

# Three-Layered QoS for eGovernment Web Services

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## ABSTRACT

An applied research for the incremental evolution of a service oriented architecture for local eGovernment portals has been developed. Our reference eGovernment environment, currently adopted by a hundred local public administrations in Veneto region, is a dual model with a G2C interface towards citizens and a complementary G2G interface for municipal government staff, both interconnected and supporting a constellation of web services-based tools and applications. XPDL-compliant, workflow technology is now being applied in order to increase software re-use, process visibility and exchange and to ease process implementation/customization and execution. A case study for a layered model of QoS for eGovernment is presented. Three kinds of quality of services: (a) perceived level of services, (b) effectiveness of processes and (c) system-level efficiency, are measured in close correspondence with the different layers of eGovernment interactions: G2C, process orchestration/WFM and G2G.

## Categories and Subject Descriptors

D.2.8 [Software Engineering]: Metrics—*performance measures*; H.3.5 [Online Information Services]: Web Services

## General Terms

Measurement, Performance

## Keywords

QoS, metrics, BPM

## 1. INTRODUCTION

Local eGovernment web services provide an interesting workbench for the design and assessment of different QoS approaches. The nearness to effective citizen needs, the level of complexity adequate to experiment concrete non-trivial innovation projects and the political pressure to provide better services to the citizens force Public Administrations to

care about the quality levels reached by their online services via a comprehensive quality management strategy.

Given the social relevance of eGovernment services, there is indeed a significant interest in the local administrations for the application of quality and business process management models to (*e-*)Government, as a coherent adoption of QoS methodologies could help Public Bodies to better satisfy citizen needs. eGovernment services are knowledge-intensive and are operating over complex processes and organizations, so *semantic web* technology can be effectively used to set and qualify the relevant associations between citizen needs and offered services, so improving the eGovernment QoS [17]. Research experiences in the application of semantic web to eGovernment architectures can be found in [9] (Germany, Schleswig-Holstein), [6] (Spain, legal domain), [19] (Italy, Regione Marche) and [8] (Finland). In this research field, QoS for the specific domain of eGovernment has been investigated in [10], where has been defined a specific *Quality of eGovernment Service* (QeGS) ontology.

A structured analysis of eGovernment experiences can be found in [14], while a thoughtful list of requirements for a comprehensive semantic web architecture has been identified in [18]; a focus on Local (municipal) eGovernment within USA, the UK, Finland, France, Germany, the Netherlands and Japan is the subject of [5], whereas in [20] the specific case of inter-municipal eGovernment collaboration within Italy was analyzed.

Our reference eGovernment architecture (see Fig. 1) is based on a dual model with an *external* interface towards citizens and a complementary *internal* interface dedicated to local (municipal) government staff, both interconnected and supporting a constellation of web services-based tools and applications. Semantic web techniques are mainly used to accumulate relevance and classification information regarding online services in rdf databases.

The external, front-side of eGovernment is the *government-to-citizen* (G2C) domain, where web portals are used to give information to citizens, to report news regarding tax procedures, laws as well as local informations about events; in this domain a set of growing online services are offered to citizens that increasingly substitute/support the existing municipal public services. Following National guidelines for the eGovernment support in small municipalities, the Italian Regione Veneto *myPortal* project, launched in 2003, addressed this

field by offering local governments free use of a common portal platform. The myPortal platform unifies at the moment a hundred local public administrations.

The internal, back-side of eGovernment is the *government-to-government* (G2G) domain, where up-to-date information is circulated internally for service requirements and structured information is transferred/processed between employees; an extension of this case occurs with cross-agency group collaborations that involve complex multi-level government processes. The Regione Veneto *myIntranet* project addressed this field by selecting the appropriate technology in a service oriented architecture to better support internal collaborations. The myPortal/myIntranet framework has then been consolidated in a WS-oriented architecture, open to specific dual-sided tools and applications.

