Quality Models for Web-based Application: A Comparative Study

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ABSTRACT
Internet is a complex, diverse, distributed, apparent, multilingual, multimedia, independent and cooperative multidisciplinary platform. Today internet is flourishing in all sectors of our life. As Web applications are part of global economy, growing demand for Web-based applications enhanced the need to compare various Web quality frameworks popularly in use. Most of the work on Web application is making them more powerful and relatively less attention has been given to ensure their quality. Quality check is essential for both the user as well as developer satisfaction. The diverse nature of Web applications and very short time-to-market makes it difficult to measure these existing quality frameworks. Due to large number of reusable components Web applications make traditional measurement models less relevant. The field of evaluating quality of framework is not yet mature so, there is still lack of an engineering approach for building Web-based applications systems. Many frameworks have been proposed for quality checking of Web-based application but they lack in one way or other. Each framework is having its own significance. Present study deals with a comparative analysis of quality frameworks proposed by contemporary researchers. This is performed with an intention to identify the limitations and to categorize the Web quality characteristics. This study will provide a concrete background for development of new generic framework according to emerging trends and necessity.

General Terms
Web-based Application

Keywords
Web-based Application; Quality Metrics; Quality Framework; Object-oriented methods.

1. INTRODUCTION
Web applications are hybrid between a Web site and a standard application and provide different rich features to potentially millions of Web users simultaneously, which mere Web sites alone cannot offer. The growing demand for use of internet is a powerful economic reason to produce and maintain high quality Web-based applications. Thus the desirable properties for a quality of Web-based application are reliability, usability, inter-operability and security. Developers of Web-based applications often neglect testing of Web-based applications due to market pressure and very short time-to-market, as it is considered too time-consuming and lacking a significant payoff [1]. This lack of testing habit negatively affects the quality of Web applications and as a result quality suffers. Fundamentally Web-based applications are not different from other software in terms of technologies used but they still lack engineering approach for building Web-based applications systems. Conventional software mainly focuses on functionality of software whereas Web-based applications are foremost concern with non-functional aspects i.e. quality aspects of Web application. This is also one of the reasons for shifting towards non-functional or quality aspects.

Web-based applications possess wide variation in quality parameter due to limitations of applicability of the existing quality models and its existing relevance.

Most of the Web quality models have their roots in ISO 9126 model which is the framework basically provided for software. In general, quality models should be developed keeping different perspective in mind.

The paper is organized into six sections: Section 2 presents briefly the related work done in the area. Section 3 compares existing related models, while section 4 presents limitations in existing models. Section 5 summaries some concluding remarks. Finally, section 6 gives potential future extensions for the implemented methodology.

2. RELATED WORK
Web application quality is one of the major issues while designing a Web-based application, as quality is directly related to parameters that directly deal with the design of any system. Today Web technology has become a promising technology to design and build complex Web-based applications. Modern Web applications are full-fledged, complex software systems. Now that most of us rely on Web-based systems and applications, so reliability, performance and maintainability are the key issues. Several methodologies have been defined to support the disciplined development of Web applications, but these methodologies are not feasible mainly due to short time-to-market and resource constraints. As a consequence, existing Web applications often lack in design quality. Also companies increasingly invest and rely on Web services; the importance of metrics for those services continues to grow. This means that software faults in Web applications have potentially disastrous consequences. Most of the efforts on Web applications have been on making them more usable and reliable, but relatively little work have been done to ensure their quality.

