Quality of service in e-government underlines the role of information usability

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

Department of Mathematics and Computer Science,
University of Camerino,
Via Madonna delle Carceri 9, Camerino, Italy
Fax: +39 0737 402561
E-mail: flavio.corradini@unicam.it
E-mail: alberto.polzonetti@unicam.it
E-mail: barbara.re@unicam.it
E-mail: luca.tesei@unicam.it
*Corresponding author

Abstract: Digital services can be thought as internet based applications that fulfil users' needs and their quality represents a basic element during the delivery process. In such a context, usability is one the main quality parameters and it refers to the ease of benefiting from the functionalities and the information the service provides. We propose a list of quality parameters and a formal model suitable for the quality assessment of digital services. In order to examine the effectiveness of our model, we report the results of an experimentation that we carried out to study the quality of a digital e-government service.

Keywords: e-government; service; quality modelling; quality assessment; usability.

Reference to this paper should be made as follows: Corradini, F., Polzonetti, A., Re, B. and Tesei, L. (2008) 'Quality of service in e-government underlines the role of information usability', *Int. J. Information Quality*, Vol. 2, No. 2, pp.133–151.

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 student 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 Assistant Professor at the University of Camerino. 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 Information and Communications Technologies (ICT) in Public Administrations combined with organisational 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; Elmagarmid and McIver (2001) and Kim et al. (2003) provide some definitions and other references. 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 information making them available through the use of digital interfaces.

Nowadays, quality of service 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 Organisation for Standardisation, 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, 2005).

Unfortunately, quality of service receives a little attention by the e-government research community; Halaris et al. (2007) present an accurate review on quality 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 modelling and assessment of quality of digital services is mandatory to satisfy the citizens and the enterprises' needs, to make people accept the use of ICT in their lives, and to improve 'government management'.

Since digital services encapsulate functionalities and information, the introduction of quality of service in e-government has to take into account both aspects. Also, for e-government services *usability* represents one of the main quality parameters. It represents the ease 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 and, in this paper, we define a comprehensive list of parameters for quality in e-government investigating the domain at different levels of abstraction (user, interface, implementation, and organisation). In particular, we consider subjective parameters, i.e., those conditioned by users's experience or knowledge and by personal mental characteristics or states.

Moreover, we propose a formal model suitable for quality assessment of digital services. It considers e-government quality features and relies on the following activities:

- homogenisation
- interaction
- grouping.

Firstly, homogenisation 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. Secondly, interaction among different parameters allows us to reason on how parameters influence each other (for instance, how the trust parameter influences adaptability). We use the measurements discussed in Re (2007) to estimate the value of parameters. Finally, the proposed model allows to group parameters and to manage 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 service development can be based, so to avoid possible structural mistakes and inaccurate descriptions. Moreover, the model constitutes a firm basis on which objective parameters are placed and on which subjective parameters can be treated in a controlled way.

In order to examine the effectiveness of our quality approach we carried out an experimentation to study step-by-step the quality of a digital e-government service. In particular, we analysed the impact of usability on the overall quality.

This paper is organised as follows. Section 2 provides an overview of the world of digital services and of the e-government domain. Section 3 discusses the role of usability and quality in this application domain. Section 4 introduces our list of quality parameters focusing on usability. Section 5 proposes the mathematical model useful to assess the quality, and Section 6 presents and discusses the results of our experimentation.

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 digital services

Since 2001 e-government has been one of the main application domains for ICT. Moreover, it represents a test bed – not just in Europe and in the USA, but worldwide – for challenges and opportunities in a cross-disciplinary area. In the 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 centred on 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 ICT 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, organisations, technical systems, social relations and value systems (Traunmüller, 2003).

In the literature, several definitions for digital services can be found. Some of them focus on the e-commerce/e-business domain; for instance, Tiwana and Ramesh (2001) refers to

> "internet-based applications that fulfil service needs by seamlessly bringing together distributed, specialised resources to enable complex, (often real-time) transactions."

In this domain, the true nature of digital services is "providing consumers with a superior experience with respect to the interactive flow of information" (Rust and Lemon, 2001). E-government distinguishes customer from 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 information making them available through digital interfaces.