A specific requirement of the government institutions imposed in the early design phases of the architecture a set of quality tools for the systematic evaluation of the online services provided [2]. Coherently with this QoS-grounded research strategy a third, workflow-based element, *myWorkflow*, was added, in the attempt to increase the re-use of software to web service composition of processes (via BPEL), to process exchange/re-use (via XPDL) and to process customization and execution (via specific workflow management platforms), with the added value of *dynamic* as well as *static* process transparency to citizens. Another key requirement, the capability to ease communications on process flows, induced us to apply Business Process Management (BPM) techniques to eGovernment: the BPM adoption is being facilitated by the recent availability of new interoperability standards and mature open source workflow management frameworks to experiment with. For a recent survey on the diffusion of BPM culture in Public Administrations, see [13].

The myPortal/myIntranet/myWorkflow framework represents the research environment where we structured a quality-centered approach, built onto a stack of systems from the lower, system level, to the middle applications layer to the higher-level workflow layer. Following the review of applicable quality models for eGovernment found in [15], where quality measurement models are classified in a) customer satisfaction, b) eGovernment "core" quality and c) "technical" QoS, we mapped these respectively to *eGif* for multi-channel citizen satisfaction surveys, *eQual* for process evaluation and measurement and *eMon* for technical- and performance-related portal measurements.

These layered Quality Tools represent our cornerstones to operate objective measurements in eGovernment projects. The eGif inquiry tool [1] was realized to create survey campaigns, submit through different media channels, retrieve the answers, elaborate and report the results. The BPM-based eQual QoS model is built upon the workflow process management architecture and is designed to measure static and dynamic quality indicators of eGovernment services. Finally, eMon [2] is aimed at collecting, monitoring and reporting a wide set of key technical, user-related and performance indicators to enhance eGovernment technical staff quality control in G2C portal services.

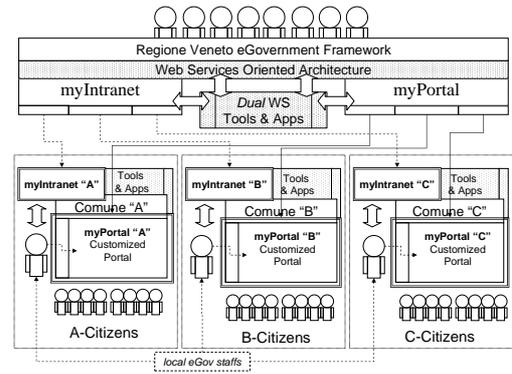


Figure 1: The Service-Oriented Dual G2G/G2C Architecture

The paper is organized as follows. In Section 2 the reference architecture is presented. Then, in Section 3, the layered QoS model is outlined and in Section 4 some conclusive considerations are reported.

## 2. A SERVICE AND PROCESS ORIENTED ARCHITECTURE FOR EGOVERNMENT

The eGovernment architecture operating in Regione Veneto is built on an enterprise open source portal and a constellation of web services and JSR-286 compliant portlets. myPortal was the first (G2C) framework developed, with the goal to offer at no cost to small and medium municipalities standard institutional web portal capabilities via the intrinsic web polymorphism. myIntranet is the G2G corresponding framework able to support the interactions needed by the government staffs.

The applications developed inside this architecture have a peculiar *dual interface*, with highly configurable console editors exposed in the G2G/myIntranet side for government staffs and flexible, easy to use applications exposed in the G2C/myPortal side for citizens. The online services expose a WSDL-compliant interface, communicate via SOAP envelopes and can be listed through a UDDI compliant registry. In this way, applications are able to interconnect and to take advantage of the functions they require in a fully decoupled and well documented fashion. Given the guarantee role assumed by Regione Veneto for local government portals, the UDDI register model finds fully appropriate use in this framework and an effort is being done in creating a set of regional standards to let local municipalities and third parties add directly new applications, documenting and exposing them in the regional registry. Information services, news, tax-payment, were the first applications developed; then, the applications were supplemented by specific quality-oriented tools, in order to better follow the citizen needs (see Section 3).