There are various quality models that are currently in use. Rafa E. Al-Qutaish [2] presented an analytical and comparative study on McCall's quality model, FURPS quality model, Boehm's quality model, Dromey's quality model and ISO 9126 quality model. In addition, author also focused on the key differences between these quality models. Though these models are capable of evaluating a Web-based application as well as a traditional desktop application software quality but evaluating a Web-based application quality is somewhat different from evaluating a traditional desktop application quality. So to evaluate a Web-based application different quality models need to be compared and

analyzed. ISO/IEC 9126 Model [3] is a standard proposed by ISO (International Standard Organization) which provides a generic standard definition of software quality in terms of six main characteristics for software evaluation. Characteristics included are functionality, reliability, usability, efficiency, portability and maintainability which are further divided into 21 sub characteristics. Though ISO model was not proposed for Web-based quality evaluation, but quality attributes it defines resembles that of the metrics required for Web-based application quality model. ISO/IEC 9126-1 defines quality model, 9126-2 defines external metrics, 9126-3 defines internal metrics, and 9126-4 defines quality in use metrics. Out of these ISO/IEC 9126-1 is the international standard and 9126-2, 9126-3, and 9126-4 are technical reports. Niessink [4] introduced Quint 2 model that also evaluates quality of software. The Quint2 model is a rarely used model and is a modified version of Quint model, which is also an extension of ISO 9126 model. Quint2 model adds 11 new sub characteristics to the 21 sub characteristics of ISO 9126 model. The model introduced by Ramler et al. [5] is a three dimensional quality model. These three dimensions are- Quality aspects, features, and phases which can be visualized as a three-dimensional cube. The cube describes standard scheme to organize tests for quality aspects of Web applications and is represented by the node at the intersection point of a quality, feature, and phase. Mich et al. [6] presented 2QCV3Q model for assessment of Web-based application quality keeping owner and user perspectives in mind. As many people are involved in development of Web applications; 2QCV3Q permits a multi-stakeholder approach that considers all perspectives of Web application designer, deployer, owner, and its users. Another Web quality model based on the concept of three dimensional model is presented by Ruiz et al. [7]. In this model the dimension representing "Phases" is replaced by new dimension "Lifecycle Processes". The three dimensions proposed by the model are Quality characteristics, Features and Lifecycle Processes. DeLone and McLean [8] presented an IS Success Model which is update of the model which authors presented earlier in 1992. Authors discussed the utility of the updated model for measuring e-commerce system success. Various parameters taken into account to define a model are: System quality, Service quality, Information quality, Usage, User satisfaction and Net benefits. Another three dimensional model is presented by Malak et al. [9] which is influenced by the three dimensional model presented by Ramler et al. [5] and Ruiz et al. [7]. In this model features dimension is replaced by application domain. The model was constructed on GQM (Goals, Questions, and Metrics) paradigm which supports a top-down approach for defining the goals behind measuring software processes and products. The PQM (Portal Quality Model) model proposed by Moraga et al. [10] is basically designed for Web portals. This model is inspired by the SERVQUAL model, presented by Parasuraman et al. [11] and the GQM (Goal Question Metric) method by Basili et al. [12]. In order to create a quality model for Web portals the different dimensions of the SERVQUAL model have been adapted to the portal context and some of them are split up into sub-dimensions. In order to measure user-perceived overall service quality of IP Web portals (Information Presenting Web portal) Yang et al. [13] developed and validated an instrument which is useful for researchers and for portal managers. The authors embrace the Technology Adoption Model (TAM) and reflected that an IP Web portal is a data framework. Model presented by Sampson and Manouselis [14] is an evaluation framework that can effect user satisfaction for addressing the multiple dimensions of Web portals. Calero et al. [15] also extended the modified three-dimensional model proposed by Ruiz et al. [7]. The three dimensions and their sub-characteristics are Quality Characteristics-Functionality, Reliability, Usability, Efficiency, Portability and Maintainability, Web Features-Content, Presentation and Navigation and Lifecycle Processes- Development, Operation, Maintenance, Effort and Reuse. Abramowicz et al. [16] presented Web Services Quality Model, SQuaRE(Software product Quality Requirements and Evaluation) based on ISO/IEC model. The three perspectives represented by model are Internal Web Service Quality, External Web Service Quality and Web Service Quality in Use. Authors also justified that Web Services are intangible objects used by other applications and have real impact on End User Experience, and overall quality delivered. Caro et al. [17] proposed a data quality model for Web portal. The model describes set of 33 attributes which are relevant for portal data quality. Olsina et al. [18] presented Web quality model for Web 2.0 and is an extension of ISO 9126-1 quality model. The model added "content quality" characteristic to the existing ISO 9126-1 quality model. Marchetto [19] describes an approach to analyze a Web application through an Object-oriented model and to study application testability using a quality model focused on the use of Object-oriented metrics and software analogies analysis.

