Quality of Service in e-Government underlines the role of information usability

Flavio Corradini, Alberto Polzonetti, Barbara Re*, Luca Tesei

Department of Mathematics and Computer Science
University of Camerino, Camerino, Italy
Tel. +39 0737 402565 - Fax. +39 0737 402561
E-mail: *name.surname*@unicam.it
*Corresponding author

Abstract: Digital services can be thought as Internet based applications that fulfill users' needs. In the e-government domain, services encapsulate functionalities and informative resources and their quality represents a base element during the delivery process. In such a context, usability is one the main quality parameters. In particular, it refers to the easiness of benefiting from the service and the information it provides. It is also the starting point for the definition of quality in e-government focusing on users.

We propose a quality model suitable for the quality assessment of digital services. Our assessment takes into account e-government quality features and relies on the following activities: (i) homogenization, (ii) interaction and (iii) grouping. In order to examine the effectiveness of our model, we report the results of a set of simulations that we carried out to study step-by-step the quality of digital e-government services.

Keywords: e-government, service, quality modeling, quality assessment, usability.

Biographical Notes: Flavio Corradini is full professor of computer science at the University of Camerino. He received a master degree in computer science from the University of Pisa and a PhD in computer engineering from the University of Rome "La Sapienza". His research interests are centred around design methods, formal and semi-formal specification and verification of complex systems, e-government and information society. He is the coordinator of "UEG - Unicam e-government research group" and "COSY - Complex systems" research group. He collaborates with several companies and public administrations for the development of innovation technology, technology transfer and scientific research.

Alberto Polzonetti is a professor of Computer Network and Service Oriented Computing at the University of Camerino. He is a member of the "UEG - Unicam e-government research group" and he is active in several e-government projects related to services infrastructure and broadband development and diffusion. His research activity is focused on the study and on the introduction of technological advanced, innovative and interoperable solutions able to encourage the Information and Communication Technology inside the Information Society.

Barbara Re is a PhD candidate in Computer Science and Complex Systems at the University of Camerino, where she received cum laude the bachelor and master degree in computer science. She is member of "UEG - Unicam e-government research group" and her research interests include quality in e-government service, models and languages for e-government interoperability and methodologies and technologies for e-government development.

Luca Tesei is an assistant professor at the University of Camerino since 2005. He received a master degree in computer science from the University of Pisa in 2000 and a PhD in computer science from the University of Pisa in 2004. His research interests include formal methods for specification and verification of real-time systems, abstract interpretation techniques for static analyses of programming languages, application of formal methods in the field of Systems Biology, and quality in e-government service.

1 INTRODUCTION

e-Government refers to the "use of ICT in public administrations combined with organizational changes and new skills in order to improve public services and democratic processes and strengthen support to public policies", European Commission (2003). These technologies allow governments to improve both the delivery of government services to citizens and the interactions with the business and industry world. Digital government services represent one of the most critical areas of the whole service domain and several definitions are available in the literature; see, for instance, Elmagarmid and McIver (2001), Kim et al. (2003) and references therein. In a broad sense, they can be thought as the provision of services, including pure services or tangible physical products, over electronic networks such as the Internet, Rust and Kannan (2003). In particular, digital government services encapsulate public administration functionalities and informative resources making them available through the use of digital interfaces.

Nowadays, quality of services is a "hot topic" of research. There is a very extensive research activity towards quality assessment in different application domains such as marketing, e-business, bioinformatics but also in software development, multimedia applications, networking, mobile computing, real-time, embedded applications, etc. According to the International Organization for Standardization, the term "quality" is intended as all the features of an entity (resources, services and tools) that influence its capability to satisfy declared or implied needs, ISO (1994).

Unfortunately, quality of service receives a little attention by the e-government research community; see Halaris et al. (2007) and references therein for a review on quality dimensions in e-government services. Within the application domain of our interest – e-government – we could rephrase the above definition of quality as follows:

> *"all the features of digital services in public administrations that influence their capability to satisfy declared or implied citizens and firms' needs".*

Certainly, quality in e-government plays a significant role. A proper modeling and assessment of digital services quality is mandatory to satisfy citizens and enterprisers' needs, to make people accept the use of Information and Communication Technology in their lives as well as to improve "government management".

Digital services encapsulate functionalities and informative resources. The introduction of quality of service in e-government has to take into account both aspects. In such a context, usability represents one of the main quality parameters for e-government services. In particular, it represents the easiness of benefiting from the service and from the information it provides. Moreover, it is the starting point for the definition of quality in e-government focusing on the users. In our opinion, an effective, efficient e-government service passes through usability. This can only be achieved as a result of a continuous process of user-centred design and quality monitoring.

The main problem in defining quality is the identification of a complete list of parameters. We have reviewed the e-government domain focusing on e-government service components. In this way, we have defined a comprehensive e-government quality model investigating the domain at different levels of abstraction (user, interface, implementation, and organization). In this paper, we develop a quality vocabulary focusing on usability. We consider parameters such as attraction, availability, completeness, specificity (just to cite a few). In particular, we consider subjective parameters, i.e. those conditioned by individual's experience or knowledge and by personal mental characteristics or states.

