An Ontology for e-Government Public Services

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INTRODUCTION

In the past few years, information and communication technologies are increasingly used for provision of public services, improvement of managerial effectiveness and promotion of democracy, a development that is commonly termed as e-government (Gil-Garcia R., 2004). Transactional services (such as electronic forms) are an indispensable tool for delivering public services and can additionally be used for democracy promotion (e.g. via questionnaires and polls), playing thus a central role in e-government; in (European Commission, 1999) transactional services are perceived as future of e-government. Transactional services development and promotion has also been in the focus of specific projects and initiatives (e.g. European Commission, 2004) or supporting frameworks (e.g. UK online, 2004).

E-government services have now been considerably developed to cover the basic services that should be delivered to citizens and enterprises (Cap Gemini, 2004). Administrations now realise however, that besides making available new electronic services or enhancing existing ones, a number of issues regarding electronic services has to be addressed, including:

1. *e-service composition*. In many cases, different public services need to be combined to fully service the needs of a service consumer (citizen or enterprise) in a particular point in time. This issue is often termed "handling of life events" (Wimmer, 2002).
2. *e-service cataloguing*. Mechanisms enabling service consumers to locate the available e-services should be provided (Gant, 2002). These mechanisms should cater for the needs of all service consumers through appropriate techniques, such as incorporation of multiple taxonomies for e-services (e.g. by delivering organisation, life event, by service category etc), provision of search facilities, retrieval of relevant legislative information etc.
3. *change management*. Legislation regarding governmental services is often revised, necessitating changes to the content or procedures of services (Vassilakis, 2003). Electronic services, are more prone to changes since the regulatory framework of electronic service provision can also be subject to modifications (e.g. stronger encryption or more strict authentication requirements), triggering additional maintenance activities. Whenever changes occur, the affected services (or service portions) must be located in order to undergo maintenance activities. *Cascading effects* may also appear,

e.g. if service A depends on service B and service B is modified, harmonisation actions may be needed for service A.

4. *administrative responsibility*. The administrative responsibility must be clearly reflected in all phases of electronic services lifecycle (Cassese and Savino 2004), since it determines both the authoritative source to define (or revise) requirements and procedures and the canonical bureau for operating the electronic service, resolving issues etc. In some cases, operation of services can be delegated by the administratively responsible authority to other agencies, e.g. the ministry of internal affairs is administratively responsible for the service "issuance of birth certificates", but municipalities or citizen service centres can be endorsed to deliver this service to the citizens.

The issues identified above reveal the need for *semantically rich* means for representing the various aspects of electronic services. Indeed, through these descriptions a number of *concepts* (i.e. types of entities such as service, document, service consumer, legislation etc) are identified, which are connected through various *relationships* (e.g. a service "issues" a document, a regulation "governs" a service and so forth). Such a representation, together with the appropriate tools, would facilitate the task of locating specific concepts, and then exploit the relationships to trace other concepts that are linked to them. For instance, if a piece of legislation is linked to a number of electronic services through links of type "governs", these links can be used to pinpoint the services that should undergo maintenance activities, when this piece of legislation is modified.

In this work, the usage of ontologies for meeting the requirements listed above is examined. An ontology for e-government services is presented, covering various aspects of services, including administrative responsibility, meta-data, involved documents and legislation. Both the development and usage phase of the ontology are covered and directions for further exploitation of the potential offered by the ontological representation are given.

BACKGROUND

According to W3C "an ontology defines the terms used to describe and represent an area of knowledge" (W3C, 2004), defining *classes* (or *concepts*), which are general things in the domain of interest, the *relationships* that may exist among things and the *properties* (or *attributes*) those things may have. Ontologies can also be viewed as descriptions (like a formal specification of a program) of the concepts and relationships that can exist for an agent or a community of agents (Gruber, 1993).

The representational capabilities of ontologies can be complemented with reasoning capabilities through specific rule languages and rule evaluation engines, [e.g. SWRL (Horrocks et al. 2004), the KAON2 reasoning engine (Motik et al., 2004)], providing thus a framework that completely supports the requirements presented above. Reasoning aims at extracting information not directly represented, mainly through the application of rules on the given facts. For example, the organisations through which a document is issued can be determined by firstly identifying the services that produce the specific document and then retrieving the

organisations that offer these services. This can be represented as a rule of the form "if(offers(Organisation, Service) AND issues(Service, Document)) THEN issues(Organisation, Document)". Such a rule is evaluated by a reasoning engine against the existing ontology to produce the list of organisations issuing a specific document. Finally, the use of ontologies enables direct integration of public services into the semantic web (Berners-Lee, 2001), multiplying the benefits of this approach. For this purpose, special languages have been designed, including DAML and OIL, whereas RDF can be also used for defining assertions (Davies et al., 2003).