In this context, we are experimenting some technologies to extend the architecture. Adoption of web service semantic annotation standards is currently under evaluation to extend the capability of the platform; with this respect, in [18] there are some interesting hints about the model to be identified. On another side, to be explained in the following,

orchestration models for web services are being evaluated in order to assemble meta-applications in the eGovernment framework; a web service BPEL-based strategy is brought forward in coherence with our efforts in workflow-based and XPD-compliant technologies (see Fig. 2).

Behind Government services there are complex and continuously changing processes that need considerable effort for management, documentation and optimization. A straightforward transition to eGovernment services has the risk to increase the complexity and the needed effort losing the required flexibility. A dialogue is to be established in order to improve the services following the needs of citizens: a shared knowledge about eGovernment processes is the main foundation layer where quality management can be developed.

There are indeed two key characteristics about Italian local government to be remarked in this context: 1) the high potential for process reuse, connected to the fact that the over eight thousands local municipalities managing citizen services have many commonalities between them, frequently offering the same services using *similar* (not identical) processes over all the Italian country; 2) the fairly common local specializations of the main Government processes, in a way that renders perhaps unsuitable a straightforward central-managed eGovernment development approach based on the design of specific applications for the municipalities.

Given the potential opportunities related to increased flexibility, easier maintenance and added transparency of the processes managed, a structured path towards better and more efficient eGovernment services could indeed find support in the field of Business Process Management (BPM). The diffusion of BPM culture in public organizations devoted to offer services to the citizens could ease mutual comprehension and legitimacy between local government and citizens [13].

Thanks to the maturity of standards like XPD (for process definition, interchange and storage) and BPMN (for process representation and editing) and the increased availability of related open source frameworks, we are experimenting a comprehensive strategy for eGovernment services to be layered upon a set of main processes managed by a Workflow Manager (WFM) platform by extending the current eGovernment service oriented dual G2G/G2C framework.

The workflow layer matches coherently with the dual myPortal/myIntranet architecture, by offering via the G2G/myIntranet interface a specific process editing/inspecting interface for Government staff and for exposing via the G2C/myPortal interface service (and connected processes) informations for citizens, with the capability to collect their opinions regarding the services used.

In an effort to achieve “intrinsic” transparency about services and processes, the adoption of the XPD standard could allow interoperability [11, 17], inheritance [21] and comparison of similar processes present in different municipalities. An XPD main *process repository*, being built at a regional level, is the key element in this strategy, where processes are managed by workflow and implemented them via BPEL-coordinated SOA interfaces satisfying XPD-compliant in-

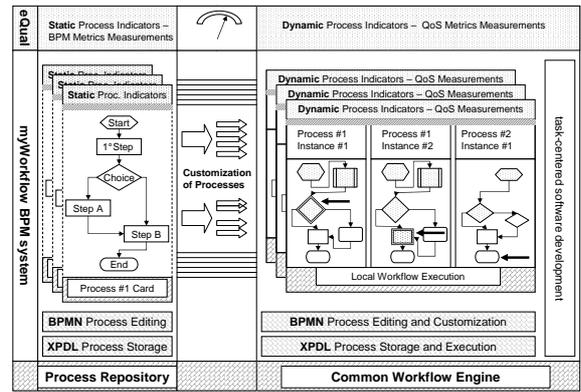


Figure 2: The Workflow-based model for process execution and measurement

teroperability standards (see [7, 4]). The maintenance activity is easier and consume less effort thanks to the gained processes abstraction, fact that helps also in the technical-to-nontechnical communications with government staff for service application requirement analysis. The required specializations can be managed as a development layer to be added to the “core” process stored in the common regional repository.

### 3. A FRAMEWORK FOR EGOVERNMENT QOS MANAGEMENT

In order to maintain an adequate control level on QoS, we designed a three-layered quality model (see Fig 3) with the goal to measure: a) *perceived service quality*, via questionnaire submissions, b) *service effectiveness*, via static metrics and dynamic indicators control, c) *service efficiency*, via direct, low level interaction with portals and systems.