Moreover, we propose a model suitable for quality assessment of digital services. It considers e-government quality features and relies on the following activities: (i) homogenization, (ii) interaction and (iii) grouping. Homogenization of the input is useful to reason over different metrics. It takes also into account whether a given parameter grows in a proportional or in an inverse proportional way with respect to the overall quality. Interaction among different parameters allows us to reason on how parameters influence each other (for instance, how trust parameter influences adaptability). We use the measurements discussed in Re (2007) to estimate the value of parameters. Using the same model, we also study dynamic relationships between each parameter and quality, and pairs of parameters. Finally, the proposed model groups parameters and manages them with different importance. The main advantages of using a formal model are that we have a description of the problem at a high level of abstraction and that we have a formal background on which the applicative solutions can be based, so to avoid possible structural mistakes and inaccurate descriptions.

In order to examine the effectiveness of our quality approach we carried out a set of simulations to study step-by-step the quality of digital e-government services. In particular, we analyzed the impact of usability.

This paper is organized as follows. Section 2 provides an overview of the e-government and service domain and Section 3 discusses the role of usability and quality in this application domain. Section 4 introduces the service quality model based on a taxonomy of parameters related to usability, distinguishing between service information and its implementation. Section 5 proposes the mathematical model useful to assess quality, and Section 6 presents the experimental results. Section 7 introduces some related works that have contributed to the development

of our work. Finally, Section 8 completes the paper with conclusions and future work.

2 E-GOVERNMENT AND SERVICE

Since 2001 e-government has been one of the main application domains for Information and Communication Technologies. Moreover, it represents a test bed – not just in Europe and in the United States, but worldwide – for challenges and opportunities in a cross-disciplinary area. In literature, several definitions for e-government can be found. Some of them are focused on the role of service, others take care of the point of view of citizens, and others are centered in the internal processes of the administration. Let us outline some of them.

- e-Government is defined as "the use of ICT in public administrations combined with organizational changes and new skills in order to improve public services and democratic processes and strengthen support to public policies", European Commission (2003).
- According to the United Nations, e-government is defined as "the use of information and communication technology and its application by the government for the provision of information and basic public services to the people", United Nations (2007).
- The World Bank states that e-government refers to "the use by government agencies of information technologies (such as Wide Area Networks, the Internet, and mobile computing) that have the ability to transform relations with citizens, businesses, and other arms of government", The World Bank's Information Solutions Group (2007).

Additionally, dealing with the particular domain of e-government requires to consider the kind of users we are dealing with. These may include individuals, organizations, technical systems, social relations and value systems, Traunmüller (2003).

In literature, several definitions for e-service can be found. Some of them focus on the e-commerce/e-business domain; see for instance Tiwana and Ramesh (2001) that refer to "Internet-based applications that fulfill service needs by seamlessly bringing together distributed, specialized resources to enable complex, (often real-time) transactions". In this domain, the true nature of e-service is "providing consumers with a superior experience with respect to the interactive flow of information", Rust and Lemon (2001). e-Government distinguishes customer by public administration's users, Mintzberg (1996), and it refers to service as "delivery of public services to citizens, business partners and suppliers, and those working in the government sector by electronic media including information, communication, interaction and contracting, and transaction", Buckley (2003). In other words, digital government services encapsulate public administration functionalities and informative resources making them available through digital interfaces.

A common classification of services is related to the interaction levels: informative, one-way, two-way and transactional services, Becker et al. (2004). Informative services are those in which just information is presented. In one-way services the

information of the service and more structured documents are available for download. Two-way interaction services support complex workflows by which citizens can submit or receive public administration information and documents. Finally, transactional services support the inter- and intra-administration case (usually also payments are supported). Moreover, the services distributed by e-government focus on the users to provide full support to citizens (G2C services), firms (G2E services) and others administrations (G2G services and inter-administration activities), see European Commission (2003).

3 QUALITY AND USABILITY

e-Government is a particular application domain characterized by different kinds of users whose satisfaction plays a fundamental role. User satisfaction is a complex topic and it is deeply linked with quality of service definition. It impacts on the subjective part of the service quality that is, in turn, conditioned by the users' experience or knowledge and by their personal mental characteristics or states. In such a context, usability – considered in terms of ease of use – provides a characterization on quality in e-government focusing on users' subjectivity, when the service is used under certain state conditions.

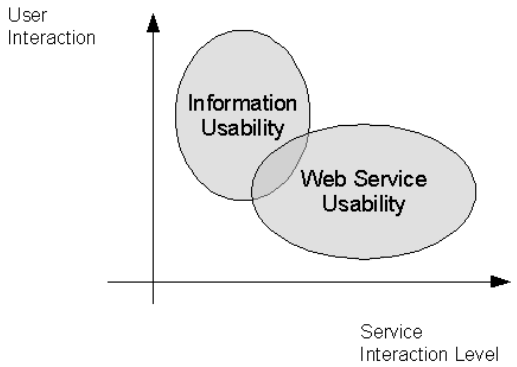

Figure 1 Usability Views in e-Government.

