Προσαρμοστικό Σύστημα Αξιολόγησης Ηλεκτρονικών Υπηρεσιών: Εφαρμογή στην Ηλεκτρονική Διακυβέρνηση

(Adaptive Evaluation of Electronic Services: An e-Government Case)

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Αφιερώνεται στους γονείς μου, Παντελή
και Τριανταφυλλιά και στην σύντροφο μου Φωτεινή.

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ΠΕΡΙΛΗΨΗ

Η διδακτορική διατριβή επικεντρώνεται στον χώρο της ποιότητας των ηλεκτρικών υπηρεσιών και ιστοχώρων και προτείνει ένα ολοκληρωμένο πλαίσιο (framework) μέτρησης της ποιότητας τους με προσαρμοστικό τρόπο. Δεδομένων των προβλημάτων των υπαρχόντων μεθόδων μέτρησης, προκύπτει η ανάγκη η μέτρηση να πραγματοποιείται έτσι ώστε κάθε χρήστης να αντιμετωπίζεται διαφορετικά, με βάση τα ιδιαίτερα χαρακτηριστικά του, και επιπλέον με τρόπο που να επιτρέπει στον πάροχο των ηλεκτρονικών υπηρεσιών να συλλέξει ουσιαστικότερη ανάδραση από τους χρήστες σχετικά με τις προσφερόμενες υπηρεσίες. Η συμβολή της διατριβής εντοπίζεται σε τρεις βασικούς άξονες:

Ο πρώτος αφορά στη θεωρητική ανασκόπηση του πεδίου των προσαρμοστικών συστημάτων και τεχνικών, καθώς και στην εκτεταμένη και συστηματική επισκόπηση ερευνητικών προσπαθειών από τον χώρο της ποιότητας ηλεκτρονικών υπηρεσιών. Η επισκόπηση, που προήλθε από την ανάγκη να δοθεί απάντηση στο ερώτημα του τι πρέπει να μετρηθεί σχετικά με την ποιότητα των ηλεκτρικών υπηρεσιών και ιστοχώρων/πυλών, κατέληξε και σε προτεινόμενη κατηγοριοποίηση και ταξινόμηση των προσεγγίσεων αυτών.

Ο δεύτερος άξονας επικεντρώνεται στην δημιουργία ενός συγκεκριμένου πλαισίου εργασίας (framework), το οποίο στοχεύει στην βελτίωση των υπαρχόντων μεθόδων μέτρησης της ποιότητας των ηλεκτρονικών υπηρεσιών. Το πλαίσιο αυτό καθιστά δυνατή την μέτρηση της ποιότητας με ευκολότερο, πιο αποδοτικό και προσαρμοστικό τρόπο και περιλαμβάνει την ανάπτυξη μοντέλων, οντολογιών, μεθόδων και εργαλείων. Παράλληλα αναπτύχθηκε ένα καινοτόμο πληροφοριακό σύστημα (SALT), το οποίο υλοποιεί το πλαίσιο και εφαρμόζει τρεις άξονες προσαρμογής των παρουσιαζόμενων ερωτήσεων σε κάθε χρήστη ξεχωριστά: την ανάδραση που παρέχει ο χρήστης μέσω του ερωτηματολογίου, τα προβλήματα που αντιμετωπίζει κατά την πλοήγηση του και τα μεταδεδομένα των σελίδων που επισκέπτεται.

Ο τρίτος άξονας περιλαμβάνει την εφαρμογή των αποτελεσμάτων της διατριβής. Η εφαρμογή και αξιολόγηση του συνολικού συστήματος πραγματοποιήθηκε στην δικτυακή πύλη ηλεκτρονικής διακυβέρνησης ενός Αυστριακού δήμου. Τα αποτελέσματα της αξιολόγησης έδειξαν ότι το σύστημα αντιμετωπίζει τα προβλήματα των υπαρχόντων μεθόδων μέτρησης της ποιότητας των ηλεκτρονικών υπηρεσιών.

Λέξεις Κλειδιά

Προσαρμοστικότητα, Αξιολόγηση Ποιότητας, Ηλεκτρονική Υπηρεσία, Προσαρμοστικό Ερωτηματολόγιο, Μοντέλο Ποιότητας, Οντολογία Ποιότητας, Ηλεκτρονική Διακυβέρνηση.

ABSTRACT

This doctoral thesis focuses on the domain of quality of e-services and portals and proposes a framework which allows adaptive quality evaluation. Considering the problems of the existing methods for measuring the quality of e-services and portals, there is a need for measuring quality in a manner that each user is treated differently, based on her/his characteristics and particularities and furthermore in a way that allows e-service providers to collect more effective and efficient user feedback with regard to the provided services. The contribution of the present doctoral thesis can be summarized in three main axes:

The first axis concerns the review of e-service quality and adaptivity methods. Basically, we substantiated an extensive and systematic review of research efforts in the domain of e-service quality models. The review, which originated from the need to answer the question about what should be measured as far as the quality of portal and e-services is concerned, concluded in a suggested categorization and synthesis of the various quality models. In the context of this axis, a review of adaptivity targets and techniques was also conducted.

The second axis focuses on the development of a framework aiming to improve the existing e-service quality evaluation methods, by enabling the evaluation to be done in an easier, more efficient and adaptive manner. The proposed framework includes the development of various models, ontologies, methods and tools. In addition, we developed an innovative software system (SALT) that can take advantage of the specific framework and apply three types of adaptation: based on previously gathered data from the user through questionnaires, based on problems encountered by the user and based on metadata of the pages visited by the user.

The third axis includes the actual application of the doctoral thesis results. The implementation and evaluation of the overall system took place in the e-government portal of an Austrian municipality. The evaluation showed that the system addresses the challenges of the existing e-service quality evaluation methods.

Keywords

Adaptivity, Quality Evaluation, e-Service, Adaptive Questionnaire, Quality Model, Quality Ontology, e-Government.

ΕΥΧΑΡΙΣΤΙΕΣ

Η παρούσα διδακτορική διατριβή αποτελεί το επιστέγασμα μιας προσπάθειας τεσσεράμισι ετών, στα πλαίσια του προγράμματος μεταπτυχιακών σπουδών του τμήματος Ηλεκτρολόγων Μηχανικών και Μηχανικών Η/Υ του Εθνικού Μετσόβιου Πολυτεχνείου. Η συναναστροφή με συναδέλφους, αλλά και το κλίμα δημιουργικότητας αποτέλεσαν βασικές πηγές έμπνευσης και συνέβαλλαν σημαντικά στη βελτίωση της προσωπικής αντιμετώπισης και επίλυσης ερευνητικών προκλήσεων.

Το αποτέλεσμα που παρουσιάζεται στις σελίδες αυτές οφείλεται στο μέγιστο βαθμό στη βοήθεια και στην καθοδήγηση που είχα από τον επιβλέποντα Καθηγητή κ. Γρ. Ν. Μέντζα. Του οφείλω ιδιαίτερες ευχαριστίες για τις ευκαιρίες που μου προσέφερε και την πίστη του σε μένα. Τα μαθήματα επιστημονικής κατάρτισης, ερευνητικού ζήλου, αλλά και ηθικής ακεραιότητας που πήρα από αυτόν αποτελούν τα σημαντικότερα εφόδια για τη μελλοντική μου πορεία.

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Ολοκληρώνοντας θα ήθελα να απευθύνω ένα μεγάλο ευχαριστώ στους γονείς μου, στην αδερφή μου και στην σύντροφό μου, για την αμέριστη αγάπη και ηθική υποστήριξη που μου προσέφεραν όλα αυτά τα χρόνια.

Μαγγούτας Π. Χαράλαμπος

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PART I

INTRODUCTION AND STATE OF THE ART

1 INTRODUCTION & MOTIVATION

This doctoral thesis focuses on the domain of quality of e-services and portals and proposes a framework which allows adaptive quality evaluation. The main research goal of the thesis is the development and application of the framework for adaptive evaluation of e-service and portal quality, as well as the design, development and evaluation of an adaptive system allowing the measurement of quality in a personalized manner. Considering the problems of the existing methods for measuring the quality of e-services and portals, there is a need for measuring quality in a manner that each user is treated differently, based on her/his characteristics and particularities and furthermore in a way that allows e-service providers to collect more effective and efficient user feedback with regard to the provided services.

This Chapter is structured as follows. In section 1.1, the importance of improving the quality of portals and e-services is highlighted. Section 1.2 describes the challenges that motivated the development of the proposed framework and system for adaptive evaluation of e-service and portal quality. In section 1.3 the main objectives of the proposed framework, as originate from the research challenges, are presented. Section 1.4 provides an overview of the main contributions of the present doctoral thesis. Section 1.5 describes how the thesis is structured, while a discussion, about how the structure of the thesis is related to the papers published, is given in section 1.6. Finally, in section 1.7 the research projects, which supported partially the present thesis, as well as their relation to the thesis, are discussed.

1.1 E-Services and their Quality

One of the most revolutionary impacts of Internet regarding the transactions between businesses or public administrations and their customers/citizens, is that it enabled the provision of e-services. An e-service is a service made available via the Internet that completes tasks, solves problems, or conducts transactions [Hoffman, 2003].

The penetration of e-services in the banking, educational, entertaining and travelling sectors, as well as in the e-learning domain is constantly increasing [Turka et. al., 2008]. Focusing on the quality of the e-services and the portals used for their provision is an important way for service providers to differentiate themselves among the competition, by increasing user

satisfaction [Yang et. al., 2005], [Douglas et. al., 2003]. User satisfaction is a way of achieving customer loyalty, which is very important for the viability of e-businesses, as in the e-business world the competitor is only a link away [Mich et. al., 2003].

As far as the e-government world is concerned, the supply trend of e-services is also increasing, as an increasing number of public administrations provide e-services to their citizens through e-government portals. According to the survey results reported by CapGemini [2006], for the 20 basic public services in the European Union, more than 90% of government organizations provide e-government services. Furthermore, more than 50% of them offer the same set of services in both the traditional and the online form. The penetration is higher (74%) for e-services addressing businesses (Government-to-Business, G2B), compared to the penetration (37%) for e-services addressing citizens (Government-to-Citizen, G2C).

In contrast to the e-business world, in the e-government one the public administrations usually have no competitors, as it is the responsibility of the government to provide the public e-services to citizens. So someone may think that in this case there is not any need to increase the quality of the public e-services, as the citizen has no other choice; the only service provider is the government. However, in reality, quality of e-government services and citizen satisfaction is a very important issue in the e-government domain as well as an issue in which the public administrators focus on, mainly for two reasons.

The first reason is that citizens require it, as they expect a significant increase of service quality through the internet channel, compared to traditional channels [Schellong and Mans, 2004]. Furthermore the provision of e-government services although more effective and friendly for citizens, as there are no constraints in time and place of service consumption, is still suffering from manifold quality problems [Rambøll, 2004]. A modern public administration, which sees citizens as customers who pay rates and taxes and thus should receive value, should be able to satisfy their requirement about high quality portals and e-services.

The second reason is that it may be beneficial for governments to move the demand side of public services from the traditional, offline channels (face-to-face or information and facilitation counters, call centres, postal, etc) to the Internet-based, online channel. The major advantage of online service delivery for the administrations are cost reduction potentials, as some fixed cost of the offline channels, like counters, agencies, etc. can be cut, leading to long term savings. Of course a critical mass of citizens should consume the e-services in order to justify the investment in e-government. Thus the government should encourage citizens to prefer online channels instead of traditional ones. The analogy with the e-business word is obvious. In the case of e-government the competitors of e-services are the offline channels of service provision, as in the world of e-business the competitors of provider's A e-services are the e-services of provider B. Hence, the administrators should pay attention to the quality of e-services in order to allow the e-service "player" to dominate the market.

1.2 Motivation

As described in the previous section, in both the e-business and e-government domains, there is a need for a constant improvement of the quality of portals and their e-services; a need which is driven by both the demand and the supply side of e-service delivery. Quality improvement would enable to shorten the gap between the current and the ideal level of e-service quality. In this way public administrations would use taxpayers' money in an effective and efficient manner, by providing better e-services to the public, while e-businesses would gain competitive advantage in their industry.

The measurement of a portal's and e-services' quality, forms the basis of an improvement process, since something that cannot be measured cannot be managed and improved [Walrad and Moss, 1993]. This is also stressed by traditional theories in the area of quality of service, like the "Plan-Do-Check-Act" cycle of Deming [1986] and the continuous quality improvement process of Juran [1994]. The most usually applied instruments for obtaining user feedback on the overall quality of portals and e-services are web surveys [Zhang and Prybutok, 2005], [Mei et. al., 2005]. These surveys are first designed in order to reflect the main aspects related to the quality of the portal and services and then are incorporated into the portal of the public organization or the business. The evaluation of e-service and portal quality is then performed by users who visit the portal and fill in the questionnaires.

Although web surveys demonstrate great advantages over the traditional surveys conducted offline (see section 2.3), they suffer from major challenges. These challenges, which can be categorized in two main groups, i.e. qualitative and quantitative ones, are described below.

The qualitative challenges are related to the inefficiency of assessments that adopt a "one size fits all" approach. Users possess different access possibilities, skills, expectations and motivation, and hence face different problems during their navigation in a portal while searching for an e-service, or during the actual service provision. This variety in users' characteristics implies that the level of importance attributed to each quality aspect differs among users. For example, for some users, who are often lost in the information space of a portal, quality is related mostly to a clear and easy to follow portal structure or the provision of help information related to the completion of submission forms. On the other hand, other users put more emphasis on issues like automatic recalling of user's personal data within a portal's submission forms. This means that some users should perform the evaluation without being bothered by irrelevant questions while an in depth examination of the various quality aspects may be needed for users facing problems.

Another drawback of "one size fits all" approaches for evaluating the quality of portals and e-services is that the user context is not taken into account. With the term "context" we mean the functionalities and/or parts of the portal that a user consumes while interacting with it. All the users do not consume the same set of functionalities and do not visit the same parts of

the portal; thus some quality aspects related to those functionalities and/or portal parts are not applicable to all cases. Therefore, the traditional approaches may present questions that are not relevant to the user context.

The nature of the second major challenge of quality assessment using user feedback is quantitative. Internet users are usually reluctant to participate in web surveys [Vehovar et. al., 2002]. This reluctance is becoming bigger as the time needed to complete the questionnaire, or the number of questions increase [Groves and Mick, 1998]. This leads often to a trade-off between the completeness of the questionnaire and the anticipated response rates at the questionnaire design phase. In case the questionnaire is complete and valid, i.e. it reflects all the quality aspects influencing quality, the number of presented questions may increase and the service provider receives small feedback for them. On the other hand in case the service provider decides to remove some quality aspects as a strategy for increasing response rates, it completely misses user feedback regarding these quality aspects.

1.3 Main Objectives

In an attempt to overcome the aforementioned challenges, this doctoral thesis proposes a framework and a set of relevant models, methods and systems, which allow an adaptive and subjective evaluation of e-service quality. The evaluation is subjective, in the sense that it is performed by users. In other words it represents users' perceptions about the quality of the portal and the provided e-services. It is adaptive, in the sense that users are treated differently, based on the problems they face and the functionalities they consume on the portal.

At the heart of the proposed framework lies an adaptive e-questionnaire which supports the presentation of questions about quality to users. The list of questions to be given to users is not fixed, but composed dynamically from a predefined set of questions, based on some criteria. More specifically the framework suggests capturing the user behaviour on the portal and then applying three axes of questionnaire adaptation: based on previously submitted user feedback through the questionnaire, based on problems encountered by the user and based on the metadata of the pages visited by the user.

The main research objectives of the proposed framework and system are directly connected to the challenges and limitations of traditional static web surveys which were discussed in section 1.2. Table 1.1 depicts the main objectives of the proposed framework and system as far as the research challenges are concerned.

The framework suggests organizing the quality evaluation in such a way as to serve each user individually, by taking into account the user context and user encountered problems. Regarding the qualitative challenge (one size fits all), the framework aims at improving the relevance of presented questions to the user context (O1) and user problems (O2). With

respect to the quantitative challenge, it aims at the improvement of the user participation to the survey (O3), by decreasing the number of questions presented to users and therefore the time needed to complete a user questionnaire. The qualitative and quantitative challenges are addressing the users that give their feedback about the quality of the portal and its e-services.

It should be noted that in addition to these two major challenges, Table 1.1 contains a third challenge addressing the service providers. This research challenge can be seen as the other side of the same coin: Traditional quality evaluation approaches treat all users similarly; this results in the presentation of irrelevant questions as well as in poor user participation. If we view it from the service providers' side, the usefulness of the user feedback collected through the presented questions is less than perfect for them in terms of both quality and user diversity. The framework and system proposed in this doctoral thesis aim to fill this gap, by increasing the service provider's satisfaction about the quality of the user feedback collected (O4).

Table 1.1: Main Research Objectives

Research Challenge	Addressing	Research Objective
Qualitative (one size fits all)	Users	O1: To increase the relevance of presented questions to the user context
	Users	O2: To increase the relevance of presented questions to the user problems
Quantitative (Reluctance to participate)	Users	O3: To increase the user participation to the survey
Usefulness of the feedback	Service Providers	O4: To increase service provider's satisfaction about the quality of the user feedback collected.

In addition to the main objectives depicted in Table 1.1, which concern primary the system that implements the proposed framework, there are also some secondary research objectives regarding other parts of the proposed framework. These objectives are presented in the relevant sections of this doctoral thesis, i.e. in the sections where the various parts of the framework are described. For example a secondary objective is to enable measurement of quality in a valid and reliable manner. This objective and the process followed to evaluate it are presented in Chapter 5.

Finally, Chapter 7 contains the evaluation of the proposed approach and system along the main objectives of Table 1.1, by translating them into hypotheses that are evaluated empirically.

1.4 Contribution of this Thesis

The contribution of the present doctoral thesis can be summarized in three main axes, as depicted in Figure 1.1. The first axis concerns the review of research efforts in the domains of e-service quality and adaptivity and personalization methods and techniques. It pertains to the theoretical foundations, basic concepts and technologies used in the context of this thesis. This axis includes the definition of basic concepts and perspectives regarding the quality of e-services and how it is evaluated. In parallel, it covers an extensive and systematic review of the state of the art regarding quality models, which define the quality aspects of e-services and portals to be evaluated. The systematic review, which originated from the need to answer the question about what should be measured as far as the quality of portal and e-services is concerned, concluded in a suggested categorization and synthesis of the various quality models. This categorization and synthesis formed the basis for the development of an e-service quality model that addresses the aforementioned question. In the context of this axis, the role of adaptive technologies and advantages from their use were also analyzed, while a review of adaptivity and personalization targets and techniques was conducted.

The second axis consists of the development of a framework aiming to improve the existing e-service quality evaluation methods, and the development of an innovative system which implements the framework and allows the evaluation of portal and e-service quality in an easier, more efficient and adaptive manner. The proposed framework includes the development of various models, ontologies, methods and tools. The e-service quality model, which is based on the results of the aforementioned first axis, defines the quality aspects of the portal and e-services that are important for users and affect their opinion concerning portal and e-service quality. It was refined and validated empirically in a real use case resulting in a quality model that can be used for measuring portal and e-service quality in a valid and reliable manner. The Ontology-based data model, which was called MAQM (Model for Adaptive Quality Measurement), represents with the help of four interrelated ontologies, all the essential concepts playing a significant role in the adaptive quality measurement. It comprises a large amount of concepts, ranging from generic knowledge about quality to specific problems encountered by users while navigating the portal or obtaining various e-services. The core concepts covered include the quality aspects considered, the questions used for capturing user satisfaction about the various quality aspects, the types of the portal pages visited by users, the user behavior and the problems encountered by users. The innovative system, which was called SALT (Self-Adaptive quaLity moniToring), combines functionalities of annotating the portal pages and elements with metadata about their characteristics, unobtrusive tracking of user interaction with the portal, discovery of problems that users encounter during their navigation or during the consumption of e-services, as well as adaptation of the presented questionnaires used for measuring the quality of e-services and portals. The system applies three axes of

adaptation: based on previously gathered data from the user through questionnaires, based on problems encountered by the user and based on metadata of the pages visited by the user.

The third axis includes the application and evaluation of the proposed system in the e-government domain and more specifically in the e-government portal of an Austrian municipality, as well as the development of a generic methodology for the implementation of the proposed approach in the e-government domain. The evaluation of the system was performed in comparison to the traditional (static) method for evaluating quality, in order to examine whether the former addresses the challenges of the latter. The results of the evaluation showed that the proposed approach meets the objectives introduced in section 1.3. The evaluation gave evidence that it is beneficial for both users and service providers to take into account the user context when monitoring quality. More specifically the evaluation showed that the added value of quality evaluation using SALT, compared to the traditional/ static approach, is two-fold. On the one hand the user experience associated with the quality evaluation process is improved, as the questions presented to users are related to the problems they encountered and the context and services they consumed, while irrelevant questions which are out of context are omitted. On the other hand the service provider gets better feedback in terms of both quality and user diversity. The feedback is better in terms of quality, as the irrelevant feedback decreases and furthermore the feedback focuses on the problematic quality factors, and better in terms of user diversity, as the response rates increase. The results and the lessons learned from the e-government use case, formed the basis for the development of a generic methodology which provides analytical guidelines and steps that should be followed by a public administration in order to implement an adaptive evaluation of its portal and e-services according to the proposed framework and system.

Theoretical and Technological Review of E-Service Quality & Adaptivity and Personalization Methods and Techniques	Proposed Framework & System for Adaptive Evaluation of e-Service Quality	Application & Evaluation of the Proposed System
• Definition of basic concepts regarding the quality of e-services and its evaluation • Review and categorization of e-service quality models • Review of adaptivity and personalization techniques	• Development of a framework for the subjective and adaptive evaluation of portal and e-service quality • Development, refinement and validation of an e-service quality model • Development of the model for adaptive quality measurement and of the relevant ontologies • Design and Implementation of the SALT System for the adaptive evaluation of portal and e-service quality	• Application of the System in the e-government domain • Evaluation of the System • Development of a generic methodology for implementing adaptive evaluation of e-services in e-government

Figure 1.1: The Contribution of this Thesis in Three Main Axes

1.5 Structure of the Thesis

The thesis consists of 9 Chapters and is structured according to the three main axes of contributions described in the previous section. Therefore, as can be seen in Figure 1.2, the thesis is presented in three parts. Part I, “Introduction and State of the Art” is related to the first contribution axis and includes Chapters 1, 2 and 3. Part II, “The Proposed Framework and System” consists of Chapters 4, 5 and 6, and describes the second main contribution, while Part III, “Evaluation and Conclusions”, presents the third contribution in Chapters 7, 8, and 9.

After this introductory Chapter, Chapter 2 describes the theoretical foundations in the area of evaluation of e-service and portal quality. Theoretical definitions and perspectives about quality of service are given while a systematic review of research efforts in the area is performed. The literature survey concludes with the categorization of the various research efforts and the discussion about the categorization results. Finally, web surveys and international standards for their development are discussed, while a review of quality ontologies is provided.

In Chapter 3 the theoretical and technological foundations in the area of adaptivity and personalization are presented. The main concepts are defined and challenges that impact on the feasibility and performance of adaptive systems are discussed. A literature review in the area is provided, with an emphasis on the questions about what can be adapted, meaning which are the targets for adaptation, and which techniques are used in order to adapt to the individual user.

Chapter 4 presents the proposed framework for adaptive evaluation of portal and e-service quality by users. The research method followed for developing the framework, the various components it consists of (e.g. models, ontologies, methods), as well as their relationships, are described. Focus is put on how the proposed framework addresses issues regarding a) what quality aspects of the portal and e-services should be evaluated, b) which instrument should be used for measuring the quality aspects influencing user satisfaction, c) which adaptation criteria to use for adapting the questionnaire to the individual, d) on what sequence the adaptation criteria are applied and e) on which data to base the adaptation. The Chapter concludes with a discussion about how the proposed framework is related to the state of the art of Chapters 2 and 3, as well as about how it is positioned in relation to the intersection of the e-service quality evaluation and the adaptivity areas, i.e. the area of adaptive questionnaires.

Chapter 5 presents the quality model, which is part of the proposed framework, and defines the characteristics of the portal and the e-services delivered through it, which are important for users and guide their satisfaction. The two-phased process followed for developing, refining and validating the quality model is described. The process includes an exploratory phase where an initial conceptual model was developed by synthesizing and extending the relevant literature, and a confirmatory phase, where the hypothesized dimensions of the initial model are tested and validated empirically in a real use case. The results of the empirical validation, which resulted in the development of a refined version of the quality model, are presented. Finally the Chapter concludes with a description and the results from a benchmarking analysis that compares the validated quality model with other similar models found in the literature.

Chapter 6 describes the proposed SALT system. The functional requirements of the system, as derived from proposed framework are described, while the technical architecture of the system is presented. The various design-time, run-time and analysis-time subsystems are

described and implementation details are given. The ontologies used in SALT are presented with an emphasis to the three-layered quality ontology, which forms the semantic foundation of the adaptation logic. An overview of the integration interfaces between the various SALT subsystems is provided, while finally a walkthrough of the system is given, by considering two different scenarios of user interactions with the system.

Chapter 7 presents the technical and trial-based evaluation of SALT. Technical evaluation includes functional testing, as well as evaluation based on standards and guidelines of the World Wide Web Consortium (W3C). Aspects like color visibility, readability of questionnaire's pages, validity of CSS, HTML and links, browser compatibility and download time are evaluated. The trial-based evaluation is directly connected to the objectives of the proposed approach, as it examines whether and in what degree they have been addressed. It concerns the empirical evaluation of the proposed system in a real use case, i.e. in the e-government portal of an Austrian municipality. The design and methodological aspects regarding the evaluation are described, the software components enabling the evaluation are presented and the evaluation results are reported. Finally a discussion regarding the conclusions drawn from the empirical evaluation is provided.

Chapter 8 describes a generic methodology that should be followed by a public administration in order to implement an adaptive evaluation of its portal and e-services according to the framework and system proposed in this doctoral thesis. The methodology is a generalization of the process followed for the implementation of the pilot case, so that it would be able to address a variety of possible use cases. It is primarily addressing the managers of public administrations and provides managerial guidelines for implementing the proposed approach in the e-government domain. Also it highlights the main roles and skills required for such an implementation.

Finally, in Chapter 9, possible implications of the proposed framework and system for users and service providers, are presented. Limitations of the system and possible improvements are discussed, while at the end of the Chapter, issues for further research are identified.

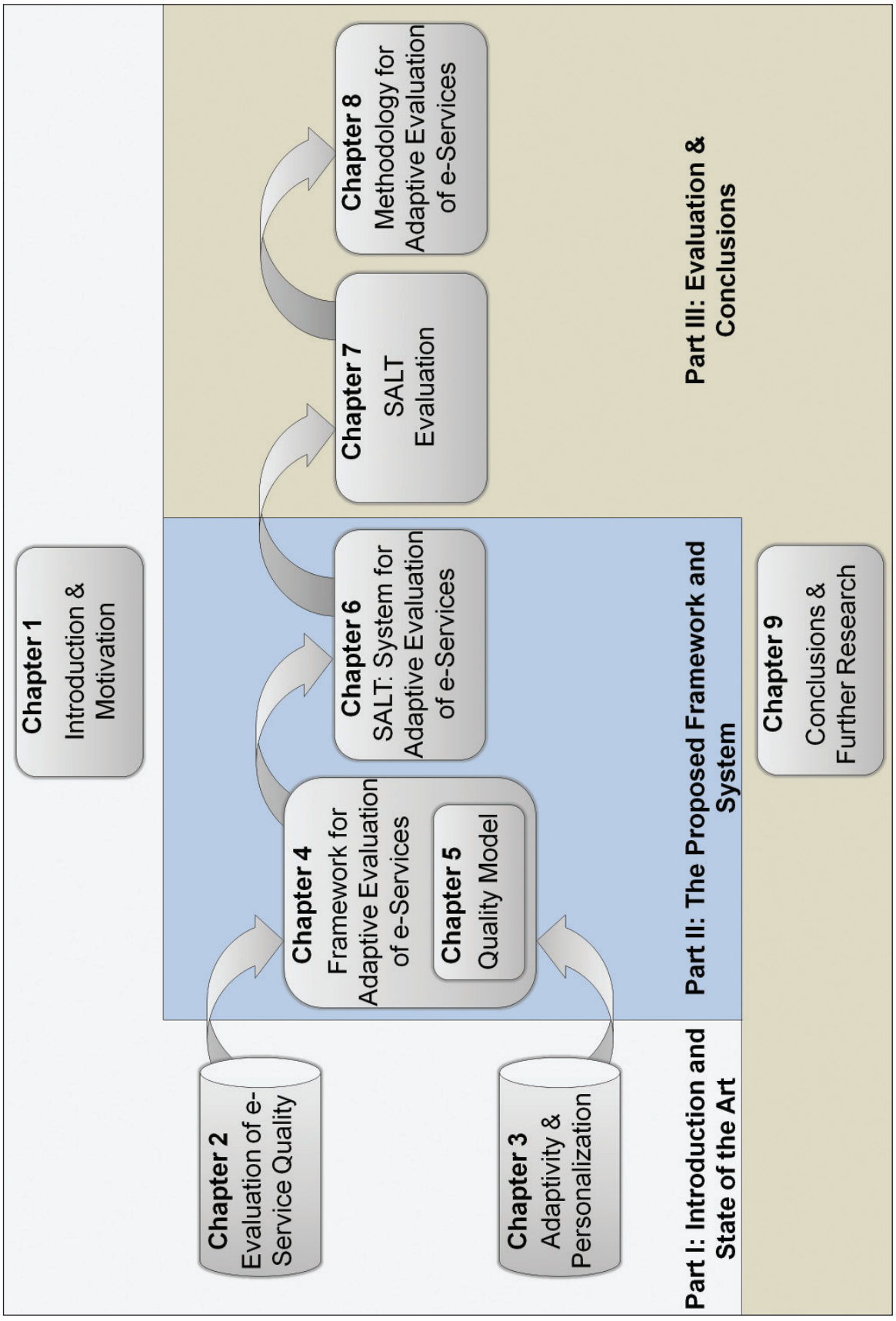


Figure 1.2: Structure of the Doctoral Thesis

1.6 Relation to Publications

This thesis resulted in three (3) journal publications, one (1) book chapter and five (5) conference presentations. This section describes how the structure of the thesis is related to these publications. The list of publications can be found at the very last page of this thesis. Although the research contributions of a single publication may concern more than one Chapters, in the following we relate each Chapter to the most relevant publication(s).

- The extensive and systematic review of research efforts in the domain of e-service quality models, as well as the suggested categorization and synthesis of the various quality models, which are described in **Chapter 2**, were published in [Papadomichelaki et. al., 2006] and [Halaris et. al., 2007], respectively.
- The review of adaptivity targets and techniques, which is described in **Chapter 3**, was published in [Magoutas and Mentzas, 2009a].
- The Model for Adaptive Quality Measurement, which is part of the framework described in **Chapter 4**, was published in [Magoutas and Mentzas, 2009c].
- The e-Service Quality Model, which is described in **Chapter 5**, was published in [Magoutas and Mentzas, 2009b].
- The Quality Ontology, which is described in **Chapter 6**, was published in [Magoutas et. al., 2007]. A first version of the SALT system, which is also described in the same Chapter, was published in [Magoutas et. al., 2008], while an elaborated version in [Magoutas and Mentzas, 2010].
- Finally, the evaluation of the system, which is discussed in **Chapter 7**, was published in [Magoutas et. al., 2010].

1.7 Relation to Research Projects

It should be noted that the present doctoral thesis was partially supported by the European Commission through the Information Society Technologies (IST) projects FIT (Fostering self-adaptive e-Government service improvement using semantic technologies, IST-2004-27090) [FIT Site], [Stojanovic et. al., 2006] and DEMO-Net (The eParticipation Network, NoE, IST-2004-27219) [DemoNet Site].

The overall objective of FIT was the development of methods and tools to publish e-government services on-line in a more efficient way in order to enable services accessibility for all users and to increase e-users satisfaction. Adaptivity was in the heart of the approach proposed by FIT. In the context of the FIT project, models, methods and tools enabling an adaptive front-office, an adaptive back-office as well as an adaptive evaluation of e-service and portal quality, were developed.

The objective of DEMO-net was the promotion and development of the technological and socio-technical excellence in eParticipation tools and methodologies, through a focused and integrated research programme, which was built on the experience accumulated by leading European research organisations that have studied the underlying principles of eParticipation and actively worked with governments across Europe in applying and evaluating it.

The research reported in this thesis is related mainly to the work that we have done in the context of the FIT project regarding the development of models, methods and tools enabling an adaptive evaluation of e-service and portal quality. Some of our work in FIT is out of the context of the present doctoral thesis, while the latter uses some system components which were developed in FIT, either by other research partners (the portal annotator tool) or by joint efforts of other partners with us (the user tracking and problem detection component). As far as the DEMO-net project is concerned, we investigated in its context, the potential of adaptivity and personalization principles and technologies when applied to the eParticipation field. The review of adaptivity and personalization techniques was used in this thesis in Chapter 3, where the theoretical foundations with respect to the research area of adaptivity are described.

2 EVALUATION OF E-SERVICE QUALITY

This Chapter describes the state of the art in the area of evaluation of e-service and portal quality. The state of the art is described in a top-down manner, from more general to more specific concepts and approaches. First some theoretical definitions and perspectives about quality of service (QoS) are given in section 2.1. Then, in section 2.2 a literature survey at the field of QoS for e-services and e-government services is presented. The survey concludes in synthetic tables that map the meanings each literature approach gives to the various quality aspects examined. In section 2.3, web surveys and international standards, upon which the web surveys should be based, are discussed. Finally, in section 2.4 a review of quality ontologies is provided.

2.1 Definitions & Theoretical Perspectives about Quality

Various perspectives can be taken into account for quality evaluation, as reflected in the theoretical ideas proposed by well known researchers in the domain of quality, such as Shewhart, Ishikawa and Parasuraman.

It has been a long time since Shewhart [1980] described quality in terms of objective and subjective quality. Objective quality is the degree of compliance of a process or its outcome with a predetermined set of criteria, which are presumed essential to the ultimate value it provides. Subjective quality is the level of perceived value reported by the person who benefits from a process or its outcome.

Ishikawa [1991] developed an approach combining the customer's and the producer's view of quality. He named the customer's view as "true characteristics" and the producer's view as "substitute characteristics" and claimed that the degree of match between true and substitute ultimately determines customer satisfaction.

Moreover, Parasuraman et. al., [1988], appoint the importance of evaluating the gap between the actual and the ideal product or service.

Table 2.1: Overview of Relevant Approaches

Area	Approach
Quality of e-services	E-S-QUAL [Parasuraman and Malhorta, 2002], [Parasuraman et. al., 2005], [Zeithaml et. al., 2000], [Zeithaml et. al., 2002]
	User-Perceived Web Quality [Aladwani and Prashant, 2002]
	E-Qual [Barnes and Vidgen, 2002], [Barnes et. al., 2001], [Barnes and Vidgen, 2001], [Kelly and Vidgen, 2005]
	E-Commerce Website Quality [Bessa and Belchior, 2002]
	Online Service Quality [Cai and Jun, 2003]
	B2C e-Commerce Web Site Quality [Cao et. al., 2005]
	Quality Model for Portal Data [Caro et. al., 2006]
	Quality Factors in Web Sites [Cox and Dale, 2002]
	Service Quality on the Web [Gounaris and Dimitriadis, 2003]
	E-Service Quality [Gwo and Lin, 2005]
	Quality Aspects in Design and Use of Web Sites [Ivaarden et. al., 2003], [Iwaarden et. al., 2004]
	Designs of Highly-Rated Web Sites [Ivory and Hearst, 2002], [Ivory and Megraw, 2005]
	WebQual [Loiacono et. al., 2000]
	Web Site Quality Evaluation [Mich et. al., 2003]
	IP-Portals [Yang et. al., 2004], [Yang et. al., 2005]
	Consumer Perspective of E-Service Quality [Zhang and Prybutok, 2005]
	Web Site Quality Model [Signore, 2005]
	SITEQUAL [Webb and Webb, 2004]
	Portal Usage Quality [Lin and Wu, 2002]
	IBM [Mani and Nagarajan, 2002]
	METEOR-S [Cardoso et. al., 2002]
	Quality of Services for Web Services (QS-WS) [Sumra and Arulazi, 2003]
	MAIS [Cappiello et. al., 2004]
Quality of e-government services	American Customer Satisfaction Index for e-government (egov-ACSI) [ACSI, 2006]
	Customer satisfaction level in e-government (g-CSI) [Kim et. al., 2005]
	Interactive E-Government [Barnes and Vidgen, 2003]
	User Satisfaction of E-Government Services [Horan et. al., 2006]
	Danish Top of the Web [Danish ToW, 2006]
	Quality of Norwegian Public Web Sites [Jansen and Ølnes, 2004]
	European Top of the Web [EC, 2004]
	e-Government in Thai [Sukasame, 2004]

2.2 Quality Approaches and Models

Various initiatives investigate the application of quality management principles to the delivery of electronic services. For the measurement of e-services' and portals' quality, an essential question that must be addressed is about what to measure. Quality models are responsible for providing an answer to the above question, as they allow the specification of quality dimensions concerning the quality of e-services and portals.

This section presents a literature survey at the field of quality of service for e-services and e-government services. Thirty one approaches regarding quality models have been elaborated as presented in Table 2.1. In the following, abbreviations are used for the various approaches, as defined in Table 2.1.

2.2.1 Quality of E-services

The approaches of this category focus on the quality of the service delivered itself. Emphasis is put on the way the user receives the services from the front office – i.e. the web site. They are user-oriented approaches, since they are motivated by the user's needs. Quality aspects examined by these approaches are related to the delivered service (availability, usability, security etc. of the service) and/or input from the receivers of the service (users' priorities and needs).

Parasuraman and colleagues [Parasuraman et. al., 2005], [Parasuraman and Malhorta, 2002], [Zeithaml et. al., 2000], [Zeithaml et. al., 2002] use the means-end framework as a theoretical foundation and conceptualize, construct, refine, and test a multiple-item scale named *E-S-QUAL* for measuring the service quality delivered by web sites on which customers shop online. Two stages of empirical data collection revealed that two different scales were necessary for capturing electronic service quality. The first is the basic E-S-QUAL scale which was developed as a 22-item scale of four dimensions: efficiency, fulfillment, system availability, and privacy. The second scale, E-RecS-QUAL, is salient only to customers who had non-routine encounters with the sites and contains 11 items in three dimensions: responsiveness, compensation, and contact.

In the *User-Perceived Web Quality* approach [Aladwani and Prashant, 2002] an instrument capturing key characteristics of web site quality from the user's perspective was developed. The 25-item instrument measures four aspects of web quality: specific content, content quality, appearance and technical adequacy.

Kelly and Vidgen [2005] conducted a series of studies to develop an effective instrument, in the beginning named Webqual and then renamed as *E-Qual*, to measure the quality of various websites [Barnes and Vidgen, 2001, 2002], [Barnes et. al., 2001]. Their instrument was originally developed based on user evaluations of four university websites rather than retail sites. It was later tested and revised for online auction sites, wireless news sites and

bookstores. When applied to three online auction sites, the instrument incorporated three quality dimensions: information quality, interaction quality and site-design quality [Barnes and Vidgen, 2001]. In testing the instrument for online bookstores [Barnes and Vidgen, 2005], the researchers replaced site-design quality with usability because the latter kept 'the emphasis on the user and their perceptions rather than on the designer and the site as simply a context-free software artifact'. Usability was defined as a measure of how a user perceives and interacts with a website.

The *E-Commerce Website Quality* approach [Bessa and Belchior, 2002], defines a relevant set of website quality attributes based on a software quality evaluation model. Research was undertaken to validate and establish the relative importance of these attributes. Quality factors that were used in this research include usability, conceptual reliability and reliability of the representation. Usability is a quality objective referring to the characteristics that allow use of an e-commerce site in the most diverse situations. Conceptual reliability concerns the ecommerce site's capacity to implement satisfactorily what was specified and designed. The reliability of the representation refers to the e-commerce site's representation characteristics that affect its understanding and manipulation along its life cycle.

The *Online Service Quality* approach [Cai and Jun, 2003], identifies four key dimensions of online service quality as perceived by two groups of Internet users, online buyers and information searchers. The dimensions derived are: web site design/content, trustworthiness, prompt/reliable service, and communication. It also reveals that there are significant differences between these two Internet user groups regarding their perceptions on the identified dimensions. Furthermore, this research reveals that all of the four dimensions significantly influence online buyers' evaluation of overall online service quality, while only three dimensions, i.e. web site design/content, trustworthiness, and communication, have a significant impact on information searchers' assessment of overall online service quality.

B2C e-Commerce Web Site Quality [Cao et. al., 2005] examines and integrates four sets of factors that capture e-commerce web site quality using an IS success model: system quality, information quality, service quality, and attractiveness. A questionnaire survey was conducted to verify the measures of web site quality. Based on the Technology Acceptance Model - TAM [Davis, 1989], a framework was also developed relating web site quality to customers' beliefs (perceived usefulness and ease of use), attitudes (preferences for the site), and intentions (to revisit the site). A set of instruments of web site quality has been developed and empirically validated by factor analysis.

The *Quality Model for Portal Data* [Caro et. al., 2006], presents a preliminary version of a data quality model for web portals that consider the data consumers point of view. It has been built on three key elements: a set of web data quality attributes based on the relevant literature, data quality expectations of data consumers on the Internet, and the functionalities which a web portal may offer its users.

The *Quality Factors in Web Sites* approach [Cox and Dale, 2002], identifies the key quality factors in web site design and use. From the factors identified, a conceptual model has been developed to assess how a web site can deliver what its users expect. The model is composed of the following quality criteria: ease of use, customer confidence, on-line resources, and relationship services.

The approach proposed by Gounaris and Dimitriadis [2003], i.e. the *Service Quality on the Web* approach, explores the quality dimensions that the visitors of national and foreign business to consumer (B2C) portals use in order to assess the performance of their service offering. Based on the SERVQUAL [Parasuraman et. al., 1988] model and previous research on web site evaluation and quality, it identifies three quality aspects: customer care and risk-reduction benefit, information benefit and interaction facilitation benefit.

E-Service Quality [Gwo and Lin, 2005] develops a research model to examine the relationship among e-service quality dimensions and overall service quality, customer satisfaction and purchase intentions. Data from online consumers were used to test the research model. The analytical results showed that the dimensions of web site design, reliability, responsiveness and trust affect overall service quality and customer satisfaction. Moreover, the latter in turn are significantly related to customer purchase intentions. However, the personalization dimension is not significantly related to overall service quality and customer satisfaction.

The *Quality Aspects in Design and Use of Web Sites* approach [Ivaarden et. al., 2003], expands and adjusts the SERVQUAL instrument from the traditional service evaluation to web site quality evaluation. The items that have been identified as most important in relation to the quality of web sites are tangibles (the appearance of the Web site, navigation, search options, and structure), reliability (the ability to judge the trustworthiness of the offered service and the organization performing the service), responsiveness (the willingness to help customers and provide prompt service), assurance (the ability of the Web site to convey trust and confidence in the organization behind it with respect to security and privacy), and empathy (the provision of caring, individualized attention to customers, including user recognition and customization). In a latter attempt of the authors [Iwaarden et. al., 2004] a survey was undertaken to identify the quality aspects perceived to be the most important in the design and use of web sites. The questionnaire utilized was based on preliminary research by Cox and Dale [2002] who had previously developed a model for assessing the quality of web sites. The results were compared to the SERVQUAL dimensions and indicated for once more that the quality dimensions found applicable in the service sector are also applicable to web sites.

Ivory and colleagues [Ivory and Megraw, 2005], [Ivory and Hearst, 2002], in their *Designs of Highly-Rated Web Sites* approach, after examining the characteristics of highly rated sites from 2000 to 2003, they identified an exhaustive set of quantitative measures in order to assess as many aspects of web interfaces as possible. As the result of this effort they developed 157 page- and site-level measures. These measures are part of a conceptual model of web

interfaces. The quality aspects examined by the conceptual model are information, navigation, graphic design, page performance and overall site architecture.

WebQual [Loiacono et. al., 2000] uses the general theoretical frames of the Theory of Reasoned Action [Fishbein and Ajzen, 1975] and the TAM model [Davis, 1989] as starting points to develop a measure of web site quality that predicts consumer reuse of the site. The development and validation process of a web site quality measure is presented, with 12 core dimensions: informational fit-to-task, tailored communications, trust, response time, ease of understanding, intuitive operations, visual appeal, innovativeness, emotional appeal, consistent image, on-line completeness and relative advantage.

The *Web Site Quality Evaluation* approach [Mich et. al., 2003], helps developers evaluate web site quality from both owner and user viewpoints. It highlights elements that, when suitably combined, permit thorough site assessment and guide development. The respective dimensions used are identity, content, services, location, management, usability and feasibility.

The *IP-Portals* approach [Yang et. al., 2004], is based on a broad conceptual framework which integrates theory and conceptualization in the domains of customer service quality, information systems quality, and product portfolio management, into online service quality. An ethnographic content analysis customer review of online banking services was employed to identify salient online service quality dimensions. The most frequently cited online service quality attributes along with literature review and personal interview results were utilized to develop the survey questionnaire. Subsequent to the pre-test, a web-based survey was undertaken to verify and test the online service quality model. A confirmatory factor analysis produced six key online service quality dimensions: reliability, responsiveness, competence, ease of use, security, and product portfolio. Moreover in a second study [Yang et. al., 2005] Zhilin Yang and his colleagues developed and validated an instrument to measure user perceived service quality of portals. Based upon conceptual models in the areas of IS and technology adoption, and using responses from users, they validated a five-dimension service quality instrument involving: usability, usefulness of content, adequacy of information, accessibility, and interaction.

The approach described in *Consumer Perspective of E-Service Quality* [Zhang and Prybutok, 2005], develops an e-service model. Specifically this model consists of constructs such as individual differences, e-service convenience, web site service quality, risk, e-satisfaction and intention. An e-service quality survey instrument was developed and validated.

The *Web Site Quality Model* developed by Signore [2005], aims at defining a quality model and a set of characteristics relating internal and external quality factors and giving clues about potential problems which can be measured by automated tools. Correctness, presentation, content, navigation and interaction are the five dimensions considered by the quality model. The model has been designed to cover a possible automated process for the

quality evaluation, using pages and page components as elements to evaluate. According to this approach, the first step in the quality assessment process is an automatic check of the source code, followed by manual evaluation, possibly supported by an appropriate user panel.

SITEQUAL [Webb and Webb, 2004] provides guidelines and an instrument to measure the quality of a web site over time.

The approach of Lin and Wu [2002], i.e. the *Portal Usage Quality* approach, provides general hints on the construction of a portal in order to keep people continuing to visit the portal site. The aim of this work is to explore users' intention and behavior as far as the portal site is concerned.

The models presented so far, are primarily focused on the quality characteristics of the service delivered, the kind of information presented, the way it is presented and some system characteristics. A characteristic of these models is that most of the studies result from composition, adaptation and extension of existing models. The constitutive studies for the models presented here are SERVQUAL [Parasuraman et. al., 1988] from service quality literature and Wang and Strong's [1996] study as well as TAM [Davis, 1989] from the data quality literature. For example *SITEQUAL* combines SERVQUAL with Wang's work; the *Portal Usage Quality* approach combines SERVQUAL with TAM, while the *IP-Portals* approach is based on the TAM model.

The e-service category of approaches includes also some technical approaches that examine quality of service for web services. Web services are used widely as the underlying technology for service provision and thus their technical characteristics influence the qualitative result of the service delivered to users.

One of these technical approaches is the approach proposed by *IBM* [Mani and Nagarajan, 2002]. It addresses the subject of quality of service delivered through web services in seven aspects. Although these aspects refer to web services, they can be easily generalized for e-services. Availability is the quality aspect of whether the service is present or ready for immediate use. Accessibility represents the degree that the service is capable of serving requests, while integrity is related to the way that the service maintains the correctness of the interaction with respect to the source. Performance is the quality aspect related to throughput and latency while reliability represents the degree of being capable to maintain the service and service quality. Regulatory is the quality aspect of the service in conformance to the rules, the law, compliance with standards, and the established service level agreement. Finally the *IBM* approach includes some security related dimensions like authentication, access control and encryption of messages.

Cardoso et. al. [2002] present, as part of *METEOR-S* project approach, a comprehensive model for the specification of workflow quality of service (QoS) as well as methods to compute and predict QoS.

Sumra and Arulazi [2003] in their *QS-WS* approach, propose seven dimensions that contribute to service quality. Performance, reliability, integrity, accessibility, availability and security quality dimensions cover the same aspects as the aforementioned IBM approach, while the interoperability dimension is related to the ability of a service to operate with different systems.

The *MAIS* project team has proposed a general framework for the definition of quality of service dimensions [Cappiello et. al., 2004]. The most relevant quality dimensions are service and data reliability, robustness and security of the application. Service security and availability, as well as time performance, are considered important quality dimensions of the model.

Finally, some other domain specific approaches examine the quality of web sites and more specifically of banking portals [Bauer et. al., 2005], health web sites [Provost et. al., 2006], nursing websites [Tsai and Chai, 2005], or sites used in higher open distance education courses [Xenos et. al., 2004].

In Table 2.2 the quality criteria/perspectives/principles examined by each approach are presented. Service Reliability refers to the ability of the portal to deliver the e-service consistently, producing the same results, preferably meeting or exceeding service's specifications. The Personalization criterion is related to the process of tailoring pages to individual users' characteristics or preferences. Information/ Content quality is a term to describe the quality of the content of information systems and furthermore is a measure of the value that the information provides to the user. Concerning the Navigation/ Accessibility criterion, web site navigation is the science and skill which is applied to a web site that helps visitors move from one page to another, while accessibility is a general term used to describe the degree to which a system is usable by as many people as possible without modification. Security refers to the protection of data, networks and computing power while the System Performance criterion is related to performance metrics that indicate the quality of a web portal.

Table 2.2: Synthetic Table for e-Services Quality Approaches

	E-S-Qual	User-Perceived Web Quality	E-Qual	E-Commerce Website Quality	Online Service Quality	B2C e-Commerce Website Quality	Quality Model for Portal Data	Quality Factors in Web Sites	Service Quality on the Web	E-Service Quality	Quality Aspects in Design and Use of Web Sites	Designs of Highly-Rated Web Sites	WebQual	Web Site Quality Evaluation	IP-Portals	Consumer Perspective of E-Service Quality	Web Site Quality Model	SITEQUAL	Portal Usage Quality	IBM	Meteor-S	QS - WS	MAIS
Service Reliability	√	√		√	√	√	√	√	√	√	√		√			√		√	√	√	√	√	√
Personalization	√	√		√			√			√			√	√	√			√	√				
Information/ Content		√	√	√	√	√	√	√	√			√	√	√	√	√	√	√	√				√
Navigation/ Accessibility	√	√	√	√	√	√	√	√		√	√		√	√	√	√	√	√		√		√	
Security	√	√	√	√	√	√	√	√	√	√	√		√	√	√	√		√	√	√		√	√
System Performance	√	√		√		√		√	√	√	√	√		√			√			√	√	√	√

By reviewing the table, it can be seen that approaches presented value mostly the dimension of security (confidentiality, non reputation, encrypting). Also important seems to be the quality of information presented on the site/portal and its characteristics as relevancy, accuracy, completeness, understandability, together with the way this information is presented i.e. appearance, navigability etc. Great importance is also given to the service dimension of a site such as reliable delivery of service, personalized services etc.

On the other hand, more technical approaches like *IBM* [Mani and Nagarajan, 2002], *Meteor-S* [Cardoso et. al., 2002] etc., consider as very important the performance (related to the response and provision time) as well as the reliability dimensions (the degree the system is capable of maintaining service quality), while security (confidentiality, non reputation, encrypting) follows.

2.2.2 Quality of E-government Services

Approaches of this area focus on the quality of the e-government portal and the overall user satisfaction with respect to the provided public e-services. User satisfaction is affected both by users' perceived quality and their expectations about the service. Many factors compose quality and are taken into account for the satisfaction measurement, aiming at the calculation of indexes describing the customer/citizen satisfaction for a service.

The American Customer Satisfaction Index [ACSI, 2006] uses two interrelated methods to measure and analyze customer satisfaction: customer questionnaires and econometric modeling. The idea of the Customer Satisfaction Index has been introduced in the traditional off-line world and then migrated to the online world. Satisfaction with an online service is a complex issue with multiple elements determining how well the online experience meets the needs of site visitors. Customer Satisfaction Index methodologies identify key drivers of satisfaction and quantify their relationship to overall customer satisfaction, i.e. they calculate the impact of the different drivers of satisfaction based on direct "voice of the customer" feedback for each measured site.

The American *egov-ACSI* [ACSI, 2006] is the more established model of this category. It evaluates quarterly more than 90 online e-government sites grouped into four categories (ecommerce/transactions, news/information, portal/dept. main sites, recruitments/careers). The second model of this group, the Korean *g-CSI* [Kim et. al., 2005], has been based on the ASCI model and therefore has many resemblances. Quality aspects addressed by these models consist of information, process, and service. Accessibility and accuracy of information, easiness and costs of the service, as well as expertness and kindness concerning customer service, are some of the quality dimensions included.

The cause-and-effect nature of these methodologies enables an agency or department to predict the impact of website enhancements in a particular area (e.g., navigation) on overall

satisfaction. Going further, such a methodology predicts how increases in satisfaction affect desired future behaviors of site visitors, such as return visits and referrals to the site. Typically, an area with a low satisfaction score and a high impact score is considered of high priority. The identification of high priority satisfaction drivers provides valuable insight into how an agency or department should prioritize website improvements based on where they will have the greatest impact on citizen satisfaction.

A key common feature of these methodologies is that they are based on a 'model'. This model consists of a number of latent variables (such as 'quality') and the cause and effect relationships between them. Each of these latent variables includes several manifest variables that act as concrete proxies for the latent variable. Consumer satisfaction is the latent variable which is at the centre of the model; it is encased within a system of variables relating to causes and effects.

The *Interactive E-Government* approach [Barnes and Vidgen, 2003] examines the results of a survey about the quality of a web site provided by the UK Government. The site is that of the Inland Revenue. The survey was administered directly after the launch of a new system, which was built in order to enable online submission of self-assessed tax returns. The instrument, E-Qual, draws on previous work in web site usability, information quality, and service interaction quality to provide a rounded framework for assessing e-government offerings. The metrics and qualitative comments provided some detailed insights into the perceptions of users who attempted to interact with the online taxation system. The research findings suggest that usability has been a major issue that requires attention and that there is a great need for empathy and personalization in the delivery of services.

The *User Satisfaction of E-Government Services* approach [Horan et. al., 2006], is a citizen-centric approach which focuses on the evaluation of citizen satisfaction in the Advanced Travel Information Systems (ATIS) domain, a form of government-citizen information service. It first details the structure and results of a preliminary study of usability that was conducted in two major metropolitan areas – Los Angeles and Minneapolis. Based on findings from the first phase, a more comprehensive concept of overall satisfaction with these services has been developed.

The *Danish Top of the Web* [Danish ToW, 2006] is an annual benchmarking of public websites in Denmark, started in 2001. The overall objective is to increase the quality of websites by focusing on the best sites to serve as inspiration. Through an annual evaluation of all public sector websites and the users' opinions on the service they encounter, Top of the Web aims to determine whether the service given by public sector websites is satisfactory. The evaluation is based on four categories: form (user-friendliness), content (the users' potential benefit from the information given), practical value and technical availability of the website in question. Moreover, accessibility as well as the openness of organization, services and processes, are incorporated as quality factors. The quality indicators are divided into general indicators (for

all public web sites) and specific indicators (specific to groups such as educational bodies, health care bodies and so on).

The Western Norway Research Institute has initiated a project (*Quality of Norwegian Public Web Sites*) which uses a set of 25 indicators and quality criteria for evaluating public websites in Norway [Jansen and Ølnes, 2004]. The quality of web sites is defined as follows: "public information and services on the Internet must meet a predefined standard or level that can satisfy some central user needs". Three main quality criteria are identified; accessibility, user orientation and useful services, while specific indexes are introduced for each one. An interesting point is that the evaluation is performed neither by the real users nor the system's administrators. For the evaluation a group of well trained evaluators is used.

The *European Top of the Web* approach [EC, 2004] focuses on the benefits gained by end users. The approach combines a) the gathering of information from service providers on the extent to which public services are being used via on-line channels compared to traditional ones and b) the use on online questionnaires addressing users of the online services. User satisfaction and perceived quality of an on-line service is measured combining:

- Usability dimensions (about whether users have experienced any problems using the service),
- Benefits experienced by the users (save time, gain flexibility, etc)
- Overall evaluation, i.e. user's overall satisfaction with the service and whether the users' expectations are met or not.

Finally the approach (*e-Government in Thai*) used by e-government sites in Thailand [Sukasame, 2004] focuses on the development of a conceptual framework and on the elicitation of factors such as reliability, linkage, content, ease of use and self-service that affect the e-services provided on the web portal of Thailand's government. Content refers to concise, useful, and current information moreover to the presentation and layout of factual information and functions on the web site. Linkage refers to the number and quality of links that a web site offers targeting to the integration of relevant information at the site and at other sites. Reliability is related to the technical functioning of the site, particularly the extent to which it is available and functioning properly, while ease of use reflects the usability of the web site during customer navigation and aims to reduce customer frustration. Finally, self-service refers to formats which enable customers to perform services for themselves quickly and conveniently.

In Table 2.3 the quality criteria/perspectives/principles examined by each model are presented. Service Reliability, Personalization, Information/Content and Navigation/ Accessibility have already been defined in the description of Table 2.2. Two additional criteria are used by the approaches belonging to the e-government category, i.e. Customer Service and Overall Evaluation. Customer Service in the web is mainly related to technical support

to citizens through email, chat, voice and the web. Finally the Overall Evaluation criterion is related to the provision of a single number / scale value that indicates the level of citizens' satisfaction.

Table 2.3: Synthetic Table for e-Government Quality Approaches

	ACSI	g-CSI	Interactive E-Gov	User Satisfaction of E-Gov Services	Danish Top of the Web	Quality of Norwegian Public Web Sites	European Top of the Web	e-Government in Thai
Service Reliability				√	√			√
Personalization			√	√		√		
Information/Content	√	√	√	√	√		√	√
Navigation/Accessibility	√	√	√	√	√	√	√	√
Customer Service	√	√	√					
Overall Evaluation			√	√			√	

By reviewing the table, it can be seen that the aforementioned models value mostly the quality of information presented on the site/portal together with the way the navigation to information and services is done.

2.3 Web Surveys and International Standards

The rapid growth of technology and the internet suggest that in the coming years traditional methods of data collection will gradually be replaced by web surveys [Couper, 2000]. The skills required to produce a web survey differ significantly from those required in other types of surveys. A web survey focuses more on technology, computer programming expertise and web page design [Couper, 2001]. With the rising trend of these sciences and the continuing influence of internet on all major aspects of the economic world, we could expect web surveys to dominate the traditional survey methods.

Web surveys, as compared to traditional surveys, are different in two main aspects: the data collection mode and the sampling mechanism; that is, the use of web pages as an interview method and self selected sample as a selection mechanism [Oberski, 2006]. Web pages offer various and dynamic options regarding the presentation of the questionnaire. Two are the main options, either screen- by- screen or scrolling. In any case, the web expands considerably the range of design and layout opportunities and allows the use of various visual

design elements to increase the response rate. Web based surveys provide a wide range of response options such as radio boxes, check boxes, Likert scales, drop down menus, graphics, color, images, sound etc. Of course, the choice between these options for the design of the questionnaire depends on the nature and purpose of the survey.