A common classification of services is related to the **interaction level** (Becker et al., 2004):

1 informative services are those in which just information is presented

2 one-way services are those in which the information of the service and more structured documents are available for download

3 two-way services support complex workflows by which citizens can submit or receive Public Administration information and documents

4 transactional services support the inter- and intra-administration case (usually also payments are supported).

Another common classification of services in e-government is related to the users: G2C services provide full support to citizens, G2E services to firms and G2G services to the same or a different administration (European Commission, 2003).

3 Quality and usability in e-government

E-government is a particular application domain characterised 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 characterisation on quality in e-government focusing on users' subjectivity, when the service is used under certain state conditions.

As previously mentioned, services in e-government provide:

- **Informative resources**, e.g., display the identity card office opening time, in which just information is presented to the user without any activity performed by the Public Administration. Services whose interaction level is 'informative' or 'one-way' belong to this group.
- **Functionalities**, e.g., identity card renewal, in which the Public Administration has to perform several activities and processes to deliver the service. Services whose interaction level is 'two-way' or 'transactional' belong to this group.

In both cases, **meta-information** about the service might be provided, e.g., the date of the last update of the information about the opening time, or, how to use the identity card renewal service. Also, in both cases **technological aspects** are relevant. We underline the role of web services as the most common implementation of digital services (Alonso et al., 2003).

All the previous aspects must be evaluated with respect to the usability view of quality.

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, 1995).

Generally speaking, in e-government usability represents the user's ease of benefiting from the service informative resources, functionalities and meta-information. It is important to say that the degree of interaction – between the service and the

user – and the involved technologies must be considered in determining the values of usability parameters.

Nowadays, every e-government portal implements at least informative resources. Thus, if they were unusable e-government would be much less useful and lose its important role in the e-society. The interaction level of users with informative resources (informative and one-way services) is very high, therefore the usability – which is a parameter strongly related to the user – need to be carefully evaluated.

Currently, services providing functionalities are mostly under development. It is important that service designers and developers are aware of the role of usability in quality: in this way the services will be incrementally developed with high usability. The impact of the user's interaction level to the usability of these services (two-way and transactional) is less than that in the case of informative resources. In this case the usability is more related with the implementing technology. The usability of the technology that implements the service introduces an additional layer of usability concerns, but it can not change the nature of the underlying service. The impact of web services and their usability is widely investigated in the literature; for instance, Martens (2003) and Batini et al. (2007) give a good overview.

As far as meta-information is concerned, the same considerations done for informative resources apply. They can be used in a knowledge intensive process, like the delivery of services of Public Administrations to all kind of users (with different level of skills in ICT). The usability of such information guarantees the delivery of services with high quality level.

Hilbert and Redmiles (2000), Ellis and Kurniawan (2000) discuss widely the role of information and usability. While researchers have performed several investigations on usability, none of the existing approaches distinguish between the usability of functionalities, informative resources, and meta-information in e-government. Our investigation coherently supports these usability views in the particular domain of e-government.

4 E-government quality parameters

In this section, we present a list of parameters that is able to assess the quality in e-government. Focusing on usability, we introduce a three level classification. The first level introduces the basic usability parameters and focuses on effectiveness, efficiency and satisfaction. The second and the third levels define a categorisation 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 end users

ii presentation parameters that analyse the front-office of services with respect to the end users' needs.

This second level is very important for informative resources (informative and one-way services). Then, the third level discusses

i behavioural parameters that describe the implementation of the back-end of services

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.

- **Understandability** is the measure of how readily the users perceive the information significance and the way the service works.
- **Learnability** measures the ability of *the service* to support the users in learning how to use it. In particular, the presence of meta-information may impact on this parameter, but it is not determinant.
- **Compliance** represents the level of the service necessary to present a harmonious environment in which its behaviour in general and its different tasks are predictable.
- **Attractiveness** is the measure of the service ability to attract users.

All four parameters have to be evaluated for the different components of services in e-government, i.e., informative resources, functionalities and meta-information. As previously mentioned, also the technology used for the implementation and the level of interaction of users take part in the measurement of these parameters. Moreover, as stated by Frokjaer et al. (2000), effectiveness, efficiency and satisfaction are three subjective, nearly independent aspects that contribute to the determination of usability in general. We consider these aspects in the measurement of the final value of usability (derived from the four parameters), as well as the factors that are domain dependent, e.g., social organisational aspects. The way in which all these factors are combined to determine the final value of each of the four parameters is given by domain experts.