As previously mentioned, services encapsulate functionalities and informative resources. The introduction of quality of service in e-government takes into account both aspects. In our opinion, usability represents the main quality parameter for e-government services in use (see Figure 1). It focuses both on service design and deployment (regarding service functionalities) and on service delivery (regarding informative resources). Moreover, it depends on the interaction level of service and on the different kind of users. Generally speaking, it represents the easiness of benefiting from the service and its information. The International Organization for Standardization defines usability as "a measure of the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in a particular environment" ISO (1993).

Concerning the functionality aspects, the impact of usability on technologies must be considered. We underline the role of web services as the most common

implementation of digital services, Alonso et al. (2003). Quality permits the service deployment into any on-line environment quickly and easily. The impact of web services and their usability is widely investigated in the literature; see, for instance, Martens (2003) and Batini et al. (2007). The quality of web services already considers, in a sort of way, the impact on the user of how the service is provided.

At the same time, to achieve the highest level of information quality has become a fundamental aim in the e-government domain. In our opinion, information related services and informative services in public administrations must be taken into consideration. They represent one of the main steps to reach a mature e-government. They can be used in a knowledge intensive process, like the design of service of public administrations. The usability of such information supports the design of services with high quality level.

Information and usability are widely investigated in Hilbert and Redmiles (2000) and in Ellis and Kurniawan (2000). While researches have performed several investigation on usability, none of the existing approaches systematically couples with service and information usability in e-government. Our investigation coherently supports both usability views in the particular domain of e-government.

In the following section we introduce a quality model and a quality assessment model focusing on quality and usability.

4 E-GOVERNMENT QUALITY MODEL

In this section we present the parameters of our quality model, which is able to assess the quality in e-government. Focusing on usability, we introduce a three level model. The first level introduces the basic usability parameters and focuses on effectiveness, efficiency and satisfaction. The second and the third levels define a categorization on digital services. In particular, the second level focuses on (i) e-government parameters that take into account how digital services of public administrations are perceived by the final users and (ii) presentation parameters that analyse front-office services with respect to the final users' needs. This second level is very important for informative services. Then, the third level discusses (i) behavioral parameters that describe the implementation of back-end services and (ii) infrastructural parameters related to the basic infrastructures enabling digital services.

4.1 Usability Related Aspects

In the following we introduce four parameters that support the assessment of the usability level of a service taking into account users and the subjective component of quality. We focus on effectiveness, efficiency and satisfaction, Frokjaer et al. (2000), and we take into account the application domain.

- **Understandability** is the measure of how readily the users perceive information significance and service behavior.
- **Learnability** is the measure of information and service level to support the user's ability to correctly use the service and to read the information with and without instructions.

- **Compliance** represents the level of service and information to introduce an harmonious environment where the behavior and the actions are predictable.

- **Attractiveness** is the measure of the service ability to attract users.

Usability in e-government domain assumes a very importance role in particular related to elderly and disability Becker (2005). At the same time, an hight level of service usability supports the citizens inclusion in line with e-government main aims Sahraoui (2007).

4.2 Service Related Aspects

Service parameters are split in two parts (i) e-government and (ii) presentation. In the e-government group we introduce the following items. **Popularity** considers the amount of population interested in the service as well as the frequency of utilization with respect to a period of time and to the number of government-users. Moreover, we introduce **Multicanality** that points out service distribution solutions (Web, mobile computing, and so on). We also consider **Internationalization** that refers to the languages used for service description and distribution, and **Reputation** that represents the service trustworthiness. We introduce **Originality** and **Contents** that are related to service contents quality. Originality focuses on the service innovation level, while Contents measures the capabilities of public administrations to provide useful and proper information. **Legality** represents laws and norms that regulate the provision and the service use. A further significant parameter is **Domain Security** that measures the process and information control level. **Trust** represents the level of confidence among stakeholders in the service execution. This parameter involves citizens, enterprises, public administration employees, software agents and organizations focusing the attention on proper skills and tasks. At the same time, a digital service underlines privacy and communication security levels. A proper service distribution allows a certain level of trust and promotes the service utilization. Moreover, **Promoting e-democracy** represents a useful parameter to estimate the impact of a service on the society. This supplies a quantitative value to show how a service can promote digital citizenship, namely, the set of practices of ICT used by citizens to take part in political choices at any level. The presence of forums, FAQs, mailing lists, etc. – related to the service – has a good impact on the value of this parameter. Finally, we consider the **Completeness** of a service, representing the Europe levels. It is evaluated starting from different ways to interact with the services.

