An Ontology-based Inquiry Framework*

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Abstract. Quality of service (QoS) and citizens satisfaction are primary objectives for any eGovernment project. Quality can be inspected directly through measurements of specific QoS indicators; in the midst of innovation processes it is however more convenient to estimate quality indirectly, through questionnaire submissions to the involved citizens. The *eGovernment Inquiry Framework* (eGif) has been designed as a key tool to keep innovation projects controlled – also being the first component of an eGovernment service oriented architecture with semantic capabilities. Written in Java, based on well known open source libraries, exposed as a standard WSDL-defined web service, eGif helps survey campaign designers by keeping semantic information about the statistical variables used and interacting with servers for user identification. Questionnaire OWL-based ontologies are now investigated as a means to facilitate the creation of reusable survey knowledge base.

Key words: eGovernment, QoS, Semantic Web, OWL, RDF, service quality, customer satisfaction

1 Introduction

1.1 The Scenario

A simple query on Google with the `site:` qualifier can be used to measure the dimension of eGovernment systems in terms of number of pages. American government, identified by the `.gov` web domain, shows over thirty million pages; more difficult is the analysis of the European government web sites, distributed across national web domains and with different administrative and naming rules. A sizing of Italian Regional (the middle level, the others are national, provincial, municipal) eGovernment sites, shows more than five million pages. The dimensional parameter outline the knowledge-intensive characteristic of governments, complex organizations that are strongly information-related and wider than companies (at least in the European case). Given the dimensions and the value contained, there is a strong (political and functional) interest in making

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eGovernment more effective through friendlier citizen interfaces, better inter-government collaborations, newer and smarter technology architectures.

Given the dimension, the complexity of processes, the knowledge focus and the civil and social implications of governments (online) services, application of semantic web (data) models to eGovernment are increasingly investigated. The U.S. have a clearly defined high level eGovernment Strategy [4]. Europe strongly supports the eGovernment initiatives through the *eGovernment Action Plan* [1], accompanied by an effort towards interoperability, IDABC [2], which will be followed by the *Interoperability Solutions for European Public Administrations* (ISA) from 2010. The report series *e-Governance: transforming Government to build trust and quality* monitors eGovernment regarding main European experiences in creating information procedures and online services for citizens (see 2008 report in [3]). A similar survey, on a wider scale, can be found from United Nations (UN) [5].

A structured analysis of eGovernment experiences can be found in [13]; a thoughtful list of requirements for a comprehensive semantic web architecture has been identified in [9], where also are listed several eGovernment projects, like German SAGA [7] and UK eGIF [6]. In [18], with the focus on semantically annotating the national digital archives, the Chinese eGovernment projects are reviewed. As suggested in [19], processes are to be defined according to the different user roles. Leaving out their electronic agents case (which is supposed to operate in a mature semantic web services scenario like the one analyzed in [20]), we can map their two other processes to *front-* and *back*-side of eGovernment.

The front-side is the *government-to-citizen* (G2C) domain, where web publishing is used to give information to citizens, to report news regarding taxes procedures or laws as well as local information about events; citizens browse the web searching for specific information but have to know in advance the government *context* where the information is located. The Regione Veneto *myPortal* project addressed this field by offering to smaller local governments free use of a common portal platform [8]. Semantic solutions for Italian regional portals have been researched in [15].

The back-side is the *government-to-government* (G2G) domain, where up-to-date information is circulated internally for service requirements and structured information (frequently documents) is transferred/processed between employees; a variation of this case are cross-agency group collaborations that involve complex multi-level government processes. The Regione Veneto *myIntranet* project is now addressing this field by selecting the appropriate technology (web services and semantic web) to enable a services architecture that could better support internal collaborations. We can look at [21] (Germany, Schleswig-Holstein) and [12] (The Netherlands) for comparable experiences.