Regarding electronic services, different aspects of them have been addressed by both research and industrial work. Service composition is typically tackled using pre-determined execution scenarios, where human experts model the execution order, flow control and data dependencies of constituent services (Wimmer and Tambouris, 2002; Bunting D. et al, 2003). More flexible frameworks allow the dynamic modification of certain model elements (Casati et al. 2000), while commercial systems enable the graphical modelling of composite services and provide engines for their execution (Iona, 2005; Oracle 2004).

In the area of e-service cataloguing, the predominant approach is the use of portals, e.g. FirstGov of US (http://www.firstgov.gov) and DirectGov of UK (http://www.direct.gov.uk/Homepage/fs/en). Portal maintenance is however a costly task, since the need for flexibility and support of multiple views in a change-prone environment, necessitates frequent updates and extensive consistency checks.

The relationship between electronic services and legal documents or administrative information is usually handled in an ad-hoc manner. In the best case, legislation databases will be used for maintaining the "point-in-time" versions of the legislation (Teratext, 2004), but no direct linkage to the relevant electronic services is established. Similarly, administrative information for e-services is stored only in an unstructured form within the legislation and/or the public authorities' regulatory framework.

In recent work, the usage of ontologies for modelling electronic services has been reported. In (Bougouettaya et al., 2001) ontologies are used as a basic model for organising and discovering e-services. An important aspect of this work is the *ontology distribution*, which facilitates a semi-autonomous maintenance of the ontology data, with each administration maintaining a specific ontology portion. In (Klischewski and Jeenicke, 2004) and (Tambouris et al., 2004), the usage of ontologies in application development is examined. Finally, in (Fraser et al., 2002) an ontology is formulated to promote knowledge management in the context of electronic service development.

PUBLIC SERVICE ONTOLOGY: KEY REQUIREMENTS, MODELLING AND USE

For a public services ontology to be useful, a number of requirements have to be met. Firstly, the ontology should be *complete*, i.e. it should cover all relevant aspects of the services. Secondly, it should facilitate *incremental ontology*

development, by incorporating certain concepts and relationships at an initial phase and then defining new ones, or creating instances as needed. Due to the de-centralised responsibility scheme for public services, it is desirable to build an ontology scheme that can be jointly developed by multiple authoritative sources. Each source would maintain its own portion of the ontology, and the combination of all portions would form the global perspective. The global perspective should also allow for relationships between different portions of the ontology to be established. The ontology should allow the extraction of different *views* [or *taxonomies* (Fraser et al., 2002)] enabling public service stakeholders to navigate within the ontology concepts as best suited to their interests, or the task at hand. The *semantics* of the concepts and relationships within the ontology should be clearly defined; in the presence of ad-hoc concept and relationship types, user navigation within the ontology is encumbered and reasoning through rules can be hindered. Relationships of non-standard semantics cannot be taken into account by rules, merely adding thus "noise" to the ontology.

The Ontology Template

In order to guarantee that the ontology only contains approved concept and relationship types, the editing process is supported by an *ontology template*. The ontology template defines all the allowable concepts and relationships that can be used by the ontology editor. For relationship types, the ontology template also designates which concept types can be linked using any particular relationship. For example, the "offers" relationship type can link concepts of types "service" and "organisation" but cannot two concepts of types "service" and "legislation". Table 1 lists some of the main ontology template concepts, while Figure 1 illustrates these concepts, along with associated selected specialisations (sub-concepts), as modelled using the KAON tool (http://kaon.semanticweb.org/).