About front-end related aspects we take into account **Cost**, **Accessibility** and **Adaptability**. The Cost parameter measures the mean amount of money involved in a complete service transaction, capturing the economic condition of the service use. It summarizes every cost related to the service provision such as execution price and pricing model. Accessibility measures the users' easiness to detect and to use the needed service capabilities. It is particularly relevant with respect to disadvantaged people. Finally, Adaptability evaluates the service capacity to change (or being changed) and make itself suitable for a new context.

4.3 Implementation Related Aspects

As service parameters, the implementation parameters are split in two parts (i) behavioral and (ii) infrastructural. In the first group, we consider the **Interoperability** level achieved by the service. It represents the amount of cooperative work among consumer applications, software agents and services in different development environments that implement and deploy procedures. From this perspective, the use of standards affects service interoperability. It is also measured by supported standard/regulatory. Moreover, **Applicative Security** represents the security level of web services introducing authentication and authorization policies and procedures. **Integrity**, about data and transactions, is another important element. It measures the service ability to prevent unauthorized access to - or modification of - computer programs or data. It is based on the ACID properties: atomicity, consistency, isolation and durability, Gray (1981). At the same time, **Robustness/Flexibility** measures the service capabilities to work correctly even when not valid, incomplete or conflicting inputs occur. It is affected by service stability in terms of its interface and/or implementation.

About infrastructure parameters we analyse the following items. **Availability** represents how the service is available when a client attempts to use it. **Performance** represents how fast a service request can be completed. It measures the speed in completing tasks using service response time, latency and execution time. **Scalability** refers to the capability of increasing the service capacity in terms of operations or transactions processed in a fixed time. Moreover, **Scheduling** refers to the quality level of the service assigning resources. **Throughput** represents the transfer rate of information in a given time interval. It is measured using successful execution request and successful execution rate. Finally, **Reliability** represents the ability of a service to perform its required functions under stated conditions for a specified period of time.

5 QUALITY ASSESSMENT MODEL

In this section we introduce our mathematical model for quality quantification of e-government digital services. After three normalization phases, the model provides the assessment of the quality level. Starting from a set of quality parameters the model estimates a value in the [0...100] range.

This model is inspired to that of Liu et al. (2004), but we introduce further elements like data homogenization and interaction between parameters. In more detail, (i) homogenization of the input is useful to reason over different e-government parameter metrics and behavior. The homogenization takes also into account whether a given parameter grows in a proportional or inverse proportional way with respect to the overall quality measurement. For example, infrastructure related parameters measured against time needs to be aggregated with security parameters measured with boolean values (or some other metrics). About trend, if the quality of the infrastructure increases, then also the quality of security increases. At the same time, we introduce (ii) interaction among parameters to measure dynamic relationships. Using this, we can take into account how parameters influence each other (for instance, usability parameter influence service trust).

5.1 Input of the Model

Let S be a service. The mathematical model uses the following input parameters.

- $Q = (q_1, ..., q_n)$ is an array of n natural numbers representing the measured value of parameters related to the service S. Each q_i , $1 \leq i \leq n$, is collected during a measurement process and represents a specific view of the service. The considered parameters are related to the second and third level of the model.

- $Z = (z_1, ..., z_n)$ is an array of n boolean values used in the normalization phase. Each z_i, $1 \leq i \leq n$, takes its value as follows:

$$z_i = \begin{cases} 1 & \text{if the } q_i \text{ parameter in } Q \text{ grows in proportional way with respect to the overall quality value} \\ 0 & \text{if the } q_i \text{ parameter in } Q \text{ grows in inverse proportional way with respect to the overall quality value} \end{cases}$$

- $C = (c_1, ..., c_n)$ is an array of n positive natural numbers used during the normalization process. Each c_i represents the upper bound of the q_i parameter in Q vector. The elements of C are related to the parameter analysis: they depend on the specific metrics used to express them and on the methodology of the measurements

- $\mathcal{I}$ is an $n \times n$ matrix of values in the range [0..1]. It shows the interaction level between the parameters in Q and introduces the impact of the usability component of the model. Each $m_{j,k}$, $1 \leq j, k \leq n$, takes its value as follows:

$$m_{j,k} = \begin{cases} \text{a value in }]0..1] & \text{if } q_j \text{ and } q_k \text{ interact} \\ 0 & \text{otherwise} \end{cases}$$

  Note that all the diagonal values of $\mathcal{I}$ should be 0, i.e. each parameter has not relevant interaction with itself. For instance, cost parameter can not interact with itself in the same spatio-temporal location.

- D is a $n \times l$ matrix of boolean values where n is the number of parameters and l is the number of quality groups. D is used to group parameters with similar features. Each parameter can belong to one and only one group, i.e. the matrix must satisfy the following constraint.

$$\forall i \; 1 \leq i \leq n, \; \sum_{j=0}^{l} d_{i,j} = 1$$

  We use h_i to denote the cardinalities of groups. Moreover, we use H to denote the array of these l values.

