A Systematic Review on Measuring and Evaluating Web Usability in Model Driven Web Development

[1]S.Sai Aparna, [2]K. K. Baseer
[1]Department of Information Technology, SreeVidyanikethan Engineering College,Tirupati, India
[2]Assistant Professor, SreeVidyanikethan Engineering College, Tirupati, India
[1] appu.samudrala@gmail.com, [2] kkbasheer.ap@gmail.com

Abstract—The unquestionable relevance of the web in our society has led to an enormous growth of websites offering all kinds of services to users. In the field of software engineering usability defines software system demand and use. HCI is the study of interaction between human and computer and one of the key aspects of the study is usability. Usability is considered to be one of the most important quality factors. To help software engineers set of usability guidelines are defined for software development. A web application or web app is any application software that runs in a web browser and relies on a common web browser to render the application. Usability has been evaluated taking into account the user's satisfaction by using different evaluation methods. To evaluate usability of web applications, WUEP (Web Usability Evaluation Process) method is proposed. In this paper we present WebML, a notion for specifying complex websites at the conceptual model. To measure the usability different metrics are proposed. Additionally, to perform experts evaluation based on heuristics a Sirius framework is defined.

Index Terms—Usability, web application, evaluation methods, quality factors.

I. INTRODUCTION

Software systems playa crucial role in our daily life. Software systems are developed to provide particular functionality that reduces human effort and supports a person to do a certain task in a specific context [22].Software development is classified with four concerns:

- Features
- Time to market
- Cost
- Quality

What is Quality?

"*Quality comprises all characteristics and significant features of a product or an activity which relate to the satisfying of given requirements".* - (DIN 55350-11) [27]

"The totality of characteristics of an entity that bear on its ability to satisfy stated and implied needs" - (ANSI standard)

What is software quality?

"Software quality is (1) the degree to which a system, component, or process meets specified requirements. (2) The degree to which a system, component, or process meets customer or user needs or expectations [16] - (IEEE 610.12-1990)

Software quality factors [29] are:

1. Usability
2. Reliability
3. Performance
4. Safety
5. Modifiability

Importance of usability is,it expresses the relationship between software product and "external" quality [20]. Usability was derived from the term "user friendly" but is often associated with terms such as usefulness, ease of use, quality of use etc. According to different authors usability can be defined as

The cost/effort to learn and handle a product (McCall et al, 1977)

The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. (ISO 9241-11)

The capability in human functional terms to be used easily and effectively by the specified range of users, given specified training and user support, to fulfill the specified range of tasks, within the specified range of scenarios (Shackel, 1991)

Usability Models:
Shackel model (1991), defines usabilitybased on four scales namely: Effectiveness, Learn ability, Flexibility and Attitude [1]. These scales further decomposed, for example learn ability is decomposed into measurable indicators such as retention and time to learn [30].

Eason's Model (1984), defines usability with task, user, and system characteristics and user reaction.

ISO 9214-11(1998), this model explains usability with the effectiveness, efficiency and satisfaction.

ISO 9126(2001), this model mentioned usability as understandability, attractiveness, learn ability, operability and usability compliance.

Usability should be measured based on combination of two different views:
• **Objective view:** Usability can be measured by analyzing how a user interacts with the software (learn ability, efficiency, and reliability).
• **Subjective view:** Usability can be measured by analyzing what a user thinks of the product (satisfaction/ attitude).

Product oriented design: In this design usability considered as a product attribute [5]. Some examples are:

- Design Heuristics
- Interface Guidelines
- Interaction Design patterns

Process oriented design: To make software usable it collects functionality by analyzing users and tasks. For analysis bundle of techniques are used, the techniques are:

- Usability testing techniques
- Usability inspection techniques
- Usability inquiry techniques

According to studies of software engineering, several organizations spend a large amount of time and money on fixing usability problems during last stage of development. According to studies of pressman, 80% of total maintenance costs are related to problems of the user with system. Among these costs, 64% are related to usability problems. Lederer and Prassad, 1992 stated that large amount of maintenance costs is spent on dealing with usability issues.

II. SOFTWARE ARCHITECTURE

In recent years the software engineering community has come to the understanding that the software architecture is an important instrument in the fulfillment of quality requirements [3] [15].

