E-GOVQOS: AN ONTOLOGY FOR QUALITY OF E-GOVERNMENT SERVICES

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Abstract – In this paper we present e-GovQoS, an ontology to specify "quality model" for digital e-Government services suitable for quality evaluation, monitoring, discovery, selection and composition. It takes into account a taxonomy for formal representation based on quality parameters and a mathematic model. Our ontology is significant for the realization of a community in which "user satisfaction" is a key element for governance development. Moreover, e-GovQoS can be a base element for a federated reality in which reuse, interoperability and cooperation are fundamental concepts.

1. Introduction

Nowadays, interoperability and cooperation among Public Administrations (PAs) are fundamental elements to promote their governance. e-Government [16] plays a base role for a better delivery of government services to citizens, business and organizations, and for a more efficient government management. For this administrations promote services to automate their activities and to improve their cooperation. To reach this aims e-Government services should be improved and integrated. Moreover, digital services in e-Government domain need the introduction of Quality of Service (QoS) and interoperability aspects. They are mandatory in order to satisfy citizens and firms' needs and to accept the use of Information and Communication Technology in our life.

A widely accepted definition of quality is given by the International Organization for Standardization (ISO) [9]. It is, of course, a very general one, but it does not take into account the peculiarities of the specific application domain. In the e-Government environment by quality we mean:

"all the features of digital services in Public Administrations that influence their capability to satisfy declared or implied citizens and firms' needs".

Interoperability has been identified as a major issue to face by all Public Administrations. If an high interoperability level is reached different administrations can cooperate and develop federate communities. In this way reuse of services is facilitated. A working paper by Commission of European Community [15] shows the important role of interoperability. It is not only a technical issues but a fundamental semantic and organizational skill. In literature, we can find different types of interoperability [10], but in this paper we take into

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consideration the semantic one. In particular, semantic interoperability is a capability derived from the application of a special software technology that infers, relates, interprets, and classifies the implicit meaning of services and digital contents without human involvement. In this way a process of adaptability about business process, PAs knowledge, and software application is engendered. The governance of knowledge is needed to promote innovation in Public Administrations and to guarantee an adaptable solution.
The introduction of the semantic representation of services and quality parameters allow a vision in which information is given clearly. In fact, engine can process and integrate information in an easily way. A semantic description of services can be a solution for the develop of knowledge in Public Administrations and, at the same time, it can be seen as a huge engineering solution. Moreover, expressing QoS parameters in an explicit way may be useful for services characterization.
During the quality estimation of e-Government digital service we propose to take into consideration the following components: (a) introduction of a mathematic model to define a utility function [3]; (b) study of quality parameters to be included in the model; (c) representation of parameters and metrics using a shared representation (ontology).
In this paper, we take in consideration the third step and we investigate about an interoperable, not ambiguous and extensible semantic representation of reality [7] useful for the quantification of QoS parameters (base on [12] [14] [13] [11]) and their related metrics. Semantic representation of reality allows shared vocabularies and semantics for all the interested parts. In this way the mismatch between different terms and meanings is removed and the assumptions in a specific domain have a more detailed description. Furthermore, interoperability and reuse of the QoS knowledge are make easy. The introduction of quality with a valid semantic support allows also the development of a federated reality in which interoperability and cooperation are fundamental concepts. Quality of Services and semantic may be foundational elements for the realization of a communities in which user satisfaction is a key element for governance development. This federated realities allow digital services sharing and their fair distribution, saving time and costs.
Summing up, we present a quality ontology e-GovQoS to describe e-Government services and their related quality. The e-GovQoS ontology will allows a useful evaluation of e-Government services during the process of service discovery and composition in order to promote the development of PA processes.
The rest of the paper is organized as follows. The Section 2 presents the role of semantic interoperability in e-Government. Section 3 examines other interesting ontologies relevant to e-GovQoS. Section 4 presents the structure of e-GovQoS. At the end, we summarize conclusions and future work.

2. Role of semantic Interoperability in e-Government

e-Government services have been deployed by a large number of Public Administrations. On one hand, those services are islands of automation. This fragmentation may be the cause of several handicaps to the widest possible impact of e-Government. On the other hand, joining-up administrations and inter-linking digital services is made possible through the interoperability of e-Government services.
In particular, a lot of the introduction of semantic interoperability in the e-Government domain brings benefits. In this way, the Public Administrations increase their capabilities and introduce the use of information technologies in their services. In a domain characterized by a large heterogeneity along several criterions we propose a solution to access and share knowledge. All this can bring greater advantages in PAs.