- $W = (w_1, ..., w_l)$ is an array of l natural numbers in which each w_i is the weight of the group i. The array must satisfy the following constraint: $\sum_{i=1}^{l} w_i = 100$. The weights can also be associated to parameters if and only if the groups are all singletons.

Figure 2 shows the phases to evaluate the overall service quality.

All the input values of the quality assessment model are estimated using the measurement model introduced in Re (2007). In particular, the values of array Q are the average values of a proper number of measurements. The other values can be derived from the values in Q and the values in $\mathcal{I}$ are the statistical correlation coefficient, which describes the strength of association between the values of all the considering measured parameters.

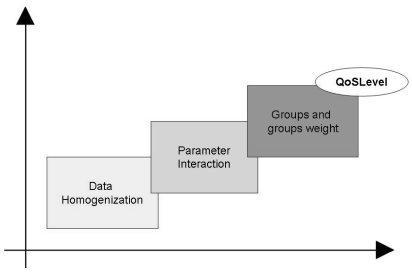

Figure 2 QoS Assessment Model Phases.

5.2 Phases of the Model

Phase 1: Data Homogenization

As a first step, let Q, Z and C be the input arrays. We introduce a normalization function f_1 which takes triples of the form (q_i, z_i, c_i) – where q_i, z_i and c_i are the i-th elements of the arrays Q, Z and C respectively – and returns a value in the range [0...100]. Using this function, we obtain a new array Q' of elements $q'_i = f_1(q_i, n_i, c_i)$. The formal definition of the function f_1 is as follows:

$$f_1(q_i, n_i, c_i) = n_i \left(\frac{q_i * 100}{c_i} \right) + (1 - n_i) \left(100 - \frac{q_i * 100}{c_i} \right)$$

Phase 2: Parameters Interaction

In the second phase we determine the interaction factors of the quality parameters. We obtain the interaction factor φ_k, $1 \leq k \leq n$, as follows:

$$\varphi_k = \frac{\sum_{j=1}^{n} m_{j,k}}{n - 1}$$

The proposed interaction factor does not take into consideration recursive impact on parameters since $\mathcal{I}$ is a matrix with null diagonal elements.

Each element q'_i obtained in the first phase must be normalized again to obtain a new array Q'' whose elements q''_i are calculated as follows:

$$q''_i = \varphi_i q'_i$$

where φ_i and q'_i are the i-th interaction factor and the i-th element of the array Q' respectively.

Phase 3: Grouping and Group Weight

At this point, we introduce the possibility of grouping the parameters in order to manage them as groups with different importance. We exploiting, to this purpose, the matrix D and the array W.

We use the matrix D to obtain a new array G (its element will be denoted by g_1, g_2, ...) of quality values for each group as follows:

$$G = Q''D$$

Finally, to give the overall quality value for the service we use the *QoSLevel* function defined as follows:

$$QoSLevel(G, H, W) = \frac{\sum_{i=1}^{l} \frac{g_i}{h_i} * w_i}{\sum_{i=1}^{l} w_i}$$

where g_i and w_i are the i-th elements of the arrays G and W respectively, and h_i is the cardinality of i-th group. The function gives a value in the range [0...100].

6 EXPERIMENTATION

The case study that we present briefly summarizes some of the results which can be obtained using our quality assessment. In order to examine the effectiveness of our approach we carried out a set of experiments to study step-by-step the impact factor of the parameters of digital e-government services on quality. We rely on an existing shared service management system, the so-called TecUt portal (`www.tecut.it`), a portal developed in collaboration with one of the Italian regions: the Marche Region, Corradini et al. (2007).

TecUt supports activities of small and medium municipalities providing a "gateway" between citizens/enterprises and public administrations. It gives a rapid access to services by means of a single access point. TecUt is an ASP.NET Web Application running on IIS6 (Windows Server 2003 Environment). The Server is a Pentium IV 3.0GHz with 1Gb of RAM located inside the Marche Region Demilitarized Zone.

We focused on the service in use and we identified the users, the organizational environment and the technical environment to define the input of the model. In this section we present the most important experimental results related to the global trend of the quality function on a specific service under stress. The service under study in the TecUt portal is the Residence Certificate request. It is used to certify personal information with respect to legal residence/domicile.

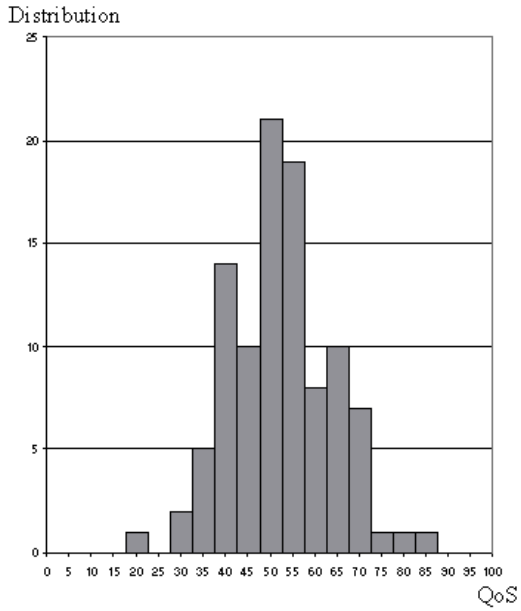

Figure 3 Quality distribution.

