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ORIGINAL ARTICLE

# Web-Based Applications quality factors: A survey and a proposed conceptual model

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**Abstract** Web-Based Applications (WBA) are fast becoming more widespread, larger, more interactive, and more essential to the international use of computers. The most successful WBA companies are beginning to realize that key critical factors of success or failure of any WBA must be highly dependable on delivering on a high quality web site. To attain the desired quality of WBA, it is necessary to suggest a model that organizes and enables the identification of WBA quality perspectives. This paper addresses WBA quality model and categorizes its quality factors. The software is an essential part of any WBA. ISO9126 standard for software engineering product quality states that the main purpose of software quality evaluation is to provide quantitative reference for software products evaluation that is reliable, understandable, and acceptable. The main weakness point here is the lack of a formal specification of key factors for WBA quality. Traditional quality models are not adequate for WBA because they do not address all problems associated with the new features of WBA. Therefore, ISO9126 and different quality models of software were investigated and partially used as an initial step to identify a conceptual quality model for WBA. WBA have common characteristics with traditional software packages, and other distinct characteristics that are particular to WBA. In this paper a proposed conceptual quality model to organize WBA quality factors in terms of its sub factors was

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identified. In addition, the proposed conceptual quality model effectively reflects the main views of WBA based on the opinion of highly skilled professionals (visitor, owner, end user). The main goal of this paper is identifying, categorizing, and modeling WBA quality factors.



## 1. Introduction

The World Wide Web (WWW) has grown as a unique space and has become one of our major channels of information and communications. The web provides a wealth of information to an incredibly diverse user population and designers reflecting the different challenge of developing Web Based Applications (WBA) that need to meet diverse user needs [1]. Considering the turbulence and size of WBA developments, it is not surprising that there has been growing interest with developing WBA with a high quality. WBA are more complicated than simple HTML web pages, and consider different views through developing them.

The quality of WBA is a property difficult to define and capture in an organized way. It is clear that WBA are more important. What is not clear is: what are factors that reflect WBA quality? How can we address developing WBA with high quality? [2,3].

This paper provides a proposed conceptual model to establish and categorize the quality factors for WBA. The suggested model used to systematically identify quality factors and its sub factors that is based on many views and usages of WBA. The main idea of proposed model is classified into two main parts:

(1) To review and extend the previous established quality factors in WBA.
(2) To develops a conceptual quality model that identify and organize different WBA quality views and usages. The structure of the paper is as follows: Section 2 presents an overview of previous established quality models and factors of WBA as well as a survey of well-known software quality models. Section 3 propose a conceptual quality model and its different quality views and usages that underlie WBA quality. Section 4 summarizes the paper and intended future work.

## 2. Theoretical background

A great amount of work in the area of WBA quality has been developed in the last decade. As the dependency on WBA increases, the need to assess characteristics with WBA quality increases. However, many existing empirical studies focusing on the quality of WBA is mainly exploratory in nature (they were advised prior to the commercialization of the internet and are more focused towards traditional data processing and information retrieval). Most of the current studies are either dealing with a limited number of quality factors or directed towards a specific WBA perspectives. Recently, research and studies are accumulating including different models to evaluate the quality of WBA. In our study, the extended ISO model was chosen as the reference point, due to its popularity and acceptance by the software industry. Its software quality characteristics were used to identify key quality factors of WBA. This section provides a brief survey of well known software quality models as well as previous established quality models and factors in WBA that would be used as initial principles in proposing a conceptual model that address different views and usages of WBA quality.

### 2.1. Software quality models

Since 1970s, researchers and practitioners have been looking for ways to characterize software quality. They found that software artifact can be breakdown into constructs that can be assured and measured. This enables evaluation of quality through the evaluation of more detailed characteristics [4]. A significant number of quality models have been presented.

Firstly, McCall et al. (1977)'s quality model [5] was one of the first well known quality models that aimed towards the system developers and the system development process. In his quality model, McCall et al. (1977) attempts to bridge the gap between users and developers by focusing on a number of software quality factor that reflect both the users' views and the developers priorities. The McCall quality model was three major perspectives for defining and identifying the quality of software product: product revision, product transition, and product operation. The model furthermore details the three perspectives in a hierarchy of factors, criteria and metrics. The quality factors describe different types of system behavioral characteristics and the quality criterions are attributes to one or more of the quality factors. The quality metric, in turn, aims to capture some of the aspects of a quality criterion.

