also section 3).

To fulfill the promises of Semantic Web a number of related technologies have been developed and matured which are now ready for use in application domains. There are several basic groups of technologies:

- Markup languages: the most discussed markup languages are XML, RDF and DAML+OIL (see [7] for a comparison), in 2003 also the Ontology Web Language OWL has been published as a candidate recommendation (http://www.w3.org/)
- Editorial/markup tools: these tools are for construction and use of ontologies (see [1] for overview)
- Inference engines: their purpose is to "deduce new knowledge from already specified knowledge", i.e. to generate new semantic expressions from available semantic-based data representations (for overview see www.semanticweb.org/inference.html)

All of the above technologies should be on the systems developer's work bench when setting up Semantic Web applications (inference functionality is only needed when semantic markup is already available). And most of these have matured far enough to provide a reliable basis for application development.

2.2 Semantic Web and information management

For systems developers, mastering the different kinds of Semantic Web technologies is already quite a challenge, and new technologies will continue to appear in short cycles; so it remains a constant battle to stay reasonably up-to-date. But still, this is not enough: the semantic markup requires also a computer supported strategy for generating the markup, i.e. any markup tool must relate to some computer readable representation of what concepts (terms, relations) should be used for achieving the markup. This is the most important link to the conceptual modeling of the application domain, and it has become state-of-the-art to employ ontologies for this purpose (cf. [4], [5]).

Ontology-based approaches seek to define common domain terminologies. For ages, the term "ontology" has been used in singular mode, relating to a long tradition of philosophical discourse on metaphysics. With the beginning of the construction of artificial (virtual) worlds,

research within Artificial Intelligence has focused on exploring and producing "ontologies", each of these applying to selected domains. The most frequently quoted definition of ontology is provided by Gruber [8]: "An ontology is a specification of a conceptualization." While this sounds much as conceptual modeling, the meta-physical background is still somewhat relevant: "The subject of ontology is the study of the categories of things that exist or may exist in some domain. The product of such a study, called an ontology, is a catalog of the types of things that are assumed to exist in a domain of interest D from the perspective of a person who uses a language L for the purpose of talking about D." [20] Therefore, ontologies are means for communication. But successful support is possible only when the concepts included and their relations are agreed on by the users and/or a group of experts, in relation to what the purpose of the communication is.

The degree of formalization may differ significantly which has consequences for the options of automation. Basically, it is important to distinguish between (cf. [20])

- informal ontology: may be specified by a catalog of types that are either undefined or defined only by statements in a natural language, and
- formal ontology: specified by a collection of names for concept and relation types organized in a partial ordering by the type-subtype relation.

The degree of formalization usually corresponds with the complexity of the conceptual modeling: a simple keyword catalogue can be quite helpful and is easy to implement, while e.g. thesauri and topic maps need far more support for construction and use (cf. [14]). To represent ontologies as knowledge objects on their own there are several languages available, of which RDF schema and DAML+OIL have received the most attention. Meanwhile there are a number of methods and tools for ontology construction, as well as a various options on how to employ ontologies in systems development and how to construct "ontology-driven" information systems [10].

Ontologies are also regarded as a key to solving interoperability problems (e.g. [17]). The standardization of ontologies used within a network provides a common frame of reference for cross-organizational applications. And if such an agreement is not possible, there is still hope to bridge semantic gaps through mapping and reconciliation of ontologies.

From the perspective of information management, the main challenges related to Semantic Web are to identify the objects which will need semantic markup, to provide (or generate) the appropriate markup, and to understand the processes which will use those objects and the related semantic markups. However, in systems development projects not only the life cycle of resources and their markup come into focus, but also the organizational aspects of information provision and use as well as the reasoning behind identifying, organizing and sharing information. Actually, many authors in the area of Semantic Web see a strong connection to knowledge management and believe that those new technologies will bring a quantum leap. In consequence, most of the envisioned applications related to Semantic Web rely on advances in knowledge representation, intelligent retrieval and facilitation of communication (or a combination of these; cf. [9]).

