Prioritizing Critical Challenges for the Web Based Systems: A Software Quality Perspective

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*Abstract-*Web based application systems are rapidly evolving round the globe. Multi-platform approach along with their heterogeneous nature makes the web based applications huge and more complex. Moreover, assuring quality of the web based application systems is becoming critical due to complexity of the web based applications. Therefore, this study aims to identify the challenges encountered by the software community in order to assure the quality of web application from the existing literature. Empirical investigations have been conducted using survey questionnaire methodology to collect the data from experts working in software industry. Different statistical models like Principal Component Analysis and Kappa statistics leads this study to extract and rank the most crucial challenges associated with the quality assurance of web systems. Whereas, Cronbach's alpha has been used to ensure the reliability and consistency of the data.

*Keywords-*Quality, Quality of Web Systems, Challenges of Web Quality, Prioritization of Web Challenges.

I. INTRODUCTION

The WWW (World Wide Web) is mostly known as web which provides a multiple platform technology to run the software application programs anywhere. Therefore it is becoming an essential part of human life and cheapest mode of communication. There are some characteristics which make web based application systems different from the other conventional software applications such as design parameters, platform independence, content services through user interface, web browser etc.

Currently the enterprises or organizations via the private or public, small or big rely on web based application systems to support critical business functions. Those systems mostly consist of multi-tier applications like the business management process and Electronic commerce (E-Commerce). These organizations switch their services through www by using web applications. Due to this usability, diversity and popularity of web applications, the number of users like educationist, scientist, businessman and researchers are increasing every day to access the information worldwide [i]. That access can be the transaction oriented or information retrieval. It seems that web has reduced the need of traditional means such as paper, books etc.

Web applications are called with different synonyms such as web information systems, web based applications, web sites, web software's and web application software [ii]. The client server applications make use of web browser (client program) that provides the services through internet. These applications comprise of functional and nonfunctional requirements. The functional requirements include system requirements whereas performance, scalability, accessibility and security etc. include nonfunctional requirements [iii]. The components of web are interlinked with each other. Each component has its own specific design layout and architecture. The components include web browser, web server, web page, application server and database. Contents of the web applications are presented by the hypermedia controls using different web technologies such as HTML(Hypertext markup Language), XML (Extensible markup Language), DHTML (Dynamic Hypertext Markup Language) and Java Script etc.[iv].

The researchers [v-vii] introduce different types of web based application systems in different perspectives. These are simple types; the challenges identified in this study are not depended on these following types of web based systems. We have considered all types of websites. Some of famous types of web applications are given below[viii].

a) **Transactional**
   Services and products can be purchased by end users. Such as E-Commerce and Online Banking [ii].

b) **Instructive/Informtional**
   Provide the information to the end-user. Online newspapers, E-books, Service Manuals[ix].

c) **Data Warehouse**
   Queries are made from large collection of database. For example Search engines like Google [ii].

d) **Web Portals**
   Web portals provide access to other web

applications and contents such as electronic shopping centers[i].

e) Customizable
End users can customize the contents based on their preferences. For example email setting system[x].

f) Service Oriented
End users receive the online services on regular, monthly or annually basis [ii].

g) Interactive
These applications provide communication channel to the end users graphical user interface e.g. Business to business[ix].

h) Database Access
This application queries a database and retrieves information[viii].

i) Online Communities
Chat groups, market places, auctions, recommenders systems[i].

j) Deliverable
End users download information from the servers such as software up gradation[viii].

Quality assurance of web based application systems is vital for the success of any organization or business. As the dependency on the web based applications increase day by day, the scalability and complexity are also growing but the development cycle is becoming shorter. Due to that magnificent increase in web based application systems, there are numerous challenges being faced which can setback to the reliability, security, accessibility etc. for the quality assurance of web based application systems [xi]. Therefore, the objective of this paper is to identify and rank the critical challenges of web based application systems.