After several experiments we were able to assess the quality trend. It increases or decreases steadily with respect to the trend of the parameters. Moreover, the behavior of the frequency distribution of the quality values follows a normal trend (Figure 3). Taking into account the central limit theorem, the sum of large and independent quality observations has an approximate normal distribution (Gaussian Distribution) under certain general conditions.

Varying all the parameters not related to usability, the overall quality assessment does not exceed a certain value. Therefore, the values of the usability parameter affect the quality upper bound (in our experimentation measured in 85, as shown in Figure 3). We also conclude that usability introduces an essential impact on quality and that the impact of the interaction between the usability parameters with the other parameters supports quality stabilization (around 50, as shown in Figure 3).

7 RELATED WORK

On application domains such as marketing, e-business, and streaming multimedia the literature on quality of services contains interesting approaches. All of these contributions influenced somehow the development of our work. However, as far as we know, our work is the first attempt to introduce a formal quality assessment of e-government digital services focusing on usability and taking into account the role of users and Information and Communication Technologies. In our case, an in-depth analysis of literature on quality has given the necessary input for both the definition of the e-government quality model and the assessment model. In this section we

essentially concentrate on those papers that have more directly contributed to the development of our work.

Starting from government quality literature we identify two main areas of interest:

- organizational performance: **CAF**, Center (2006), **Balanced Scorecard**, Kaplan and Norton (1992), and **Six Sigma**, De Feo and Barnard (2005);
- site quality: **SiteQual**, Webb and Webb (2004), **Portal Usage Quality**, Liu et al. (2004), **IP-Portal**, Yang et al. (2005), **Norwegian Approach**, Jansen and Olnes (2004), and **G-Quality**, Garcia et al. (2005).

Regarding organizational performance, the papers mainly discuss the role of organizations, while services play a marginal role. Quality models are defined, but without introducing specific ICT and usability aspects. Our approach takes into account organizational elements for the identification of implicit relationships in the e-government domain and, also, focuses on the distribution of digital services and related issues.

The site quality area introduces facilities to measure the quality of web sites focusing on the e-government front-end aspects. We referred to this line of research for the definition of parameters and metrics related to the front-end layer of the services. Indeed, the evaluation and the monitoring of digital government services must consider aspects like adaptability, accessibility, etc. The introduction of a proper client side represents a fundamental part of the distribution of e-government services. We also mention e-government in Thai approach, Sukasame (2004). This work presents a conceptual framework and some factors (content, linkage, reliability, ease of use and self-service) affecting the e-service provided on the web portal of the Thailand's government. Unfortunately, it does not introduce a complete discussion on the objectively measurable parameters of the quality of digital services and does not underline the potential of usability representation.

In the area of marketing of services we have considered interesting works, such as SERVQUAL, Parasuraman et al. (1998). The marketing literature always states that the perceptions of quality of services are important elements of the customers' satisfaction. The e-government setting heavily relies on technological and domain dependent constraints. Interesting suggestions also came from the business management domain with a special focus on the quality policies, see Seth et al. (2005) and references therein. In particular, Yang and Jun (2002) introduce a business service quality model that underlines the role of users (purchasers and non-purchasers). Their satisfaction plays a role in this setting, too. In the e-government domain, of course, we do not rely on business executives, but the customers', that is citizens, perception of services quality is crucial. Santos (2003) introduces a model of e-quality to achieve high customer retention, customer satisfaction, and profitability for the organizations in e-business. He proposes a model of e-service quality that takes into account static and dynamic parameters. Unfortunately, none of the presented models propose a complete set of parameters and the impact of usability on it. It has to be said that the literature on marketing contributed to our quality approach on the subjective part, helping us in the area of investigating the users' feeling on the services. At last, but with the same importance, we mention Barnes and Vidgen (2006); it supported the definition of our quality model in the

extraction of the information on user interface. It is an interesting effort in the introduction of usability.

