An Effective Quality Model for Evaluating Mobile Websites

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Abstract-The Evolution in Web development in recent years has caused emergence of new area of mobile computing. Mobile phone has been transformed into high speed processing device capable of doing the processes which were suppose to be run only on computer previously. Modern mobile phones now have capability to process data with greater speed then desktop systems and with the inclusion of 3G and 4G networks, mobile became the prime choice for users to send and receive data from any device. As a result, there is a major increase in mobile website need and development but due to uniqueness of mobile website usage as compared to desktop website, there is a need to focus on quality aspect of mobile website. So, to increase and preserve quality of mobile website, a quality model is required which has to be designed specifically to evaluate mobile website quality. To design a mobile website quality model, a survey based methodology is used to gather the information regarding website unique usage in mobile from different users. On the basis of this information, a mobile website quality model is presented which aims to evaluate the quality of mobile websites. In proposed model, some sub characteristics are designed to evaluate mobile websites in particular. The result is a proposed model aims to evaluate features of website which are important in context of its deployment and its usability in mobile platform.

Keywords-ISO 9126 Quality Model, Key Quality Attributes, Mobile Websites, Mobile Website Development, Mobile website Quality Model

I. INTRODUCTION

Mobiles are becoming popular and have revolutionized the IT sector. In three years over 300,000 mobile applications have been developed and the frequency of downloads for these applications has been increased every year from 2010 to 2014. But these applications are not bug-free and require testing so for their verification and validation, specific testing approaches are required. The aim of a systematic software testing approach is to maximize fault detection, enabling results reproducible and to reduce influence of external factors. A study of Gartner [i] suggested that, in second quarter of 2013, the number of Smartphone sales to end users reached 225 million which is 46.5% from the 2nd quarter of 2012, which shows the increased use of mobiles. The statistical study presented by info graphics [ii] shows that 56% of people use a smart phone and people who use mobile phone as key internet source are 50% of mobile phone users. 80% of time on mobile is consumed inside apps and 72% of tablet owners purchase online from their tablets each week. This fast proliferation has intensely amplified the requirement of mobile website development and growth. As a result of this voracious appetite, enterprises and individual developers have vast amount of opening in mobile website development. There come some challenges with these opportunities and it is very difficult to have triumph in present prosperous area of mobile website development. Assessment of quality of mobile website is the one of the biggest challenge where ease of use with respect to mobile, efficiency and enactment of mobile website are core aspects for its triumph from user's point of view. Mobile website development is analogous to desktop website development but there are few aspects that differentiate mobile websites from desktop websites, some of them are the way people use mobile websites, the latency problem in mobile and multiple flavors of OS and browsers, small size of mobile, less power consumption all make it difficult to build a quality website specifically for mobile. So, specific quality metrics for mobile website have to be designed to evaluate mobile website in specific which can guaranty of obtaining a positive feedback from user and so far there is no model which has been proposed to address the quality of mobile websites in particular. A survey is conducted where information is gathered from different users. This information is regarding problems they face while using website on mobile. On the basis of above information a thorough knowledge of constraints imposed on website by mobile platform is obtained. Specific metrics are then designed to address identified constraints. On the basis of these constraints a framework is build to assess mobile website quality which will help testers to test websites in mobile environment.

This paper includes following sections. Section II presents Literature review associated with mobile websites and mobile applications. Section III presents proposed Quality model for evaluation of mobile

websites. In Section IV Quantitative comparison is done and Section V concludes our study while Section VI presents future work.

II. LITERATURE REVIEW

The mobile website and mobile application are quite similar in a way people use it, the limited hardware and memory processing problems, multiple flavors of OS and browsers etc. are all common problem in context on mobile application or website development. But there is a key difference between mobile application and websites i.e. mobile websites are retrieved through a web browser, usually use an inert menu of navigation, needs an Internet connection and has restricted features compared to most mobile apps while mobile applications are first being installed and then can be accessed on a mobile device, typically has an communicating user interface, can be retrieved offline and can make use of phone features such as camera, accelerometer, etc.

Evaluating usability of mobile website is one of the key factors as it gives us direct response from user regarding website's ease of use. Reference [iii] focused on usability of mobile websites and to evaluate the usability of mobile websites, introduced a usability evaluation tool to use it in Guided-Based Usability Evaluation Model(GBUAM) in which an evaluation tool named Usability Evaluator (UE) is used to evaluate the usability of mobile websites according to defined set of usability rules.