ISO/IEC 9126/2001 [6] standard defined software quality, which is described as using internal and external software qualities and their connection to attributes of software in a so-called software quality model(SQM). The software quality model defined in ISO 9126 follows the factor-criteria-metrics model proposed by McCall (1977). It defines six quality factors, which are refined into criteria. These criteria are in turn assessed by metrics measuring the design and the development process and the software itself.

The ISO 9126 quality factors as shown in Table 1 are functionality, reliability, usability, efficiency, maintainability, and portability .these factors are further subdivided into sub characteristics such as suitability, accuracy, security, and time behavior. These sub characteristics are comprehensive, that is, any component of software quality can be described in terms of some aspects of one or more of these six factors.

Some attributes are in conflict with each other. Therefore, the customer and the software developer must work together to define which attributes are essentials to a particular project.

### 2.2. WBA quality models

WBA is rapidly expanding into all sectors of our society and becoming an indispensable platform of any computer

**Table 1** Six quality characteristics of ISO9126.

| | |
|---|---|
| Functionality | Shows the existence of a set of functions and their specified properties. The functions satisfy stated or implied needs |
| Reliability | That capability of software which maintains its level of performance under given conditions for a given period of time |
| Usability | Attributes that determine the effort needed for use and the assessment of such use by a set of users |
| Efficiency | The relationship between the level of performance of the software and the amount of resources used under stated conditions |
| Maintainability | The effort needed to make specified modifications |
| Portability | The ability of the software to be transformed from one environment to another |

applications. WBA are complex, ever evolving and rapidly updated software systems. Since 1994, many WBA quality models had appeared aiming to assess WBA quality characteristics that are described below:

Further quality factors and attributes were researched to ensure having a comprehensive list of quality factors. In particular, scalability and availability were added as, according to Suh et al. [7], E-commerce website software is large and complex, but quality requirements demand the key performance of factors such as availability, performance, scalability, and security. This, in essence, provides the biggest influence on the effective implementation of any WBA.

In 2002, Albuquerque and Belchior [8] have organized a comprehensive set of software quality attributes into objectives where each objective is composed of a set of quality factors. Each quality factor is further decomposed into sub-factors. According to Albuquerque and Belchior, three broad objectives formulate which enables the evaluation of an E-commerce WBA quality.

During 2002, Eppler and Muenzenmayer [9–13] propose WAB content quality model. Content quality is a very important concern that must be taken into consideration when talking about the quality factors of WBA. Content quality is commonly thought of as a multi-dimensional concept with varying characteristics and attributes. Eppler's model divided quality of WBA into two quality perspective: content quality and media quality. Content quality breakdown into two categories (relevant information and sound information). Each category consists of dimensions. These mentioned content quality model framework varied in their approach and application. However, they share a number of characteristics.

In 2000, Fitzpatrick presented WBA quality model considering five quality characteristics related to the WWW domain, their sub characteristics (sub-factors), and a checklist which can be used by all IS professionals as essential issues to be addressed when creating quality web applications. These characteristics are visibility, intelligibility, credibility, engaging the visitor, and differentiation. Visibility refers to the ease with which a user can visit web sites. Intelligibility refers to the ease with which a user can assimilate and interpret web content. Credibility refers to the level of user confidence with the content of the web site. Engaging the visitor refers to the extent to which a user achieve a complete experience. And differentiation refers to the extent to which a web site demonstrates corporate superiority [12].

Early in 2000, Luisa and Mariangela proposed an original model for evaluating and designing the quality of WBA. The model, called 2QCV3Q, has been developed using classic rhetorical principles and can be used to single out elements which, when suitably combined, permit evaluation of the quality of WBA and provide suggestions for improvements. Symmetrically, the model provides guidelines for the design of WBA and allows identification and classification of the owners' and users' requirements. The first step in the application of the model is its customization in order to take account of the goals of WBA's owner and the needs of users [13].

Early also in 1998, Lu and Hong introduced WAB Interactivity quality model that is focused on the importance of interactivity factor in WBA environment that can meet visitors' satisfaction. Adding interactivity features is crucial to improve the communication quality, engage users, improve user satisfaction and hence make the application more acceptable and more usable. Ha and James' Interactivity model present five WAB quality dimensions. These dimensions are playfulness, choice, connectedness, information collection and reciprocal communication. These dimensions require two-way communication [12,14,15].

Several WBA quality factors have recently been proposed in the literature. However, most of them are built upon the previously WBA quality models and devoted for empirically validating.