Regarding the technological aspects, we underline the role of web services, Batini et al. (2007), as the most common implementation of digital services in e-government. In Ran (2003), Farkas and Charaf (2003), and Maximilien and Singh (2004) there is a first approach to define non-functional aspects in the discovery of web services. From these works we have selected interesting parameters. In particular, Ran (2003) suggests an UDDI (Universal Description Discovery and Integration) quality extension as a solution for the discovery of web services. In this way, during the discovery phase, functional and non-functional service aspects are introduced. In Farkas and Charaf (2003) a software architecture is proposed to provide web services with high quality. They implement a broker for service discovery to reflect quality parameters stored in UDDI. Maximilien and Singh (2004) discuss the lack of a description of non-functional attributes needed for the discovery of web services. They propose an ontology-based framework to describe quality in order to improve the stakeholders' interaction. In Nahrstedt et al. (2001) and Tsetsekas et al. (2001), quality is introduced in a middleware domain. In Nahrstedt et al. (2001) the authors discuss quality middleware information able to support quality-based applications like streaming and e-business. This work presents key aspects about service quality introducing application and process quality information at a low abstraction level. In Tsetsekas et al. (2001) a middleware that drives service presentation to the users is proposed. It allows the description and the selection of quality parameters and the resources that support the quality. In general, distributed applications and their quality provide several hints to quality of services in e-government. Finally, Menasce (2003) and Corradini et al. (2004) introduce digital service quality in e-commerce and bioinformatics, respectively. They propose an approach for domain related quality investigation.

8 CONCLUSION AND FUTURE WORK

In this paper we have defined a quality model based on the role of information usability, which is one of the main aspects in the quality assessment for e-government digital services. The quality model focuses both on information and service aspects. Moreover, we have defined an assessment model useful for having a description of a complex environment where the interactions play an important role. We have presented the results of a step-by-step experimentation to show how our model works. In our case study we observe a significant impact of usability parameters on the overall quality.

As future work, we first want to further evaluate the proposed approach with a different and larger experimentation, not focusing only on usability. We also plan to define a comprehensive quality of service methodology that adds to the presented model the organizational aspects of public administrations. Related to this, we intend to propose our model as a mean to make a comparison among services (with the same functionalities) provided by several public administrations.

References

Alonso, G., Casati, F., Kuno, H., and Machiraju, V. (2003). *Web Services - Concepts, Architectures and Applications*. Springer.

Barnes, S. J. and Vidgen, R. T. (2006). Data triangulation and web quality metrics: a case study in e-government. *Information & Management*, 43(6):767–777.

Batini, C., Bertini, E., Comerio, M., Maurino, A., and Santucci, G. (2007). Visual languages and quality evaluation in multichannel adaptive information systems. *Journal of Visual Languages and Computing*, 18(5):513–522.

Becker, J., Niehaves, B., Algermissen, L., Delfmann, P., and Falk, T. (2004). e-Government Success Factors. In *EGOV*, pages 503–506.

Becker, S. A. (2005). E-government usability for older adults. *Communications of the ACM*, 48(2):102–104.

Buckley, J. (2003). E-service quality and the public sector. *Managing Service Quality*, 13(6):453–462.

Center, C. R. (2006). Common assessment framework. Retrieved June 20, 2007, from: http://www.eipa.nl/CAF/CAFmenu.htm.

Corradini, F., Ercoli, C., Merelli, E., and Re, B. (2004). An Agent-based Matchmaker. In *Proceeding of WOA04 Sistemi Complessi e Agenti Razionali*, pages 150 – 156.

Corradini, F., Sabucedo, L. Á., Polzonetti, A., Anido-Rifón, L. E., and Re, B. (2007). A Case Study of Semantic Solutions for Citizen-Centered Web Portals in eGovernment: The Tecut Portal. In Wimmer, M., Scholl, H. J., and Grönlund, Å., editors, *Proceedings of EGOV 2007*, volume 4656 of *Lecture Notes in Computer Science*, pages 204–215. Springer.

De Feo, J. A. and Barnard, W. W. (2005). Juran institute's six sigma breakthrough and beyond - quality performance breakthrough methods. *Tata McGraw-Hill Publishing Company Limited*.

Ellis, R. D. and Kurniawan, S. H. (2000). Increasing the usability of online information for older users: a case study in participatory design. *Int. J. Hum. Comput. Interaction*, 12(2):263–276.

Elmagarmid, A. K. and McIver, W. J. (2001). The ongoing march toward digital government - guest editors' introduction. *IEEE Computer*, 34(2):32–38.

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

Farkas, P. and Charaf, H. (2003). Web Services Planning Concepts. *Journal of WSCG*, 11(1).

Frokjaer, E., Hertzum, M., and Hornbaek, K. (2000). Measuring usability: are effectiveness, efficiency, and satisfaction really correlated? In *CHI'00: Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 345–352, New York, NY, USA. ACM.

Garcia, A. C. B., Maciel, C., and Pinto, F. B. (2005). A quality inspection method to evaluate e-government sites. In Wimmer, M., Traunmüller, R., Grönlund, Å., and Andersen, K. V., editors, *EGOV*, volume 3591 of *Lecture Notes in Computer Science*, pages 198–209. Springer.

Gray, J. (1981). The transaction concept: Virtues and limitations (invited paper). In *Very Large Data Bases, 7th International Conference, September 9-11, 1981, Cannes, France, Proceedings*, pages 144–154. IEEE Computer Society.

Halaris, C., Magoutas, B., Papadomichelaki, X., and Mentzas, G. (2007). Classification and synthesis of quality approaches in e-government services. *Internet Research*, 17(4):378–401.