The interoperability can reduce time and costs to develop new solution for Public Administrations. If we take into consideration the organizational aspects of semantic interoperability (for the process coordination intra PAs and inter PAs) we can single out that it can solve most PAs problems. Moreover, in a federated reality a common semantic may be a foundational element to increase the knowledge of the system. The lack of interoperability in e-Government domain can induce economical and social effects. Indeed, when the Public Administrations are static and do not take into account interoperability aspects they are too expensive and unable to implement the right policies.
Nowadays, in e-Government system we point out some problems as: (i) the need of development of added-value services, (ii) the high development costs, (iii) the administrative skills and (iv) competitive disadvantages. For this reason the interoperability can be one solution for them as well as the development of e-Government in Italy can take advantage from interoperability.

2. Background

2.1 Web Ontology Language

OWL (Web Ontology Language) [17] is used to satisfied the needs to process information instead of just presenting them. OWL promotes interoperability of contents providing a dictionary with a formal semantic. It doesn't allow any range specification for datatype value but this drawback is overcome using an extension of OWL, the XSP ontology [8] that defines RDF properties used in XML Schema functionality includes into OWL ontologies.

2.2 OWL-Service Ontology

OWL-S (OWL-Service Ontology) [1] is an OWL based Web Services ontology. The first vantages of using it, rather than another approach to semantic Web Services description (as WSMO [4]), is the OWL-S generic model to present services. It is structured around the class Service, which consists of one or more ServiceProfiles, ServiceGroundings and a single ServiceModel. The ServiceProfiles gives a high level description of the service and its provider. It is a concise statement of the service and it is generally used for service publication and selection. The ServiceModel is a representation of the external behavior of a service as a process, as it describes how the service works and the functional model of the service. Finally, the ServiceGrounding specifies the binding information needed for the service invocation (protocol, message formats, transport and addressing information). This upper ontology for services specifies only two constraints: a Service can be described by at most one ServiceModel, and a ServiceGrounding must be associated with one and only one service.

2.3 QoSOnt

QoSOnt [5] ontology is an OWL-S extension and it describes the Quality of Service with a set of generic concepts [6]. We underline the extensibility and the reusability of this ontology. It is structured as a set of interconnected smaller ontologies composed of a base module and three layers (i.e. usage domain, attribute, and unit). Metric attributes and other basic QoS concepts are defined in the base module. In particular, about the unit of measure only time is take into consideration and it is described inside the QoSOnt. About the quality attributes [2] only dependability and performance parameters are introduced. Finally, about domain layer QoSOnt supports network and services as the type of system that QoS may refer to.

Relationships between QoSOnt and OWL-S are well-defined and they allow metrics and attributes to be referred to services.

4. The e-GovQoS Ontology

Our aim during the plan of e-*GovQoS* ontology is to describe e-Government services and their related quality making easy a better interoperability among PA services. We propose a formal and explicit specification about concepts, relations and other important elements of interest for e-Government domain. Our ontology is based on specific parameters taking into consideration the taxonomy presented in [12] [14] [13] [11] and a study about metrics. We enrich OWL-S to supply a formal description of non functional aspects to include Quality of Service for e-Government. At the same time our implementation reuse and extend the concepts of QoSOnt ontology and overcome its restrictions preserving modularity to reach a compressive solution. For example, regarding units of measurement we notice that temporal units are not sufficient for e-Government domain. In fact, we need the introduction of some value graduations, monetary values, information measures, etc. Moreover, regarding quality attributes expressed in QoSOnt like dependability and security we underline that they are not enough to describe quality in a domain in which parameters like legality, trust, content management and supported standard must be take into consideration. In the next sections we present the ontology structure and metrics for service quality evaluation. In particular, in the propose figure we sign using a sketch line the QoSOnt and OWL-S imported parts.