Concept	Description
Service	A means offered to the public for conducting business with the government
Service consumer	A citizen or enterprise that is a potential user of a service
Organisation	A governmental division that is responsible for defining and/or offering services to service consumers
Service implementation	A concrete form of a service, offered by an organisation and made available to service consumers
Legislation	Any type of official document or practice that regulates the operation of services
Form	An instrument through which a service consumer requests a service, typically by provision of field values and submission
Document	An official certificate issued by services
Life-event	An incident for a service consumer that necessitates the use of a number of services

Table 1 – Concepts in the ontology template

In Figure 1, only *isa*-type relationships (specialisations) are displayed, for clarity purposes. The input for this ontology was gathered from e-government

public service stakeholders (including managers, domain experts, help desk workers and IT staff) in three European countries (UK, Greece and Spain). Cognitive maps (Axelrod, 1976) were the basic tool for guiding the input collection process.
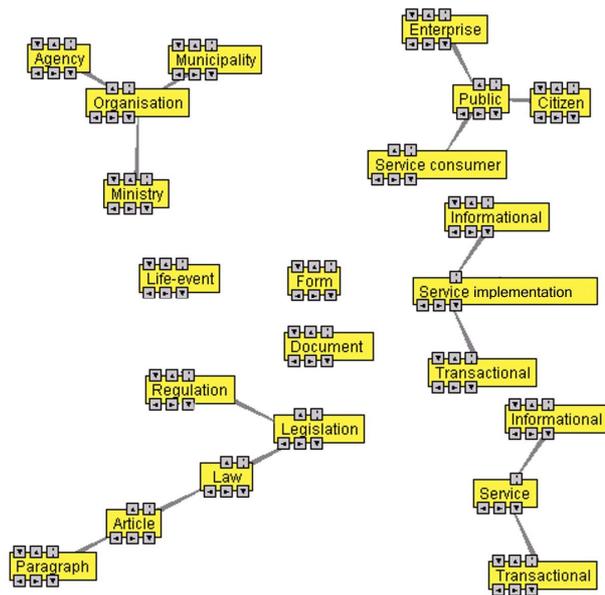

Figure 1 – Part of the electronic services ontology

Ontology population

The ontology template is the basis for enabling the ontology development process, since it defines the semantics available to ontology editors. A second necessary step is the definition of public authority *administrative responsibilities*, associating specific editing rights on portions of the ontology to different public authorities. Under this scheme, first-level administration entities (such as ministries) are created as *instances* of the relevant "organisation" sub-concept and they are granted the privilege to create sub-concepts or instances of the concepts in the ontology. For example, the Ministry of Finance may create the "Taxation Office" concept as a sub-concept of "Agency" and instantiate it multiple times to populate the ontology with information about tax offices. Additionally, the Ministry of Finance can directly instantiate a concept of the ontology template (e.g. "regulation") to provide data for a new piece of legislation. The organisation creating a specific sub-concept or instance is its *owner* and automatically assumes full permissions on it. Other organisations may view all sub-concepts and relationships between them in the "global" view, however they cannot modify them. Establishment of relationships between concepts may be subject to restrictions, depending on the relationship semantics. For example, the "offers" relationship linking an organisation to a service can only be established by the organisation that is administratively responsible for the service. Such a linkage states that the organisation has the right to offer this service and enables it to create an instance of the "service implementation" concept, which describes the characteristics of the specific service offering. Conversely, no restrictions are placed for the

establishment of the "involves" relationship between a life-event and a service, since life-events may include services offered by any organisation, regardless of the organisation defining the life-event.

Both concept and relationship instances host various data items describing the information items they represent, constituting thus *meta-data*. The allowable data items per concept and relationship type are recorded within the ontology template. For example, a "service implementation" concept instance will contain data slots regarding the method for invoking the service (web form, web service, RMI, etc), the address at which the service is accessible (e.g. URI for web form, WSDL file location for web services and so forth), the expected turnaround time for an invocation etc.

Service composition using the ontology

Two of the relationship types defined in the ontology template, namely the "issues" and "uses", are of particular interest for the purposes of service composition. A relationship of type "issues" is established between an instance of the "service" concept and an instance of the "document" concept, to assert that the specific service may be used by a service consumer to obtain the designated document. A relationship of type "requires" is created between an instance of the "document" concept and an instance of the "service" concept to declare that the service uses as input a document of the indicated category. For example, a "requires" link pointing from the "Marriage License Issuance" service to the "Birth Certificate" document illustrates that service consumers must present a "Birth Certificate" document as input to the "Marriage License Issuance" service. These relationship types can be exploited by *dynamic service composition engines* to formulate on-the-fly service composition paths. When a service consumer requests a service S, the service composition engine extracts all relationships of type "requires" emanating from it. Through these relationships the required input documents are identified and, by subsequently following the "issues" relationships, the services producing these documents are pinpointed. This procedure is iteratively executed until no further dependencies exist. Note that if multiple services can issue the same document, or if multiple implementations for a single service exist, the service composition path will contain alternative routes leading to the desired result. The service composition path enactment mechanism may select the most prominent routes for fulfilling the request, employing optimisation criteria (e.g. current system load or expected turnaround time of services, as indicated by the metadata in the ontology).