Semantic Web started out with a document oriented approach; the basic idea was to make Web pages identifiable as informational resources and to annotate them with semantic markup. However, designing and using informational resources is not only a technical and organizational challenge, it must also take into account the social aspects of information. "In fact the concept of a unit of information is central, not only in the technical architecture, but in society's concepts of information, as a document is not only the unit for reference, retrieval and presentation (typically), but also the unit of ownership, license to use, payment, confidentiality, endorsement, etc. (…) so we can't mess with it too much." [2]

2.3 E-government approaching the Semantic Web

The domain specific research and real-life projects in organizations both are only starting to integrate the diverse technical and organizational issues focused on in information management, knowledge management and Semantic Web. This applies also to the field of e-government.

In practice, there are strong efforts in information management to support also e-government issues, mainly through defining metadata standards and interoperability frameworks (most notably in the UK; see [18]). Just recently there is a growing interest in Semantic Web technologies which are reckoned to be a key to solve many e-government interoperability problems (cf. [11], [13]).

Within e-government research, only a few published papers make strategic use of Semantic Web technologies up to now. Approaches in this direction are mainly related to knowledge management. For example, Fraser et al. [6] describe the development of the e-government service ontology and how taxonomies (derived from the ontology) as its domain map may assist knowledge management within service delivery. In the same line, Kavadias and Tambouris [12] propose GovML as a markup language for describing public services and life events: it is a format for XML documents to be exchanged between service portal and authorities (or among them) and it also may support multi-channel presentation of information to citizens. However, both of

these research efforts (based on projects funded by the European Commission) rely on a number of assumptions concerning the view of the domain and the needs of supporting interoperability. It remains to be seen whether these suggestions will be accepted by other actors or the e-government community at large.

From the administrative point of view, Semantic Web and ontology-based approaches seem to promise support for at least the following objectives (cf. [13], [14]):

- systematic management of dealing with all kinds of (electronic) informational resources
- support for administrative processes crossing borders of organizations, systems and infrastructures
- improving service quality: e.g. responding to requests, information retrieval and knowledge management with respect to different actor perspectives

In all of these, each of the local administrations has its own understanding of the domain (e.g. of the services to be given to the citizens and other clients) as well as of the interoperability needs. Domain specific standardization as well as methods and tools may certainly help, but they will not unify the perspectives and the (professional) language of the actors involved. The variety of perspectives and interpretations will even increase since Semantic Web technologies and the use of ontologies enable the treatment of informational resources on a far more fine grained level: now any bit of information or any knowledge object could be given an identity and assigned attributes (metadata) allowing for more sophisticated applications and services also in e-government.

Therefore, the main challenge of applying Semantic Web technologies for e-government services is how to support corporate as well as cooperative information management (and partly even knowledge management) taking into account the increased granularity of informational resources and the manifold semantic differences in dealing with those resources. In the next section we examine a case of developing a prototype for an ontology-driven e-government application based on Semantic Web technologies in order to learn more about how to interrelate systems development with the tasks of information and knowledge management related to the e-government service provision.

3. Semantic Web technologies in action – experiences from developing a prototype

In October 2002 the informatics department of Hamburg University started an explorative project which focused on the application of Semantic Web technologies to enable the "contextualisation" of DiBIS, the Web-based citizen information service mainly for the Hamburg area (see www.hamburg.de or dibis.dufa.de). The overall aim of the project was to obtain knowledge about the users' context, make it computer readable and automatically use it for enhancing the service quality without increasing the workload on the service provider side.

The project involved more than 10 graduate students who carried out all of the tasks described below, the authors acted mainly as project managers. From October to January project meetings were held on a weekly basis. Development, cooperation and documentation within the project were supported through a web-based community system (www.commsy.de), an integrated development environment as well as a version control system.