1.2 An Inquiry Framework for Measuring The Quality of Service

Quality, along with its several instances, *quality control*, *quality assurance*, *quality management*, *total quality*, shows a long and successful history, started in the production, organization and engineering fields. Subsequently, quality models

for process improvement were defined, like *lean production* [22], *six sigma* [23], *total quality* [25]; this evolution has been consolidated with the 2000 edition of the widely adopted ISO 9001 standard [24]. These models are increasingly applied also to *immaterial* services, where *Quality of Service* (QoS) has to be measured and established contractually through *Service Level Agreements* (SLA).

The mutual interplay between quality and *Information Technologies* (IT) is increasingly common in the services industry, where quality can be a tool for IT, but also IT can be a tool for quality [40]. Service providing (as opposed to manufacturing) is really the domain of eGovernment. Quality in eGovernment services has been investigated in [27], where has been even defined a specific *Quality of eGovernment Service* (QeGS) ontology; a review of applicable quality models can be found in [26], where a classification for external measurements has been also identified: a) customer satisfaction, b) eGovernment portal quality and c) "technical" QoS. These classes map in our research to:

a) *eGif*, for multichannel citizen satisfaction surveys,
b) interface/technology innovation for better user effectiveness,
c) *eMonitor*, for technical and performance-related portal measurements.

The tool *eGovernment Inquiry Framework* (eGif)[1], the first step in our applied research program, has been realized [39] to create survey campaigns, submit through different media channels, retrieve the answers, elaborate and report the results. eMonitor should later follow eGif in order to collect, continuously monitor and report a wide set of technical, user-related and performance indicators to enhance eGovernment technical staff quality control in G2C portal services.

User satisfaction analysis is a required ingredient in service quality management, where there is the need to compare *internal* measurements with *external* measurements. In eGovernment user satisfaction sometimes is intended to include some form of deliberative democracy ([28]; see [29] for a recent analysis), a model that can have a substantial help from the new web-based communication models; here, however, we focus on the smaller domain of citizen satisfaction for eGovernment (mainly online) services [32].

Quality measurements based on citizens surveys are by no means easy in order to be objective. Structured methodologies from two main research lines are commonly applied:

a) quality-related models like SERVQUAL [30] and subsequents, mainly applied in the business domain to measure *customer satisfaction* through the use of suggested indicator classes and an analytical comparison of perceived Vs believed quality;
b) social research (see the handbooks [33], [35]), where more emphasis is given to a right survey definition and to the social models of interaction, with questionnaires based on quantitative as well as *qualitative* variables.

[1] Our choice of name was perhaps unfortunate, as there is a clash with the UK electronic Government Interoperability Framework (eGIF) [6]; please note, however, that the scope of our eGif *tool* is smaller and different from the one of UK eGIF *project*.

By analyzing the literature and the techniques used, we have seen wide space for improvements by activating synergies between internet technologies and these methodology models, specifically in the b) social research line. Web surveys (see, for instance, [38]) are relatively new to social research: surveys emerged in an historical context where questionnaires were designed to fit in paper forms and computers were mainly used for elaboration purposes. Submission of questionnaires through the web [36] or email [37] channel rendered surveys popular and easy to manage; coherent *asymmetric* combinations of traditional media with web (for acquisition) and email (for submission) can even raise the respondent percentage. New interaction models, as are appearing every year (like interactive forms on digital TV handsets, cellular phone interfaces, instant messengers plug-in, etc, see [39]), offer several advantages over paper, but raise also some critical problem. The point is that technology interfaces: (a) are simpler to use and can be software-assisted, (b) facilitate automatic collection of data, (c) can reduce the costs of conventional surveys. On the other side: (1) not all citizens use them, even the simpler web & email – and other technologies are less diffuse, (2) identification/authentication problems have to be solved, (3) technical problems can inhibit the submission to users in some configurations.