According to Becker (2005), usability in e-government services is specially important to the elderly and disabled. In addition, Sahraoui (2007) suggests that citizens are more likely to have favourable attitudes about e-government if their experience with digital services in general has been positive.

4.2 Service related aspects

Service parameters are split in two parts

- e-government
- 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 utilisation with respect to a period of time and to the number of e-government users.
- **Multicanality** points out service distribution solutions (web, mobile computing, and so on).
- **Internationalisation** refers to the languages used for service description and distribution.
- **Reputation** represents the service trustworthiness.

- **Originality** focuses on the service innovation level.
- **Contents** measures the capabilities of Public Administrations to provide useful and proper information.
- **Legality** represents laws and norms that regulate the provision of the service and its use.
- **Domain security** measures the control level of the service.
- **Trust** represents the level of confidence among stakeholders in the service execution. This parameter involves citizens, enterprises, Public Administration employees, software agents and organisations focusing the attention on proper skills and tasks. At the same time, a digital service requires privacy and communication security levels. A proper service distribution allows a certain level of trust and promotes the service utilisation.
- **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.
- **Completeness** of a service represents the interaction levels. It is evaluated starting from the different ways to interact with the service.

About front-end related aspects we take into account the following parameters.

- **Cost** measures the average amount of money involved in a complete service transaction, capturing the economic condition of the service use. It summarises every cost related to the service provision such as execution price and pricing model.
- **Accessibility** measures the users' ease to detect and to use the needed service capabilities. It is particularly relevant for disadvantaged people.
- **Adaptability** evaluates the service ability 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

- behavioural
- infrastructural.

In the first group, we consider the following parameters.

- **Interoperability** represents the amount of cooperative work among consumer applications, software agents and services in different development environments that implement and deploy procedures. It is measured by the degree of supported standard/regulatory.
- **Applicative Security** represents the security level of web services introducing authentication and authorisation policies and procedures.

- **Integrity**, about data and transactions, is another important element. It measures the service ability to prevent unauthorised access to – or modification of – computer programs or data. It is based on the ACID properties: atomicity, consistency, isolation and durability (Gray, 1981).
- **Robustness/Flexibility** measures the service ability 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** considers 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.
- **Scheduling** evaluates the quality level of the service assigning resources.
- **Throughput** measures the transfer rate of information in a given time interval. It is measured using successful execution request and successful execution rate.
- **Reliability** is 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 assessment of e-government digital services. After three normalisation phases, the model provides the assessment of the quality level. Starting from a set of quality parameters the model estimates the quality as value in the [0...100] range.

This model is inspired to that of Liu et al. (2004), but we introduce further elements like data homogenisation and interaction between parameters. In more detail, (i) homogenisation of the input is useful to reason over different e-government parameter metrics and measurement techniques. The homogenisation 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 overall quality 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 influences 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, $1 \le i \le n$, is collected during a measurement process and represents a specific view of the service.
- $Z = (z_1, ..., z_n)$ is an array of n boolean values used in the normalisation phase. Each z_i, $1 \le i \le n$, takes its value as follows:

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

- $C = (c_1, ..., c_n)$ is an array of n positive natural numbers used during the homogenisation phase. Each c_i represents the upper bound of the q_i parameter in the Q array. The elements of C are related to the measurement of parameters: they depend on the specific metrics used to express the parameters and on the methodology of the measurement.
- $\mathcal{I}$ is an $n \times n$ matrix of values in the range [0..1]. It shows the interaction level between the parameters in Q and allows to explicitly state the impact of the usability component on the other parameters and on the overall quality. Each $m_{j,k}$, $1 \le j, k \le n$, takes its value as follows:

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

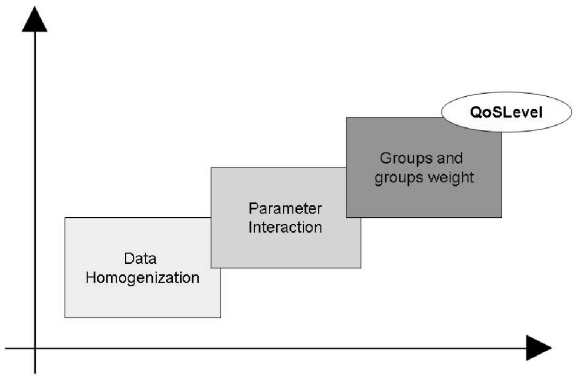
  Note that all the diagonal values of $\mathcal{I}$ must be 0, i.e., each parameter has not relevant interaction with itself. For instance, cost parameter can not interact with itself in the same spatio-temporal location.
- D is a $n \times l$ matrix of boolean values where n is the number of parameters 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.