Rest of the paper is structured as follows: Section II presents background of web based application systems. Section III discusses the research method which is followed. Section IV discusses the results obtained from empirical investigation. Research Implications and limitations are described in Section V and the last Section which is VI state the conclusions of this work.

II. BACKGROUND

In the start when internet technology was developed, internet was used as a medium for exchange of information over networks. Early websites are just the set of loosely connected pages. Websites were only some hyperlinked documents containing text information so the quality of old websites is not good. If someone wants to access computing power then it is required to log in to terminal which is connected to a mainframe or server computer.

With the passage of time web based applications gained popularity and the size of the websites also increased and the number of web hosts reached over billions, so the organization of contents became fundamental requirement [xii]. Now a days web based application systems is not just the medium for sharing information, enterprises also offer their service through E-commerce. Therefore the web applications are designed for all types of people irrespective of their cultural, geographical, mental and physical capabilities but there are certain milestones for this purpose that are yet to be accomplished.

Various researchers came up with propositions of various challenges encountered by the quality of web based systems. An effort has been made by [xiii] addressing the cross browser issues in terms of different resources like time , effort, page layout and application functionality issue that are difficult to identify and do not have visible effect. Furthermore, [xiv] delineates the challenges of web security regarding the unauthorized access, vulnerabilities, and dangerous attacks that exploit the web applications. It has been urged by [xv] that when an activity or task not finish subsequently the highy qulaity of error reports are recived by the end users which are actuallty the cryptic error messages. Whereas [ii] highlighted the challenge of interoperability only, such as the components fail to meet the architectural constraints because the functional requirements are not fulfilled. On the basis of extensive literature review, no study has been found addressing web challenges associated with the quality assurance of such applications. Therefore this study contributes in a fashion to identify the challenges that are associated with the quality assurance of web systems. Furthermore, the extracted challenges of quality of web applications are prioritized on the basis of empirical study which has never been done before. In order to achieve the objectives of this study, following research questions have been formulated;

Rq1: What are the critical challenges of web based application systems?

Rq2: What challenges are crucial for quality assurance of web based applications?

Rq3: Which challenges are more crucial than others with respect to their severity?

III. RESEARCH DESIGN

A. Sample

85 questionnaires were sent to the sampled population targeted for this study. However, only 63 responses were received at the rate of 75%. Before sending the questionnaire, a pilot test was also conducted with four experts in order to check the validity and consistency of the items of the survey. The experts were selected from software industry on the basis of their experience in developing web based applications. It is pertinent to highlight that targeted experts are having at least 5 years of experience in the domain. Table I tabulates the demographic detail of the respondents.

TABLE I
DEMOGAPHIC PROFILE

Demographics	Frequency	Percent
Gender:		
Male	33	50.76
Female	32	49.23
Qualification:		
MS(CS)	10	15.38
Master	55	84.61
Designation:		
Web Developer	36	50.76
Software Engineer	29	49.23

B. Data Gathering

A list of challenges was formulated after reviewing various articles, books, and published research papers from the well-known journals. Questionnaire method is used to collect the response from the practitioners (respondents). The questionnaire is designed according to the research questions which are previously discussed in section III. Data was gathered by requesting the experts to rate each challenge by using Likert Scale from unimportant (1) to most important (5) according to their severity level. The scale values which was assigned to five responses as shown in Table II.

TABLE II
LIKERT SCALE

Scale Value	Agreement Level
1	Un Important
2	Least Important
3	Neutral
4	Important
5	Most Important

C. Data Analysis

In order to find answers to RQ1, an exhaustive study of existing literature was conducted and 22 challenges of web based application systems were identified as illustrated in Table III. The identified challenges encountered by developers in diverse perspectives like user, designing and development. In order to obtain the answer of research question RQ2, identified challenges are extracted which relate to the quality assurance of web based application systems. For this purpose PCA is deployed on the survey responses, the survey was conducted among the practitioners, the calculated results of PCA are shown in Fig. I and Table V. Whereas Table VI providing the answer of research question RQ3 i.e. prioritization of the extracted challenges with respect to their importance and cruciaity.