There are many advantages relating to web-based surveys. The greatest of all is the cost and the ease of data collection and analysis. Also, advantages related to faster response rate, dynamic error checking ability, option for self-administrated questionnaire, the use of drop down questions, relatively easier data processing, ability to send reminders to participants and ability to create customized questionnaires [Zanutto, 2001].

The internet as a mean for conducting a research is a powerful tool for collecting and disseminating information. However, it raises a number of ethical and technical issues that must be addressed if the medium is to be used effectively and responsibly for market and opinion research purposes. For this reason, there is a number of standards upon which the web surveys should be based, like the principles of the Codes of Ethical Practice and International Professional Standards [ESOMAR, 2007], [Code of Conduct, 2005], which govern the way market, social and opinion research are conducted. They fully encompass guidelines on international best practice and the corresponding values of professionalism, excellence and effectiveness in conducting internet research.

Specifically, the ESOMAR (Word Association of Opinion and Marketing Research Professionals, formerly, European Society for Opinion and Marketing Research) International Code of Marketing and Social Research Practice, as well as the MRS (Market Research Society) Code of Conduct have specific sections regarding internet research issues [ESOMAR, 2007], [Code of Conduct, 2005]. Both associations aim at establishing codes of ethical practice and professional standards in order to promote the development and use of marketing, social and opinion research as an important basis for effective management decision in both public and private sectors alike.

International codes and rules provide guidance in maintaining professional standards in market research execution. Codes are also intended to reassure the general public and other interested parties that research is carried out in a professional and ethical manner.

The rules and codes cover the full range of work done in carrying out a research/survey. In particular, they cover the following research/survey phases:

- Designing and setting up the research project (or the survey project)
- Designing the questionnaire
- Preparing for fieldwork
- Fieldwork
- Analysis and reporting of research findings
- Treatment of data and data storage

Special aspects of the application of the Code to Internet Research should be taken into account when designing web surveys, as described in the "Guidelines on Conducting Market and Opinion Research using the internet" published by ESOMAR [ESOMAR, 2007] and the "Internet research guidelines" published by MRS [MRS, 2006]. In essence, these guidelines set out the basic principles which should guide researchers when using the internet.

- *Co-operation is voluntary*: Intruding unnecessarily on privacy of internet responders should be avoided. Survey responders' co-operation must, at all times, be voluntary.
- *The researcher's identity must be disclosed*: Survey responders must know the identity of the researcher carrying out the project and the address at which they can re-contact the latter if they wish to do so.
- *Responder's anonymity must be safeguarded*: The anonymity of the responders must always be preserved unless they have given their informed consent to the contrary. If responders have given permission for data to be passed on in a form which allows them to be personally identified, the researcher must ensure that the information will be used for research purposes only.
- *Privacy policy statements*: Researchers are encouraged to post their privacy policy statements on their online site. When such privacy policy statements exist, they should be easy to find, easy to use and comprehensible.
- *Data security*: Researchers should take adequate precautions to protect the security of sensitive data. Researchers must also reasonably ensure that any confidential information provided to them by responders is protected (e.g. by firewall) against unauthorized access.
- *Reliability and validity*: Users of research and the general public must not be in any way misled about the reliability and the validity of the internet research findings.
- *Unsolicited e-mail*: Researchers should not send unsolicited messages on line to responders who have indicated that they do not wish to receive such messages relating to a research project or to any follow-up research resulting directly from it.

2.4 Quality Ontologies

There are several ontologies in literature that are explicitly called QoS ontologies. The e-GovQoS, an Ontology for Quality of e-Government Services [Corradini et. al., 2006] takes into consideration dynamic aspects related to Quality of Services and their impact on the service composition, in particular when a large number of services are available to reach the same goal. The role of this Ontology is service discovery and composition based on their QoS characteristics. The emphasis is put on quality of web-services and low level quality metrics are mainly modeled.

A similar to e-GovQoS ontology is the one developed in Lancaster University [Dobson et. al., 2005]. This ontology has been named QoSOnt, an ontology for Quality of Service and its role is service discovery and selection based upon QoS requirements. QoSOnt supports network and services as the type of system that QoS may refer to and the focus is given to its application in the field of service-centric systems.

Service discovery and composition is also the main role of the quality taxonomy developed in [Cappiello et. al., 2004]. This taxonomy defines the quality characteristics of networks, channels of communication and access devices that can be used for the delivery of services and describes quality elements of a multichannel environment.

An ontology for the specification of QoS metrics for tasks and Web services has been developed in [Cardoso et. al., 2002]. The information formalized in the ontology allows the discovery of Web services based on operational metrics. The focus of this quality ontology is put on quality dimensions of time, cost and reliability.

The literature has been proved poor in the area of top level quality ontologies. Two of the well-known ontologies that are built specifically with the purpose of being formal top-level ontologies are the Suggested Upper Merged Ontology (SUMO) [Niles and Pease, 2001] and DOLCE [Gangemi et. al., 2003]. SUMO is an effort by the IEEE Standard Upper Ontology Working Group aimed at developing “a standard upper ontology”. The SUMO ontology defines high level concepts as object, process, quantity, relation, but unfortunately the concept of quality is not defined. Similarly, the DOLCE ontology which is a formal foundational ontology developed as a top-level ontology in the WonderWeb project, does not contain high level concepts related to the notion of quality.

3 ADAPTIVITY AND PERSONALIZATION

Web sites are increasingly adapted towards their users by a variety of dynamic techniques, providing improved personalization for the individual. An overall description of the technology of adaptivity and personalization is provided in this Chapter. Before introducing the techniques used for personalizing the user's experience and the adaptivity targets (section 3.5), we briefly define the terms adaptivity (section 3.1) and personalization (section 3.2), we try to resolve the confusion usually made between various terms which are used in this research area (section 3.3), and we highlight the major challenges (section 3.4).

3.1 Definition of Adaptivity

Adaptivity is a particular functionality that alleviates navigational difficulties by distinguishing between interactions of different users within the information space. Adaptive Systems employ adaptivity by manipulating the link structure or by altering the presentation of information, based on a basis of a dynamic understanding of the individual user, represented in a user model [Germanakos et. al., 2005].

An adaptive hypermedia system is a hypermedia system which reflects some features of the user in the user model and apply this model to adapt various visible and functional aspects of the system to the user [Eklund and Sinclair, 2000], [Brusilovsky, 2001]. A system can be classified as an Adaptive Hypermedia one if it is based on hypermedia, it has an explicit user-model representing certain characteristics of the user, it has a domain model which is a set of relationships between knowledge elements in the information space, and it is capable of modifying some visible or functional part of the system based on the information maintained in the user-model [Eklund and Sinclair, 2000], [Brusilovsky, 2001], [Brusilovsky and Nejdl, 2004].

Such a system should have the ability to recognize users and events, to reason about, and plan for the future. Therefore, creating adaptive websites requires server-side functionality for user modeling and for the adaptive generation of (HTML) pages. The broadest definition of an adaptive website is a website which changes based on the way it is used [Lieberman, 1995]. Changes can take on many forms, as they may either be immediate (as in the case of

recommendation systems) or gradual (as in the case of systems which suggest changes to a website administrator).

3.2 Definition of Personalization

A relatively new research area, very closely related to adaptive web systems, is web personalization. Web personalization has a more extended scope than adaptive hypermedia, exploring adaptive content selection and adaptive recommendation based on modelling user interests and it is primarily used in the e-business application domain [Germanakos et. al., 2005].

As is often the case with a good marketing buzzword, the term personalization is used rather loosely [Crawford, 2000]. It has come to stand for an ultimate goal of customer relationship management by businesses, supporting for example one-to-one marketing. It has also come to mean delivery of information of high relevance to an individual, in the context of receiving from a large body of information only the part that is of interest to an individual or a group of individuals [Won, 2002].

In [Won, 2002], personalization is defined as delivering (to a group of individuals) relevant information that is retrieved, transformed, and/or deduced from information sources, while authors of [Nasraoui, 2005] state that, web personalization refers to the whole process of collecting, classifying and analyzing Web data, and determining based on these the actions that should be performed so that the user is presented with personalized information. In [Montgomery and Smith, 2009] personalization is defined as the adaptation of products and services by the producer for the consumer using information that has been inferred from the consumer‘s behaviour or transactions, by using technology.

In summary, personalisation takes place between one or several “providers” of personalised “offerings” and one or several “consumers”. Personalised “offerings” include content (such as web pages and links), product and service recommendations (such as books, CDs, and travel packages), e-mail, information searches, dynamic prices, and products for individual consumers (such as custom CDs).

3.3 Adaptable vs Adaptive Systems

One important aspect of personalized and adaptive systems is how the information, that is used in order to build the user model, is acquired. To this end, we distinguish between adaptable and adaptive portals. Adaptive web sites are not the same as adaptable ones, although both kinds of sites seek to customize the user’s visit.

A portal is merely adaptable if the way it performs or behaves changes based on explicit information, such as a user profile. This profile will not vary over time unless the user explicitly changes it. In other words adaptability, also referenced as customization, occurs when the user can configure an interface and create a profile manually, by adding and removing elements in the profile [Bonnet, 2002]. The control of the look and/or content of the site are explicit and user-driven; i.e. the user is involved actively in the process and has direct control [Bowen and Fantoni, 2004]. Portal web sites such as Yahoo.com and iWon.com are adaptable; they allow users with Yahoo or iWon accounts to choose how information is displayed on their personal view of the web site. For example, Yahoo users can choose the types of news that they would like on their “my.yahoo.com” page [Wei, 2001].

On the other hand, a portal is considered adaptive if it changes based on implicitly discovered information, such as an analysis of the way it is used. The user model is updated during the browsing process. The site monitors the user’s browsing behaviour (and in particular the pages that are visited) in order to create a user model representing the user’s interests and knowledge. In other words the web site is customized by unobtrusively observing the user’s actions [De Bra, 2001], [Maglio et. al., 2000]. In adaptive systems the user is seen as being passive, or at least somewhat less in control [Bonnet, 2002].

The obvious limitation, which is implicit in explicit personalization techniques, is that they do not take into account that the visitor’s interests and needs might change during the exploration and might demand a reconfiguration of the system [Bowen and Fantoni, 2004].

3.4 Challenges

The environment in which an adaptive web system operates presents certain challenges which impact their feasibility and performance. In the following we present the most interesting ones.

3.4.1 Impact on User Experience

When adaptation takes place, there are by definition some changes which are made to the website, perhaps to the content of the pages, the structure of the site or the links which are presented to the user. Since the website is changing, it is important to consider the impact of making such changes to the user’s experience, and avoid or modify changes in light of how the experience would be maintained. For example, in a website which has a highly visual layout, the addition or removal of links may have a disastrous effect on that layout; even the modification of the color of the links or the augmentation of link icons, might confuse the users as to what links they had already visited as opposed to which links they have

yet to visit [Brusilovsky, 1997]. In another case, while there may be a large number of links which are deemed relevant to a particular user, some subset of these must be chosen to avoid overwhelming the users and putting them back into the “lost-in-hyperspace” situation. In yet another example, the adaptation of content may confuse or disorient a user, as the location of familiar items may be radically altered based on the system’s perceived shift of interests.

Another challenge concerning interfaces that are unique to each user is that there is no longer a common interface that can be assumed that everyone has seen, and in fact, it may become harder for people to help each other when they have questions about an adaptive web site [Kay, 2001].

To counteract the user’s sense of powerlessness, adaptive web sites should explicitly demonstrate that they are still learning about the user and can be trained to work with the user [Wei, 2001]. Users are more likely to trust an agent that demonstrates that it is learning and are more open or feel more positive towards an adaptive web site that they know is working to adjust to them [Maes, 1995].

As a general rule, an adaptive system should provide relevant but not critical information [Maglio et. al., 2001]. This will alleviate the negative impact that an adaptive system may have to the user’s experience. Amazon [2010] is a good example of this requirement. It recommends products for the user to browse, but these recommendations are not a crucial part of the user’s visit to the web site. The user can ignore the recommendations and still get full functionality from the site.

3.4.2 Changing Interests

While different users may have different interests, a single user’s interests may also change over time such as short time interest under a certain situation and long-time interest which reflects the real interest of a user [McTear, 1993]. Some users may want information about a specific topic after they explore different kinds of information. On the other hand, some users may need wider background knowledge after they study a specific topic. Along with the changes of the environment, a user’s interest in a particular area may wax and wane. These and other reasons may cause changes in a user’s interests, which may happen abruptly and rapidly (concept shift) or gradually and slowly (concept drift) [Lam and Mostafa, 2001]. Ideally, adaptive web systems should be able to adapt to such interest changes.

Additionally, a user’s interests may not simply change, but things which interested a user in the past may become interests again at some future point. So, in addition to some form of interest forgetting, which represents a shift over time, there is also the idea of interest remembering, where old interests may reappear [Koychev, 2001].

3.4.3 Poor Modeling

Poor user modeling may lead to poor adaptations on a web site. Since the system is trying to draw conclusions and common features from a less-than precise body of information, it will on occasion have considerable difficulty in reaching accurate, or even at all correct generalizations. This happens when the system, while trying to make decisions based on its perception of the user, tries to make more or bigger decisions than its understanding of the user really allows.

Another problem related to poor user modeling is that the system may not be able to distinguish between a deliberate user choice and a mistake [Baecker, 1995]. For example at Amazon.com, a user might purchase a book not of not his/her taste, as a gift for someone else, yet the web site might persist on recommending similar books because it thought that he/she liked it [Wei, 2001]. These incorrect assumptions could lead to inappropriate adaptation [Baecker, 1995].

If there is no way to inspect the decision process made in reaching conclusions and potentially correcting them, there could be disastrous results, with the system generating entirely inappropriate suggestions, as in the case of Amazon described above or as in the case of a TiVo gone wild, which is described in [Zaslow, 2002].

3.4.4 Privacy

Adaptive systems which capture information about users in order to build a profile about them, can be viewed as an impingement on personal privacy by some users which are sensitive about sharing personal information with anyone. User modeling requires data collection, which leads to the possibility that the information may be misused [Baecker, 1995]. This issue is a social one and not a technological one, but does imply that the results of a user model that describes a user or group of users should be treated carefully and not casually. Privacy laws may restrict both the content of personal user data and the methods that may be used for processing them. Furthermore, Web systems normally face customers from all over the world. In this case, the fact, that different countries have different privacy laws, may need to be taken into account in user modeling [Kobsa et. al., 2001]. A recommended practice is to declare a privacy statement (or disclosure statement) which describes exactly what kind of information is gathered and the policies about how that information is used and shared [Bonnet, 2002].

3.5 Adaptivity Targets and Techniques

There are two major questions that must be taken into account when an adaptive/personalized system or application is considered.

- What can be adapted, meaning which are the targets for adaptation
- Which techniques are used by the system in order to collect user information and create the user profile, which is subsequently used to adapt to the user.

In this section we describe the targets of adaptation, as well as the adaptation techniques that are commonly found in adaptation systems.

3.5.1 Targets for Adaptation

The heart of an adaptive web system is its ability to change in response to the way it is used. This section provides an overview of the kinds of changes that such a system may perform. It should be recognized that the content, presentation and navigation of a web page are closely related, so there is bound to be a crossover between these categories.

3.5.1.1 Content

One of the basic modifications that might be made, is to change the content of the web page, based on the model that the system has been able to deduce about the user [Kobsa et. al., 2001]. Content might be added or removed, or it might be simply rearranged [De Bra, 2001]. These modifications might be done to accomplish several things, including the following:

- **Optional Explanations**: Additional explanations might be presented (or removed) to complement a user's presumed background knowledge in the subject [Kobsa et. al., 2001]. Among the many ways to perform adaptation to text, the technique of inserting or removing fragments is the most popular. This is probably due to the fact that this technique is easy to implement. With a fragment, a condition can be associated, a Boolean expression on information from the user model, and this condition determines whether a fragment will be shown or not. We distinguish three areas in which this technique is often used:
  - In prerequisite explanations an extra explanation is added for users who need it. A page that uses a technical term or a name the user has not yet seen, may conditionally include a short introduction or explanation for that term or name.
  - Additional explanations can be given to users who are ready for them. While, prerequisite explanations try to compensate for missing knowledge, additional explanations take advantage of users' knowledge to offer more in-depth information to users who can understand it.
  - A special kind of additional explanations are the comparative explanations. This technique refers to a comparison between topics described in different pages. The comparison can only be understood by users who have read both pages. So when

visiting one of these pages first, the comparison will not be made, but when visiting the other page the comparison appears.

- **Optional Detail**: Additional detailed information might be added or removed to pages depending on a user's perceived interest in the topic [Kobsa et. al., 2001].
- **Personalized Recommendations**: Particularly in the ecommerce world, recommendations for offers or products in which the user might be interested may be presented. In other websites, this would include putting links to other conceptually related subsections that the user might find interesting [Kobsa et. al., 2001].
- **Optional Opportunistic Hints**: Hints to understanding or discovering information might be added based on the users' interests and on current circumstances [Kobsa et. al., 2001].
- **Substitution of Content**: Depending on the perceived browser capabilities or user interests, content of one type may be replaced with equivalent content of a lesser or greater browser requirement. For example, an image of a map might be replaced with a textual description of the map for users who are visually impaired and using a text reader, or a video might be replaced with a still picture with a link to the video for a user whose actions (or preferences) indicate a low-bandwidth connection [Germanakos and Mourlas, 2008].

3.5.1.2 Presentation

In addition to modifying the content of the page, one can also change the way it is presented in order to serve a user. Most of the research on adaptive presentation deals with adaptive text presentation, and mostly with canned text presentation (and not natural language generation). In multimedia the selection of a presentation mode or the presentation medium (text, image, video and audio) is most feasible. Automatic adaptation of multimedia content, like in automatic summarization of video or audio, is still considered to be pretty much future work.

Adaptive natural-language generation generates alternative text descriptions for different users [Kobsa et. al., 2001]. A similar technique can be seen in online page translators such as Altavista's Babel Fish [Altavista, 2009]. Figure 3.1 represents a classification of the techniques for adaptive presentation. In this section we will provide a detailed description of canned text adaptation, as an example, because it is the area that adaptive presentation research is focused.

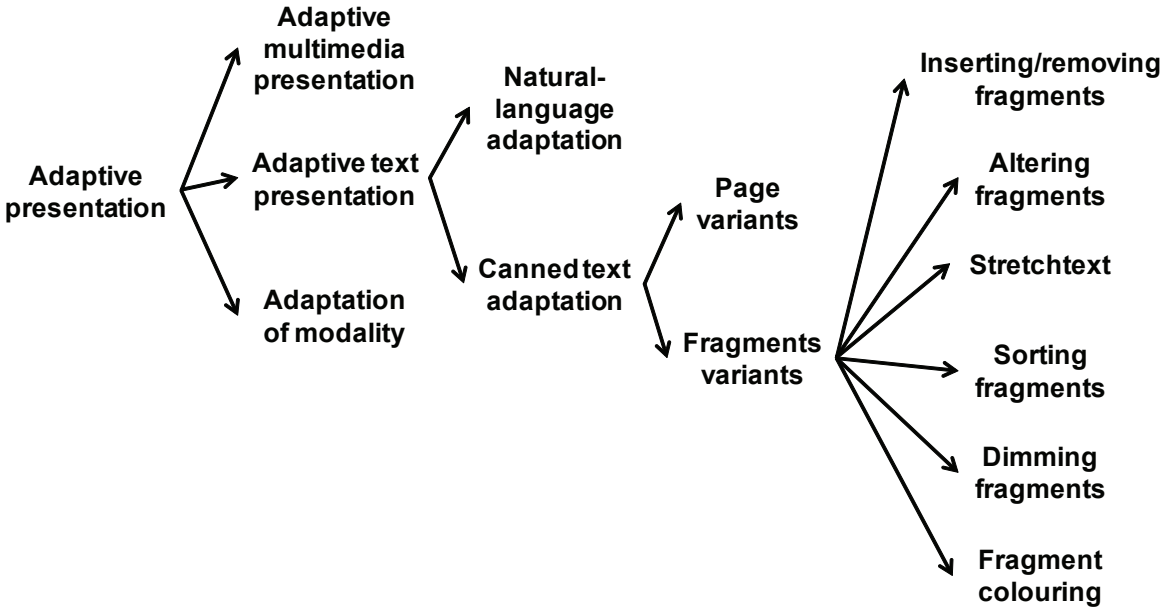


Figure 3.1: Adaptive Presentation Techniques

Canned text adaptation consists of the following techniques:

- **Page Variants**: Different versions of all possible adaptive variations may be stored in the system, and the particular page selected at run time [Kobsa et. al., 2001]. One common case where this occurs is for multi-lingual websites, where a version for each web page, translated into each language, is stored and then selected based on the user's language preference.
- **Fragment Variants**: Similar to the technique of page variants this technique stores content fragments (or atoms) and selects the appropriate fragments at runtime, assembling them into a static page when needed [De Bra et. al., 2005]. This technique can readily be seen for any site which has easily separable atoms of content, such as news sites [Ardissono et. al., 2001].

The meaning of concrete presentation techniques (cf. most right part of Figure 3.1) is straightforward. We just provide several examples:

- **Inserting or Removing Fragments**: Among the many ways of performing adaptation to text, the technique of inserting or removing fragments is the most popular. With the use of it all the available information about a concept is divided into several fragments of text (or multimedia content). With each fragment a (Boolean) condition is associated on elements of the user model. When displaying a page about the concept, the system only presents the fragments for which the condition is true.
- **Dimming Fragments**: There are many ways in which some information can be emphasized or deemphasized. Less important or urgent information can be presented using a smaller

font, in a sidebar, as a footnote, as a pop-up activated when you move the mouse over a tooltip icon, etc.

- **Fragment Coloring**: This technique colors fragments to highlight which ones are important and de-emphasize those which are irrelevant. In this case, the content of the pages is the same for all users; this avoids the problem of an incorrect characterization of a user having too negative an impact on his/her experience [De Bra et. al., 2005].

3.5.1.3 Navigation

Adaptation of navigation realizes adaptation by changing the links of the system [Kobsa et. al., 2001]. This adaptation speeds up the search for a particular page and helps to avoid the problem of users lost in hyperspace. There are several techniques to realize adaptation of navigation that are represented in Figure 3.2.

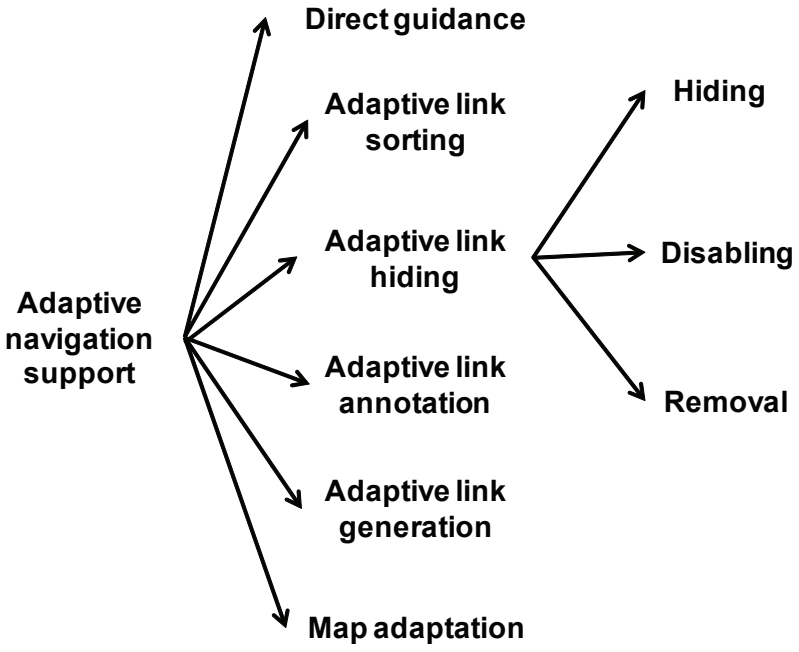


Figure 3.2: Adaptive Link (Navigation Support) Techniques

- **Direct Guidance** ([Brusilovsky, 2007], [Brusilovsky, 1997]): is a technique to offer users a possibility to be guided as in a guided tour. Typically a “next” button invites the user to go to the “next” page. But unlike in a static guided tour the adaptive system determines the destination of that “next” button, so different users may go to a different page when clicking on the “next” button on the same page and when a user revisits a page the “next” button on that page may take him/her to a different page than the previous time. Of course

direct guidance can also be more subtle. Apart from buttons that clearly lead to a tour, other links on a page may also have adaptively determined link destinations. The user may have the impression that there is a lot more navigational freedom than is actually the case, because links may not lead to where he/she thinks they do.

- **Adaptive Link Sorting**: This technique first selects the most relevant pages based on the users' interests or goals, then sorts them based on their relevance, finally presents them to the users as an ordered list of hypertext links. The most relevant link is always presented first, but if the user is not happy with this link for some reason, he or she can try the second and the following suggested links [Kobsa et. al., 2001]. However, this technique has two problems (i) it is hard to use for indexes and content pages, and (ii) it cannot be used with non-contextual links and maps. The order of links may also change frequently as the user visits pages, possibly contributing to a user's disorientation [Brusilovsky, 1996].
- **Adaptive Link Hiding Guidance** ([Brusilovsky, 2007], [Kobsa et. al., 2001]): means that links, which are not considered relevant to the user (at a specific time), are hidden, disabled or removed in some way. Link hiding means that the link anchor cannot be seen as being a link anchor. When the text on a page is black, a black link anchor not underlined, looks just like plain text. If the link is still there many browsers will show a special cursor when the mouse pointer is moved over the anchor. The link can also be disabled [Kobsa et. al., 2001], meaning that the anchor text is no longer a link anchor. On the web this is easy to realize by removing the anchor tag. However, that performs hiding as well as disabling. It is possible to use font color and optionally underlining to make the anchor still look like a link anchor, but this is seldom done because it is frustrating for users to see link anchors that do not work as links. Adaptive link removal [Brusilovsky, 1997] means that the anchor text (for undesired links) is removed, thereby automatically disabling the link as well. Link removal can easily be done in a list of links, but not in running text because removing words from the text may seriously alter its meaning and also disrupt the reading process (especially if sentences with words removed are no longer valid sentences). When asked in an informal setting a large majority of users has indicated that they preferred links in a list to be annotated or "hidden", but not removed.
- **Adaptive Link Annotation** ([Brusilovsky, 2007], [Joachims et. al., 1997], [Weber and Specht, 1997]): is the most popular link adaptation technique. It is the least restrictive technique: all the links are accessible. Annotations are used to indicate how interesting the link is for user, at the time of reading the page containing the link. Many systems use some kind of icon in front of or behind the link anchor to indicate the relevance of the link. Since the Web has been extended with style sheets it has also become possible to use the color of the link anchor itself as an annotation. This is not without drawbacks: some users are so used to links on the Web being blue or purple that they do not recognize words in other colors as being link anchors.

- **Adaptive Link Generation**: goes one step further and not only generates link destinations but the link anchors as well. There are many ways in which the system can decide to create new links. In open hypermedia all links are always generated. This is done by matching text on a page with a database of links. Adaptive link generation can also be based on the discovery of similarities between (the topics of) pages. This is certainly adaptive if it is done in pages from an open corpus of documents. The list of links that result from a search request in information retrieval or filtering systems is also adaptively generated.
- **Map Adaptation**: In order to give to the user an idea of the whole hyperspace, and some orientation support regarding where the user is in this space, many applications offer some kind of map. Websites often offer a textual sitemap, mostly because this is easy to generate. A graphical map, preferably based on conceptual relationships rather than link relationships, is a better tool for giving insight into the application's structure. However, maps are often too large to be insightful. A map can adaptively be reduced so that the user can still grasp the overall picture. Nodes on the map can also be annotated to indicate relevance, to indicate where the user has gone before, and perhaps even to indicate where other users have gone.

3.5.1.4 Structure

It is also possible for an adaptive system to modify the long-term structure of the website in a "permanent" fashion, rather than the per-request temporary fashion suggested above. Usually, the final decision to add or remove a page or atom should be ultimately made by some human administrator, but the indication of whether it should be added or dropped can be made by the system. In this way, the adaptive system can be viewed as a tool to help the administrator measure the effectiveness of a website.

Several indications may be given by the system, including:

- **New Index Pages**: Based on the perceived common viewing patterns of a group of users, the system might suggest new index pages which capture links serving as a central point to support that group [Perkowitz and Etzioni, 1998].
- **Measurement of Use of a Set of Pages**: By generating statistics about commonly viewed pages and subsets of pages, the administrators will be more informed about whether the viewing pattern matches their expectations. Pages which are included in some groups might actually be omitted, indicating that those pages are incorrectly promoted or linked, for example.
- **Permanent New Link Suggestions**: The system might suggest that certain links between pages should be made permanent for similar reasons to the suggestion above, that they could be added for individual page views.

While the adaptation of links might also be seen as the adaptation of the structure of a website, such adaptations are of a short-term time period and have little lasting impact on the website beyond an individual browsing session. Also, normal, short-term adaptations can not change the form and structure of image maps, which would require a human administrator to accomplish [Brusilovsky, 1996].

3.5.2 Adaptation Techniques

The techniques available to collect information about users, and the methods used to process such information to create user profiles and provide adapted content, presentation and/or structure, vary. Most web personalization techniques fall into four major categories: content-based filtering, collaborative filtering, rule-based filtering and web usage mining. A brief description of the aforementioned techniques and methods is provided in this section.

3.5.2.1 Content-based filtering

Content-based filtering systems recommend items to users (such as content, services, and products) like the ones they preferred in the past. Content-based methods analyze the common features among the items a user has already rated highly. Only the items similar to user's past preferences are then recommended. In other words these systems are solely based on individual users' preferences [Pazzani and Billsus, 2007], as they use correlations between the content of the items and the user's preferences in order to build the user model and adapt to the individual user. All of the content-based approaches represent items by the "important" words in the items.

Content-based filtering is a technique that has been used mainly in the context of recommending items such as books, web pages, news, etc. for which informative content descriptors exist [Pazzani, 1999], [Basilico and Hofmann, 2004]. An example of a content-based filtering system is NewsWeeder [Lang, 1995]. In the case of NewsWeeder the user provides active feedback by rating articles on a scale of 1 to 5. The process of building a profile for a user requires the transformation of each article into a bag or words representation, with each token being assigned a weight using some learning method [Mobasher and Anand, 2005]. In this way the content of the article is represented with a set of terms. The system uses then this profile in order to recommend articles to the user. Another example, in the context of an online museum, is the following: if a user shows an interest in paintings of a particular style or period, or by a particular artist, links to other related pictures are presented [Bowen and Fantoni, 2004].

Content-based filtering systems build an individual model of user likes and dislikes and use this profile to predict/tailor future interactions with that user. The major disadvantages of this

technique are content limitations and over-specialization. The content limitation weakness is related to the fact that the system depends on the availability of content descriptions of the items being recommended [Mobasher and Anand, 2005]. But IR (Information Retrieval) methods, which are used for the creation of content descriptions, can only be applied to a few kinds of content, such as text and image and furthermore they can only capture certain aspects of the content. Concerning the over-specialization issue, the provided recommendations are merely based on individual user profiles; therefore, users have no chance of exploring new items that are not similar to those items included in their profiles [Germanakos et. al., 2005b]. This lack of serendipity leads to over-specialization.

On the other hand, the advantage of this approach is that it can be implemented on the client side, resulting in reduced worries about user privacy [Mobasher and Anand, 2005].

3.5.2.2 Collaborative filtering

Collaborative filtering systems invite users to rate the objects or divulge their preferences and interests and then return information that is predicted to be of interest to them. These systems make automatic predictions (filtering) about the interests of a user by collecting preferences from many users (collaborating) and then recommend items to the user that people with similar tastes and preferences have liked in the past. The basic idea underlying collaborative systems is that the adaptation is based on the experiences of a population of users, rather than on an individual user profile. This is based on the assumption that users with similar behaviour (e.g., users that rate similar objects) have analogous interests and that those who agreed in the past tend to agree again in the future [Schafer et. al., 2007].

Collaborative filtering systems usually take two steps:

- Look for users who share the same rating patterns with the active user (the user who the prediction is for), i.e. for users that have provided similar feedback to a large number of the items that have been consumed by the active user. This group of users is called the neighbourhood of active user, in collaboration filtering terminology.
- Use the ratings from those like-minded users found in the first step to calculate a prediction for the active user. Items that have been consumed by likeminded users but not by the current user are candidates for recommendation.

A typical example of the use of this technique is Amazon (http://www.amazon.com), which determines a user's interests from previous purchases as well as from ratings given to titles [Linden et. al., 2003]. The user's interests are compared to those of other customers to generate titles that are then recommended during interaction. Other examples of systems that incorporate collaborative filtering techniques are GroupLens [Resnick et. al., 1994], Ringo [Shardanand and Maes, 1995] and Net Perceptions [Netperceptions, 2007].

In contrast to content-based filtering, the collaborative filtering technique does not use

the actual content of the items for recommendation [Germanakos et. al., 2005b], and hence it overcomes the drawbacks of the content-based filtering that have been mentioned in the previous section. Nevertheless, a collaborative filtering system suffers from two major disadvantages: the new item rating problem and the new user problem. The first problem is related to the system's inability to provide recommendations or predictions for new or recently added items. This inability comes up because of the reliance on the availability of ratings for any item prior to it being recommendable. In other words, a user's rating on a new item cannot be compared with the ratings of other users on the same item [Mobasher et. al., 2004]. The new user problem, on the other hand, is related to the fact that a new user needs to rate a number of items before he can start to obtain useful recommendations from the system.

3.5.2.3 Rule based filtering

Rules-based personalization is the delivery of personalized content based on the subjection of a user's profile to a set of rules or assumptions [Deitel et. al., 2004]. The rules are used to affect the content served to a particular user, based on relationship analysis. Rules-based personalization systems use business logic embedded in conditional (if/then) statements to create content display. Under rules-based personalization, a user's known preferences fulfill certain criteria, and corresponding content is served accordingly. A system administrator typically uses a visual interface to input if/then criteria, specifying each condition and the content which should be recommended in response. These rules can be straightforward and simple, like a single keyword, or balanced and complex (equal weights) using multiple keywords and Boolean operators.

For example, association rules could explicitly encode the fact that users who visit two pages may also be likely to be interested in the third related page. More concretely, an interest in albums of Scorpions and Pink Floyd could potentially demonstrate a general interest in rock. Examples of systems that belong to this category are Yahoo!'s personalization engine [Manber et. al., 2000] and Broadvision [Broadvision, 2007].

This kind of personalisation presupposes the existence of rules, which constitutes an inherent drawback of the specific approach, as manual creation of rules is time-consuming and their creation depends on users knowing in advance the content that interests them. This drawback has been partially outreached by using automatic rule extraction. For instance, geographical locations can be derived from IP-addresses. Such rules can consequently be used when filtering or adding certain elements from or to the set of returned information. On the other hand, the primary benefit of this approach lies in its ability to directly link organizational strategy or policy to customer interactions.

Content-based, rule-based, and collaborative filtering may also be used in combination, for deducing more accurate conclusions.

3.5.2.4 Web usage mining

Web usage mining techniques rely on the application of statistical and data mining methods (e.g. association rule mining, sequential pattern discovery, clustering, and classification) to the web log data, resulting in a set of useful patterns that indicate users' navigational behavior. These patterns are used in order to predict user behavior and provide personalized experience while users interact with the Web [Wang and Shao, 2004].

Web server logs provide an abundant collection of data, by recording interactions of users within the website, in other words, by recording the way that the website is used. This collection of data may be described in terms of simple page views, transactions (which are "significant" events, and may combine multiple page views), and sessions (which are a combination of page views or transactions that together represent an individual users' experience) [Cooley et. al., 1999]. In addition to the simple sequence of events, information about time of access and frequency of access is also useful. User's interests can be identified from the pages they visit and the amount of time they spend on them. Revisiting a certain page and spending more time on it may be considered for example as an indication of strong interest in that page [Lieberman, 1995].

A typical example of the use of this technique is the WebPersonalizer system [Mobasher et. al, 2000]. It provides a list of recommended hypertext links to a user while browsing through a Web site, by relying solely on anonymous usage data provided by web server logs and the hypertext structure of a site. Other noteworthy applications are Alta-Vista, Lycos, WebSift, and SpeedTracer [Eirinaki and Vazirgiannis, 2003], [Pierakkos et. al., 2001].

Web usage mining has several advantages over traditional personalization techniques [Mobasher et. al., 2000b]. For example, it can dynamically develop user profiles from user patterns while reducing the need to explicitly obtain subjective user ratings or registration-based personal preferences, which are prone to biases [Sung, 2002]. In this way the system performance does not degrade over time as the profiles age. Additionally, traditional web personalization techniques, including collaborative or content-based filtering, have the problem of reliance on subject user ratings, which does not exist in web usage mining.

On the other hand, web usage mining can be problematic when little usage data is available pertaining to some objects, or when the content attributes of a site must be integrated into a Web mining framework and used by the recommendation engine in a uniform manner [Mobasher et. al., 2000c], [Mobasher et. al., 2000d].

PART II

THE PROPOSED FRAMEWORK AND SYSTEM

4 THE PROPOSED FRAMEWORK

This Chapter describes the proposed framework for adaptive evaluation of portal and e-service quality by users. First, an overview of the framework is given in section 4.1 and then the various components of the framework are described in section 4.2. The Chapter concludes in section 4.3, with a discussion about the positioning of the framework in relation to the theoretical foundations of the present thesis that were discussed in Chapters 2 and 3.

4.1 Overview of the Proposed Framework

As already mentioned in Chapter 1, traditional methods for measuring portal and e-service quality, suffer from qualitative and quantitative challenges. Such methods follow a “one size fits all” approach, in the sense that the user context and the user behaviour in the portal are not taken into account during quality evaluation by users. This means that all users visiting the portal in order to satisfy their information or service consumption needs are treated in the same way: they are all presented with the same set of questions which are used for collecting their feedback about the quality of the portal and its e-services. Further, such methods usually suffer from small user participation and may result in the collection of user feedback which has little exploitability potential for service providers.

This Chapter describes the proposed framework which aims at the improvement of the existing quality measuring methods. The objectives of the proposed framework are to increase the relevance of the presented questions to the users’ context and encountered problems, to increase the users’ participation in the survey about the quality of the portal and e-services, as well as to increase the service provider’s satisfaction about the quality of the users’ feedback collected through the survey. The proposed framework, which is depicted schematically in Figure 4.1, meets these objectives by describing the models, methods and tools allowing an adaptive evaluation of portal and e-service quality by users. Adaptive evaluation of quality means that the questionnaire used for collecting the users’ feedback about quality is composed dynamically for each individual user. The list of questions given to each user is not fixed, but adapted to the current user based on some criteria. This would allow individual users to put emphasis only on those quality aspects that are related to the problems they encounter during

their navigation in the portal and the characteristics of the portal they visit. Such an adaptive evaluation would additionally offer more and better data that could then be used as input for supporting quality improvement decisions made by service providers.

As can be seen in Figure 4.1 the adaptation of the questionnaire in the proposed framework is based on three criteria: a) the *User Feedback*, i.e. the feedback that a user has provided to previously submitted questions, b) the *User Problems*, i.e. the problems that a user has encountered during his/her interaction with the portal and c) the *Visited Content*, i.e. the user's browsing behaviour with regard to the visited content.

The *User Feedback* reflects user's point of view regarding the quality of the portal and its e-services and is provided through the *Questionnaire*. The questions contained in the questionnaire correspond to quality aspects of the portal and e-services that are important for users and affect their opinion concerning portal and e-service quality. These quality aspects are specified in an *e-Service Quality Model* which is responsible for defining what to measure as far as quality is concerned.

The *User Problems* as well as the *Visited Content* are derived by taking into account user interactions with the portal. The user interacts with the portal in order to consume information or services provided by it. The framework suggests annotating the portal's web objects (e.g. pages) and services with semantic information and then tracking the semantically enriched user interactions, in order to detect possible problems that the user may encounter during the interaction and in order to derive the semantics of the visited content. User tracking and problem detection are achieved with the help of ontologies describing the semantics of the web objects and rules specifying user behaviors that might indicate problems.

Based on the user feedback, the detected user problems and the metadata of the content that the user has visited, the *Questionnaire* is dynamically composed and presented to the current user. The *Adaptation Logic* drives the adaptation process by defining in details how, in what order, and which of the three adaptation types (user feedback, user problems and visited content) will be applied in each case. The Adaptation Logic uses an *Ontology-based Data Model* which defines all the essential concepts playing a significant role in the adaptive quality measurement.

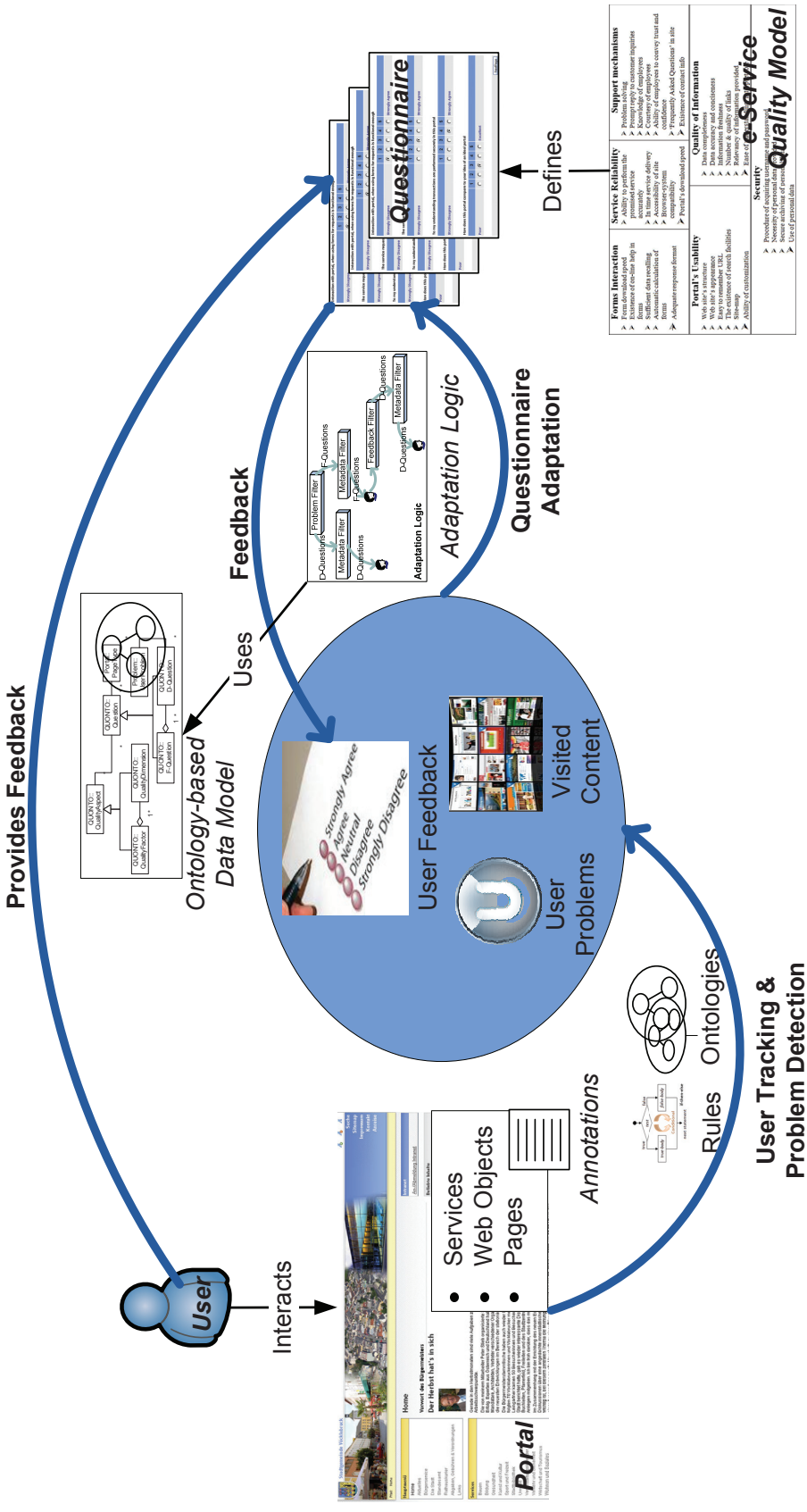


Figure 4.1: The Proposed Framework

4.2 Major Framework Components

In this section the major components of the proposed framework for adaptive evaluation of portal and e-service quality are described. The description is based on the research method that was followed in order to develop the proposed framework. The research method involves the development of models, instruments and methods required for addressing the issues implied in section 4.1 where an overview of the framework was given. These issues are:

- What quality aspects to measure?
- Which instrument to use for measuring the quality aspects influencing user satisfaction?
- Which adaptation criteria to use for adapting the questionnaire to the individual?
- On which data to base the adaptation on?

By addressing these issues, concrete research results, which are part of the proposed framework discussed previously (see Figure 4.1), came up. The research method followed, including the research results as well as the relation of the results with the aforementioned issues can be seen in Figure 4.2.

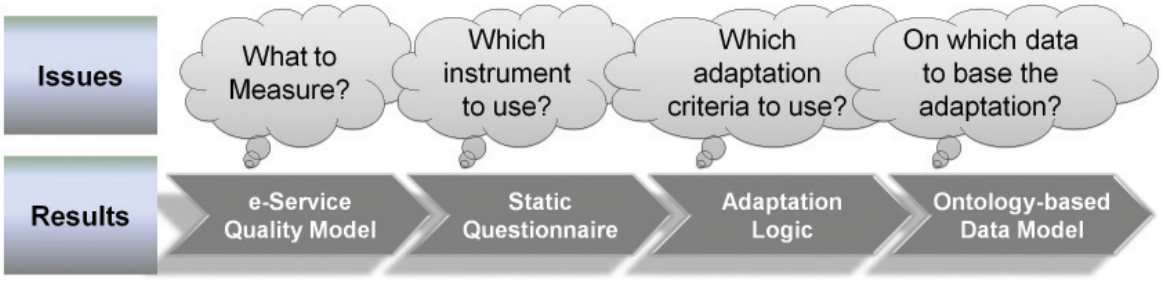


Figure 4.2: The Research Method

In order to answer the question about what to measure, quality aspects that play an important role in user satisfaction with respect to portals and e-services, were defined. This resulted in the development of an e-service quality model that defines quality in the domain of portals and e-services. For measuring the quality aspects defined in the quality model, a measuring instrument was developed. This resulted in a valid and reliable but static questionnaire which contains statements about the various quality aspects. These statements are used by the users in order to provide their feedback. The adaptation logic defines the adaptation criteria used for composing a personalized questionnaire to the individual user, as well as the sequence in which these criteria are applied to the various cases. Finally the ontology-based data model, hereafter referred to as MAQM (Model for Adaptive Quality

Measurement), specifies the concepts and data used by the adaptation logic for adapting the questionnaire.

In the rest of this section, we examine for each issue the actions taken for addressing it, as well as the results of these actions. It should be noted that although an overview of the e-Service quality model is given below, it is discussed in more details in Chapter 5. Moreover, the results regarding the various systems and subsystems implementing the proposed approach are not shown in Figure 4.2, as they are detailed in Chapter 6.

4.2.1 What to Measure?

The first issue is about what should be measured, i.e. which characteristics of the portal or of the e-services delivered through it, are important for users and guide their satisfaction. In order to address this issue, a comprehensive literature review on the topic of quality of portals and e-services was conducted (see Chapter 2), which formed the basis for the development of the quality model. The process followed in order to come up with the quality model based on the literature review is detailed in Chapter 5. The initial quality model, which was developed by synthesizing and extending the relevant literature, was empirically evaluated in terms of validity and reliability in the portal of the Greek Ministry of Interior, resulting in a second refined version. The refinement and validation process, as well as the importance of using valid and reliable instruments are also discussed in Chapter 5.

The result of the aforementioned processes was the development of the quality model depicted in Table 4.1 which can be used for measuring portal and e-service quality in a valid and reliable manner. As can be seen in the table, the model has a hierarchical structure and includes all the quality factors and dimensions influencing users' perceptions regarding the quality of the portal and e-services. Quality factors and dimensions are both quality aspects; however, they examine quality in different levels of abstraction. Each quality factor corresponds to a high level quality aspect and consists of one or more quality dimensions. For example, data completeness and information freshness are quality dimensions of the information quality factor.

Table 4.1: The Quality Model

Forms Interaction	Service Reliability	Support mechanisms
➢ Existence of on-line help in forms ➢ Sufficient data recalling ➢ Automatic calculation of forms	➢ Ability to perform the promised service accurately ➢ In time service delivery ➢ Accessibility of site ➢ Browser-system compatibility ➢ Download speed ➢ Form download speed	➢ Problem solving ➢ Prompt reply to customer inquiries ➢ Knowledge of employees ➢ Courtesy of employees ➢ Ability of employees to convey trust and confidence ➢ 'Frequently Asked Questions' in site ➢ The existence of contact information

Portal's Usability	Quality of Information
➢ Web site's structure ➢ Web site's appearance ➢ The existence of search facilities ➢ Site-map ➢ Ability of customization	➢ Data completeness ➢ Data accuracy and conciseness ➢ Information freshness ➢ Relevancy of information provided ➢ Ease of understanding/ Interpretable

Security
➢ Procedure of acquiring username and password ➢ Necessity of personal data provided ➢ Secure archiving of personal data ➢ Use of personal data

A detailed definition of all quality factors and dimensions is given in section 5.1.5.

4.2.2 Which Instrument to Use for Measuring Quality?

In order to address this issue, we used as basis the quality model and developed a set of questions/statements which are used for measuring user satisfaction regarding each one of the quality dimensions and factors. The relation between statements and quality dimensions/ factors is one by one, meaning that for each quality dimension/factor, one relevant statement has been added to the questionnaire. In this way the questionnaire operationalized all the quality factors and dimensions of the quality model. Special attention was given to the wording of statements, so that each statement represents the relevant quality dimensions and factors as precisely as possible.

The questions/statements reflecting the hierarchical structure of the quality model were formed in such a way that the user could agree or disagree with each one on a five point Likert scale [Likert, 1932]. Factor level (F-level) questions measure quality in a high level, while dimension level (D-level) questions examine in more detail the issue addressed by the relevant factor. For example the F-level question regarding portal usability, is further examined

by D-level questions concerning portal's structure and layout, search engine's effectiveness and so on. In this way we came up with an instrument (questionnaire) for measuring the quality of portals and e-services.

The whole questionnaire is available in Annex A. The structure of the questionnaire with respect to F-level questions is as follows:

- Question 1 aims at measuring the portal's usability and specifically how easy the use of the portal is.
- Question 2 aims at measuring the portal's quality of information and specifically the portal's content in terms of quality.
- Question 3 aims at measuring the portal's forms interaction quality factor and specifically the functionality of the request forms.
- Question 4 aims at measuring the portal's service reliability and specifically the accuracy and in-time service delivery.
- Question 5 aims at measuring the portal's support mechanisms for resolving users' problems such as the help desk, e-mail, FAQs etc.
- Question 6 aims at measuring the portal's security and specifically the users' understanding regarding the security of the transactions taking place in the portal.

In addition to the questions aiming at measuring the perceived quality of the portal user, based on quality factors and dimensions of the Quality Model, the questionnaire contains one more F-level question as well as some demographic questions.

With respect to the additional F-level question (Question 7), it measures the gap between users' expectations for excellence regarding a portal and their perception about the actual portal. Particularly, it aims at identifying or investigating how the portal is compared to users' idea of an ideal portal. The relevant D-level questions of this F-level question are available in Annex A. The purpose of this specific category of F-level and D-level questions is to enable the extraction of weights of importance for each one of the quality factors (see section 8.1.7, where guidelines are given with respect to the interpretation of user responses, for more details on that).

As far as the demographic questions are concerned, they aim at gaining a better understanding of the participating users:

- Question 8 aims at identifying the profile of the user.
- Question 9 refers to the user's age.
- Question 10 refers to the education of the user.
- Question 11 aims at determining the level of internet use by the visitor of the portal.

4.2.3 Which Adaptation Criteria to Use?

Another issue that should be addressed is about which user particularities to take into account for presenting instrument's questions in a personalized manner. As already mentioned in section 4.1, the adaptation of the questionnaire is based on three criteria, or in other words it is performed across three adaptation axes:

- **Real-time user feedback**. Previously submitted responses of an individual are taken into account for adapting the questionnaire to him/her.
- **User problems**. The problems that a user encounters during his/her interaction with the portal are the driving force behind this adaptation type.
- **Page metadata**. The questions presented to two users, who have visited different types of pages during their interaction with the portal, differ.

In the following, we describe how each criterion is used and how these three criteria are combined and embedded in the adaptation logic of the adaptive questionnaire.

4.2.3.1 Adaptation Based on Real-Time User Feedback

The first adaptation criterion is the feedback given by users while filling in the questionnaire in order to express their opinions about the quality of the portal and the provided e-services. According to this criterion or adaptation axis, when a user evaluates an F-level question with a low grade, the relevant D-level questions are incorporated in the questionnaire. In other words, the feedback given by users at runtime regarding their perceptions about the various quality factors is the driving force behind this type of adaptation. The idea of this mechanism is that a low grade for an F-level question implies that the user's perceived quality of the corresponding quality factor is low; however it is not possible for the service provider to figure out which quality dimensions are responsible for this poor quality and thus initiate the appropriate actions for quality improvement. This is resolved by the introduction of the D-level questions that examine which quality dimension(s) is responsible for that. For example, in case a user is dissatisfied with portal's usability, the relevant D-level questions are presented dynamically in order to examine whether this is attributed to the poor portal's structure, the poor layout, the ineffectiveness of the search engine and so on.

4.2.3.2 Adaptation Based on User Problems

The dynamic composition of questionnaires is not based only on user's feedback to F-level questions. Another criterion used for the selection of questions that will be presented to a user, is the problems that he/she encounters during his/her navigation or while consuming

an e-service, as detected by the system (detection of user problems is discussed in section 6.6).

More specifically, for each problem detected, the e-questionnaire presents D-level questions that are related to it, in order to examine the problem's root cause. This mechanism implies a semantic relationship of D-level questions with possible user problems; this knowledge is available into instantiations of the MAMQ model (please see section 4.2.4 below for a detailed description of MAQM). For example, a navigation problem is related to navigation questions, so, if a navigation problem has been detected for a user, only D-level questions relevant to navigation are presented. The purpose of this mechanism is to get user feedback for the problematic quality aspects, reducing the need for many questions, as users answer only questions which relate to the specific problems. Hence, the required time for answering questions is reduced, the questionnaire is adapted to the needs of the user and furthermore the user feedback is targeted to the specific problem. Examples of mappings between D-level questions and user problems are depicted in Table 4.2.

Table 4.2: Examples of Mappings between User Problems and D-Level Questions

Problem	D-Level Questions
Finding Service/ Navigation Problem	This portal's structure is clear and easy to follow.
	This portal's search engine is effective.
	This portal's site map is well organized
Form Problem	Forms in this portal are downloaded quickly.
	Automatic recalling of user's personal data within forms is satisfactory.
	The level of automatic calculation within the portal's forms is satisfactory.
	Information about a field's completion in this portal is enough.
	This portal works properly with your default browser.
Presentation Problem	This portal's layout is pleasant, clean and functional
	This portal is well customized to individual users needs.
	This portal works properly with your default browser.
Service Problem	This portal is well customized to individual users needs.
	The information displayed in this portal is detailed enough.

4.2.3.3 Adaptation Based on Metadata of Visited Pages

A third criterion used for the selection of questions that will be presented to a user, is the metadata of the pages that he/she has visited during the session. There are some quality aspects and therefore questions of the questionnaire, intended to evaluate specific parts of the portal, implementing specific functionalities. But the majority of user sessions concerns a small portion of the portal's pages, so there is a high possibility that a user is asked about

something that he has not met or consumed during his/her session. This situation is far from perfect for both users and service providers; on the one hand it discourages users to provide their feedback through the questionnaire, while on the other hand service providers may collect feedback with questionable validity.

According to the metadata-based adaptation criterion, the above mentioned issues are addressed, as the questions related to non-visited page types are filtered out. The MAMQ model, described in section 4.2.4, relates each page type to one or more quality aspects, and therefore questions, at different levels of abstraction (i.e. D-level questions as well as F-level questions). For example associations between the search engine of a portal and the F-level question about usability as well as the D-level question about the effectiveness of the search functionality are defined. Questions about the search engine are not presented in case the user has not used the search functionalities at his/her session. Yet, another example are questions concerning forms used for submission of information which are presented only in case of a user session that includes forms. Table 4.3 depicts some examples of mappings between questions and portal's page types.

It should be noted that the basis for this adaptation type is the annotation of portal pages with the page types they contain. One web page can be annotated with as many types as applicable. This is done with a portal annotator tool as described in section 6.4.

Table 4.3: Examples of Mappings between Questions and Visited Page Types

F-Level Question	D-Level Questions	Related Page Type
Portal's usability	This portal's search engine is effective.	search engine page
	This portal's site map is well organized	site map page
Forms Interaction	Automatic recalling of user's personal data within portal's forms is satisfactory.	forms page
	The level of automatic calculation within portal's forms is satisfactory.	
	Information about field's completion in this portal is enough.	
Support mechanisms	This portal provides contact information	contact info page
	Employees showed a sincere interest in solving users' problem.	
	Employees give prompt replies to users' inquiries.	
	Employees have the knowledge to answer users' questions.	
	Employees are courteous	
	Employees have the ability to convey trust and confidence	
	The FAQ section of this portal covered completely the topic that you were interested in.	FAQ page

Security	Acquisition of username and password in this portal is secure.	login page
	Only necessary personal data are provided for authentication in this portal.	
Service Reliability	Forms in this portal are downloaded in short time.	forms page

4.2.3.4 Adaptation Logic

Figure 4.3 depicts the proposed adaptation logic, focusing on the sequence in which the three adaptation criteria or axes are applied. These adaptation criteria can be seen as filters of questions which take as input questions (either F-level or D-level) as well as knowledge related to the user context (i.e. user problems, metadata of visited pages) and filter out questions letting only questions fulfilling specific criteria pass through. At this point we consider that the tracking of visited pages and detection of user problems, as described in section 4.1, have been completed (please see section 6.6 for more details on that).

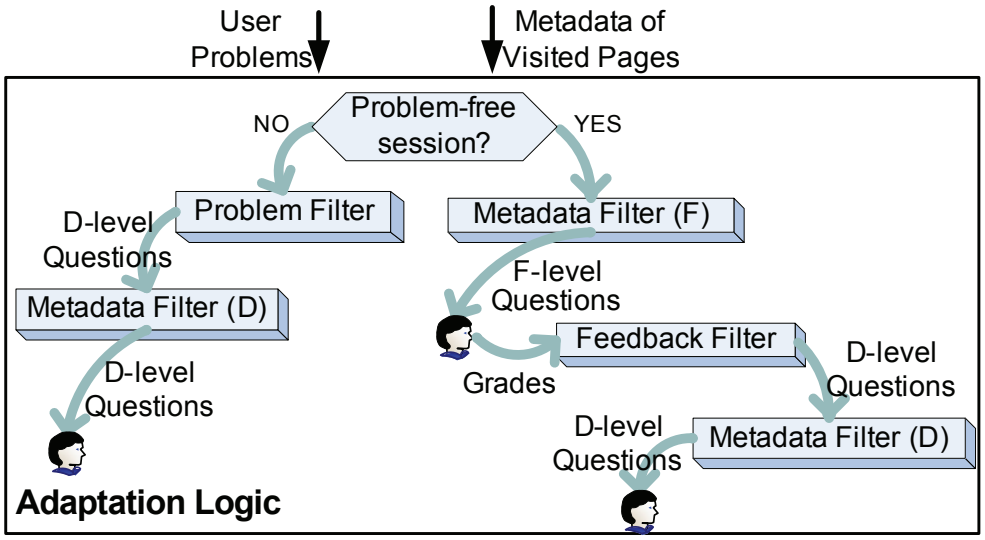


Figure 4.3: Adaptation Logic

As can be seen in Figure 4.3, the adaptation path followed depends on whether the user has experienced a problem-free session or not. If at least one user problem has been detected during the user's navigation on the portal (left path of Figure 4.3), the questionnaire is first adapted to these problems, i.e. the problem filter selects the D-level questions associated to the problem(s), and then the metadata filter for D-level questions, i.e. the "D-level metadata filter", is applied, in order to filter out D-level questions related to page types the user has not visited. The D-level questions that have not been filtered out from the sequential application of

the problem and the D-level metadata filter are finally presented to the user. The logic applied by the problem filter as well as the metadata filter for D-level questions is depicted in the flow charts of Figure 4.4a and Figure 4.4b respectively. These flow charts are actually a zoomed in view of the corresponding boxes of Figure 4.3.