The project was carried out in cooperation with city administration and the company hamburg.de hosting the city's website. The main contact person from the administration was the manager of the citizen web information service who was recently appointed also information manager to coordinate the provision of all information about the city's administration to be displayed on the web as well as to be used through other channels such as call center. By the end of January 2003, a prototype providing some basic functionality was presented to representatives of the city administration and of the hamburg.de company. At the end of the project, the prototype had been further improved and evaluated.

During the system development process a number of tasks and issues related to Semantic Web technologies, knowledge management and information management appeared to be critical. In the following we identify four issues; for each of these the specific systems development problems are described, requirements for cooperation with the administration are pointed out, and the role of an information manager is highlighted. At the end of this section we summarize the lessons we learnt.

3.1 Requirement analysis

The first task in any software system development project is to define the scope and to elucidate the requirements of the system to be built. State-of-the-art of Requirements Engineering (e.g. [15]) recommends the analysis and negotiation with users and/or contractors (including documentation and validation) and proposes techniques such as user interviewing and analysis of existing systems. Within our project, all of these turned out to be difficult: citizens using Web-based services are a diverse crowd, requirements for innovative Semantic Web applications are mostly unknown to service users as well as service providers, and Semantic Web applications in e-government are not yet around for analysis. Given these limitations we chose the following strategy to obtain some insights on the requirements

- A session was scheduled with the DiBIS manager to present his view of the current service and user dissatisfaction as well as his vision of the future service.

- The scope of application was restricted to 'moving home' to/from or within Hamburg as one example of a life event.
- The application prototype should supply the end-user with information on how to proceed as well as with administrative forms
- Scenario writing was used to highlight and discuss requirements for information and services from the user perspective.
- The use of prototyping was planned to explore how semantic web technologies could support both the end users as well as the administrative users.

Based on the main objective to improve efficiency and service quality, the overall vision of the administration is to implement and support information management which can handle elementary informational resources as well as complex aggregations of these without being dependent on (1) the media/channel of service delivery, (2) a certain editorial and/or information management system, (3) specialized technical expertise. From our interaction with the administration we understood the following main requirements for IT to support the service provider:

- Administrative staff must be able to identify, select, edit, and publish informational resources with the help of IT systems, but without needing IT expertise.
- Relating semantic markup to informational resources and relating both to conceptual models (e.g. of a life event) must be an easy and understandable process.
- The web-based application must be able to handle public as well as private informational resources (i.e. for general use or related to a client's case). In particular, data relevant to the context of a client should be accessible through distinct objects.
- It should be possible to exchange structured information (i.e. complex knowledge objects containing public and/or private data) with other services or service providers.

In Germany, citizens must notify the residents' registration office about the move from one address to another even if they stay in the same town. Usually they have to deregister at one office and register at the office next to the new location. In order to describe this process, a number of scenarios 'moving home' to/from or within Hamburg were produced. The scenarios produced for 'moving home' to/from or within Hamburg were complex enough to highlight a number of requirements from the service user perspective and to experiment with contextualisation as well as with the exchange of information between different city information systems. Within this project, contextualisation (not to be confused with personalisation) was defined as striving for

- display of information relevant (only) for the context of the user
- context-sensitive support and control of the user dialog
- obtaining and use of available context-relevant data

For prototyping purposes, it was assumed that knowledge about the users' context may be obtained through interpretation of user navigation and of user input (e.g. in forms) as well as through reuse of data from recent sessions. As this strategy must raise serious concerns about privacy, the overall premise was from the beginning that all information obtained is to be displayed to the user and to give her/him the complete control over what to do with this data.