Testing of mobile websites or applications is a challenging task and is not same for both desktop websites and mobile websites. According to [iv] analyzed different mobile applications and divided into two types i.e. First, traditional applications rewritten to run on mobile devices using limited resources and driven by user-inputs, called APP4Mobile. Second type is of particular APP4Mobile called MobileApp that are driven by user actions and/or surrounding environment and produce content-based outputs. To test these applications different peculiarities were implemented on each application. The peculiarities used for testing APP4Mobile were mobile connectivity, limited resources, autonomy and user interface while peculiarities for second type i.e. MobileApp were content awareness and adaption in addition to the peculiarities of APP4Mobile. To deal with these peculiarities different dimensions were used.

Although testing a mobile application or website is hectic task but some models have been proposed like Reference [v] presented a model to test mobile applications using ISO 9126 quality model [i]. They extracted core quality attributes like Functionality, Usability, Efficiency, Maintainability, Data Integrity, Portability, Security, Suitability, Adaptability and extensibility from traditional ISO 9126 quality model because these are the key attributes which affect the quality of mobile applications. This model helps to save time by focusing only on these attributes to test mobile applications rather than all of quality attributes of traditional ISO 9126 quality model. Reference [vi] proposed a quality model to assure website quality considering the technological challenges and rapid development in interaction between customers and web. To enhance the quality from both client and server sides this model is divided into three parts. First part consists of testability, flexibility, reliability, maintainability and reusability factors, called server side factors that improve the quality of server side. Second part consists of portability, usability, privacy, standard design and correctness, called client side factors to improve quality of client side. Third part consists of some factors that influence both server and client sides named which are security, efficiency, integrity and ethics.

Along with models some frameworks also have been proposed to evaluate website quality. According to [vii] proposed a framework to evaluate website quality by discovering new special factors like Visibility, Intelligibility, Creditability, Engagability and Differentiation for quality Assessments of web applications in addition to core factors which include external factors like Suitability, Installability, functionality etc. and internal factors like maintainability, sustainability, testing.etc. These special quality factors along with core quality factors provide us a best framework to evaluate website quality in future effectively within web applications domain. Reference [viii] proposed a framework for measuring quality attributes i.e. maintainability and usability of web-based application systems. The quality of a web application can be measured from two perspectives that how much the site is maintainable for the programmers and what is usability experienced by the end-users. The diverse nature of web applications makes it difficult to measure these attributes so by some refinement in Reference [ix] i.e. Factor-Criteria-Metrics structure, a new model was proposed to maintain this rapidly changing nature of the website.

According to [x] extracted few attributes out of 15 attributes to obtain the standard for evaluating the usability of web sites. They collected data from 524 sites and analyzed it by using logistic regression to determine the quality of a site. Values for these attributes were calculated with great accuracy by using an automated tool developed in JSP. Four predictive models were built after analysis with respect to the year of collected data, in which some matrices out of these 15 matrices are selected to identify that which pages are good or bad.

Reference [xi] explained the dependency between different quality attributes by using methodologies like "experience based approach" and "online survey". Fifteen relations were defined between different quality attributes of ISO 9126 quality

model, which can be used to evaluate aggregated score for a particular website.

Reference [xii] presented a new five dimensional model considering correctness, presentation, content, navigation and interaction as five quality criteria's. These criteria's are mainly considered in context of automating the testing process for web applications and design mainly for user perspective of evaluating website who can measure the website using these criteria's objectively.

All above proposed frameworks generally aim to evaluate desktop websites and not all ISO 9126 model core attributes are covered in discussed models. Most importantly, existing research work on mobile website testing is very limited. Although According to [v] presented a model to test mobile applications but no attempt has been made to evaluate mobile websites in specific which are different from mobile applications. Therefore, we aim to provide a framework which will evaluate quality of mobile websites covering all ISO 9126 core attributes. Our proposed model would help testers to evaluate mobile websites quality thoroughly. It aims to focus on those quality areas of website which are critical to its deployment and usage in mobile phones.