TABLE III
IDENTIFIED CHALLENGE OF WEB QUALITY

Identified Challenges	Literature
Interoperability	[ii, v]
Reliability	[xvi]
Scalability	[xvii], [xvi]
Security	[vi], [vii], [xviii]
Browser Compatibility	[xix], [xx]
Maintainability	[xiv]
Availability	[xxi]
Reusability	[xiii]
Performance	[xvi], [xxii]
Supportability	[xxiii]
Usability	[xxiv],[xxv],[xxvi]
Testability	[xxvii], [iii]
Limitation for Web Page Layout	[xxviii]
Navigation	[xxix]
Database Design	[xxx], [xxxi]
Content Design and Management	[xxviii]
User Interface Design	[xxxii], [xxxiii]
Control Flow	[xxxiv]
Integrating Different Technologies	[xxxv]
Network Load Management	[xxxvi]
Cryptic Error Message	[xxxvii]
Data Integrity	[xxxviii]
Socio culture	[xxiii]

D. Research Tools

Different statistical tools are used to analyze the data which is collected through survey such as Principle Component Analysis (PCA), Cronbach's Alpha, and Cohen's Kappa which are briefly defined below.

a) Principle Component Analysis (PCA)

PCA is used to visually assess which challenges have most variability in data. It is popular and common multivariate statistical method used for factor reduction. The purpose to deploy the Principle component analysis is to reduce the large number of challenges, the items with too small proportion (say≤0.03) can be negligible [xxxix]. The challenges are extracted using PCA are shown in scree plot in Fig. I.

b) Cronbach's Alpha

Cronbach's alpha is used to measure the internal validity and reliability of the data. It ranges from 0.7 to 1.0. The greater value shows the higher reliability of the data [xl]. The value of our result is 0.87 which depicts thatthe data is reliable.

c) Cohen's Kappa

Kappa coefficient measures the categorical agreement between two ratters or methods [xli]. The strength agreement value of kappa statistics should be ≤ 1.0. The strengths of raters agreement obtained is 0.74 which is substantial according to[xlii] as shown in Table IV.

TABLE IV
LEVELS OF AGREEMENT

Agreements	Values
No Agreements	≤0
Slightly Agreement	0.01–0.20
Fair Agreement	0.21–0.40
Moderate Agreement	0.41– 0.60
Substantial	0.61–0.80
Almost Perfect	0.81–1.00

IV. RESULTS

Mean values of responses which are collected through survey are arranged in descending order and are summarized in Appendix-A.

a) Extraction of Challenges

In Scree plot as shown in Fig. I, Eigenvalues are shown on the y-axis and challenges are displayed on the x-axis. As depicted in Fig. I, curve is straight after 12 challenges. So, it portrayed that 12 out of 22 challenges are most crucial on the mutual agreement based on the raters.
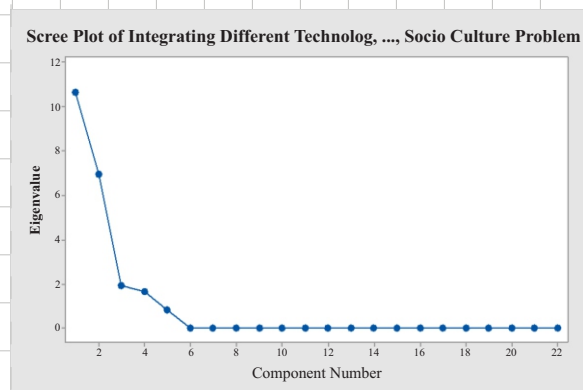

Fig. 1. Scree plot for the web based challenges

The proportion of the most crucial challenges of web based application systems is illustrated in Table V. Security is the most crucial challenge which have a big proportion value. The remaining challenges show very small proportion values and are likely to be unimportant.