The models presented above fail to evaluate the overall quality of the software. Several Web-based Application quality factors have recently been proposed in the literature. However, most of them are designed upon the previously Web-based Application quality models or is devoted for a specific web application.

3. COMPARISION AMONG EXISTING RELATED MODELS

This section provides a brief survey of well known software quality models as well as previous established quality models and factors in Web-based applications that would be used as initial principles in proposing a conceptual model that address different views and usages of Web application quality. The main approach for developing standards of quality models is to satisfy the requirements of the developers, maintainers, purchasers, and end clients [3]. Quality models can be categorized in one of the two ways as shown in figure:

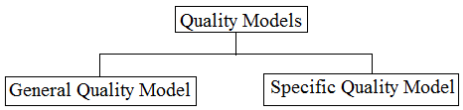

Figure 1: Categorization of Quality Models

General Quality Models can be adopted in its present condition and specify what has to be measured and how [20].

Specific Quality Models are adapted from generic models and are valid for a specific real framework.

Table 1 below shows classification and sub-classification of characteristics among existing related framework.

4. LIMITATIONS IN EXISTING MODELS

Table 2 below shows different models along with the various parameters taken to evaluate Web quality. Table clearly states that Web quality models introduced till date lacked one or other important quality parameter. Every introduced model

lacked something requiring the necessity of another Web quality model. Also most of the Web applications are developed on adhoc basis which rarely follows software life cycle.

5. CONCLUSION

The main approach for developing standards of quality models is to satisfy the requirements of the developers, maintainers, purchasers, and end clients. Also, quality of software varies depending upon the application to be developed. In our study, different quality models are surveyed and it is found that most of the Web quality models are derived from ISO/IEC 9126 model which is the most widely used and accepted model to evaluate quality of software. Most of the current quality models focuses on limited number of quality characteristics or is dealing with a specific Web-based application perspective. This gives motivation to critically analyze and differentiate the existing Web quality models and identify the limitations and accordingly categories of the Web quality factors. The factors thus categorized can be used to develop a new generic Object-oriented

Table 1: Classification and Sub-classification of Characteristics of different Models

Model	Reference No.	Classification	Characteristics	Sub-characteristics
ISO/IEC 9126 Model	[3]	Internal and External Quality	Functionality	Suitability, Accuracy, Interoperability, Security, Functionality Compliance
			Reliability	Maturity, Fault Tolerance, Recoverability, Reliability Compliance
			Usability	Understandability, Learn ability, Operability, Attractiveness, Usability Compliance
			Efficiency	Time Behaviour, Resource Utilization, Efficiency compliance
			Maintainability	Analyzability, Changeability, Testability, Stability, Maintainability Compliance
			Portability	Adaptability, Instability, Co-Existence, Replaceability , Portability Compliance
Quint2 Model	[4]	Extension of ISO 9126 model	Reliability	Availability and Degradability
			Functionality	Traceability
			Usability	Explicitness, Customizability, Attractiveness, Clarity, Helpfulness and User-friendliness
			Maintainability	Manageability and Reusability
Ramler Model	[5]	Three Dimensional Quality Model	Quality Aspects	Functionality, Reliability, Usability, Efficiency
			Features	Functions, Content, Infrastructure and Environment
			Phases	Specification and Development, Testing and Installation, Operation and Maintenance.
2QCV3Q Model	[6]	Multi-stakeholder Approach	**Q**uis (Persona: Who?) Identity	Identification, Characterization