3.2 Choice and mastering of Semantic Web technologies

In order to meet the requirements listed above, we decided to incorporate an ontology of all informational resources (public and private) relevant to the administrative services centered around the life event 'moving home'. This ontology can be used to produce the semantic markup of the resources and their markup and to provide a machine readable "explanation" of how those resources are interrelated. The resources are accessible through the internet and may be connected to backend processes (e.g. transactions). The editorial processes then may focus on the "resource ontology" which is used to set up, structure, and maintain the service provision, thus forming the presentation of the informational resources on the Internet (see figure 1).

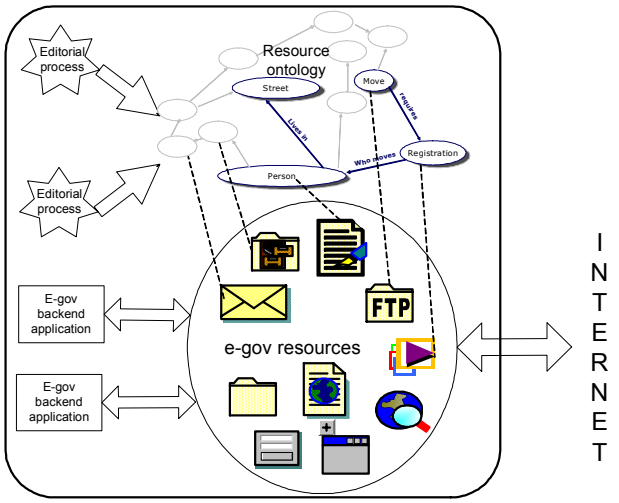

Figure 1. Use of an ontology to mark up informational resources of an e-government service

From the systems development perspective, the next step was to choose and master Semantic Web technologies mainly for construction and representation of the resource ontology. Small teams of project participants evaluated various possible technologies and representations (see section 2.1). The goal of this analysis was to determine the most promising approach. The two most important criteria were the complexity of the technology

and/or its representation and the availability of well documented frameworks or program libraries implementing the concepts of the approaches. The RDF language and DAML were selected to be used because of comprehensibility, standardization, and the availability of software toolkits. For providing run-time components representing and manipulating the RDF models we chose the Java based Jena Toolkit [16] which also includes DAML+OIL functionality on top of the RDF models for handling ontologies.

As for most Web-based applications the information architecture needs to be implemented along with the architecture of software components (cf. [19]). Applying Semantic Web technologies opens the door to enriching the information architecture through the use of an ontology or other semantic concepts. Here, the ontology is meant to serve as the core semantic expression to support the retrieval/production and display of contextualized information. We therefore chose an approach in which the ontology, represented by a Jena model (i.e. an RDF representation) will be interpreted by the application logic. The resulting architecture is depicted in figure 2. The content management system (CMS) component for compilation and delivery of the final content to the browser has been included as a given component of the corporate IT infrastructure at the service provider. However, the CMS is not an integral part of the application architecture and therefore could be replaced. In our case, it has been supplemented by a component for visualization of the user context data (see section 3.4).

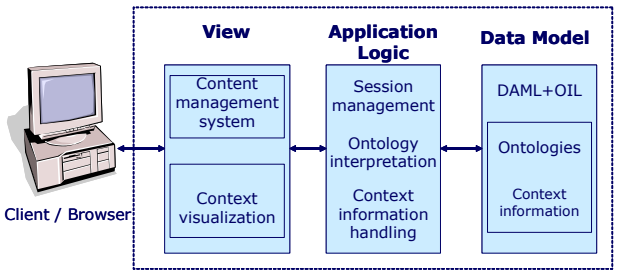

Figure 2. The system architecture for the e-government application based on Semantic Web technologies

The choice of technology and architecture was largely influenced by the requirements for incorporating and processing semantic expressions. Increased sophistication of the technical implementation may augment the quality of service application, but at the same time it boosts the effort for mastering the technology (in terms of required knowledge, components to be integrated, refinement of software process etc.). Since at the beginning of the project the systems requirements could not be elucidated in much detail, the project team spent considerable time in balancing technical sophistication with the approach for representing ontology and informational resources.