III. Mobile Website Quality Model

Mobile website development although fairly analogous to mobile applications but differ in variety of operating system, devices and networks, latency problem, non-conventional usage of websites in mobile, no hover state in mobile and limited screen size all are major holdups in their way. So there is a requirement to have quality criteria for mobile websites to follow, to validate both functionality and quality of mobile websites. Old-fashioned ISO 9126 quality model [xiii] underline all the quality characteristics for quality evaluation of websites in general, but these attributes are abundant and are not feasible to evaluate mobile websites. The proposed research paper mainly focus on constraints which mobile environment imposed on website. These constraints are due to limited processing ability, small screen size etc. Different information gathering techniques are used to obtain information about these constrains from mobile users like one to one interviews, group interviews, observation and questioning. Different blogs have been visited to have a sufficient knowledge of problems which mobile user face while using website on mobile. By making these problems as a baseline, a quality model has been proposed. Different distinctive quality attributes/metrics are defined to address these identified problems. For each ISO9126 core quality attribute, specific metrics are defined which are related to that core attribute. These matrices will help tester to evaluate mobile website efficiently and result will always be a better quality Website.

A. Portability [xiv]

1) Cross Browser

Websites should be able to perform along different browser like Firefox, safari etc. with same performance and efficiency.

2) Cross Platform

Websites should work similarly along different platform like iOS, android etc. with same performance and efficiency.

3) Cross Devices

Websites should appear properly having same User interface (UI) and perform with same efficiency along different mobile devices which may have different processing capacity.

B. Usability [xv]

1) Context Preservation

The common problem with long form having large amount of data in mobile is that due to small screen often user forget what user have entered previously. The solution is that context can be preserve, Summary screen or header fixed at top of form can be used to maintain context so that user remain informed about what is going on.

2) Smooth Navigation

In navigation menu, emphasize should be given to those pages that are most valuable to mobile website users. Google Analytics can be used to determine which pages users have already visited through mobile i.e. which are important. Some pages on desktop site might not even be necessary in the mobile context, so they should not be used in menu and user needs should be given priority.

3) Graphics and Color Scheme

One of the basic requirements for mobile website is to have a right distinction between the background and content of website. Appropriate level of contrast makes content of mobile website understandable and easy to read. Lacking correct amount of contrast makes it very tough for users to read website content and this problem become more severe when website content are viewed on mobile where limited screen size is a critical constraint on reading web content effectively.

4) Formatting and Positioning of Elements

The size and proximity of all clickable elements such as navigational links, control button etc. are checked to evaluate their positioning and size so that in accurate clicks and fat finger problem can be avoided [xvi-xvii].

5) Heterogeneous Input Compatibility

The multiple input types for mobile like touch, keypad. Virtual keyboard, track ball/wheel and pointer

should be checked against website to check its compatibility against different input methods.