			Quid (Factum: What?) Content	Coverage, Accuracy
			Cur (Causa: Why?) Services	Functionalities, Control
			Ubi (in Latin **V** stands for U) (Locus: Where?) Location	Reachability, Interactivity
			Quando (Quando: When?) Management	Currentness, Maintenance
			Quomodo (Modus: How?) Usability	Accessibility, Navigability, Understandability
			Quibus Auxiliis (Facultas: With what means and devices?) Feasibility	Resources, Information and Communication Techniques
Ruiz Model	[7]	Three Dimensional Model	Quality characteristics	Functionality, Reliability, Usability, Efficiency, Portability Maintainability
			Features	Functions, Content and Infrastructure & Environment
			Lifecycle Processes	Development, Exploitation and Maintenance
D&M IS Success Model	[8]	Updated D&M IS Success Model	Information Quality	Completeness, Ease of understanding, Personalization, Relevance, Security
			System Quality	Adaptability, Availability, Reliability, Response time, Usability
			Service Quality	Assurance, Empathy, Responsiveness
Malak Model	[9]	Three Dimensional Model inspired by GQM (Goals, Questions, and Metrics) paradigm	Behavioral Model Validation	Validity Characterization, Compatibility Assessment, Adequacy Assessment
			Context	Prediction Context, Behavioral Context
			Inaccuracy	Aleatory Uncertainty and Epistemic Uncertainty
PQM Model	[10]	Inspired by SERVQUAL Model and GQM (Goal Question Metric) Method	Tangible	Adaptability, Transparent, Access
			Reliability	Fault Tolerance, Availability, Search Quality, Resource Utilization
			Responsiveness	Scalability, Speed
			Security	Access Control, Security Control, Confidentiality, Integrity
			Empathy	Navigation, Presentation, Integration, Personalization

			Data Quality	Intrinsic, Representation, Accessibility, Contextual
Yang Model	[13]	Embrace the Technology Adoption Model (TAM)	Information Quality (IQ)	Usefulness of content, Adequacy of Information
			System Quality (SQ)	Usability, Accessibility, Privacy/Security, Interaction
Sampson and Manouselis Model	[14]	Satisfaction Factor	Web portal content	Satisfaction from content organization Satisfaction from content creditability Satisfaction from content usefulness Satisfaction from content integration
			Design of a Web portal	Satisfaction from information architecture Satisfaction from usability Satisfaction from graphical design Satisfaction from technical integrity/ performance
			Personalization	Satisfaction from the personalization of navigation Satisfaction from the personalization of information/content Satisfaction from the personalization of interface
			Community support	Satisfaction from the communication support Satisfaction from the collaboration support
Calero Model	[15]	Modified Three-Dimensional Model Proposed by Ruiz	Quality Characteristics	Functionality, Reliability, Usability, Efficiency, Portability and Maintainability
			Web Features	Content, Presentation and Navigation.
			Lifecycle Processes	Development, Operation, Maintenance, Effort and Reuse.
SQuaRE Model	[16]	ISO/IEC model	Internal Web Service Quality	Functionality, Security, Interoperability, Reliability, Usability, Efficiency, Maintainability, Portability
			External Web Service Quality	
			Web Service Quality in Use	Usability in Use, Context in Use, Safety in Use, Security in Use, Support in Use, Adaptability in Use
Caro Model	[17]	Data Quality (DQ) Attributes	DQ Intrinsic	Accuracy, Objectivity, Believability, Reputation, Currency, Duplicates, Expiration, Traceability
			DQ Operational	Accessibility, Security, Interactivity,