3.3 Representing ontology and informational resources

Besides choosing the new Semantic Web technologies and tools, the main challenge within the development process was how to capture and obtain the life event service ontology on the conceptual level (from the perspective of an administrative information manager) and to determine the need for processing semantic expressions. Given the overall requirements (section 3.1) the procedure of creating, editing, and enriching information with semantic markup had to be developed in detail, and the context of the individual user had to be represented in machine readable form for any component within or outside the server environment providing the site.

To find adequate solutions from the application point of view, a number of issues had to be clarified related to the scope and granularity of concepts to be included (e.g. “person”, “family member”, “address”) and the (dynamic) relations between them. At first, it seemed that the development project would imperatively need an on-site domain expert from the Hamburg administration. But discussions with those in charge of information management for the web information service revealed that production of this kind of ontology is a difficult task for which the administrative staff is not prepared. Instead, in the project we established a sub-team in charge of the ontology, the relevant informational elements and the application processes incorporating those elements. Because the choice of technology is related to the syntax and semantics of the data representation, this team was closely interacting with those integrating the Semantic Web technology and designing the architecture of the prototype (see above). After several weeks this cooperation settled for the following strategy:

1. An editorial board produces an ontology (here: for the life event ‘moving home’) which identifies and represents the semantic structure of all resources incorporated in the Web-based information service (topics, key words, information elements, transactions, downloads, relations/links, services, etc.).
2. This ontology serves as a schema for creating an instance of representing the individual life event including specific user context. Through this all elements of these instances are machine readable, marked up and semantically interrelated.
3. Presentation of public resources through the web site follows the structure of the life-event ontology. If “private” (case-based) resources need to be displayed, the individual life event instance is taken into account.

4. The data representing the individual user context within the life event instance is visualized so that the user can view/explore all information elements and their interrelations which the website has stored about him/her at the time of viewing.
5. The user is given complete control over his individual user context instance, e.g. he/she can decide about deletion or storing all or part of the information, or about passing on all or part of the information to other web site services if feasible.

In the project it became obvious that developing Semantic Web applications requires the role of an information manager who is capable of and responsible for designing elementary and complex informational resources and developing conceptual models as blue prints for construction of ontologies as the basis of web information systems.

Hence, the next step is to cooperate with the information manager to learn about future requirements, to enroll administrative staff for interviews and to learn about their tasks of information management for e-government services. Due to limited time and resources within the project we did not develop components or tools for editing informational resources along with conceptual models and semantic structures. However, the key to developing those tools is the understanding of the editorial process from the administration point of view.

3.4 Creating external interfaces: Web user interaction and service interoperability

The practical value of the system developed is largely determined by its interfaces to users as well as other components and external services (like agents and other city information systems). The following had been in the focus of the project:

- For the first version of the prototype we relied on the layout of the existing citizen information system as well as on the same kind of CMS the city is using for new Web applications. The design of the interface with the CMS includes (1) the extraction of relevant data from user input for representing the user context and (2) informing the delivery of information resource on the basis of interpretation of the life event service ontology and the user specific context data.
- User access to all of the specific context data (for viewing, editing, transferring and deleting) was imperative from the beginning of the project. This development task was assigned to a small team that then also acted as virtual user in order to explore the need of the users for this part of the interface. After evaluating several possible presentation layouts it was decided to use primarily a tree-type view resembling the folder view in the Microsoft Windows-Explorer to supplement the current layout, with additional links to a data net model. A visualization component, interacting with the run-time components representing the RDF models, was then implemented and integrated into the architecture (see figure 2).
- From the beginning of the project we sought for a technical solution which remains independent from the given infrastructure and organizational context at hamburg.de. The technical implementation succeeded in encapsulating the core semantic concepts in RDF-encoded “knowledge objects”, primarily the life event resource ontology and all of the individual user context representations. Allowing access to these RDF objects, a remote editorial process can be set up for the legitimate actors (administrative staff, clients), viewing and manipulating the informational resources. Within the project, we realized several options for visualization whereas the editing had not (yet) been supported.
- Similarly, the interface to external agents and systems was not implemented in the first version of the prototype. However, the vision of seamless e-government services and back-to-back interoperability of e-government systems had motivated the choice of employing Semantic Web technologies. Therefore, the system’s architecture now allows for easily implementing an interface to publish the life event service ontology and to securely export private user related data which may be semantically interpreted on the basis of the public ontology which was used for internal data representation.