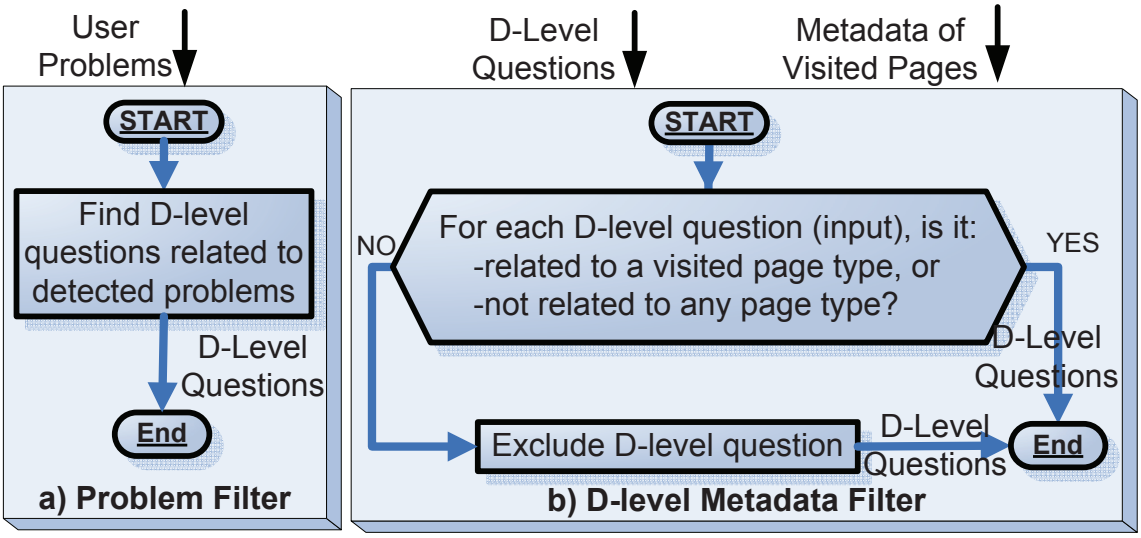


Figure 4.4: a) Problem Filter Logic and b) Logic of the D-level Metadata Filter

If no user problem was detected, i.e. the user has experienced a problem-free session (right path of Figure 4.3), the questionnaire would be first adapted to the metadata of the pages that the user has visited during his/her session. That is, the metadata filter for F-level questions, selects F-level questions having at least one corresponding D-level question which has one of the following characteristics (see the flowchart of Figure 4.5a, which provides a zoomed in view of the Metadata Filter (F) box of Figure 4.3):

- It is not related to a specific page type, or
- It is related to one or more specific page types and the user has visited at least one page of these types during her/his session.

In other words an F-level question is not filtered out in case that at least one of the corresponding D-level questions passes through the metadata filter for D-level questions, i.e. the D-level Metadata Filter. In this way, it is guaranteed that the adaptation of F-level questions does not dominate the adaptation of D-level ones.

As can be seen in the right path of Figure 4.3, once the F-level questions are presented to the user and rated by him/her (= real time user feedback), if at least one of these questions is rated below a given threshold, the real time feedback filter selects the D-level questions corresponding to this F-level question, as depicted in the flow chart of Figure

4.5b. Each selected D-level question is then submitted to the page metadata filter for D-level questions in order to avoid its presentation if it is related to non-visited page types (see Figure 4.4b).

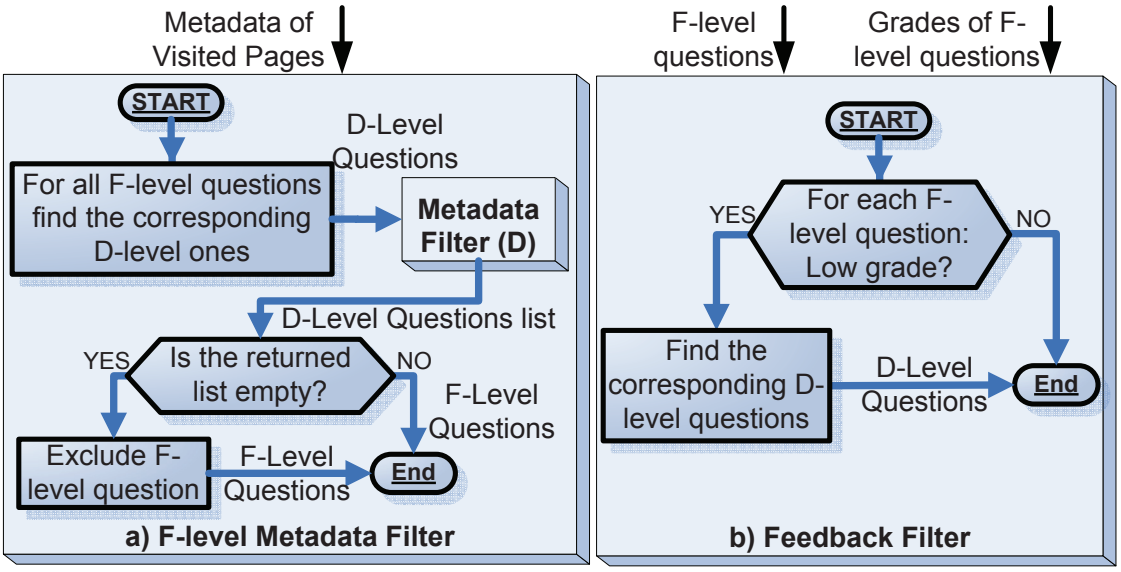


Figure 4.5: a) Logic of the F-level Metadata Filter and b) Feedback Filter Logic

A different schematic representation of the adaptation logic is finally provided by the high level flow chart of Figure 4.6, while detailed examples that enable a better comprehension of the adaptation logic are given in section 6.12, where a system walkthrough is described by considering two user scenarios.

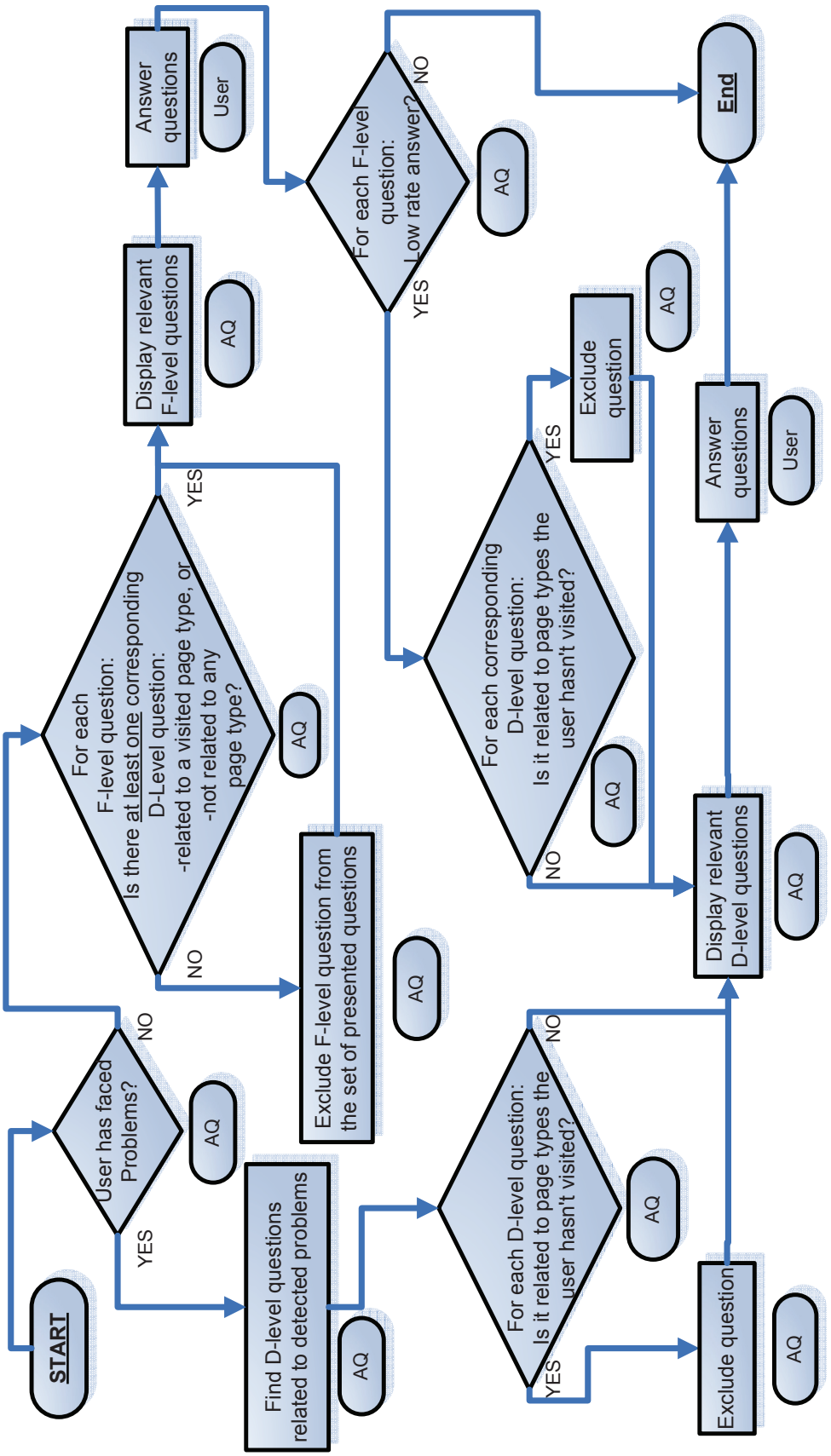


Figure 4.6: High Level Flowchart of Adaptation Logic. AQ = Adaptive Questionnaire

4.2.4 On which Data to Base the Adaptation?

The process of adapting the questionnaire to the individual user is supported by an ontology-based model. This model, hereafter referred to as *Model for Adaptive Quality Measurement (MAQM)*, represents all the essential concepts playing a significant role in the adaptive quality measurement. It comprises a large amount of concepts, ranging from generic knowledge about quality to specific problems encountered by users while navigating the portal or obtaining various e-services. Here we limit the description on the high-level concepts of the model, while a detailed description of the various ontologies comprising the model is given in sections 6.8 and 6.9. The core concepts covered include: (i) the quality aspects considered, (ii) the questions used for capturing user satisfaction about the various quality aspects, (iii) the types of the portal pages visited by users, (iv) the user behavior and (v) the problems encountered by users. Figure 4.7 depicts a conceptual UML diagram that shows the core model entities used as the knowledge base for adapting the questionnaire to the individual user.

The elements of the model are structured in four interrelated ontologies: a) a quality ontology which addresses the core concepts (i) and (ii), b) a portal ontology addressing the core concept (iii), c) a problem ontology covering the core concept (v) and d) a user ontology addressing (iv). The ontologies are showed as UML namespaces in Figure 4.7. It should be noted that the instantiation of the MAQM model with ontologies is only one of the potential instantiation methods. We decided to use ontologies mainly because of the need to detect user problems by monitoring user browsing behavior and because of ontologies' role as common reference models enabling interoperability between the two major components of the proposed system (for more details about this decision the reader is referred to sections 6.8.1 and 6.2.2 respectively).

As can be seen in Figure 4.7, an important part of MAQM describes the quality aspects, i.e. the characteristics of a portal or of the e-services delivered through it that are important for users and guide their satisfaction. The quality aspects are defined in a hierarchical quality model, the quality ontology (QUONTO) [Magoutas et. al., 2007], which is described in detail in section 6.9. The QUONTO ontology is a formal specification of the comprehensive quality model introduced in section 4.2.1. As already described, we applied a 'divide and conquer' strategy to the challenging task of quality evaluation by users, in the sense that we divided the quality aspects into specific *quality factors* and *dimensions* that address - in different levels of abstraction - the various quality aspects.

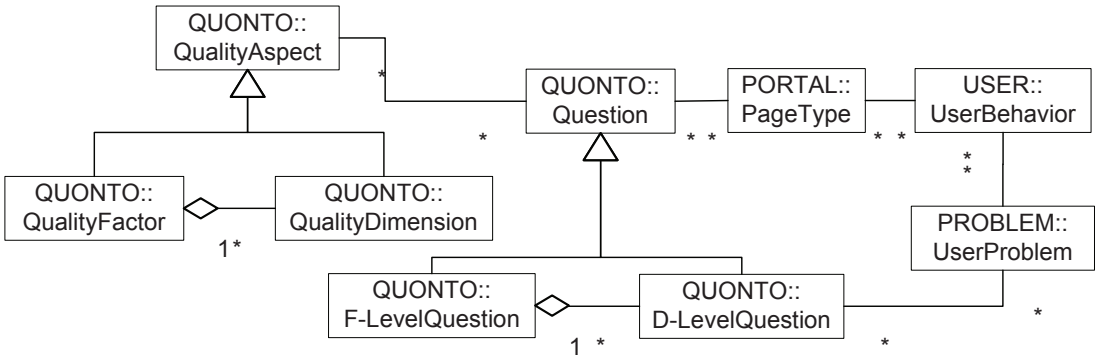


Figure 4.7: Core Classes of MAQM

As we aim to use close-ended opinion questionnaires, we represent also in MAQM the knowledge about the questions that enable the collection of user opinions, regarding each one of the quality dimensions and factors, according to his/her particularities. In other words the hierarchical structure of the quality model is reflected to factor level (*F-LevelQuestion*) and dimension level questions (*D-LevelQuestion*), as described in section 4.2.2. The distinction and the semantic relationships between F- and D-level questions, as defined in the MAQM model, enable the application of adaptation based on real-time user feedback which was discussed in section 4.2.3.1.

Since it is possible that participants may face problems during their interaction with the portal (e.g. navigation problems, service completion problems etc), a collection of typical problems has been modelled in the Problem Ontology. A given user problem is semantically related to one or more D-level questions which may examine in detail the problem's root cause. For example a navigation problem is related to D-level questions which examine whether the portal's structure is clear and easy to follow, the search engine is effective, or the site map is well organized. The semantic relationships between user problems and D-level questions, as defined in the MAQM model, enable the application of adaptation based on user problems (see section 4.2.3.2 above).

Since there are some questions intended to evaluate specific parts of the portal, implementing specific functionalities, we have incorporated in MAQM a typical set of such portal parts. The Web Portal ontology models the types of pages and the structural elements of a page. A portal part may be semantically related to one or more questions at different levels of abstraction (i.e. D-level questions as well as F-level Questions). For example, the search engine of a portal is related to the F-level Question about usability as well as to the D-level question about the effectiveness of the search functionality. The semantic relationships between portal parts and questions, as defined in the MAQM model, enable the application of adaptation based on metadata of visited pages (see section 4.2.3.3 above).

We should note that the MAQM represents the various portal parts as types of web pages, as we are using a portal annotation tool in order to populate the relevant Web Portal ontology – see section 6.4 for more details on this. One web page can be annotated with as many types as applicable. For example, a web page that enables users to login through a form is characterized as both *loginPage* and *formPage*.

The knowledge about the user's web usage behavior is represented in the MAQM by the User Ontology. The usage behavior of an individual user is defined by his/her clickstream data. A clickstream encompasses all user interactions with a web application as mouse movements, key strokes or page requests. A specific user browsing behavior may concern several parts of the portal modeled as page types and may indicate that he/she encounters specific problems during his/her navigation. Therefore, associations between user behavior and page types, as well as between user behavior and user problems have been incorporated in MAQM. It should be noted that the conceptual relation between user behavior and potential problems is operationalized in terms of rules indicating user problems for the various user behaviors (see section 6.6).

4.3 Positioning of the Framework

In this section we describe how the framework proposed in this Chapter is positioned in relation to the state of the art discussed in Chapters 2 and 3. In Chapter 2 the theoretical foundations in the area of evaluation of e-service and portal quality were examined, while in Chapter 3 a review of the area of adaptivity and personalization was given. At the intersection of these two areas (web surveys and adaptivity), lies the area of adaptive questionnaires. Therefore, we also examine how the proposed framework is positioned in relation to the latter area. Figure 4.8 depicts schematically the three main relationships of the framework that are discussed in the rest of this section.

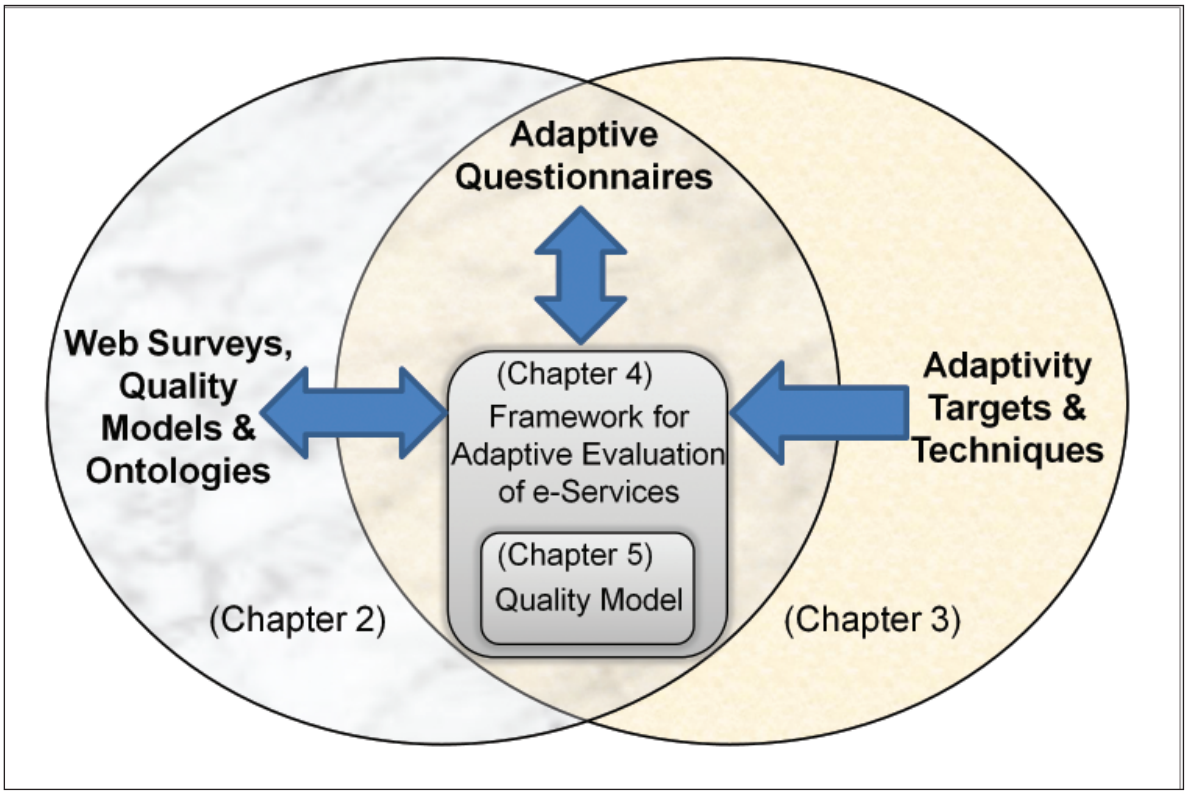


Figure 4.8: Relationships between the Proposed Framework and the State of the Art

4.3.1 Positioning Related to Evaluation of e-Service Quality

The relationship of the proposed framework to the state of the art regarding quality evaluation of e-services (presented in Chapter 2) is bidirectional, as can be seen in Figure 4.8. The framework proposes to perform the evaluation of portal and e-service quality in an adaptive manner, with the objective to tackle the challenges of traditional quality evaluation approaches (traditional web surveys), as already discussed in sections 1.2 and 1.3. As far as the other direction of the relationship is concerned, the framework follows the international standards and guidelines described in section 2.3, in order to define the instrument (questionnaire) used for quality evaluation by users (see section 4.2.2 above).

Regarding the relationship of the proposed quality model, which is part of the framework, to the relevant literature (presented in Chapter 2), it is also a two-way relationship. On the one hand, the proposed quality model uses quality dimensions of the relevant literature approaches, as the basis for defining the quality aspects of the portal and e-services that are important for users and guide their satisfaction. On the other hand, it extends the relevant literature in two different manners. First, it extends the range of quality aspects taken into account for quality evaluation and second it provides an instrument that can be used for measuring portal and e-service quality in a valid and reliable manner. The process followed

for conceptualizing the quality model by synthesizing and extending the relevant literature, the model validation methodology and more information about the bidirectional relationship between the quality model and the relevant literature, are given in Chapter 5.

As described in section 4.2.4, the process of adapting the questionnaire to the individual user is supported by the ontology-based model MAQM which is also part of the proposed framework. In the state of the art of Chapter 2, several ontologies formalizing quality of e-services were presented (see section 2.4). All these ontologies focus on quality characteristics of web services that must be taken into account for a QoS–based service discovery and composition. They do not take into account quality characteristics related to user interaction with the portal or service provider's perception about the provided e-services. Their role is to enable a quality-aware service discovery. This is meaningful only in case that many web-services reaching the same goal are available, and quality is used as a criterion for their selection. However, they cannot be used for the subjective evaluation of a single portal providing a set of distinct e-services. The proposed quality ontology (see section 6.9), which is part of MAQM, is a three-layered openly available ontology that seeks to address these gaps, by enabling a multi-perspective and adaptive evaluation of portals and e-services.

4.3.2 Positioning Related to Adaptivity & Personalization

The relationship of the proposed framework to the relevant literature about adaptivity and personalization (presented in Chapter 3) is a one-way relationship, as can be seen in Figure 4.8. The adaptation logic of the proposed framework (see section 4.2.3.4) is encapsulated to the SALT system which implements the framework. The adaptation logic applies the adaptation criteria described above, by employing adaptivity techniques introduced in Chapter 3, but it does not provide any significant contribution back to this field. Therefore this relationship has one direction, from the research area of adaptivity to the proposed framework.

In order to describe which adaptation techniques are employed, let us provide a different perspective of the adaptation logic. As can be seen in Figure 4.3, the adaptation logic may present the questions in multiple pages, i.e. it may compose dynamically a page consisting of relevant questions, then present this page to the user, then compose another page with relevant questions, by taking into account the user feedback, then present the new page to the user, and so on. Hence, the adaptation is performed at two different levels; the navigation and the presentation level. At the navigation level, the next page is determined by the adaptation logic, and the user is guided to that page. At the presentation level, each page is created by the adaptation logic on the fly, by selecting the appropriate questions to be included, and then this page is presented to the user.

At the navigation level, techniques of adaptive navigation support are used, and more specifically the technique of direct guidance (described in section 3.5.1.3). At the presentation

level, techniques of canned text adaptation are used and more specifically the technique of inserting and removing fragments (see section 3.5.1.2). Each question is considered a distinct fragment and the inclusion or removal of fragments from the set of questions to be presented is orchestrated by the adaptation logic. The whole process of adapting the questionnaire to the individual user, employs rule-based filtering techniques (see section 3.5.2.3), in the sense that the adaptation logic is embedded in conditional (if/then) statements to display the relevant questions.

4.3.3 Positioning Related to Adaptive Questionnaires

In addition to the positioning of the framework in relation to the areas of adaptivity and web surveys, its positioning in relation to their intersection is also discussed hereafter. In this intersection lies the area of adaptive questionnaires, i.e. questionnaires that treat each individual user differently, depending on his/her particularities. An overview of relevant research efforts is provided, while emphasis is given to their relation to the proposed approach. It should be noted that research concerning adaptive questionnaires is rather limited and focuses mainly on the adaptation of a questionnaire based on previously gathered data.

In [Barra et. al., 2002] an adaptive system for training and teaching is presented. This system uses adaptive questionnaires/tests in order to enable the self-training of students in various topics, drawing their attention to the topics they need to study more. Each question has a predefined correct answer and is related to a specific topic. The main adaptation axis of this system is the wrong answers that students give to the various tests/questions. In such a case, the system presents more questions related to the topic that the student is weak, suggesting (implicitly) that further study is needed. The idea used by the adaptation axis of [Barra et. al., 2002] is similar to our idea of constructing and adapting the questionnaire based on quality factors and dimensions (see section 4.2.3.1 where the real-time user feedback adaptation axis of the framework is described). Learning topics correspond to quality factors of the proposed framework, while questions related to a specific topic correspond to D-level questions.

In [Nokelainen et. al., 2001] and [Miettinen et. al., 2005] the authors present a system for creating adaptive multi-choice questionnaires. The idea behind this system is to build a model from previously gathered data and employ it for profiling new users on the basis of a subset of the questions in the original questionnaire. At a first phase, the system tries to classify the current user into one of the available user groups as precisely as possible, based on his/her answers to a subset of the questionnaire. At a second phase, the identified user group is taken into account and the questions as well as the order in which they are presented are chosen adaptively.

Chou et. al., [2000] describe an adaptive questionnaire that allows branching based on the answers provided by the responder. In other words, the questionnaire is considered as a set of structured questions whose path, for the user, may be modified so that different individuals interact within it according to their own responses. The same approach is also followed in [Issac and Hû, 2002]. Furthermore, in [Abernethy et. al., 2008] a framework is proposed for designing adaptive choice-based conjoint questionnaires. Each question for every individual is designed in real time based on their responses to earlier questions.

In [Garcia et. al., 2004] an ontology-based adaptive questionnaire that takes into account some kinds of semantic relationships is described. However the 'adaptation' is done with respect to the questionnaire designer through a guided dialogue with him/her at the design phase. Therefore all users, except from the designer, are still treated similarly.

The aforementioned approaches are using solely previously gathered data in order to adapt the questionnaire to the individual; they do not make use of the valuable data coming from user traces when interacting with the portal. Compared to the above mentioned approaches, the proposed framework is also using previously gathered data in order to adapt the questionnaire based on user perceptions (real-time user feedback). However, in comparison to these approaches, the framework uses two additional adaptation axes, the problem and page metadata based ones.

Furthermore, the proposed approach is the only one that uses ontologies in order to model all the needed knowledge for the adaptation of the questionnaire; an exception to this is the approach followed in [Garcia et. al., 2004], but as already said in this approach the adaptation is done with respect to the questionnaire designer and not with respect to the user.

An additional drawback of the literature approaches is that the users are obliged to login to a system or to use specific java applications in order to be provided with a personalized evaluation experience. In contrast, the proposed approach identifies the user and constructs the user model at runtime without depending on whether the user has logged in or not. This is very useful in e-business and e-government, where log-in is not always mandatory - for example for navigation and search for services.

Finally, all the adaptive questionnaires found in literature, address the educational domain. The approach proposed in this thesis for adaptive evaluation in the domain of portal and e-service quality is unique.

5 QUALITY MODEL DEVELOPMENT REFINEMENT & VALIDATION

This Chapter describes how the Quality Model, which was introduced in section 4.2.1, has been developed, refined and validated. The quality model is part of the proposed framework (which was described in Chapter 4) and addresses the question about what should be measured, as far as the quality of portals and e-services are concerned. It does so, by defining the characteristics of the portal or of the e-services delivered through it, which are important for users and guide their satisfaction.

The quality model was developed in two phases. First, an initial quality model was constructed, by synthesizing and extending the relevant literature which was described in section 2.2. Then, the initial model was empirically evaluated in terms of validity and reliability in a real use case, resulting in the development of a refined version. The model resulted from the validation process can be used for measuring portal and e-service quality in a valid and reliable manner.

In section 5.1, the process followed for developing the initial quality model by synthesizing the relevant literature is presented, while section 5.2 describes the way that the initial quality model was refined and validated. Finally, section 5.3 presents the results of a benchmarking analysis that compares the validated quality model with other similar models found in the literature.

5.1 Development of the Quality Model

The development of a quality model for the domain of e-services and portals is challenging, due to the complexity and number of parameters that must be taken into account. The model development process starts with an exploratory phase where the hypothesized dimensions are developed. This includes the identification of salient attributes and dimensions of the construct of interest which in our case is the quality of e-services and portals. Such a conceptualization of dimensions addresses the question about what is included and/or excluded in the definition of e-service and portal quality. The state of the art is a very valuable source of information for choosing which dimensions should be included in the construct (model) and which should

not. This is stressed by the authors of [Churchill, 1979], who state that it is imperative that researchers consult the literature when conceptualizing constructs and specifying domains. In this way, the domain of the construct of interest is specified in a complete manner and the conceptualized dimensions incorporate various facets of the construct.

Many different approaches concerning quality of e-services and e-government services were reviewed in section 2.2, in order to provide a holistic view of the field of e-service and portal quality. In this section, the process followed for the construction of the initial conceptualized quality model, based on the state of the art, is described.

The literature approaches that were reviewed in section 2.2 focus on different aspects of e-service and portal quality and on different levels of detail. Some of them deal with major quality areas such as information, while others examine in more detail these quality areas. A detailed examination of quality of information for example, is provided by considering information freshness, completeness and ease of understanding. Another differentiation point between literature approaches is the meaning that each one gives to a quality factor. Some approaches use a quality factor's name with different meaning than others or refer to the same quality aspect with different names.

The synthetic Table 2.2 and Table 2.3, which were presented in section 2.2, are the result of the effort to correlate the meaning each researcher gives to each quality dimension with the corresponding dimensions of other models. This correlation was not always feasible on a detailed level, so the higher (i.e. less detailed) view of quality factors was used in order to achieve it. For example for an approach that deals with the information freshness quality dimension, the relevant quality factor that includes information freshness, i.e. the quality factor of information/content, was ticked in the aforementioned synthetic tables. The correlation of the various approaches at the quality factor level enables a synthetic view of literature but creates a problem. Synthetic tables do not include a detailed examination of quality factors, i.e. they do not include quality dimensions. Furthermore there are two synthetic tables, one for each category of approaches and not a single one that provides a holistic view of the state of the art.

In order to overcome this problem and furthermore combine all quality aspects of approaches of the two categories, more synthesis is required. This would enable a better understanding of dimensions for service providers and people that their domain of expertise is not related to quality in general and quality of e-services more specifically. A holistic and comprehensive view can be achieved with the presentation of factors categorized as quality Layers. Quality Layers are major quality areas (i.e. they are even less detailed than Quality Factors) affecting perceived quality, and are related to the way that a portal is constructed.

Three major quality layers have been identified:

- Service quality layer
- Content quality layer
- System quality layer

A similar to quality layers idea is used by Jansen and Ølnes [2004]. They consider a portal as a complex construction which consists of several layers and functions. Hence they believe that the qualitative result of the delivered service is influenced from a number of quality layers and factors. Webb and Webb [2004] introduced a conceptual model and an instrument to measure web site quality, SITEQUAL, composed of two major layers, **Service Quality** and **Information Quality**. Yang et. al. [2005] developed and validated, an instrument to measure user perceived overall service quality of web portals. According to this model, an Information Presenting web portal (IP-Portal) is essentially an Information System (IS), consisting of digital information and an information delivery infrastructure (browsers, search engines, encryption, networking systems, etc.). Accordingly, Information Quality and **System Quality** are of great importance to portal's users.

Figure 5.1 depicts the terminology used for referring to Quality Layers, Factors and Dimensions. Quality layers are the major key areas that affect the quality perceived by users when using an e-service and are mostly related to the way that a portal is constructed. Layers are composed of Quality Factors, while factors consist of Quality Dimensions, i.e. quality dimensions examine in more detail the relevant quality factor.

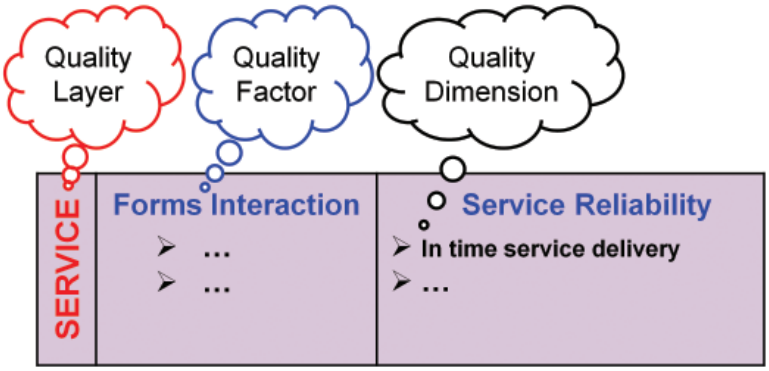


Figure 5.1: Layer, Factor and Dimension Terminology

An example for the quality factor of service reliability is also depicted in Figure 5.1. This factor is related to the e-service that is provided to users through the portal and thus is closely related to quality aspects of the service layer. Furthermore, an important characteristic of service that influences its perceived reliability is the time required for the delivery. This means that a dimension which examines in a more detailed level the service reliability factor is the "in time service delivery" one.

An overview of the methodology used for developing the Quality Model is depicted in Figure 5.2, while the following sections discuss in detail the various steps followed. As can be seen in the figure, based on the quality factors included in the synthetic tables of section 2.2, and after appropriate modifications and improvements, the quality factors of the initial

quality model were identified; more details on this can be found in section 5.1.1 below. These Quality Factors were categorized into Quality Layers, as discussed in section 5.1.2. As already described above, the Quality Layers (i.e. Service, Content and System), have been identified by reviewing the relevant literature. On the other hand, the Quality Factors were decomposed into Quality Dimensions by taking into account the state of the art, as described in section 5.1.3. The hierarchy of Quality Layers, Factor and Dimensions constitute the initial Quality Model, an overview of which is given in section 5.1.4; while its various factors and dimensions are explained in detail in section 5.1.5.

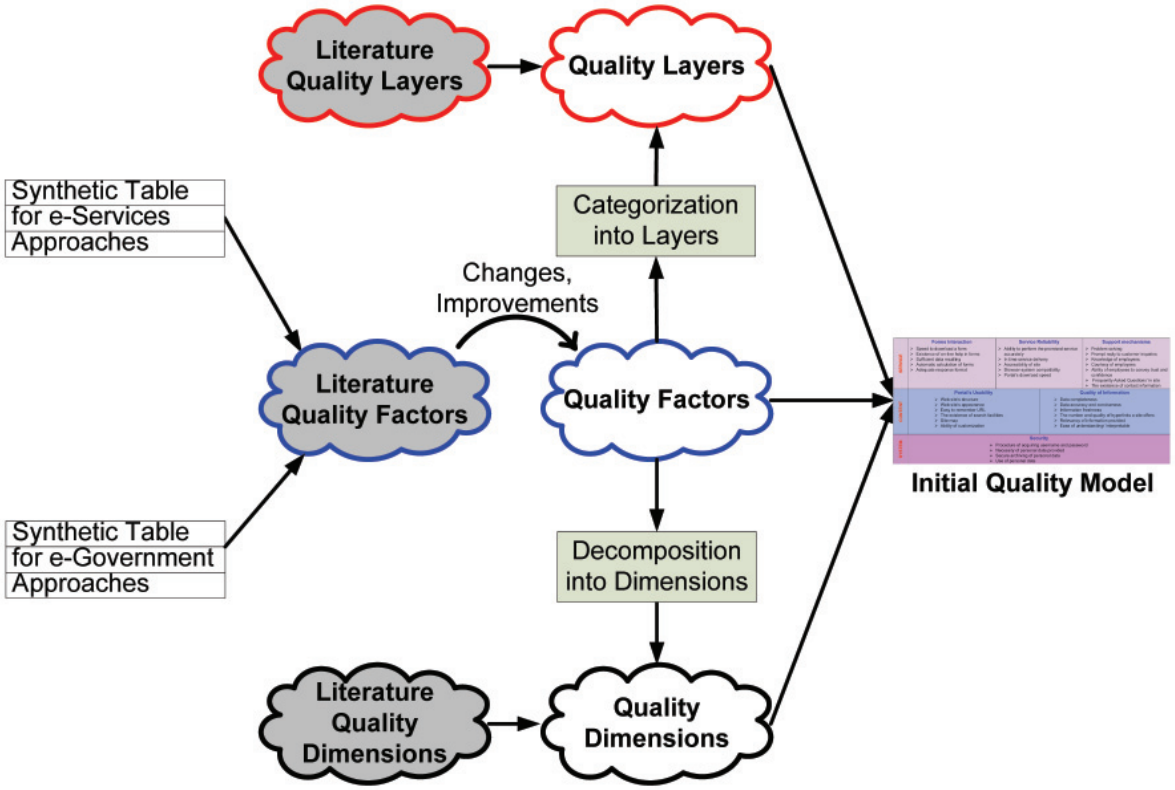


Figure 5.2: Methodology Followed for SOTA Synthesis

5.1.1 Identification of Quality Factors

The first step followed for the construction of the Quality Model was the identification of quality factors that are relevant to the provision of e-services through an e-business or e-government portal. The literature survey was a source of useful insights that helped in this effort. This section describes the process followed for the identification of quality factors that were finally incorporated into the Quality Model. The set of literature's quality factors comes from the merging of the synthetic tables regarding the e-services and e-government services approaches, as depicted in Figure 5.2.

Some of the quality factors found in the literature review were changed, improved or omitted and furthermore some new were added. Some of the literature's factors, like *Service Reliability*, *Information Quality* and *Security,* are composed of several quality dimensions. Therefore, the same name and level of detail were kept for them. Literature's factors "Navigation/Accessibility" and "Customer Service" cover a smaller quality area than our perception about the level of abstraction that a quality factor should examine. We identified as quality factors of the model the more generic factors of *Portal Usability* and *Support Mechanisms* which include among other quality dimensions, "Navigation/Accessibility" and "Customer Service" respectively. The "Personalization" and "System Performance" of the synthetic tables have been incorporated for the same reason under *Portal Usability* and *Service Reliability* factors, respectively.

The concept of "Overall Evaluation", which appears in the synthetic Table 2.3 of the literature survey, is not used in the quality model as a quality factor. It is used however in the questionnaire (see section 4.2.2), in combination with the theoretical perspective of ideal versus actual service, described in section 2.1.

Finally, the state of the art was poor in the area of quality characteristics of online forms. Forms play an integral role on portals in allowing users to communicate and interact with the service providers, allowing the collection of required information. Therefore, the quality characteristics of forms are very important and influence perceived quality. Based on this belief, a new quality factor was identified in addition to the factors obtained from the literature review. This factor was named *Forms Interaction*.

The six quality factors that were identified as described above are:

- Forms Interaction
- Service Reliability
- Support mechanisms
- Portal's Usability
- Information Quality
- Security

5.1.2 Categorization of Factors into Layers

Forms Interaction, *Service Reliability* and *Support Mechanisms* are closely related to the e-service delivered to users and thus they are categorized as quality factors belonging to the Service Layer. The quality factors of *Portal Usability* and *Information Quality* are related to the content presented at the portal, while *Security* is a system-related quality factor. Figure 5.3 depicts the categorization of quality factors under quality layers. It should be noted that this categorization is not as strict as the categorization of quality dimensions under quality factors (see section 5.1.3 where a description of the latter categorization is given) and was primarily done for presentation issues.

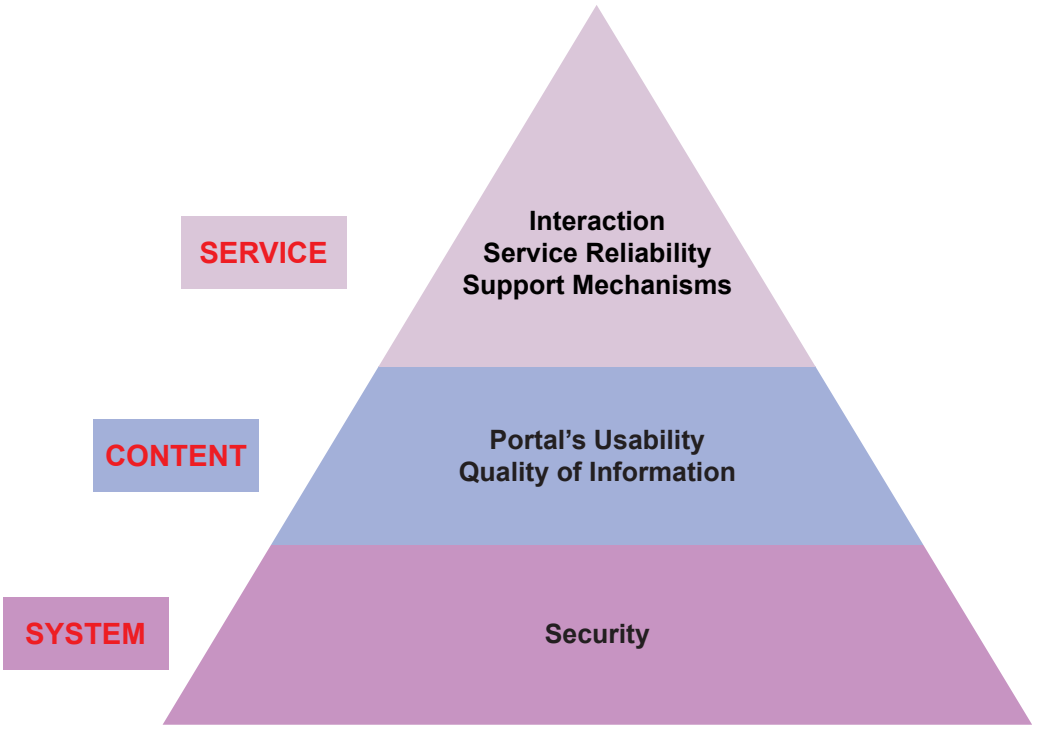


Figure 5.3: Layers – Factors Relationships

5.1.3 Decomposition of Factors into Dimensions

The purpose of this section is to identify the major quality dimensions that examine in detail each quality factor and to present the categorization of these dimensions under relevant quality factors.

The Forms Interaction factor was decomposed into relevant quality dimensions based on a typical interaction lifecycle. This quality factor deals mainly with the attributes of interaction with the portal using forms. Such attributes are the speed of forms downloading, the existence and usefulness of on-line help in forms, the level of automatic calculation of form fields, the sufficient data recalling from previously submitted data and the provision of several alternative choices to the users, concerning what they can do with a filled form (e.g. submit it, print it, save it).

As far as the service reliability factor is concerned, it is related to the ability of the portal to deliver the e-services in a sufficient and adequate way or even a better one. This quality factor involves the ability of the portal to perform the promised service accurately, and in time, the portal's accessibility, the speed in which the web pages are downloaded and the compatibility of the portal with all the browsers that users use for navigation.

Support mechanisms are related to the process that is followed in order to provide support to portal's users. If a user faces a problem or has a specific question while he tries to obtain an e-service delivered through the portal, he/she searches either for answers to frequently asked questions or for contact information. If the user finally contacts organization's employees for support, attributes of his/her interaction with them influence user's perception of quality concerning the e-service he/she tries to obtain. Such attributes are the prompt reply of employees, their knowledge, their ability to convey trust and confidence and solve user problems, and their courtesy.

The quality of information presented at the portal is represented by the information quality factor. This factor is related to the accuracy, freshness, completeness, relevancy and ease of understanding of data and the number and quality of hyperlinks the site offers. The way the information is presented influences highly its ease of use. This presentation part of information is represented by the portal's usability quality factor which deals with the web site's structure, its design and appearance, the quality and effectiveness of search facilities, the easiness of navigation and an easy to remember URL.

The provision of e-services very often includes financial transactions or the submission of the users' personal data. The security that the portal provides to its users is represented by the security quality factor. This factor is related to the procedure of username and password acquisition, the necessity of personal data provided by users, the secure archiving of personal data and the use of personal data only for the reason that they were submitted.

5.1.4 The Initial Quality Model

The initial categorization of dimensions into factors and of factors into layers resulted in the construction of the initial quality model which is depicted in Table 5.1. A detailed definition of each quality factor and dimension is provided in the next section.

Table 5.1: The Initial Quality Model

SERVICE	**Forms Interaction** ➢ Speed to download a form ➢ Existence of on-line help in forms ➢ Sufficient data recalling ➢ Automatic calculation of forms ➢ Adequate response format	**Service Reliability** ➢ Ability to perform the promised service accurately ➢ In time service delivery ➢ Accessibility of site ➢ Browser-system compatibility ➢ Portal's download speed	**Support mechanisms** ➢ Problem solving ➢ Prompt reply to customer inquiries ➢ Knowledge of employees ➢ Courtesy of employees ➢ Ability of employees to convey trust and confidence ➢ Frequently Asked Questions' in site ➢ The existence of contact information
CONTENT	**Portal's Usability** ➢ Web site's structure ➢ Web site's appearance ➢ Easy to remember URL ➢ The existence of search facilities ➢ Site-map ➢ Ability of customization	**Quality of Information** ➢ Data completeness ➢ Data accuracy and conciseness ➢ Information freshness ➢ The number and quality of hyperlinks a site offers ➢ Relevancy of information provided ➢ Ease of understanding/ Interpretable	
SYSTEM	**Security** ➢ Procedure of acquiring username and password ➢ Necessity of personal data provided ➢ Secure archiving of personal data ➢ Use of personal data		

5.1.5 Factors and Dimensions of the Quality Model

The purpose of this section is to provide a detailed definition of the quality factors and dimensions used in the quality model. As described in section 5.1 above, literature approaches use different names for a quality concept, either factor or dimension, and vice versa. It is apparent that such a variety leads to misunderstandings; therefore, a common definition of the factors and dimensions used in the quality model is necessary.

5.1.5.1 Forms Interaction Factor

Forms play an integral role on e-government and e-business in allowing users to communicate and interact with the public administrations and private companies. Forms are used as the major medium for submitting information online; hence, quality characteristics of online forms are of high importance to users during their interaction with the portal, and influence significantly the qualitative result of the delivered service. Table 5.2 depicts the definition of quality dimensions relevant to interaction using online forms.

Table 5.2: Forms Interaction Quality Dimensions

Quality Dimension	Definition
Speed to download a form	Self explanatory. For example: downloading a form for 1 sec is good, for 2 is acceptable, whereas for longer time is unacceptable
Existence of on-line help in forms	Automatically presented help text in form fields which aids users to fill in the form.
Sufficient data recalling	The ability of the system to recall previously submitted information
Automatic calculation of forms	The ability of the system to fill in all possible fields as a result of internal calculations on other fields or previously submitted information
Adequate response format	The ability of the system to provide several alternative choices to the user, concerning what he/she can do with a form he/she has filled in (e.g. submit it, print it, save it, etc.)

5.1.5.2 Service Reliability Factor

Reliability refers to the ability of the portal to deliver the e-service consistently, producing the same results, preferably meeting or exceeding service's specifications. Service reliability is very important to user satisfaction and is used a lot as a major quality factor in literature. Table 5.3 depicts the definition of quality dimensions relevant to service reliability.

Table 5.3: Service Reliability Quality Dimensions

Quality Dimension	Definition
Ability to perform the promised service accurately	Correct service delivered as expected by customer
In time service delivery	Self explanatory
Accessibility of site	Accessibility is a general term used to describe the degree to which a system is usable by as many people as possible without modification. It is not to be confused with usability which is used to describe how easily a thing can be used by any type of user
Browser-system compatibility	The capability of the system to be displayed and used independently of the web browser used
Portal's download speed	Self explanatory

5.1.5.3 Support Mechanisms Factor

Support mechanisms, like technical support and helpdesk, provide support to users through email, chat, voice and the web. An end-user support centre is designed to help and support an end-user of a particular portal or service. Many users are not familiar with Internet and face many problems during their navigation in a portal. Support mechanisms are an important medium for assisting users to obtain the service they want. Thus, users' assessments of portal and e-service quality include not only experiences during their interactions with the portal but also quality aspects of support mechanisms. Table 5.4 depicts the definition of quality dimensions relevant to support.

Table 5.4: Support Mechanisms Quality Dimensions

Quality Dimension	Definition
Problem solving	The ability of employees to provide solutions to user problems
Prompt reply to customer inquiries	Self explanatory
Knowledge of employees	The state of employees' knowing and range of information
Courtesy of employees	Employees' good manners and politeness
Ability of employees to convey trust and confidence	Self explanatory
'Frequently Asked Questions' in site	FAQ section of a portal contains answers to frequently asked questions. The main purpose of this portal's section is to help users find answers to their question, before contacting organization's employees. This dimension examines the usefulness and completeness of the FAQ section.
The existence of contact information	Existence and visibility of contact information

5.1.5.4 Portal Usability Factor

Usability refers to the elegance and clarity with which the interaction with a portal is designed. Usability is a measure of how easy it is for a user to complete a task. It concerns how easy it is for users to find the information they require and obtain the service they want. Table 5.5 depicts the definition of quality dimensions relevant to portal's usability.

Table 5.5: Portal's Usability Quality Dimensions

Quality Dimension	Definition
Web site's structure	The way in which the web site is organised
Web site's appearance	The visible aspect of the web site
Easy to remember URL	Self explanatory
The existence of search facilities	This dimension measures the effectiveness of search engine. Search engines that return a lot of results that are not closely related to the search query are not effective.
Site-map	A site map is a hierarchical visual model of the pages of a portal. Site maps help users navigate a portal that has more than one page by showing the user a diagram of the entire site's contents [Webopedia, 2006]. Similar to a book's table of contents, the site map makes it easier for a user to find information on a site without having to navigate the site's many pages. Also a site map can make it easier for a search engine spider to find all site's pages. The quality and usability of site map used to facilitate the site navigation, is represented in the quality model by this dimension
Ability of customization	Customization means the presentation of a page that has been customized for the user, taking into consideration that person's habits and preferences and requirements

5.1.5.5 Information Quality Factor

Information quality is a term to describe the quality of the content of information systems and furthermore is a measure of the value which the information provides to the user. Quality of information can vary among users and among uses of the information. Information of portals is deemed of high quality if it represents correctly the real-world construct to which it refers. Information represents a big part of portals, and thus information quality contributes significantly to the quality perceived by users, during their interaction with the portal for the provision of e-services. Table 5.6 depicts the definition of quality dimensions relevant to information.

Table 5.6: Information Quality Dimensions

Quality Dimension	Definition
Data completeness	Data is complete if nothing needs to be added to it. This means that data refers to all aspects that it should.
Data accuracy and conciseness	Accuracy refers to how correct and near reality is the data presented in the portal. Information is concise if it expresses much in few words, clearly and succinctly.
Information freshness	This dimension refers to the degree that the information and data are up to date.
The number and quality of hyperlinks a site offers	This dimension represents the relevancy of links with the subject presented, the number of broken links and the information provided for each link (e.g. on mouse over)
Relevancy of information provided	This dimension refers to the degree of relation of presented information to the respective portal thematic section that is presented, or to the portal subject in general
Ease of understanding/ Interpretable	The information is easy to understand if e.g. no technical terminology is used.

5.1.5.6 Security Factor

Security refers to the protection of data, networks and computing power. A secure system is a system which does exactly what we want it to do and nothing that we do not want it to do even when someone else tries to make it behave differently. Several methods are used in e-government and e-business in order to protect information and other system assets. Information security is of high importance as it deals with several different "trust" aspects of information and its protection. Secure portals convey trust and confidence to users and contribute to their satisfaction. Table 5.7 depicts the definition of quality dimensions relevant to security.

Table 5.7: Security Quality Dimensions

Quality Dimension	Definition
Procedure of acquiring username and password	The mechanism used for access control in portals is mainly the registration of a user in the portal and the provision of user name and password. The procedure that has been followed for the acquisition of username and password influence a lot system's security.
Necessity of personal data provided	This dimension is related to user's perception concerning the necessity of provided personal data
Secure archiving of personal data	This dimension represents the physical and digital security of the place and system, used for user's data archiving, respectively
Use of personal data	This dimension measures the degree to which the personal data provided by users are used only for the reason submitted.

5.2 Quality Model Refinement and Validation

It is stressed by several researchers that it is very important to use standardized instruments and models for measuring user satisfaction [Doll et. al., 1951]. The process of developing a standardized model involves two major phases [Mackenzie and House, 1979]: (i) the exploratory phase where the hypothesized measurement dimensions are developed and (ii) the confirmatory phase where the hypothesized dimensions are tested and validated empirically. In other words, the purpose of the confirmatory phase is to test the a priori model developed in the exploratory phase.

In this section the refinement and validation of the initial quality model (see section 5.1.4), which was conceptualized in the exploratory phase, is presented. First, in section 5.2.1, the major risks and concerns revealing the need for validating the quality model are identified. The methodology followed for validating and refining the model is described in section 5.2.2, while section 5.2.3 includes the validation results and the developed refined model.

5.2.1 The Need for Validation

Although the initial quality model (see Table 5.1) was the result of a thorough and complete investigation of the relevant literature, it needs to be validated. Measurement of intangible constructs is neither simple nor straightforward [Straub, 1989]. A difficulty in using any method to measure a phenomenon of social science is that one never knows for certain whether he/she is measuring what he/she wants to measure, or whether he/she is measuring it the right way. Inaccuracies of measurement, applicability of the measuring instrument and the research method utilized are some aspects that must be taken into account during instrument validation [Sedera et. al., 2003]. In the case of the quality model described in section 5.1, it examines and integrates factors and dimensions that capture e-service and portal quality which is an intangible concept. By taking into account the aforementioned difficulties of measuring an intangible concept, three major categories of concerns and risks that reveal the need for validating the initial quality model, can be identified:

- Concerns and risks related to the validity of the model [Straub, 1989]. This involves the questions whether the quality model conceptualizes what it was designed to measure, whether important aspects of e-service and portal quality are omitted, or whether the selected dimensions are true indicators of quality of e-services.
- Concerns and risks related to the reliability of the quality model [Cronbach, 1951]. This involves the extent to which the measurements made using the model remain consistent over repeated tests of the same subject under identical conditions. In other words, this risk is related to the extent to which an individual juror could assess the same quality dimension the same way each time.

- Concerns and risks related to the dimensionality of the model [Churchill, 1979], i.e. to the correctness of the various groupings of quality dimensions under quality factors.

5.2.2 Methodology for Refinement and Validation

Measures and metrics are the sine qua non of solid, scientific research [Straub et. al., 2002]. The conceptualized quality model, depicted in Table 5.1, identifies specific quality measures (factors and dimensions) which define user satisfaction with portals and e-services. As described in the previous section, it needs to be validated that the dimensions derived are actually capturing the six factors assumed in the initial quality model and that it is valid and reliable. This is part of the confirmatory phase of the model development process where the hypothesized dimensions are tested and validated empirically.

Figure 5.4 depicts schematically the methodology followed for testing and validating the a priori quality model of Table 5.1. The application of this methodology results in the development of a refined version of the model that addresses the concerns and risks introduced in section 5.2.1. As can be seen in Figure 5.4, the methodology, which is based on the idea of the two-phased model development process, consists of four major steps and two feedback transitions between steps:

- The first step concerns the conceptualization of dimensions realized in the initial quality model, and was covered in section 5.1.
- The next steps (steps 2-4) are followed in order to produce the refined version of the quality model and include the collection of data, the empirical validation of the model by using the collected data and finally the development of refined versions in an iterative process.

In the next sections the various steps are discussed in detail.

5.2.2.1 Data Collection

In an effort to test empirically the suggested dimensions of the construct of interest, it is important to find a real-world application domain. In our case the application domain was the e-government portal of a public authority that offers public e-services to citizens. In this step, user feedback is collected which is used later for validating empirically the initial quality model. This is achieved by using a survey in order to collect data from a sample of real users concerning their ratings of all the construct's attributes and dimensions.

So an online questionnaire was developed, which is constituted of statements that concern the quality characteristics of the portal and its e-services. The statements represent the quality dimensions of the initial quality model. The relation between statements and

quality dimensions/factors is one by one, meaning that for each quality dimension/factor, one relevant statement has been added to the questionnaire. In this way, the questionnaire operationalized the 33 dimensions and 6 factors of the initial quality model. Special attention was given to the wording of statements, so that each statement represents the relevant quality dimensions and factors as precisely as possible. This questionnaire has been integrated with the e-government portal of the Greek Ministry of Interior [CSC, 2008] and citizen responders have been asked to complete it, by rating their perceptions of each of the dimensions/factors using a 1 to 5 scale, in which the anchor for 1 was “strongly disagree” and for 5 “strongly agree”.

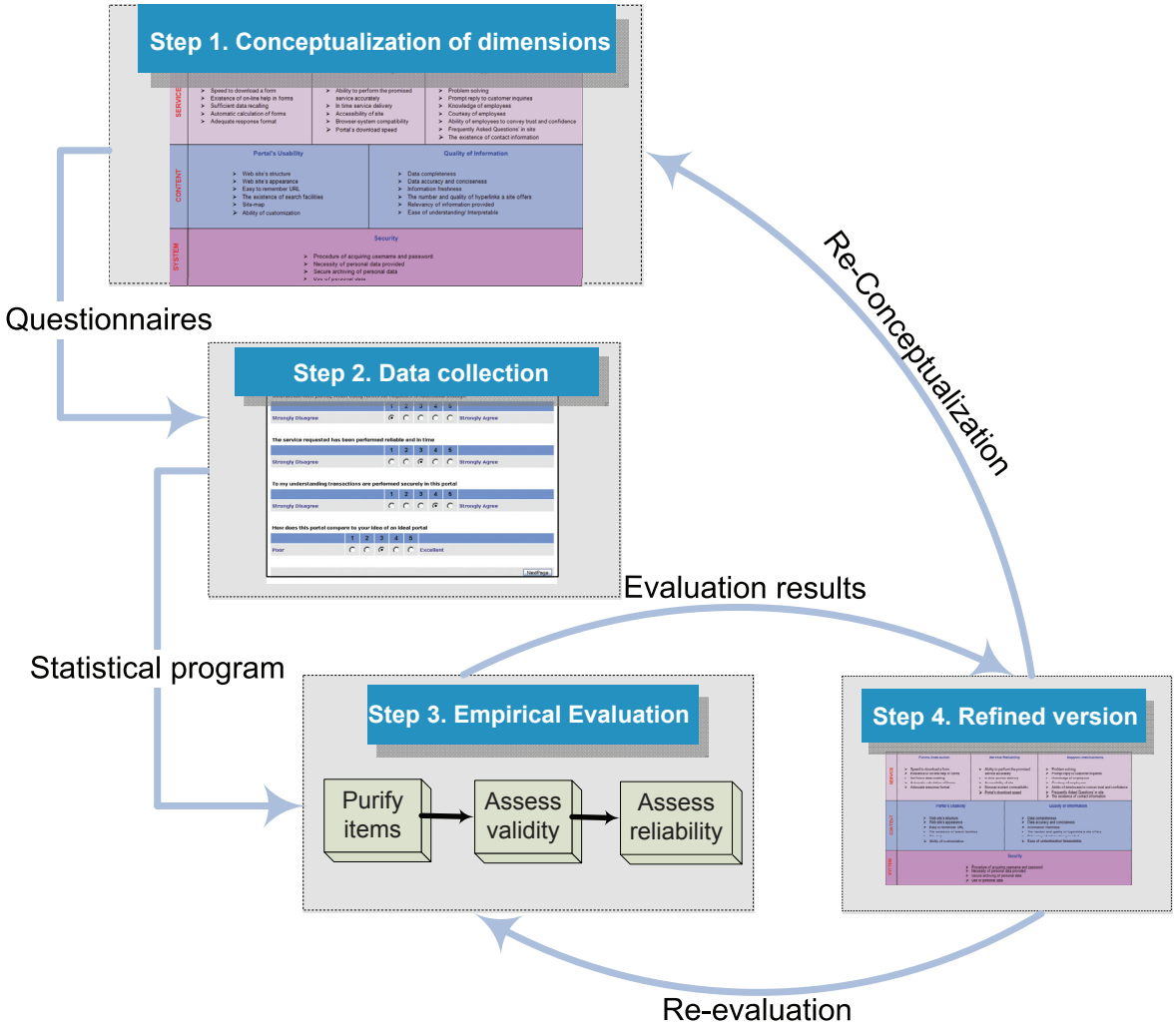


Figure 5.4: Methodology for Validating and Refining the Initial Quality Model

5.2.2.2 Empirical Validation and Refinement

The data collected were used in order to validate empirically the categorization of quality dimensions into relevant quality factors, i.e. model's dimensionality, as well as its validity and reliability. This was done by using statistical methods. Initially, preliminary item purification was carried out, as described in [Churchill, 1979], to identify and purify any cases that can affect the correctness of the aforementioned statistical methods.