To this extent, we developed a set of tools to satisfy the measurement needs of each quality layer:

- *eGif*, an inquiry framework to design, submit and report *survey campaigns* to citizens about quality of (e-)Government services,
- *eQual*, a workflow management -based model to set, monitor and measure *process indicators*,
- *eMon*, a tool to monitor operations, performance and usage of eGovernment systems and services via *key performance indicators*.

The corresponding QoS metrics are:

- citizen evaluations/opinions (mainly nominal or ordinal) variables pre-structured with the closed answers provided in the questionnaires,
- *static* process metrics, like cyclomatic or similar complexity measures (see for instance [3]) and *dynamic* process effectiveness measures, mainly time of transactions and successful completion of inspected processes,

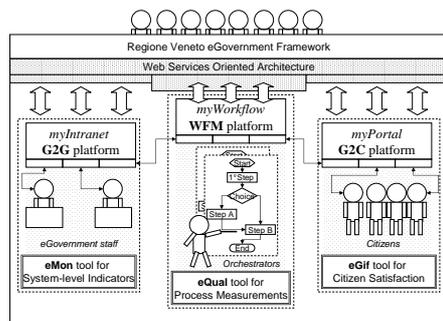


Figure 3: The three-layered tools for QoS and their match with the corresponding G2G/WFM/G2C framework.

- system-, network- and software-level key performance indicators.

In the following subsections will be given an outline of each layer.

### 3.1 A QoS Inquiry Framework for Measuring Citizen Satisfaction

User satisfaction analysis is a required ingredient in service quality management, where there is the need to compare internal measurements with external measurements. Well known, structured methodologies exist:

- quality-related models like SERVQUAL [16] 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 versus believed quality;
- social research [12], where more emphasis is given to the right survey definition and to the social models of interaction, with questionnaires based on quantitative as well as qualitative variables.

An effort was done to design a more “intelligent” survey tool by linking the statistical knowledge of the variables inspected with the questionnaire design process – mainly working on answer *constraints* and submission channels *capabilities*. By knowing *in advance* the statistical properties of the variables (being *nominal*, *ordinal*, *cardinal*, in ranges, etc), the survey tool is able to pre-structure the data, so constraining user input acquisition, gaining a better control on the submission channels to coherently elaborate/report the results. Semantic-web techniques were also experimented to ease the sharing of the surveys between the social researchers: an associative memory of common [question + predefined answers] blocks is built on-top of a variables library containing their statistical properties, social semantics, and its relations with other variables.

The eGif tool fits neatly in the myPortal/myIntranet dual model (see Fig 4). The eGif G2G/myIntranet interface exposes a complete *survey editor* that allows designers to build

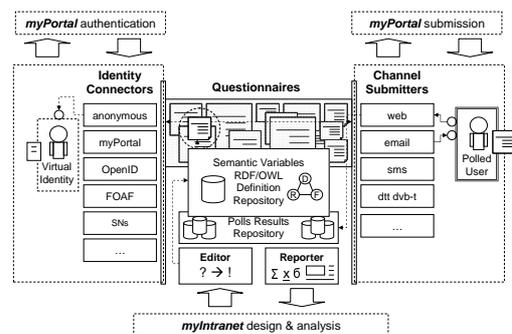


Figure 4: The eGif Inquiry Tool components.

arbitrary complex survey structures, including multiple choices, indented questions and different choices for statistical variables. eGif exploits a web *user interface* to allow survey designers to manage questionnaires with ease and flexibility, where the symbols “?” (for *questions*) and “!” (for *answers*) allows a dense and clear packing of the information on the screen and facilitates the users in the creation of questionnaires. The editor interface is based on server-side Echo2 Open Source (OS) GUI libraries. The reporter module can then be used for the statistical analysis of the responses.