4.1 e-GovQoS Structured

Our ontology is based on the quality model presented in [3] and it takes into consideration the metrics able to refer quality parameters. Starting from *EGovQoSModel* concept, representing the quality model and using to make a link with service representation (OWL Service Profile), our ontology refers four groups of parameters showed in Figure 1: *e-Government*, *Application*, *Web Service* and *Infrastructure*. All this concepts are subclasses of *GroupOfCriteria* concept. QoS computation considers every parameter in a group that is able to aggregate similar criterion. To detect the importance of the group we define, related to *GroupOfCriteria*, the *HasWeight* relation. In this way we can specify users or developers preferences over a specific group. Moreover, the relation HasParameter connects groups with their related parameters. Every quality parameter refers to a single group, hence we believe proper to split parameters in respect of the group they refer to realizing a complete taxonomy.
E-GovAttribute represents common characteristics about parameters. This concept has four subclasses and every quality parameter is a subclass of one of these. In the concept *E-GovAttribute* we define several relations showed in Figure 2. These relations are inherited from all parameters defined in the model.

- *IsDefinedBy* relation permits association between a metric and a single quality parameter. It connects the parameter concept to the concept *MetricValue* defined into the QoSOnt ontology.
- *IsParameterOf* relation combines parameter taxonomy with the related group. On the other hand, we define a relation *HasParameter* linking groups with parameters.
- *HasTrend* relation joins the concept *E-GovAttribute* to *Trend* concept. The latter assumes discreet value 0 or 1 to differentiate proportional and inverse proportional growing of quality parameter respect to overall quality. In the mathematical model this correspond to a value in vector N.

- *HasUpperBound* relation links every quality parameter to the related upper bound value. Value associated to this concept is bound to the study on single parameter and it depends on specific metrics used to express parameter other than methodology applied to measurement. Regarding mathematical model there is a correspondence with values in vector C.
- *HasInteractionFactor* relation connects the *E-GovAttribute* to *Interaction Factor* concept showing the interaction level between pair of parameters. This is represented in the mathematical model through interaction function value.

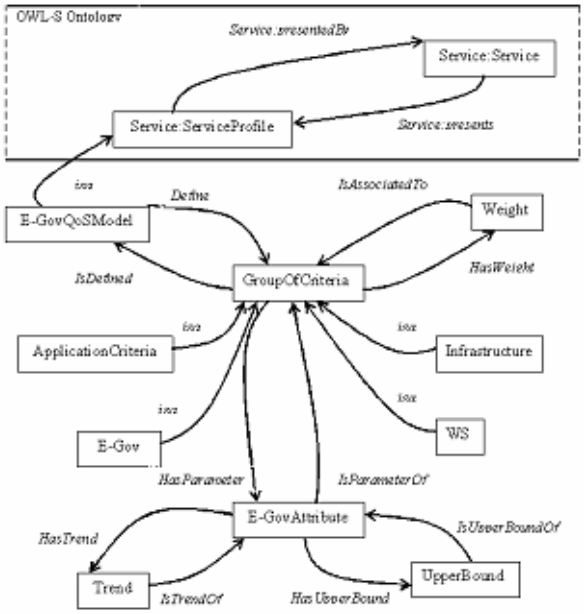

Figure 1: Group of parameters

The latter point require a better explanation to define what we mean for parameters interaction. The interaction measures dynamic relation between service parameters to indicate how a parameter behaviour affect the others. Considering n parameters for every one we have *n-1* instances of the *InteractionFactor* concept that relate couples of parameters showing an interaction value.

4.2 e-GovQoS Metrics

To represent quality of service we introduce metrics for assessment of quality value. Our starting point is QoSOnt ontology metric related to time and able to specify several units (minutes, seconds, etc.) and their conversions. This is important when different users use the same metric but different measurement units.

In *E-GovQoS* ontology some parameters cannot be measurable by temporal units, thus we introduce new metrics as showed in Figure 3 and new measurements units. These components are defined like subclasses of QoSOnt concepts *MetricValue* and *TypeIndicator*. In particular, we introduce concepts value graduation, information measures, boolean, monetary values and so on. Value graduation is a metric that can be used in a large number of e-Government parameters. It combines each parameter to an evaluation that can vary in a range of value. This metric is represented in *E-GovQoS* with the *ValueGraduation* concept, and it has five subclasses defining every quality level as showing in Figure 4.