Tools and web-based services for creating and using web/mail surveys are commonly found in internet (for a "survey about surveys", see the detailed comparing grid in [41]). Such systems however are mainly focused on interface and personalization versatility. Given the critical role of surveys for eGovernment and their near link with deliberative democracy, an effort should be done instead to design "intelligent" survey tools. Through interventions in two directions:

1. by strictly *linking the statistical core* of the survey campaigns with the questionnaires design. The survey tool has to know *in advance* the statistical characteristics of the variables inspected (being *nominal*, *ordinal*, *cardinal*, in ranges, etc), in order to be able to constrain its user acquisition, to better control the submission channels and to coherently elaborate/report the results;
2. by introducing *semantic-web techniques* for the accumulation of "usable knowledge" for survey designers, in order to facilitate the construction of "consistent bricks" for surveys to be shared among social researchers. Two kinds of "bags" are necessary: (a) a *knowledge library* for commonly used variables, their statistical properties, their social semantics, their relations with other variables; (b) an *associative memory* about common ways for [question + predefined answers] blocks, their social semantics, their relations with other blocks and with the variables.

1.3 e-Gif as a Semantic Web Tool

Semantic Web has been defined as [42] "an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation". As public Institutions are knowledge-intensive organizations, it is a common thinking that semantic web technology should

find natural application in eGovernment. Architecture evolutions are intimately connected to innovations in data representations; the baseline data model for the semantic web architecture has been identified as the *Resource Description Framework* (RDF) [45, 46], an highly flexible XML language where statements are *triples* composed of *subject*, *predicate*, *object*, represented graphically as two nodes connected by an edge. Subject and object are either *resources*, identified through an URI, *blank nodes* or *datatype/XML elements*.

It appears to us that encoding questionnaires knowledge in RDF should easy the mindful reuse of surveys between designers and could easy the statistical engine interpretation of data and the variables relationships. *RDF Schema* (RDFS) [47] gives more expressivity through precise identification of classes, resources, datatypes, allowing the construction of taxonomies and classification of resources, properties, variables relating to domains and ranges. With RDFS, we can, for instance (following the guidelines depicted in [51]):

- declare classes like `Country`, `Person`, `Student` and `Venetian`;
- state that `Student` is a subclass of `Person`;
- state that `Padova` and `Venezia` are both instances of the class `Comune`;
- declare `Citizenship` as a property relating to the classes `Person` (its domain) and `Comune` (its range);
- state that `age` is a property with `Person` as its domain and `integer` as its range;
- state that `Mario Rossi` is an instance of the class `Venetian`, and that his age has value 36.

For our needs, RDFS could be sufficient, but we are looking at OWL *Web Ontology Language* [48, 50, 51], as the language supports more complex statements that could be needed in order to establish and maintain a reference basis for domain knowledge exchange outside the survey-related eGif framework. Formal specifications of specific domains could be defined through *ontologies* to help Government operators share information unambiguously and ease computer-mediated knowledge exchange (see [44]). Ontologies are to be created on the basis of a a common vocabulary, a set of assumptions for the intended meaning and a consistent set of relationships between concepts – a typical situation for Public Administrations. Common standard vocabularies [52, 53] can help managing the task.

2 The Inquiry Framework Tool

The Regione Veneto *myPortal* project [8], launched in 2003, has defined a common framework for local (province, comuni, comunità montane) government portals. By using the characteristic location-independence of web, it has been possible to active a single technological center (managed by the regional staff and providers) where portals are technically maintained, leaving the content management to the local government. myPortal unifies at the moment a hundred local

administrations (in Veneto there are seven "province", 19 "comunità montane", 581 "comuni").

eGif is the first block of a technology model which exhibits a dual interface towards (a) the G2C local eGovernment Portal *myPortal* and (b) the G2G local eGovernment web-based collaboration tool *myIntranet*. Written in Java, it has been based upon a *web service* (WS) architecture: eGif exposes a WSDL-compliant interface, communicate through SOAP envelopes and can be listed through UDDI compliant registry. Given the role assumed by Regione Veneto for local government portals, the UDDI register model could indeed find fully appropriate use in this framework; we are also investigating about the adoption of semantic annotation standards (the simpler WSDL-S and the more complete OWL-S); with this respect, in [9] there are some interesting hints about the model to be identified.