Service cataloguing through the ontology and rules

The ontology can be exploited by service cataloguing mechanisms (e.g. portals), to present service consumers with flexible means for locating services. Since service catalogues are generally organised as taxonomies, the first step towards building a catalogue is to locate the root entry of the taxonomy. This can be any top-level concept, e.g. "Organisation", "Life-event" or "Document". Afterwards, sub-concepts and instances are extracted to formulate lower-level taxonomy branches, and relationships are used to identify services that will become

the taxonomy intermediate-level or leaf nodes. For example, if the "Life-event" node is used as root entry, its instances ("Birth of a child", "Building a house" etc) are extracted and afterwards the "involves" relationships between the life-event instances and the respective service instances are traversed to populate taxonomy branches with the pertinent services. Through this approach, the ontology may be used to create multiple service classification schemes, by selecting alternate root entry concepts and/or traversing different relationship types. The rules for service catalogue creation (i.e. the definition of concept and relationship types that will be used, the order of processing etc) can be stored alongside the ontology, or be incorporated within each service cataloguing mechanism. Finally, querying mechanisms may be provided to enable service consumers to locate elements of the ontology whose contents match a set of criteria (e.g. the name of a service or a document), as an alternative to browsing.

FUTURE TRENDS

Ontologies are considered nowadays a key element for semantic interoperability, and information exchange between computers and humans in high complexity environments, providing an effective means for representing information in high levels of abstraction. For a more efficient use of ontologies, it would be beneficial if the immediate possessors of the knowledge could directly maintain the relevant ontology portions, without ontology experts' intermediation. To this end, ontology elucidation frameworks should be designed and appropriate tools must be developed and made available to domain experts.

Temporal characteristics are also of particular importance, especially in highly volatile environments such as the one of public services. The ontology framework must be thus extended to cater for the creation and querying of concept and relationship versions, maintaining simultaneously temporal consistency rules for concepts, relationships and instances (e.g. only one version should be active at any point in time).

CONCLUSION

In this article we have presented an ontology for e-government public services. The ontology covers multiple aspects of services, including administrative responsibility, involved documents, legislation and meta-data, formulating a semantically rich network of interrelated concepts. This network can be jointly developed by public administrations, subject to administrative authorisation, and directly supports essential tasks of service provision, such as service composition, change management and service cataloguing. This ontology may be complemented with active mechanisms, including rule processing engines, workflow enactment modules etc., to deliver value-added services e.g. invocation, coordination and data exchange between the constituent services within a service composition path. Future work will focus on the definition and management of temporal characteristics, the creation of an integrated platform that will fully manage the ontology and encompass mechanisms for provision of value added services. Integration with third-party information systems, such as legal databases for extracting legislation information, will be also considered.

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TERMS AND DEFINITIONS

Public service: A means offered to the public for conducting business with the government. The service may be directly targeted to be used by humans (e.g. web forms and the associated back-end programs) or be oriented towards invocation by information systems (e.g. a web service).

Ontology: An ontology defines the terms used to describe and represent an area of knowledge, defining classes (or concepts - general things in the domain of interest), the relationships that may exist among things and the properties (or attributes) those things may have.A set of concepts interrelated by binary typed roles. The concepts may be organised in specialisation/generalisation hierarchies. Ontologies may be used for information exchange between computers and humans in environments of high complexity.

Reasoning: The extraction of information not directly available, mainly through the application of rules on the given facts. This procedure is driven by the reasoning engine.

Service composition: The combination of simple services to achieve a value-added result and fully service the needs of a service consumer (citizen or enterprise) in a particular point in time

E-service catalogues: Mechanisms enabling service consumers to locate the available electronic services. Most often, these mechanisms are hierarchical classifications of the services under some categorisation axis (offering organisation, target group, etc)

Ontology distribution. A mode of semi-autonomous maintenance of ontology data, according to with each public authority maintains specific portions of an ontology.

Life-event: An incident for a service consumer that necessitates the use of a number of services.

Change management: The procedure that controls the evolution of public services to keep them consistent with their governing legislation, user needs, technological developments etc.