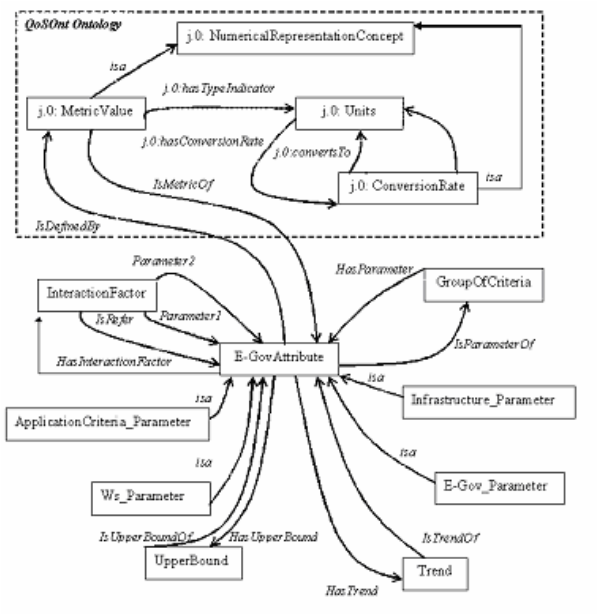

Figure 2: E-GovAttribute relations

We define the *Request* concept to represent the measurement of the number of requests completed or not in a determinate time interval in relation to related requests. We define *Serve* and *NotServe* subclasses that represent respectively the number of served and not served requests in a range of time. As these requests are evaluated on temporal basis, the relation *hasTypeIndicator* connects the two subclasses to the *RequestToSecond* instance of the QoSOnt *Units* class. Quantity of information is another metric introduced in the ontology and it is used to provide values to particular parameters like throughput. Its ontological representation is realized by means of *QuantityOfInformationMeasure* concept and its related subclasses as showed in Figure 4. Measurements units defined in the ontology for these metrics are instances of a subclass *InformaticMesaure* from *Units*: *Bit*, *Byte* and their multiples. As we using for time, it is possible to convert one measure into another. This is possible because of *InformationMeasure* inherits from its base class one relation that links itself to *ConversionRate* in QoSOnt.

Some parameters need a value that is simply a number. For this we have inserted in the model the *SimpleNumber* concept. Surely, there isn't an explicit relation associated with a specific measurement units. On the other hand, the subclass related to percentage concept defines a relation connecting itself to *Percentage* instance of *Units* class. This permits abbreviation with "%" symbol for the metric value. For boolean values, we have simply realized two instances *False* and *True* of *MetricBoolean* concept.

The latter metric presented is the *Currency*. It has two subclasses: the first one representing Euro and the second one representing Euro cent. Furthermore, there is possible to convert into these two concepts by the *ConversionRate* class.

Finally, our ontology need the reppresentation of range of value. For this aim we insert the concept MetricRange. It inherits all properties and attributes from the base MetricValue. This concept have also two relations connected to concept Currency.