## 3. Proposed WBA model development

Web Base Applications (WBA) represents one of the fastest growing trends of the software market that provide a new method to deploy software applications. WBA are built with a number of different, new languages, technologies, and programming model, and are used to implement highly interactive applications that have very high quality requirements. WBA lends itself to software applications. On the other hand, it has its distinct features and problems that associated with the new features of WBA. This led to traditional software quality models are not adequate for all features of WBA. The proposed conceptual quality model for WBA has been developed based on ISO/IEC9126 (2001) for software quality model [4,6].

### *3.1. Structure of WBA quality model (WBAQM)*

Dromey's generic quality framework [16] provides a methodology for the development of quality model in a bottom–up fashion. It relied on the decomposition of high level quality attributes into tangible, quality-carrying properties of software product components. There are three main principal elements to Dromey's generic quality model: product property that influence quality, a set of high level quality attributes, and a mean of linking them.

The proposed WBA Quality Model (WBAQM) applies the same bottom up mechanism and focuses on defining different WBA quality factors and WBA quality sub factors based on ISO 9126 quality frameworks. Then it attempts to link these quality factors and sub factors together. Fig. 1 shows the levels that constitute this model [5]:

Layer 1: identifying WBA quality views and usages

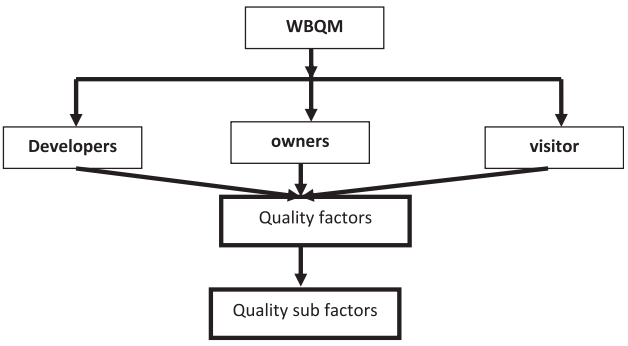


**Figure 1** WBAQM structure.

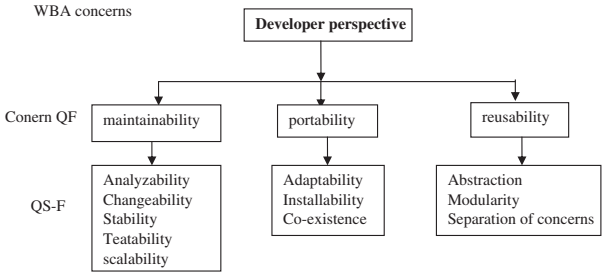


**Figure 2** Quality factors and subfactors of developer perspective.

Layer 2: categorizing quality factors to each quality view
Layer 3: Mapping quality sub-factors to each quality factor.
Each of these levels will be described in the following subsections.

*3.1.1. Layer1: identifying WBA views*

According to the ISO, quality is ''the totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs''. In order to understand the quality requirements of WBA, it is necessary to consider the purpose of WBA. Very often, evaluation of quality is based on internal criteria established by an owner company according to its goals. But more accurate evaluation of WBA should also take account of the needs of its users which may be different than the needs of owner company. We must also remember that the hypermedia nature of the Internet and the importance of aspects to do with interfaces, speed of access to information, and the security of transactions differentiate WBA from traditional information systems. Moreover, those involved in WBA design have different skills. The heterogeneity of the subjects involved in the building of WBA can influence the quality enormously. In many cases, the developers of WBA that are often in charge of WBA development projects, may be unaware of the characteristics of the technology determining the performance of WBA.

From a user (visitor) perspective there is a substantial range of ''need to include'' features, ''easy to find'', ''easy to download'', ''easy to understand''. Users' need to be confident with the content of WBA and with the objectives of owner company application. WBA need to be interactive and need to incorporate a full range of navigational aids. From an owner company perspective, WBA is intended to communicate an organizational image and message, to inform visitors to the company web applications, to support access to information and knowledge. These objectives for WBA are different to those of traditional applications, which generally perform a data processing activity. Consequently, WBA have different quality views. Each of these views will be described in the following subsections.

*3.1.1.1. Developer concerns*. Communications between a firm and its customers, other than face-to-face discussions, take place through one or more media, via interactions with the media by both parties. The features of a web-based interface make it an attractive choice as a medium for interaction between the firm and its customers. The need to develop a sound WBA integrated of the visitors needs and owner promotion with various quality characteristics is most crucial problem for any WBA developer [9,10,17,18].