The structure or structures of the system, which comprise software elements, the externally visible properties of those elements, and the relationships among them. (Bass et al, 1998)

The fundamental organization of a system, embodied in its components, their relationships to each other and the environment, and the principles governing its design and evolution (IEEE, 1998)

According to Bonnie John et al., the architectures of the 1980s and 1990s usability were considered as a property of the presentation of information. To made usability both software architects and usability professionals understood the relationship between architecture and usability early [21] [22] .According to Bass et al, 1998 software architecturedefined as
• **Communication**
• **Evaluation**
• **Design:**
Software architecture objective is to fulfill the requirements which can be classified into two types [16]:

- Functional requirements define what the system needs to do (e.g. "backup my hard drive")
- Non Functional requirements describe how the system will do it (e.g. "backup my hard drive without crashing"). Nonfunctional requirements are often associated with software quality requirements e.g. the "ilities" such as usability, maintainability, etc.

"Usability engineering, also known as human-computer interaction engineering, is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and the study of major phenomena surrounding them".
Usability engineering has several benefits:

- Improve software

- Save customer's money
- Minimize engineering costs

III. RELATED WORK

Stefano CeriŁ, PieroFraternali, Aldo Bongio, Main goals of software industry is designing and maintaining web applications, we presenting WebML, a notation for specifying complex websites at the conceptual level. WebML describes a website under distinct orthogonal dimensions: Structural model, composition model, navigation model, presentation model, personalization model. WebML specifications are independent of both client- side language and server-side platform. It guarantees a model-driven approach to website development [24].

Ankita Madan, Sanjay Kumar Dubey, for all software quality models usability is an important quality factor.Lack of usability leads to substantial monetary loss, time wastage, user dissatisfaction, staff unproductively. Usability correlates with the functionality of the system. Usability models are: Eason's model, Shackel model, Nielsen model, ISO 9214-11 model, ISO 9126 model [4].

Adrian Fernandez Martinez, for web applications usability is considered to be one of the most important quality factors. Majority of web development process do not take advantage of the software artifacts produced at the design stages. Performing usability evaluations on these artifacts can be difficult [6].

Fernando Molina, AmbrosioToval, Web Engineering development projects have grown increasingly complex and critical to the smooth running of organizations. Recent studies reveal that a high percentage of these projects fail to attain the quality parameters required by stakeholders. To reduce some of the quality failures detected in web engineering development projects by proposing the consideration and evaluation of quality attributes from early stages of the development process. Once the requirements are identified, the approach focuses on the extension of the conceptual models used by Web Engineering methodologies with the aim of allowing the explicit consideration of usability requirements along with the evaluation of quality metrics during the design of the system [12].

Ahmed Seffah · Mohammad Donyaee · Rex B. Kline · Harkirat K. Padda, There are many individual methods for evaluating usability they are not well integrated into a single conceptual framework. The consolidated model is called Quality in Use Integrated Measurement (QUIM). It also explains how this can help in developing a usability measurement theory [23].

Laura Carvajal, Ana M. Moreno, Maria-Isabel Sanchez-Segura and Ahmed Seffah, According to software development process and software architecture used in each application design artifacts can be used. Use of guidelines reduces [1]

- Development time.
- Improves the quality of designs.
- Decreases the perceived quality.

IV. WEB APPLICATION

A Web application (Web app) is an application program that is stored on a remote server and delivered over the Internet through a browser interface [6]. Types of web applications are:

- Web mail
- Online retail sales
- Online Auctions
- Wikis

Web applications are provided by software that is distributed, implemented in multiple styles and languages, integrates reuse and third-party components [13]. Web applications are made up of group of people, using technologies, HTML files and programs. To build this type of web software new and unique challenges are found by software developers and managers. For success of web applications the important quality factors are:

1. Reliability
2. Usability
3. Security

Jakob Nielsen explained the usability of web application with the statement "On the internet, your competition is only one click away", means while using a web application users get frustrated when not achieving their needs quickly [6].