For the assessment of model's validity, factor analysis was used which has enjoyed widespread use as a statistical method of measuring construct validity [Thompson and Daniel, 1996], [Eysenck, 1950]. By using factor analysis in order to assess the validity and dimensionality of the model, two out of the three major concerns and risks identified in section 5.2.1 are addressed. For the assessment of the model's reliability, the coefficient alpha [Cronbach, 1951], known also as Cronbach's alpha, was used. It was decided to use this reliability statistic, although there are many statistical methods that can be used for determining reliability, because it is the most commonly used, especially in the domain of quality monitoring, and thus benchmarks with other models can be produced (see section 5.3 where the refined quality model is benchmarked with other related models).

Factor loadings emerging from the factor analysis show the degree to which each quality dimension is correlated with each quality factor. Greater than 0.5 factor loadings are considered significant [Field, 2005], [Hair et. al., 1995]. Low loadings on the other hand indicate that some dimensions are not drawn from the domain and thus are producing error and unreliability. To this end, factor loadings can suggest the following refinements to the initial version of the quality model: (i) Dimensions that did not meet the loading cut-off for any factor are removed; (ii) Dimensions that load significantly with a different factor from the one initially conceptualized, are moved to the new factor.

On the other hand, alpha coefficients are estimators of reliability at the factor level as well as at the model level. Several scales have been developed to serve as a benchmark to determine model reliability, using alpha coefficient, like the scales developed by Landis and Koch [1977] and George and Mallery [2003]. The general accepted cut off value for a model to be considered as reliable and rigorous is 0.8 [Field, 2005]. The reliability of models that do not meet this cut off value is questionable. At a finer-grained level, a low coefficient alpha for a quality factor is an indication that the specific factor is not reliable.

By taking into account the suggestions produced by the purification, validity and reliability statistical methods, and after implementing the changes proposed, a new refined version of the model is made available. This new version is subject to a new evaluation, as can be seen in Figure 5.4. This kind of evaluation in several rounds is stressed in [Churchill, 1979] and has been followed for the evaluation of several quality models which were reviewed in section 2.2. The process of iterative evaluation continues until significant levels of validity and reliability

are achieved. Generally, there are three possible scenarios depending on the results of the first evaluation:

a) The evaluation shows satisfactory coefficient alphas and the dimensions agree with those conceptualized. This is the most desirable scenario. The interpretation of such results is that the model shows significant levels of validity and reliability and furthermore that the dimensionality and groupings hypothesized are confirmed. In this extreme case, there is no need for any iteration, as the refined version of the model is identical to the initial version and hence the "refined version" step of the methodology is skipped.

b) Dimensions, which were conceptualized as independent, clearly overlap. In this case, new groupings of dimensions should be defined by moving dimensions from one factor to another, according to the suggestions of the factor analysis. The refined version of the model that is produced in this way, should be checked again concerning its validity and reliability, i.e. it is subject to a new round of evaluation.

c) The alpha coefficients and factor loadings are too low. This is the least desirable scenario. The interpretation of such results is that perhaps the dimension pool of the conceptualization phase did not cover all aspects of the domain. The appropriate strategy in this case is to loop back to step 1 and redo the conceptualization.

Figure 5.5 depicts the three possible scenarios - i.e. a), b) and c) - described above.

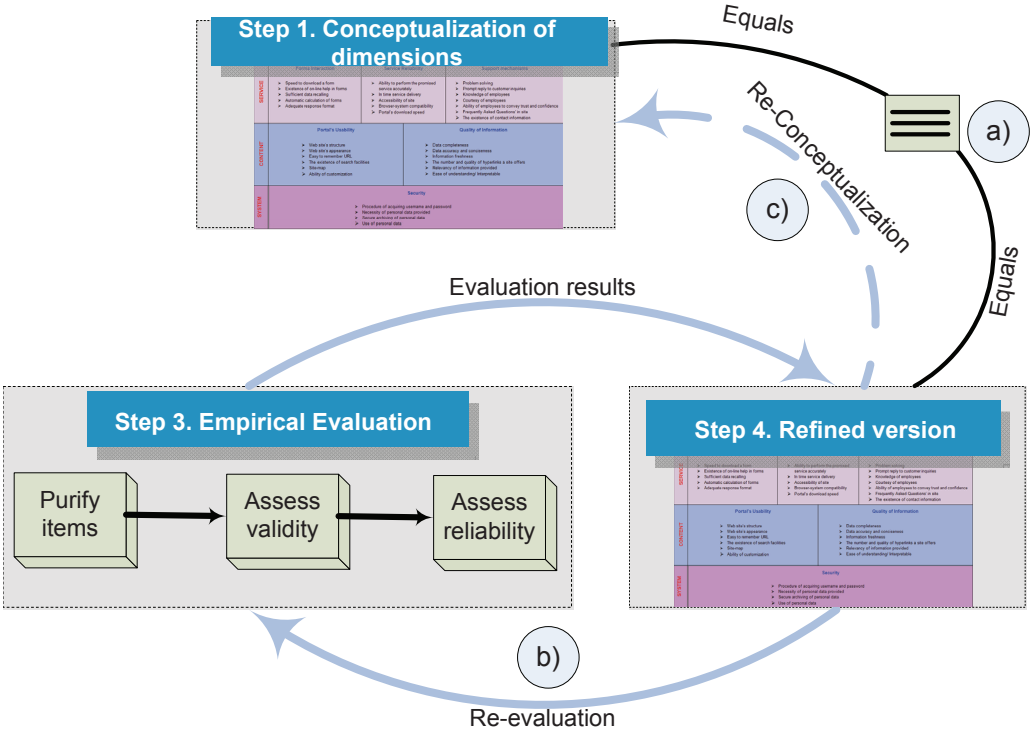


Figure 5.5: Possible Transitions between the Various Steps of the Iterative Evaluation Process

5.2.3 Model Refinement and Validation

The questionnaire was available online for the period February - June 2007. All in all, 634 completed and usable responses were received, each of which evaluated the e-government portal of the Greek Ministry of Interior [CSC, 2008] and the public e-services delivered through it. The body of responses came from a range of ages and educational backgrounds, as depicted in Table 5.8 and Table 5.9 respectively.

Table 5.8: Range of Ages

Age	Frequency	%
No answer	1	0.2%
Less than 16	2	0.3%
16-25	49	7.7%
26-35	367	57.9%
36-45	180	28.4%
46-55	29	4.6%
56-65	6	0.9%
Total	634	100%

Table 5.9: Range of Education Background

Education	Frequency	%
No degree	1	0.2%
PhD Degree	7	1.1%
Masters Degree	34	5.4%
Bachelors Degree	436	68.8%
High School Diploma or equivalent	148	23.3%
Vocational Degree	8	1.3%
Total	634	100%

The responses came mainly from people in the age group between 26 and 45, something which is expected as it is the age group that mainly uses the internet in Greece and also needs to interact with government services. For ages less than 26, although they use the internet a lot, they are in an age group that does not need to interact with government services yet. On the other hand users older than 46 do not use the internet so much, and thus do not use e-government services, as reported in [Observatory, 2008]. Concerning the responders' educational level, the higher percentage of them has also a higher education degree. This is consistent with the findings of [Observatory, 2008], that higher educated people tend to use the internet more for interacting with the Greek government. Hence the composition of the sample is in line with the general demographic characteristics of e-Government users in Greece.

The answers collected were transferred to the Statistical Package for the Social Sciences (SPSS) [George and Mallery, 2003] for further analysis. By using this statistical software, the statistical methods described in section 5.2.2.2 were employed, in order to confirm that the model captures the 6 factors initially conceptualized (Forms Interaction, Reliability, Support Mechanisms, Information, Usability, and Security) and in order to assess its validity and reliability. By following the methodology defined in section 5.2.2, and after three iterations the refined version of the model came up. The Rotated Matrix of the Factor Analysis for the final quality model, showing the factor loadings of each dimension to each factor, can be

found in Annex B. The process confirmed the existence in the model of the six factors using the dimensions which were conceptualized in the exploratory phase. This process though, suggested that five dimensions (number & quality of links, FAQ, easy to remember URL, adequate response format, existence of contact information) do not load adequately to any of the factors and also that there is one dimension (form download speed) that loads to a different factor from the one it was assigned to in the exploratory phase. Looking more carefully at these suggestions the reasons for the changes proposed – i.e. removing the five dimensions from the initial version of the model and moving one dimension to the factor that loads more - can be intuitively identified.

- The number & quality of links dimension which is stated as “This portal offers enough and of high quality hyperlinks”, does not imply so strong a relation to the “Information” quality factor and this is because (as it appears from the factor analysis) it has been perceived more as a reliability attribute (loads more in the “Reliability” factor), but still not enough to remain in the model.
- The FAQ dimension, “The FAQ section of this portal covered completely the topic that you were interested in”, appears in the factor analysis to load more on the “Information” factor, than on the “Support Mechanisms” one, although not enough to remain in the model. A possible explanation is that the FAQ pages actually contain information, while all the other support dimensions involve the participation of an employee from the portal.
- The easy to remember URL dimension, “This portal’s URL is easy to remember”, is not very relevant either to the “Usability” of a web site or to any other factor in the model, thus its factor loadings are low for all factors. It seems that the initial conceptualization of this dimension was wrong.
- The adequate response format dimension, “Submitted requests or results of their elaboration are easy to be stored locally or printed”, although it is loading in the “Forms Interaction” factor, it is not loading enough to remain in the model. Intuitively it happens because this dimension is referring to a slightly different function of the e-government portal, compared to the other “Interaction” dimensions that refer mainly to interaction with online forms. A possible reason explaining this result is that the e-government portal of the Greek Ministry of Interior does not offer the functionalities that this dimension is referring to.
- The form download speed dimension, “Forms in this portal are downloaded in short time”, has a strong element of speed in it which is more a “Reliability” attribute than a “Forms Interaction” attribute. So the results of the analysis that categorize this dimension under the “Reliability” factor are intuitively correct.
- Finally it seems that the existence of contact information, “This portal provides contact information”, does not contribute so much to quality of e-services.

The reliability analysis was conducted at the model level by calculating the alpha coefficient for the total questionnaire, as well as at the factor level by calculating the coefficient for each factor individually [Field, 2005]. The test at the model level resulted in an alpha coefficient score of 0.97, suggesting that the scale is in fact very reliable. Furthermore, the reliability tests resulted in alpha coefficient scores greater than 0.8 for all factors, suggesting that the scales by factor are also very reliable. The alpha coefficients per factor as well as for the whole model can be seen in Table 5.10.

Table 5.10: Cronbach's Alpha Summary

Total	0.970
Usability Factor	0.848
Information Factor	0.853
Interaction Factor	0.870
Reliability Factor	0.894
Support	0.925
Security	0.900

5.3 Benchmarks of the Refined Quality Model

This section covers benchmarks of the refined quality model with other quality models from literature. The purpose of the comparison with other models is to provide a bird's eye view of the reliability of the refined model compared to the state of the art, and not to give a rigorous benchmark, as the latter is not feasible for models that have been developed for different purposes and do not measure exactly the same concept.

In order to select the quality models that will be used for comparison, we researched the literature approaches used as the basis for conceptualizing the initial quality model (see section 5.1). Those quality models that have been validated and whose reliability is reported were selected to be included in the benchmarking analysis. Only 8 out of the 31 approaches that concern quality of e-services and e-government services report reliability results. This finding is in line with the results of [Boudreau et. al., 2001], according to which the proportion of researchers in IS research that validate their instruments is small. For each one of the 8 models selected, the overall Cronbach's alpha, as well as the number of dimensions used in order to conceptualize quality, have been collected. We should note that each one of these models does not measure the same attributes of quality. For this reason, the validity is not used as a criterion for the comparison between models, as it is strongly related to the concept that is conceptualized by each model (e.g. e-government service quality, human-computer interaction quality, nursing website quality, etc.). On the other hand, reliability is a more general concept of model performance, since comparisons of reliability can be done at a coarse-grained level.

Another important note is that the reliability of a model is a function of the number of dimensions examined by it. The more parsimonious a model is the more realistic the estimation of the fit of the model to the collected data is, for a given level of reliability [Thompson and Daniel, 1996]. In other words, if we take a given model with a given reliability and remove some dimensions, then the reliability of the new model will decrease. For this reason, in addition to the model reliability axis, a second axis was added to the benchmarking analysis, i.e. the number of dimensions. The results of the benchmarking in terms of reliability are reported in Table 5.11.

Table 5.11: Comparison of Quality Models in Terms of Reliability

Model	ID	Cronbach's α	Dimensions
Initial Quality Model (section 5.1.4)	1)	0.974	33
Refined Quality model	2)	0.970	28
E-Qual [Barnes and Vidgen, 2001]	3)	0.960	27
HCI Satisfaction [Chin et. al., 1988]	4)	0.939	27
Public e-Services Satisfaction [Galan and Sabadie, 2002]	5)	0.930	29
Nursing Website Quality [Tsai and Chai, 2005]	6)	0.930	32
e-Commerce quality [Wang et. al., 2001]	7)	0.930	38
User-perceived web quality [Aladwani and Prashant, 2002]	8)	0.910	25
E-S-QUAL [Boshoff, 2007]	9)	0.900	22
e-government in Thai [Sukasame, 2004]	10)	0.874	20

As can be seen in the table, where the models have been sorted according to their reliability, the refined version of the quality model surpasses all of the eight models drawn from the relevant literature, in terms of reliability. On the other hand, the initial version comes ahead of the refined. This is attributed to the purification of some dimensions which had as a result the increase of the model's validity, but at the cost of a slight decrease of its reliability. Nevertheless the overall reliability of the refined model remains very high; it is considered "excellent" and "almost perfect" according to George and Mallery [2003] and Landis and Koch [1977] reliability scales, respectively.

As mentioned before, conclusions about the ranking of the refined quality model compared to competitive models regarding their reliability, can be drawn only if the second axis of benchmarking, which was introduced above, is taken into account. If someone looks at the Table 5.11 closely, he/she can conclude that the refined version of the quality model is better than models with IDs 5, 6 and 7, because these models report lower reliability (0.930) and the target concept of interest has been conceptualized using more dimensions than the refined quality model (29, 32 and 38 respectively).

Models 3, 4, 8, 9 and 10 on the other hand, although they report lower reliability (0.960, 0.939, 0.910, 0.900 and 0.874), they also use fewer dimensions (27, 27, 25, 22 and 20). In order to enable a comparison with these models, each model's pair of (reliability, number of dimensions) has been depicted in the Reliability-Dimensions space. This graphical representation can be seen in Figure 5.6. The X-axis corresponds to the reliability axis, while the Y-axis corresponds to the number of dimensions. The vertical and horizontal position of each model in this two-dimensional space is displayed with a data label and a number indicating the model's ID, which was defined in Table 5.11 above. Ideally, a model should have a reliability coefficient close to 1.00, and should contain as few dimensions as possible (a perfectly reliable and very parsimonious model). This means that the models that are closer to the lower-right corner of Figure 5.6 are better.

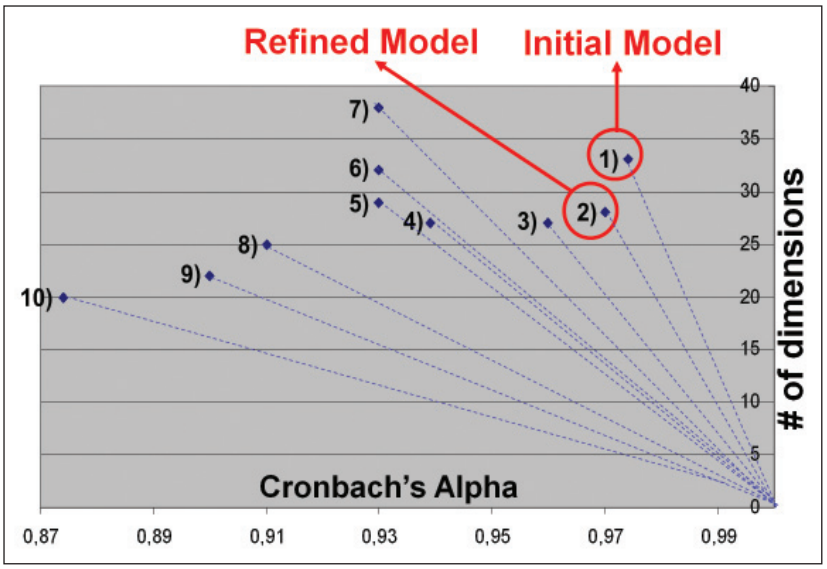


Figure 5.6: Quality Models in the Reliability-Dimensions Space

By observing the figure we can conclude that the refined version of the quality model has achieved a better combination of reliability and parsimony than models 4, 8, 9, 10 and the initial quality model, because it is closer to the lower-right corner, compared to the aforementioned models. The only competitive model that is very close to the refined quality model, in terms of performance, is the model with ID 3, i.e. the E-Qual model.

These very good results are attributed to the thorough and complete investigation of the state of the art which formed the basis for the development of the quality model. These results show that the refined quality model is rigorous, as it has been conceptualized with a significant level of accuracy.

6 THE SALT SYSTEM

In order to enable the adaptive evaluation of portal and e-service quality, as proposed in the framework of Chapter 4, a concrete system is necessary. The system, hereafter referred to as SALT (Self-Adaptive quaLity moniToring), consists of a number of components, which aim at the implementation of the proposed framework. In addition to the adaptive questionnaire and user tracking components, components for designing the questionnaires and annotating the portal, as well as components for reporting the results are part of the proposed SALT system. This Chapter describes the various components of the SALT system.

The Chapter is structured as follows. In section 6.1, the functional requirements of the system, as derived from the three adaptation criteria (which were described in section 4.2.3), are described. Section 6.2 provides an overview of the various SALT subsystems, while the technical architecture of the system is presented in section 6.3. Sections 6.4 and 6.5 discuss the design-time subsystems, i.e. the portal annotator and questionnaire designer, respectively. The subsystem which tracks the user behavior and detects user problems is described in section 6.6. Section 6.7 presents more details about the heart of the SALT system, the Dynamic Questionnaire Subsystem, which applies the adaptation criteria and implements the adaptation logic described in section 4.2.3.4. The ontologies used in SALT are discussed in section 6.8, while section in 6.9 the three-layered quality ontology, which forms the semantic foundation of the adaptation logic, is presented in detail. Section 6.10 describes the MERIT subsystem, which allows the analysis of the user feedback about the quality of a portal and its e-services with the help of charts. Section 6.11 provides an overview of the integration of the various SALT subsystems. Finally, in section 6.12 a walkthrough of the SALT system is given, by considering two different scenarios of user interactions with the system.

6.1 Functional Requirements of the System

In this section we present the functional requirements of the system which are derived from the adaptation criteria described in section 4.2.3. The requirements are categorized as run-time, design-time and analysis-time, depending on the phase they are applicable to.

In order to enable the adaptation of the questionnaire based on the user feedback (first adaptation criterion) the system should possess the functionality of run-time intelligent branching based on the responder's answers (**requirement 1**). This means that the system should be able to decide which questions to present next based on previously gathered data.

Adaptation based on user problems (second adaptation criterion), implies a way of tracking the user behavior and detecting potential problems based on this behavior, at run-time (**requirement 2**). The problem detection functionality (described in section 6.6 below) is based on the knowledge about the type and characteristics of some web pages and page elements (e.g. the knowledge that a page is a navigation page, a service start page, or the knowledge that a page element is a button etc.). Hence, a way to characterize the various portal pages and page elements with predefined page types – at design time - is also needed (**requirement 3**).

In order to allow the personalization of the questionnaire to the individual, based on the characteristics of the portal pages he/she visited (third adaptation criterion), the system should be able to track the visited page types at run-time (**requirement 4**). Furthermore, the knowledge about the page type(s) that each page has, is also mandatory for enabling metadata-based adaptation. For this reason **requirement 3** applies here as well.

In addition to the aforementioned requirements which are derived from the adaptation criteria, there are three more requirements that are more general. **Requirement 5** is related to the need to design the questionnaire in an electronic form at design time. This includes the ability to insert statements and Likert scales, to change the look and feel of the questionnaire etc. **Requirement 6** is related to the need to run the adaptation logic described in section 4.2.3.4 at runtime, by applying the three adaptation criteria in the appropriate order. **Requirement 7** originates from the need to present the data collected through the adaptive questionnaire in a human understandable way. This would allow the analysis and comparison of the various quality aspects.

Table 6.1 summarizes the functional requirements of the SALT system:

Table 6.1: Functional Requirements of SALT

Req. ID	Requirement Description	Phase	Required by Adaptation Criterion
1	Performing runtime intelligent branching based on the responder's answers	Runtime	Adaptation based on user feedback
2	Tracking the user behavior and detecting potential problems based on this behavior	Runtime	Adaptation based on user problems
3	Characterizing portal pages and elements with predefined page types	Design time	Adaptation based on user problems Adaptation based on visited page types
4	Tracking the visited page types	Runtime	Adaptation based on visited page types
5	Design the questionnaire in an electronic form	Design time	All
6	Run the adaptation logic	Runtime	All
7	Data presentation	Analysis-time	None

6.2 Overview of SALT Subsystems

Figure 6.1 depicts an overview of the various SALT subsystems. The subsystems, which have been categorized according to the phase (design time, run time, analysis time) they are applied, implement together the functional requirements described in section 6.1. In this section, we discuss the various subsystems and components depicted in Figure 6.1, by putting emphasis on the functional requirements implemented by each one.

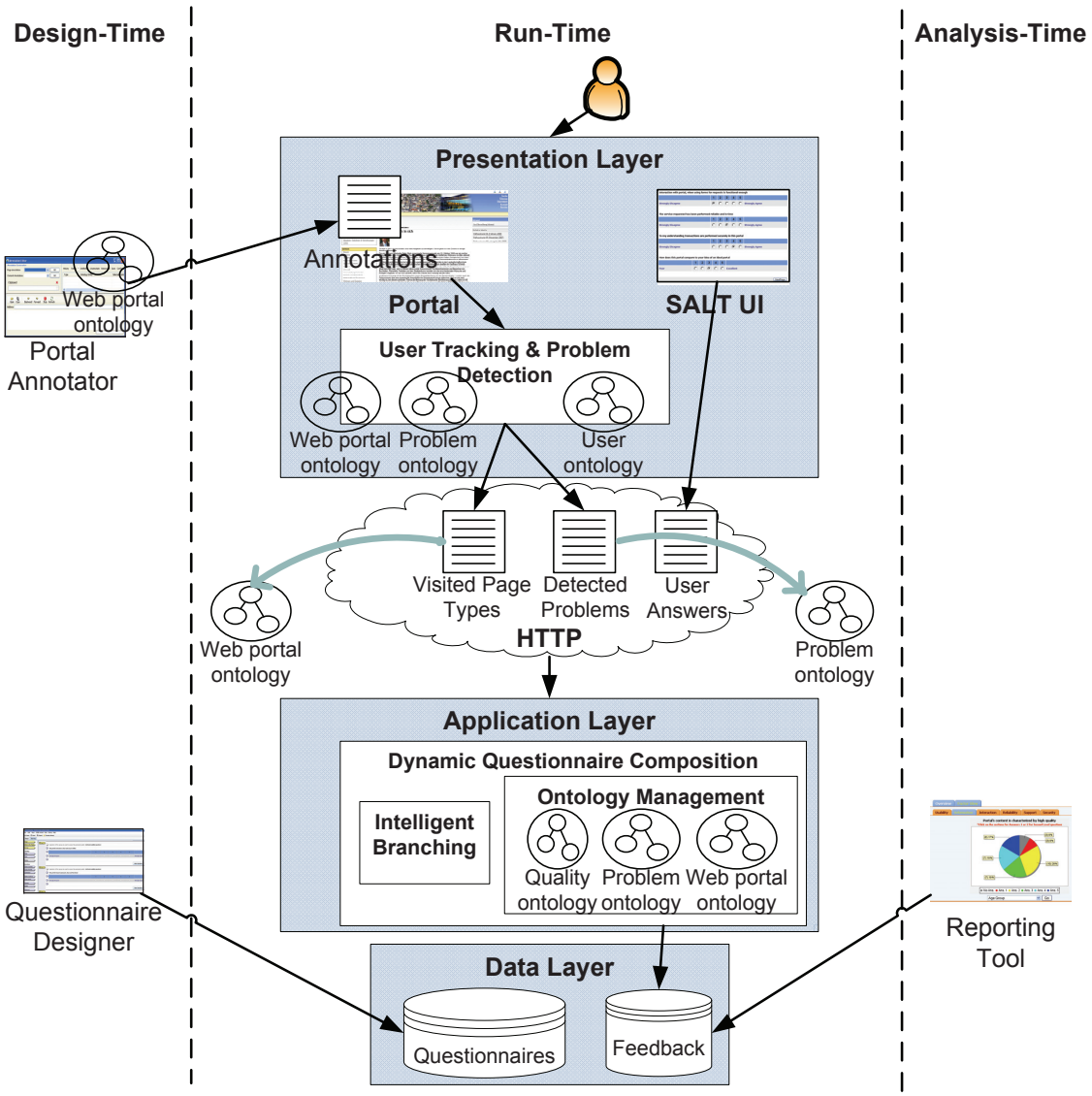


Figure 6.1: Overview of SALT Subsystems

6.2.1 Design Time Subsystems

Starting from the requirements of the design-time phase, **requirement 3** is supported by the *Portal Annotator* subsystem which is detailed in section 6.4. This subsystem enables the annotation of the web pages of the portal with concepts from the *Web Portal Ontology*, which models the various types of web pages (see section 6.8.3). The annotations produced by the annotation tool are used in order to enable the *User Tracking & Problem Detection* subsystem to derive a meaningful user context which is used for questionnaire adaptation.

The design-time **requirement 5** is supported by the *Questionnaire Designer* subsystem, which provides a graphical user interface (GUI) for creating the questions/statements in a convenient way. More details about this subsystem can be found in section 6.5.

6.2.2 Run Time Subsystems

The run time **requirements 1, 2, 4 and 6** are supported by subsystems residing in both the client and server side, while the integration of the various subsystems is supported by ontologies and databases. The following describe these subsystems as well as the data tier of the whole system.

The *User Tracking & Problem Detection* subsystem fulfils **requirements 2 and 4**. This subsystem resides in the **client side** and tracks the user behavior, keeps track of the metadata of the visited Ajax pages and detects user problems. User actions that are taken into account by this subsystem can be all kinds of recognizable interactions of the user with the browser like mouse movements or key strokes. For the detection of user problems the subsystem employs ontologies and rules. Rules indicate user problems for the various user behaviors, by referring to ontological concepts. The main ontology used is the *User Ontology* which serves as a template for the online real-time acquisition of the user's browsing behaviour. It should be noted that in addition to *User Ontology*, the *User Tracking & Problem Detection* subsystem also uses the *Problem* and *Web Portal Ontologies*. These two ontologies are also used as common reference models for the communication between this subsystem and the *Dynamic Questionnaire Composition* one – see below the description of the latter for more details.

The second major subsystem of the solution is the *Dynamic Questionnaire Composition*, which resides in the **server side**. It implements the functionality of runtime intelligent branching (**requirement 1**) and is responsible for running the adaptation logic (**requirement 6**) based on the specified adaptation criteria (see section 4.2.3). When the user ends his/her session on the portal, excerpts of the user model, necessary for the adaptation of the questionnaires, are send to this subsystem via HTTP parameters. The portions of the user model of interest are the metadata of the visited pages and the user encountered problems, as can be seen in Figure 6.1. Based on this information and on the answers given by the user, which are also sent to the *Dynamic Questionnaire Composition* subsystem at runtime, the personalized questionnaire is displayed to him/her.

In order to enable the interoperability between the two major subsystems of our framework, i.e. the *User Tracking & Problem Detection* subsystem and the *Dynamic Questionnaire Composition* subsystem, we decided to also employ formal ontologies in the latter which model: the quality factors and dimensions, which are defined in the quality model introduced in section 4.2.1, as well as their hierarchical relationships (*Quality Ontology*); the types of web pages and the structural elements of a page (*Web Portal Ontology*); and the problems encountered by

the user while using a portal (*Problems Ontology*). As can be seen in Figure 6.1, *Web Portal* and *Problem Ontology* act as the interface between the two major sub-systems, because the parameters of the user model transferred from the client to the server side through HTTP, refer to these common ontologies (in section 6.11 the HTTP parameters are defined in detail).

The ontologies are not used solely in order to allow interoperability between the two major subsystems, as they also play a crucial role in the enablement of the personalized and semantically adaptive measurement of portal and e-service quality by the *Dynamic Questionnaire Composition* subsystem. As already described in section 4.2.4, where the MAQM model was described, semantic relations of questions to possible user problems and portal's page types, allow the realization of the problem-based and metadata-based adaptations, respectively. These semantic relations are modelled as inter-connections between the *Quality Ontology* on the one hand and the *Problem* and *Web Portal Ontologies* on the other hand, in terms of ontology object properties. The *Ontology Management* subsystem, which is part of the *Dynamic Questionnaire Composition* one, is responsible for querying and manipulating the ontologies at runtime, providing an interface between the adaptation logic and the underlying semantic data models.

More details about the *ontologies* and their role in the questionnaire adaptation can be found in section 6.8, where the various ontologies are described, and section 6.12, where a typical system walkthrough is presented.

In the data layer of the system's 3-tier architecture reside two databases. The *Feedback* database, as the name implies holds users' feedback about the quality of e-services and portals, which can be exported to spreadsheets or statistical packages for further analysis. The *Questionnaires* database contains the questions/statements that were discussed in section 4.2.2, and is created by the *Questionnaire Designer* subsystem.

6.2.3 Analysis Time Subsystems

The analysis time **requirement 7** is supported by a *Reporting Tool* subsystem, hereafter referred to as MERIT. It is a web-based tool that accesses the *Feedback* database in order to retrieve the data collected through the adaptive questionnaire. Based on the collected data it generates and presents human understandable charts, providing a comprehensive view of portal and e-service quality and facilitating the data analysis. More details about this tool can be found in section 6.10.

6.2.4 Index for the Various System Components

In the next section a more technical view of the proposed system is given, while the various system components, such as the design time, runtime and analysis subsystems, the ontologies and the integration of the various subsystems are described in more detail in separate

sections. Table 6.2 contains an index for the distribution of the various system components in the various sections of this Chapter.

Table 6.2: Index for the Various System Components

System Phase	System Component	Section
Design time	Portal Annotator	6.4
	Questionnaire Designer	6.5
Runtime	User Tracking & Problem Detection	6.6
	Dynamic Questionnaire Composition and Databases	6.7
	Ontologies	6.8 and 6.9
Analysis	Reporting Tool (MERIT)	6.10
-	Integration of Subsystems	6.11

6.3 Technical Architecture

The system proposed in this doctoral thesis consists of several components, which implement a variety of functionalities, as already mentioned in section 6.2. The technical architecture of the system is depicted in Figure 6.2. In the following, some technical issues about the components are discussed.

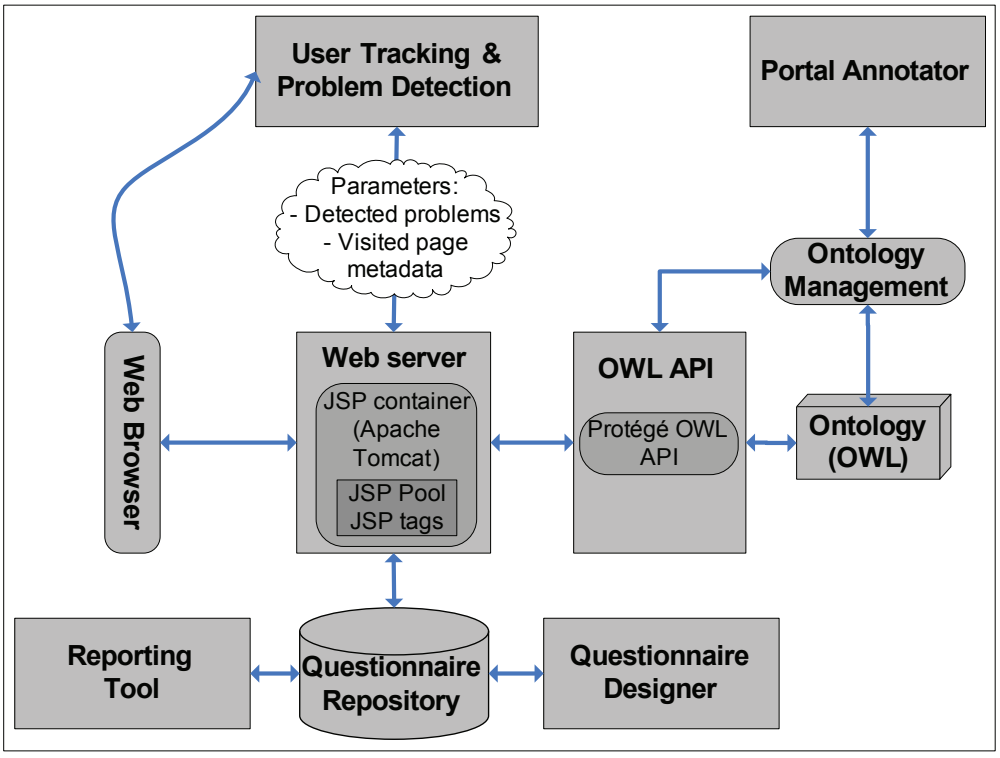


Figure 6.2: Technical Architecture of the System

The *Portal Annotator* Tool (see section 6.4) is a windows-based application that stores the semantic annotations in a server-side knowledge base. It thus stores the annotations separately from the content and layout of the portal's pages.

The *Questionnaire Designer* component is used for designing the questionnaire templates. The open source survey tool Web Survey Toolbox [Powers, 2007], which was developed by the Human Computer Interface (HCI) laboratory at the Carnegie Mellon University, was used for that purpose. This open source tool interacts with MySQL database management system (DBMS). A *Questionnaire Repository* is responsible for storing questions as well as users' answers. It should be noted that the *Questionnaire Repository* depicted in Figure 6.2 represents both the Feedback and the Questionnaires database of Figure 6.1.

Conditioned by the Ajax technology the *User Tracking & Problem Detection* component (see section 6.6) resides as a JavaScript library inside the browser. This enables user tracking beyond simple click streams. A rich set of user interactions can be traced while the user interacts with the portal page. With the help of the ontologies linked to the web page via the annotations produced by the annotation tool, a meaningful user context can be derived. Finally, the detected user problems as well as the metadata of the visited pages are communicated via HTTP to the *Dynamic Questionnaire Composition* subsystem for further processing.

The *Dynamic Questionnaire Composition* subsystem is based on the Web Survey Toolbox, and extends it with the adaptation logic of section 4.2.3.4 as well as with ontology communication capabilities. It resides in the adaptive e-questionnaire server which is hosted by an Apache Tomcat server [Chopra et. al., 2004]. It retrieves the appropriate set of questions dynamically (based on the current user context) from the *Questionnaire Repository*, by using the Java Database Connectivity (JDBC) API [White et. al., 2001], and presents them to the user. This subsystem takes advantage of the JSP tags - which are used by the Web Survey Toolbox as the main API for encapsulating business logic in the questionnaire presentation – and extends its JSP pages, in order to allow them to communicate with the ontologies. The user responses to the statements of the questionnaire are stored into the *Questionnaire Repository* for further analysis.

The ontologies, i.e. the Quality, Web Portal and Problem ontology, are used by the adaptation logic of the adaptive questionnaire as described in section 4.2.4 where the MAQM model was described. As a Semantic Web Framework we used Protégé OWL API [Knublauch and Horridge, 2005] which is an abstract layer above Jena [McBride, 2002]. The Protégé OWL API provides classes and methods to load and save OWL files, to query and manipulate OWL data models, and to perform reasoning based on Description Logic engines. The API is built on top of a collection of Java interfaces from the model package which provide access to the OWL Model and its elements such as classes, properties and individuals. The OWL Model can be used to create, query, and delete resources of different types; and it provides

objects to perform operations such as getting and setting resource property values, building relationships between resources, and obtaining the set of restrictions for a property at a class. Other advanced features such as querying, and reacting to changes using listeners are also managed through this API.

Finally the *Reporting Tool* was built by using JSP and open source frameworks and libraries for graphical chart creation. It connects to the *Questionnaire Repository* of Figure 6.2 through JDBC (Java Database Connectivity) for fetching the information required for generating the visual charts. More details about this tool are provided in section 6.10.

6.4 The Portal Annotator Subsystem

To take advantage of the knowledge modeled in the ontologies (see the description of MAQM in section 4.2.4) the portal first has to be annotated. The web sites of the portal are annotated with concepts from the ontologies at design-time, i.e. the annotation is done only once. Annotations link real web objects to their types; for instance web pages are linked to page types. Finally, they are stored into a Knowledge Base.

In order to annotate the web pages and elements of the portal with concepts describing their types, we used the portal annotator tool described in [Stojanovic et. al., 2007a, 2007b]. It is browser-based and has a simple user interface that hides the complexity of ontologies from the annotator. The tool allows annotating not only the whole page but also part of a page.

A screenshot of the tool is provided in Figure 6.3. As can be seen in the figure first the user should open the web page to be annotated, by entering its web address in the Address Combo or by opening it from the file dialog. Then, in order to annotate the web page, the user can select one type from the list of possible page types and click the OK button. The created annotation will be displayed in the right table. It should be noted that the Web Portal Ontology, which contains a definition of page types, should be imported in the annotation tool at design time. In this way, the page types defined in the ontology would become available to the tool during the actual annotation process.

Figure 6.3: Screenshot of the Portal Annotation Tool

6.5 Questionnaire Designer Subsystem

There are a lot of tools that enable the design and execution of web-based questionnaires. In order to decide which one is the most appropriate to be used in the context of the proposed framework, a research was conducted among the available tools. The primary requirements that have been used for the selection of the most appropriate tool were:

- To be open source, so that it can be re-used
- To be extendable and flexible, in order to allow its extension to an adaptive questionnaire for measuring portal and e-service quality
- To be compatible with Java, in order to allow its integration with the Java-based protégé OWLAPI that is used as a semantic web framework for communication with the ontologies used by the adaptive questionnaire (for more details about this technical requirement please see section 6.3 above).

Feature comparison tables across popular tools are available at [Web Survey Toolbox site, 2007] and [Gesis, 2007]. As can be seen in these tables, the Web Survey Toolbox [Powers, 2007] is the only one that fulfils these requirements. Survey manager is the major component of this open source tool. It allows to create surveys and to run the survey editor, which is a java web start application, used for designing questionnaires.

The Survey Editor has been used in order to create all the questions of the questionnaire. Using the GUI provided by this tool, someone can create pages and questions by dragging them from toolbar on the left - depicted in Figure 6.4 - into the location that he/she wants them dragged to [JSP Survey Library, 2007]. More instructions concerning the design of questionnaires using this open source tool are available at [Powers, 2007].

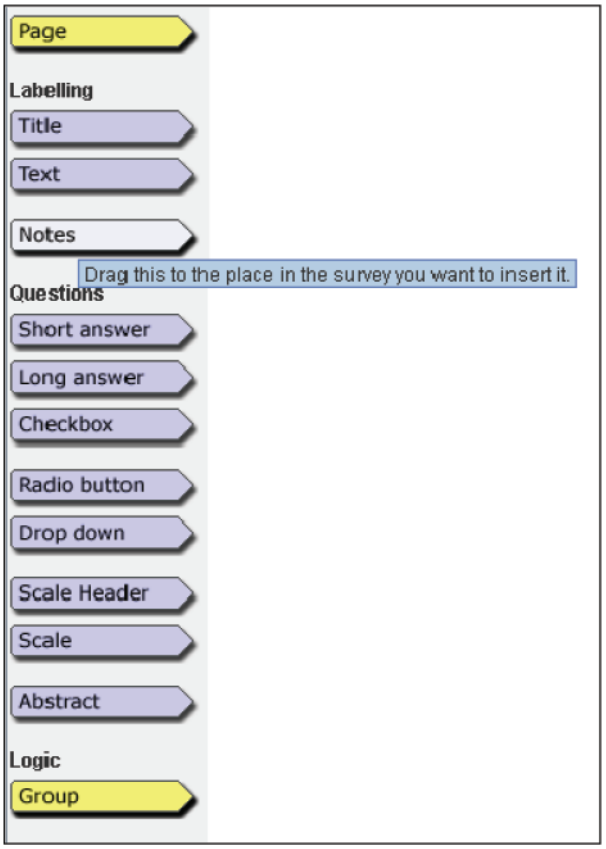


Figure 6.4: Survey Editor's Toolbar[1]

Using this tool and the above mentioned instructions, the static questionnaire was created at design time. By following this approach, the questionnaire has been transformed from a paper-form (see Annex A) to a web survey.

1. Figure from [JSP Survey Library, 2007]

After creating a survey, it can be exported as a .survey file and imported afterwards on another deployment of the questionnaire designer. This functionality allows the timely and convenient transfer of surveys, eliminating the need of creating a survey from scratch. Figure 6.5 depicts a sample of the static questionnaire, designed with the survey editor.

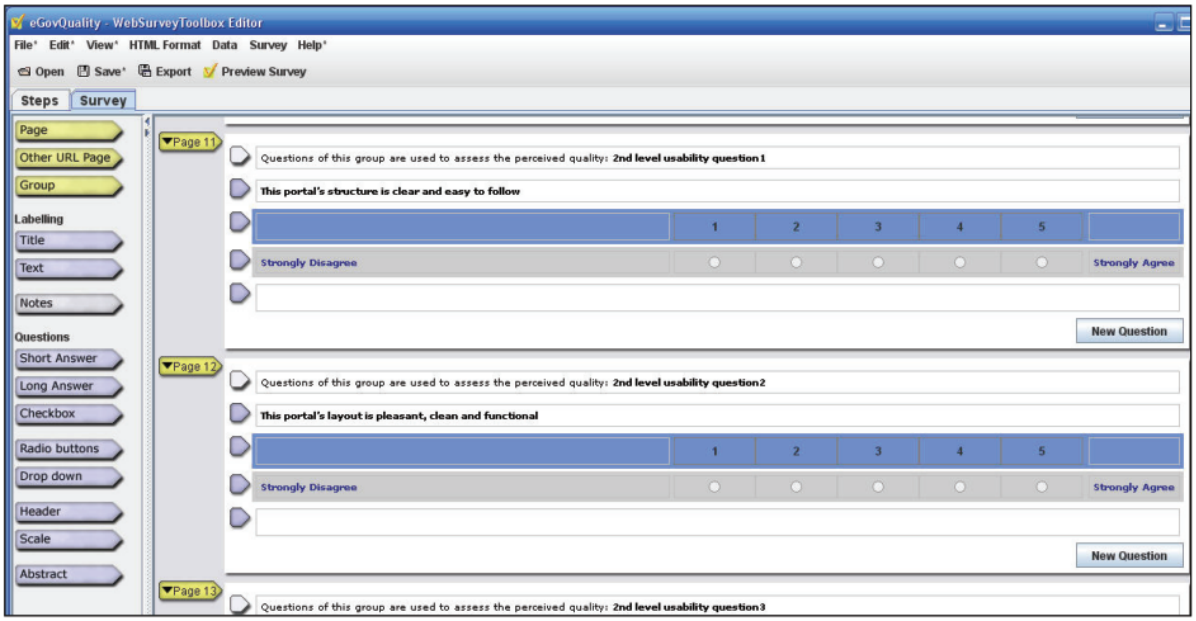


Figure 6.5: Questionnaire Designed with Survey Editor

6.6 User Tracking & Problem Detection Subsystem

In this section, an overview of the *User Tracking and Problem Detection* subsystem is given, while more details about it can be found in [Schmidt et. al., 2007]. Tracking the user behavior and building up a user model is the vital prerequisite for personalized dynamic questionnaire composition. User models are widely studied in the field of e-learning systems and adaptive hypermedia systems, see e.g. [Brusilovsky, 1996]. However, they both have the web page paradigm in common. That is, the work done so far in the above mentioned fields builds up the user model on the server-side based on the HTTP requests issued by the client. But this is only a subset of the traceable user interactions of a web application. With the dawn of Ajax in early 2005 [Garrett, 2005], a new potential of tracking a user's browsing behavior, as well as new adaptation strategies arose. The range of user actions that can be tracked is extended beyond just mouse clicks. For example, scrolling, mouse over and keystroke events can be tracked, enabling the detailed recording of user actions on the client-side. The well-known problem of assigning clicks to users, which applies when the user is tracked on the server-side, is solved on the fly in the case of client-side tracking. Additionally, in this case,

the user's web browsing behavior can be processed directly on the client and the browser can immediately detect problems the user might encountered while browsing the portal. On the contrary, in the world of the web page paradigm, the web server is not able to obtain such detailed information; it can only track a subset of user clicks. It misses browser events, like the back button and cached links.

The *User Tracking and Problem Detection* subsystem, takes advantage of the aforementioned potentials, by tracking the user behavior and building the user model at the client with the help of ontologies. Moreover, it immediately detects problems the user might encounter while browsing the portal, by applying rules which infer problems based on the web behavior of individual users.

As there is a demand for a user model, ontologies are as well suited as any other modeling technique. But as the *User Tracking and Problem Detection* also includes rules for detecting user problems, ontologies are the natural candidate and superior to other technologies. The subsystem is build upon the intensive use of semantic technologies, mainly for two reasons. First, ontologies enable semantic interpretation of user behavior in a portal, which enables meaningful, effective and context-aware problem detection. Secondly, ontologies used in rules can make adaptation logic more explicit. This declarative representation, expressed as rules using concepts and relations from the ontology, helps the domain experts to model, inspect, understand and modify the rationales behind the problem detection functionality. The subsystem uses the Web Portal, Problem and User Ontologies which are described in section 6.8 below.

The Web Portal Ontology is used at design-time in order to annotate the portal with the appropriate concepts describing the type and domain of the web pages. In order to read and write the ontologies at the client and to execute the tracking rules responsible for detecting user problems, the ontologies, the portal annotations as well as the rules are transformed into a client-readable format. The transformation of ontologies and rules is done with a help of a converter [Kalyanpur et. al., 2004], [Schmidt et. al., 2007], which transforms them to JSON, a subset of JavaScript used for encoding data structures [Crockford, 2006].

Figure 6.6 illustrates the run-time aspects of the *User Tracking and Problem Detection* subsystem. At run-time, the web usage behavior of the current user is tracked and stored into the aforementioned JSON format directly on the client-side. The user actions, which indicate user problems, are tracked by a JavaScript script that can be seen as an additional layer over the original portal. This script is also responsible for executing rules which infer problems within a user session. More details about how the *User Tracking and Problem Detection* subsystem tracks user actions and detects user problems can be found in [Schmidt et. al., 2007].

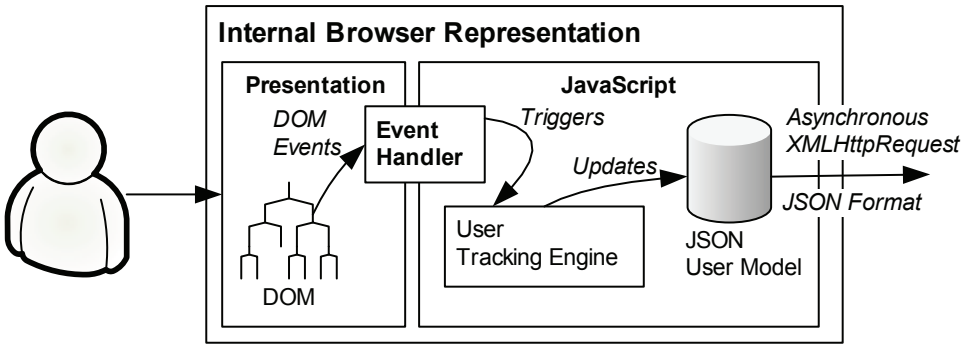


Figure 6.6: Run-time User Tracking

Table 6.3 depicts some examples of user problem detection by taking into account behaviors that might indicate user problems. As can be seen in the table the problem detection functionality is based on the knowledge about the type of some web pages and page elements (e.g. the knowledge that a page is a navigation page, a service start page, or the knowledge that a page element is a button etc.).

Table 6.3: Examples of User Behaviors and Detected Problems

Detected Problem	User Behavior that might Indicate Problem
Finding Service, Navigation Problem	Reading many tool tips without clicking a link A quick sequence that indicates confusion, e.g., follow a link, press the back button, then follow another link from the same menu Using the search function of the portal, without following the returned links to any depth
Presentation Problem	The user scrolls and then interacts with an interactive element like a button The user changes or attempts to change the text size
Service Problem, Form Problem	Quitting a service execution between the service start-page and service end-page. E.g. quitting the task of filling in a form

In order to show how the low-level details of user's behavior can be transformed into descriptions that have to do with the higher level details of the user context, in Table 6.4 we present a running example. The example is taken from Table 6.3 and demonstrates the entailment how a service problem can be deduced from the pure web usage data of an individual user. For the sake of simplicity the example is written in SWI-Prolog.

Table 6.4: Example of a Rule for Detecting a Service Problem

```
00 userWithServiceProblem(U) :-
01 user(U),
02 hasVisited(U,S),
03 start(S),
04 findall(E1,(end(E1), hasVisited(U,E1)),L),
05 L=[].
```

The rule depicted in Table 6.4 simply states that whenever a user has visited a page annotated as starting page of a service without reaching the page annotated as end page he/she has encountered a service problem. The code for not reaching an end page is shown in Line 04 and Line 05.

When the user ends his/her session, excerpts of the user model, necessary to the adaptation of the questionnaires (i.e. detected problems and the visited page types), are sent to the *Dynamic Questionnaire Composition* subsystem. Based on the detected problems, the visited pages and the feedback provided by users through the e-questionnaire, the latter adapts itself to the individual.

6.7 Dynamic Questionnaire Composition Subsystem

The Dynamic Questionnaire Composition subsystem is the heart of SALT. It presents the questionnaire in multiple-pages and is responsible for adapting the set of questions to be included in each page, based on the knowledge about the current user context (i.e. user problems, metadata of visited pages and previously submitted user responses). To do so, it runs the adaptation logic described in section 4.2.3.4, by employing adaptation techniques and ontologies.

Each question of the questionnaire is considered a distinct fragment. The inclusion of a fragment to the set of fragments that constitute a single page is orchestrated by the Dynamic Questionnaire Composition subsystem. The pages that contain fragments (questions) are created on the fly by JSP pages employing JSP tags. The subsystem guides the user from the one dynamically composed page to the next, as in a guided tour. This is achieved with conditional (if/then) statements that are included in the JSP pages, in order to implement the adaptation logic. So, the subsystem, on the basis of the three adaptation criteria, displays the next appropriate page which consists of the appropriate fragments (questions). A “next” button invites the user to go to the “next” page. But unlike in a static guided tour, the Dynamic Questionnaire Composition subsystem determines dynamically the destination of the “next”

button, so different users may go to a different page when clicking on the “next” button on the same page. Furthermore, when a user revisits a page, the “next” button on that page may take him/her to a different page than the previous time, depending on the current user context.

The ontologies form the formal representation of the concepts and relationships described in the MAQM model (see section 4.2.4), and are used by the subsystem for the application of the adaptation logic. The Dynamic Questionnaire Composition subsystem is finally responsible for storing user responses to the Questionnaire Repository for further analysis.

In this section, implementation details about the Dynamic Questionnaire Composition subsystem are given, such as the JSP pages and tags, java and OWL API classes and methods used. Morover, details about the Questionnaire Repository schema are provided.

6.7.1 Dynamic Questionnaire Composition: Use of JSP Pages, Tags and Classes

In this section, the most important JSP pages, tags and java classes, which are used by the Dynamic Questionnaire Composition subsystem, are described.

The major JSP pages are:

- *Index.jsp*: It is responsible for presenting the instructions concerning the completion of the questionnaire, and for storing the URL parameters, which incorporate user problems and page types, to the Questionnaire Repository (the URL parameters are detailed in section 6.11, where the integration of the various SALT subsystems is described). This JSP page always guides the user to the first adaptively created JSP page, i.e. to the pageD.jsp
- *PageD.jsp*: It is responsible for the parsing of the URL parameters, the querying of the underlying ontologies as well as for applying the Problem Filter and the Metadata Filter (D) of the adaptation logic (see Figure 4.3). It uses the TransactionBean Java Class, which is described below, in order to perform the aforementioned functionalities. Depending on the user problems and the metadata of visited pages, it guides the user either to pageF.jsp or to the DemographicsPage.jsp
- *PageF.jsp*: It is responsible for the parsing of the URL parameters, the querying of the underlying ontologies as well as for applying the Metadata Filter (F) of the adaptation logic (see Figure 4.3). It uses the TransactionBean Java Class in order to perform the aforementioned functionalities. Finally, it guides the user to pageFD.jsp
- *PageFD.jsp*: It is responsible for the parsing of the URL parameters, the querying of the underlying ontologies as well as for applying the Feedback Filter and the Metadata Filter (D) of the adaptation logic (see Figure 4.3). It uses the TransactionBean Java Class in order to perform the aforementioned functionalities. It guides the user to DemographicsPage.jsp
- *DemographicsPage.jsp*: It is responsible for displaying demographic questions

The most important Java class used is the following.

- *TransactionBean.java*: This class is responsible for constructing an OWL model from the .owl ontologies, for querying the ontologies through the Protege OWL API (see section 6.7.3 below) as well as for communicating with the Questionnaire Repository through JDBC. It provides the various JSP pages with methods enabling the application of all the Filters used by the adaptation logic (see Figure 4.3).

The main JSP tag provided by the Web Survey Toolbox and used for the dynamic composition of the questionnaires is the *surveyblank* tag. Every JSP page, which presents dynamically composed questions, incorporates this tag that allows the selection of the questions to be presented. Within this tag, the API provides the option of putting plain questions inside, by encapsulating some other JSP tags. The *questionsFromDatabase* tag was used, inside the *surveyblank* one. This tag allows the presentation of questions that have been modelled under a specific page, using the *Questionnaire Designer*. The following code snippet for example, has as a result the presentation of all questions that have been modelled under the page X of the questionnaire:

<survey:questionsFromDatabase pageName="Page X"/>

On the other hand, for JSP pages which present a static set of questions, the major tag that is used is the *surveypage* one. This tag loads one page of the survey which is specified using the tag's survey flow parameters. There are four groups of parameters, depending on the functionality they provide. Parameters of the survey flow group are related to the flow of the questionnaire; another group contains parameters affecting visual options; login options parameters specify information related to user login, while finally there is an "other option" group, containing parameters that cannot be categorized into anyone of the aforementioned groups.

6.7.2 The Questionnaire Repository

The major tables of the *Questionnaire Repository* are:

- *perceivedquality2ndlevelanswers*
- *questions*
- *questionchoices*
- *users*
- *perceivedquality1stlevelanswers*
- *demographicsandusageanswers*

When a survey is designed with the Questionnaire Designer, the questions are stored into the *questions* table of the *Questionnaire Repository*. For those questions that multiple answers are available, the possible choices are stored into the *questionchoices* table. The *users* table models the users that take part in the survey. Users' answers to F-Level questions are stored into the *perceivedquality1stlevelanswers* table, the D-Level answers to the *perceivedquality2ndlevelanswers* table, while demographic information for each user is archived to the *demographicsandusageanswers* table. Figure 6.7 depicts the fields of these tables and the relations between them.

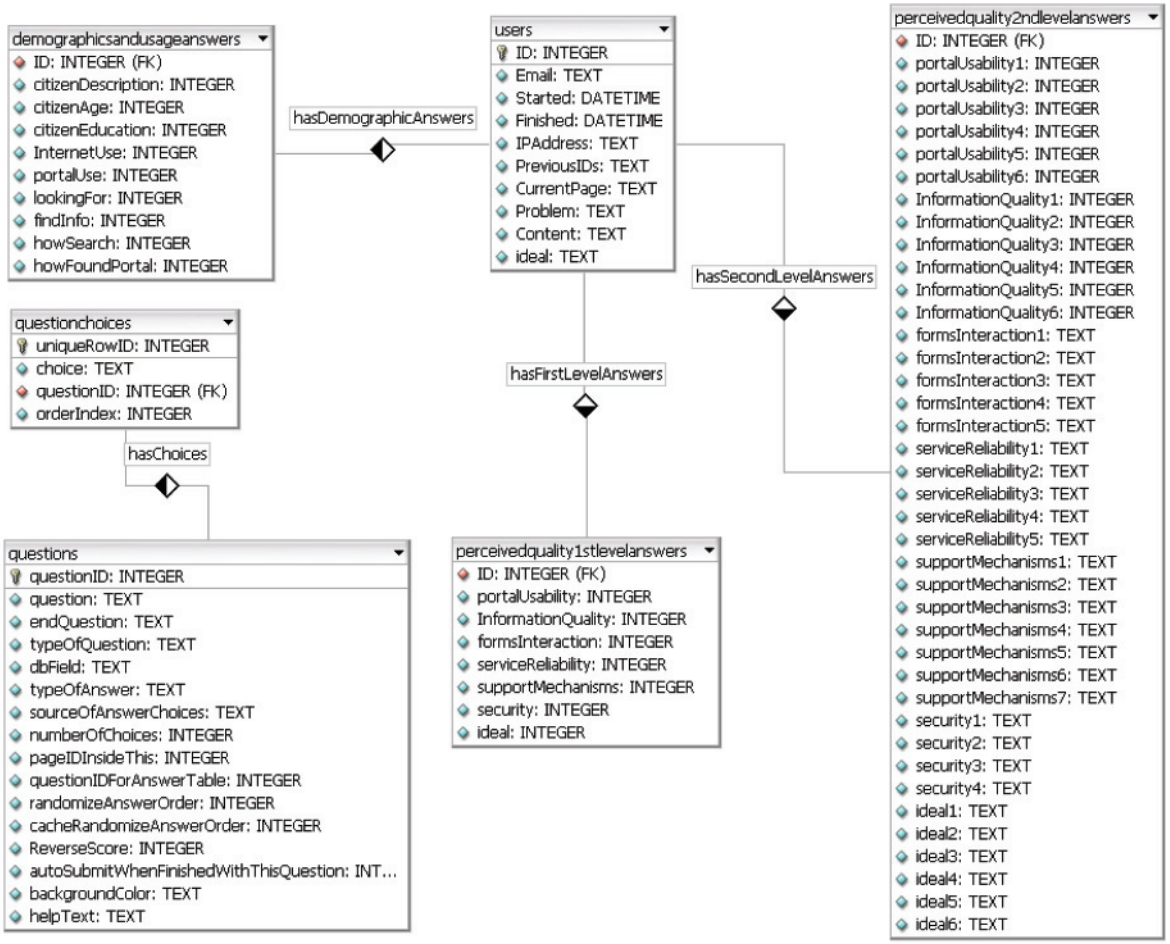


Figure 6.7: Major Tables of the Questionnaire Repository

6.7.3 Dynamic Questionnaire Composition: Use of Protégé OWL API

In this section we describe the most important classes and methods of the Protégé OWL API that are used by the Dynamic Questionnaire Composition subsystem.