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

  We use h_i to denote the cardinalities of the 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, $1 \le i \le l$, 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 1 shows the phases to evaluate the overall service quality.

Figure 1 QoS assessment model phases



5.2 Measurement and derivation of input values

In this section, we discuss the way in which the input values of the model should be obtained.

The values of objective parameters of array Q of the quality assessment model are estimated using the measurement model introduced by Re (2007). They are run-time measures taken during the execution of the service. The values of subjective parameters of array Q are obtained by anonymous questionnaires compiled by users. All the values of array Q are the average values of the measurements of each parameter in the set of data of the considered quality assessment. The values of array C are the maximum measured values of each parameter.

The values of array Z (that is the trends of parameters with respect to the overall quality), the values of matrix D (grouping) and the values of array W (weights of groups) are derived from the opinion of domain experts.

The values in $\mathcal{I}$ are derived from the measurements as the absolute values of the statistical correlation coefficients between each pair of different parameters. These values describes the strength of the association between the two parameters and allows the definition of the interaction factors in Phase 2 below. The use of the absolute value of the correlation is compensated, in the model, by the specification of the trends in array Z.

5.3 Phases of the model

Now we present in detail the three phases of our model to determine the quality assessment.

Phase 1: Data homogenisation

As a first step, let Q, Z and C be the input arrays. We introduce a function f_1 that normalises the values, which are measured with different metrics. The function takes triples of the form (q_i, z_i, c_i) – where q_i, z_i and c_i are the ith appearance 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 $q'_i = f_1(q_i, z_i, c_i)$. The formal definition of the function f_1 is as follows:

$$f_1(q_i, z_i, c_i) = z_i\left(\frac{q_i \times 100}{c_i}\right) + (1 - z_i)\left(100 - \frac{q_i \times 100}{c_i}\right).$$

Phase 2: Parameters interaction

In the second phase we introduce the interaction factors of the quality parameters. The interaction factor increases the importance of the relative parameter in the overall quality assessment. We obtain the interaction factor φ_k, $1 \le k \le n$, as the mean of the values in the column k of the matrix $\mathcal{I}$:

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

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 normalised 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 ith interaction factor and the ith element of the array Q' respectively.

The normalised values q_i'' encapsulate the information about the interaction between parameters. This allows the model to determine a quality assessment in which the parameters are not considered as single items, but they influence each other in the particular experimentation context. This makes the quality assessment more accurate than a model in which the parameters are considered independent.

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 use the matrix D to obtain a new array G (its elements will be denoted by $g_1, g_2, \ldots$) of values for each group as follows:

$$G = Q''D.$$

Note that each element of G is the sum of the values, in Q'', of parameters in the same group.

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

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

where g_i and w_i are the ith elements of the arrays G and W respectively, and h_i is the cardinality of ith group. The function gives a value in the range [0...100] since the denominator is always 100 and the average value of each group is weighed by the corresponding value in W.

6 Experimentation

In this section, we present a case study to show some of the results that can be obtained using our quality assessment model.

We relied 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 Demilitarised Zone. 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.

In Section 5.2, we described how to measure and derive the input values needed to apply our model. For simplicity we report here only some particular details of the process we followed. The server makes run-time measurements of objective parameters (e.g., all those implementation related, multicanality, adaptability, etc.) every 20 seconds and maintains them in an incremental data storage. The on-line questionnaires, collected in another data storage, are composed of validated (by domain experts) multiple-choice questions. The answers give a value to the subjective parameters (e.g., the final value of usability, popularity, trust, etc.) by ranking the user choices in line with a predetermined schema of weights (also produced by domain experts).