Table 1: Usability principles

Constantine & Lockwood (1999)	ISO 9241-11 (1998)	Schneider man (1993)	Nielsen (1993)	Preece et al., (1994)	Shackel (1991)
Efficiency in use	Efficiency	Speed of performance	Efficiency of use	Through put	Effectiveness (Speed)
Learn ability		Time to learn	Learn ability (Ease of learning)	learn ability (Ease of learning)	Learn ability (Time to learn)
Remember ability		Retention over time	Memorability		Learn ability (Retention)
Reliability in use		Rate of errors by users	Error/ Safety	Through put	Effectiveness (Error)
User satisfaction	Satisfaction (Comfort & acceptability of use)	Subjective satisfaction	Satisfaction	Attitude	Attitude

Table 1 shows, Usability explained by different authors by using principles like Efficiency in use, learn ability, rememberality, reliability in use, user satisfaction [12]. Nielsen'susability principles can be mentioned as
Web application learn ability: Itrepresents the ease for Web users to understand the contents and services through application and easily look for particular information by browsing.
Webapplicationsefficiency: It means users find their contents efficiently through web application.
Memorability: It implies that, users forget after some period of time how to get back his previous data, by using navigation bars users can easily point out to their pages.
Fewerrors: It means that if users did any erroneous work, they should be able to return to their location.
User'ssatisfaction: Finally refers to the position in which users feel that they are in control with respect to the hypertext.

Offutt stated that along with reliability and security, usability is main quality factor for web application. To address web usability issues variety of methods, techniques and tools are used.
Advantages of Web Applications:

- Ubiquity of web browsers.
- Convenience of using a web browser as a client.
- Sometimes as a thin client.

Usability issues benefiting both web developers and end-users. Some of the benefits are Reduction in cost (development, maintenance, and support stages), Increase in user productivity, direct impact on sales and scope, better marketing.

In the field of HCI [7], usability definition proposed in ISO/IEC 9241-11(1988) standard- "*The extent to which a product can be used by specified users to achieve specific goals with effectiveness, efficiency and satisfaction in a specified context of use*". It deals when product can be used. This standard moved to ISO/IEC 9241-210(2010) to deal when product, system or service used.

In Software Engineering, usability proposed in standard ISO/IEC 9126-1(2001), "*the capability of the software product to be understood, learned, operated, attractive to the user, and compliant to standards/guidelines, when used under specific conditions*" . It uses in the early stages of development process and the main objective of this is predicting usability problems.

V. UEMs (USABILITY EVALUATION METHODS)

Definition: It is a process that is used to produce a measurement of usability or is a systematic procedure for recording data relating to end-user interaction with a software product or system [4].
UEMs developed to evaluate WIMP interfaces
W-Window
I-Icon
M-Menu
P-Pointing device
Evaluation Methods:

- Empirical
- Inspection

Empirical Methods: Evaluation performed by the end-users involvement. Capturing and examining usage data from real end-users. End-users employ software product to complete a predefined set of tasks. While tester records outcomes of their work. We can get useful information by analyzing these outcomes [4]. This information is used to detect problems.

Disadvantages:

- Empirical methods are not cost effective.
- It requires large amount of resources
- Evaluation done at last stages of web development process.

Inspection Methods: Evaluation performed by evaluators and designers no need of end-users involvement. Reviewing the usability aspects of web artifacts (user interfaces) models, their conformance with a set of guidelines.

Advantages:

- It requires less resources
- Cost effective.
- Evaluation performed at early stages.

Problem: The artifacts which are delivered at requirement and design stages are not considering by many of the web development processes. Performing usability evaluations on artifacts is difficult because of not understanding the traceability software artifacts and web applications.

Solution: The problem is facilitated in Model-Driven Web Development (MDWD) processes in which intermediate artifacts (models), which represent different perspectives of a Web application, are used in all the steps of the development process, and the final source code is automatically generated from these models.

MDWD Process:

- MDWD processes break up the Web application design into three models: content, navigation and presentation.It allows establishment of levels of abstraction.
- An MDWD process fundamentally translates models that are (i.e., Platform-Independent Models - PIMs) such as structural models, navigational models or abstract user interface (UI) models into other models that contain specific aspects from a specific technological platform (i.e., Platform-Specific Models - PSMs) such as concrete user interface models or database schemas.
- To develop the source code of the final Web application (Code Model - CM) PSMs are automatically compiled.
- This approach is followed by several methods such as: OO-H (Gómez et al. 2001) or WebML (Ceri et al. 2000).
- Usability problems which are presented in final web applications are detected by considering traceability among these models. And also provides recommendations to correct these problems in the early stages of development process.