The Protégé-OWL API is centered around a collection of Java interfaces from the model package. These interfaces provide access to the OWL model and its elements like classes, properties, and individuals. Using these interfaces there are no worries about the internal details of how Protégé stores ontologies. The most important model interface is *OWLModel*, which provides access to the top-level container of the resources in the ontology. The *OWLModel* can be used to create, query, and delete resources of various types and then the objects returned by the *OWLModel* can be used to do specific operations.

The construction of a new *OWLModel*, using an owl file located in an URI, is done using the method *createJenaOWLModelFromURI* of the *ProtegeOWL* class, as can be seen in the snippet depicted in Figure 6.8.

```
String uri = fixedPathToOntologies.startsWith("/") ?
owlModel = ProtegeOWL.createJenaOWLModelFromURI(uri)
```

Figure 6.8: Using Protégé OWL API to Create OWLModel

The most important *OWLModel's* methods used by the Dynamic Questionnaire Composition subsystem are:

- *getOWLObjectProperty* that returns an *OWLObjectProperty* object
- *getOWLNamedClass* that returns an *OWLNamedClass* object
- *getOWLDatatypeProperty* that returns an *OWLDatatypeProperty* object

The objects returned by these methods, correspond, as the names imply, to object properties, concepts, data type properties of the ontologies respectively, and are used in order to do specific operations on them. The most important methods that these objects are involved are depicted in Table 6.5.

Table 6.5: The Most Important Methods of Protégé OWL API

Class	Method Involved	Comments
OWLObjectProperty	*OWLIndividual::getPropertyValueCount*	The number of property's domain resources is returned
	OWLIndividual::getPropertyValues	A collection of property's domain resources is returned
OWLNamedClass	getInstances	Returns a collection of this concept's individuals
	getNamedSubclasses	Returns a collection of this concept's sub-concepts
OWLDatatypeProperty	*OWLIndividual::getPropertyValue*	A property's domain resource is returned
	OWLModel::getRDFResourcesWithPropertyValue	A collection of all resources that have a specific value for this specific property is returned

6.8 Ontologies in SALT

In this section we describe the role and use of ontologies in SALT. Ontologies form the formal semantic foundation for deriving the user's current context from the user's behavior which, in turn, enables meaningful, effective and context-aware adaptation of the questionnaires. Four ontologies are used in the SALT system, as already discussed in section 4.2.4 where the MAQM model was presented: User, Quality, Web Portal and Problem ontology. The User ontology resides in the *User Tracking & Problem Detection* subsystem, the Quality ontology in the *Dynamic Questionnaire Composition* subsystem, while the Web Portal and Problems ontologies are used by both subsystems. The ontologies are formalized using OWL [Guinness and Harmelen, 2003], since it is a standard language for representing ontologies on the web.

6.8.1 User Ontology

The User ontology introduces concepts and properties to model users and their behavior and is used solely by the *User Tracking & Problem Detection* subsystem for tracking the user behaviour and detecting user problems. In fact the User ontology serves as a template for the online real-time acquisition of the user's browsing behavior. In other words, it describes the data structures holding user actions collected by the *User Tracking & Problem Detection* subsystem. The most important data set is the recording of interactions of users with the portal.

Even though data from user interaction is by far the most abundant collection of data, provided by Ajax, it is, however, the least informative on its own and needs to be enriched with semantics and interpreted. However, interpreting event data is difficult if the data are not normalized into a common, complete, and consistent model. This entails not only re-formatting the data for better processing and for achieving readability, but also breaking them down into more granular pieces. The User ontology enables to condense the received events into a single event directly indicating a problem. It structures information about the user's interactions and dependencies between interactions. The most important concept of this ontology is the concept Event that describes what happened, why it happened, when it happened, and what the cause was. More details about the User ontology can be found in [Schmidt et. al., 2007].

6.8.2 Quality Ontology

The quality ontology, which is described in details in section 6.9 below, allows the specification of quality dimensions and factors concerning the quality of portals and their e-services. Besides quality factors and dimensions, their hierarchical relationships are modeled explicitly. The *Dynamic Questionnaire Composition* subsystem takes advantage of these hierarchical relationships and their well defined semantics, for implementing adaptive quality evaluation by users. Independently of the adaptation criterion used, the knowledge modeled in the Quality ontology is always used for enabling the adaption, as already decribed in section 4.2.4.

6.8.3 Web Portal Ontology

The Web Portal ontology contains entities representing the types of pages (such as *serviceType*, *searchType*, *formsType* etc.) and the structural elements of a page (e.g. *Hyperlink*, *Figure*, *Table*, *Content*, *Button* etc.). It provides this knowledge to the *User Tracking & Problem Detection* subsystem, in order to allow it to detect the visited page types and the user problems. The detected page types and problems are then communicated to the *Dynamic Questionnaire Composition* subsystem through HTTP parameters. The parameters concerning the visited page types refer to concepts of the Web Portal Ontology in order to allow the smooth integration of the two system components. Finally, the *Dynamic Questionnaire Composition* subsystem employs the knowledge about the types of pages modeled in this ontology, as well as the semantic relationships between portal types and questions (the latter are modeled in the quality ontology), in order to enable the application of adaptation based on the metadata of visited pages. The interconnection of the Quality with the Web Portal ontology is done through the object property *hasRelatedContent*, as depicted in Figure 6.9.

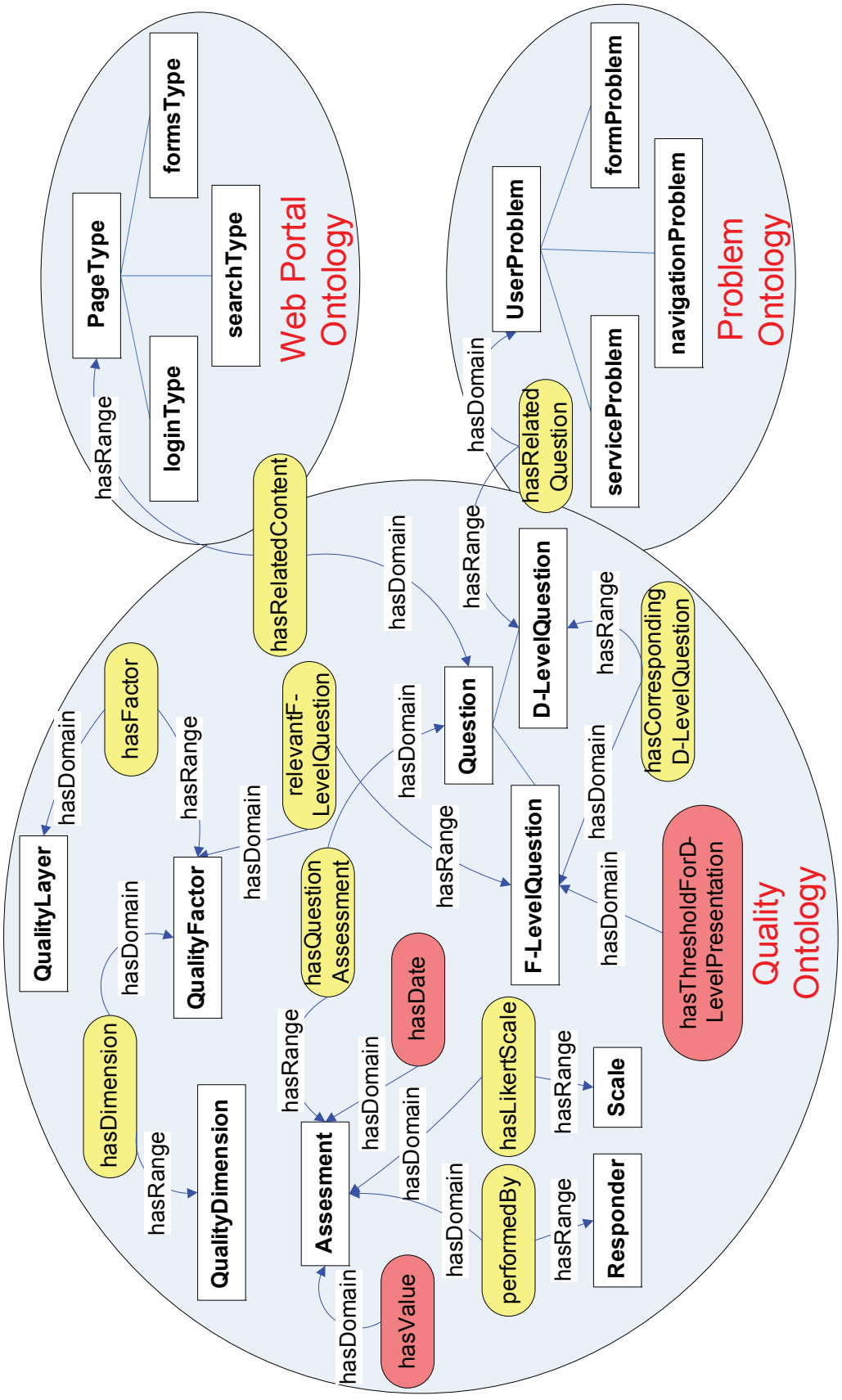


Figure 6.9: Indicative Concepts and Relations of Quality, Problem and Web Portal Ontologies

6.8.4 Problem Ontology

The Problem ontology models the problems that users may encounter during browsing through the portal in order to get e-services. It is based on the work done in [Webber, 2005], [Forrester, 2004] and [Fukuda and Bubb, 2003] where commonly encountered user problems are discussed. It contains entities such as *serviceProblem*, *formProblem*, *navigationProblem* and so on. All these entities are subclasses of the *UserProblem* class. This ontology provides the *User Tracking & Problem Detection* subsystem with the knowledge about the types of user problems, while the subsystem uses this knowledge in order to detect user problems. The problems detected, are then communicated to the *Dynamic Questionnaire Composition* subsystem through HTTP parameters, which refer to concepts of the Problem Ontology, in order to allow the smooth integration of the two system components. Finally the *Dynamic Questionnaire Composition* subsystem employs the knowledge modeled in this ontology, as well as the semantic relationships between problems and questions (the latter are modeled in the quality ontology), in order to apply problem-based adaptation. The interconnection of the Quality, with the Problem ontology, is done through the object property *hasRelatedQuestion*, as depicted in Figure 6.9.

6.8.5 Relationships between Ontologies

The major relationships between the concepts of the Quality ontology as well as the major links between the Quality, Problem and Web Portal ontologies are depicted in Figure 6.9. It should be noted that the concepts of the Quality ontology are detailed in section 6.9 below.

6.9 The Quality Ontology: QUONTO

The quality ontology, hereafter referred to as QUONTO (QUality ONTOlogy), is part of MAQM, the ontology-based model for quality measurement described in section 4.2.4. It plays an important role in the SALT system, enabling adaptation of the questionnaire to the individual user and interoperability between the system components. It should be noted that the QUONTO covers a broader range of aspects than those required by the SALT system, as it formalizes all the needed knowledge for the realization of a multi-perspective evaluation of e-services and portals.

The QUONTO is a three-layer ontology, consisting of 122 concepts, 50 properties and 160 restrictions. It has been partially developed using the open source ontology editor Protégé [2009] and has been successfully checked for inconsistencies using the Description Logic Reasoner RacerPro [2006].

Each layer of the ontology is related to a different level of abstraction concerning the modeled concepts and relations between concepts. The top layer is the most abstract, the middle layer follows, while the third one is application-specific and strongly related to the particular portal where the ontology will be integrated.

The aim of the top layer ontology is to define a minimal set of high level concepts and relations between them that are needed to describe the notion of quality of service. This layer, which is discussed in section 6.9.1, concerns quality of service in general and models the various perspectives that can be used for measuring quality (see section 2.1 where these perspectives are defined).

The middle layer ontology, which is presented in section 6.9.2, concerns quality of e-services and portals and models quality aspects related to them. The third layer of the ontology, the bottom one, is domain-specific. The aim of this layer is to support the different configurations of each portal's system. For example, it is possible that some concepts of the middle layer ontology cannot be applied to a specific portal. The bottom layer ontology is responsible for the relevant configurations to the middle layer one, in order to support compatibility with each service provider's system. In the following sections the top and middle layer ontologies are presented.

6.9.1 QUONTO Top Layer Ontology

General quality concepts such as subjective, objective, true, substitute and ideal quality characteristics, and other general concepts related to the customer and his expectations and experience as well as to the organization that provides the e-service, are modeled by the top layer of the QUONTO ontology.

There are five categories of quality characteristics. The assessment of objective ones is performed objectively by using specific quality metrics, such as system metrics obtained from system's operation. Objective characteristics can also be assessed by expert groups, which consist of one or more experts of the domain. Substitute characteristics represent the producer's view of quality and thus are assessed by the service provider. The customer's point of view is represented by true and subjective quality characteristics which are influenced by customer's experience and expectations. Customer's opinion concerning the quality characteristics of the actual delivered service differs from what he/she would expect from an ideal service. This gap may be taken into account when evaluating customer satisfaction.

The concepts of the top layer ontology and the relations between them, described above, are depicted in Figure 6.10:

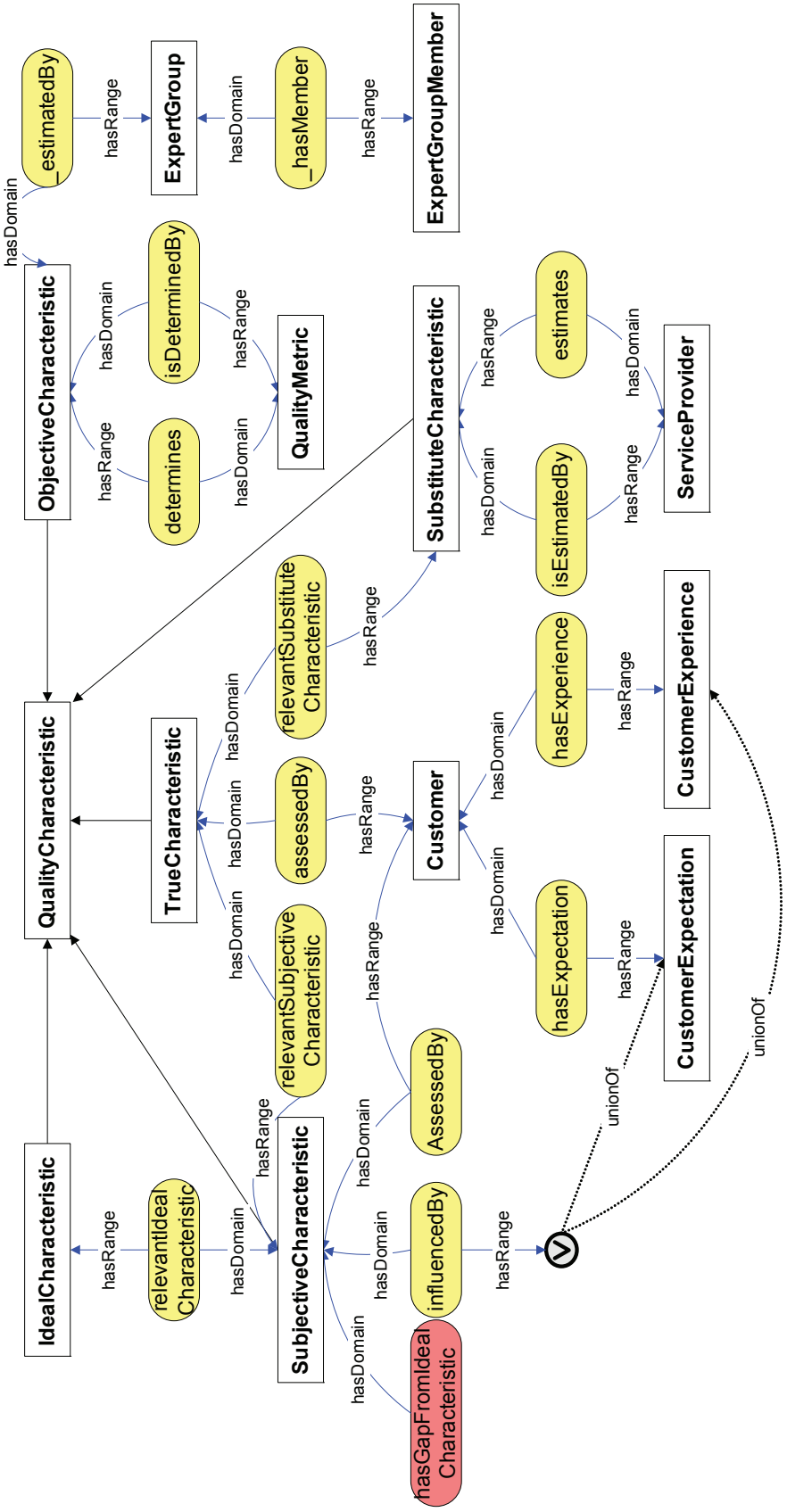


Figure 6.10: QUONTO Top Layer Ontology

6.9.2 QUONTO Middle Layer Ontology

The middle layer QUONTO ontology is based on the quality model (see Chapter 5) and models quality aspects related to portals and e-services. This section describes the classes of the middle layer of QUONTO, the main properties and subclasses of each class, as well as the major relations between classes. The various classes, subclasses, properties and individuals use the terminology defined in section 5.1, i.e. terms such as quality layers, quality factors and quality dimensions are used.

6.9.2.1 QualityLayer Class

This class represents the quality layer concept of the quality model, as a container for quality factors. The three major quality layers, i.e. service quality, system quality and content quality are subclasses of this class, as can be seen in Figure 6.11. The fourth subclass of *QualityLayer* is the *idealQualityLayer* one, which is a container for the quality factor that is relevant to the assessment of an ideal portal with ideal e-services. The property *hasFactor* relates individuals of the *QualityLayer* class to *QualityFactor's* ones. Universal and existential restrictions have been added to the *hasFactor* property in order to define that if an individual is a member of the class *QualityLayer*, then it must have at least one quality factor and that the quality factor must only be kind of *QualityFactor.*

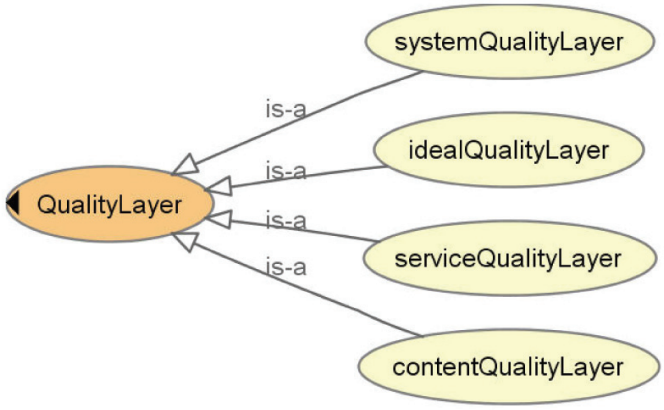


Figure 6.11: *QualityLayer* Class

6.9.2.2 QualityFactor Class

This class represents the quality factor concept of the quality model, as a placeholder for quality dimensions. There are two major categories of quality factors. The first includes factors that can be assessed either by users who visit the portal or by the technical staff of the organization

and represent the user's or technical staff's perception of quality, respectively. The factors of the second category do not represent perceptions. They are measured objectively by using system metrics obtained from system's operation. These two major categories of quality factors are depicted in Figure 6.12 as the two subclasses of *QualityFactor*, the *AssessableFactor* and *SystemPerformanceFactor*. The four subclasses of *AssessableFactor*, *serviceQualityFactor*, *contentQualityFactor*, *systemQualityFactor* and *idealQualityFactor*, represent subsets of assessable quality factors categorized by the quality layer they belong to.

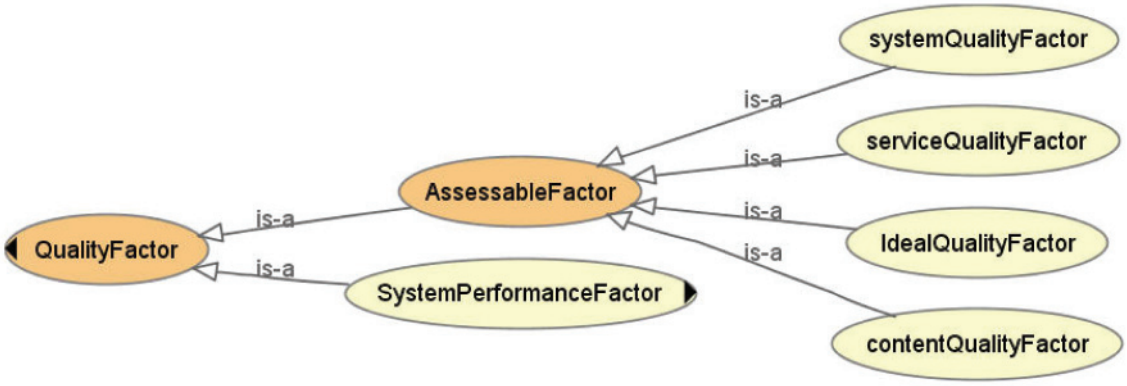


Figure 6.12: *QualityFactor* Class

One object property of the *QualityFactor* class is the property *belongsToLayer*. It is the inverse property of *hasFactor* and connects the *QualityFactor's* individuals with the corresponding individuals of the *QualityLayer* class. We have added universal and existential restrictions for this property - at each quality factor's subclass - in order to restrict its range for the various subclasses. For example, the service quality factor is restricted to belong to the service quality layer and only to this layer. Another property of the *QualityFactor* class is *hasDimension*, which relates each quality factor to the quality dimensions that are relevant to this factor. Universal and existential restrictions on the *hasDimension* property, for each subclass, define which quality dimensions are relevant to each quality factor's subclass. The *hasWeight* is a datatype property of *QualityFactor* that represents the weight of importance of each factor. Finally, the *relevantF-LevelQuestion* object property represents the relation between assessable quality factors and F-level questions of the quality model. Each assessable quality factor has a relevant F-Level question which is defined by using restrictions.

6.9.2.3 QualityDimension Class

This is the base class for all the quality dimensions of the quality model. There are two major categories of quality dimensions; these that can be assessed and represent perceptions concerning quality as well as these that cannot and are measured objectively with system

metrics. Therefore there are two major subclasses of the *QualityDimension* class, i.e. the *AssessableDimension* and the *SystemPerformanceDimension*, as depicted in Figure 6.13. The seven assessable dimension's subclasses, *serviceReliabilityQualityDimension*, *SecurityQualityDimension*, *formsQualityDimension*, *supportMechanismQualityDimension*, *informationQualityDimension*, *portalUsabilityDimension* and *idealQualityDimension*, represent subsets of assessable quality dimensions, categorized by the seven quality factors they belong to.

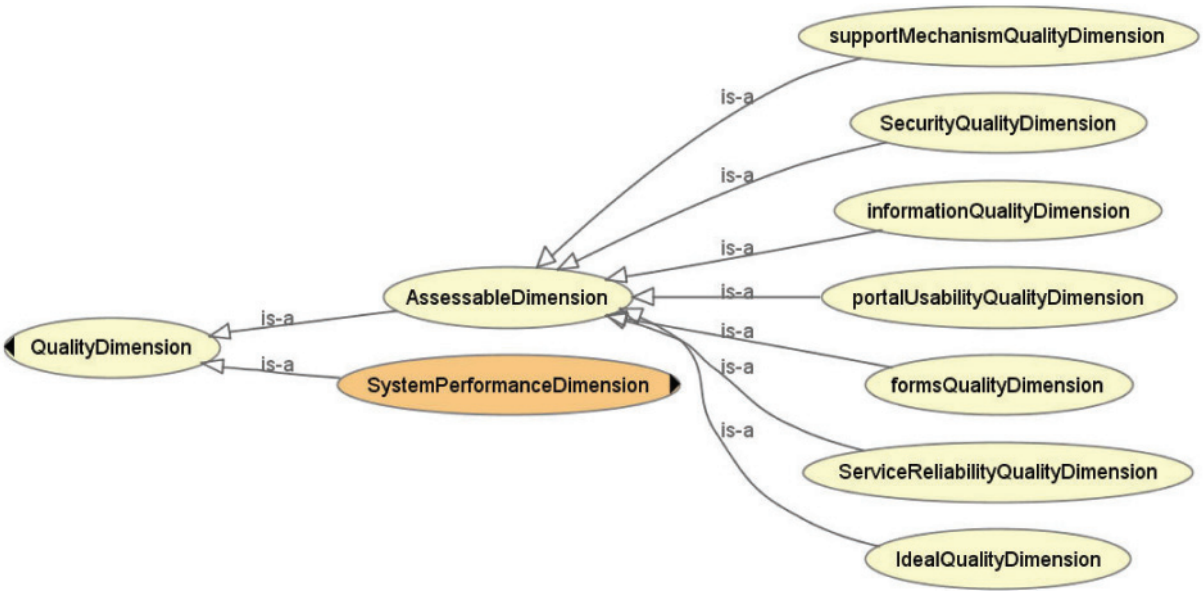


Figure 6.13: *QualityDimension* Class

The *partOfFactor* object property is the inverse property of the *hasFactor* one and relates the individuals of *QualityDimension* taxonomy to the corresponding individuals of *qualityFactor* taxonomy. The appropriate mapping between the two taxonomies though this property is achieved with the use of restrictions. For example, the *serviceReliabilityQualityDimension* is part of the *serviceQualityFactor* and cannot be part of other quality factors. The dimensions obtained from system operation are measured with metrics. This relationship is represented in the ontology with the *systemPerformanceDimension's* object property *hasSystemMetric*.

6.9.2.4 Question Class

This is the base class for all the questions used in order to obtain user perceptions about the quality of the portal and the provided e-services. The two major subclasses of this taxonomy, *F-LevelQuestion* and *D-LevelQuestion*, represent the F- and D-Level questions of the questionnaire, respectively. The subclasses of *F-LevelQuestion* and *D-LevelQuestion* represent F- and D-Level questions respectively, categorized by the quality factors these questions belong to. Each question, either F- or D-Level, has an object property *hasQuestionAssessment* which is used to hold the assessment that a responder gives to each answer. Specific properties of the *F-LevelQuestion* class are the following:

- *RelevantQualityFactor*, which correlates each F-Level question with the corresponding quality factor (inverse property of the *relevantF-LevelQuestion* one). Restrictions for this property have been added for each F-Level question subclass, in order to define which quality factor is relevant to each one of these subclasses.
- *hasCorrespondingD-LevelQuestion*, which connects each F-Level question with the D-Level questions taking a closer look to the quality factor of the respective F-Level question. Although the appropriate mapping between the two taxonomies through the property *hasCorrespondingD-LevelQuestion* is obvious for humans (for example the F-Level service reliability question has corresponding D-Level questions belonging to the service reliability group), it is not for OWL. This is the reason we have added universal and existential restrictions for this property for all subclasses of the *F-LevelQuestion* taxonomy.
- *hasThresholdForD-LevelPresentation*, which is a data type property used for defining a threshold for each *F-LevelQuestion*. This threshold is used by the adaptation logic for the application of the real-time user feedback adaptation axis, as already described in section 4.2.3.4.

Finally, the *hasCorrespondingF-LevelQuestion* is the only *D-LevelQuestion*-specific object property, and is the inverse property of the *hasCorrespondingD-LevelQuestion* one.

Figure 6.14: *Question* Class

6.9.2.5 Assessment Class

This is the base class for all the assessments of the questionnaire's questions. An assessment may concern F- or D-Level questions, so two subclasses of this base class have been defined, i.e. the *F-LevelAssessment* and *D-LevelAssessment*, respectively. There are seven subclasses of *D-LevelAssessment*, as can be seen in Figure 6.15, depending on the D-Level

questions that are assessed. For example, the *portalUsabilityAssessment* subclass, contains individual assessments of D-Level questions concerning portal usability.

Each assessment is performed by a responder. This relation is represented by the *performedBy* object property. Also, the assessment is made at a specific date and time and thus the datatype property *hasDate* was defined. The response (value) that the responder gives to each assessment is represented by the datatype property *hasValue*. Finally, the Likert scale used for the assessment is represented by the object property *hasLikertScale*.

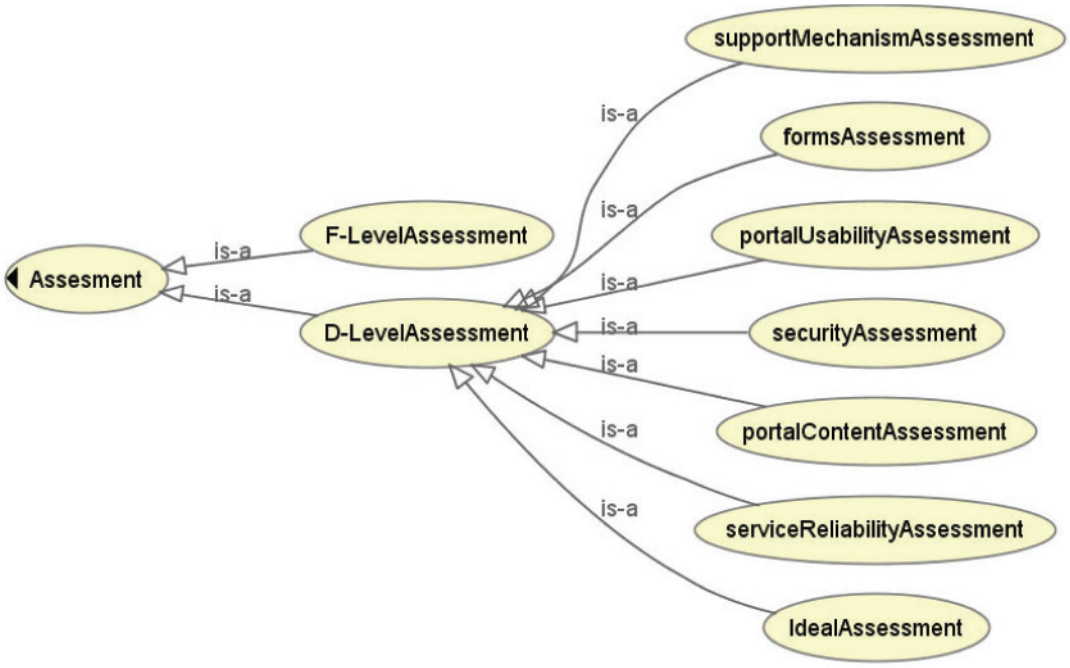


Figure 6.15: *Assessment* Class

6.9.2.6 Responder Class

This is the base class for all the responders who answer the questionnaire. Two categories of responders may exist; users and technical staff. Therefore two subclasses of the *Responder* class have been defined; the *UserResponder* and *TechnicalStaffResponder*, as can be seen in Figure 6.16. Each responder performs an assessment and this relation is represented by the object property *performsAssessment*, the inverse property of the *performedBy* one. Demographic information about the *UserResponder* is modeled into the QUONTO Ontology, concerning the user's age, education, work and Internet use habits. The relations between a user and the aforementioned demographic information are represented by object properties, such as *hasAge*, *hasDescription*, *hasEducationalDegree* and *hasInternetUse*.

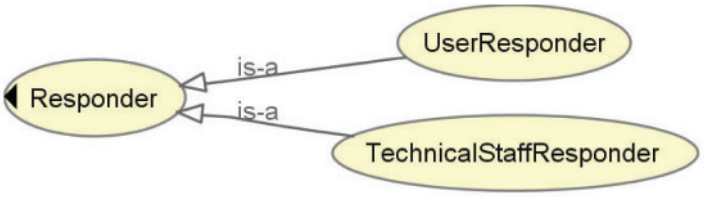


Figure 6.16: *Responder* Class

6.9.2.7 Scale Class

This class represents the scale that is used for the assessment of the various questions. A commonly used scale is a five point Likert scale. However, other scales are also supported. New scales can be added as individuals of this class. Each scale has low and upper limits. All possible answers fall inside these two limits which are represented by the data type properties *fromScaleValue* and *toScaleValue* respectively.

6.9.2.8 SystemMetric Class

System performance dimensions are measured using relevant system metrics. There are two types of system metrics; these that are the ratio of two numbers and these that are measured in time units. This distinction is represented in the ontology with two major subclasses of *systemMetric*, the *RatioMetric* and *TimeMetric*. A time metric can be measured in seconds, minutes or hours and thus the three *TimeMetric's* subclasses *TimeMinutesMetric*, *TimeHoursMetric* and *TimeSecondsMetric*.

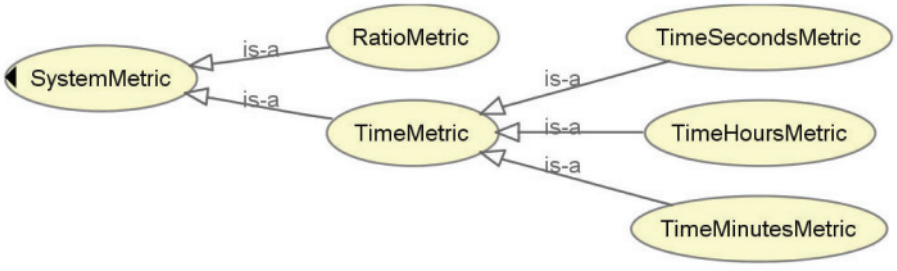


Figure 6.17: *SystemMetric* Class

6.9.2.9 Demographics Class

This is the base class for all the questions concerning user demographics. The weekly use

of internet (*InternetUse*), the educational degree (*EducationalDegree*), the age (*Age*) and a description concerning the occupation of the responder (*UserDescription*) are demographics for a specific user that visits the portal and answers to the questionnaire. Therefore, these are represented as subclasses of the *Demographics* class in the ontology, as depicted in Figure 6.18.

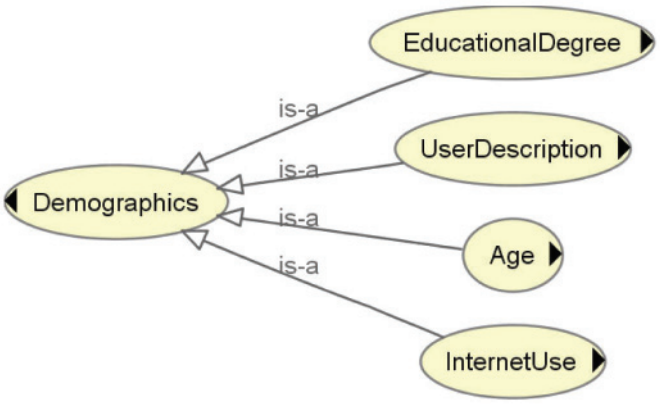


Figure 6.18: *Demographics* Class

Each subclass is subsequently divided into its own subclasses. Table 6.6 represents the taxonomy for each subclass:

Table 6.6: Demographic Classes and Subclasses

Class	Relevant subclasses
InternetUse	From1To5_Hours
	From6To10_Hours
	Less_than_1_Hour
	More_than_10_Hours
EducationalDegree	Bachelor
	High_School_Diploma
	Master
	NoDegree
	PhD
	Vocational

Age	Above66
	From16To25
	From26To35
	From36To45
	From46To55
	From56To65
	Less_than_16
UserDescription	AcademicFaculty
	FreeLancer
	GovernmentEmployee
	Other
	PrivateSectorEmployee
	Retired
	Student_9To12
	Unemployed
	UniversityStudent

6.9.2.10 Relations between Concepts of the Middle Layer Ontology

To sum up, the major relationships between the concepts of the middle layer ontology are depicted in Figure 6.19.

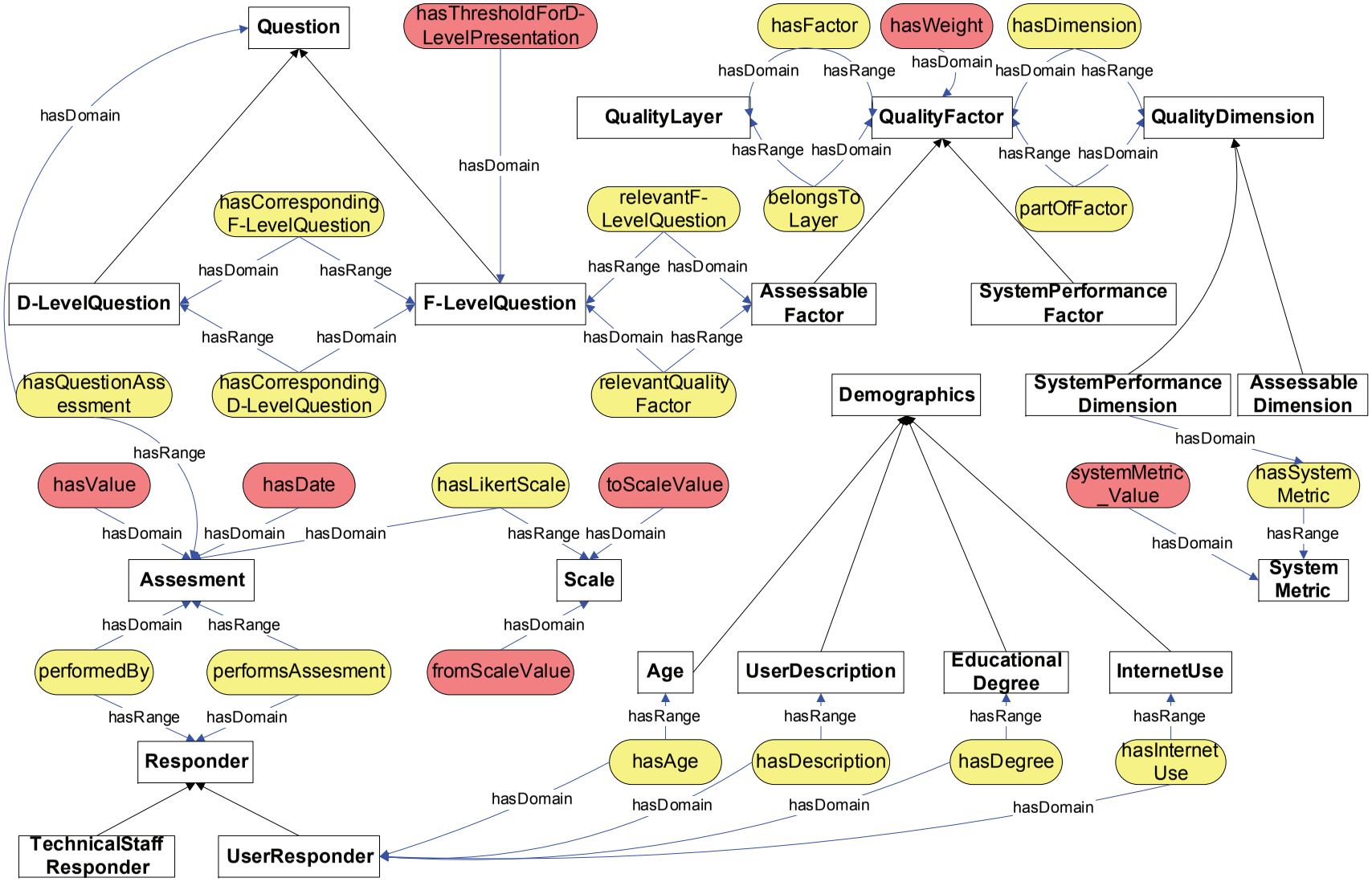


Figure 6.19: QUONTO Middle Layer Ontology

6.10 Reporting Tool: MERIT

As briefly overviewed in section 6.2, in order to allow the analysis of the user responses about the quality of a portal and its e-services, a tool was developed. The tool, hereafter referred to as MERIT - MEtrics ReportIng Tool - generates and presents charts of the data collected through the adaptive questionnaire. It organizes the data according to the quality factor they belong to. By presenting the data in a human understandable way, the tool provides a comprehensive view of portal and e-service quality, and facilitates the analysis and comparison of the different quality factors and dimensions.

6.10.1 Tool Overview

The tool is web based and is accessed through a web browser. As can be seen in Figure 6.20, there are two main pages, an Overview page where an overview of the questionnaire results is given, and a Factor View page. The Factor View page is organized in a tabbed form preserving the separation of the different quality factors. This means that the various charts are accessible through tabs, according to the quality factor they belong to. For example, the tab 'Usability' provides access to the chart about the quality factor of usability and so on.

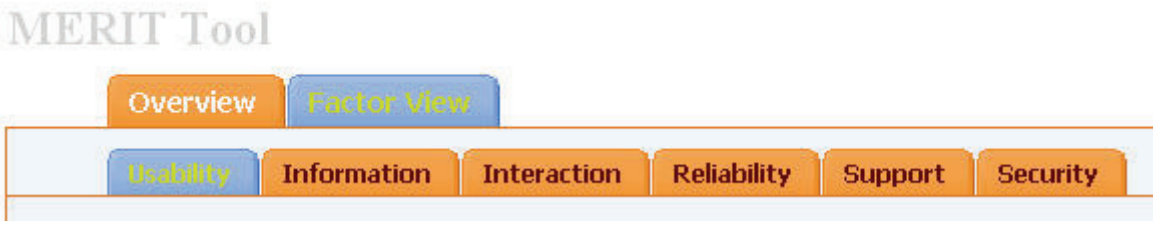


Figure 6.20: MERIT Overview

6.10.1.1 Overview Page

In the first page of the MERIT tool, an overview of the questionnaire results is given by a chart which displays the average score for each quality factor (see Figure 6.21). The average score for each factor takes into account user responses to both F-Level and D-Level questions. The average scores are displayed in a vertical bar chart with one bar per factor, while legends indicate which bar corresponds to which factor.

Figure 6.21: MERIT, Overview Page

6.10.1.2 Factor View

In the Factor View, for each factor selected from the relevant tab, a Pie Chart is displayed, showing the responses to the associated **F-Level** question. Each Pie Chart displays the total responses given to each value of the five point Likert scale (i.e. to values 1, 2, …, 5), as well as the percentage that each value of the scale received. Each value is represented as a different section of the Pie Chart, with a different color. For example, the Pie Chart displayed in Figure 6.22 concerns the F-Level question about information quality. In this example, 17% of the responses (6 responses) strongly agreed (as they gave a grade of 5) with the statement that the portal's content is characterized by high quality.

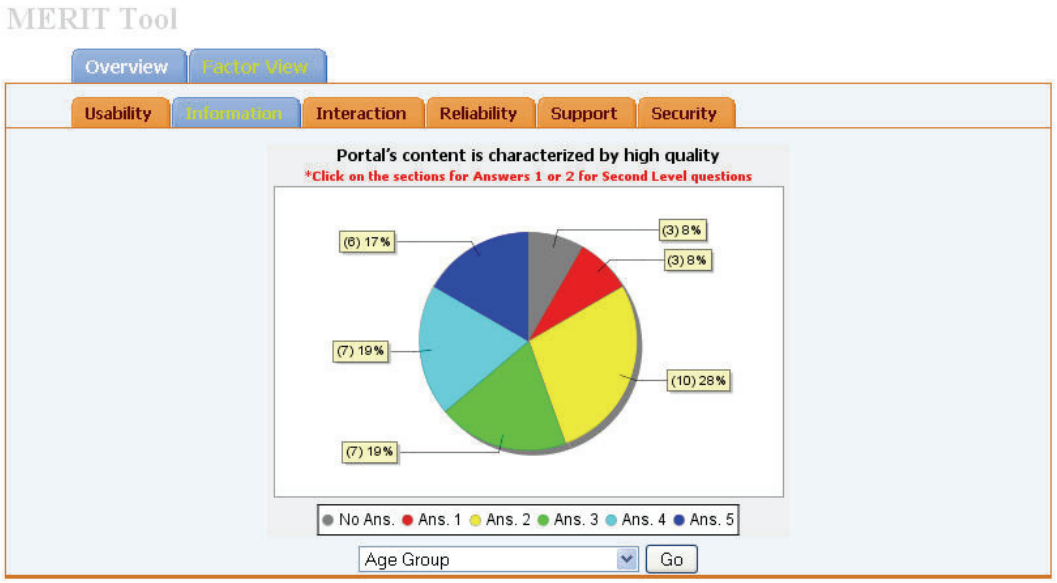


Figure 6.22: MERIT, The Factor View

For each factor selected, if there have been F-level responses with values below the threshold (of the five point Likert scale), then links appear on the sections of the Pie Chart that correspond to these values. These links, guide the user to a pop-up window, which contains charts depicting **D-level** responses for the selected factor. A relevant message is displayed under the title of the F-level question indicating the existence of a pop-up window, if applicable. It should be noted that the threshold has been set to 3 at the example depicted in the screenshot of Figure 6.22, therefore values below the threshold are 1 (meaning strongly disagree) and 2 (meaning disagree). Hence, links, which guide the user to the pop-up window, appear in the red and yellow sections of the Pie Chart depicted in Figure 6.22.

The responses to D-Level questions also range in a Likert scale from 1 to 5; therefore, the charts included in the pop-up window are also of a Pie Chart type. For example, Figure 6.23 shows one of the Pie Charts which are included in the pop-up window displaying D-Level responses about information quality.

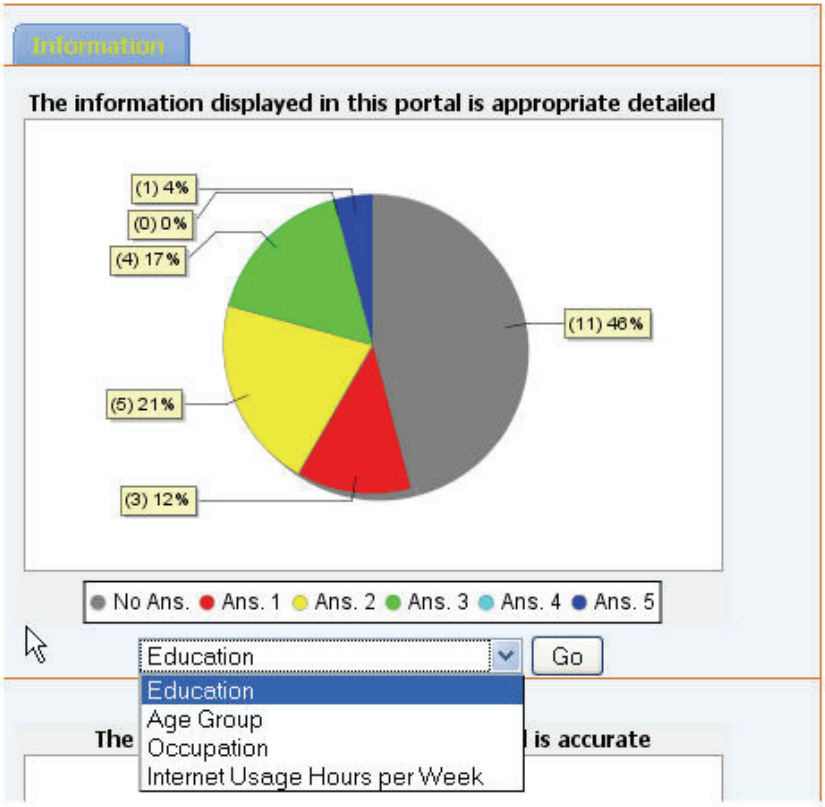


Figure 6.23: Example of Pie Charts for D-Level Questions

At the bottom of each Pie Chart, in both F-Level and D-Level questions, there is a drop down list with all demographic questions (see e.g. Figure 6.23). From this drop down list and by pressing the available “Go” button, another pop-up window is displayed. This pop-up contains Bar Charts, which depict all the responses from the corresponding Pie Chart, categorized by the demographic group chosen in the drop down list. For example, Figure 6.24 depicts the pop-up window displayed when the F-level responses about security are categorized per internet usage. This functionality of the tool enables a targeted to specific segments analysis of the results.

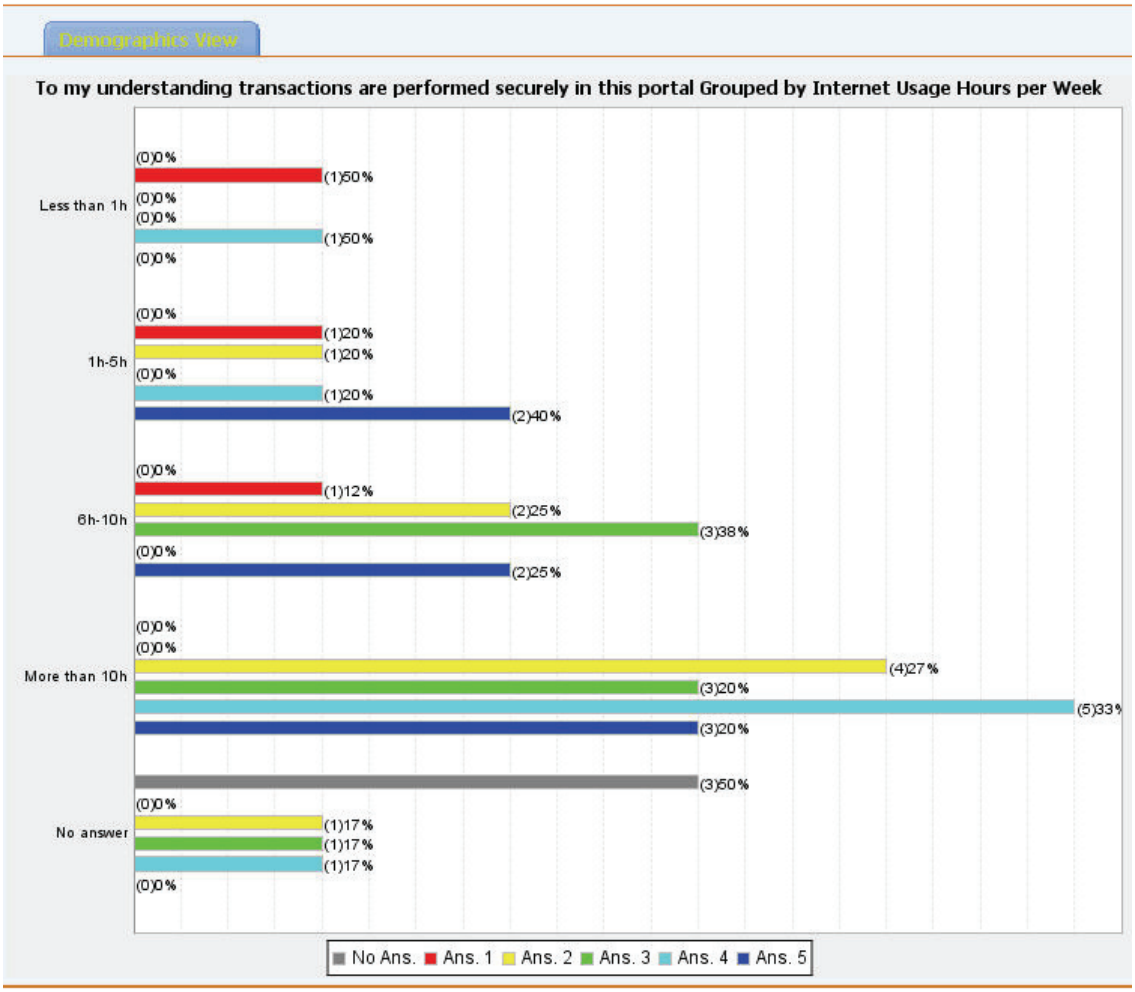


Figure 6.24: Responses Grouped by Internet Usage

It has been chosen to display all Likert scale responses as Pie Charts for better readability and appearance. Each section of a Pie Chart is sized according to the percentage of responses given to the particular Likert scale value. The color of each section identifies a response, and the color – response correspondence is given in the legend of the chart. The colors of the charts are consistent for all Likert scale questions throughout the tool (i.e.“Red“ always corresponds to 1, “Blue“ always corresponds to 5), making the charts easily understood and comparable. The color “Gray” represents “No Answer” in all charts in the tool. Every section of a Pie Chart has a label, which displays the number of responses given to the particular value and the percentage of this number in the total number of responses.

The colour scheme of the Bar Charts that categorize the responses by demographic groups, maintains the consistency with the colours of the charts regarding Likert scale questions (see Figure 6.24). It also includes a label for each bar displaying the number of answers given to

the particular response in the group category and the percentage of this number in the total number of answers belonging to this category.

6.10.2 Tool Architecture

In the section the MERIT tool architecture and implementation details are discussed.

The tool has been built using JSP (Java Server Pages) and the “Cewolf” - Chart Enabling Web Object Framework [Cewolf, 2007]. The Cewolf framework is open source and can be used inside a Servlet/JSP based web application to embed graphical charts into a web page. Cewolf is based on JFreeChart [JFreeChart, 2004] and uses it’s rendering engine to render the final chart image into the clients response stream. JFreeChart is an open source Java chart library that enables the rendering and display of graphical charts.

Cewolf consists of:

- One servlet which handles the chart rendering using JFreeChart and
- A tag library which translates the chart definition included in the JSP into an HTML img tag. Then this img tag consults the rendering servlet for retrieval of the appropriate chart.

As can be seen in Figure 6.25, where a high level package diagram of the MERIT tool is depicted, the tool (displayed as “surveyres” in the figure) imports and implements classes from both Cewolf and JFreeChart class packages.

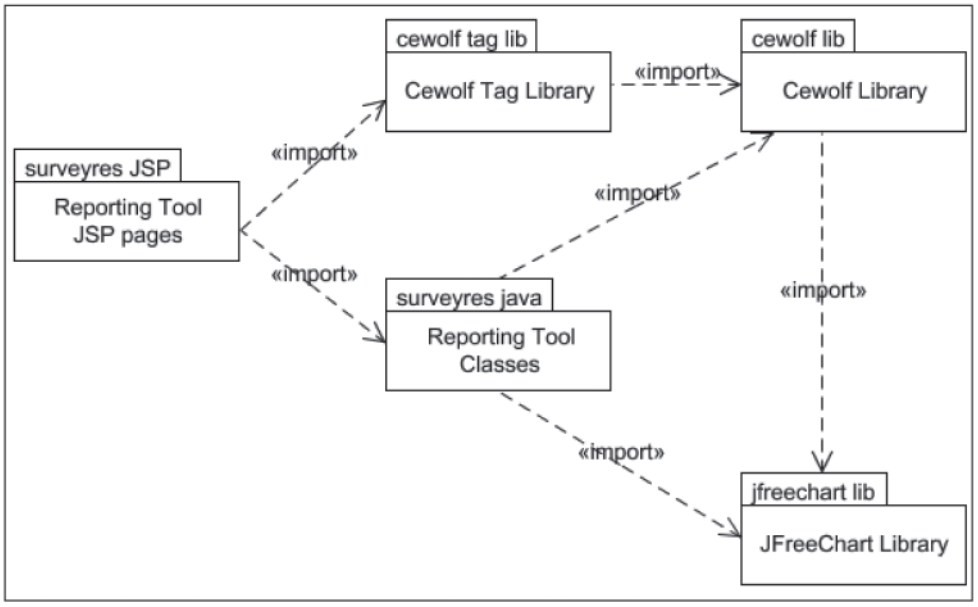


Figure 6.25: Package Diagram of MERIT

The MERIT tool is using its own MySQL database schema “surveyres” for holding all the information regarding the questions displayed (see Figure 6.26). For each question, it holds the view and factor it belongs to, the type of the question (e.g. Likert scale, demographic question, multiple choice etc.), the answer values and labels, the title, as well as the DB table and table field that holds the answers.

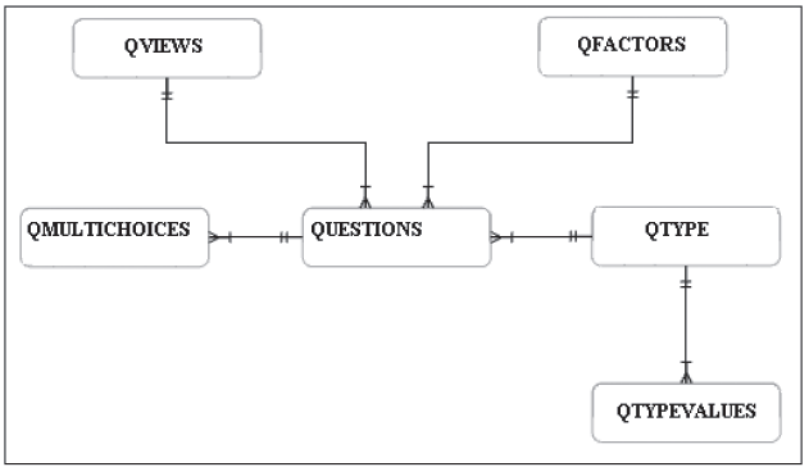


Figure 6.26: High Level ER Diagram of MERIT Database

The tool connects to MySQL databases through JDBC (Java Database Connectivity) for fetching the required information. As can be seen in Figure 6.27, it connects to the “surveyres” schema for the question details, and to the questionnaire database, described in section 6.7.2, which contains the answers of the adaptive questionnaire.

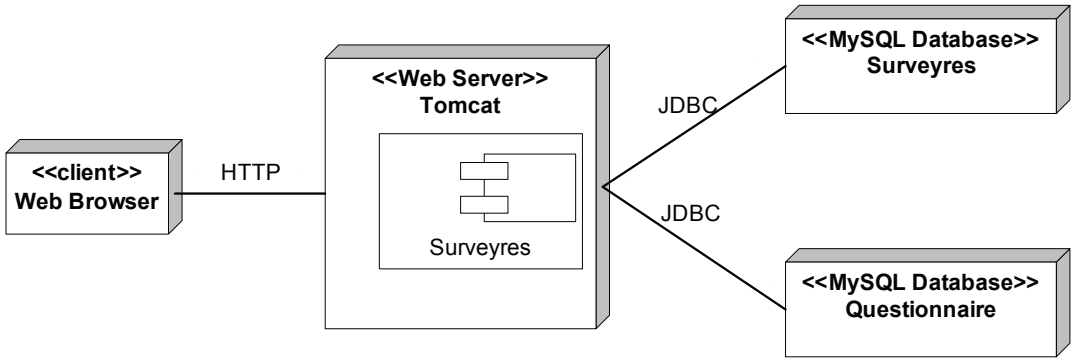


Figure 6.27: Deployment Diagram of MERIT

The MERIT Tool consists of:

- Four JSP pages, one for each view:
  - **overview.jsp** - Generates the overview web page

- **usersview.jsp** - Generates the factor view web page
- **SecondLvl.jsp** - Generates the web page for D-Level responses
- **usersdemo.jsp** - Generates the web page where the responses are grouped by demographics

- The following java class:
  - **QuestionsModel.java** - The class connects to the "surveyres" database schema, reads all the information regarding the questions and stores them in java data structures. It implements getter methods so all JSP pages can access the information. This has been done for improving performance as the connection to the "surveyres" database is done only once, at the first time it is invoked. (It is called from the JSP pages with application scope).

- The following Java classes generate the dataset to be used for charts generation by implementing the cewolf DatasetProducer interface:
  - **OverviewChart.java** - The class connects to the questionnaire database and creates the dataset to be used for the overview chart.
  - **UsersCreateChart.java** - The class connects to the questionnaire database and creates the dataset to be used for the chart in the factor view. The question for which the chart is created is passed as a parameter.
  - **UsersDemoCreateChart.java** - The class connects to the questionnaire database and creates the dataset to be used by the chart of the web page where the responses are grouped by demographics. The question and demographic group for which the chart is created are passed as parameters.

- The following Java classes are used to format the layout and appearance of the charts by implementing the cewolf ChartPostProcessor interface:
  - **OverviewLooks.java** - The class is used for formatting the appearance of the overview chart in the overview page.
  - **PieChartLooks.java** - The class is used for formatting the appearance of all Pie charts.
  - **DemoChartLooks.java** - The class is used for formatting the appearance of all Bar charts used in the web page where the responses are grouped by demographics.