The eGif G2C/myPortal interface is used for the questionnaires submissions; coherently with myPortal multimedia capabilities, a plugin-based multichannel engine makes eGif capable to deal with a wide array of different media channels; different plugin types are available for the different tasks needed to reach true independence from the publication media.

The eGif tool is now a standard component of the Regione Veneto eGovernment framework.

### 3.2 A Workflow-based Model for eGovernment Processes QoS Measurements

Quality management is increasingly applied to *immaterial* services, where *Quality of Service* (QoS) has to be measured and established contractually through *Service Level Agreements* (SLA). Such SLAs are now common in public service contracts between public organizations and citizens via *Service Charts*.

This kind of culture is centered on the process as the fundamental unit where quality management can be effectively grounded. The limit of conventional quality management is related to the *static model* of information management, where textual as well as graphics process representations are manually updated and then shared with the organization, with sensible resource efforts. Workflow management frameworks, able to manage dynamic processes, give indeed the opportunity to overcome this limit; the XPD standard offers then the capability to make process interoperability possible also outside the organization.

With the workflow architecture outlined in Section 2 and shown in Fig. 2, both *static* process metrics and *dynamic* process indicators can be managed, satisfying the require-

ment to evaluate the services both intrinsically and while they are provided to the citizens. In the *eQual* QoS subsystem we are structuring for eGovernment, the static metrics to be used in measurements of the processes are similar to the ones used in software programming, like the cyclomatic metrics, and can be computed thanks to the XPDL formal definitions found in the repositories. Dynamic indicators can be also set, in the QM frame, with a strong focus to the citizens, monitoring eventual time delays between process phases and other values connected to the quality of service (like the right conclusion of the processes) that has an impact on the citizens. Quantitative indicators (like the number of times a process is executed, or the dimension of the staff assigned) should also be known, in order to make a correct evaluation of the processes inspected. BPEL-XPDL interoperability, found in some workflow engines, should also ease a progressive development approach where *IT-supported*, XPDL-managed organizational processes are mixed to *IT-managed*, BPEL-orchestrated procedures.

In eQual, the process-based quality framework is interfaced directly with the citizens in order to collect the specific evaluations regarding the services used, in a higher precision complement to the standard customer satisfaction model where feedbacks are directly connected to the (sub-)processes involved in the services.

The eQual model is currently being experimented in specific use cases occurring in selected municipalities in Regione Veneto.

### 3.3 A Technical-level Monitor for QoS Portal Measurements

In order to complete our quality program to include technical-level QoS, a comprehensive architecture built around atomic “indicator units” was designed. The quality tool eMon was designed (see Fig. 5) to give eGovernment technical staff full knowledge for operation, performance and responsiveness of portal services and applications:

- by identifying a set of strategies to insert low level key performance indicators in eGovernment portals and applications,
- by structuring a real time information flux feed model of the resulting indicators for system administrators via a messaging subsystem (using email, sms, IM and portlets),
- by including a statistical analyzer to elaborate and report the evolution of the indicators and the correlation between them; finally,
- by making indicators manageable via a dedicated user interface.

The technical-level plug-in interface model is created as an abstraction layered out on-top of well known, widely used Open Source tools for monitoring, helping to further decouple the model from language- or system-level details, as well as over more portal- and system-specific interfaces. Three

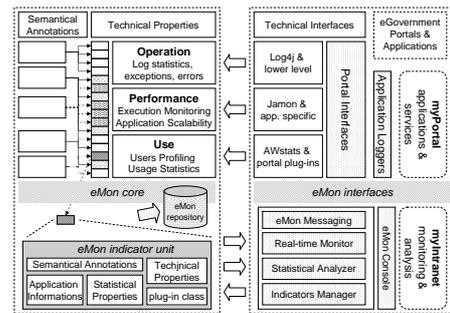


Figure 5: The eMon tool for technical-level QoS measurements and its components.

main areas for the deployment of the technical sensors were identified (see again Fig. 5):