3.5 Lessons learned

The prototype which was presented to city representatives in January 2003 has basically provided the functionality to support the strategy described above. However, from the service provider perspective a number of unresolved issues remain for systems development, among the most pressing are:

- taking care of security, privacy, data protection and authentification
- selecting and structuring domain information and related resources in relation to life event ontologies
- supporting the editorial process for ontology production
- control of user dialog based on ontology interpretation
- integration of external services

While security and privacy issues were considered the most critical for service quality acceptance, it was agreed that the editorial process is the most critical issue on the way to implement semantics in the citizen web information service and to improve efficiency of information management within e-government services. The introduction of semantic expressions on several levels suggests multi-layered editorial processes to make full use of Semantic Web technologies for Web information

management. To sum up our experience, the important lessons learned in this case are:

- Developers do not have time and the necessary domain knowledge to decide about the semantic issues of the application to be developed. Therefore, the informational design of the Web-based service should be as independent as possible from the technical implementation. This also allows for more flexibility after finishing systems development activities.
- However, the levels of sophistication and granularity of the conceptual modeling and of the implementation of Semantic Web technology are interrelated. To decide on an adequate balance requires detailed knowledge of application oriented requirements and of the technological potentials. As both of these are currently hard to obtain for systems developers, Semantic Web projects are likely to require a time consuming process to achieve this balance during development.
- The project has chosen to codify the relation of all public informational resources related to the selected life event service within an ontology. Up to now, the evaluation of the prototype has not yet proven the success or failure of this approach, and future research is needed to inform systems development in this respect. One of the criteria for success is envisioned to be whether the administrative staff will be able to easily create and use the life event resource ontology (which is not to be confused with a life event ontology). In order to do so, the editorial process as well as the process of information management must be clarified; thus a service for providing the service must be defined.
- E-government services employ informational resources on several different levels; at each of these, different ways of semantic markup and approaches to the editorial process are needed. The first level is related to the basic domain knowledge, i.e. to the administration's corporate view on what is relevant for a life event such as moving home. The second level comprises more "operational" information, e.g. pointing to the opening hours of an office or telephone numbers of an official in charge. The third level embraces information about the resources itself, for example about its format, its life cycle or options for being combined or used by other applications. Since each of these require different editorial processes and semantic models, this necessitates a more elaborated approach than just having one resource ontology to govern all of these levels of information management.

The tasks of the information service manager (or whoever is able to answer the questions) turned out to be more extensive than we envisioned beforehand. The development could have largely benefited from a "user representative" (i.e. a person from the organization to use the system; e.g. an on-site customer known from eXtreme Programming and other agile methods). Thus we conclude that projects targeting at Semantic Web applications should from the beginning enroll an "information manager" to answer all these questions or unfold activities to obtain the answers. This is especially necessary in the area of e-government services where a large number of different actors and administrative organizations are involved and have to interact on different (administrative) levels. The information manager has to fill out the role of an integrator, a person who has an overview of the processes and serves as a contact person for the administrative users as well as real world users. It also comprises the task of managing surveys among and/or negotiations with users inside and outside the administration in order to supply the developers with the necessary information about functionality.