				Availability, Customer Support, Ease of Operation, Response Time
			DQ Contextual	Applicability, Completeness, Flexibility, Novelty, Reliability, Relevancy, Specialization, Timeliness, Validity, Value-Added
			DQ Representational	Interpretability, Understandability, Concise Representation, Amount of Data, Attractiveness, Documentation, Organization
Olsina Model	[18]	Internal and External Quality	Functionality	Suitability, Accuracy, Interoperability, Security, Functionality Compliance
			Reliability	Maturity, Fault Tolerance, Recoverability, Reliability compliance
			Usability	Understandability, Learn ability, Operability, Attractiveness, Usability Compliance
			Efficiency	Time Behaviour, Resource Utilization, Efficiency compliance
			Maintainability	Analyzability, Changeability, Testability, Stability, Maintainability Compliance
			Portability	Adaptability, Instability, Co-Existence, Replaceability, Portability Compliance
			Content Quality	Content Accuracy, Content Suitability, Content Accessibility, Content Legal Compliance
Alessandro Marchetto Model **(OQMw: OO Quality Model for Web Applications)**	[19]	Three Dimensional Model	Application Behavior Analysis	Uses static and dynamic analysis to extract information
			Application Model Building	Represent UML meta-model
			Model Validation	Uses reverse engineering technique

Table 2: Limitations of Web Quality Models

Models	Web Quality Evaluation Parameters				
	Lifecycle Process	Feature Dimension	Emotional Attributes	Cognition Factor	E-commerce System
ISO/IEC 9126 Model	x	x	√	√	√
Quint2 Model	x	x	x	√	√
Ramler Model	x	√	√	x	√
2QCV3Q Model	x	x	√	x	√
Ruiz Model	√	√	√	x	√
D&M IS Success Model	√	√	√	√	√
Malak Model	√	x	√	x	√
PQM Model	x	√	√	√	√
Yang Model	x	√		x	√
Sampson and Manouselis Model	√	√	√	√	√
Calero Model		√	√	x	√
SQuaRE Model	x	√	√	x	√
Caro Model	x	√	x	x	√
Olsina Model	x	x	√	√	√
Alessandro Marchetto Model	x	√	x	√	√

X refers to Not Supported; √ refers to Supported

Web quality framework in which metrics for evaluating specific software can be easily added or deleted as per requirement. Thus study of different models for Web application will provide a way to develop new generic framework through which different models can be derived.

6. FUTURE PERSPECTIVE

Comparison among different models is performed in order to evaluate quality of a Web application. Accessing quality of software decides whether it conforms to the customer's requirement or not. Study of different models for Web application will provide a way to develop new generic framework through which different models can be derived. Most of the current frameworks are having limitations like either they deals with limited number of characteristics or is dealing with a specific Web-based application perspective. Very less work is being done on making the framework Object-oriented. Making a framework Object-oriented means each heterogeneous component of Web can be viewed as an object that can easily derive Object-oriented relationships on these objects making architecture flexible for use. By using Object-oriented technology one can easily decompose problem into easily understandable objects. Decomposition of a problem makes reusable components possible. These reusable components may inherit other components of Web application. Introducing inheritance can eliminate redundant code and extend the use of existing classes. The security to a class can be provided by data hiding. Through objects aiding, future modification is possible and software complexity can be easily managed. In general, the Object-oriented approach provides flexible and extensible solutions to Web applications.

Another problem of a Web-based application is that it hardly follows a life cycle process model and cognition factors. Further Web-based systems undergo changes more often and quite extensively making the system more complex. Also for a large scale system different levels of skills are required necessitating distributed collaborative development. This again affects the quality of software. So there is a need to adopt sound strategies that follow a suitable methodology to successfully manage the development and maintenance of Web systems.

Many methods have so far been proposed for measurement of quality parameters of Web-based applications but they lack in one way or other. Fuzzy logic is one of the emerging fields in the evaluation of Web quality parameters. So, fuzzy weighted average multi-criteria approach can be applied to quantify quality matrices of the framework.

The Object-oriented methodologies can also be applied to test errors in content, interface, navigation, component, integration, configuration, security, and performance of Web applications. With the advancement of technology there is a need to develop Object-oriented model for the Web-based application.

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8. REFERENCES

[1] Hieatt, E. and Mee, R. 2002. Going Faster, Testing the Web Application. IEEE Software. 19(2), 60–65.