The sequence diagram depicted in Figure 6.28 shows the sequence of methods invocation when a user accesses the factor view of the MERIT tool. A similar sequence takes place for other views of the tool as well.

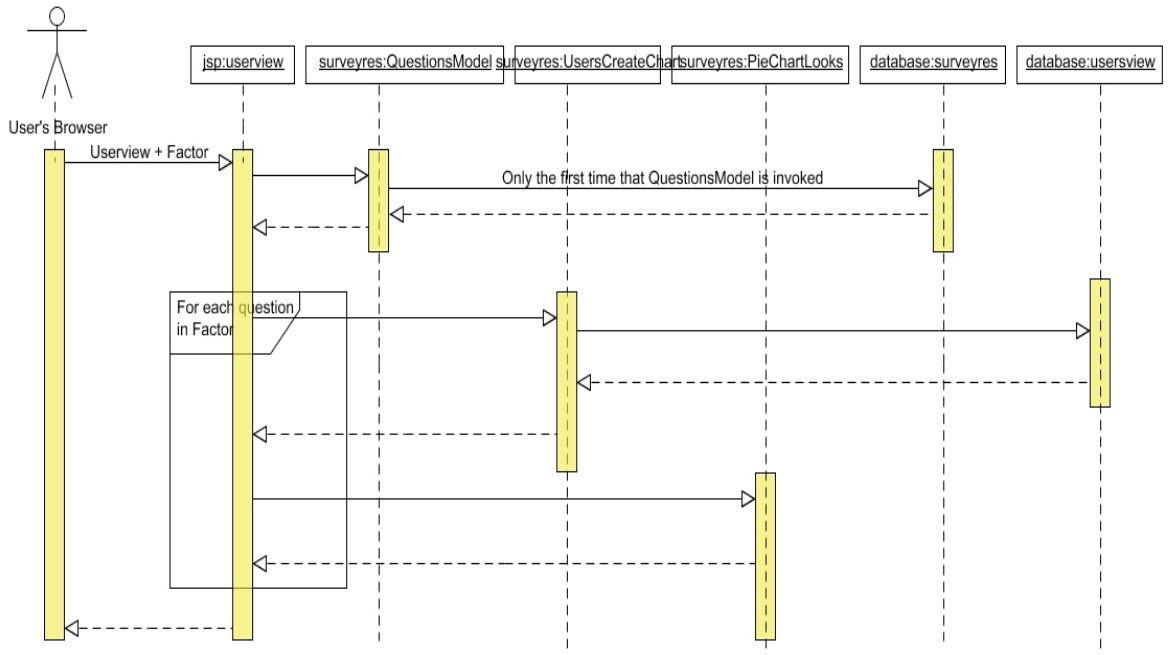


Figure 6.28: Sequence Diagram for the Factor View of MERIT

6.11 Integration of the SALT Subsystems

This section provides an overview of the integration of the various SALT subsystems. The sequence diagram depicted in Figure 6.29, shows how the various subsystems and system actors interact and in what order. The interactions have been categorized as design-time, run-time and analysis-time interactions. It should be noted that the *Ontology Editor* subsystem depicted in Figure 6.29, was not discussed in section 6.2, where an overview of SALT subsystems was given. This subsystem represents an ontology editor tool (such as Protégé) that is used for the development of the various ontologies.

In the rest of this section, the sequence diagram is described by focusing on the integration of the various system components. Some integration interfaces are human interfaces, i.e. a human actor intervenes in order to enable the integration of two subsystems. There are also technical interfaces between two subsystems, such as common databases, ontologies, or interaction protocols used for communicating parameters from one subsystem to another.

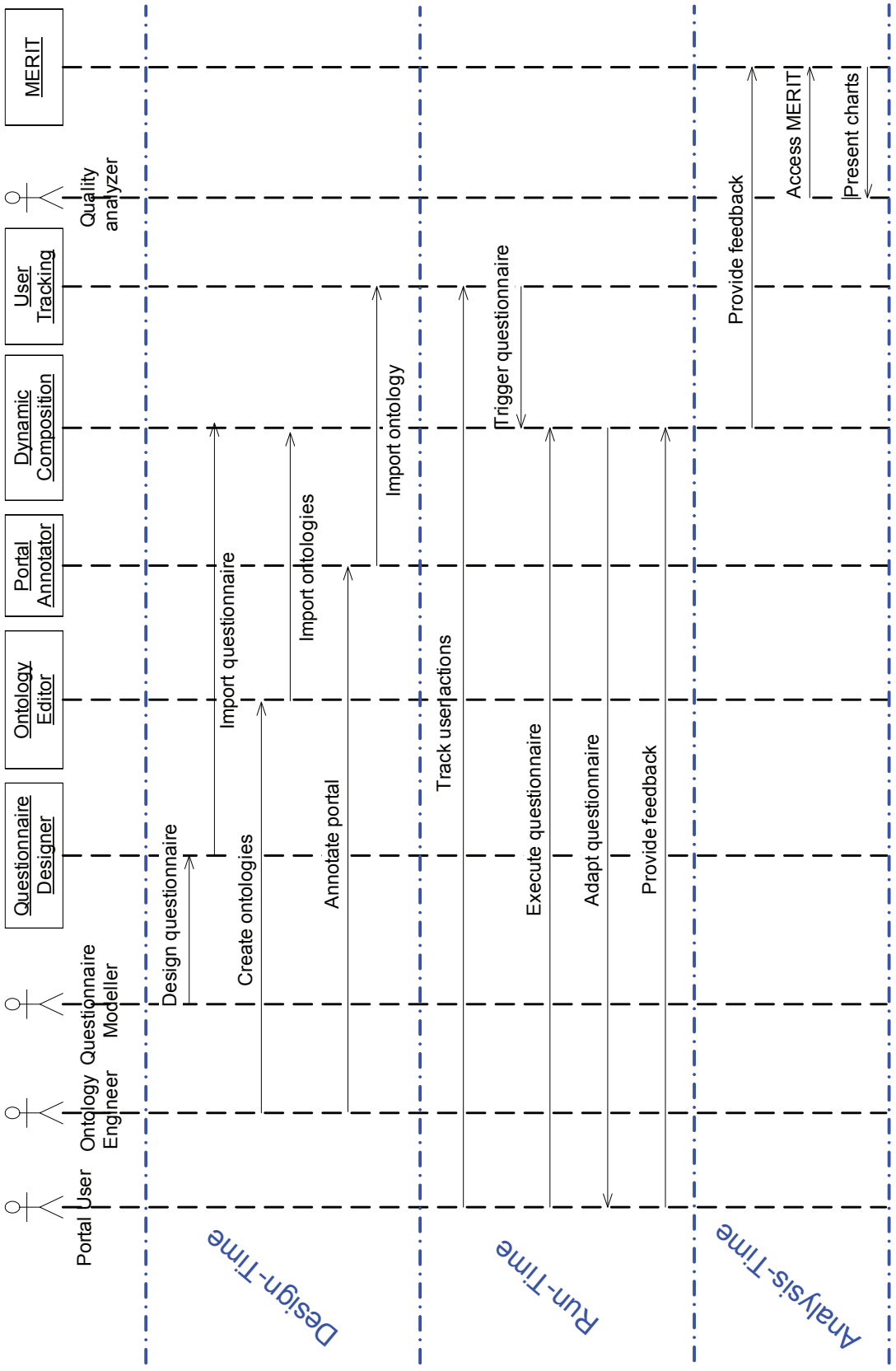


Figure 6.29: SALT Sequence Diagram

As can be seen in Figure 6.29, at design-time the *Questionnaire Modeller* actor, uses the *Questionnaire Designer* subsystem in order to design the questionnaire. The questionnaire is then imported to the *Dynamic Questionnaire Composition* subsystem. This is done through the *Questionnaire Repository,* described in section 6.7.2, which is commonly used by both subsystems; therefore the integration interface between these two subsystems is a database interface.

As already described, the *Dynamic Questionnaire Composition* subsystem employs the quality, web portal and problems ontologies, which formalize the semantics of the adaptation criteria used for the dynamic composition of the most appropriate set of questions. The *Ontology Engineer* actor develops these ontologies at design-time, by using the *Ontology Editor* subsystem and then imports them to the *Dynamic Questionnaire Composition* subsystem, thus representing a human interface between the two subsystems.

Another responsibility of the *Ontology Engineer* actor is to annotate the portal at design-time by using the *Portal Annotator* subsystem and then import the web portal ontology to the *User Tracking & Problem Detection* subsystem. The ontology is first transformed from OWL to JSON through a software converter, thus the interface between these two subsystems is both human and technical.

At run-time the *User Tracking & Problem Detection* subsystem tracks the actions of the *Portal User* actor and derives his/her current context from his/her behavior. At the end of the user session, it triggers the presentation of the adaptive questionnaire, as described in section 6.2. The adaptation of the questionnaire is handled by the *Dynamic Questionnaire Composition* subsystem; hence an interface between the *Dynamic Questionnaire Composition* and the *User Tracking & Problem Detection* subsystems has to be established. The triggering of the adaptive questionnaire is performed by the latter, by passing the parameters of the user model via HTTP and redirecting the user to the URL of the adaptive questionnaire server. The syntax of the parameters, which are included in the URL, is depicted in Figure 6.30:

```
index.jsp?
problem=problem:concept1,…,problem:conceptN
&
content=portal:concept1,…,portal:conceptN
```

Figure 6.30: Syntax of URL Parameters

For the *Dynamic Questionnaire Composition* to run the adaptation logic, the problem parameter (*problem*=…) and the page type parameter (*content*=…) have to be passed. The

problem parameter is mandatory; in case no problem occurred, it would have to be passed as follows: *problem=problem:noProblem*. The page type parameter is optional; it would not be passed in case no page associated to specific page types was visited. It should be noted that the concepts used (depicted as concept1 … conceptN in Figure 6.30) by both problem and page type parameters, are concepts of the Web Portal and Problem Ontologies which act as common reference models between the two subsystems. Therefore, the integration interface between the *User Tracking & Problem Detection* and *Dynamic Questionnaire Composition* subsystems can be characterized as both technical and ontological.

At analysis-time, the *Quality Analyzer* actor uses the *MERIT* subsystem in order to view data and charts with respect to user responses. The data is retrieved from the *Questionnaire Repository DB (*see section 6.7.2), where it was previously stored by the *Dynamic Questionnaire Composition* subsystem. Therefore, the integration interface between these two subsystems is a database interface.

6.12 SALT System Walkthrough

In this section, two simple user scenarios are considered, in order to show how the user interacts with the system, and what happens from a system as well as a user perspective for each interaction step. In both scenarios, the user enters an e-Government portal and after navigating, she/he finally visits the page used for online applications concerning building permissions. The user fills in and submits the application form. The first scenario considers a problem-free user session, while the second one a user who has faced problems during the navigation or service consumption process.

6.12.1 Problem-Free User Scenario

In this scenario, a problem-free session is considered, i.e. the user was able to find and submit the application form for building permissions without any problem. As far as the metadata of the visited pages are concerned, the page containing the application form was the only page of the user session which had metadata attached to it. More specifically, this page has been annotated as of type “forms page”.

In the following, a description is given about how the system makes use of the knowledge modeled in the ontologies in order to compose dynamically the questionnaire. The description follows the time line of user-system interactions, while for each step of the interaction the viewpoint (user or system) is defined.

6.12.1.1 Step 1 (System): User Tracking Triggers the Dynamic Questionnaire Composition

The User Tracking & Problem Detection system component triggers the Dynamic Questionnaire Composition one, by redirecting the user in a pop-up window to the URL that corresponds to the questionnaire's start page. The URL which is being called, incorporates the query string containing references to the relevant concepts of the problem and the web portal ontologies (see section 6.11 where the integration of these components is described). The URL for the problem-free user scenario is the following:

- …/index.jsp?problem=problem:noProblem&content=portal:formsType

The questionnaire's starting page, which is presented to the user by the Dynamic Questionnaire Composition Component, contains instructions and guidelines about its completion as depicted in Figure 6.31.

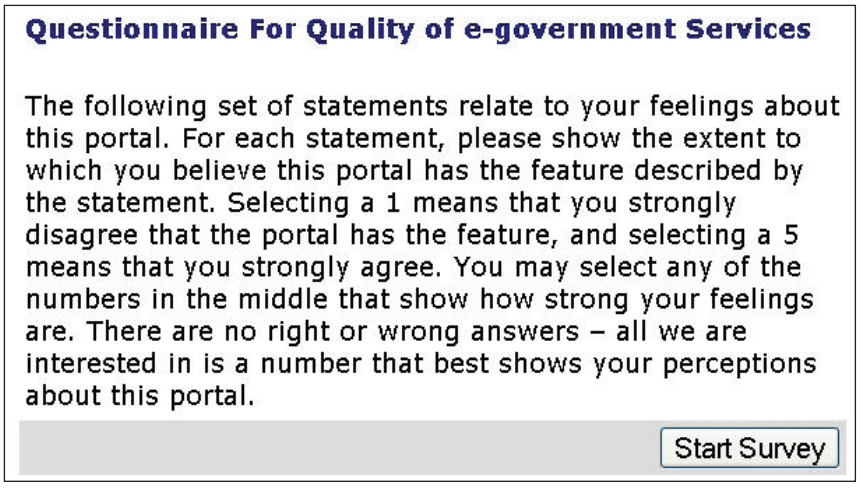


Figure 6.31: First Page of the Questionnaire

6.12.1.2 Step 2 (User): Read Instructions and Start Survey

The user reads the questionnaire instructions and presses the "Start Survey" button.

6.12.1.3 Step 3 (System): Apply Metadata-Based Adaptation

When the user pushes the "Start Survey" button, the adaptation logic described in section 4.2.3.4 is executed. In this use case, where a problem-free user session is considered, F-level questions are displayed. More specifically, those F-level questions that have at

least one corresponding D-level question satisfying the criteria taken into account by the page metadata-based adaptation axis, are displayed, while those not satisfying these criteria are filtered out. As described in section 4.2.3.4, these criteria are satisfied in case a corresponding D-level question is related to a visited page type or it is page metadata independent.

In order to evaluate the above mentioned criteria and apply the adaptation logic, in the background the system obtains references to all F-level questions of the Quality ontology, by using the appropriate Protégé OWL API methods (see section 6.7.3). For each question of the F-level, the relevant list of D-level questions is retrieved. Then, for each question of this list, the value of the *hasRelatedContent* object property, which links the Quality ontology with the Web Portal ontology (see section 6.8.5), is being read. If there is at least one question in the list that satisfies the criteria of the page metadata based axis, the relevant F-level question is displayed. Otherwise, it is left out during the dynamic composition of the questionnaire. For the evaluation of the criteria, in addition to the value of the *hasRelatedContent* object property, the value(s) of the content parameter(s) of the URL query string are also taken into account.

Figure 6.32 depicts some F-level questions that are presented in this use case along with a relevant code snip set. As can be seen in the figure, the F-level question related to forms is incorporated into the set of questions that are displayed, during the dynamic composition of the questionnaire. The same applies for F-level questions concerning reliability, usability, information quality and security, as these questions pass through the F-level Metadata Filter (see section 4.2.3.4). However, this is not the case for the F-level question regarding support mechanisms, as in this scenario the user has not visited pages, which are annotated as pages used for the initiation of the support process (e.g. FAQ page or contact information page).

6.12.1.4 Step 4 (User): Respond to F-level Questions

The next step of this scenario is performed by the user, as he grades the presented F-level questions using the five point Likert scale. In this scenario, it is assumed that the user believes that interaction with the portal, when using forms for requests, is not functional enough, thus he gives a low grade for the relevant question; see Figure 6.32. The user responds to the presented F-level questions and after that he/she clicks the *NextPage* button.

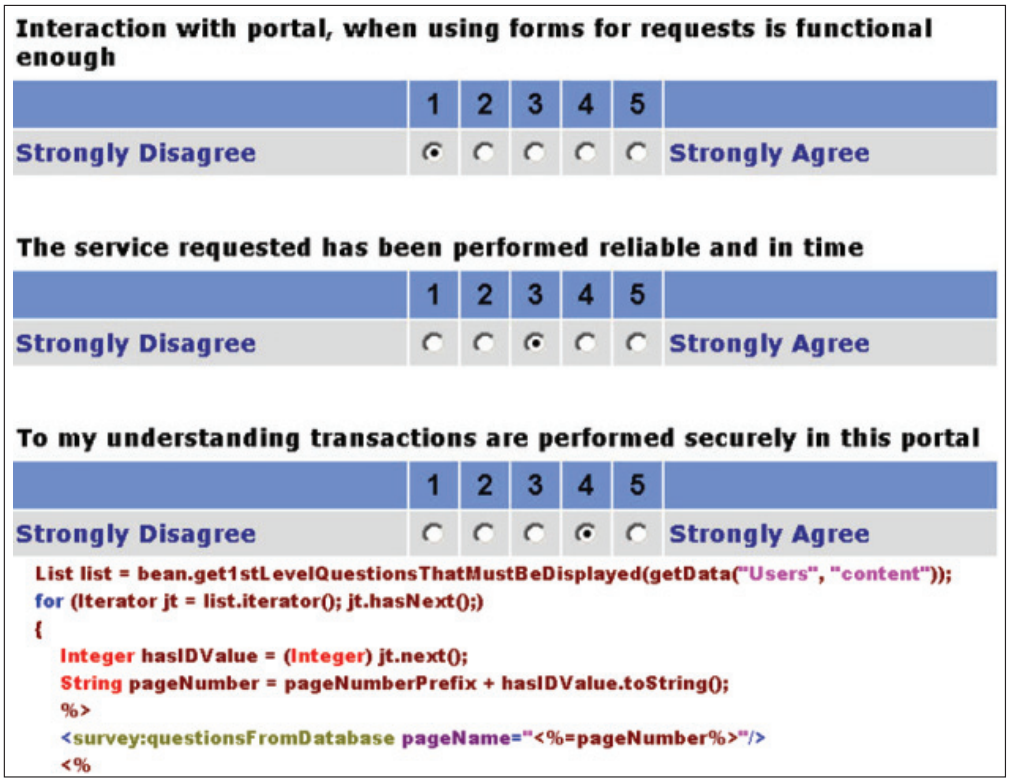


Figure 6.32: Part of the Adaptive Questionnaire for Step 3 of the Problem-Free Scenario and a Relevant Code Snip Set

6.12.1.5 *Step 5 (System): Apply the User Feedback and Metadata – Based Adaptations*

After the user has answered the F-level questions and clicked the *NextPage* button, the control is given back to the system which applies subsequently the real time user feedback adaptation and then the metadata adaptation axes (see section 4.2.3.4).

For the application of the real time user feedback adaptation axis, in the background a reference to each F-level question of the Quality ontology that the user has graded, is obtained by the system. Furthermore, the value of the *F-LevelQuestion* concept's property *hasThresholdForD-LevelPresentation* is retrieved for each one of these questions. This property represents a threshold in the five point Likert scale, under which, corresponding D-level questions should be presented. Depending on the value of this property and for all the questions that the given grade was below the threshold, corresponding D-level questions are candidates to be displayed in the questionnaire. The knowledge about corresponding D-level questions for each F-level one, is retrieved from the Quality ontology through the object property *hasCorrespondingD-LevelQuestion.*

In order to decide whether a D-level question, which is candidate to be displayed, will be

finally displayed or not, the system applies the metadata-based adaptation criterion. In general, some candidate D-level questions should not be displayed, because they are related to page types which were not part of the current user session. These questions are identified by the system after making use of knowledge from Web Portal and Quality ontologies and the values of the URL parameters. More specifically, in addition to the value(s) of the *hasRelatedContent* object properties, which link the aforementioned ontologies (see section 6.8), the value(s) of the content parameter(s) of the URL query string are also taken into account.

In this specific user scenario the threshold of the five point Likert scale, under which D-level questions are displayed, is considered the grade 3 (i.e. the property *hasThresholdForD-LevelPresentation* has the value of 3 for all *F-LevelQuestions*). As can be seen in Figure 6.32 above, in this scenario only the F-level question concerning portal's forms was below the threshold. Therefore, with respect to the real time feedback adaptation, candidate D-level questions are all the D-level questions concerning forms. As far as the metadata-based adaptation is concerned, all candidate D-level questions are displayed. This is done because all candidate D-level questions are of type formPage, which is part of the user session. Hence, the system presents detailed questions (D-level) about forms, in order to achieve a detailed examination of user's low perceptions about portal forms (F-level). Part of the dynamically composed user questionnaire, along with a relevant code snip set, is depicted in Figure 6.33.

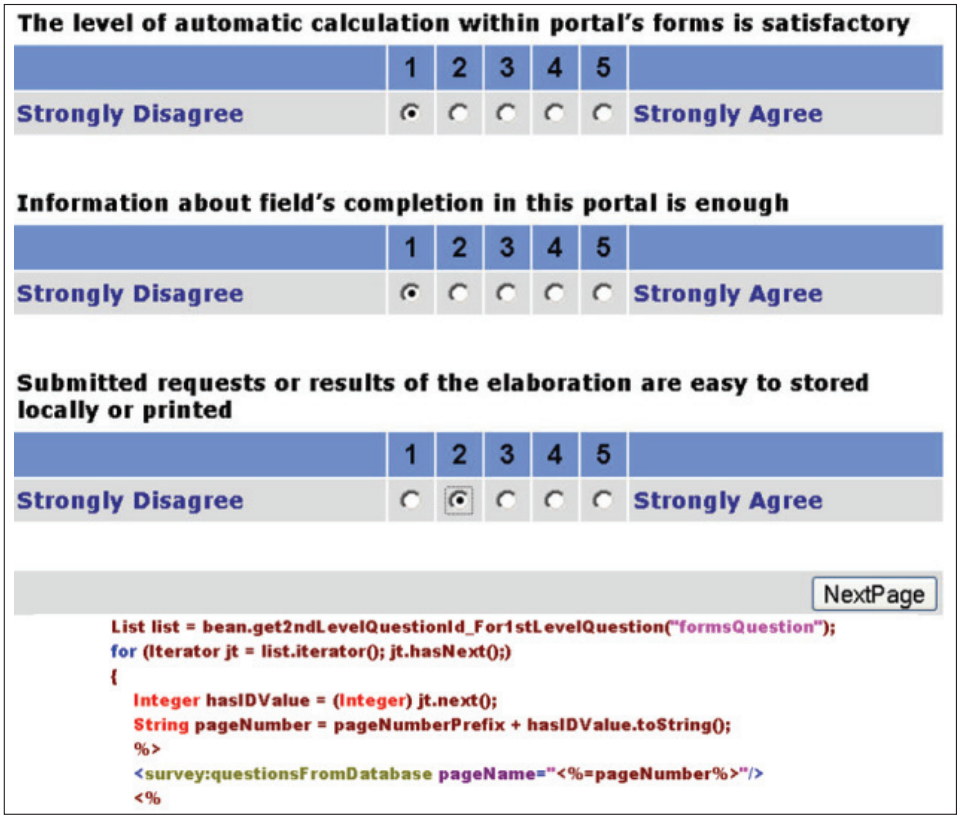


Figure 6.33: Part of the Adaptive Questionnaire for Step 5 of the Problem-Free Scenario and a Relevant Code Snip Set

6.12.1.6 Step 6 (User): Respond to D-level Questions about Forms

The next step of this scenario is performed by the user, as he grades the presented D-level questions about forms by using the five point Likert scale. After that, the user clicks the *NextPage* button.

6.12.1.7 Step 7 (System): Present Demographic Questions

The control is given back to the system which displays some questions, which aim to collect demographic information about the user (see Figure 6.34).

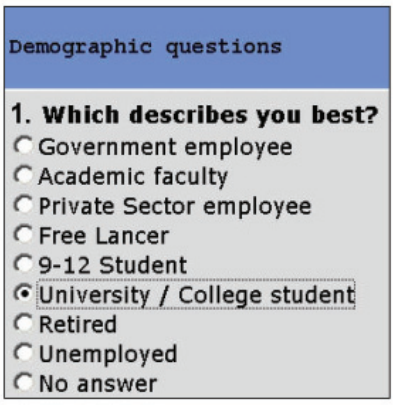


Figure 6.34: Part of the Questionnaire for Demographic Information

6.12.1.8 Step 8 (User): Respond to Demographic Questions

The user responds to the demographic questions and after that he/she clicks the *NextPage* button.

6.12.1.9 Step 9 (System): Store Feedback in Repository

The scenario ends with the system storing the user feedback in the feedback repository and presenting the user with a 'thank you for filling out the survey' message.

6.12.2 User Scenario with Problems

In this scenario the user is considered to have faced navigation problems during the session, i.e. followed a link, pressed the back button, and then followed another link from the same menu and so on. This user was not able to find and submit the application form for building permissions. As far as the metadata of the visited pages are concerned, no one of the pages

visited had metadata attached to them. So there was no page - of the set of visited portal pages - related to specific aspects.

In the following, a description is given about how the system makes use of the knowledge modeled in the ontologies in order to compose dynamically the questionnaire. The description follows the time line of user-system interactions, while for each step of the interaction the viewpoint (user or system) is defined. It should be noted that the description focuses on the main differences from the previous user scenario.

6.12.2.1 Step 1 (System): User Tracking Triggers the Dynamic Questionnaire Composition

In this scenario, the URL of the Dynamic Questionnaire Composition component, which is called by the User Tracking & Problem Detection one, is the following:

- *…/index.jsp?problem= problem:navigationProblem*

The user reads the questionnaire instructions and presses the “Start Survey” button (Step 2 – User), as described in the previous user scenario

6.12.2.2 Step 3 (System): Apply Problem and Metadata-Based Adaptations

In this user scenario where the user has encountered problems, D-level questions, which are relevant to these problems, are presented by the system in order to examine these problems and their root cause in detail. The system subsequently applies the problem-based adaptation and then the metadata-based adaptation axes (see section 4.2.3.4).

For the application of the problem-based adaptation axis, in the background, using the problem query parameters of the URL, as well as the appropriate Protégé OWL API methods, references to all detected problems of the Problem ontology are obtained. For each one of these problems, the values of the object property *hasRelatedQuestion*, which links the Problem with the Quality ontology (see section 6.8), are retrieved. For each problem, the D-level questions, which are indicated by the aforementioned object property, are candidates to be displayed in the questionnaire.

In order to decide whether a D-level question, which is candidate to be displayed, will be finally displayed or not, the system applies the metadata-based adaptation criterion, as already described in Step 5 of the previous user scenario (see section 6.12.1.5).

In this second user scenario, with respect to the problem-based adaptation, candidate D-level questions are the D-level questions relevant to navigation. As far as the metadata-based adaptation is concerned, only the candidate D-level question concerning portal’s

structure is displayed. This is done because all the other candidate D-level questions are of specific page types which are not part of the user session in this scenario; bear in mind that it was considered that no one of the pages visited had metadata attached to them (see 6.12.2). Hence, the system presents the D-level question about the portal structure. Part of the dynamically composed user questionnaire, along with a relevant code snip set, is depicted in Figure 6.35.

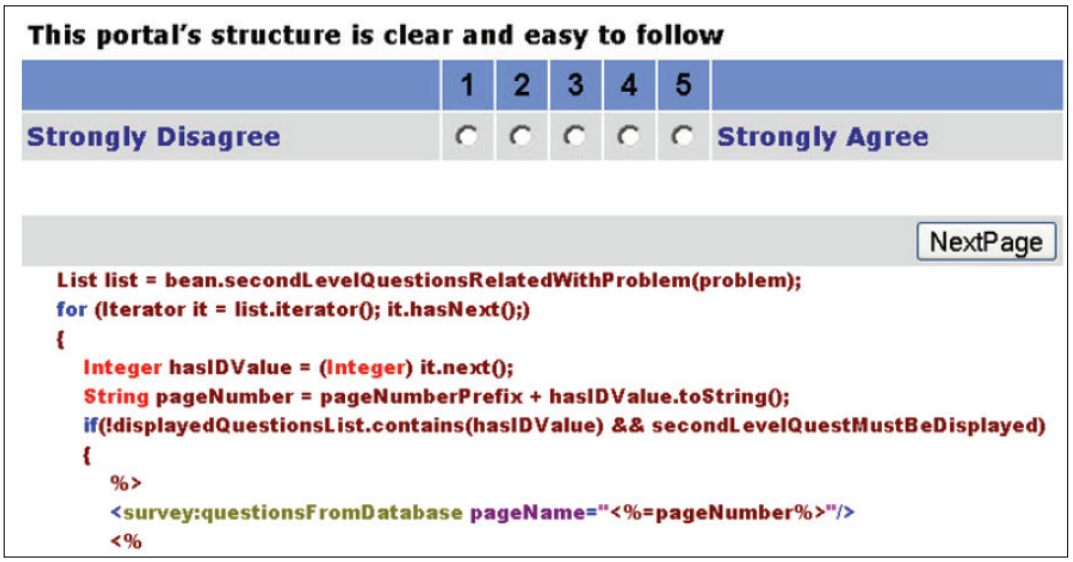


Figure 6.35: Part of the Adaptive Questionnaire for Step 3
of the User Scenario with Problems and a Relevant Code Snip Set

Next steps of this scenario are very similar to the previous one, so their description is skipped.

PART III

EVALUATION AND CONCLUSIONS

7 SALT EVALUATION

It is always difficult to evaluate an innovative solution, since it is usually driven by research aspects and not only by the technical realization of the system. These research aspects are usually defined in the form of research hypotheses which researchers are trying to justify during the realization of the system. So, the efforts for evaluating the proposed approach have been divided into two major types:

- **Technical Evaluation**: related to the evaluation of technical characteristics of the system
- **Trial-based evaluation**: related to the evaluation of the system in a real use case

As far as the technical evaluation is concerned, the system was evaluated by functional testing as well as by testing its conformance to World Wide Web Consortium (W3C) guidelines for web tools. Regarding the trial-based evaluation, the proposed approach was evaluated in the e-Government portal of the Stadt Voecklabruck Austrian municipality (www.voecklabruck.at). In this Chapter, details about the technical and the trial-based evaluation of the proposed approach are presented.

7.1 Technical Evaluation

The adaptive questionnaire contributes to the main research objectives of the proposed approach, which were described in section 1.3. These objectives can be summarized to the following high level objective:

- It is beneficial for both users and service providers to take into account the user context when monitoring quality

Since the benefits for users and service providers are coming to surface by the usage of the system, the evaluation of how the system contributes to the objectives is empirical, i.e. it is based on system's usage by users (see section 7.2). Nevertheless, for the sake of completeness, in this section we present the technical evaluation of the system; first the

system's conformance to W3C guidelines for web-based tool is evaluated, while the functional evaluation of the adaptive questionnaire follows.

7.1.1 Conformance to W3C Guidelines

This evaluation is based on standards and guidelines of the World Wide Web Consortium (W3C), and more specifically of the W3C's Web Accessibility Initiative (WAI). WAI is an effort to improve the accessibility of the World Wide Web for people using a wide range of user agent devices, not just standard web browsers. This is especially important for people with physical disabilities who require such devices to access the Web.

Web Content Accessibility Guidelines (WCAG) are part of a series of Web accessibility guidelines published by the W3C's Web Accessibility Initiative. They consist of a set of guidelines on making content accessible, primarily for disabled users, but also for all user agents, including highly limited devices, such as mobile phones. The primary goal of WCAG is to promote accessibility. However, following them will also make Web content more available to all users, whatever user agent they are using (e.g., desktop browser, voice browser, mobile phone, automobile- based personal computer, etc.) or constraints they may be operating under (e.g., noisy surroundings, under- or over-illuminated rooms, in a hands-free environment, etc.). Following these guidelines people are helped to find information on the Web more quickly [Chisholm et. al., 1999].

Conformance to guidelines is necessary for qualitative, usable and accessible web sites; thus it can be used as a criterion for the evaluation of the web-based adaptive questionnaire. WAI proposes a set of web accessibility evaluation tools, either software programs or online services that help determine if a Web site meets accessibility guidelines [W3C WAI, 2007]. The following tools, of those proposed, have been used for evaluating the adaptive questionnaire:

- NetMechanic HTML Toolbox - http://www.netmechanic.com/
- Juicy Studio's Readability Test - http://juicystudio.com/services/readability.php
- Paciello Group's Colour Contast Analyser - http://www.paciellogroup.com/resources/contrast-analyser.html

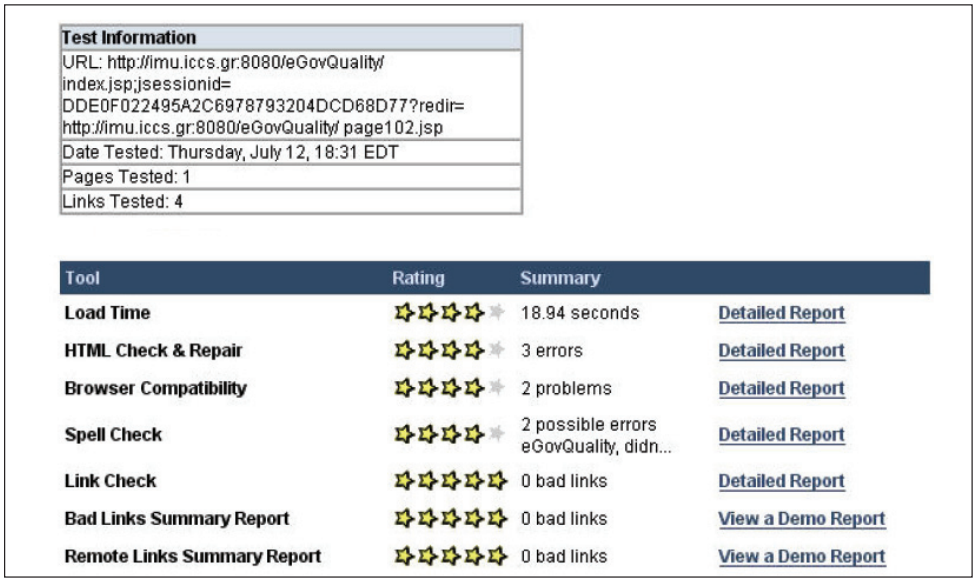
These tools cover the evaluation of all the proposed aspects like colour visibility, readability of questionnaire's pages, validity of CSS, HTML and links, browser compatibility and download time. The results of the evaluation using the aforementioned tools are described in the rest of this section.

7.1.1.1 Syntax, load time and spell evaluation

NetMechanic HTML ToolBox [NetMechanic, 2007] is an online checker tool that scans web pages and interrogates the structural quality, content accuracy and consistency of the page. It detects common HTML errors, broken links and checks load time [Helm, 2001]. The results are reported in HTML pages. NetMechanic HTML Toolbox comes with these state-of-the-art tools:

- HTML Check & Repair: discovers bad HTML tags and syntax that prevents browsers from processing the HTML, and as consequence prevents also visitors, both humans and spiders, from reading the web site.
- Spell check: automatically checks for spelling errors in 11 languages, or using a customized dictionary, so that spelling errors do not block visitors.
- Browser compatibility: scans a site and reports any unsupported HTML tags and attributes that block viewing on specific browsers.
- Load Time Check: checks websites for slow download time, reporting problems including object size, html errors, server connections or graphics that delay page loading and frustrate customers.
- Link Check: tests each link to identify, locate and report any broken or bad links that drive customers and spiders away.
- Bad Link Report: reduces webmaster's repair link time by providing information needed to fix links without searching each individual page.
- Remote Link Report: identifies and reports external links and their page location.

Adaptive questionnaire's pages have been evaluated by using this tool and the results are depicted in Figure 7.1.

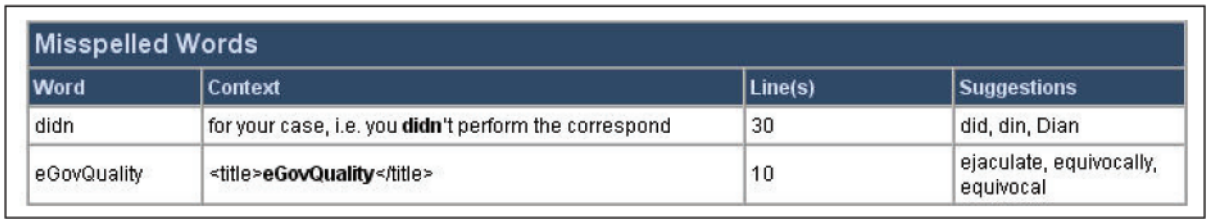


Test Information
URL: http://imu.iccs.gr:8080/eGovQuality/index.jsp;jsessionid=DDE0F022495A2C6978793204DCD68D77?redir=http://imu.iccs.gr:8080/eGovQuality/ page102.jsp
Date Tested: Thursday, July 12, 18:31 EDT
Pages Tested: 1
Links Tested: 4

Tool	Rating	Summary	
Load Time		18.94 seconds	Detailed Report
HTML Check & Repair		3 errors	Detailed Report
Browser Compatibility		2 problems	Detailed Report
Spell Check		2 possible errors eGovQuality, didn...	Detailed Report
Link Check		0 bad links	Detailed Report
Bad Links Summary Report		0 bad links	View a Demo Report
Remote Links Summary Report		0 bad links	View a Demo Report

Figure 7.1: Syntax, Load Time and Spell Evaluation Results

As can be seen in the figure, adaptive questionnaire's pages have been judged at higher than "very good" level, as they have been awarded with four or five stars by all the tools of the NetMechanic HTML Toolbox. Load time strongly depends on user connection speed and has been estimated for a 28.8Kbps modem connection. Thereby, although the absolute load time value is rather long, the overall evaluation is very good. Adaptive questionnaire showed a very good level of conformance with W3C's HTML and CSS standards, as the relevant ratings by the HTML Check & Repair and the Browser compatibility tools, are four out of five stars. The level of conformance indicates how many of the priorities set by the WAI have been met. Concerning the spell check item, the dictionary used by NetMechanic HTML Toolbox detected two possible errors regarding misspelled words, but none of these words are indeed misspells as can be seen in Figure 7.2. Finally, the tool did not find broken links in the adaptive questionnaire's pages.



Misspelled Words

Word	Context	Line(s)	Suggestions
didn	for your case, i.e. you **didn**'t perform the correspond	30	did, din, Dian
eGovQuality	<title>**eGovQuality**</title>	10	ejaculate, equivocally, equivocal

Figure 7.2: Possible Misspelled Words

7.1.1.2 Readability Evaluation

Readability is the measure of how easy it is to read and comprehend a document and is a very critical quality aspect of web content, especially for online questionnaires. Readability aspects are stressed in guideline 14[2] of the Web Content Accessibility Guidelines, which requires that documents are clear and simple.

Readability tests can provide a rough guide to the likelihood of a document being clearly understood. Juicy Studio provides an online readability test tool that can be used in order to test the readability of a web site [Juicy Studio, 2007]. This tool uses reading level algorithms, like Gunning Fog [Gunning, 1952], Flesch Reading Ease [Flesch, 1948], and Flesch-Kincaid [Kincaid et. al., 1975], in order to determine how readable the content of a web site is. Reading level algorithms only provide a rough guide, as they tend to reward short sentences made up of short words. Whilst they're rough guides, they can give a useful indication as to whether the content has been pitched at the right level for the intended audience.

The results of the evaluation of the adaptive questionnaire's pages using this online tool are depicted in Figure 7.3.

2. http://www.w3.org/TR/WCAG10/wai-pageauth.html#gl-facilitate-comprehension

Reading Level Results

Summary	Value
Total sentences	22
Total words	181
Average words per Sentence	8.23
Words with 1 Syllable	114
Words with 2 Syllables	39
Words with 3 Syllables	20
Words with 4 or more Syllables	8
Percentage of word with three or more syllables	15.47%
Average Syllables per Word	1.57
Gunning Fog Index	9.48
Flesch Reading Ease	65.74
Flesch-Kincaid Grade	6.13

Figure 7.3: Adaptive Questionnaire's Readability Results

As can be seen in the figure, the readability test tool calculates the three aforementioned indexes for a comprehensive readability evaluation:

- The Gunning Fog index indicates the number of school years needed to understand the piece of writing. The lower the number, the more understandable the content will be to visitors. Texts that are designed for a wide audience generally require a fog index of less than 12 [Wikipedia, 2007a]. The adaptive questionnaire meets this requirement, as its Gunning Fox index is 9.48; thereby it passes successfully the Gunning Fog index test.
- The Flesch Reading Ease scale shows scores from 0 to 100. Zero means practically unreadable and 100 means extremely easy. English documents are normally around 60 or 70 [Sancho, 2006]. Documents in this scale can be easily understood by 8th and 9th grade students [Wikipedia, 2007b], i.e. by students of age 13-14. The adaptive questionnaire scores 65.74, a grade that is very good for the Flesch Reading Ease scale.
- The Flesch-Kincaid formula translates the 0–100 score to a U.S. grade level, making it easier for teachers, parents, librarians, and others to judge the readability level of various books and texts [Wikipedia, 2007b]. The relation between the score of this formula and the readability is reversely proportional, as in Gunning Fog index. The score of 6.13 of the adaptive questionnaire means that the text is expected to be understandable by an average student in 6th grade, i.e. an 11 year old student, which is a very satisfactory result.

7.1.1.3 Color contrast evaluation

Contrast ratio is a suggestion by the WAI WCAG 2.0 working group to help determine whether or not the contrast between two colours can be read by people with colour blindness or other visual impairments. Contrast analyser tools help to determine the legibility of text on a web page and the legibility of image based representations of text. The adaptive questionnaire pages' have been tested for compliance to WCAG suggestion by using Paciello Group's Colour Contrast Analyser tool [Paciello, 2007].

This is primarily a tool for checking foreground & background colour combinations to determine if they provide good colour visibility. It also contains functionality to create simulations of certain visual conditions such as colour blindness. Determining "colour visibility" is based on the Contrast Ratio algorithm, suggested by the World Wide Web Consortium[3].

The results, regarding the analysis of foreground and background colour contrast of the adaptive questionnaire pages, are depicted in Figure 7.4. As can be seen in the figure, all the different combinations of foreground/background colours that appear in questionnaire pages have been tested:

- Black foreground with white background
- Black foreground with cerulean background
- Blue foreground with light gray background

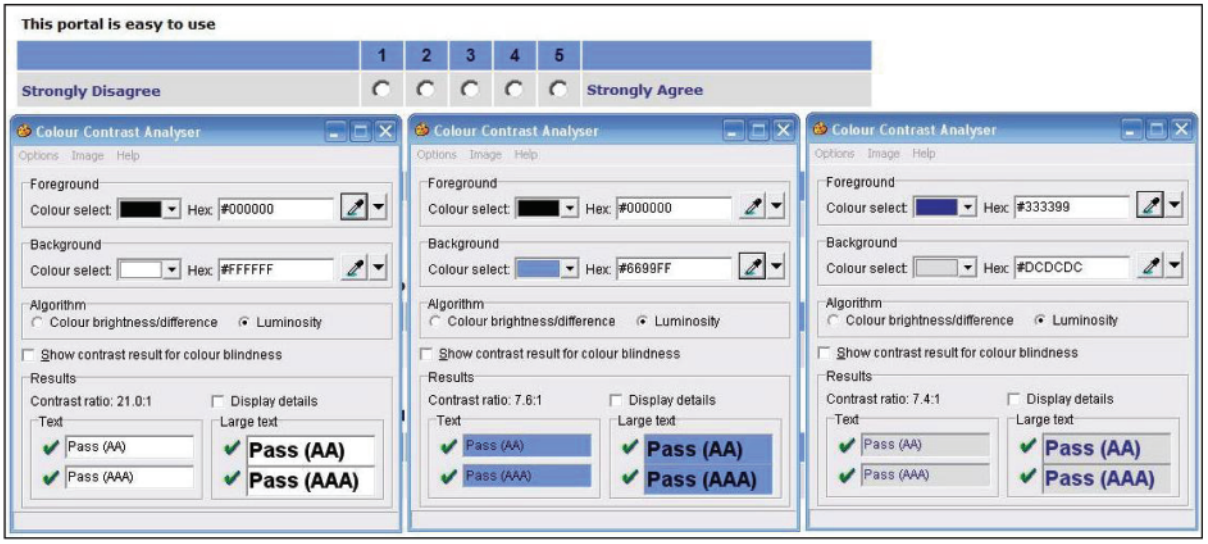


Figure 7.4: Adaptive Questionnaire's Results for Color Contrast

3. http://www.w3.org/TR/2007/WD-WCAG20-TECHS-20070517/Overview.html#G18

In order to describe the results of colour contrast evaluation, we will first describe briefly the three WCAG's conformance levels. The WCAG checkpoints are organised into levels of priority. Priority 1 checkpoints must be met to prevent lack of access for some groups of users. Priority 2 checkpoints should be met to prevent difficulties in access for some users, while Priority 3 checkpoints may be met to improve access to web documents [Chisholm et. al., 1999]. For conformance level A, a website must satisfy all the priority 1 checkpoints; for conformance level AA, all the Priority 1 and 2 checkpoints; and for conformance level AAA, all the Priority 1, 2 and 3 checkpoints.

The three different foreground/background colour combinations of the adaptive questionnaire pass the tests successfully, both on WCAG' conformance level AA and AAA, thus they also pass the test on conformance level A. It is a perfect result that enables the questionnaires to be read and filled in by people with colour blindness or other visual impairments.

7.1.2 Functional Testing

The adaptive questionnaire has been integrated with user tracking, as described in section 6.11. User tracking triggers the adaptive questionnaire and provides it, via URL parameters, with the user's current context from the user's behaviour. The adaptive questionnaire takes advantage of the user context and enables meaningful, effective and context-aware adaptation of the questions. In this section, the technical evaluation of the adaptive questionnaire by functional testing is described.

Functional testing [Sommerville, 2007] is based on requirements with no knowledge of the internal program structure or data. This test indicates whether or not a program meets required specifications. As the internal program structure is not known, functional testing is also called Black Box testing. The adaptive questionnaire tool has to execute the adaptation logic and provide the correct adaptations for the various user contexts. Regarding the adaptation logic, three axes of adaptation are applied, as described in detail in section 4.2.3:

a) based on real-time feedback from users through the questionnaire
b) based on problems encountered by users during their navigation in the portal
c) based on metadata of the pages visited by the user.

So the adaptive questionnaire can be seen as a black box that takes as input a) the user feedback b) the user problems and c) page metadata, and provides as output adaptive questions (see Figure 7.5).

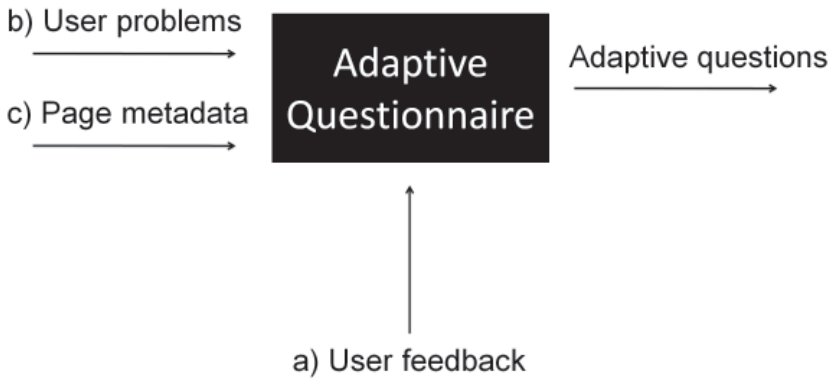


Figure 7.5: Adaptive Questionnaire as a Black Box

The results of testing questionnaire's adaptation based on the user feedback, were successful for all possible values of input a. In order to test adaptation based on the other two axes, test cases were developed which check all the possible combinations of inputs b and c. In Table 7.1 some indicative test cases performed can be seen. As the table depicts, all test cases were successfully tested.

Table 7.1: Functional Testing of the Adaptive Questionnaire

Test Case	Result
The user has not faced any problem during session and the metadata of the visited pages are not related to quality questions.	Successfully tested
The user has not faced any problem during session and he/she has visited pages annotated as FAQ page, contact information page and form page.	Successfully tested
The user has not faced any problem during session and he/she has visited a page annotated as form page.	Successfully tested
The user has faced a navigation problem during session and the metadata of the visited pages are not related with quality questions.	Successfully tested
The user has faced a forms problem and a layout problem during session and he/she has visited pages annotated as contact information page and form page.	Successfully tested
The user has faced a forms problem and a navigation problem during session and he/she has visited pages annotated as search engine page and a form page.	Successfully tested

The conclusion that can be drawn from the results of the functional evaluation is that the adaptive questionnaire is capable of providing adaptive questions based on the user context. This capability is necessary but not efficient for showing adaptive questionnaire's contribution to the high level objective defined in section 7.1. In other words, while it was proven that the user context can be taken into account when monitoring quality, it was not shown that this is beneficial for users and service providers. The added value for users and service providers

from the usage of the system is proved in the trial-based evaluation of the next section, as already mentioned.

7.2 Trial-Based Evaluation

This section describes the evaluation of the system in a real use case. The proposed approach was evaluated empirically in the e-Government portal of an Austrian municipality. The design and methodological aspects regarding the evaluation are described, the software components enabling the evaluation are presented and the evaluation results are reported.

7.2.1 Design and Methodological Aspects

In sections 1.2 and 1.3 the research challenges and main objectives of the proposed approach and system have already been discussed. In this section they are translated into research hypotheses and operational hypotheses (with the help of indicators) in order to evaluate whether and in what degree they have been addressed.

As the research challenges pertain to traditional (static) questionnaires for measuring portal quality, the evaluation of the adaptive questionnaire (SALT) was performed in comparison to a similar but static one, in order to examine whether the former addresses the challenges of the latter. This kind of comparative evaluation is often used for evaluating adaptive systems/ questionnaires; see for example [Barra et. al., 2002].

An overview of the methodology that was followed for the evaluation of the proposed approach is depicted in Figure 7.6. Both the adaptive (SALT) and the static questionnaire have been translated in German language and deployed at the portal of the Austrian municipality. Besides the SALT system's components and the static questionnaire, some software components which have a supportive role to the evaluation, were also developed and deployed to the same environment (please see section 7.2.2 below for details about these supportive components).

Participants were Austrian citizens who were visiting the aforementioned portal from home or work, in order to interact with it. At the end of each session, each citizen was asked to fill in an evaluation questionnaire to report his/her feedback on the session. Participation was voluntary and citizen's motivation towards taking part in the survey was their intention to help the public administration to improve their e-government portal and services, as clearly stated in the text of the initial questionnaire page. Participants were randomly divided in two equally-sized groups: the first group worked with the adaptive questionnaire, while the second with a similar, but "static", questionnaire which includes all the questions of the questionnaire repository (46 questions). Citizens did not know to which group they belong. Both questionnaires

were presented as a pop-up window, while the questions were presented in multiple pages. The feedback collected through the adaptive (SALT) and static questionnaires was analyzed comparatively as explained in detail below.

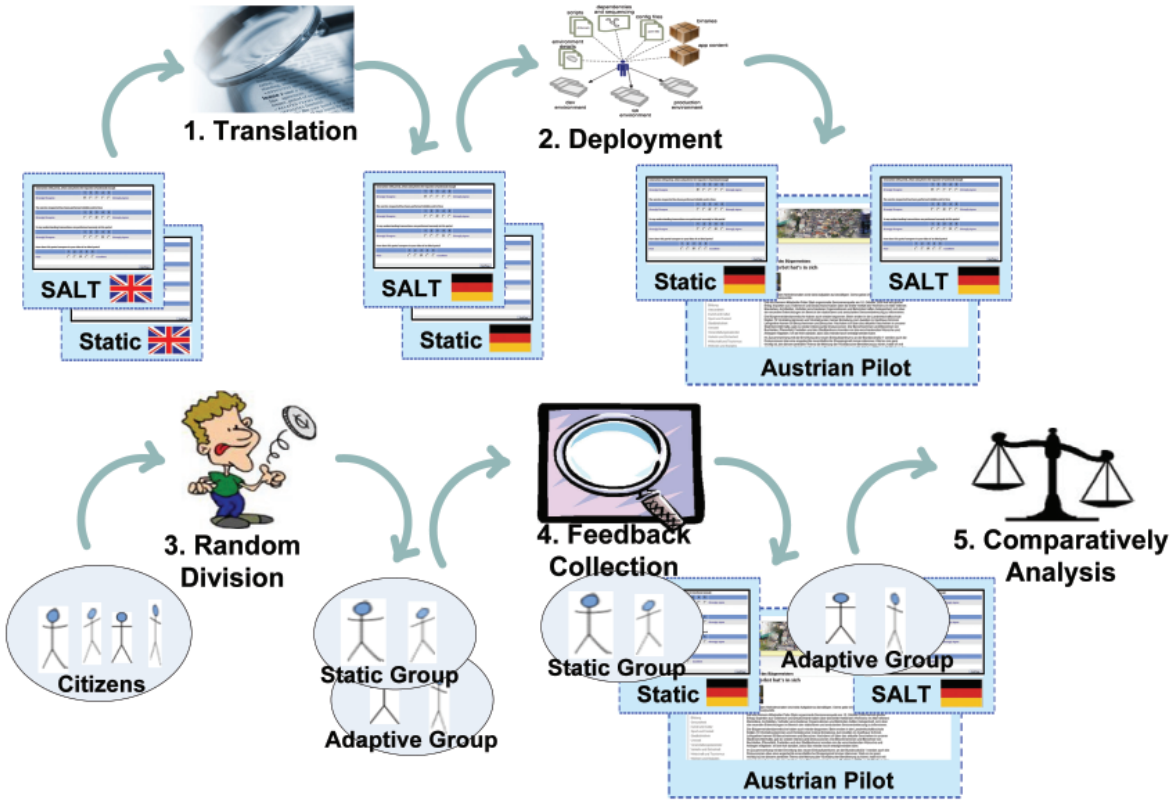


Figure 7.6: Overview of the Evaluation Methodology

In Table 7.2 the general hypotheses to be evaluated, as originate from the main research objectives (see Table 1.1), are presented. These general hypotheses should be translated into operational hypotheses that the evaluation data allow to analyze. The transition from general to operational hypotheses is facilitated by indicators which are proxy measures of the main concepts used in the research objectives and general hypotheses. Such main concepts are the relevance of questions to (i) the user context and (ii) problems as well as (iii) the reluctance of users to participate. Three main indicators pertaining to the three pairs of objectives and general hypotheses O1(H1)-O3(H3) were defined (see Table 7.2), while for the pair O4(H4) qualitative measures were used instead of an indicator, as the latter was not feasible; please see the explanation below. A detailed description of the three indicators follows:

1. **Non-Completion Rate (NCR)**: It is defined as the percentage of responses returned that were not completed, i.e. that were left blank. As can be seen in Table 7.2, NCR is an indicator of the relevance of the presented questions to the user context. The rationale behind this is that when a user considers that a question is not relevant to his/her navigation and/or service consumption experience, it is more likely not to respond to it, compared to the case that the presented question is relevant. NCR is a negative indicator of questions' relevance to the user context, i.e. the higher the NCR, the less relevant the questions to the user context.
2. **Disagreement Rate (DR)**: It refers to the questions (assertions) with which users rather disagree. More specifically DR is defined as the percentage of questions answered that users have graded low (1-2 in the five point Likert scale ranging from strongly disagree to strongly agree). As can be seen in Table 7.2, DR is an indicator of the relevance of the presented questions to the user problems. The rationale behind this is that users tend to give lower grades to the questions related to the problems they encounter during their interaction with the e-government portal, compared to those that are not related to their problems. DR is a positive indicator of questions' relevance to the user problems, i.e. the higher the DR, the more relevant the questions to the user problems.
3. **Response Rate (RR)**: It is defined as the percentage of presented questionnaires that have been returned. It should be noted that a questionnaire is considered as returned in case at least one question has been answered. As can be seen in Table 7.2, RR is an indicator of the users' reluctance to participate to the survey. The rationale behind this is that the more reluctant the users are, the less likely to respond and vice versa. RR is a negative indicator of users' reluctance to participate and a positive indicator of user participation, i.e. the higher the RR the less reluctant the users are and thus the bigger their participation to the survey is.

As far as O4(H4) is concerned, although it could be possible to define some quantitative indicators regarding the efficiency and effectiveness of the quality improvement process that would be followed by the public administration in order to improve the quality of its portal and e-services based on the user feedback, such an improvement effort was not in the direct plans of the Austrian municipality. The reason for this is that the public administration has recently re-launched its e-government portal. For this reason, the evaluation of O4(H4) was limited to the subjective opinion that municipality's technical staff had about the feedback collected through the adaptive questionnaire, compared to that collected through the static questionnaire. More specifically, 3 employees were asked about their opinion regarding the potential usefulness and exploitability of the collected feedback as well as their satisfaction with it.

Table 7.2: General Hypothesis and Indicators

Objective	General Hypothesis	Indicators
O1: To increase the relevance of presented questions to the user context	**H1**: The users provided with the adaptive questionnaires are presented with questions that are more relevant to their context (functionalities consumed, parts of portal visited) than those presented to the users provided with the static questionnaires.	Non-completion rate (**NCR**)
O2: To increase the relevance of presented questions to the user problems	**H2**: The users provided with the adaptive questionnaires are presented with questions that are more relevant to the problems they encountered than those presented to the users provided with the static questionnaires.	Disagreement rate (**DR**)
O3: To increase the user participation to the survey	**H3**: The users provided with adaptive questionnaires are less reluctant to participate than the users provided with static questionnaires.	Response Rate (**RR**)
O4: To increase service provider's satisfaction about the quality of the user feedback collected.	**H4**: The portal providers examining the answers given by the users provided with the adaptive questionnaires find these answers more exploitable than the answers given by the users provided with static questionnaires (which reproduced the classical web survey situation).	Measured qualitatively

Having defined the indicators above, the three **operational hypotheses (h1 – h3)** corresponding to the three general hypotheses (H1 – H3) of Table 7.2, can be defined as follows:

- **h1: NCR(A) < NCR(S)**: The Non-Completion Rate of the adaptive group [NCR(A)] is smaller than the Non-Completion Rate of the static group [NCR(S)]
- **h2: DR(A) > DR(S)**: The Disagreement rate of the adaptive group [DR(A)] is greater than the Disagreement rate of the static group [DR(S)]
- **h3: RR(A) > RR(S)**: The Response Rate of the adaptive group [RR(A)] is greater than the Response Rate of the static group [RR(S)]

These operational hypotheses will be tested for statistical significance with hypothesis testing. The purpose of hypothesis testing is to test the viability of the null hypothesis in the light of experimental data. The null hypothesis is a hypothesis about a population parameter. It is typically a hypothesis of no difference (e.g. no difference between population means, proportions, variance etc.), although it can also include the direction of the effect. That is why the word "null" in "null hypothesis" is used - it is typically the hypothesis of no difference. Depending on the data, the null hypothesis either will or will not be rejected as a viable possibility for a given level of significance[4]. A null hypothesis is usually the reverse of what the

4. The significance level is defined as the probability of a false rejection of the null hypothesis in a statistical test.

researcher actually believes; it is put forward to allow the data to contradict it. The alternative hypothesis, on the other hand, relates to the statement to be accepted if the null is rejected. In this study, the alternative hypotheses are the operational hypotheses h1 - h3, while the null hypotheses, hereafter referred to as h1* - h3*, are the reverse of the operational. For example h1* is that NCR(A) >= NCR(S) and so on.

A two-sample Z-test of proportion [Zou et. al., 2003], was used for deciding whether a null hypothesis should be rejected for a given level of significance, as all the three null hypotheses (h1* - h3*) that were tested, concern indicators (NCR, DR, RR) which are proportions. The p-value of the test has a central role in the decision regarding the rejection of the null hypothesis. A p-value is a measure of how much evidence we have against the null hypothesis (the smaller the p-value, the more evidence we have against it). In section 7.2.3, where the evaluation results are reported, for each operational hypothesis the test results regarding its significance are reported. Popular levels of significance are 10%, 5% and 1% [Kleynhans, 2007]. In the current study, the levels 0.05 and 0.01 were used. This means that a statistics p-value is compared against 0.05 (or 0.01) and if smaller, the null hypothesis is rejected, i.e. the result is statistically significant. It should be noted that Z-test calculations were made by using the PHStat2 XLA version 2.7 (www.prenhall.com/phstat) Excel Add In.