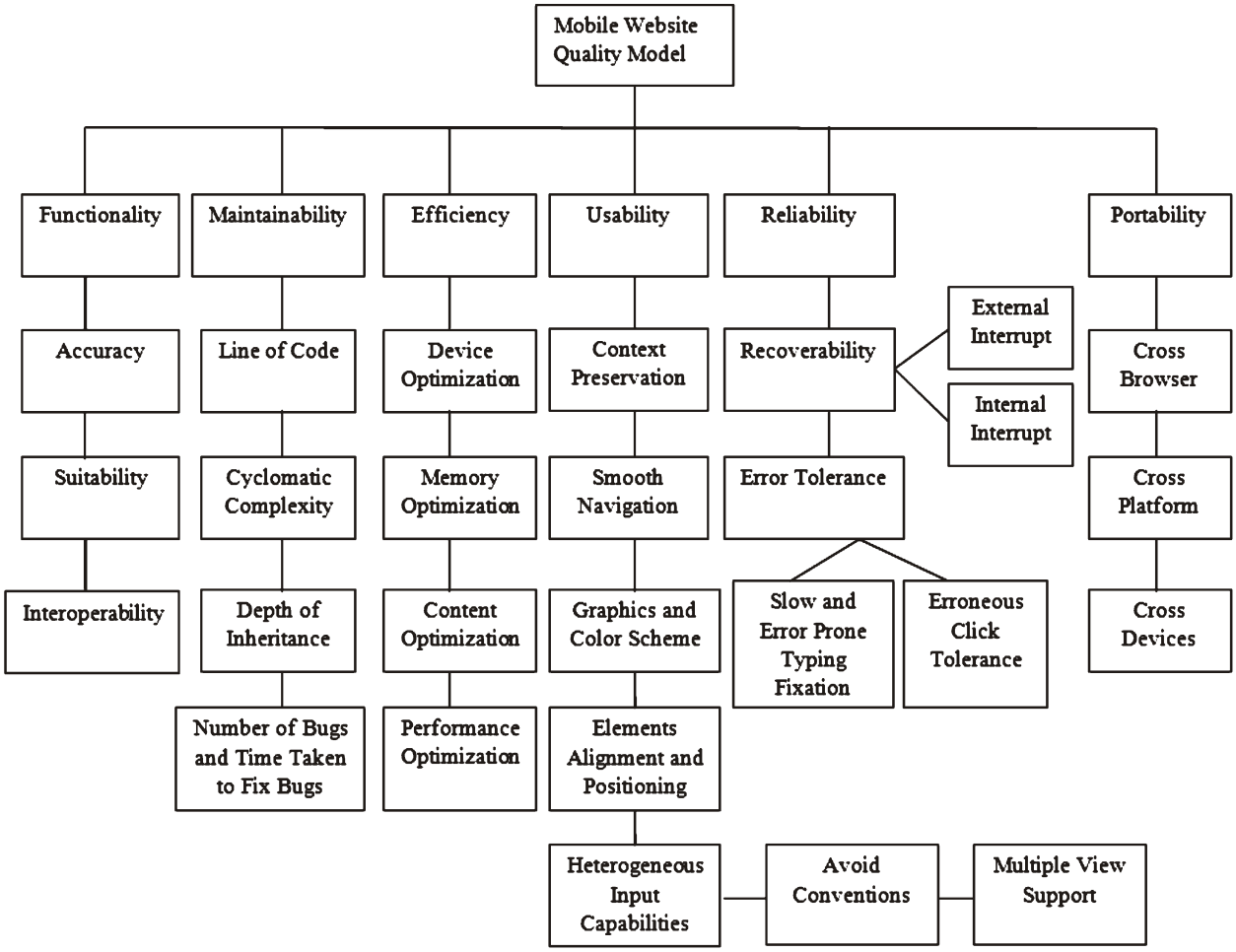

Fig. 1. Proposed Model

6) Avoid Conventions

Mobile web sites don't have "hover state" that is challenging for website with lots of content so we have to keep all navigational related elements (buttons, links) prominent or visible also avoid any assumption that mobile users will use mobiles websites in a conventional way. So, use of any convention should be avoided.

7) Multiple view support

Website should be checked to see that its work equally good in devices with different sizes like tablets, smart phones of different screen size and also, website should be checked along different view types available in phones like landscape, portrait.

C. Reliability [xviii-xix]

With reference to ISO 9126 model [xiii] reliability for mobile website can be measured in term of following factors:

1) Recoverability

The property of being able to recover from internal or external interrupt. Internal interrupt includes call/message interrupt, device shutdown, remove battery, camera activated etc. and External interrupt include loss of internet connectivity, electromagnetic interference etc.

2) Error Tolerance

The ability of system to tolerate errors. There are two types of error handling which can be useful while testing mobile website error tolerance capability.

i) Erroneous Click Tolerance

It measures how much a website provide fixation to in accurate clicks which can be fixed via providing confirm scenarios or confirmation checks which makes sure that

each input is subjected to confirmation so that wrong input can be discarded. Auto complete, inline validation, address validator can be used for correcting user input.

ii) *Slow Typing Fixation*
The small screen size of mobile often limit input typing speed so it is a better option that typing has to be absolute minimum which can be done using pre select or default text. Auto complete option can also be used to facilitate user and to increase typing speed.

D. Efficiency [xx-xxi]

1) Device Optimization

For mobile websites the issues of low memory and slow processing speed have to be considered in mind as different mobile devices have different processing capabilities. Also, mobile phones have limited hardware capabilities as compared to desktop systems. Because of that, it is required to consider not only user who is interacting with websites but also, device which is being used to perform required operations. So, there should be a standard development pattern which should be acceptable for making a mobile website capable of running on different devices having different performance and processing capabilities.

2) Memory Optimization

The limited memory on mobile phones and its usage in browsers often creates memory issues. Simple processes, such as we add a new node into the Document Object Model (DOM) [xxii-xxiii], can generate memory issues if not handled properly, which cause the browser to become sluggish or impassive and ultimately crashes. Images are major area of apprehension regarding memory which are loaded in the DOM, regardless of their visibility on the screen, uses extra memory. One possible way to avert this is frequent elimination of elements from the DOM when not required. So reduction in image dimensions, numbers and avoidance of flash in a mobile website is one way to achieve memory optimization.

3) Content Optimization

Content optimization is actually a way to make web content attractive for limited screen reading by using CSS in your coding. It can be achieved by reducing the image sizes and simplifying fonts and content so that it can quickly scan and mobile search and strategically sprinkling them throughout your pages. Avoidance of content duplication can also be used to optimize content.