Web usability evaluation methods:

The ease or difficulty experienced by users largely determines their success or failure. Development of more usable Web applications has promoted the emergence of a large number of usability evaluation methods. The main goal of web engineering is defining methods for ensuring usability [13].

1. Heuristic Evaluation
2. WUEP(Web Usability Evaluation Process)

Heuristic evaluation:

One of the most common usability guidelines is the Nielsen's set of ten usability heuristics(Nielsen 1993) Riihiaho (2000) suggests that the output of a heuristic evaluation be a list of usability problems. The list should state the heuristic rule that the problem violates and the severity of the problem [25].

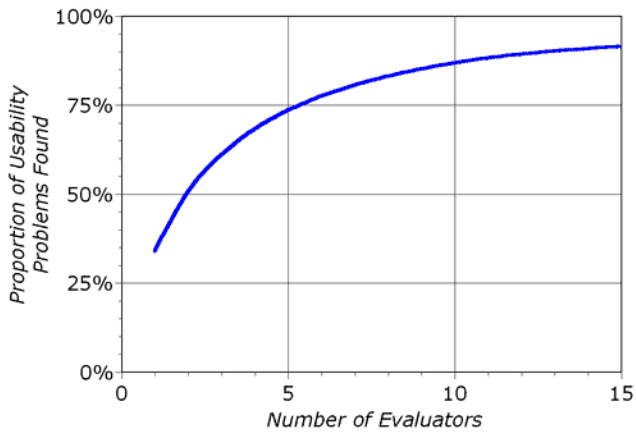

Figure 4: Heuristic evaluation performed by number of evaluators

Figure 4showthat different number of evaluators performed heuristic evaluation to detect percentage of problems. From the curve it is evident that reasonable results can be obtained by having only five evaluators, and certainly not less than three.

WUEP (Web Usability Evaluation Process):

To address web usability issues, usability inspection method (Web Usability Evaluation Process – WUEP) is proposed, which can be instantiated and incorporated into different model-driven Web development processes. Inspections of the PIMs and PSMs can provide early usability evaluation reports to identify potential usability problems that can be corrected prior to the generation of the source code. The Web Usability Evaluation Process (WUEP) has been defined by expanding and polishing the quality evaluation process that is proposed in the ISO 25000 standard. The aim of WUEP is to integrate usability evaluation into model-driven Web development processes by applying a Web Usability Model as the primary inputartifact [6]. This model breaks down the usability concept into 16 sub-characteristics and 66 measurable attributes, which are then associated with 106 measures in order to quantify them. These measures provide a generic definition, which should be operational zed in order to be applied to models obtained at different abstraction levels (PIMs, PSMs, and, CMs) in different MDWD processes (e.g., WebML, OO-H).

The main stages of WUEP are:

1**. E*stablishment of the evaluation requirements* stage**, the evaluation designer defines the scope of the evaluation by

(a) Establishing the purpose of the evaluation

(b) Specifying the evaluation profiles (type of Web application, Web development method employed, context of use)

(c) Selecting the Web artifacts (models) to be inspected

(d) Selecting the usability attributes from the Web usability model which are going to be evaluated.

2. S*pecification of the evaluation* stage, the evaluation designer operationalizes the measures associated with the selected attributes in order for them to be applied to the models to be evaluated. This operationalization is to define a concept or variable represented in the Web artifacts (modeling primitives of models or UI elements in the final Web application) so that it can be measured or expressed quantitatively. In addition, thresholds are introduced for range of values. These thresholds provide a usability problem classification based on their severity: low, medium, or critical [17]. It is significantly note that the operationalization should be performed once within a specific model-driven Web development method, and can be reused in future evaluations that involve Web applications developed using the same method.

3. Design *of the evaluation* stage, the template for usability reports is defined and the evaluation plan is elaborated (e.g., number of evaluators, evaluation constraints).

4. E*xecution of the evaluation* stage, the evaluator applies the measures to the selected Web artifacts (i.e., models) in order to detect usability problems by considering the rating levels established for each measure.

5. A*nalysis of changes* stage, the Web developer analyzes all the usability problems in order to propose changes with which to correct the affected artifacts from a specific stage of the Web development process. The changes are applicable to the previous intermediate artifacts (i.e., PIMs, PSMs and model transformations if the evaluation is performed on the final Web user interface).