Hilbert, D. M. and Redmiles, D. F. (2000). Extracting usability information from user interface events. *ACM Computing Surveys*, 32(4):384–421.

ISO (1993). ISO cd 9241-11: Guidelines for specifying and measuring usability. International organization for standardization.

ISO (1994). ISO 8402 quality management and quality assurance. Vocabulary. International organization for standardization.

Jansen, A. and Olnes, S. (2004). Quality assessment and benchmarking of norwegian public web sites. In *4th European Conference on e-government*.

Kaplan, R. S. and Norton, D. P. (1992). The balanced scorecard: measures that drive performance. *Harvard Business Review*.

Kim, D. J., Agrawal, M., Jayaraman, B., and Rao, H. R. (2003). A comparison of b2b e-service solutions. *Commun. ACM*, 46(12):317–324.

Liu, Y., Ngu, A. H., and Zeng, L. Z. (2004). QoS computation and policing in dynamic web service selection. In *WWW Alt. '04: Proceedings of the 13th international World Wide Web conference on Alternate track papers & posters*, pages 66–73, New York, NY, USA. ACM.

Martens, A. (2003). Usability of web services. *Web Information Systems Engineering Workshops, 2003. Proceedings. Fourth International Conference on*, pages 182–190.

Maximilien, E. M. and Singh, M. P. (2004). A Framework and Ontology for Dynamic Web Services Selection. *IEEE Computer Society*, 4:84–92.

Menasce, D. A. (2003). Automatic QoS Control. *IEEE Computer Society*, 3:92–95.

Mintzberg, H. (1996). Managing government, governing management. *Harvard Business Review*, 57(2):115–126.

Nahrstedt, K., Xu, D., Wichadakul, D., and Li, B. (2001). QoS Aware Middleware for Ubiquitous and Heterogeneous Environments. *IEEE Communications Magazine*, 39(11):140–148.

Parasuraman, A., Zeithaml, V., and Berry, L. (1998). Journal of retailing. *SERVQUAL: A Multiple-Item Scale for Measuring Consumer Perceptions of Service Quality*, 64(1):12–40.

Ran, S. (2003). A model for web services discovery with QoS. *SIGecom Exch.*, 4(1):1–10.

Re, B. (2007). Run Time Quality Assessment of e-Government Services. In *1st internationa conference on Methodologies, Technologies and Tool enabling e-Government - Metteg07*, pages 213–227, Camerino, Italy.

Rust, R. T. and Kannan, P. (2003). E-service: a new paradigm for business in the electronic environment. *Commun. ACM*, 46(6):36–42.

Rust, R. T. and Lemon, K. N. (2001). E-Service and the Consumer. *Int. J. Electron. Commerce*, 5(3):85–101.

Sahraoui, S. (2007). E-inclusion as a further stage of e-government? *Transforming Government: People, Process and Policy*, 1(1):44–58.

Santos, J. (2003). E-service quality: a model of virtual service quality dimensions. *Managing Service Quality*, 13(3):233–246.

Seth, N., Deshmukh, S. G., and Vrat, P. (2005). Service quality models: a review. *International Journal of Quality & Reliability Management*, 22(9):913–949.

Sukasame, N. (2004). The development of e-service in thai government. *BU Academic Review*, 3(1):17–24.

The World Bank's Information Solutions Group (2007). About e-Government. Available at http://www.worldbank.com/egov.

Tiwana, A. and Ramesh, B. (2001). e-Services: Problems, Opportunities, and Digital Platforms. In *HICSS'01: Proceedings of the 34th Annual Hawaii International Conference on System Sciences*, volume 3, page 3018, Maui, Hawaii. IEEE Computer Society.

Traunmüller, R., editor (2003). *Electronic Government, Second International Conference, EGOV 2003, Prague, Czech Republic, September 1-5, 2003, Proceedings*, volume 2739 of *Lecture Notes in Computer Science*. Springer.

Tsetsekas, C., Manitias, S., Fünfstück, F., Thoma, A., and Karadimas, Y. (2001). A QoS middleware between users, applications and the network. In *8th Intl. Conf. on Advances in Communications and Control*, Crete, Greece.

United Nations (2007). Global e-Government readiness report 2004. Towards access for opportunity. Available at http://unpan1.un.org/intradoc/groups/public/documents/UN/UNPAN019207.pdf.

Webb, H. W. and Webb, L. A. (2004). Sitequal: an integrated measure of web site quality. *Journal of Enterprise Information Management*, 17(6):430–440.

Yang, Z., Cai, S., Zhou, Z., and Zhou, N. (2005). Development and validation of an instrument to measure user perceived service quality of information presenting web portals. *Information Management*, 42(4):575–589.

Yang, Z. and Jun, M. (2002). Journal of business strategies. *Consumer perception of e-service quality: from internet purchaser and non-purchaser perspectives*, 19(1):19–41.