TABLE V
PROPORTION LEVEL OF CHALLENGES

Variable	Proportion	Cumulative Proportion
Security	0.33	0.33
Reliability	0.16	0.49
Performance	0.12	0.61
Scalability	0.11	0.72
Availability	0.06	0.78
Usability	0.05	0.83
Supportability	0.04	0.87
Maintainability	0.02	0.89
Testability	0.02	0.91
Reusability	0.02	0.93
Data Integrity	0.02	0.95
Navigation	0.01	0.96

b) Ranking of Challenges

Mean values have been calculated for each challenge based on their raters' responses. To find the answer of third question, all challenges are then arranged in descending order as the challenges which are most significant are on the top as shown in Table VI. The total answers are five (Likert Scale) therefore the median of five values is 3. Those challenges attaining the score greater or equal to 3 are considered as crucial challenges. However, the challenges having mean value less than 3 are considered as least important challenges[xliii].

TABLE VI
PRIORITIZED CHALLENGES

Challenges	Mean
Security	4.38
Reliability	4.30
Performance	4.15
Scalability	4.13
Availability	3.96
Usability	3.95
Supportability	3.84
Maintainability	3.61
Testability	3.58

Reusability	3.50
Data Integrity	3.43
Navigation	3.40
Network Load Management	3.24
User Interface Design	3.00
Browser Compatibility	2.93
Database Design	2.90
Control Flow	2.78
Socio Culture	2.76
Integrating Different Technologies	2.73
Interoperability	2.72
Limitation for Web Page Layout	2.41
Content Design and Management	2.23
Cryptic Error Message	2.23

V. DISCUSSION

In this section the identified challenges of web based application system are described and the implications along with limitations of the study are also construed.

a) Implications

This research work furnishes various implications for the software industry in Pakistan. The prioritized challenges may be considered for the development of diverse web based applications like e-commerce, e-business, e-learning, e-banking and etc. in order to enhance the quality of applications.

b) Limitations

There are some limitations regarding the challenges of implementing web applications. The study is restricted to only one country i.e. Pakistan. Furthermore, this work is also limited by considering just the quality assurance challenges of web based application system. The most crucial challenges, extracted in this study are shown in table V providing the considerable influence on the quality assurance of web based application systems but that cannot be considered the final list of challenges.

VI. CONCLUSION

The pace of business life has become faster as compared to the past. Enterprises are exponentially burgeoning their business using web applications through internet or intranet. Consequently, web based application systems need to be developed much quicker and better as compared to earlier applications. The quality assurance of web application systems is a critical challenge to web developer because of its heterogeneous nature, and involvement of interlinked web components. Therefore, quality measurement of web based application system is not an easy task but at the same time it is crucial. There is no single design and ultimate solution for the quality of web based application systems. The research attracts the decision makers of web developers, designers and software engineers to assess the quality assurance of Web systems. Additionally, this research provides guideline to various stakeholders of web application systems for the quality assurance of their applications.

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Appendix-A

Challenges	5	4	3	2	1	Mean
Integrating Different Technologies	4	19	14	18	10	2.73
Scalability	26	27	7	3	2	4.13
Security	37	20	4	2	2	4.38
Browser Compatibility	3	13	30	15	4	2.93
Content Design and Management	6	4	11	31	13	2.23
Data Integrity	18	12	19	12	4	3.43
Reusability	23	11	17	7	7	3.50
Interoperability	7	10	16	25	7	2.72
Navigation	20	15	13	9	8	3.40
Supportability	22	25	6	9	3	3.84
Testability	24	17	9	7	8	3.58
Limitation for Web Page Layout	3	15	14	18	15	2.41
Usability	26	24	7	3	5	3.95
Database Design	6	15	15	25	4	2.90
Availability	20	27	14	2	2	3.96
User Interface Design	12	13	15	17	8	3.00
Control Flow	10	14	13	16	12	2.78
Maintainability	26	15	7	10	7	3.61
Network Load Management	10	23	13	13	6	3.24
Reliability	40	12	6	5	2	4.30
Cryptic Error Message	10	12	5	14	24	2.23
Performance	30	18	14	1	2	4.15
Socio Culture	6	10	16	29	4	2.76