VI. MUSIC (METRICS FOR USABILITY STANDARDSIN COMPUTING) METHODS

Music (Bevan, 1995, Macleod et al., 1997) was developed at the National Physical Laboratory, UK, for the purpose of quantitative and qualitative data required to support usability engineering. This method evaluates the measures of effectiveness and efficiency [12] [14].

DRUM (Diagnostic Recorder for Usability Measurement):

Purpose: Record video clips of end-users working with a system provide convincing evidence for designers and developers of 2 us abilities of their system and specific problems [24].

Advantages:

1. It can be used in real time to collect and store usability evaluation data and mark up evaluator defined critical incidents for diagnostic evaluation [25].
2. Supports retrospective analysis which has previously been very time consuming.

Effectiveness:

As Quantity and Quality are both measured as percentages, Task Effectiveness can be calculated as a percentage value:

Task Effectiveness = 1/100 (Quantity x Quality) %

Quantity: It a measure of the amount of a task completed by a user.

Quality: It is a measure of the degree to which the output achieves the task goals.

Efficiency:

Measures of efficiency relate the level of effectiveness achieved to the expenditure of resources.

Temporal Efficiency = Effectiveness/Task Time

Productive Period:

The Music Performance Measurement Method defines the productive period of a task as the proportion of the time a user spends on the task building towards the task goals, regardless of whether the goals are eventually achieved. The Productive Period of a user is

Productive period = Task Time - unproductive time /Task Time x 100%

Measures of Learning:

Relative User Efficiency =User Efficiency x 100%/Expert Efficiency

Software Usability Measurement Inventory (SUMI):

SUMI was developed by University College Cork Software Usability Measurement Inventory as part of the Music project (Kirakowski, Porteous and Corbett, 1992). It evaluates software system qualityfrom the view of end user's. It consists of industry standardized questionnaire statements which are answered by the user according to whether they Agree, Don't Know, or Disagree [12].

VII. WEBML (WEB MODELING LANGUAGE)

Major challenges for the software industry is designing and maintaining web applications [24]. WebML, a reference for determining complex web sites at the conceptual level. WebML dimensions are:

1. Structural Model/Data Model
2. Hypertext Model
    - Composition Model
    - Navigation Model
3. Presentation Model
4. Personalization Model

WebML specifications are independent of both the client-side language used for delivering the application to users, and of the server-side platform used to bind data to pages, but they can be effectively used to produce a site implementation in a specific technological setting. It guarantees a model-driven approach to Web site development, which is a key factor for defining a novel generation of CASE tools for the construction of complex sites, supporting advanced features like multi-device access, personalization, and evolution management. The WebML language and its accompanying design method are fully implemented in a pre-competitive Web design tool suite, called Toriisoft [23].

(1) *Structural Model*, shows the data content of the site, in terms of the relevant entities and relationships (See Fig 3). WebML does not usingany other language for data modeling, but is compatible with classical notations like the ER model, the ODMG object-oriented model, and UML class diagrams [6].

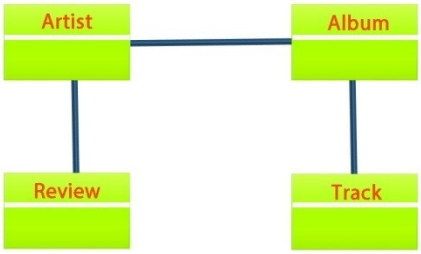

Figure 3: Example for Structural model

(2) *Hypertext Model*depicts one or more hypertexts that can be released in the site. Each different hypertext defines a so-called site view (see Fig 4). Site views descriptions in turn consist of sub-models are

Composition Model defines which pages compose the hypertext, and which subject units make up a page. Six types of content units can be used to compose pages: data, multidata, index, and filter, scrolled and direct units.

*Navigation Model*shows how pages and subject (content) units are linked to form the hypertext. Links are either non-contextual, when they connect semantically individual pages, or contextual, when the content of the destination unit of the link depends on the content of the source unit.