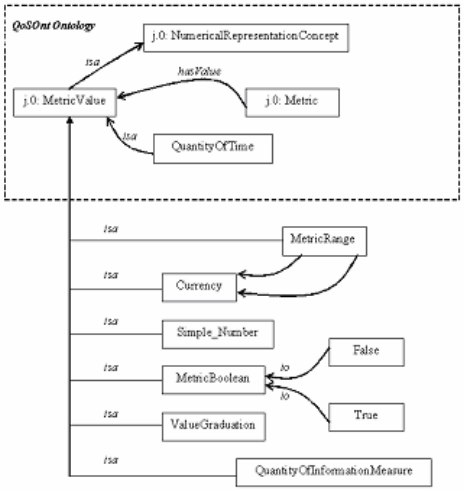

Figure 3: Definite metrics

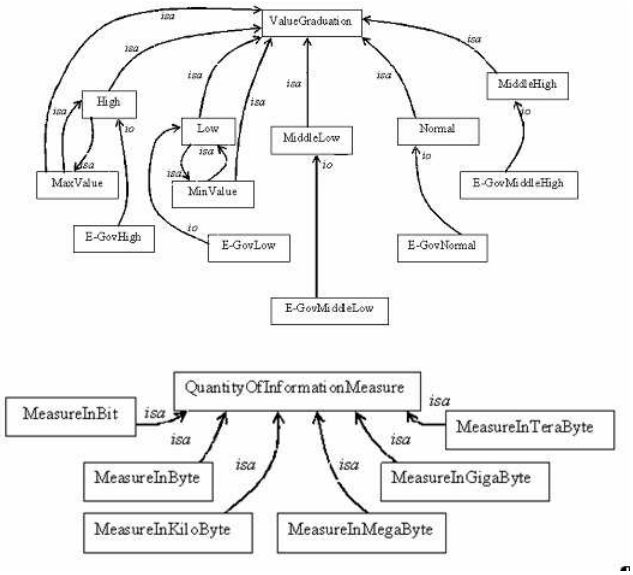

Figure 4: Definite metrics

4. Conclusion and Future Work

QoS is an important aspect when we deal with services provided by Public Administration to citizens and firms. Services in e-Government domain can be differentiated, estimated and compared specially when we choose one that fit some non functional requirements. In our work we propose an overall approach to Quality of Service in e-Government domain taking into consideration a study over a range of parameters that we hope to include a quality model starting from a mathematical model to aggregate parameters in a unique overall value and a formal representation through ontology. The developed ontology extends the QoSOnt ontology and it describes the service quality with a set of generic QoS concepts while the OWL-S service ontology to describes Web Services functionality. The purpose of the ontology is to be used in applications that are able to aggregate parameter values in order to obtain an overall evaluation to expressing service quality.

Moreover, from an e-Government perspective this ontology can be viewed such a base tool to promote interoperability among PAs services reaching a definite quality level. Summing up, e-Government and Quality of Service allow to increase rapidly flexibility, speed and access to the PAs functionalities. They promote also reduction of governance costs. At the same time

the increase of the quality allows service integration for citizens and the competence increasing of Public Administrations. Furthermore, interoperability and reuse of the QoS knowledge are made easy. Semantic interoperability through ontology nowadays allows an improvement of system values that are characterized by homogeneity for both data and processes. In this way, an opportunity for citizen participation of democratic and institutional processes is provided.
In the future we hope to continue our efforts in the expansion of the ontology in parallel with the development of the e-Government digital services. In particular, we would like to take into consideration dynamic aspects in the description of QoS for services.

References

[1] Ontology Web Language - Service. http://www.daml.org/services/owl-s/.

[2] Algirdas Avizienis, Jean-Claude Laprie, Brian Randell, and Carl Landwehr. Basic concepts and taxonomy of dependable and secure computing. IEEE Trans. Dependable Secur. Comput., 1(1):11–33, 2004.

[3] Flavio Corradini, Francesco De Angelis, Alberto Polzonetti, and Barbara Re. Quality Evaluation of e-Government Digital Services. Poster section of d.go06, 2006.

[4] H. Lausen J. Bruijn R. Lara M. Stollberg A. Polleres C. Feier C. Bussler D. Roman, U. Keller and D. Fensel. Web service modelling ontology. Applied Ontology, 1(1):77 – 106, 2005.

[5] G. Dobson, R. Lock, and I. Sommerville. QoSOnt: a QoS Ontology for Service- Centric Systems. In 31st Conference on Software Engineering and Advanced Applications (EUROMICRO-SEAA'05), 2005.

[6] Glen Dobson. Quality of Service in Service-Oriented Architectures. http://digs.sourceforge.net/papers/qos.pdf.

[7] T. R. Gruber. A translation approach to portable ontologies. knowledge Acquisition, 5(2):199 – 220, 1993.

[8] Holger Knublauch. User-Defined Datatypes in Protege-OWL. http://protege.stanford.edu/plugins/owl/xsp.html.

[9] Technical Committee ISO/TC 176 International organization for standardization. ISO 8402: Quality management and quality assurance, 1994. Vocabulary. 2nd ed. Geneva: International organization for standardization.

[10] Jeffrey T. Pollock and Ralph Hodgson. Adaptive Information. Wiley, 2004.

[11] WonSeok Lee Seong-Ho Jeong KangChan Lee, JongHong Jeon and Sang-Won Park. Qos for web services: Requirements and possible approaches. Technical report, World Wide Web Consortium (W3C) note, November 2003.

[12] M. Boogers M. Thaens and M. Poelmans. Making e-government work: the content and significance of an e-citizens carter, September 1-4 2004. Ljubljana.

[13] A. Mani and A. Nagarajan. Understanding quality of service for web services. Technical report, IBM, India, January 2002.

[14] E. M.l Maximilien and M. P. Singh. A Framework and Ontology for Dynamic Web Services Selection. IEEE Computer Society, 4:84 – 92, September - October 2004.

[15] Commission of the European Communities. Linking up Europe: the importance of Interoperability for e-Government Service. Commission Staff Working Paper SEC, July 2003.

[16] Commission of the European Communities. The Role of e-Government for Europe's Future. Communication from the commission to the council the European parliament the European economic and social committee and the committee of the regions, 2003.

[17] W3C. OWL Ontology Web Language. http://www.w3.org/TR/owl-guide/.