*3.1.1.2. Visitor concerns*. WBA are used by a diverse population of visitor with heterogeneous backgrounds in terms of their knowledge, skills, and needs. The ultimate goal is that these WBA can facilitate visitor's information seeking, which, in turn, can improve their performance and perception in rela-

**Table 2** Quality subfactors of developer perspective.

| Quality factor | Quality subfactor | Description |
|---|---|---|
| Portability | Adaptability | The extent to which WBA can be adapted for different specified environment |
| | Installability | The extent to which WBA can be easily installed in a specific environment |
| | Co-existence | The extent to which WBA can be co-existed with other independent software in a common environment sharing common resources |
| Maintainability | Analyzability | The extent to which WBA can be diagnosed for deficiencies or caused of failures and identify the parts which must be modified |
| | Changeability | The extent to which the specified modifications can be implemented. Stability refers to avoid unexpected effects from modifications |
| | Testability | The extent to which the implemented modifications can be validated |
| | Scalability | The extent to which WBA can be easily and efficiently expanded to meet specific needs and situations |
| Reusability | Abstract action | The act of representing essential concepts away from low level and unimportant details |
| | Modularity | Divide WBA into modules or components then integrate them to produce the whole system |
| | Separation of concerns | The capability to separate among concerns such as separating navigational elements from data and separating presentation from structure |

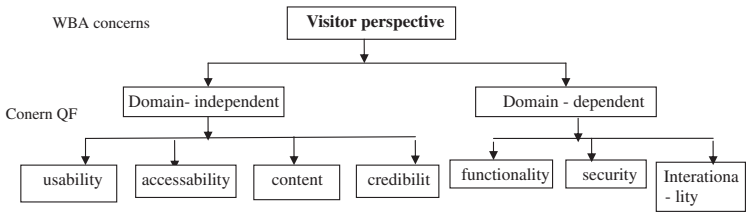


**Figure 3** Quality factors of visitor perspective.

tion to the WBA being used. Therefore, visitors quality factors are key issues for the development of WBA [18,19].

Visitor concerns involve quality factors that are most important to WBA visitors and are reflecting the needs and performance of the visitors with various characteristics.

*3.1.1.3. Owner concerns.* Many firms have realized, as their marketplaces have become more global and service oriented using WBA. WBA promise potential benefits for firms, including reduced transaction costs, reduced time to complete transactions, reduced clerical errors, faster responses to new market opportunities, improved monitoring of customer choices, improved market intelligence, more timely dissemination of information to stakeholders, and more highly customized advertising and promotion [9,12,15,20]. Based on the extensive literature research in the area of web quality models, we found that Firm's WBA owner is mainly concerned with three quality factors: differentiation, popularity, and profitability.

*3.1.2. Layer 2: categorize quality factors to quality view*

The ISO 9126 quality factors functionality, reliability, efficiency, usability, maintainability, and portability were selected as the initial set of quality factors of the proposed WBAQM. These factors were individually reviewed to find out if they contributed towards the nature of WBA and whether this set is sufficient broad to include all quality aspects of WBA quality model. Firstly; some of ISO quality factors such as maintainability, and portability were related towards developers' perspectives [6].

For example, maintainability addresses the extent to which WBA can be easily modified during its life. It includes any corrective, adaptive, perfective, and preventive activities made to the application during its operational phase to meet/improve specific requirements. It respectively considered as an important quality factor of developer. Portability is also important characteristics that present the strategy of building

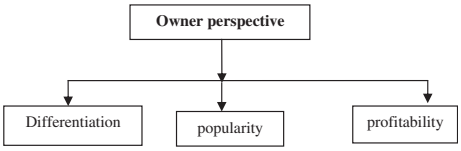


**Figure 4** Owner quality factors.

WBA to run on a specific environment or hardware configuration while it can be refined with minimum effort to run on other environment or hardware configurations. Therefore, it was decided to include portability as a quality factors with developer perspective [21,22].

Reusability reflects the presence of WBA characteristics that allow it to be reapplied to a new problem without significant effort. Thus, the initial set of quality factors and sub factors of developer perspective shown in Fig. 2 and Table 2 are: portability, maintainability, and reusability. This set of quality factors for developer perspective is broad enough to desirable quality factors of developer to be identified.