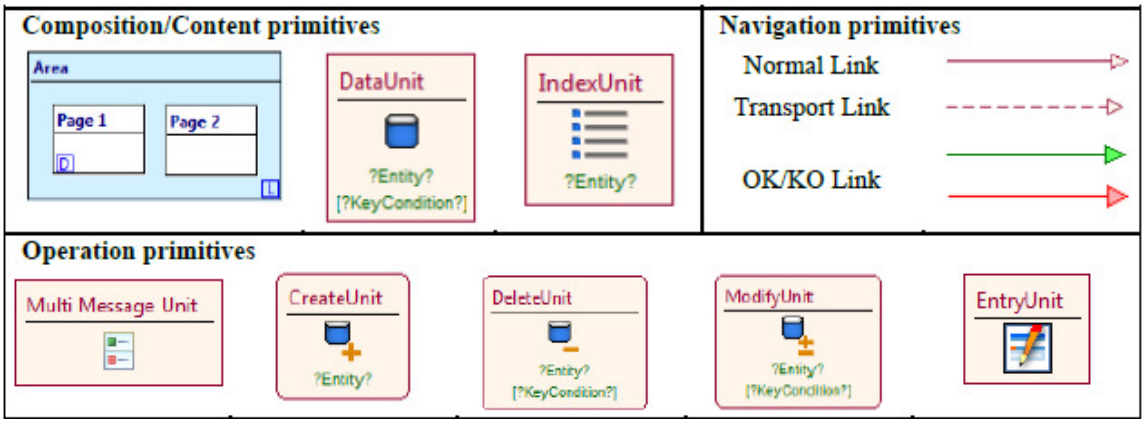

Figure 4: Hypertext model

(3) *Presentation Model*, defines the layout and visual aspect of pages, independently of the output device and of the interpreting language, by means of an abstract XML syntax. Display specifications are either page-specific or generic.
(4) *Personalization Model*, models explicitly users and user groups in the structure schema in the form of predefined abstractions called User and Group. The characteristics of these abstractions can be used for storing group-specific or individual content, like shopping suggestions, list of favorites, and resources for graphic customization.

VIII. SIRIUS FRAMEWORK

Sirius, an evaluation framework based on heuristics to perform expert evaluations that takes into account different types of websites. We also provide a specific set of evaluation criteria, and a usability metric that quantifies the usability level achieved by a website depending on its type.

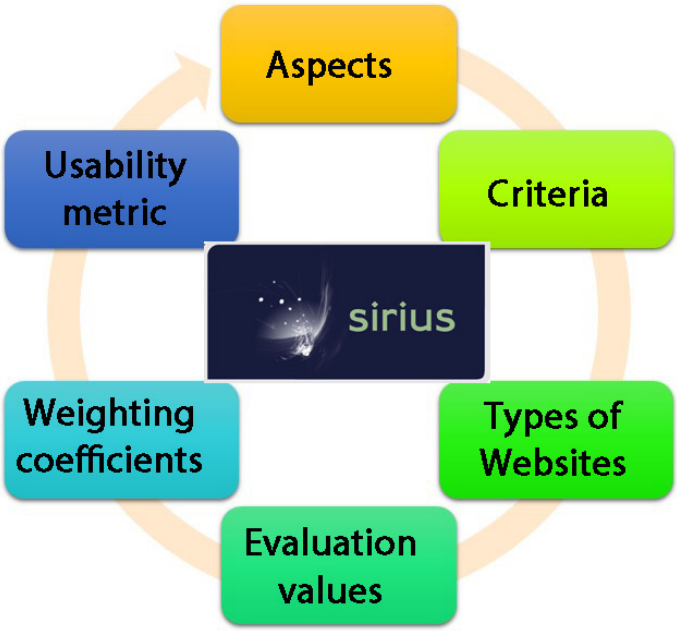

Figure 5: Pillars of SIRIUS Framework

To check a non-vague, detailed set of criteria that not only contributes to a clear and concrete evaluation framework, but provides a perceptual measure of the usability of a website adapted to the particular type of website analyzed. In order to achieve this tuning of the measure to the type of website, a classification of websites with respect to functionality has been developed. Aspects and criteria to be considered when performing the evaluation are listed, and used as the basis for evaluation. Then the level of relevance of the non-compliance with the aspects and criteria is computed with weighting coefficients tailored to the type of website. Therefore, this level always depends on the type of website being evaluated, adapting the measure of the level of usability to the type of site. Detailing concrete evaluation criteria, taking into account the type of website, and including a usability metrics are pillars of the Sirius evaluation framework [2].