4) Performance Optimization

Mobile devices have comparatively weak hardware and processing capability so building a website with acceptable performance speed is a major area of concern. The following are some suggestions which can increase website performance speed considerably.

i) *External Dependency Reduction*
Less files to download means fewer HTTP requests are to process which ensure faster loading times and increased performance. Otherwise, long loading time often limits mobile website efficiency.

ii) *Images Usage Reduction*
Valuable processing power and memory are used to store and manage high-resolution images so by reducing image size, numbers and resolution, we can improve performance of a mobile website by decreasing its loading time.

iii) *Client-Side Processing Reduction*
Careful consideration for the use of JavaScript and keeping it to a minimum are best, so that minimum processing time is lost on processing client side requests and validations which increase website performance.

iv) *Latency problem*
Latency is actually the amount of time a server takes to receive and process the user's request for a page object which depends on how far away the user is from server. Any internet connection can transfer a definite quantity of data in limited timescale which is called Bandwidth. Latency put constraint on users to achieve that maximum bandwidth even their connections have capability to handle it. So it must be properly managed to improve performance.

E. Maintainability [xxiv]

1) Line of Code (LOC)

Software metric that is used to assess the size of a source code written for any application by counting the number of lines of that code. This metric is easy to use because we can easily count up lines of code but it depends on the developer and the language used to develop the program. Two major types of LOC exist in the code: Physical LOC and Logical LOC. Physical LOC counts lines of a source code including comments and blank lines and are sensitive to logically unrelated formatting and styling conventions. On the other hand Logical LOC counts number of executable statements and are less sensitive to formatting and styling conventions. If LOC of a code is greater, code is more complex and will require more testing effort and time. Lines of code can be counted using two measurement units LOC and KLOC but we have to wait until the system is implemented completely.

2) Cyclomatic Complexity

Cyclomatic complexity [xxv] is software metric to provide a quantitative measure of the global complexity of a program to measure the testing efforts

required to test any application. If a code has greater cyclomatic complexity then code is more complex and will require more testing time and effort. Cyclomatic complexity is computed using control flow graph of the program in which nodes are used to represent one or more procedural statements and to represent flow of control from one node to another arrows called edges are used. Cyclomatic complexity is based on graph theory and measures the number of linearly independent paths comprising the program. Cyclomatic complexity V (G) is computed in three different ways:

The numbers of regions of the flow graph correspond to the cyclomatic complexity.

V (G) = E-N+2 where E is the number of edges and N is the number of nodes in flow graph.

V (G) = P+1 where P is the number of predicate nodes i.e. node containing a condition, in the flow graph.

Cyclomatic complexity helps to predict testing effort, defects, maintenance costs etc.

3) Depth of Inheritance

Depth of Inheritance also called Depth of Inheritance Tree (DIT) is the maximum length from the node to the root node of the tree. In multiple inheritance an application may consist of different number of classes inheriting methods of different classes and the DIT of a class is the maximum distance between the class and the root node. A deeper class in the inheritance tree will be more likely to inherit the greater number of methods from parent classes which makes difficult to predict its behavior and it becomes difficult to maintain the application. So, DIT should not be greater than 4 as it compromise Encapsulation and increases complexity.

4) Number of Bugs and Time taken to fix bugs

A software bug [xxvi] is any event in the program that causes an unexpected behavior. A code with more number of bugs will be difficult to maintain and will take more time to fix bugs. So it is required to avoid bugs to avoid failures to occur in the code and make maintainability an easy task.

F. Functionality [xxvii]

1) Accuracy

Accuracy is the measurement of how correct an application behaves in response of any input and produces expected output exactly without any error. A mobile application will be accurate if it produces expected output corresponding to the provided input. It includes testing of controls, storage media and other operational aspects to check how exactly everything is performing.

2) Suitability

Suitability is concerned with an investment strategy that meets the objectives and means of an investor. It is the degree to which something is suitable for a particular purpose. A Mobile application or website will be suitable if it performs a particular task for which it is designed and fulfills the customers' requirement by providing expected output. Basically it is strategy to check how much the website is appropriate for the purpose that is needed.

3) Interoperability

Interoperability is the ability of an application to communicate with other applications to exchange data and use this exchanged data. Basically it is a testing type of mobile websites to check that how will it perform when a website has to interact with database or any other website to process a request.