In the presented experimentation we calculated the overall quality value 100 times consulting the data at not regular time intervals. Each calculation was performed by determining all the input values of the parameters (as specified above and in Section 5.2) and then applying all the phases described in Section 5.

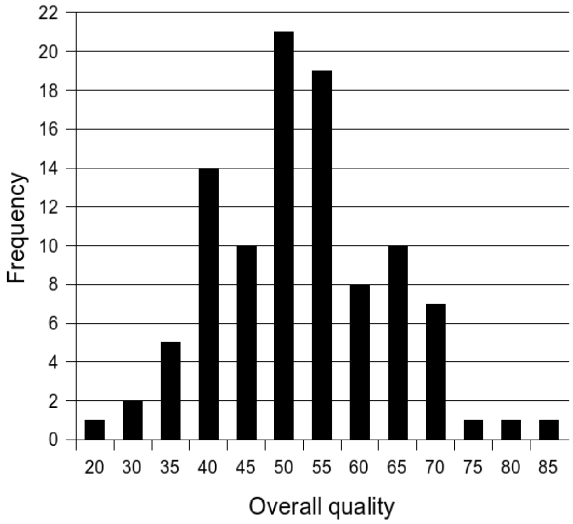
The frequency distribution of the obtained discretised overall quality values is reported in Figure 2. The average value μ is 52.20, the minimum value is 20 and the maximum value is 85. The standard deviation σ is 11.49.

We observe that about 82% of the quality values of our service are in the interval $[\mu - \sigma, \mu + \sigma]$. This means that the quality of the service is fairly stable. This result may be justified by the fact that the architecture in which the service is deployed is reliable and the network infrastructure supporting the service delivery guarantees constant performances. The remaining 18% more dispersive values depend on subjective parameters and on users' skills. Values under $\mu - \sigma$ are determined by the evaluations of non-skilled users, while values above $\mu + \sigma$ are determined by the evaluations of expert users.

To study the usability impact on the overall quality of the service we selected from our data the measurements (of all parameters) in which the usability parameter is high (above 75) and those in which the usability is low (under 25). We observed that:

- When the model is run on measurements with usability above 75, the obtained overall quality values have a mean of 79.40
- When the model is run on measurements with usability under 25, the obtained overall quality values have a mean of 34.50.

Figure 2 Frequency distribution of quality



Therefore, the impact of usability on the quality is significant. Moreover, it can be inferred that the value of the usability parameter affects the quality upper and lower bound (in our experimentation measured in 85 and 20). These results are due to the interaction levels in the matrix $\mathcal{I}$ between usability and all the other measured parameters. The high correlation of these pairs generated the observed large fluctuations on quality. For instance, between usability and response time there is in general a strong correlation: when the service responds in a long time, then the user is not attracted by the service and the value of usability derived from its answers to the questionnaire is low. Thus, the quality value decreases sensibly.

In line with our experience, in the e-government domain users and their satisfaction is very important. Usability is a parameter deeply dependent on users and, thus, the observed high impact of usability on the overall quality is quite justifiable.

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 of ICT.

The definition of the e-government quality parameters in Section 4 and of the assessment model in Section 5 derives from an in-depth analysis of the literature on quality. In particular, we compiled a list of sometimes overlapping parameters from our literature review. Then, we eliminated synonyms and chose the most relevant and representative parameters. In this section we report those papers that have more directly contributed to the development of this work and we underline the main differences and similarities between their approach and our one.

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

- organisational performance: **CAF** (Center, 2006), **Balanced Scorecard** (Kaplan and Norton, 1992), and **Six Sigma** (De Feo and Barnard, 2005)
- site quality: **SiteQual** (Webb andWebb, 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 organisational performance, the papers mainly discuss the role of organisations, while digital services play a marginal role. Quality models are defined, but without introducing specific ICT and usability aspects. Instead, our approach takes into account organisational elements – by the introduction of domain expert evaluations – for the identification of implicit relationships in the e-government domain. Moreover, our approach focuses on digital services considering delivery related aspects (informative resources, functionalities and meta-information) and technological related aspects (e.g., web services).