[2] Al-Quta Rafa, E. 2010. Quality Models in Software Engineering Literature: An Analytical and Comparative Study. Journal of American Science. 6(3), 166-175.

[3] ISO/IEC 9126-1. 2001. Software Engineering-Product Quality—Part 1: Quality Model. International Organization for Standardization. www.iso.org

[4] Niessink, F. 2002. Software Requirements, Functional and Non-Functional Software Requirements. www.cs.uu.nl/docs/vakken/swa/Slides/SA-2-Requirements.pdf

[5] Ramler, R., Weippl, E., Winterer, M., Schwinger, W., and Altmann, J. 2002. A Quality-Driven Approach to Web Testing. In Proceedings of Ibero-american Conference on Web Engineering. Santa Fe. 81–95.

[6] Mich, L., Franch, M., and Gaio, L. 2003. Evaluating and Designing Web Site Quality. IEEE Multimedia. 34–43.

[7] Ruiz, J., Calero, C., and Piattini, M. 2003. A Three-dimensional Web Quality Model. In Proceedings of the International Conference on Web Engineering (ICWE 2003). 384-385.

[8] William, H., Delone, E.R., and McLean, 2003. Model of Information Systems Success, A Ten-Year Update. Journal of Management Information Systems archive. 19(4), 9–30.

[9] Malak, R. and Paredis, C. 2004. Foundations of Validating Reusable Behavioural Models in Engineering Design Problems. In: Ingalls, RG, Rossetti MD, Smith JS, Peters BA (ed) Proceedings of the 2004 Winter Simulation Conference, Piscataway, New Jersey: Institute of Electrical and Electronics Engineers. 420–428.

[10] Moraga, M.A., Calero, C., and Piattini, M. 2004. A First Proposal of a Portal Quality Model. IADIS International Conference, E-society 2004, Ávila, Spain. 1(2), 630-638.

[11] Parasuraman, A., Zeithaml, V.A., and Berry, L.L. 1988. SERVQUAL, A Multi-item Scale for Measuring Customer Perceptions of Service Quality, Journal of Retailing. 64 (1), 12-40.

[12] Basili, V., Daskalantonakis, M., and Yacobellis, R. 1994. Technology Transfer at Motorola, IEEE Software. 11(2), 70-76.

[13] Yang, Z., Cai, S., Zhou, Z., and Zhou, N. 2004. Development and Validation of an Instrument to Measure User Perceived Service Quality of Information Presenting Web Portals, Information and Management. 42(4), 575-589.

[14] Sampson, D. and Manouselis, N. 2004. Web Portals- the New Gateways on Internet Information and Services. In: Tatnall A (Ed.) Chapter 9: A Flexible Evaluation Framework for Web Portals Based on Multi-Criteria Analysis, Idea Group Inc.

[15] Calero, C., Ruiz, J., and Piattini, M. 2005. Classifying Web Metrics Using the Web Quality Model, Online Information Review. 29(3), 227-248.

[16] Abramowicz, W., Hofman, R., Suryn, W., and Zyskowski, D. 2008. SQuaRE based Web Services Quality Model, In: International Multiconference of Engineers and Software Scientists IMECS.

[17] Caro, A., Calero, C., Caballero, I., and Piattini, M. 2008. A Proposal for a Set of Attributes Relevant for Web Portal Data Quality, Software Quality Journal. 16 (4), 513-542.

[18] Olsina, L., Godoy, D., Lafuente, G., and Rossi, G. 1999. Assessing the Quality of Academic Web sites: a Case Study, New Review of Hypermedia and Multimedia. 5 81–103.

[19] Marchetto, A. 2009. OQMW, An OO Quality Model for Web Applications, Tamkang Journal of Science and Engineering. 12(4), 459–470.

[20] Brajnik, G. 2001. Towards Valid Quality Models for Websites. In: Proceedings of the 7th Conference on Human Factors and the Web.