IV. Quantitative Comparison

Most models proposed for evaluating mobile websites or applications focus only on certain quality factors presented by ISO 9126 model [xiii]. Reference [iii] model for evaluating mobile website focuses only on usability aspect of mobile websites. Signore proposed quality model focuses only on functionality and usability aspect of mobile application while model proposed by references [iv-v] focuses on functionality, usability and maintainability of mobile applications. Table I shows the comparison of attributes discussed between models. Until now, no model has been proposed specifically to address the quality of mobile websites as there is difference between mobile website and application. Although, models have been proposed to evaluate mobile applications. The unique aspect of proposed model as shown in Table I is that it provides framework to evaluate mobile websites in specific and also covers all core key ISO 9126 quality factors and present a set of sub characteristics to evaluate all ISO 9126 core quality attributes in context of mobile website quality evaluation. To further elaborate the effectiveness of proposed model, the Graph 4.1 shows the feasibility and effectiveness of model where on x-axis different models are given and on y-axis no of attributes of ISO 9126 model are given which are six in total i.e. Functionality, usability, efficiency, portability, reliability and maintainability. Thus, we have an overall evaluation of number of quality attributes discussed by different models. Our presented model focus on all attributes of ISO 9126 model with respect to mobile website quality evaluation. In comparison to our proposed model, all other models focus only on certain attributes while proposed model underline all quality attributes. Thus, it provides a diverse view of quality of mobile website by covering all major features for evaluation.

V. CONCLUSIONS

This research work presented a quality model to evaluate mobile website quality which is actually an extension of ISO 9126 quality model [xiii] and will help in development of high quality mobile websites. This is generic model for mobile websites aims to evaluate features of website which are important in context of its deployment and its usability in mobile environment; it can be enhanced to specific domain which can increase its efficiency. This paper main focus is to point out those factors regarding mobile websites which are critical and can limit website efficiency in mobile environment.

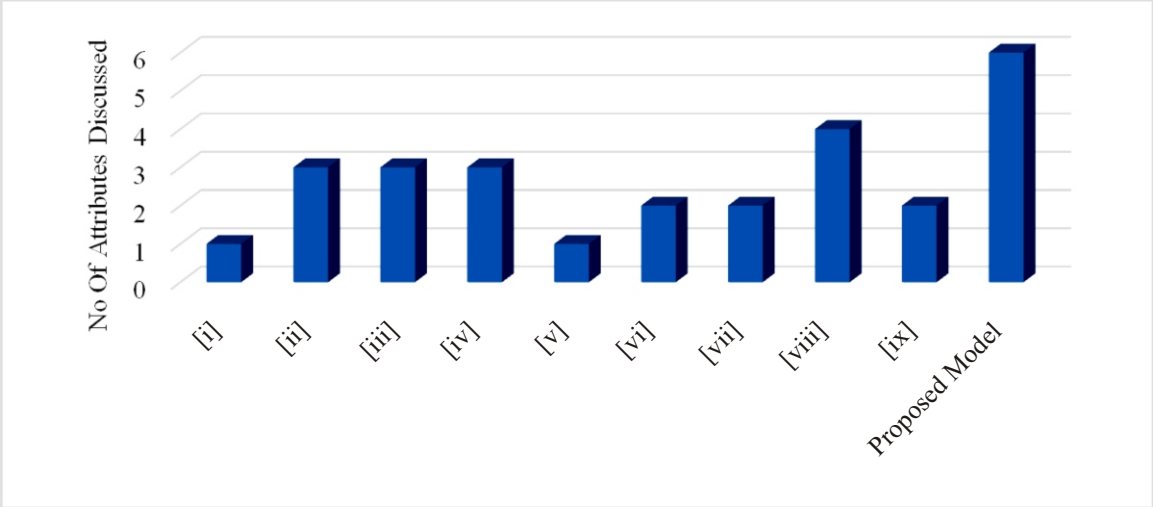

Fig. 2. Models comparison

TABLE I
COMPARISON BETWEEN MODELS

Models	Quality Attributes					
	Functionality	Usability	Maintainability	Efficiency	Portability	Reliability
Bahadir et al. [i]	X					
Henry et al. [ii]	X	X		X		
Sobia et al. [iii]	X		X		X	
Emad et al. [iv]	X	X	X			
Ronan Fitzpatrick [v]		X				
Ben et al. [vi]		X	X			
Yogesh et al. [vii]	X	X				
Hazura et al. [viii]	X	X	X	X		
Signore et al. [ix]	X	X				
Proposed Model	X	X	X	X	X	X

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