- the *operation* area, to maintain information about the state of the services. In addition to other lower-level interfaces, the OS tool log4j has been identified as a useful and flexible tool to feed eMon (through *appenders*) with informations at various levels of severity that the *loggers* can transmit – a form of generalization for language-specific exceptions;
- the *performance* area, to maintain information about the performance in production, to identify possible execution bottlenecks and to verify service scalability and application user responsivity. For this task, the OS tool Jamon was identified;
- the *user-related* area, to collect informations about users accessing the portals: hits, views, robots and worm accesses, search keywords to reach the sites, through AWStats, a mature OS tool capable of interacting with the main web-, mail- and ftp-server platforms.

Like eGif, eMon exhibits a dual interface, collecting data from the G2C *myPortal* and exposing it to authorized staff with a management console via the internal G2G *myIntranet*. eMon shares with eGif the same technology choices: the eXist OS XML-native dbms for the eMon repository and the server-side Echo2 web GUI framework for the eMon management console.

The eMon tool is currently under test in the Regione Veneto eGovernment framework.

## 4. CONCLUSIONS

In this paper we presented the three-layered approach adopted in our quality-oriented eGovernment research program. The project is characterized by a dual G2G/G2C architecture based on open source technologies, and recently it has been enriched with a workflow process management framework. We believe that this model can be applied to other local eGovernment scenarios: the generalization of this work and its instantiation to other specific case studies is the object of our ongoing research.