An effort was also done to make eGif capable of managing complex multi-indented questionnaire forms. Standard social research commonly uses dependency links between questions to be activated upon specific answers of the interviewed, posing serious difficulties to standard survey tools. We worked with two parallel strategies:

1. by identifying a web *user interface* that would allow survey designers to manage questionnaires with ease and flexibility. We choose to lay out a graphics interface where the symbols "**?**" for *questions* and "**!**" for *answers* could ease the packing of information on the screens and could facilitate the user in the creation of questionnaires. We used server-side Echo2 open source GUI libraries;
2. by precisely defining a *data structure* in XML, that can be validated and remains consistent between changes. We used the eXist open source XML-native database. As eGif is based on XML data, the planned transition to RDF (an XML derivation) for the transition to the semantic data model will be greatly simplified.

2.1 Architecture

Several key requirements, both technical and practical, have been taken into account during the design of the eGif tool. As one of the main goals of the system is to serve as an abstract survey platform to many and diverse frontends, a standard service interface and a plugin-oriented architecture are both mandatory features. The service interface is used by a wide number of external applications, such as the analysis and reporting tools and the presentation layer of each of the several channel frontends and user interfaces (see Fig. 1).

According to the best practices about services oriented architectures, the services can be exposed through an UDDI registry and their semantic is explained through WSDL descriptors. In this way, third party applications or eGif extensions are able to connect to the eGif backend and take advantage of the function they require in a fully decoupled and well documented fashion. The services

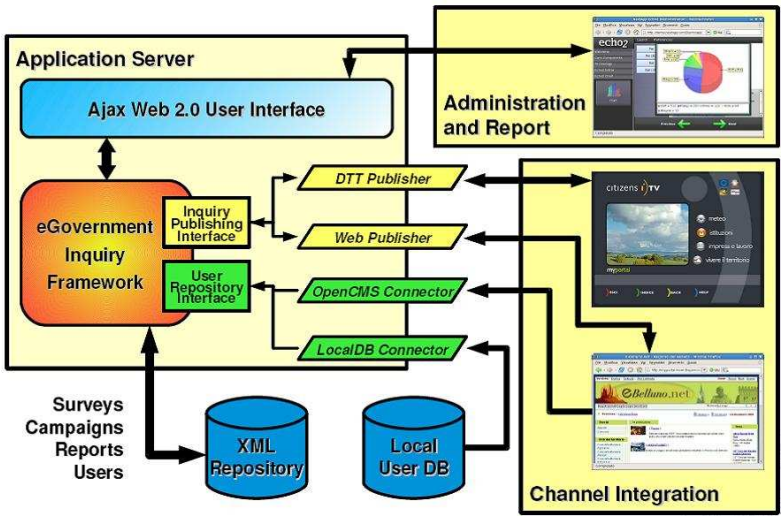

Fig. 1. Architecture of the eGif.

exposed belong to the domain of user authentication, survey repository access (both for publication or analysis purposes), campaign creation and so on.

A large part of the design effort was devoted to the definition of a deployment system capable to deal with a wide array of different media channels. The goal has been reached by providing a plugin-based multichannel engine; different plugin types are available for the different tasks needed to reach true independence from the publication media. We experimented with plugins for web, email, digital TV set-top boxes and mobile phones. Specialized plugins are built to interoperate with media channels by exchanging demographic variables, such as the age or sex of the respondents.

eGif stores all its data in XML files: the role of XML is not limited to the surveys serialization, but also to user profiles, configurations and all the other data are stored in hierarchical structured repositories. Flexible data structure is a key point for eGif variable management.

2.2 Question/Answers Taxonomies

A common scheme used in social research distinguishes between three kinds of variables (see Fig. 2):

1. demographic/census data, like age, sex, name, location and other fixed attributes of the respondent. These are standard independent variables required for classification purposes;

2. objective (i.e., linked to *actions*) data, like common habits or information about past events/experiences, where variability is narrower, being data related to *facts*. These can be used as (model-specific) independent variables;
3. subjective (i.e., linked to *preferences*) data, like religious or political preferences, taste, interests, motivations, judgements, where variability is wider, being data related to *opinions*. These are commonly the (model-specific) dependent variables.