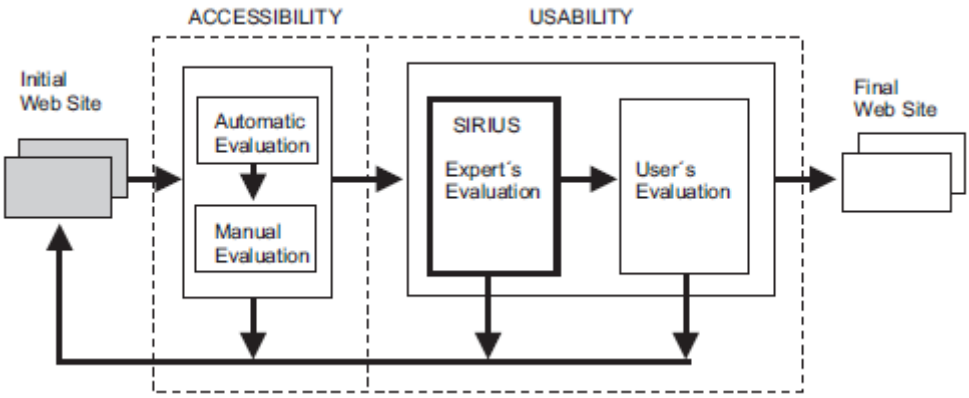

Figure 6: SIRIUS Framework Process [2]

Sirius provides a framework for heuristic evaluation but it can be framed within a multi-stage global evaluation process of a website. This process starts with (as shown in Fig.) an accessibility evaluation before the usability evaluation. This is a decision based on the results of different authors, who think that increasing the accessibility of a website also increases its usability. Therefore, first, a review of accessibility is performed both automatically and manually. [2]This review is done according to the W3C's Conformance evaluation method. Then the heuristic evaluation of usability proposed here (Sirius) would be performed. Finally, this would be completed with an evaluation model with users, considering the critical or relevant tasks, and involving users from all the target audiences of the site. This is included as skills; aims and equipment of target groups of users, context of use, different services and tasks, etc. also affect the level of usability of a site. Should the site have to be redesigned because of the results of each evaluation, the reviewing process would have to be performed again.

IX. Conclusion

In the software development, to help software engineers set of usability guidelines are defined. This review focuses on usability evaluations; usability has been evaluated taking into account the user's satisfaction by using different evaluation methods. For specifying complex websites at the conceptual model a WebML is presenting. Web applications usability is evaluating using WUEP(Web Usability Evaluation Process) method. To perform expert evaluations by considering type of website, Sirius framework is using. The results are in the progress, by using these methods and framework we can detect and predict usability problems in the early stages of development and we can provide recommendations to solve these problems.

References

[1] Laura Carvajal et al., "Usability through Software Design", in IEEE Transactions on Software Engineering, 2013.
[2] M. Carmen Suárez Torrente et al., "Sirius: A Heuristic-Based Framework for Measuring Web Usability Adapted to the Type of Website", in The Journal of Systems and Software, pp.649– 663, 2013.
[3] Naki Chiam and Masitah Ghazali, "A Systematic Literature Review on The Role of Usability in Software Engineering Education", in International Conference on Information and Knowledge Management (ICIKM 2012) vol.45 pp.170-174, 2012.
[4] Ankita Madan "Usability Evaluation Methods: A Literature Review", in International Journal of Engineering Science and Technology (IJEST), ISSN: 0975-5462 Vol. 4 No.02, pp. 590-599, February 2012.
[5] Laura Carvajal, "Usability Oriented Software Development Process", Thesis, 2012.
[6] Adrian Fernandez Martinez," A Usability Inspection Method for Model Driven Web Development Process", Thesis, November 2012.
[7] Anirudha N. Joshi, "Integration of Human-Computer Interaction Activities in Software Engineering for Usability Goals Achievement", Thesis-Department of Computer Science and Engineering Indian Institute of Technology Bombay, pp.1-287, 2011.
[8] Anirudha Joshi,"Measuring effectiveness of HCI integration in software development processes", in The Journal of Systems and Software, 2010 Elsevier, pp.1-14, 2010.
[9] Fernando Molina, AmbrosioToval," Integrating usability requirements that can be evaluated in design time into Model Driven Engineering of Web Information Systems", Advances in Engineering Software, 1306-1317, 2009.
[10] Jose Ignacio Panach "Understandability Measurement in an Early Usability Evaluation for Model-Driven Development: An Empirical Study ", in International Symposium on Empirical Software Engineering, pp.354-356, 2008.
[11] Pedro Campos and Nuno Jardim Nunes," Practitioner Tools and Work styles for User-Interface Design", in IEEE SOFTWARE, pp.73-80, J an n u an r y / F e b r u an r y 2 0 7.
[12] Ahmed Seffah," Usability measurement and metrics: A consolidated model ", in Springer- Software Qual J (2006) 14: pp.159–178, 2006.
[13] Maristella Matera," Web Usability: Principles and Evaluation Methods", in Web Engineering, Springer, 2006.
[14] Jeff Sauro & Erika Kindlund," Making Sense of Usability Metrics: Usability and Six Sigma", in UPA Conference 2005, pp. 1-10, 2005.