The site quality area introduces facilities to measure the quality of websites focusing on the e-government front-end aspects. The introduction of a proper client side represents a fundamental part of the distribution of e-government services. 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 parameters like adaptability, accessibility, etc. In this area we also mention e-government in Thai approach (Sukasame, 2004) that presents a conceptual framework and some factors (content, linkage, reliability, ease of use and self-service) affecting the digital services provided on the web portal of the Thailand's government. Differently from our work, 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.

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 perception of quality of service is an important element of the customers' satisfaction. For this reason, we introduced usability parameters and we focused on their effectiveness, efficiency and satisfaction. Our approach respects e-government general requirements putting together users' satisfaction (stressed by the marketing area) with organisational, technological and domain dependent constraints. Interesting suggestions also came from the business management domain with a special focus on the quality policies (Seth et al., 2005). 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 the marketing setting, too. In the e-government domain, of course, we do not rely on business executives, but our model – including subjective parameters – gives an important role to the citizens. Their perception of the service quality is crucial and is captured by the anonymous questionnaires, that are the measurement means of our subjective parameters. Santos (2003) introduces a model of e-quality to achieve high customer retention, satisfaction, and profitability for the organisations in e-business. He proposes a model of digital service quality that takes into account static and dynamic parameters. This list of parameters is not complete and, since it focuses on marketing, it does not include e-government dependent parameters, such as legality. Summarising, none of the presented models in the area of marketing propose a complete set of

parameters and the impact of usability on users' satisfaction (this mainly because their approach proposes a different view on quality in which technology is marginal). However, 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. In particular, it inspired us the introduction of the validation of the parameter list by domain experts and the use of anonymous questionnaires. At last, but with the same importance, Barnes and Vidgen (2006) supported the definition of our quality model in considering the information on user interface. It is an interesting effort in the introduction of usability.

Regarding the technological aspects, Ran (2003), Farkas and Charaf (2003) and Maximilien and Singh (2004) propose a first approach to define non-functional aspects in the discovery of web services. From these works we have selected the infrastructure parameters of Section 4.3. In particular, Ran (2003) suggests an Universal Description Discovery and Integration (UDDI) 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. Farkas and Charaf (2003) introduce a software architecture 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 nonfunctional attributes needed for the discovery of web services. They propose an ontology-based framework to describe quality in order to improve the stakeholders' interaction. Nahrstedt et al. (2001) and Tsetsekas et al. (2001) introduce quality in a middleware domain, which is a more general setting than that of web services. We selected some infrastructure parameters also from these works. In general, distributed applications and their quality provide several hints to quality of service in e-government. Nahrstedt et al. (2001) 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. Tsetsekas et al. (2001) propose a middleware that drives service presentation to the users. It allows the description and the selection of quality parameters and the resources that support the quality.

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. These works inspired us to consider separately the domain dependent parameters.

8 Conclusion and future work

In this paper, we have defined a list of quality parameters in which we give a significant role to usability, that is one of the main aspects in the quality assessment for e-government digital services. The quality parameters focus on informative resources, functionalities, meta-information, users and technological aspects. The list of parameters is currently satisfactory, but it is subject to updating in line with the evolution of the domain and of the ICT.

We have also defined a formal assessment model useful for having a description of a complex environment where the interaction between parameters play an important role. For our purposes, the defined model is satisfactory: it allows to carefully assess the quality of e-government services focusing on all the different involved aspects

(parameters, weights, groups, etc.). We recognise that the accuracy of the model depends on the accuracy of the validation and evaluation done by domain experts. It depends also on the accuracy of the answers given by the users to the questionnaires. However, this is a general characteristic of the e-government domain, in which the subjective component is very important. Positively, the choice of putting together a formal model and subjective evaluations allowed us to fix a clear basic formal frame for objective aspects of the quality assessment on which subjectivity can be introduced in a controlled way.

Finally, we have presented the results of a step-by-step experimentation to show how our model works. In our case study we have observed a significant impact of usability on the overall quality. In line with our experience, in the e-government domain users and their satisfaction is very important. Usability is a parameter deeply dependent on users and, thus, the observed high impact of usability on the overall quality is quite justifiable.

Concluding, the characteristics of digital services in e-government and the importance of information (informative resources and meta-information) in this domain support our considerations on the role of usability. This is a parameter deeply linked with information and, at the same time, with the interacting users. The promotion of usable services reinforces the whole e-government field and pushes it towards maturity.

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 organisational 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.

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