This classification can ease the path towards the construction of questionnaires ontologies, as the categories are related to use domains and to variables properties. Commonly used demographic variables can be defined and their relations stored in appropriate ontologies easing to questionnaire designers the task of identifying the demographic dimensions of the surveys; a similar approach can be used for non-demographic variables. Further ontology attributions can be found by using higher-level domain-related information, by connecting the variables to areas like Education, Health, Transports, Administration and so on.

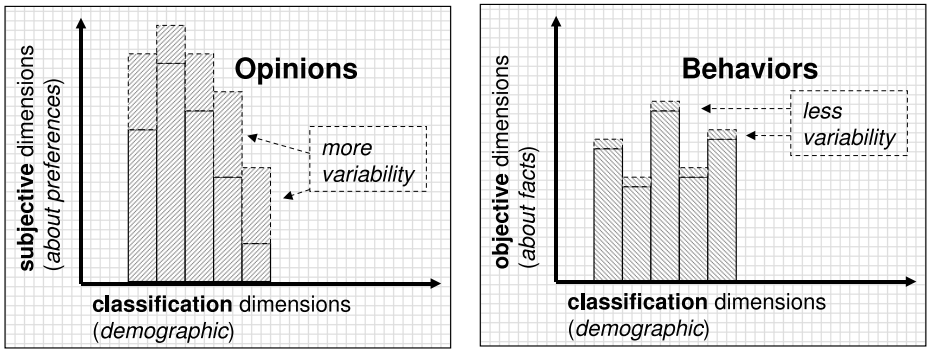

Fig. 2. Different dimension roles assumed by different classes of variables.

Questionnaires, as experimental tools, are built as sequence of *questions* to be submitted to users in order to have an instance of the variables inspected; depending on the designer's choice, we can have open or closed-format *answers*, the latter being preferred for quantitative research; depending on the choice, a variable can be inspected in different ways through different sets of answers.

In eGif, descriptive statistics is used to (pre-)classify the variables:

1. *nominal* variables – only classification can be applied;
2. *ordinal* variables – they can be ordered;
3. *cardinal* variables – common operations can also be applied.

This variable classification brings several implications on the statistical operations that can be applied and on the graphics representations that can be used (see Fig. 3); it will also ease the definition of variable-based ontologies.

Operational Classes		Property States	Operating Procedure	Admissible Operations	Central Trend Measure	Dispersion Measures
qualitative ("mutables")	nominal	*separated*	*classification*	= ≠	mode	homogeneity index
	ordinal	*ordered*	*ordering*	> <	median	interquartile difference
quantitative ("variables")	cardinal	*discrete*	*counting*	+ -	mean	standard deviation
		continuous	*measurement*	x :		

Fig. 3. Operational variable classes.

2.3 The eGif Frontend

The service oriented interface exposed by eGif can be used in order to exploit all the functions of the system, including the uploading and retrieval of surveys. Nevertheless, for the sake of ease of use, a fully working web-based frontend has been included in the system. This frontend offers a modern and practical interface to perform tasks such as users creation, plugin management and system monitoring. In addition to this tasks a full-fledged *survey editor* has been added, that allows designers to build an arbitrary complex survey structure, including multiple choices, indented questions and different choices for statistical variables.

3 Conclusions

A research applied to eGovernment through new ontology- and semantic-based technology has been conducted. The project has been developed on-top of a common web platform named "myPortal" based on open source technologies. The Inquiry Tool eGif is now available in all *myPortal*-served local administrations in Veneto. Documentation and source code are available at `http://grifo.dsi.unive.it/egif/`.

At the moment, the results of questionnaires and polls are not yet provided in RDF/OWL format: this will be the next step, leading to meta-surveys integrating results coming from different channels and campaigns.

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