[15] K.K.Basheer, A. Rama Mohan Reddy, C. ShobaBindu "Systematic Use of Architecture Patterns to Achieve Non-Functional Requirements "National Conference on Data Modeling, Image Analysis and Pattern Recognition (DMIAPR) - 2011", organized by GITAM, University, Vishakhapatnam on 13th to 14th September, 2011
[16] Proefschrift," Software Architecture Analysis of Usability", in Thesis-Rijksuniversiteit Groningen, pp.1-240, 2005.
[17] Atterer, R., Schmidt," Adding Usability to Web Engineering Models and Tools", in Proceedings of the 5th International Conference on Web Engineering, 36-41, 2005.
[18] Leena Norros, Paula Savioja," Usability Evaluation Of complex Systems- A literature review", in STUK-YTO-TR 204-study, pp.1-44, APRIL 2004.
[19] Jeff Tian, "Quality-Evaluation Models and Measurements", in IEEE Software Published By the IEEE Computer Society pp. 84-91, 2004.
[20] Jeff Offutt, "Quality Attributes of Web Software Applications", in IEEE Software special issue on Software Engineering for Internet Software, 25-32, 2002.
[21] Bonnie E. John and Len Bass, "Usability and Software Architecture", in Behavior& Information Technology, Vol. 20, NO. 5, pp. 329-338, 2001.
[22] Xavier Ferré and Natalia Juristo et.al, "Usability Basics for Software Developers", in IEEE Software, pp.22-29, January /February 2 00 1.
[23] Manuel F. Bertoa and Antonio Vallecillo, "Usability Metrics for Software Components", in White paper, pp.1-10, 2000.
[24] Stefano CeriŁ, PieroFraternali, Aldo Bongio," Web Modeling Language (WebML): a modeling language for designing Web sites", in 9th International World Wide Web Conference, 137-157, 2000.
[25] Andreas Lecerof and Fabio Paternò," Automatic Support for Usability Evaluation", in IEEE Transactions on Software Engineering, Vol. 24, NO.10, pp.863-888, October 1998.
[26] K.K.Baseer, A. Rama Mohan Reddy, C. ShobaBindu, SaiBharath "Framing the Principles Involved in the Design of Software Architecture to achieve Quality Attributes", 3rd International Conference on Science, Engineering and Technology (SET) November 17-18, 2011, @ VIT University, Vellore-632 014, TN, India. Paper ID: 113, Vol. 5, pp. 739-746
[27] Nigel Bevan, "Measuring Usability as Quality of Use", in Software Quality Journal, 4, pp. 115-150, 1995.
[28] Basili, V., Rombach, H, "The TAME Project: Towards Improvement – Oriented Software Environments.", in IEEE Transactions on Software Engineering, vol 14, Issue 6, pp. 758-773,1988.
[29] K.K.Baseer, A. Rama Mohan Reddy, C. ShobaBindu "A Survey of Synergistic Relationship: Scenarios, Quality Attributes, Patterns, Decisions, Reasoning Framework", International Journal of Web Technology, Vol 01, Issue 02, December 2012: ISSN: 2278-2389
[30] SaiBharathKadati, K. K. Baseer, A. Rama Mohan Reddy & CH. Gowthami, "A Naive Based Approach for Mapping Two ADL Models", Global Journal of Computer Science and Technology Software & Data Engineering Volume 12 Issue 11 Version 1.0 June, Year 2012 Type: Double Blind Peer Reviewed International Research Journal Publisher: Global Journals Inc. (USA) Online ISSN: 0975-4172 & Print ISSN: 0975-4350