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## 6. REFERENCES

- [1] A. Candiello, A. Albarelli, and A. Cortesi. An ontology-based inquiry framework. In A. Gangemi, J. Keizer, V. Presutti, and H. Stoermer, editors, *SWAP 2008*, volume 426 of *CEUR Workshop Proceedings*, 2008.
- [2] A. Candiello, A. Albarelli, and A. Cortesi. Advanced quality tools for e-government services. In M. Winckler, M. Noirhomme-Fraiture, D. Scapin, G. Calvary, and A. Serna, editors, *DEGAS 2009*, volume 492 of *CEUR Workshop Proceedings*, pages 24–29, 2009.
- [3] J. Cardoso, J. Mendling, G. Neumann, and H. Reijers. A discourse on complexity of process models. In J. Eder and S. Dustdar, editors, *BPM 2006 Workshops*, volume 4103 of *Lecture Notes in Computer Science*, pages 117–128. Springer-Verlag, Berlin, 2006.
- [4] V. Danciu. Formalisms for IT Management Process Representation. In *Business-Driven IT Management, 2006. BDIM'06*, pages 45–54, 2006.
- [5] H. Drüke, editor. *Local electronic government: a comparative study*. Routledge, New York, 2005.
- [6] A. Gómez-Pérez, F. Ortiz-Rodríguez, and B. Villazón-Terrazas. Legal Ontologies for the spanish e-Government. In R. Marín, E. Onaindía, and A. B. J. Santos, editors, *Current Topics in Artificial Intelligence*, volume 4177 of *Lecture Notes in Computer Science*, pages 301–310. Springer-Verlag, Berlin Heidelberg, 2006.
- [7] T. Hornung, A. Koschmider, and J. Mendling. Integration of heterogeneous BPM Schemas: The Case of XPD and BPEL, in CAiSE. In N. Boudjlida, D. Cheng, and N. Guelfi, editors, *CAiSE\*06 Forum, Theme: Trusted Information Systems*, volume 231 of *CEUR Workshop Proceedings*, 2006.
- [8] E. Hyvönen, K. Viljanen, J. Tuominen, and Seppälä. Building a national semantic web ontology and ontology service infrastructure. In S. Bechhofer, M. Hauswirth, J. Hoffmann, and M. Koubarakis, editors, *ESWC 2008*, volume 5021 of *Lecture Notes in Computer Science*, pages 95–109. Springer-Verlag, Berlin Heidelberg, 2008.
- [9] R. Klischewski and S. Ukena. E-Government Goes Semantic Web: How Administrations Can Transform Their Information Processes. In T. Vitvar, V. Peristeras, and K. Tarabanis, editors, *Semantic Technologies for E-Government*, volume 5184 of *Lecture Notes in Computer Science*, pages 99–125. Springer-Verlag, Berlin Heidelberg, 2010.
- [10] B. Magoutas, C. Halaris, and G. Mentzas. An ontology for the multi-perspective evaluation of quality in e-government services. In M. Wimmer, H. Scholl, and A. Grönlund, editors, *EGOV 2007*, volume 4656 of *Lecture Notes in Computer Science*, pages 318–329. Springer-Verlag, Berlin Heidelberg, 2007.
- [11] L. B. Merino and G. B. Elguezabal. Business Process Definition Languages Versus Traditional Methods Towards Interoperability. In X. Franch and D. Port, editors, *COTS-Based Software Systems*, volume 3412 of *Lecture Notes in Computer Science*, pages 25–35. Springer-Verlag, Berlin Heidelberg, 2005.
- [12] W. Neuman. *Social Research Methods: Qualitative and Quantitative Approaches*. Allyn & Bacon, Needham Heights, MA, 2002.
- [13] B. Niehaves and R. Malsch. Democratizing process innovation? On citizen involvement in public sector BPM. In W. van der Aalst, A. ter Hofstede, and M. Weske, editors, *EGOV 2009*, volume 5693 of *Lecture Notes in Computer Science*, pages 245–256. Springer-Verlag, Berlin Heidelberg, 2009.
- [14] D. Osimo. Web 2.0 in government: Why and how? Technical Report EUR 23358 EN, European Commission, 2008.
- [15] X. Papadomichelaki, B. Magoutas, C. Halaris, D. Apostolou, and G. Mentzas. A review of quality dimensions in e-government services. In M. A. Wimmer, H. J. Scholl, Å. Grönlund, and K. V. Andersen, editors, *EGOV 2006*, volume 4084 of *Lecture Notes in Computer Science*, pages 128–138. Springer-Verlag, Berlin Heidelberg, 2006.
- [16] A. Parasuraman, L. Berry, and V. Zeithaml. SERVQUAL: a multiple item scale for measuring customer perceptions of service quality. *J. Retailing*, 64:12–40, 1988.
- [17] V. Peristeras, K. Tarabanis, and S. K. Goudos. Model-driven e-government interoperability: A review of the state of the art. *Computer Standards & Interfaces*, 31(4):613 – 628, 2009.
- [18] L. Sabucedo and L. Rifón. A proposal for a semantic-driven e-government service architecture. In M. A. Wimmer, R. Traunmüller, Å. Grönlund, and K. V. Andersen, editors, *EGOV 2005*, volume 3591 of *Lecture Notes in Computer Science*, pages 237–248. Springer-Verlag, Berlin Heidelberg, 2005.
- [19] L. M. A. Sabucedo, L. E. A. Rifón, F. Corradini, A. Polzonetti, and B. Re. Knowledge-based platform for e-government agents: A web-based solution using semantic technologies. *Expert Systems with Applications*, 37(5):3647 – 3656, 2010.
- [20] M. Sorrentino and E. Ferro. Does the answer to e-government lie in intermunicipal collaboration? an exploratory italian case study. In M. Wimmer, H. Scholl, and E. Ferro, editors, *EGOV 2008*, volume 5184 of *Lecture Notes in Computer Science*, pages 1–12. Springer-Verlag, Berlin Heidelberg, 2008.
- [21] W. van der Aalst. Inheritance of business processes: A journey visiting four notorious problems. In H. Ehrig, W. Reisig, G. Rozenberg, and H. Weber, editors, *Petri Net Technology for Communication-Based Systems - Advances in Petri Nets*, volume 2472 of *Lecture Notes in Computer Science*, pages 383–408. Springer-Verlag, Berlin Heidelberg, 2003.