7.2.2 Software Supporting the Evaluation of SALT

In order to run the evaluation of SALT according to the evaluation methodology described in section 7.2.1, some software components with a supportive role in the evaluation were developed. The role of these components is on the one hand to divide randomly citizens into the two groups, by implementing a coin-tossing functionality, and on the other hand to store some data required for the calculation of indicators in a database. Figure 7.7 provides an overview of these components by depicting their technical architecture, while in the rest of this section the various components and the functionality implemented by each one are described.

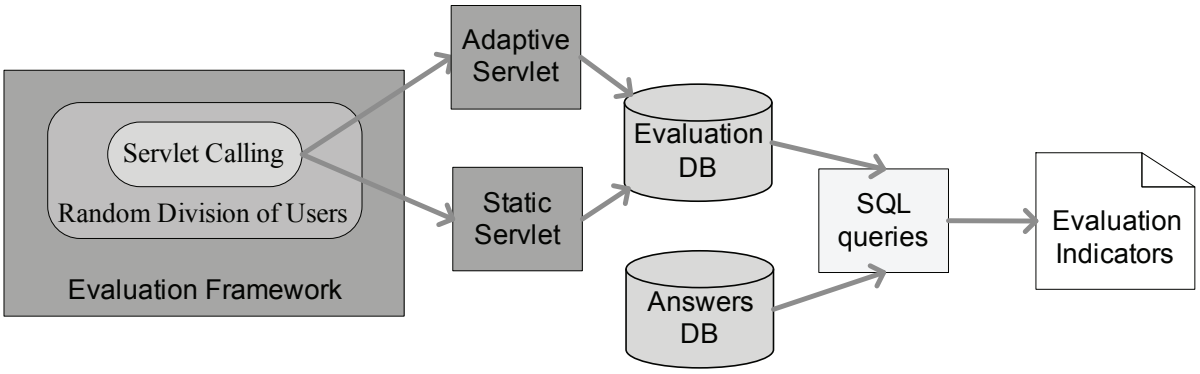


Figure 7.7: Technical Architecture of Components Supporting Evaluation

As already mentioned, users should be divided into two equally-sized groups. For this reason, the software component "*Random Devision of Users"* was developed and integrated with the evaluation framework. As the name implies, this component implements the random division of users into two equally-sized groups, by triggering either SALT or the static version of the questionnaire in a random way.

Furthermore in order to be able to calculate the Response Rate (RR) indicator, there was a need to keep track of the number of presented questionnaires of each category (static, SALT). Both tools (SALT and static questionnaire) log the returned questionnaires. However, in case a user is presented with a questionnaire and he/she chooses not to respond by closing the pop-up window, nothing is logged and therefore the calculation of the RR indicator is not possible. In order to address the aforementioned need and thus enable the calculation of RR, two servlets (*staticServlet*, *adaptiveServlet*) were developed and deployed. These servlets keep track of the number of presented questionnaires of each category.

Besides these two servlets, the software component "*Servlet Calling*" was developed and integrated with the random division component described above. *Servlet Calling* is responsible for deciding which servlet should be called. More specifically, the static servlet is called every time a static questionnaire is presented and it logs the current date and time, as well as that the questionnaire type is static. Similarly, the adaptive servlet is called every time the SALT is presented and it logs the current date and time, as well as that the questionnaire type is adaptive. A simple database (the *Evaluation DB*) was used for storing these data.

Finally, for the calculation of the indicators which are used in order to evaluate SALT, a set of SQL queries was developed. These queries select the appropriate records and fields from the *Evaluation* and *Answers* (which contains the user feedback) databases and return the indicators defined in section 7.2.1.

7.2.3 Evaluation Results

The evaluation took place during October 2008 and the collected feedback was analyzed by using the indicators defined in section 7.2.1. The questionnaires have been presented to 50 different citizens, 25 from each group, while the results for each group regarding the three indicators (i.e. NCR, DR and RR) can be seen in Table 7.3. For example, the citizens of the adaptive group that finally provided their feedback through the presented questionnaire were 14 out of the 25. Furthermore, they did not answer (i.e. they left blank) just 19 questions out of the 157 returned; while the low-graded answers (i.e. with grades 1 or 2 of the five-point Likert scale used) were 39 out of the 138 of the non-blank questions returned by this group.

Table 7.3: Indicators per Group

	Adaptive Group	Static Group
Non-Completion Rate (NCR = QLB/ReR)	**12,1%**	**50,18%**
Responses Returned (ReR)	157	552
Questions Answered (QA)	138	275
Questions Left Blank (QLB)	19	277
Disagreement Rate (DR = LGA/QA)	**28,26%**	**6,91%**
Questions Answered (QA)	138	275
Low-Graded Answers (1-2) (LGA)	39	19
High-Graded Answers (3-5) (HGA)	99	256
Response Rate (RR = RQ/PQ)	**56%**	**48%**
Presented Questionnaires (PQ)	25	25
Returned Questionnaires (RQ)	14	12

By analyzing the results depicted in Table 7.3, three interesting findings (one finding per indicator) came up.

The finding related to the Non-Completion Rate (NCR) indicator, is that the number of questions left blank differs between the responsive citizens of the two groups (19 blank questions for the adaptive and 277 for static responders). Although this is partially explained because of the less feedback given by the adaptive group (157 returned questions in total versus 552 of the static case), a more accurate comparison in terms of blank questions can be done by means of the corresponding percentages (NCR indicators). These percentages support more accurately this first finding: more responsive citizens of the static group left questions blank, compared to the responsive citizens of the adaptive group (50,18% versus 12,10%). The null hypothesis (h1*) in this case assumes that NCR(A) >= NCR(S), while the alternative hypothesis (h1) is that NCR(A) < NCR(S). The results of the two-sample Z-test of proportion for the null hypothesis h1* are depicted in the first column of Table 7.4. As can be seen in the table, the h1* should be rejected (p-value < 0.01) and thus the alternative h1 is true. In other words, the observed difference between the two groups, regarding the Non-Completion Rate, is statistically significant at the 0.01 level.

The finding regarding the Disagreement Rate (DR) indicator, is that the scores of the adaptive group concerning their perceived quality are worse compared to the relevant scores of the static group: the DR indicator is 28,26% in the adaptive case, compared to 6,91% in the static one. The null hypothesis (h2*) in this case assumes that DR(A) <= DR(S), while the alternative hypothesis (h2) is that DR(A) > DR(S). The results of the two-sample Z-test of proportion for the null hypothesis h2* are depicted in the second column of Table 7.4. As can be seen in the table, the h2* should be rejected (p-value < 0.01) and thus the alternative h2 is true. In other words, the observed difference between the two groups, regarding the Disagreement Rate, is statistically significant at the 0.01 level.

As far as the Response Rate (RR) indicator is concerned, the finding is that the response rate of the adaptive group (56%) is higher compared to the static one (48%). The null hypothesis (h3*) in this case assumes that RR(A) <= RR(S), while the alternative hypothesis (h3) is that RR(A) > RR(S). The results of the two-sample Z-test of proportion for the null hypothesis h3* are depicted in the third column of Table 7.4. As can be seen in the table in this case the null hypothesis h3* cannot be rejected (p-value > 0.05). This means that there is no significant evidence of a difference between the two groups, regarding the Response Rate, at the 0.05 significance level.

Table 7.4: Z-Tests for the Three Null Hypotheses

Z-Test	**Null Hypothesis**		
	h1*: NCR(A) >= NCR(S)	**h2*: DR(A) <= DR(S)**	**h3*: RR(A) <= RR(S)**
Data			
Hypothesized Difference	0	0	0
Level of Significance	0,01	0,01	0,05
Static Group			
Number of Successes	277	19	12
Sample Size	552	275	25
Adaptive Group			
Number of Successes	19	39	14
Sample Size	157	138	25
Intermediate Calculations			
Static Group Proportion	0,502	0,069	0,48
Adaptive Group Proportion	0,121	0,283	0,56
Difference in Two Proportions	0,381	-0,214	-0,08
Average Proportion	0,417	0,140	0,52
Z Test Statistic	8,537	-5,891	-0,566
Tail Test			
Tail Test Type (Upper/Lower)	Upper	Lower	Lower
Critical Value	2,326	-2,326	-1,645
p-Value	0	1,92E-09	0,286
Null Hypothesis (Reject / Don't Reject)	**Reject**	**Reject**	**Don't Reject**

With respect to the service provider's view, the latter confirmed that the feedback received from citizens of the adaptive group – Feedback(A) - seems to focus more on users' problems and context, compared to the feedback received from static groups' responders - Feedback(S). Their overall satisfaction with Feedback(A) is greater than their satisfaction with Feedback(S), as the latter contained more blank questions and the response rate was lower; therefore they

consider that Feedback(A) is more useful and exploitable. It should be noted that although the evaluation of the adaptive questionnaire from the service providers was positive, it was only qualitative; a more systematic empirical evaluation should be conducted, in order to be able to conclude to safer interpretations about O4 and H4.

In the next section, the three aforementioned findings are discussed, while interpretations for these findings are provided.

7.2.4 Evaluation Conclusions

The result that the Non-Completion Rate (NCR) of the adaptive group is lower than NCR of the static group is interpreted as follows: for the static group, unanswered questions are the result of asking questions about non-visited page types or questions that are not important for the users. On the other hand, users of the adaptive group tend to fill in the entire questionnaire, showing that the proposed approach addresses the “one size fits all” challenge, as the evaluation is targeted to the user context.

The interpretation regarding the Disagreement Rate is that the adaptive group’s users are more challenged by the adaptive questionnaire, compared to users of the static group, as questions related to their problems (which either have been tracked by monitoring their actions, or they have been identified by taking into account their answers to F-level questions) are presented. This kind of quality monitoring, which is targeted to specific user problems, supports further the claim that the proposed approach addresses the “one size fits all” challenge. Finally, such a targeted assessment allows the proper prioritization of actions that must be performed for the improvement of portal e-service quality.

Regarding RR, the increase of the Response Rate in the adaptive group, although not statistically significant, is explained by the fact that the number of presented questions in the adaptive group (11,21 questions in average, i.e. 157 responses / 14 returned questionnaires) has decreased compared to the static (46 questions), as the user context and problems have been taken into account for questionnaire composition. Besides completion time, another incentive for users of the adaptive group, which may explain the observed increase of response rates, is their intention to provide feedback about quality factors with which they had faced problems. In this way, they would contribute indirectly – through their feedback – towards the improvement of the portal along the appropriate quality dimensions.

It should be noted that the response rates, for both groups, seem to be higher than the average response rate of web-based questionnaires which is below 20% [Vehovar et. al., 2001]. This probably happened because the evaluators were in an “evaluation attitude” when they were presented with the questionnaires, as the portal used for the evaluation was not the productive portal of the Austrian Municipality, but a pilot portal which was a copy of the productive portal extended with the functionalities provided by SALT components. The pilot

portal was live in parallel with the productive one and was used only by users who accepted the invitation to take part in the evaluation. The overall evaluation session included not only the evaluation of SALT but also the evaluation of other functionalities which are out of scope of this doctoral thesis. Therefore, participants were in an “evaluation attitude” and thus somehow biased towards responding. We believe that in a different context where this kind of bias would not exist, the difference between the response rates of the two groups would be even greater. Finally, another reason explaining the insignificant evidence of difference between the two groups regarding the users’ proportions who responded, is that the sample size regarding RR may be inadequate for rejecting the null hypothesis.

Concluding, in this Chapter the evaluation of the adaptive questionnaire (SALT) was done comparatively to a similar but static questionnaire, in order to examine whether the former addresses the challenges of the latter. The results gave evidence to the high level hypothesis, that it is beneficial for both citizens and service providers to take into account the user context when monitoring quality. More specifically the evaluation showed that the added value of quality monitoring using SALT, compared to the traditional/static approach, is two-fold.

- On the one hand the user experience associated with the quality assessment process is improved, as the questions presented to users are related to:
  - The problems they encountered (DR indicator).
  - The content and services they consumed, as irrelevant questions which are out of context are omitted (NCR indicator).
- On the other hand the service provider gets better feedback in terms of both:
  - Quality, as the irrelevant feedback decreases (NCR indicator) and furthermore the feedback focuses on the problematic quality factors (DR indicator)
  - User diversity, as the response rates increase, although this was not proved to be statistically significant (RR indicator).

8 METHODOLOGY FOR IMPLEMENTING ADAPTIVE EVALUATION OF E-SERVICES IN E-GOVERNMENT

As described in the previous Chapter, the SALT system proposed in this doctoral thesis has been implemented and evaluated empirically in a real use case in the e-government domain. The purpose of this Chapter is to explain the generic methodology that should be followed by a Public Administration (PA) in order to implement an adaptive evaluation of its portal and e-services according to the proposed framework and system (see Chapters 4 and 6, respectively). The methodology takes into consideration the results and the lessons learned from the use case. More specifically, the process followed for the implementation of the pilot case has been conceptualized and furthermore enhancements have been made, in order to address a variety of other use cases. The result of this effort is the generic methodology, including analytical guidelines and steps for implementing adaptive evaluation of e-services in e-government.

It should be noted that the generic methodology described in this Chapter can be also seen as a methodology for the maintenance of the proposed system and its underlying models. For example the process that should be followed for the extension of the semantic relationships between the user's problems and questions (defined in the MAQM model) or the extension of the quality factors and dimensions (defined in the quality model), are detailed in the methodology.

The Chapter is structured as follows. In section 8.1 managerial guidelines for implementing the proposed approach are given, while section 8.2 highlights the main roles and skills required for such an implementation.

8.1 Management Guidelines

In this section guidelines are provided for the implementation of the adaptive evaluation of e-services. The main purpose of these guidelines is the facilitation of the implementation process from a managerial perspective. Detailed technical guidelines concerning e.g. the installation and configuration of tools are not included. Nevertheless, these managerial guidelines will be also beneficial for technical staff of the PA and/or the external consultants that will be involved

in the implementation, as the latter will obtain an overview of the implementation process and task dependencies.

Figure 8.1 provides a graphical representation of the steps that should be followed. As can be seen in the figure, there are two possible paths. The path that the PA will follow depends on a decision about the configuration of the quality model. If the PA decides to use the quality model as it is, the first path is followed, which contains only three steps - the annotation of the portal, the deployment of the tools and the analysis of the results. Otherwise the PA should follow the second path which additionally includes the configuration of the quality model, of the questionnaire and of the quality ontology.

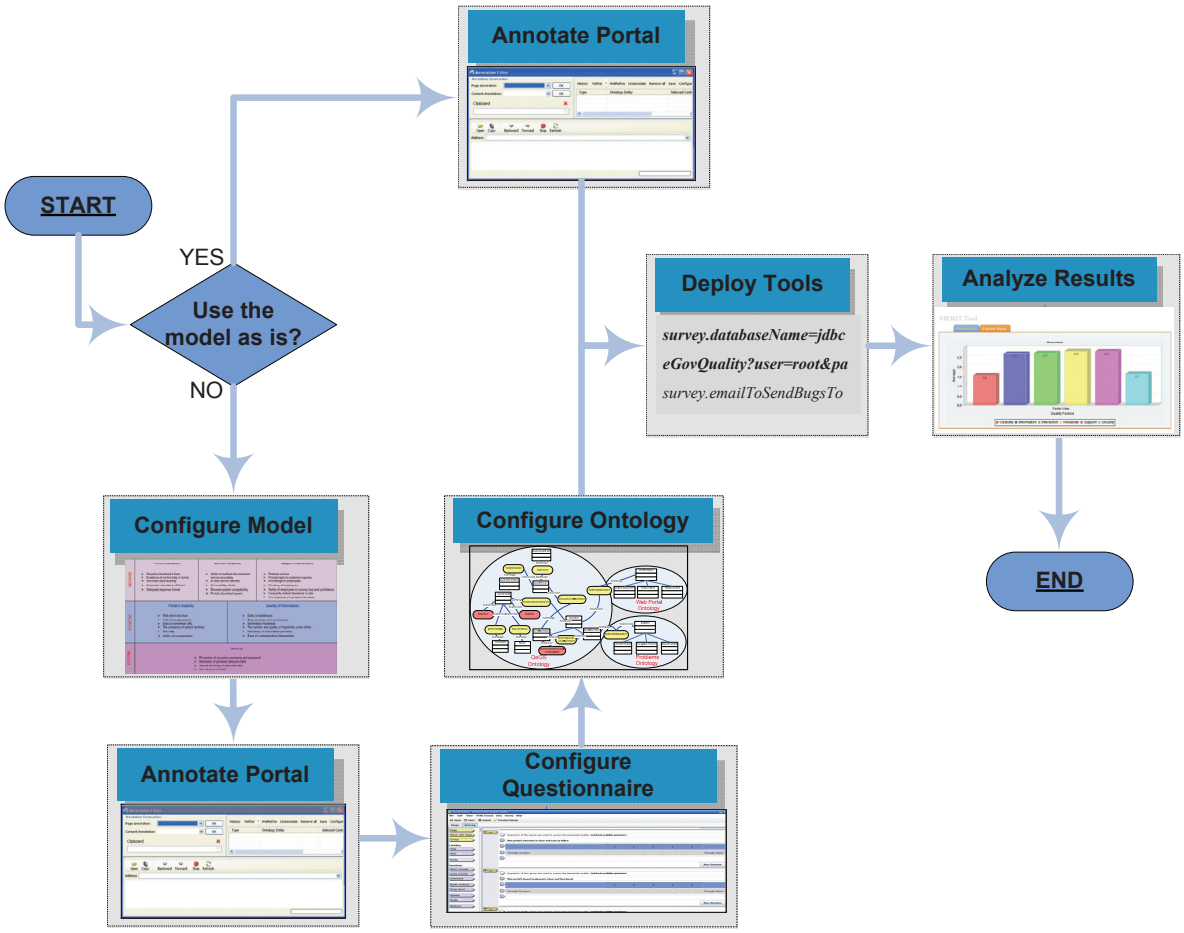


Figure 8.1: Steps for Implementing Adaptive Evaluation of e-Services

8.1.1 Decide whether the model should be configured

The path that the PA will follow in order to implement an adaptive evaluation of e-service and portal quality, depends on whether it wants to configure the quality model or not. In this section the criteria that should be used for such a decision are discussed.

Although the quality model has been developed in such a way so it can be applied to every e-government portal, some configurations may be necessary in order to optimize the performance of the underlying methods and tools. For example, quality aspects related to security may not apply for portals that do not involve transactions or user accounts. Whereas the adaptive questionnaire will hide e.g. quality aspects regarding login pages and forms, its performance will decrease, as the relevant adaptation logic will first examine those aspects before deducing to hide them.

In order to decide if the configuration of the quality model is necessary, the PA should examine whether all the quality aspects included in the model are relevant to its e-government portal. As described above, the quality model covers a variety of quality aspects corresponding to a range of portals in terms of online sophistication. In case the portal has a low level of sophistication, some quality aspects may be irrelevant and so a configuration of the quality model may be necessary. For more details about the relation of sophistication levels with quality aspects, the reader is referred to section 8.1.2 below.

In case the PA finds out that the quality model examines more quality aspects than those which are relevant for its portal, the decision about whether the irrelevant quality aspects should be removed from the model is based on a second criterion. This is related to the technical characteristics of the web server hosting the adaptive questionnaire. In case these characteristics imply CPU and network speed of high performance, the performance of the adaptive questionnaire is anticipated to be also high, independently of whether the irrelevant aspects are removed or not. For this reason, in this case it is recommended that the PA should not configure the quality model, but it should use it as it is.

In any case the decision to configure the quality model implies some extra effort, as it results in the implementation of three more steps (see Figure 8.1). For this reason it is recommended to the PA not to follow this path unless it is really necessary. One good approach in order to decide about this effort - performance trade-off is to use the model as it is and then evaluate the performance of the adaptive questionnaire. If the performance is not satisfactory and furthermore the time and skills for following the second path are available, then a configuration of the model may be decided. The configuration should be done according to the section 8.1.2.

8.1.2 Configure the Quality Model

As described in the previous section, the configuration of the model is optional and is not recommended for PAs that prefer a “plug and play” solution. Nevertheless, in order to cover as much PAs as possible, in this section the methodology for configuring the quality model is presented. This will have as result a subset of the quality model, so that it will fit to the e-government portal to which it will be applied.

The guidelines for configuring the model are based on the maturity of online public services. One of the most important indicators defined by the European Commission, in

order to evaluate how the 20 common public e-services progress in the various member states, is “availability of public services online”. In order to measure this indicator, an e-service sophistication model is used [Cap Gemini, 2009] which illustrates the different degrees of sophistication of online public services, going from ‘basic’ information provision over one way and two way interaction to ‘full’ electronic case handling and personalization (see Figure 8.2). The five levels of sophistications are:

- Level 1: information: The necessary information to start the procedure to obtain a service is available on the portal.
- Level 2: one-way interaction (downloadable forms): The portal offers the possibility to obtain the paper form to start the procedure to obtain the service in a non electronic way.
- Level 3: two-way interaction (electronic forms): The portal offers the possibility of an electronic intake with an official electronic form to start the procedure to obtain the service.
- Level 4: transaction (full electronic case handling): The service provider offers the possibility to completely treat the service via the portal.
- Level 5: personalization (pro-active, automated): The government pro-actively performs actions to enhance the service delivery quality and the user friendliness. Examples of pro-activity are: the government warns the user that action could be required, the government pre-fills data in the application forms that it already contains in governmental databases to the extent permitted by law.

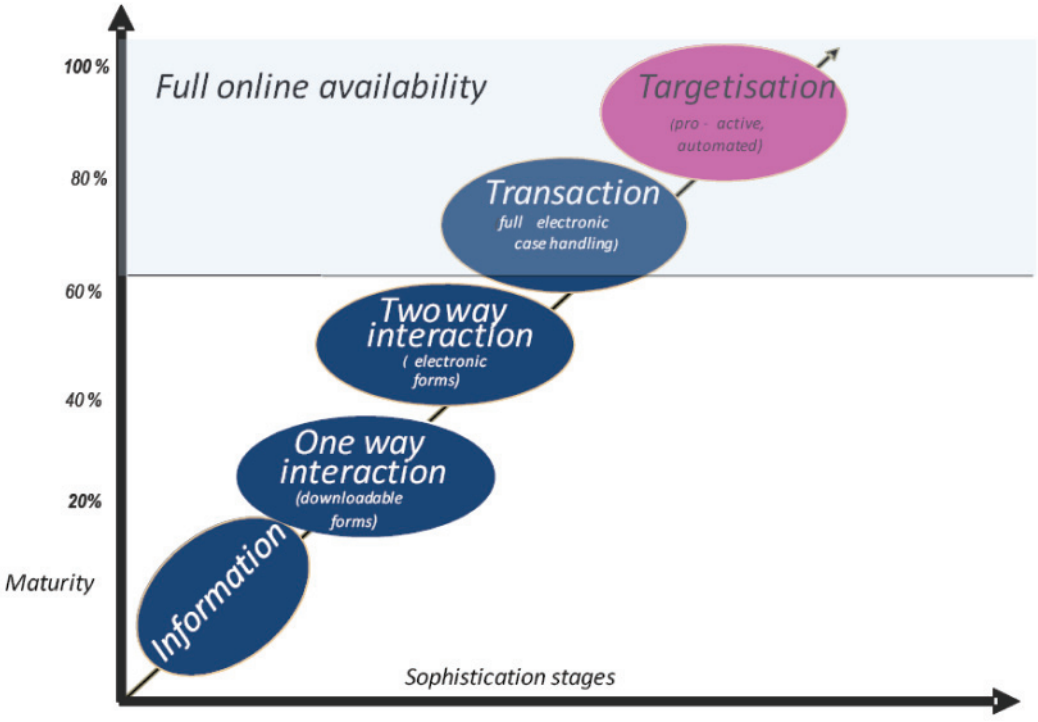


Figure 8.2: Sophistication of Online Services. Source: [Cap Gemini, 2009]

Depending on the degree of sophistication of the public e-services that a PA makes available on its portal, some dimensions of the quality model may not apply. The PA managers should consider removing those dimensions from the quality model and the underlying methods and tools. Table 8.1 depicts the dimensions that are candidate for removal, per service sophistication level.

Table 8.1: Guidelines for Configuring the Quality Model Based on Services Sophistication

Level of Service Sophistication	Factor	Dimensions to be Considered for Removal
Information One-way interaction	Interaction	All
	Service Reliability	Speed to download a form
	Security	All
	Usability	Ability of customization
Two-way interaction Transaction	Interaction	Automatic calculation of forms Sufficient data recalling
	Usability	Ability of customization
Personalization	-	-

E-government portals that provide only information (sophistication level 1) do not necessarily contain forms, as the latter are commonly used as the major medium for submitting information online. Furthermore, these kind of e-government portals usually work with anonymous users, as there is no need for user authentication. So, quality aspects related to security and use of personal data may not be relevant. For this reason, all quality dimensions regarding interaction with the portal using forms and security should be considered for removal. The same is true for the dimension “speed to download a form” of the service reliability factor and the dimension “ability of customization” of the usability factor, as the first refers to forms and the second implies a mechanism for the collection of personal data upon which the customization is based.

The same situation is commonly found in portals of the second sophistication level. The only difference with the portals of the previous category is that the latter offer the ability to download a paper form that citizens can fill in and send it offline to the relevant governmental office in order to start the service provision procedure. There is still no need for online interaction through forms, user login and customization. For this reason, the set of dimensions to be considered for removal is the same.

This is not however the case for portals offering online services of sophistication level 3 or 4. These kinds of portals allow users to communicate and interact online with the public administrations. They should at least (for level 3 sophistication) offer the possibility to users

to electronically start the procedure to obtain a service, by submitting user identification and service-specific data through official electronic forms. In addition, portals of maturity of level 4 should also enable the complete treatment of services online. This means that these portals must provide means for user authentication and submission of information through forms. For this reason the quality dimensions related to security and forms interaction are mandatory. The only exceptions are quality dimensions concerning advanced features of forms regarding personalized views of them, like automatic calculation of fields and sufficient data recalling of previously submitted information. Furthermore, there is no need for customization on the portal level.

Finally e-government portals providing services of level 5 should provide both the advanced features of forms mentioned above and portal customization. For this reason all quality dimensions of the quality model are mandatory for this category of portals.

It should be highlighted that although a portal may be classified to levels 1 or 2 of sophistication, it can still contain forms, work with registered users and provide customized user experiences. This means that the dimensions depicted in Table 8.1 should not be necessarily removed from the quality model. The final decision about the elimination of dimensions resides to the management of the PA and should be done per case, after taking into account the particularities of each portal.

In addition to the sophistication level of the services provided by a PA, another criterion that may be used for supporting the decision about which quality dimensions should be removed from the quality model is the functionalities provided. More specifically if an offline channel for providing support to users is available, the relevant quality aspects (Support Mechanisms) are applicable, otherwise they should be considered for removal.

8.1.3 Annotate the portal

In order to enable the adaptation of questionnaires used for monitoring quality, advantage of the metadata of portal's pages should be taken. For this reason, the portal should be annotated with the appropriate concepts describing the type and domain of the web pages. This is done by using the annotation tool which is described in section 6.4.

8.1.4 Configure the questionnaire

This step is optional and belongs to the second path which starts with a decision to configure the quality model. In that case, the configuration of the questionnaire is necessary because the questionnaire should always reflect the quality model. This means that if some quality aspects have been removed from the model, the same should be done for the questionnaire. The questionnaire design environment should be used in order to achieve this synchronization

between the questionnaire and the underlying model. Details about using the questionnaire designer tool are available in section 6.5.

Although the questionnaire can be designed from scratch, this is not recommended. Instead, the PA is advised to import the survey files corresponding to the as-is quality model. These files are available with the adaptive questionnaire tool. Importing of survey files is as simple as selecting the file and clicking import, as depicted in Figure 8.3.

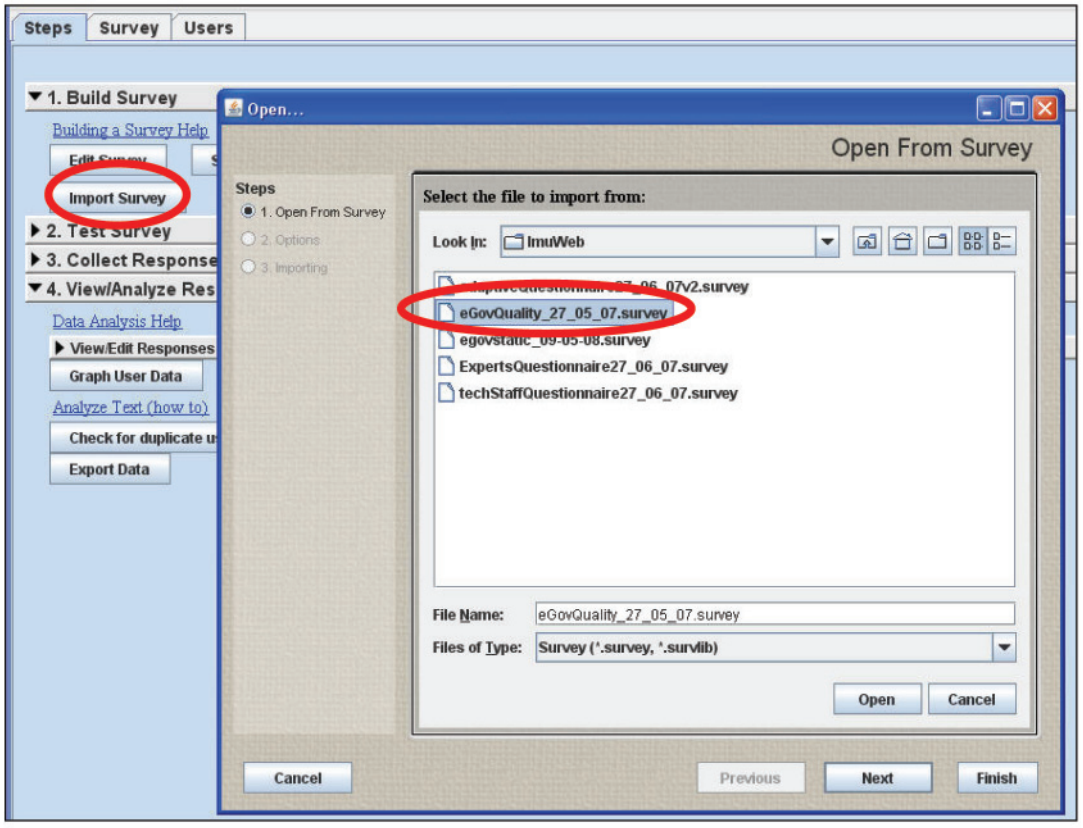


Figure 8.3: Importing a Survey File

After importing the survey, the designer should change the questionnaire, in a manner that reflects the changes introduced in section 8.1.2. In this way, the designer will use the design tool only for deleting questions, which is much more convenient and trivial than creating questions from scratch. Each question is modeled in the questionnaire design tool as a separate page. For this reason, in order to delete a question the designer should right click on the relevant page and then select the option *"Delete Page"*, as can be seen in Figure 8.4.

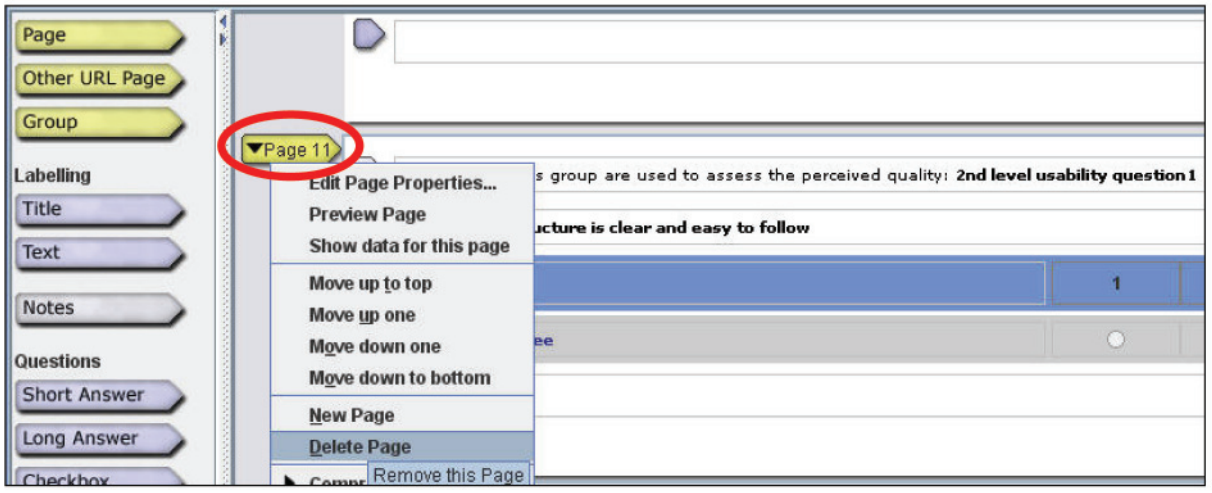


Figure 8.4: Deleting a Question

Concluding, the result of this step is a set of questions corresponding to the factors and dimensions of the quality model. These questions are used by the adaptive questionnaire and the most relevant are displayed according to the criteria described in section 4.2.3.

8.1.5 Configure the quality ontology

This step is also optional, as it also belongs to the second path shown in Figure 8.1 and is very similar to the previous one. The only difference is that its purpose is to guarantee the synchronization of the questions included in the quality ontology with the quality aspects of the quality model. Again we recommend that the initial version of the quality ontology should be used as a starting point and the irrelevant questions should be removed from it. This should be done with an ontology editor.

As described in section 6.9, the questions of the questionnaire are modeled in the quality ontology under the *Question* taxonomy. The two major subclasses of this taxonomy, *F-LevelQuestion* and *D-LevelQuestion*, represent the F-level and D-level questions of the adaptive questionnaire, respectively. Their subclasses represent F-level and D-level questions, respectively, categorized by the quality factors these questions belong to (see Figure 6.14). In order to remove an irrelevant question, the appropriate subclass as well as the object properties that have as range the specific subclass, should be removed from the ontology.

The quality ontology is formalised using OWL [Guinness and Harmelen, 2003] and has been developed using the open source ontology editor Protégé [2009]. OWL is a standard language for representing ontologies on the web, so any editor that supports this standard may be used for making the appropriate changes to the quality ontology.

8.1.6 Deploy the tools

This is obviously a required step and involves the installation and configuration of the SALT tools to the web servers of the PA.

8.1.7 Analyze results

So far, the PA has deployed the SALT tools to its e-government portal regardless of the path it has followed. After deployment, the adaptive questionnaire is presented to end users and their feedback concerning the quality of the e-government portal and services is collected in the questionnaire database. The collected data can be analyzed with a variety of tools. This section provides an overview of the possible options for analyzing and interpreting user feedback.

The first option is the MEtrics calculation and ReportIng Tool (MERIT) that has been described in section 6.10. Using the MERIT tool, the analyzer can see Pie Charts for the responses to both F- and D-level questions. One Pie Chart for each question exists and each Pie Chart is divided in sections. Every Pie Chart section, which corresponds to a response item, has a label that displays the number of answers given to the particular response item and the percentage of this number in the total number of answers. The tool also enables a targeted to specific segments analysis of the results, as it incorporates filters based on user demographics.

Another option is to export the database data into an MS Excel worksheet. This can be done either directly or indirectly by first exporting the data at a CVS (Comma-Separated Values) format and then importing them to MS Excel. Using excel functionalities the analyzer can calculate frequencies and percents, means, modes and medians; ranges, standard deviations and variance [Leahy, 2004]. Finally, more advanced calculations are offered by the Statistical Package for the Social Sciences (SPSS) [George and Mallery, 2003].

Whichever of the above tools will be used, the generated reports should be interpreted and appropriate actions for improving the quality of e-government services should be defined. Interpretation of results is case specific, as each PA has its own goals, mission, portal, services and users. Although user feedback can be interpreted in a variety of ways by different PAs, there are two criteria that should be always taken into account.

The first criterion refers to the distribution of user ratings among the various quality dimensions and factors. Users may be satisfied with some quality aspects and dissatisfied with others. For example, the usability of a portal may be considered as excellent, but on the other hand its information may be considered poor. The PA should examine, by using the collected data, which quality dimensions related to information are mainly responsible for the problem and should focus on their improvement, by taking the appropriate actions. For

example, in case the results about the dimension “information freshness” are low, one action may be to update the information of the portal more often.

A second criterion that should be taken into account when interpreting user feedback is the weight given to the various quality aspects by portal’s users. All the quality factors influence the perceived quality of the e-government portal, but each one may have a different degree of influence. For this reason the PA should start its improvement efforts for the problematic quality factors that are of great importance to their users. Every PA may have its own target group, i.e. its own group of users it considers more important and is made to serve. Usually the target group is defined as part of the PA’s mission statement or policy. Furthermore, the degree of importance of each quality factor for each target group may differ. So the PA should give priority to the problematic quality factors that are of high importance to its main target group.

The problematic quality factors can be easily found from user feedback, as already described above, while the group where a user belongs can be determined by the demographic questions of the questionnaire. These questions examine users’ age, educational level, employment information and internet usage (the questions are described in section 4.2.2). In case these characteristics are not enough in order to decide to which group a user belongs, the PA is advised to extend the demographics’ questions properly. Finally, concerning the importance of each quality factor, it can be calculated from user perceptions about an ideal portal. More specifically, users’ expectations about specific quality factors of an excellent portal, as they are reflected in their answers to the relevant questions, can be used as the weights of importance for each factor. In other words, if a user states that his/her expectation about a quality factor in an excellent e-government portal is low, then this quality factor does not contribute so much to his/her opinion about the portal’s quality and thus the factor’s weight is low. The calculation of the weight for factor “i” can be done as follows:

$$W_i = Q_i,\ 0 <= W_i <= 5$$

where W_i is the weight of factor i and Q_i is the average of user ratings on the question that examines users’ expectations about factor i on an excellent portal.

Figure 8.5 depicts graphically the aforementioned criteria that should be considered by the PAs when analyzing the collected data. The user rating criterion is depicted as the vertical axis, while the second criterion, i.e. the importance of a quality factor for a given target group, is depicted as the horizontal plane, as it depends on both factor weights and target groups. User ratings and factor weights are user dependent, while on the other hand, the target group that the PA focuses on is PA-dependent.

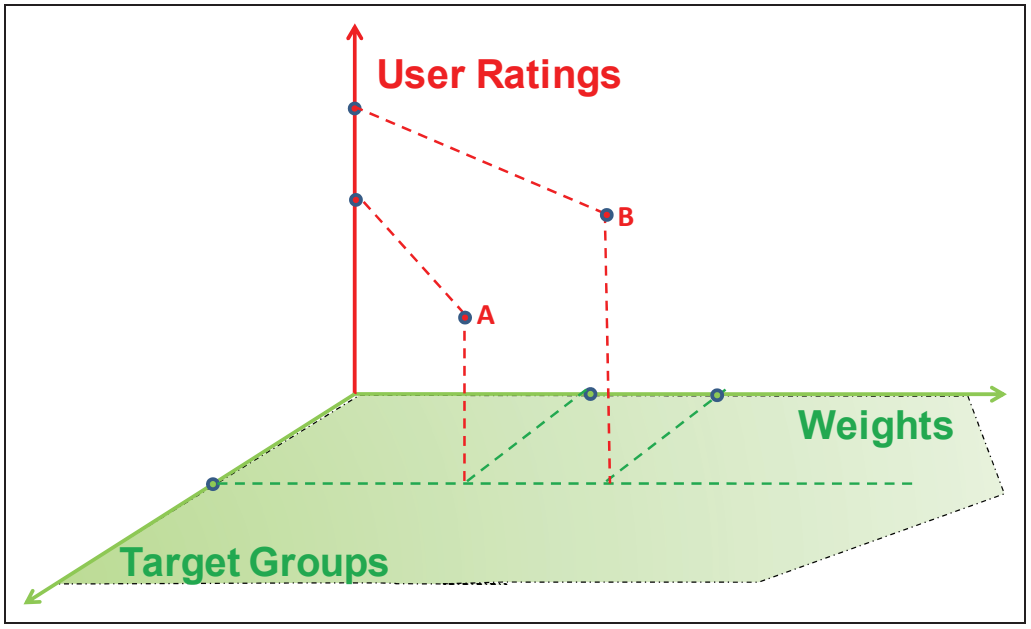


Figure 8.5: Criteria Considered for the Analysis of Results

It should be noted that sometimes the PA may face a contradictory situation while analyzing the results of the questionnaire. For example, according to the user ratings criterion, factor A may be more problematic than factor B, while in parallel, factor B may be more crucial than factor A for a given target group. This situation is contradictory because on the one hand the PA should focus on the improvement of the problematic factor (factor A), but on the other hand, a small improvement of factor B may be more beneficial because of the multiplicative nature of the corresponding weight. There is not unique way to overcome this situation, as the decision environment in each case is unique. It is the responsibility of the decision makers to find the appropriate trade-off between these two decision driving forces, something that requires a full comprehension of both the upside and downside of a particular choice.

8.2 Roles/Skills Required

The implementation of the adaptive evaluation of portal and e-service quality, by following the guidelines introduced in the previous section, requires the employment of people with various skills and roles. This section describes the main roles involved in the adoption of the proposed approach by a PA and the skills that each role should be qualified with. Figure 8.6 illustrates graphically the main roles involved in each step of the aforementioned guidelines.

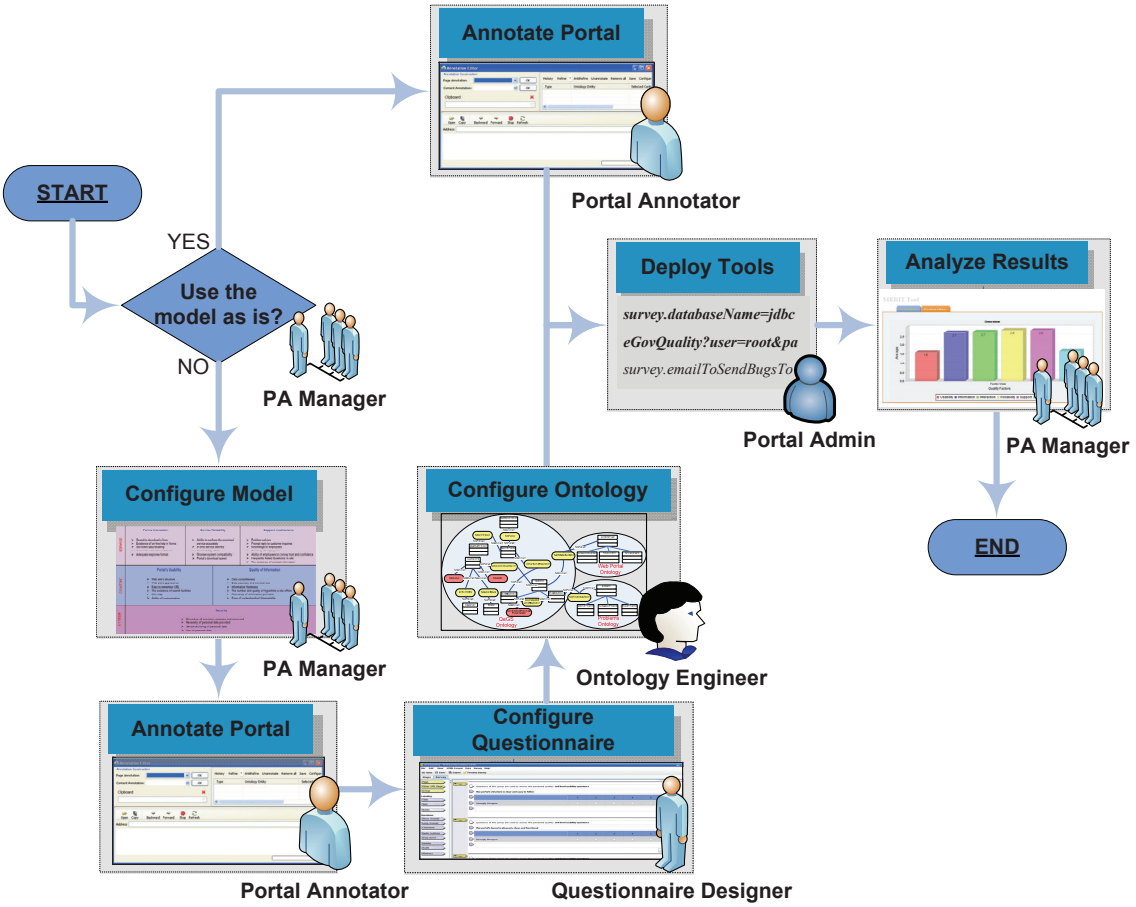


Figure 8.6: Roles Involved in the Implementation of the Proposed Approach

The PA managers should first examine whether the portal is in line with the quality model, and whether the skills for configuring the model are available or can be found outside the PA in a timely manner and with a reasonable cost. Based on these, the managers should then decide whether a configuration of the quality model is necessary. Probably the decision will be influenced by technical characteristics of the portal which can be acquired by the portal administration team. PA managers are also involved in the analysis of the collected data as the coordinators of the analysis process and the final decision makers regarding actions for quality improvement. So, the main skills required by a PA manager are his/her knowledge about the organization chart, the market, the functionalities provided by the portal and their level of sophistication, as well as his/her ability to communicate with PA employees and/or external workers.

The portal annotator is responsible for the annotation of the portal with metadata regarding the types of pages and pages' domain, using an appropriate software tool. So, the main skill that this role should have is the ability to use simple browser-like tools and the knowledge about the domain of the pages. Similarly, a basic knowledge of computers is the main skill

that the questionnaire designer should be qualified with, as the main task of this role is to configure the questionnaire using a simple tool.

The ontology engineer should be able to handle ontologies and understand the main concepts used in ontology engineering like classes, subclasses, object properties and data type properties. Furthermore, he or she should have a basic knowledge of an ontology editor tool that is compatible with OWL and should be used in order to manage the quality ontology.

The portal administrator will deploy the tools needed in order to enable adaptive quality evaluation. Thus, this role should have the ability to deploy web applications in a web server, to import a Mysql database to a Mysql DataBase Management System (DBMS) and to do some basic setup, e.g. to edit configuration files.

Table 8.2 summarizes the main skills per role.

Table 8.2: Roles and Skills for Adaptive Evaluation of e-Service Quality

Role	Skills
PA Manager	• knowledge of: - the organization chart - the market - portal functionalities - portal sophistication level • communication skills
Portal Annotator	• Basic computer knowledge • Knowledge of portal's domain
Questionnaire Designer	• Basic computer knowledge
Ontology Engineer	• Basic knowledge of ontology engineering • Knowledge of usage of an ontology editor tool
Portal Administrator	• Web application deployment • Basic Mysql knowledge • Ability to edit configuration files

9 CONCLUSIONS AND FURTHER RESEARCH

In this Chapter, conclusions of the present doctoral thesis are discussed, as far as the proposed framework and system are concerned (section 9.1). In section 9.2 limitations of the system and possible improvements are highlighted, while the Chapter concludes in section 9.3, where directions for further research are identified.

9.1 Conclusions

Nowadays, the acceptance of the World Wide Web as the most important platform for distribution and supply of information and e-services creates a new challenge for a constant improvement of the quality of the latter. Quality evaluation is the foundation, upon which the efforts for improvements are based. Evaluating the degree of the user's satisfaction with portals and e-services is necessary in order to understand user perceptions about the quality of e-services they consume. By understanding the opinions users have about the various quality aspects of portals and e-services, the service providers would be able to plan the appropriate actions for improving the underperforming aspects.

In this thesis we introduced a framework, models, methods and a software system (SALT), which allow an adaptive evaluation of e-service and portal quality, with the aim to overcome the challenges of static (as-is) evaluation approaches. The proposed approach makes the quality evaluation process more dynamic, by tailoring the quality aspects for which the user is asked to provide his/her feedback, to the individual's context, problems and previously submitted feedback. Therefore, in contrast to the static approach, the delivery of questions is not a "one way" delivery from the questionnaire to the user, in the sense that the user problems and context are captured during the user interaction with the portal. Then, based on these as well as on previously submitted user responses, the questions are delivered in a context-aware manner. In other words, there are multi-context views of a questionnaire for the various users, in contrast to the static approach where all users experience a single and isolated view of the questionnaire. Furthermore, the feedback collected through the proposed approach is focused on the user problems and context, as opposed to that collected through the static one, which additionally may contain a lot of "noise" (e.g. responses regarding functionalities or parts of the portal that the user did not interact with).

Figure 9.1 depicts graphically the as-is approach for evaluation of e-service quality versus the one proposed in this thesis.

The implications of the proposed approach are two-fold and concern both the service providers and the users. The following description, which concerns these implications, implies a comparison of the proposed approach to the static one (e.g. words like “more”, “less” etc. are used to compare with the static approach).

The service providers can employ the proposed approach as a frame of reference to evaluate and improve their portals and e-services in a more effective and efficient way. The adoption of the proposed approach by service providers (which can be done as detailed in Chapter 8) will enable them to collect more exploitable user feedback, in the sense that the feedback is more focused on the user problems and also is less “noisy”. Furthermore, it is more diverse, i.e. it comes from a larger group of users, as the response rates increase. Therefore, the service providers will be able to understand the quality dimensions for portals and e-services and take corrective actions, based on user feedback of better quality. An indication about how the service providers may interpret the user feedback, and define, based on the interpretations, the appropriate actions for improving the quality of e-services and portals, was provided in Chapter 8.

Another implication of the proposed approach for service providers is that the reliable and valid quality model can be used by portal and e-service designers, in a proactive manner. For example, its various quality dimensions may be considered explicitly in the design of the portal and e-services. Moreover, it can also be useful for synthesizing and comparing results of similar case studies and accumulating knowledge in evaluations of e-government and e-business portals and services. Results of such studies would help public administrations and service providers to provide better services and to enhance user satisfaction.

The main implication for users is that the proposed approach improves the user experience associated with the quality evaluation process, as it allows them to perform the evaluation in a more convenient and personalized manner. The scarce resource of user time is exploited in a more effective way, as users are asked about quality aspects related to the problems they encountered and the content and services they consumed. Moreover, they do not have to respond to questions that are redundant. In this way, users spend less time to respond to more focused questions.

Another implication for users is that the proposed approach may facilitate inclusiveness and accessibility, with regard to the participation in the quality evaluation process, across a diversity of user needs. Users that encounter problems related to the use of portals and e-services are at the center of the proposed approach. Furthermore, the web-based system, which implements the approach, conforms to accessibility guidelines; e.g. the questionnaires can be read and filled in by people with color blindness or other visual impairments. Moreover, the questions asked to users are very readable, enabling for example young students to understand them. Therefore, we can say that the proposed approach may have a small contribution towards the efforts to build a digital inclusive society and to bridge the digital divide.

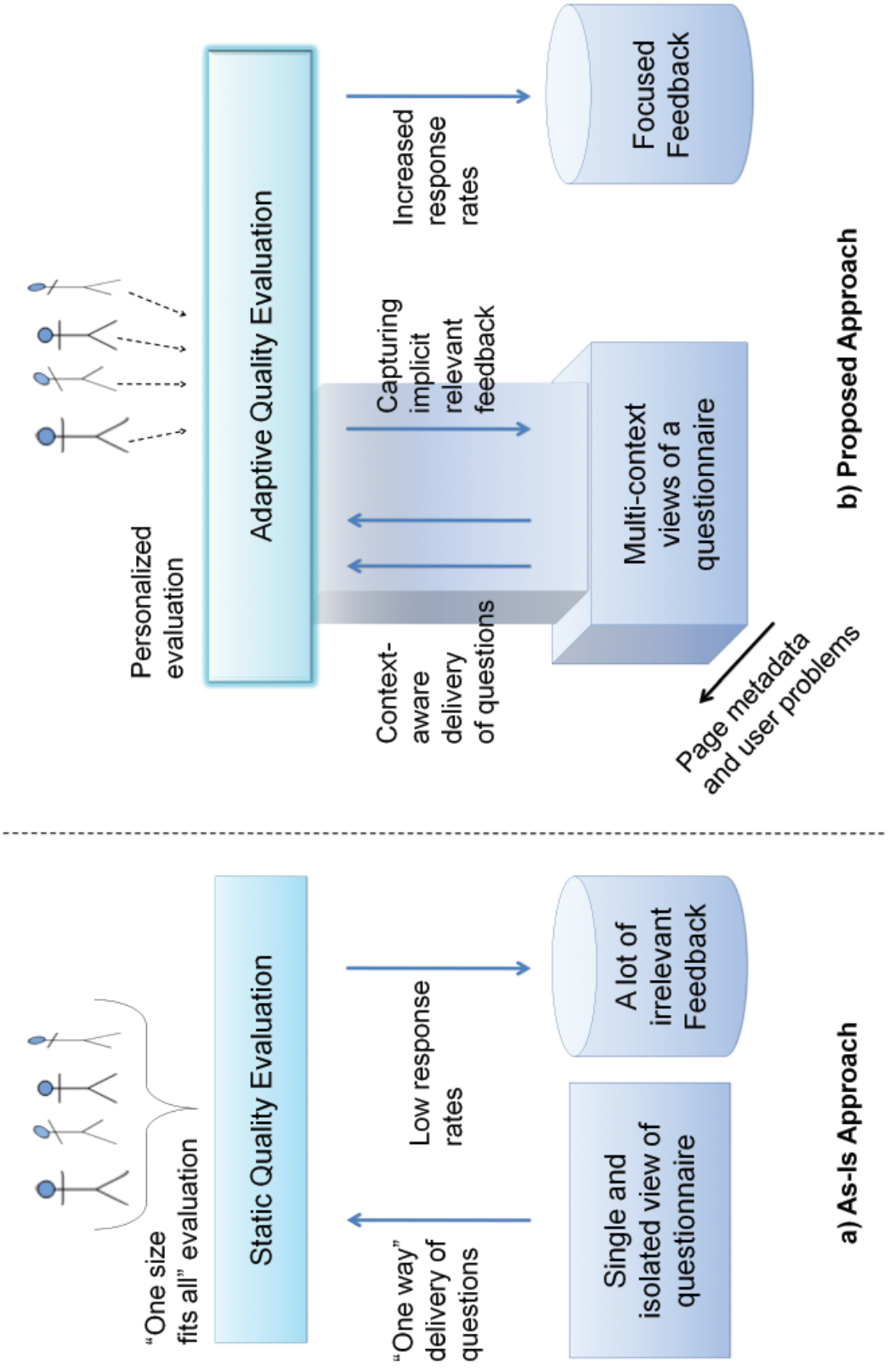


Figure 9.1: As-Is Approach vs Proposed Approach for Evaluation of e-Service and Portal Quality

The implications for users may act as multipliers to those for service providers and vice versa. On the one hand, the users are more satisfied with the questionnaire used for providing their feedback. Also, they spend less time to participate in the adaptive quality evaluation. Therefore, they are more willing to participate in the evaluation procedure. This has a multiplicative effect for service providers, as they collect even more, as well as even more diverse user feedback. On the other hand, the service providers can evaluate and improve their service offerings more effectively and efficiently. The improvement of services has a multiplicative effect for users, as far as their participation to the quality evaluation is concerned. So, they are even more willing to participate, as they understand that their voice matters. Moreover, they are asked even more focused as well as even less questions, as they encounter fewer problems, because of the aforementioned service improvements. This cycle may go on and on, as it represents a win-win situation for both users and service providers.

Concluding, we can say that the proposed approach enhances the effectiveness and efficiency of quality evaluation, as fewer resources (time of users and service provider employees, questions, responses, employment costs) are required for basing the quality improvement decisions on a more focused, relevant and diverse user feedback.

9.2 Limitations and Possible Improvements

A useful extension of the proposed system would be the implementation of functionalities that will enhance system maintenance. Currently, the addition of more concepts underlying the adaptation (such as page types, questions etc.) in the system, requires ontology engineering skills, as the relevant ontologies should be altered or extended by using ontology editor tools. In our plans for future work we foresee the automatic extension of the underlying ontologies by using a tool that would allow the addition of new concepts with the help of a simple user interface. Such a tool would also allow the extension of the semantic relationships between the various ontological concepts.

Regarding the evaluation of the proposed SALT system, while empirical evidence on the value of the proposed approach was provided in this doctoral thesis by using a sample gathered in Austria, a cross-cultural evaluation is in our plans, in order to advance its generalizability. In future case studies we can envision some tests to demonstrate more effectively the validity of the proposed approach, especially for service providers. For example, it would be interesting to compare the impact of the modifications made by the portal providers after a dynamic questionnaire based evaluation as well as after a static one.

The limitations of the proposed quality model include those customarily associated with instrument-building: instruments are always subject to further improvement. While the quality model was refined and validated using a large sample gathered in Greece, a cross-country

validation using other large samples is required for its greater generalization. We plan to perform such cross-country validations as part of our future work. Another possible improvement of the quality model concerns its application in the e-government domain. The model has been developed in such a way so it can be applied to e-government portals possessing the fifth level of online sophistication. This is currently the maximum level of sophistication an e-government portal can possess. The quality model should be kept up to date, by reflecting possible advancements that may occur in the state of the art of e-government portals and services; therefore an interesting direction of future work is the extension of the model, by incorporating new quality aspects that may arise. This could be done by following the two-phased model development and validation methodology presented in Chapter 5.

9.3 Further Research

In this section we provide suggestions for further research which could be based on this thesis. We consider as interesting the following research directions:

- A question which may motivate further research is whether the proposed approach could be extended in order to allow a multi-perspective evaluation of e-service and portal quality. This would mean that in addition to the user's point of view, which represents subjective quality, the service provider's perspective reflecting substitute quality, as well as the objective quality, which can be obtained from system operation data (e.g. web log, process log), could be integrated in the approach. The top layer of the QUONTO ontology, described in section 6.9.1, may form the basis for such an extension, as it defines formally the various perspectives. The user point of view, which was taken into account in this thesis, is the most important, as users are the final receivers of the e-services. However, service providers could also provide their opinion about the various quality factors and dimensions, especially about some technical aspects that most of users are not able to evaluate. According to the objective quality perspective, quality could be measured and monitored using specific metrics that are relevant to each quality factor, e.g. the percentage of hits that were served by the web server successfully, as well as the percentage of workflow instances that have reached the completion state successfully, could be used as measures for system's reliability. The introduction of this third perspective would enable an objective and un-contradictable view of quality. A challenge related to the introduction of objective quality, would be the development of methods and tools which would allow the automatic calculation of objective metrics, using data mining techniques to web server's and workflow engine's log. The integration of the three perspectives would enable the mapping of assessments performed by each one of the three "actors" representing the three different perspectives, thus it would offer a 360 degree assessment of quality.