4. An agenda for the cooperation of information managers and systems developers

At the beginning we had asked for an adequate kind of information technology as well as a direction of systems development to enable the next steps in information and knowledge management needed for e-government services. From our project experience we had identified four critical issues in interrelating systems development and information management This last section generalizes the lessons learned from the project and presents an agenda of cooperation between system developers and the "information manager" as a prerequisite for successfully employing Semantic Web technologies in e-government services.

In our project we could interact with the information manager in charge, although we learnt only over time how to cooperate efficiently. However, because of the electrification of document and information processing and in order to meet the challenges related to e-government information management (see section 1), all administrations are forced to streamline their information management efforts. Therefore we expect that in the future the role of an information manager will be implemented in many administrations, or even several roles with divided responsibility. Based on the analysis of problems encountered in our project, we suggest the following to be included in an agenda for the cooperation of the systems developers with the administrative information managers:

Systems development tasks	**Critical questions beyond the technical scope of systems developers**	**Activities of administrative information manager providing ground for technical design decisions**
Requirements analysis	– What are the requirements for innovative Semantic Web applications? – What is the significance of semantics?	➢ Deficit analysis of existing e-government services ➢ Future application scenarios ➢ Elucidating service provider and user perspectives on service quality and efficiency
Choice and mastering of Semantic Web technologies	– What is the best choice of technologies and architecture? – What are the implications of the conceptual models on the system design and performance, and vice versa?	➢ Identifying the relevant informational resources for the e-government services in focus ➢ Determination of the need for semantic expression and for automatic processes in future applications and infrastructures ➢ Designing elementary and complex resources on different levels of informational resources, determining the level of granularity to be addressed, and developing conceptual models as blue prints for construction of ontologies
Representation of ontology and informational resources	– How can the conceptual models as perceived by administrative staff be captured and represented by ontologies? – What kind of editorial process needs to be supported?	➢ Agreement on editorial process, identifying staff tasks contributing to information management
Creating external interfaces	– What do citizens and other "users" (Web agents, external systems) want/need? – What are their interface requirements?	➢ Determination of the need for informational resources to be shared across borders of organizations and infrastructures ➢ Agreement with actors involved on service quality and interoperability

Table 1. An agenda for the cooperation of systems developers and administrative information managers as prerequisite for the successful employment of Semantic Web technologies

The agenda is organized along development tasks related to employing Semantic Web technologies (table 1). For each task, critical questions beyond the technical scope of systems developers are contrasted with activities of administrative information manager which are likely to provide answers to these questions and thus ground for the necessary technical design decisions. In the table there is no borderline between the activities related to the tasks of choice and mastering of Semantic Web technologies and of the representation of ontology and informational resources. Assuming that no conceptual, technical or organizational legacy constrains freedom of decision, it is within those tasks and related activities that the actors involved have to find out and agree on an appropriate equilibrium between systems architecture and information architecture, between functionality expectations and feasibility, between cost and benefit of the envisioned e-government service. In any case, the cost/benefit-assessment should include development trade-offs beyond any particular e-service, i.e. contributions to the IT and information infrastructure within the administration which may serve also other IT-based government activities.

However, this agenda is brought up from a systems development point of view – it does not cover the concerns of the information managers related to Semantic Web technologies and the development process. It is a first effort to systematically highlight the new challenges for systems development employing Semantic Web technologies to support information management within e-government services. It will need further research to consolidate this agenda and to explore the requirements and success factors to work off this agenda, e.g. in terms of project participation, handling complexity of administrative settings, domain knowledge and communicating skills etc.

Building an innovative system is always an iterative process in which learning and envisioning new applications and functions is an integral part. Since e-government applications, the demands for information management and e-government interoperability, and also the Semantic Web technologies are changing fast, it is very difficult to recommend technical solutions and identify best practices. However, we are convinced that especially in this dynamic environment a role such as the information manager is required to link systems develop-

ment and information management, in order to meet the challenges and needs of the e-government providers and users (on social/personal, organizational and technical level) as well as to understand their demands and capabilities on dealing with semantic expressions.

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