Secondly, visitor perspective can be decomposed into domain-independent quality factors and domain-dependent quality factors. Domain-independent quality factors represent quality considerations that are common between all WBA domains that involve four factors: usability, accessibility, content quality and credibility. On the other hand, domain dependent quality factors represent quality considerations that are quite distinct from one domain to another. Its quality factors include security, functionality and internationalization. Fig. 3 and Table 3 represent quality factors of visitor perspective [23,24].

Finally; owner perspective is mainly concerned with three quality factors: differentiation, popularity, and profitability. Fig. 4 and Table 5 represent quality factors of owner perspective. These proposed quality factors are not exclusive and it

**Table 3** Quality factors of visitor perspective.

| Visitor perspective | Quality factor | Description |
|---|---|---|
| Domain independent | Accessibility | The extent to which WBA is easy and quickly findable and available for most internet user groups |
| | Content | The extent to which the offered information is accurate, consistent, suitable to visitor's needs and evoke his/her interest, and current |
| | Credibility | The extent to which web visitors confident with the owner of the application and with the presented content |
| | Usability | The extent in which WBA can be easily used |
| Domain dependent | Security | The extent to which the data/information/processes are protected so that unauthorized persons/systems cannot read/modify them and authorized persons/systems are not denied access to them |
| | Functionality | The extent to which WBA provide an appropriate set of functions for specified tasks and provide a suitable content in terms of the amount and relevancy |
| | Internationalization | The extent to which the designing WBA so that it can be adapted to various languages and regions |

**Table 4** Quality sub-factors of visitor perspective.

| Visitor quality factors | Quality sub factor | Description |
|---|---|---|
| Accessability | Findability | The ease in which WBA can be founded by web visitors and by search engines |
| | Compatibility | The extent to which WBA and its pages appear the way they should with a variety of browsers, versions, and platform |
| | Download speed | The extent to which WBA and its pages can be downloaded |
| Content | Accuracy | The extent to which the information is correct, authoritative, verifiable, and objectively |
| | Consistency | The extent to which the information is presented in the same format and compatible with previously presented information |
| | Suitability | The extent to which the information is relevant, complete, concise, and value-added |
| | Currency | The extent to which the information is sufficiently up-to-date and this is crucial for web visitors |
| Credibility | Identity | The extent to which the organization responsible for the application and its motivations are clear |
| Security | Confidentiality | The requirement that data and processes be protected from unauthorized disclosure |
| | Integrity | The requirement that data and processes be protected from unauthorized modification |
| | Availability | The requirement that data and processes should be available to authorized users (website is running 24 h a day, 7 days a week and 365 days a year) |
| Functionality | Domain specific functions | Every application provides an array of functions that are should related to the domain |
| | Content suitability | The presented information should be suitable to the visitor's needs and tasks in terms of the amount and the relevancy |

**Table 5** Quality factors of owner perspective.

| Quality factor | Description |
|---|---|
| Differentiation | The extent to which the identity and superiority of the owner are clearly demonstrated |
| Popularity | The extent to which WBA go public. Popularity has not sub-factors in our model because the achievement of it is closely related to the achievement of all visitor concerns especially accessibility and the achievement of differentiation |
| Profitability | The extent to which WBA achieve the purpose from building it |

can be easily changed to represented different developer objectives and goals.

*3.1.3. Layer 3: mapping WBA quality sub factors to its quality factor*

The third step of the proposed WBA quality model is to provide a set of quality sub factors. The identification of WBA quality sub factors extends ISO 9126 software quality sub characteristics. Due to distinct feature of WBA, usage of some ISO 9126 is limited and a new set of quality sub factors is suggested. For example; the key issue of visitor perspective quality factors is the extent in which WBA can be easily used. WBA usability is sub-divided into seven quality sub-factors: understandability, navigability, searching, consistency, legibility, audibility, and simplicity. Understandability addresses the extent to which web visitors can quickly assimilate and interpret the structure and content of the information space of WBA. Also, navigability reflects the extent to which WBA is easy to browse. WBA should support a complete set of navigational aids to allow visitors to link to any part of the application, to link to other applications, and acquire more of the information they are seeking for [25,26]. A complete definition of quality sub factors that related to WBA perspective shows in Table 5 and its linkage to quality factors appear in Tables 2 and 4.