- Another interesting research direction is the extension of the proposed approach, by the addition of a new adaptation axis. This new axis could take into account the specific application domain, where the questionnaire is integrated, in order to enable its adaptation, in the sense that specific groups of users could be asked specific questions. Such an adaptation axis could employ semantic relationships of questions with domain-specific knowledge modeled in a domain ontology. Domain specific knowledge may include the meaning of services / information offered by a portal, existing categorizations of e-services as well as typical terminology used in the domain. For example in the e-Government domain, typical terminology may include concepts such as building permission, building application, etc., while e-government services may be categorized as residential affairs, residential permissions, identification, certifications, naturalization citizenship, moving, education, etc. The envisioned adaptation axis could employ such domain-specific knowledge in order to present specific questions about the services of specific categories, to specific groups of users. For example, for the target group of home-builders, there could be specific questions about the services related to home building and so on.
- Due to the difficulty in the automatic discovery of problems, which the user might encounter while browsing the portal, another interesting research question is whether the user feedback submitted through the questionnaire can be used either off-line or semi-automatically as feedback for the evaluation and improvement of user tracking and problem detection. For example, the user feedback might confirm or disconfirm a potential user problem, which was detected by tracking the user actions, thereby closing a feedback loop between user tracking and adaptive evaluation of e-services and portals.
- Finally, a research direction of interest may be to examine the applicability of the approach introduced in this thesis, in other domains. We could envision for example, the application of adaptive questionnaires in the e-participation domain and more specifically in the consultation e-participation area. One of the major activities of consultation, include the expression of citizens' opinions on specific themes and issues of the political agenda that are affecting them, through various means, such as web surveys. The latter are mainly used to research views, attitudes and experiences of citizens; the e-participation website shows a list of questions, in which users answer and submit their responses online. In this domain, the criteria for adapting the questionnaire may include user profile data such as citizen's interests, geographical information, experience and abilities. In this way citizens' feedback to the decision makers would be more targeted, as each citizen would provide feedback for the consultation topics/questions of the questionnaire that he/she is more knowledgeable and interested. In other words citizens with insight and knowledge in a given topic would get more in touch with decision makers.

REFERENCES

A

[Abernethy et. al., 2008] J. Abernethy, T. Evgeniou, O. Toubia, J.P. Vert. *Eliciting Consumer Preferences Using Robust Adaptive Choice Questionnaires*. IEEE Transactions on Knowledge and Data Engineering, vol. 20, no. 2, pp 145-155, 2008.

[ACSI, 2006] American Customer Satisfaction Index. *The American Customer Satisfaction index - the Voice of the Nation's Consumer*. www.theacsi.org, 2006.

[Aladwani and Prashant, 2002] A.M. Aladwani, C.P. Prashant. *Developing and Validating an Instrument for Measuring User-Perceived Web Quality*. Information and Management, 39, pp. 467-476, 2002.

[Altavista, 2009] Altavista Babel Fish translator. http://babelfish.altavista.com, 2009.

[Amazon, 2010] Amazon. Amazon.com: online shopping for electronics, apparel, etc., 2010, http://www.amazon.com.

[Ardissono et. al., 2001] L. Ardissono, L. Console, I. Torre. *An Adaptive System for the Personalized Access to News*. AI Communications, 14(3), pp 129–147, 2001.

B

[Baecker, 1995] R.M. Baecker, J. Grudin, W.A.S. Buxton, S. Greenberg. *From Customizable Systems to Intelligent Agents*. In Readings in Human-Computer Interaction: Toward the Year 2000, 2d ed., pp. 783-92. San Francisco: Morgan Kaufmann Publishers, Inc., 1995.

[Barnes and Vidgen, 2001] S.J. Barnes, R.T. Vidgen. *Assessing the Quality of Auction Web Sites*. Proceedings of the Hawaii International Conference on Systems Sciences, Maui, Hawaii, January 4-6, 2001.

[Barnes and Vidgen, 2002] S.J. Barnes, R.T. Vidgen. *An Integrative Approach to the Assessment of e-Commerce Quality*. Journal of Electronic Commerce, 3, 114–127, 2002.

[Barnes and Vidgen, 2003] S.J. Barnes, R.T. Vidgen. *Interactive E-Government: Evaluating the Web Site of the UK Inland Revenue*. Journal of Electronic Commerce in Organizations, 2(1), pp.22, 2003.

[Barnes et. al., 2001] S.J. Barnes, K. Liu, R.T. Vidgen. *Evaluating WAP News Sites: the WEBQUAL/M Approach*. Proceedings of the Ninth European Conference on Information Systems, Bled,Slovenia, June 27-29, 2001.

[Barra et. al., 2002] M. Barra, A. Lannaccone, G. Palmieri, V. Scarano. *Test++: an Adaptive Training System on the Internet*. In 7th International Symposium on Computers and Communications, ISCC 2002, pp 225- 230, 2002.

[Basilico and Hofmann, 2004] J. Basilico, T. Hofmann. *Unifying Collaborative and Content-Based Filtering*. Proceedings of the 21st International Conference on Machine Learning, Banff, Canada, 2004.

[Bauer et. al., 2005] H. Bauer, M. Hammerschmidt, T. Falk. *Measuring the Quality of e-Banking Portals*. International Journal of Bank Marketing, 23,(2), pp. 153-175, 2005.

[Bessa and Belchior, 2002] A.A. Bessa, A.D. Belchior. *E-Commerce Website Quality Evaluation*. 28th Euromicro Conference, IEEE, 2002.

[Bonnet, 2002] M. Bonnet. *Personalization of Web Services: Opportunities and Challenges*. Ariadne, Issue 28, June, 2002.

[Boshoff, 2007] C. Boshoff. *A Psychometric Assessment of E-S-Qual: A Scale to Measure Electronic Service Quality*. Journal of Electronic Commerce Research, 8 (1), pp 101-114, 2007.

[Boudreau et. al., 2001] M. Boudreau, D. Gefen, D. Straub. *Validation in IS research: A State-of-the-Art Assessment*. MIS Quart. 25(1), pp 1–24, 2001.

[Bowen and Fantoni, 2004] J. Bowen, S.F. Fantoni. *Personalization and the Web from a Museum Perspective*. In D. Bearman, J. Trant (Eds.), Museums and the Web, pp. 63–78, Toronto, CA7 Archives and Museum Informatics, 2004.

[Broadvision, 2007] Broadvision. www.broadvision.com, 2007.

[Brusilovsky and Nejdl, 2004] P. Brusilovsky, W. Nejdl. *Adaptive Hypermedia and Adaptive Web*. © 2004 CSC Press LLC, 2004.

[Brusilovsky, 1996] P. Brusilovsky. *Methods and Techniques of Adaptive Hypermedia*. User Modeling and User Adapted Interaction, 6(2-3), pp 87-129, 1996.

[Brusilovsky, 1997] P. Brusilovsky. *Efficient Techniques for Adaptive Hypermedia*. Intelligent Hypertext: Advanced Techniques for the World Wide Web, 1326, pp 12–30, 1997.

[Brusilovsky, 2001] P. Brusilovsky. *Adaptive Hypermedia*. User Modeling and User-Adapted Interaction, 11, pp 87-110, 2001.

[Brusilovsky, 2007] P. Brusilovsky. *Adaptive Navigation Support*. In: P. Brusilovsky, A. Kobsa, W. Neidl (eds.): The Adaptive Web: Methods and Strategies of Web Personalization. LNCS, Vol. 4321. Springer-Verlag, Berlin Heidelberg New York, pp 263-290, 2007.

C

[Cai and Jun, 2003] S. Cai, M. Jun. *Internet Users' Perceptions of Online Service Quality: a Comparison of Online Buyers and Information Searchers*. Managing Service Quality, 13(6), pp. 504–19, 2003.

[Cao et. al., 2005] M. Cao, Q. Zhang, J. Seydel. *B2C e-Commerce Web Site Quality: an Empirical Examination*. Industrial Management and Data Systems, 105(5), pp. 645-661, 2005.

[Cap Gemini, 2009] Cap Gemini. *Smarter, Faster, Better eGovernment*. 8th Benchmark Measurement. Brussels, 2009.

[CapGemini, 2006] CapGemini. *The Renewed EU eGovernment Benchmark Model Proposed*. www.egov-goodpractice.org, 2006.

[Cappiello et. al., 2004] C. Cappiello, P. Missier, B. Pernici, P. Plebani, C. Batini. *Qos in Multichannel IS: the MAIS Approach*. Workshop on Web Quality, Munich, 2004.

[Cardoso et. al., 2002] J. Cardoso, A. Sheth, J. Miller, J. Arnold, K. Kochut. *Modeling Quality of Service for Workflows and Web Service Processes*. Technical Report #02-002 v2, LSDIS Lab, Computer Science, University of Georgia, December 2002.

[Caro et. al., 2006] A. Caro, C. Calero, I. Cabalero, M. Piattini. *Defining a Quality Model for Portal Data*. 6th International Conference on Web Engineering (ICWE'06), Palo Alto, California, USA, July 11-14, 2006.

[Cewolf, 2007] Cewolf, Chart Enabling Web Object Framework http://cewolf.sourceforge.net/new/index.html , 2007.

[Chin et. al., 1988] J.P. Chin, V.A. Diehl, K.L. Norman. *Development of a Tool Measuring User Satisfaction of the Human-Computer Interface*. In CHI '88 Conference: Human Factors in Computing Systems, pp 213-218, 1988.

[Chisholm et. al., 1999] W. Chisholm, G. Vanderheiden, I. Jacobs. *Web Content Accessibility Guidelines 1.0*. http://www.w3.org-/TR/WCAG10, W3C Recommendation 5 May 1999.

[Chopra et. al., 2004] V. Chopra, A. Bakore, J. Eaves, B. Galbraith, S. Li, C. Wiggers. *Professional Apache Tomcat 5*. Published by Wrox, ISBN 0764559028, May 17, 2004.

[Chou et. al., 2000] C. Chou, Y. Chang, Y. Jiang. *The Development of an Online Adaptive Questionnaire for Health Education in Taiwan*. Computers & Education, vol 35, pp. 209–222, 2000.

[Churchill, 1979] G.A. Jr Churchill. *A Paradigm for Developing Better Measures of Marketing Constructs*. Journal of Marketing Research, 16 (1), pp 64-73, 1979.

[Code of Conduct, 2005] Code of Conduct. http://www.mrs.org.uk, 2005

[Cooley et. al., 1999] R. Cooley, B. Mobasher, J. Srivastava. *Data Preparation for Mining World Wide Web Browsing Patterns*. Knowledge and Information Systems, 1(1), pp. 5–32, 1999.

[Corradini et. al., 2006] F. Corradini, F.D. Angelis, A. Polzonetti, B. Re, E. Brugnoni. *e-GovQoS: an Ontology for Quality of e-Government Services*. In 5th International EGOV Conference, DEXA, Krakow (Poland), pp. 171-178, September 2006.

[Couper, 2000] M.P. Couper. *Web Surveys a Review of Issues and Approaches*. Public Opinion Quarterly, 65(2), pp.230-253, 2000.

[Couper, 2001] M.P. Couper. *Web Surveys: The Questionnaire Design Challenge*. In Proceeding of the 53rd session of the ISI, http://134.75.100.178/isi2001, 2001.

[Cox and Dale, 2002] J. Cox, B.G. Dale. *Key Quality Factors in Web Site Design and Use: an Examination*. International Journal of Quality & Reliability Management, 19(7), pp. 862-888, 2002.

[Crawford, 2000] D. Crawford. Communications of the ACM, Special Issue on Personalization, 43 (8), August 2000.

[Crockford, 2006] D. Crockford. *JavaScript Object Notation (JSON)*. Technical report, The Internet Engineering Task Force, 2006.

[Cronbach, 1951] L.J. Cronbach. *Coefficient Alpha and the Internal Structure of Tests*. Journal of Psychometrika, 16 (3), pp. 297-334, 1951.

[CSC, 2008] Citizen Service Centres' e-government portal, http://www.kep.gov.gr, 2008.

D

[Danish ToW, 2006] Danish Top of the Web. Available at www.bedstpaanettet.dk/Content?content=76, 2006

[Davis, 1989] F.D. Davis. *Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology*. MIS Quarterly, 13, 1989.

[De Bra et. al., 2005] P. De Bra, N. Stash, D. Smits. *Creating Adaptive Web-Based Applications*. Tutorial at the 10th International Conference on User Modeling, Edinburgh, Scotland, 2005.

[De Bra, 2001] P. De Bra. *Design Issues in Adaptive Web-Site Development*. In the 2nd Workshop on Adaptive Systems and User Modeling on the WWW, 2001.

[Deitel et. al., 2004] H.M. Deitel, P.J. Deitel, K. Steinbuhler. *e-Business and e-Commerce for Managers*. Prentice Hall 2004.

[Deming, 1986] W. E. Deming. *Out of the Crisis*. MIT Center for Advanced Engineering Study, Cambridge, MA, 1986.

[DemoNet Site] http://www.demo-net.org/

[Dobson et. al., 2005] G. Dobson, R. Lock, I. Sommerville. *QoSONT: A QoS Ontology for Service-Centric Systems*. In: EUROMICRO-SEAA, 2005.

[Doll et. al., 1951] W.J. Doll, W. Xia, G. Torkzadeh. *A Confirmatory Factor Analysis of the End-User Computing Satisfaction Instrument*. MIS Quarterly, 18 (4), pp 453-461, 1951.

[Douglas et. al., 2003] A. Douglas, L. Muir, K. Meehan. *E-quality in the e-Services Provision of Legal Practices*. Managing Service Quality, 13 (6), pp. 483-91, 2003.

E

[EC, 2004] eGovernment Unit, DG Information Society, European Commission. *Top of the Web: User Satisfaction and Usage Survey of e-Government Services.* 2004.

[Eirinaki and Vazirgiannis, 2003] M. Eirinaki, M. Vazirgiannis. *Web Mining for Web Personalization*. ACM Transactions on Internet Technology (TOIT), 3(1), pp.1-27, 2003.

[Eklund and Sinclair, 2000] J. Eklund, K. Sinclair. *An Empirical Appraisal of the Effectiveness of Adaptive Interfaces of Instructional Systems*. Educational Technology and Society 3 (4), pp. 1436-4522, 2000.

[ESOMAR, 2007] ESOMAR. *Guidelines on Conducting Market and Opinion Research Using the Internet*. http://www.esomar.org, 2007.

[Eysenck, 1950] H.J. Eysenck. *Criterion Analysis: an Application of the Hypothetico-deductive Method in Factor Analysis*. In Journal of Psychological Review, 57, pp. 38-53, 1950.

F

[Field, 2005] A.P. Field. *Discovering Statistics Using SPSS*. Sage Publications, London, 2005.

[Fishbein and Ajzen, 1975] M. Fishbein, I. Ajzen. *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*. Reading, MA: Addison-Wesley, 1975.

[FIT Site] http://www.fit-project.org

[Flesch, 1948] R.F. Flesch. *A New Readability Yardstick*. Journal Applied Psychology, 32, pp 221-233, 1948.

[Forrester, 2004] Forrester Research Inc. Executive Q&A: Customer Experience Reviews. March 26, 2004, Best Practices.

[Fukuda and Bubb, 2003] R. Fukuda, H. Bubb. *Eye Tracking Study on Web-use: Comparison between Younger and Elderly Users in case of Search Task with Electronic Timetable Service*," PsychNology Journal, 1(3), pp. 202-228, 2003.

G

[Galan and Sabadie, 2002] J.P. Galan, W. Sabadie. *Construction of a Measurement Tool to Evaluate the Satisfaction of Public Service Web Sites Users*. In 7th international research seminar in service management, 2002.

[Gangemi et. al., 2003] A. Gangemi, N. Guarino, C. Masolo, A. Oltramari. *Sweetening Wordnet with DOLCE*. AI Magazine, 24(3), pp. 13–24, 2003.

[Garcia et. al., 2004] E. Garcia, M.A. Sicilia, L. Gonzalez, J.R. Hilera. *Dialogue-based Design of Web Usability Questionnaires Using Ontologies*. In Proc. of the 5th International Conference on Computer-Aided Design of User Interfaces, pp. 133-146, 2004.

[Garrett, 2005] J.J. Garrett. *Ajax: A New Approach to Web Applications.* http://www.adaptivepath.com/publications/essays/archi-ves/000385.php, February 2005.

[George and Mallery, 2003] D. George, P. Mallery. *SPSS for Windows Step by Step: A Simple Guide and Reference (4th ed.)*. Allyn & Bacon. Boston, 2003.

[Germanakos and Mourlas, 2008] P. Germanakos, C. Mourlas. *Adaptation and Personalization of Web-based Multimedia Content*. In Multimedia Transcoding in Mobile and Wireless Networks, 2008.

[Germanakos et. al., 2005] P. Germanakos, C. Mourlas, C. Isaia, G. Samaras. *An Optimized Review of Adaptive Hypermedia and Web Personalization - Sharing the Same Objective*. Proceedings of WPRSIUI, Reading, October 3-7, pp. 43-48, 2005.

[Germanakos et. al., 2005b] P. Germanakos, C. Mourlas, C. Panayiotou, G. Samaras. *Personalization Systems and Processes Review based on a Predetermined User Interface Categorization*. Proceedings of the III International Conference on Communication and Reality, Digital Utopia in the media: from discourses to facts. A balance, Barcelona, May 20-21, pp. 431-444, 2005.

[Gesis, 2007] Gesis. *Guide to Online Survey Software*. http://www.gesis.org/en/methods_consultation/data_collection/Onlinesurveys/software.htm#freesoftware, 2007.

[Gounaris and Dimitriadis, 2003] S. Gounaris, S. Dimitriadis. *Assessing Service Quality on the Web: Evidence from Business-to-Consumer Portals*. Journal of Services Marketing, 17(5), pp. 529-548, 2003.

[Groves and Mick, 1998] R.M. Groves, P.C. Mick. *Nonresponse in Household Surveys*. New York, Wiley, 1998.

[Guinness and Harmelen, 2003] D.L. Guinness, E.F. Harmelen. *OWL Web Ontology Language Overview*. W3C Proposed Recommendation, www.w3.org/TR/2003/PR-owl-ref-20031215/, 2003.

[Gunning, 1952] R. Gunning. *The Technique of Clear Writing*. New York, NY: McGraw-Hill International Book Co., 1952.

[Gwo and Lin, 2005] G.L. Gwo, H.F. Lin. *Customer Perceptions of e-Service Quality in Online Shopping*. International Journal of Retail & Distribution Management, 33(2), pp. 161-176, 2005.

H

[Hair et. al., 1995] J.F. Hair, R.E. Anderson, R.L. Tatham, W.C. Black. *Multivariate Data Analysis with Readings*. Prentice-Hall, New York, NY, 1995.

[Halaris et. al., 2007] C. Halaris, B. Magoutas, X. Papadomichelaki, G. Mentzas. *Classification and Synthesis of Quality Approaches in E-government Services*. Internet Research Journal: Electronic Networking Applications and Policy, 17(4), pp. 378-401, 2007.

[Heckmann et. al., 2005] D. Heckmann, T. Schwartz, B. Brandherm, M. Schmitz, M. Wilamowitz-Moellendorf. *GUMO - the General User Model Ontology*. In Proceedings of the 10th International Conference on User Modeling, Edin-burgh, Scotland, Jun 2005.

[Helm, 2001] J.C. Helm. *Web-Based Application Quality Assurance Testing*. The Fourteenth International Internet & Software Quality Week, San Francisco, CA, May 29 - June 1, 2001.

[Hoffman, 2003] D.K. Hoffman. *Marketing + MIS = e-Service*. Communications of the ACM 46 (6), pp. 53–55, 2003.

[Horan et. al., 2006] T.A. Horan, T. Abhichandani, R. Raghuvira. *Assessing User Satisfaction of E-Government Services: Development and Testing of Quality-in-Use Satisfaction with Advanced Traveler Information Systems (ATIS)*. Proceedings of the 39th Hawaii International Conference on System Sciences, 2006.

I

[Ishikawa, 1991] K. Ishikawa. *What Is Total Quality Control? The Japanese Way*. Prentice Hall, 1991.

[Issac and Hû, 2002] F. Issac, O. Hû. *Formalism for Evaluation: Feedback on Learner Knowledge Representation*. Computer Assisted Language Learning (CALL), 15 (2), pp. 183 -199, 2002.

[Ivaarden et. al., 2003] J. Ivaarden, T. Wiele, L. Ball, R. Millen. *Applying SERVQUAL to Web Sites: an Exploratory Study*. International Journal of Quality and Reliability Management, 20(8), pp. 919-935, 2003.

[Ivory and Hearst, 2002] M.Y. Ivory, M.A. Hearst. *Statistical Profiles of Highly-Rated Web Sites*. CHI2002, 1(1), pp. 367-374, 2002.

[Ivory and Megraw, 2005] M.Y. Ivory, R. Megraw. *Evolution of Web Site Design Patterns*. ACM Transactions on Information Systems, 23(4), pp. 463-497, October 2005.

[Iwaarden et. al., 2004] J. Iwaarden, T. Wielea, L. Ball, R. Millen. *Perceptions about the Quality of Web Sites: A Survey Amongst Students at Northeastern University and Erasmus University*", Information and Management 41, pp. 947-959, 2004.

J

[Jansen and Ølnes, 2004] A. Jansen, S. Ølnes. *Quality Assessment and Benchmarking of Norwegian Public Web Sites*. Proceeding from European Conference on e-government, 2004.

[JFreeChart, 2004] JFreeChart. www.jfree.org/jfreechart, accessed 31 March , 2004.

[Joachims et. al., 1997] T. Joachims, D. Freitag, T. Mitchell. *WebWatcher: A Tour Guide for the World Wide Web*. In Proceedings of the 15th International Joint Conference on Artificial Intelligence, pp. 770–775, Morgan Kaufmann, August 1997.

[JSP Survey Library, 2007] JSP Survey Library. *How To Build A Survey: Using The Survey Editor GUI*. Available at http://jspsurveylib.sourceforge.net/help/buildingASurvey.html, accessed May 2007.

[Juicy Studio, 2007] Juicy Studio. *Juicy Studio: Readability Test*. Available at http://juicystudio.com/services/readability.php, accessed June 2007.

[Juran, 1994] J.M. Juran. *The Upcoming Century of Quality*. Quality Progress, pp. 29-37, August 1994.

K

[Kalyanpur et. al., 2004] A. Kalyanpur, D. Pastor, S. Battle, J. Padget. *Automatic Mapping of OWL Ontologies into Java*. In 16th International Conference on Software Engineering and Knowledge Engineering (SEKE), Banff, Canada, pp. 98–103, 2004.

[Kay, 2001] J. Kay. *User Modeling for Adaptation*. In User Interfaces for All: Concepts, Methods, and Tools, edited by C. Stephanidis, pp. 271-94. Mahwah, N.J.: Lawrence Erlbaum Associates, 2001.

[Kelly and Vidgen, 2005] B. Kelly, R. Vidgen. *A Quality Framework For Web Site Quality: User Satisfaction and Quality Assurance*. WWW 2005, Chiba, Japan, May 10-14, 2005.

[Kim et. al., 2005] T.H. Kim, K.H. Im, S.C. Park. *Intelligent Measuring and Improving Model for Customer Satisfaction Level in e-Government*. 4th International Conference EGOV 2005 Proceedings, 3591,Copenhagen, Denmark, August 22-26, 2005.

[Kincaid et. al., 1975] J.P. Kincaid, R.P. Fishburne, R.L. Rogers, B.S. Chissom. *Derivation of New Readability Formulas (Automated Readability Index, Fog Count and Flesch Reading Ease Formula) for Navy Enlisted Personnel*", Research Branch Report 8-75, Millington, TN: Naval Technical Training, U. S. Naval Air Station, Memphis, TN, 1975.

[Kleynhans, 2007] J. Kleynhans. *Employee Satisfaction Levels of Drivers at Dawn Wing Couriers*. Dissertation submitted for the Master's Degree in Business Administration, at Tshwane University of Technology, 2007.

[Knublauch and Horridge, 2005] H. Knublauch, M. Horridge. *The Protégé-OWL API*. Available at http://protege.stanford.edu/plugins/owl/api/index.html, 2005

[Kobsa et. al., 2001] A. Kobsa, J. Koenemann, W. Pohl. *Personalized Hypermedia Presentation Techniques for Improving Online Customer Relationships*. The Knowledge Engineering Review, 16(2), pp. 111–155, 2001.

[Koychev, 2001] I. Koychev. *Learning about Users in the Presence of Hidden Context*. In Proceedings of the UM2001 Workshop on Machine Learning for User Modeling, pp. 49–58, Sonthofen, Germany, July 13-17, 2001.

L

[Lam and Mostafa, 2001] W. Lam, J. Mostafa. *Modelling User Interest Shift Using a Bayesian Approach*. Journal of the American Society for Information Science and Technology, 52(5), pp. 416–429, March 2001.

[Landis and Koch, 1977] J.R. Landis, G. Koch. *The Measurement of Observer Agreement for Categorical Data*. J. Biometrics, 33, pp. 159-74, 1977.

[Lang, 1995] K. Lang. *Newsweeder: Learning to Filter Netnews*. In Proceedings of the 12th International Conference on Machine Learning, 1995.

[Leahy, 2004] J. Leahy. *Using Excel for Analyzing Survey Questionnaires*. Cooperative Extension of the University of Wisconsin-Extension, 2004.

[Lieberman, 1995] H.L. Lieberman. *An Agent that Assists Web Browsing*. In Proceedings of the 14 International Joint Conference on Artificial Intelligence, pp. 924–929, San Mateo, CA, USA, Morgan Kaufmann Publishers Inc., 1995.

[Likert, 1932] R.A. Likert. *Technique for the Measurement of Attitudes*. Archives of Psychology 140, 55, 1932.

[Lin and Wu, 2002] C.S. Lin, S. Wu. *Exploring the Impact of Online Service Quality on Portal Site Usage*. Proceeding of the 35th Hawaii International Conference on Systems Science, Hawaii , USA, 2002.

[Linden et. al., 2003] G. Linden, B. Smith, J. York. *Amazon.com Recommendations: Item-to-Item Collaborative Filtering*. IEEE Internet Computing, 7(1), pp. 76-88, 2003.

[Loiacono et. al., 2000] E.T. Loiacono, R.T. Watson, D.L. Goodhue. *WebQual™: A Website Quality Instrument*. Working Paper 2000-126-0, University of Georgia, 2000.

M

[Mackenzie and House, 1979] K.D. Mackenzie, R. House. *Paradigm Development in the Social Sciences*. In Research organizations: Issues and controversies. Goodyear Publishing. Santa Monica, CA, 1979.

[Maes, 1995] P. Maes. *Agents that Reduce Work and Information Overload*. In Readings in Human-Computer Interaction: Toward the Year 2000, 2d ed., pp. 811-21. San Francisco: Morgan Kaufmann Publishers, Inc., 1995.

[Maglio et. al., 2000] P.P. Maglio, R. Barrett, C.S. Campbell, T. Selker. *Suitor: An Attentive Information System*. In Proceedings of the International Conference on Intelligent User Interfaces 2000. New Orleans, LA: ACM Press, 2000.

[Maglio et. al., 2001] P.P. Maglio, C.S. Campbell, R. Barrett, T. Selker. *An Architecture for Developing Attentive Information Systems*. Knowledge-based Systems 14, pp. 103-110, 2001.

[Magoutas and Mentzas, 2009a] B. Magoutas, G. Mentzas. *Adaptivity and Personalization Application Scenarios in eParticipation*. In E. Tambouris, A. Macintosh (Eds.): eParticipation, 1st International Conference, ePart 2009, Linz, Austria, September 1-3, 2009 Trauner Druck: Linz, Schriftenreihe Informatik # 31, pp. 205-215, 2009

[Magoutas and Mentzas, 2009b] B. Magoutas, G. Mentzas. *Refinement, Validation and Benchmarking of a Model for e-Government Service Quality*. In Electronic Government, 8th International Conference, EGOV 2009, Linz, Austria, August 30 - September 3, 2009, Proceedings. Springer Verlag: Heidelberg et al, LNCS # 5693, pp. 139-150, 2009.

[Magoutas and Mentzas, 2009c] B. Magoutas, G. Mentzas. *Adaptive Evaluation of Portal Quality: An eGovernment Case*. In 13th Panhellenic Conference on Informatics (PCI), 10-12 September 2009, Corfu, Greece. IEEE Computer Society, pp. 136-140, 2009.

[Magoutas and Mentzas, 2010] B. Magoutas, G. Mentzas. *SALT: A Semantic Adaptive Framework for Monitoring Citizen Satisfaction from eGovernment Services*. Expert Systems with Applications, 37(6), pp. 4292-4300, June 2010, doi: 10.1016/j.eswa.2009.11.071.

[Magoutas et. al., 2007] B. Magoutas, C. Halaris, G. Mentzas. *An Ontology for the Multi-perspective Evaluation of Quality in E-Government Services*. In M. Wimmer, H.-J. Scholl, Å. Grönlund (Eds.): Electronic Government, 6th International Conference, EGOV 2007, Regensburg, Germany, September 3-7, 2007, Proceedings. LNCS 4656 Springer 2007, pp. 318-329, 2007.

[Magoutas et. al., 2008] B. Magoutas, C. Chalaris, G. Mentzas. *A Semantically Adaptive Interface for Measuring Portal Quality in e-Government*. In C. Mourlas and P. Germanakos (Eds.): Intelligent User Interfaces: Adaptation and Personalization Systems and Technologies, pp. 147-166, Hershey, PA: IGI Global, 2008.

[Magoutas et. al., 2010] B. Magoutas, K.U. Schmidt, G. Mentzas, L. Stojanovic. *An Adaptive e-Questionnaire for Measuring User Perceived Portal Quality*. Accepted for publication in the International Journal of Human-Computer Studies, 2010.

[Manber et. al., 2000] U. Manber, A. Patel, J. Robison. *Experience with Personalization on Yahoo!*. Communications of the ACM, 43(8), August 2000.

[Mani and Nagarajan, 2002] A. Mani, A. Nagarajan. *Understanding Quality of Service for Web Services*. IBM DeveloperWorks, www-128.ibm.com/developerworks/library/ws-quality.html, 2002.

[McBride, 2002] B. McBride. *Jena: A semantic Web Toolkit*. IEEE Internet Computing, 6(6), pp. 55-59, 2002.

[McTear, 1993] M.F McTear. *User Modelling for Adaptive Computer Systems: A Survey of Recent Developments*. Artificial Intelligence Review 7, pp. 157–184, 1993.

[Mei et. al., 2005] C. Mei, Q. Zhang, J. Seydel. *B2C e-Commerce Web Site Quality: An Empirical Examination*. Industrial Management and Data Systems, 105(5), pp. 645-661, 2005.

[Mich et. al., 2003] L. Mich, M. Franch, L. Gaio. *Evaluating and Designing Web Site Quality*. IEEE MultiMedia, pp.34-43, January-March 2003.

[Miettinen et. al., 2005] M. Miettinen, P. Nokelainen, J. Kurhila, T. Silander, H. Tirri. *EDUFORM - A Tool for Creating Adaptive Questionnaires*. In International Journal on E-Learning, 4(3), pp. 365-373, 2005.

[Mobasher and Anand, 2005] B. Mobasher, S.S. Anand. *Intelligent Techniques for Web Personalization*. In Lecture Notes in Artificial Intelligence (LNAI 3169). Springer, 2005.

[Mobasher et. al, 2000] B. Mobasher, R. Cooley, J. Srivastava. *Automatic Personalization Based on Web Usage Mining*. Communications of the ACM 43 (8), pp. 142–151, 2000.

[Mobasher et. al., 2000b] B. Mobasher, H. Dai, T. Luo, Y. Sun, J. Zhu. *Integrating Web Usage and Content Mining for More Effective Personalization*. Proc. 1st Int'l Conf. Electronic Commerce and Web Technologies (EC-Web 2000), Lecture Notes in Computer Science and Engineering, no. 1875, Springer-Verlag, Heidelberg, pp. 165–176, 2000.

[Mobasher et. al., 2000c] B. Mobasher, H. Dai, T. Luo, Y. Sun, J. Zhu. *Combining Web Usage and Content Mining for More Effective Personalization*. [online], http://citeseer.ist.psu.edu/mobasher00combining.html, 2000.

[Mobasher et. al., 2000d] B. Mobasher, H. Dai, T. Luo, M. Nakagawa, J. Wiltshire. *Discovery of aggregate usage profiles for Web personalization*. [online], http://maya.cs.depaul.edu/~mobasher/papers/webkdd2000.pdf, 2000.

[Mobasher t. al., 2004] B. Mobasher, X. Jin, Y. Zhou. *Semantically Enhanced Collaborative Filtering On the Web*. Lecture Notes in Computer Science, Vol. 3209. Springer-Verlag, Berlin Heidelberg, pp. 57–76, 2004.

[Montgomery and Smith, 2009] A.L. Montgomery, M.D. Smith. *Prospects for Personalization on the Internet*. In Journal of Interactive Marketing, 23(2), pp. 130-137, 2009.

[MRS, 2006] MRS. *Internet Research Guidelines*. Available at www.mrs.org.uk, 2006

N

[Nasraoui, 2005] O. Nasraoui. *World Wide Web Personalization*. In J. Wang (ed), Encyclopedia of Data Mining and Data Warehousing, Idea Group, 2005.

[NetMechanic, 2007] NetMechanic HTML Toolbox. Available at www.netmechanic.com/products/maintain.shtml, 2007

[Netperceptions, 2007] Netperceptions www.netperceptions.com, 2007.

[Niles and Pease, 2001] I. Niles, A. Pease. *Towards a Standard Upper Ontology*. In The 2nd International Conference on Formal Ontology in Information Systems (FOIS-2001), Ogunquit, Maine, 2001.

[Nokelainen et. al., 2001] P. Nokelainen, M. Niemivirta, J. Kurhila, M. Miettinen, T. Silander, H. Tirri. *Implementation of an Adaptive Questionnaire*. In Proc. ED-MEDIA 2001, AACE, pp. 1412-1413, 2001.

O

[Oberski, 2006] D. Oberski. *Correcting for Bias in a Self-Selected Sample Using a Random Sample as Auxiliary Information*. The Dutch Mobility Study, SMABS-EAM Conference, 2006.

[Observatory, 2008] Observatory for the Greek Information Society. *Online Statistics of the eEurope Indicators Survey*. http://stats.observatory.gr. Accessed 01/2008

P

[Paciello, 2007] Paciello Group. *Contrast Analyser, Version 2.0*. Available at www.paciellogroup.com/resources/contrast-analyser.html, 2007

[Papadomichelaki et. al., 2006] X. Papadomichelaki, B. Magoutas, C. Halaris, D. Apostolou, G. Mentzas. *A Review of Quality Dimensions in E-government Services*. In M. Wimmer, H.J. Scholl, Å. Grönlund, K.V. Andersen (Eds.): Electronic Government, 5th International Conference, EGOV 2006, Krakow, Poland, September 4-8 2006, Proceedings. LNCS 4084 Springer 2006, pp. 128–138, 2006.

[Parasuraman and Malhorta, 2002] A. Parasuraman, A. Malhorta. *Service Quality Delivery through Web Sites: A Critical Review of Extant Knowledge*. Journal of the Academy of Marketing Science, 30(4), pp. 362–375, 2002.

[Parasuraman et. al., 1988] A. Parasuraman, V.A. Zeithaml, L. Berry. *SERVQUAL: A Multiple-Item Scale for Measuring Consumer Perceptions of Service Quality*", Journal of Retailing, 64, 1988.

[Parasuraman et. al., 2005] A. Parasuraman, V.A. Zeithaml, A. Malhotra. *E-S-QUAL: A Multiple-Item Scale for Assessing Electronic Service Quality*. Journal of Service Research, vol. 7, pp. 213-234, 2005.

[Pazzani and Billsus, 2007] M. Pazzani, D. Billsus. *Content-Based Recommendation Systems*. In P. Brusilovsky, A. Kobsa, & W. Nejdl, The Adaptive Web: Methods and Strategies of Web Personalization, Berlin Heidelberg NewYork: Springer-Verlag, 2007.

[Pazzani, 1999] M.J. Pazzani. *A Framework for Collaborative, Content-Based and Demographic Filtering*. Artificial Intelligence Review, 13(5-6), pp.393-408, Dec. 1999.

[Perkowitz and Etzioni, 1998] M. Perkowitz, O. Etzioni. *Adaptive Web Sites: Automatically Synthesizing Web Pages*. In Proceedings of the 15th National Conference on Artificial Intelligence, Madison, WI, USA, 1998.

[Pierakkos et. al., 2001] D. Pierakkos, G. Paliouras, C. Papatheodorou, D.C. Spyropoulos. *KOINOTITES: A Web Usage Mining Tool for Personalization*. [online], http://iit.demokritos.gr/~paliourg/papers/PCHCI2001.pdf, 2001.

[Powers, 2007] A. Powers. *Web Survey Toolbox Home Page*. Available online at: https://hciresearch.hcii.cs.cmu.edu/docs/display/wst/Home, 2007.

[Protégé, 2009] Protégé, http://protege.stanford.edu, 2009.

[Provost et. al., 2006] M. Provost, D. Koompalum, D. Dong, B.C. Martin. *The Initial Development of the WebMedQual Scale: Domain Assessment of the Construct of Quality of Health Web Sites*", International Journal of Medical Informatics, 75, pp.42-57, 2006.

R

[RacerPro, 2006] RacerPro http://www.racer-systems.com/, 2006.

[Rambøll, 2004] Rambøll. *Top of the Web: User Satisfaction and Usage Survey of eGovernment Services*". Available at: http://www.eprocnet.gov.ie/other-documents/topofthewebsurveyresults.pdf, 2004.

[Resnick et. al., 1994] P. Resnick, N. Iacovou, M. Sushak, P. Bergstrom, J. Riedl. *Grouplens: An Open Architecture for Collaborative Filtering of Netnews*. In Proceedings of the 1994 Computer Supported Collaborative Work Conference, 1994.

S

[Sancho, 2006] M.L. Sancho. *Next Generation Web Design*. Master Thesis at School of applied sciences, Cranfield University, 2006.

[Schafer et. al., 2007] J.B. Schafer, D. Frankowski, J. Herlocker, S. Sen. *Collaborative Filtering Recommender Systems*. In Brusilovsky, P., Kobsa, A., Neidl, W. (eds.): The Adaptive Web: Methods and Strategies of Web Personalization. Lecture Notes in Computer Science, Vol. 4321. Springer-Verlag, Berlin Heidelberg New York, pp. 291-324, 2007.

[Schellong and Mans, 2004] A. Schellong, D. Mans. *Citizens Preferences Towards One-Stop Government*. The 2004 annual national conference on Digital Government research, ACM International Conference Proceeding Series, Seattle, WA, 2004.

[Schmidt et. al., 2007] K. Schmidt, L. Stojanovic, N. Stojanovic, S. Thomas. *On Enriching Ajax with Semantics: TheWeb Personalization Use Case*. In Proceedings of the 4th European Semantic Web Conference, Innsbruck, Austria, 2007.

[Sedera et. al., 2003] D. Sedera, G. Gable, T. Chan. *Measuring Enterprise Systems Success: A Preliminary Model*. In Proceedings of the 9th AMCIS, pp. 576-591. Tampa, Florida, 2003.

[Shardanand and Maes, 1995] U. Shardanand, P. Maes. *Social Information Filtering: Algorithms for Automating "Word of Mouth"*. Proceedings of the Conference on Human Factors and Computing Systems, ACM, Denver, Co, May 1995.

[Shewhart, 1980] W.A. Shewhart. *Economic Control of Quality of Manufactured Product*. American Society for Quality Control, 230 West Wells, Milwaukee, Wis, 1980.

[Signore, 2005] O. Signore. *A Comprehensive Model for Web Sites Quality*. Proceedings of the 2005 Seventh IEEE International Symposium on Web Site Evolution (WSE'05), 2005.

[Sommerville, 2007] J. Sommerville. *Software Engineering*. Pearson Education Limited, 2007.

[Stojanovic et. al., 2006] N. Stojanovic, L. Stojanovic, K. Hinkelmann, G. Mentzas, A. Abecker. *Fostering Self-Adaptive eGovernment Service Improvement Using Semantic Technologies*. AAAI Spring Symposium: The Semantic Web meets eGovernment, Stanford University, California, USA, March 27-29, 2006.

[Stojanovic et. al., 2007a] L. Stojanovic, N. Stojanovic, J. Ma. *An Approach for Combining Ontology Learning and Semantic Tagging in the Ontology Development Process: eGovernment Use Case*. WISE 2007 - the 8th International Conference on Web Information Systems Engineering, Nancy, France, 3-7th December, 2007.

[Stojanovic et. al., 2007b] L. Stojanovic, N. Stojanovic, J. Ma. *On the Conceptual Tagging: An Ontology Pruning Use Case*. IEEE/WIC/ACM WI-2007. Silicon Valley, USA, 2-5 November 2007.

[Straub et. al., 2002] D.W. Straub, D. Hoffman, B. Weber, C. Steinfield. *Toward New Metrics for Net-Enhanced Organizations*. Journal of Information Systems Research, 13 (3), pp. 227-38, 2002.

[Straub, 1989] D.W. Straub. *Validating Instruments in MIS Research*. MIS Quarterly 13 (2), pp. 147-170, 1989.

[Sukasame, 2004] N. Sukasame. *The Development of e-Service in Thai Government*. BU Academic Review, 3, 2004.

[Sumra and Arulazi, 2003] R. Sumra, D. Arulazi. *Quality of Service for Web Services - Demystification, Limitations, and Best Practices*. Available at: http://www.developer.com/services/article.php/2027911, 2003.

[Sung, 2002] H.H. Sung. *Helping Customers Decide through Web Personalization*. IEEE Intelligent Systems, 17 (6), pp. 34-43, November/ December 2002.

T

[Thompson and Daniel, 1996] B. Thompson, L.G. Daniel. *Factor Analytic Evidence for the Construct Validity of Scores: A Historical Overview and Some Guidelines*. Journal of. Educational and Psychological Measurement 56, pp. 197-208, 1996.

[Tsai and Chai, 2005] S.L. Tsai, S.K. Chai. *Developing and Validating a Nursing Website Evaluation Questionnaire*. Journal of Advanced Nursing, 49(4), pp.406-413, 2005.

[Turka et. al., 2008] T. Turka, B.B. Jerman, P. Trkman. *Factors of Broadband Development and the Design of a Strategic Policy Framework*. In Journal of Technological Forecasting and Social Change, 75 (7), pp. 933-951, 2008.

V

[Vehovar et. al., 2001] V. Vehovar, K.L. Manfreda, Z. Batagelj. *Errors in Web Surveys*. E-Proceedings of the ISI 2001. The 53rd Session of the ISI, Seoul, 22-29, August 2001.

[Vehovar et. al., 2002] V. Vehovar, Z. Batagelj, M.K. Lozar, M. Zaletel. *Nonresponse in Web Surveys*". In R.M. Groves et al. (Eds.): Survey nonresponse. New York: John Wiley & Sons, pp. 229-242, 2002.

W

[W3C WAI, 2007] W3C Web Accessibility Initiative. *Complete List of Web Accessibility Evaluation Tools*. available at www.w3.org/WAI/ER/tools/complete, 2007.

[Walrad and Moss, 1993] C. Walrad, E. Moss. *Measurement: the Key to Application Development Quality*. IBM Systems Journal, 32(3), pp. 445-60, 1993.

[Wang and Shao, 2004] F.H. Wang, H.M. Shao. *Effective Personalized Recommendation based on Time-Framed Navigation Clustering and Association Mining*. Expert Systems with Applications, 27(3), pp. 365–377, 2004.

[Wang and Strong, 1996] R.Y. Wang, D. Strong. *Beyond Accuracy: What Data Quality Means to Data Consumers?*. Journal of Management Information Systems, 12, 1996.

[Wang et. al., 2001] Y.S. Wang, T.I. Tang, J.T.E. Tang. *An Instrument for Measuring Customer Satisfaction Toward Web Sites That Market Digital Products and Services*. Journal of Electronic Commerce Research, 2 (3), pp. 89-102, 2001.

[Web Survey Toolbox site, 2007] Web Survey Toolbox site. *Survey about Surveys*. Available at www.websurveytoolbox.org/FeatureTable.html, 2007

[Webb and Webb, 2004] H.W. Webb, L.A. Webb. *Sitequal: An Integrated Measure of Web Site Quality*. Journal of Enterprise Information Management, 17, 2004.

[Webber, 2005] A.E. Webber. *Making e-Government Web Sites Usable*. Forrester Research Best Practices, September 28, 2005.

[Weber and Specht, 1997] G. Weber, M. Specht. *User Modelling and Adaptive Navigation Support in WWW-based Tutoring Systems*. In A. Jameson, C. Paris, and C. Tasso (eds) Proceedings of the 6th International Conference of User Modelling, UM'97, pp. 289– 300. Springer-Verlag, 1997.

[Webopedia, 2006] Webopedia, Online Computer Dictionary for Computer and Internet Terms and Definitions. Available at http://www.webopedia.com/, accessed 11/2006

[Wei, 2001] C. Wei. *Adaptive Web Sites: An Introduction*. Available at http://eserver.org/courses/s01/tc510/adaptivity/wei/wei.html, 2001.

[White et. al., 2001] S. White, M. Fisher, R. Kattell G. Hamilton, M. Hapner. *JDBC API Tutorial and Reference, Second edition*. Addison Wesley, 2001.

[Wikipedia, 2007a] Wikipedia. *Gunning Fog Index*. Available at http://en.wikipedia.org/wiki/Gunning_fog_index, 2007

[Wikipedia, 2007b] Wikipedia. *Flesch-Kincaid Readability Test*. Available at http://en.wikipedia.org/wiki/Flesch-Kincaid_Readability_Test, 2007

[Won, 2002] K. Won. *Personalization: Definition, Status, and Challenges Ahead*. Journal of Object Technology. 1(1): pp. 29-40, 2002.

X

[Xenos et. al., 2004] M. Xenos, E. Dermitzioti, C. Pierrakeas. *Assessing the Qualtiy of Web Sites Used in Higher Open Distance Education Courses*. Education, Communication & Information, 4(2/3), July/Nov. 2004.

Y

[Yang et. al., 2004] Z. Yang, M. Jun, R.T. Peterson. *Measuring Customer Perceived Online Service Quality - Scale Development and Managerial Implications*", International Journal of Operations & Product Management, 24(11), pp. 1149-1174, 2004.

[Yang et. al., 2005] Z. Yang, S. Cai, Z. Zhou, N. Zhou. *Development and Validation of an Instrument to Measure User Perceived Service Quality of Information Presenting Web Portals*. Information & Management, vol. 42, pp. 575-589, 2005

Z

[Zanutto, 2001] E. Zanutto. *Web & E-mail Surveys*. Available at www-stat.wharton.upenn.edu/~zanutto/Annenberg2001/docs/websurveys01.pdf, 2001.

[Zaslow, 2002] J. Zaslow. *If TiVo Thinks you are Gay, here's how to Set it Straight*. The Washington Post Online, November 2002.

[Zeithaml et. al., 2000] V.A. Zeithaml, A. Parasuraman, A. Malhotra. *A Conceptual Framework*

for Understanding e-Service Quality: Implications for Future Research and Managerial Practice. Working Paper, Report No. 00-115, 2000, Marketing Science Institute, Cambridge, MA, 2000.

[Zeithaml et. al., 2002] V.A. Zeithaml, A. Parasuraman, A. Malhotra. *Service Quality Delivery through Web Sites: A Critical Review of Extant Knowledge*. Journal of the Academy of Marketing Science, 30(4), pp. 362-375, 2002.

[Zhang and Prybutok, 2005] X. Zhang, V.R.Prybutok. *A Consumer Perspective of E-Service Quality*. IEEE Transactions on Engineering Management, 52(4), Nov. 2005.

[Zou et. al., 2003] K.H. Zou, J.R. Fielding, S.G. Silverman, C. Tempany. *Hypothesis Testing I: Proportions*. Radiology 226(3), pp. 609-613, 2003.

ANNEX A.
THE QUESTIONNAIRE

Directions

The following set of statements relate to your feelings about this portal. For each statement, please show the extent to which you believe this portal has the feature described by the statement. Selecting a 1 means that you strongly disagree that the portal has the feature, and selecting a 5 means that you strongly agree. You may select any of the numbers in the middle that show how strong your feelings are. There are no right or wrong answers – all we are interested in is a number that best shows your perceptions about this portal.

Factor level questions

Question 1: This portal is easy to use

1=Strongly Disagree 5=Strongly Agree

1	2	3	4	5	Don't Know/Haven't Use
○	○	○	○	○	○

Question 2: Portal's content is characterized by high quality

1=Strongly Disagree 5=Strongly Agree

1	2	3	4	5	Don't Know/Haven't Use
○	○	○	○	○	○

Question 3: Interaction with portal, when using forms for requests is functional enough

1=Strongly Disagree 5=Strongly Agree

1	2	3	4	5	Don't Know/Haven't Use
○	○	○	○	○	○

Question 4: The service requested has been performed reliable and in time.

1=Strongly Disagree 5=Strongly Agree

1	2	3	4	5	Don't Know/Haven't Use
○	○	○	○	○	○

Question 5: Support mechanisms of this portal (help desk, e-mail, FAQ) resolve users' problems

1=Strongly Disagree 5=Strongly Agree

1	2	3	4	5	Don't Know/Haven't Use
○	○	○	○	○	○

Question 6: To my understanding transactions are performed securely in this portal

1=Strongly Disagree 5=Strongly Agree

1	2	3	4	5	Don't Know/Haven't Use
○	○	○	○	○	○

Dimension Level Questions

Table A.1: Mappings between Factor - Dimension Level Questions

Factor Level Question	Dimension Level Questions
1. This portal is easy to use	1.1 This portal's structure is clear and easy to follow.
	1.2 This portal's layout is pleasant, clean and functional
	1.3 This portal's URL is easy to remember.
	1.4 This portal's search engine is effective.
	1.5 This portal's site map is well organised
	1.6 This portal is well customized to individual users' needs.
2. Portal's content is characterized by high quality	2.1 The information displayed in this portal is appropriate detailed.
	2.2 The information displayed in this portal is accurate.
	2.3 The information displayed in this portal is fresh.
	2.4 The information displayed in this portal is easy to understand (it does not use formal language)
	2.5 This portal offers enough and of high quality hyperlinks.
	2.6 The information displayed in this portal is relevant
3. Interaction with portal, when using forms for requests is functional enough	3.1 Forms in this portal are downloaded in short time.
	3.2 Automatic recalling of user's personal data within portal's forms is satisfactory.
	3.3 The level of automatic calculation within portal's forms is satisfactory.
	3.4 Information about field's completion in this portal is enough.
	3.5 Submitted requests or results of the elaboration are easy to stored locally or printed
4. The service requested has been performed reliable and in time	4.1 This portal is available and accessible whenever you need it.
	4.2 This portal performs the service successfully upon first request.
	4.3 This portal provides services in time.
	4.4 Portal's pages are downloaded quickly enough.
	4.5 This portal works properly with your default browser.
5. Support mechanisms of this portal (help desk, e-mail, FAQ) resolve users' problems	5.1 This portal provides contact information
	5.2 Employees showed a sincere interest in solving users' problem.
	5.3 Employees give prompt replies to users' inquiries.
	5.4 Employees have the knowledge to answer users' questions.
	5.5 The FAQ section of this portal covered completely the topic that you were interested in.
	5.6 Employees are courteous
	5.7 Employees have the ability to convey trust and confidence

6. To my understanding transactions are performed securely in this portal	6.1 Acquisition of username and password in this portal is secure.
	6.2 Only necessary personal data are provided for authentication in this portal.
	6.3 Data provided by users in this portal are archived securely
	6.4 Data provided in this portal are used only for the reason submitted

Questions about Ideal Portal

Question 7: How does this portal compare to your idea of an ideal portal.

1=Poor 5=Excellent

1 2 3 4 5

○ ○ ○ ○ ○

Table A.2: D-Level Questions about Ideal Portals

Factor Level Question	Dimension Level Questions
How does this portal compare to your idea of an ideal portal	7.1 An excellent portal should be primarily easy to use.
	7.2 An excellent portal should primarily been characterized by high quality content.
	7.3 Within an excellent portal, emphasis is given to interaction functionality when using forms.
	7.4 An excellent portal, primarily delivers the service reliable and in time.
	7.5 Within an excellent portal, emphasis is given to support mechanisms (help desk, e-mail, FAQ).
	7.6 Within an excellent portal emphasis is given to the security of transactions.

Demographic questions

Question 8: Which describes you best?

- Government employee
- Academic faculty
- Private Sector employee
- Free Lancer

- 9-12 Student
- University / College student
- Retired
- Unemployed
- Other (please specify)

Question 9: Your age is?

- Less than 16
- 16-25
- 26-35
- 36-45
- 46-55
- 56-65
- > 66

Question 10: Which of the following is the highest educational degree you have achieved?

- PhD Degree
- Masters Degree
- Bachelors Degree
- High School Diploma or equivalent
- Vocational Degree
- no degree

Question 11: On average, how many hours do you spend on the Internet each week?

- Less than 1
- 1-5
- 6-10
- More than 10

ANNEX B.
FACTOR ANALYSIS ROTATED MATRIX FOR THE REFINED QUALITY MODEL

The Rotated Matrix of the Factor Analysis for the refined quality model, showing the factor loadings of each dimension to each factor, is depicted in Table B.1. In this table factor labels have been added to the six factors of the factor analysis, according to the type of dimensions that are grouped together (i.e. Reliability, Support, etc,), in order to enable the comprehension of the results. Furthermore the factor loadings of dimensions that constitute a group (factor) have been highlighted with a gray colour, while the dimensions that load in a different factor from the one initially conceptualized have been formatted in bold.

Table B.1: Factor Analysis Rotated Component Matrix for the Refined Quality Model

Questionnaire Item	Component					
	Support	Reliability	Information	Usability	Security	Interaction
	1	2	3	4	5	6
Employees give prompt replies to users' inquiries	**0.834**	0.163	0.152	0.195	0.146	0.139
Employees showed a sincere interest in solving users' problem	**0.827**	0.210	0.159	0.165	0.190	0.114
Employees have the knowledge to answer users' questions	**0.826**	0.129	0.176	0.168	0.129	0.175
Employees have the ability to convey trust and confidence	**0.822**	0.134	0.190	0.164	0.181	0.193
Employees are courteous	**0.637**	0.255	0.269	0.037	0.297	0.031
This portal works properly with your default browser	0.117	**0.783**	0.079	0.127	0.211	0.051
Portal's pages are downloaded quickly enough	0.112	**0.772**	0.041	0.118	0.192	0.201

This portal is available and accessible whenever you need it.	0.216	**0.728**	0.260	0.114	0.101	0.024
This portal performs the service successfully upon first request	0.165	**0.658**	0.246	0.205	0.146	0.195
Forms in this portal are downloaded in short time	0.166	**0.636**	0.108	0.188	0.159	0.416
This portal provides services in time	0.210	**0.607**	0.375	0.207	0.147	0.157
The information displayed in this portal is fresh	0.240	0.181	**0.767**	0.176	0.188	0.000
The information displayed in this portal is accurate	0.261	0.151	**0.628**	0.241	0.128	0.293
The information displayed in this portal is appropriate detailed	0.180	0.192	**0.614**	0.376	-0.007	0.267
The information displayed in this portal is easy to understand (it does not use formal language)	0.208	0.246	**0.612**	0.200	0.273	0.181
The information displayed in this portal is relevant	0.167	0.187	**0.578**	0.215	0.245	0.310
This portal's site map is well organised	0.192	0.229	0.190	**0.721**	0.094	0.209
This portal's layout is pleasant, clean and functional	0.139	0.241	0.152	**0.718**	0.163	-0.024
This portal's structure is clear and easy to follow	0.102	0.068	0.212	**0.658**	0.289	0.283
This portal is well customized to individual users' needs	0.182	0.178	0.329	**0.653**	0.242	0.155
This portal's search engine is effective	0.265	0.112	0.217	**0.524**	0.052	0.466
Only necessary personal data are provided for authentication in this portal.	0.226	0.206	0.137	0.223	**0.764**	0.178
Acquisition of username and password in this portal is secure	0.308	0.287	0.255	0.196	**0.646**	0.174
Data provided by users in this portal are archived securely	0.331	0.359	0.228	0.237	**0.646**	0.250
Data provided in this portal are used only for the reason submitted	0.326	0.359	0.250	0.258	**0.609**	0.035
The level of automatic calculation within portal's forms is satisfactory	0.236	0.362	0.263	0.306	0.179	**0.637**
Information about field's completion in this portal is enough	0.166	0.245	0.370	0.217	0.269	**0.609**
Automatic recalling of user's personal data within portal's forms is satisfactory	0.326	0.343	0.262	0.193	0.213	**0.606**

PUBLICATIONS

This section contains references to publications resulted from my research activities to date. In summary there are three (3) journal publications, one (1) book chapter publication and five (5) conference publications, which have received more than thirty (30) citations from other researchers.

Journal Publications

[J1] Halaris, C., Magoutas, B., Papadomichelaki, X., Mentzas G., (2007), *Classification and Synthesis of Quality Approaches in E-government Services*, Internet Research Journal: Electronic Networking Applications and Policy, Volume 17, Number 4, 2007, pp. 378-401(24).

- (Science Citation Index Expanded, Impact Factor 2007: 0.836)

[J2] Magoutas, B., Mentzas, G., (2010), *SALT: A Semantic Adaptive Framework for Monitoring Citizen Satisfaction from eGovernment Services*, Expert Systems with Applications, Vol. 37, No 6, pp. 4292-4300, June 2010, doi: 10.1016/j.eswa.2009.11.071

- (Science Citation Index Expanded, Impact Factor 2008: 2.596)

[J3] Magoutas B., Schmidt K-U., Mentzas G. and Stojanovic L., (2010), *An Adaptive e-Questionnaire for Measuring User Perceived Portal Quality*, accepted for publication in the International Journal of Human-Computer Studies

- (Science Citation Index Core, Impact Factor 2008: 1.769)

Book Articles

[B1] Magoutas B., Chalaris C., Mentzas G., (2008), *A Semantically Adaptive Interface for Measuring Portal Quality in e-Government*. In C. Mourlas and P. Germanakos (Eds.): Intelligent User Interfaces: Adaptation and Personalization Systems and Technologies, Hershey, pp. 147-166, PA: IGI Global.

Conference Publications

[A1] Papadomichelaki X., Magoutas B., Halaris C., Apostolou D., Mentzas G., (2006), *A Review of Quality Dimensions in E-government Services*. In M. Wimmer, H.J. Scholl, Å. Grönlund, K.V. Andersen (Eds.): Electronic Government, 5th International Conference, EGOV 2006, Krakow, Poland, September 4-8 2006, Proceedings. LNCS 4084 Springer 2006, pp. 128–138.

- (Science Citation Index Expanded, Impact Factor 2007: 0,513)

[A2] Magoutas B., Halaris C., Mentzas G., (2007), *An Ontology for the Multi-perspective Evaluation of Quality in E-Government Services*. In M. Wimmer, H.J. Scholl, Å. Grönlund (Eds.): Electronic Government, 6th International Conference, EGOV 2007, Regensburg, Germany, September 3-7, 2007, Proceedings. LNCS 4656 Springer 2007, pp. 318-329.

[A3] Magoutas B., Mentzas G., (2009), *Adaptivity and Personalization Application Scenarios in eParticipation*. In E. Tambouris, A. Macintosh (Eds.): eParticipation, 1st International Conference, ePart 2009, Linz, Austria, September 1-3, 2009 Trauner Druck: Linz, Schriftenreihe Informatik # 31, pp. 205-215, 2009

[A4] Magoutas B., Mentzas G., (2009), *Refinement, Validation and Benchmarking of a Model for e-Government Service Quality*. In M.A. Wimmer, H.J. Scholl, M. Janssen, R. Traunmüller (Eds.): Electronic Government, 8th International Conference, EGOV 2009, Linz, Austria, August 30 – September 3, 2009, Proceedings. Springer Verlag: Heidelberg et al, LNCS # 5693, pp. 139-150, 2009.

- This paper was one out of the three papers nominated for the best paper award in the category “The most interdisciplinary and innovative research contribution”

[A5] Magoutas B., Mentzas G., (2009), *Adaptive Evaluation of Portal Quality: An eGovernment Case*. In 13th Panhellenic Conference on Informatics (PCI), 10-12 September 2009, Corfu, Greece. IEEE Computer Society, pp. 136-140.