## 4. Conclusion

In summary, this paper has determined the factors that assess the quality of WBA, identifying the main quality factors and its sub factors based on WBA views and usages. Firstly: this study suggested a conceptual model for identifying WBA different views and usages which conclude in visitor, owner, and developer view. Second; identifying and categorizing quality factors and sub factors of WBA that reflects these views. The proposed model applied ISO 9126 quality factors and sub factors to review the common features between WBA and software, and then proposes a set of new WBA quality factors that fits the particular characteristics of WBA. In the future, the model will be extended by experimental study and supported by validation framework to provide some evidence about the suggested WBA quality factors and sub factors.

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## References

[1] Moshe Z, Chanan G, Itay A. User satisfaction from commercial web sites: the effect of design and use. Inform Manage 2006;43:157–78.
[2] Chen YS, Robert M. Web-based interaction: a review of three important human factors. Int J Inform Manage 2010;30:379–87.
[3] Solomon N, Terry R, Magid I. Quality and effectiveness in Web-based customer support systems. Inform Manage 2003;40:757–68.

[4] Eldesouky IA, Hesham A, Hazem R. Toward complex academic websites quality evaluation method (QEM) framework: quality requirements phase definition and specification. Cairo, Egypt: Mansoura University, Faculty of Engineering, Computer and Systems Engineering Department; 2008.
[5] ELKorany A, Nabil D, ELDin AS. Quality measurement model for KADS domain knowledge. J Softw Eng 2009:1–14.
[6] ISO/IEC TR 9126-3. Software engineering – product quality – Part3: internal metrics. International Organization for Standardization; 2003.
[7] Suh W, Jongho K, Heeseok L. A benchmarking-based requirement analysis methodology for improving web sites. Int J Electron Comm 2009;13(3):119–62.
[8] Albuquerque AB, Belchior AD. E-commerce websites: a qualitative evaluation. In: 11th international WWW conference proceedings. Hawaii: ACM Press; 2002. p. 294–300.
[9] Beg MMS. A subjective measure of web search quality. Inform Sci 2005;169:365–81.
[10] Shirleen K, Burn J. Developing a framework for assessing information quality on the World Wide Web. Inform Sci J 2005;8:159–72.
[11] Gabriel JI. Usability metrics for measuring usability of business to consumer (B2C) E-commerce sites. In: 6th Annual ISO world conference proceedings. Las Vegas, NV; April 2007. p. 102–15).
[12] Filippo R, Liu C. Special section on web systems evolution. Int J Softw Tools Technol Trans (STTT) 2009;11(6):419–25.
[13] Luisa M, Mariangela F, Stefano N. Evaluating and designing the quality of web sites. IEEE Multimed J 2003;10(1):34–43.
[14] Lu YH, Hong Y, Varia J, Lee D. Pollock: automatic generation of virtual web services from web sites. In: ACM SAC Software engineering track; March 2005.
[15] Signore S. A comprehensive model for websites quality. In: Proceedings of WSE 2005, seventh IEEE international symposium on web site evolution. Budapest, Hungary; September 26, 2005. p. 30–6.
[16] Dromey GR. A model for software product quality. IEEE Trans Softw Eng 1995;21(2):146–62.
[17] Hongyu Z, Fang LY, Tan KHB. Measuring design complexity of semantic web ontologies. The J Syst Softw 2010(83):803–14.
[18] Leung KNH. Quality metrics for intranet applications. Inform Manage 2001(38):137–52.
[19] Layla H, Emad A. Assessing the quality of websites. Appl Comput Inform J 2011;9:11–29.
[20] Ramakanta M, Ravi V, Patra MR. Web-services classification using intelligent techniques. Expert Syst Appl 2010(37): 5484–90.
[21] Casteleyn S, Daniel F, Dolog P, Matera M. Engineering web applications, data-centric systems and applications. Berlin Heidelberg: Springer-Verlag; 2009, p. 362–80.
[22] Weimiao F, Zheng Y. Factors affecting response rates of the web survey: a systematic review. Comput Human Behav 2010;26:132–9.
[23] Andrews AA, Jeff O, Curtis D, Mallery JC, Kshamta J, Roger A. Scalability issues with using FSM Web to test web applications. Inform Softw Technol 2010;52:52–66.
[24] Lucca AGD, Fasolino RA. Testing Web-based applications: the state of the art and future trends. Inform Softw Technol 2006;48:1172–86.
[25] Miranda FJ, Cortes R, Barriuso C. Quantitative evaluation of e-banking web sites: an empirical study of Spanish banks. Electron J Inform Syst Eval 2006;9(2):73–82.
[26] Soliman A, Kamel A, Sheta W, Bahgat R. P2G: peer to peer semantic grid framework architecture 2011;12(2):125–38.