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User-Perceived Quality Factors for Certification Model of Web-Based System

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***Abstract*—**One of the most essential issues in software products is to maintain it relevancy to the dynamics of the user's requirements and expectation. Many studies have been carried out in quality aspect of software products to overcome these problems. Previous software quality assessment models and metrics have been introduced with strengths and limitations. In order to enhance the assurance and buoyancy of the software products, certification models have been introduced and developed. From our previous experiences in certification exercises and case studies collaborating with several agencies in Malaysia, the requirements for user based software certification approach is identified and demanded. The emergence of social network applications, the new development approach such as agile method and other varieties of software in the market have led to the domination of users over the software. As software become more accessible to the public through internet applications, users are becoming more critical in the quality of the services provided by the software. There are several categories of users in web-based systems with different interests and perspectives. The classifications and metrics are identified through brain storming approach with includes researchers, users and experts in this area. The new paradigm in software quality assessment is the main focus in our research. This paper discusses the classifications of users in web-based software system assessment and their associated factors and metrics for quality measurement. The quality model is derived based on IEEE structure and FCM model. The developments are beneficial and valuable to overcome the constraints and improve the application of software certification model in future.

***Keywords*—**Software certification model, user centric approach, software quality factors, metrics and measurements, web-based system.

I. Introduction

BASIC definition of quality software in general is referred to the software product that meets user requirements. Several studies and researches concerns of finding ways on how to establish high quality software processes and how to produce a high quality software product that meets user's requirement and expectation have been carried out and investigated. Currently, software processes and software products are evaluated and assessed so that the quality level of the software process and product can be determined. One of the approaches is to certify the software process and product based on prescribed criteria. Research and development of this effort in software certification can be found in [1]. Continuous improvement in the quality of software is essential in the software industry as discussed in [1], [2]. It could also be achieved through implementation of software certification within user environment itself. In contrast with other works, previous studies in certifications were carried out by third party or in the testing laboratory.

Nowadays, the role of software in human life is continuously increased and demanded. Software developers compete among themselves to produce software products quicker and in simple approach. However, software projects failure are still being reported. According to Ropponen & Lyytinen [3] and Berntsson-Svensson & Aurum [4], a software project is considered failed if it is over schedule, over budget, does not meet business objective and does not meet user requirements. From the social and economic aspects, customers or users will lose their confidence while in term of economy; maintenance cost will increase if the project fails.

Previous works conducted by our research group developed and implemented in real industry environment a software product certification model named SCM-Prod model which focused on measuring the behavioral and technical aspects of the software and limited focused on the user's aspect of measurements [5]. Our past researches and experiences have indicated and shown that involvement of users in software assessment and certification process enable to evaluate the quality of software products based on user's expectations and needs [6], [21]. However, SCM-Prod and other certification models do not emphasis on the quality metrics of user centric perspective and approach. Therefore, this approach can be considered as an alternative mechanism for assessment and certification to resolve the uncertainties related of software quality in user's perspective. In this research, user centric approach is defined as a method in which the requirements and limitations of end-users of software are given extensive attention at each stage of the processes. The scope of this research is on web-based system which is very common nowadays and users use system in their daily activities. The users can be classified into several categories and will be discussed in this paper. This paper is organized as the following: Section II presents the background and related works, Section III presents the conceptual model of user centric software certification model, Section IV discusses the classification and FAME quality factors and Section V will conclude this paper.

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II. Background and Related Works

A review on current literature shows that software is a designed and developed, and not a manufactured like other industrial products. The design and development processes are based on individual creativity, skills and experiences in software development. Some believes that novelty of software indicated by its quality without respective of the process used [7]. Nowadays, software is an important tool that people often used and therefore needs to be improved and enhanced its quality frequently [8]. In addition, the attributes of software quality is difficult to measure directly such as maintainability, usability and efficiency because it relates to developer and users which they must use and experience with the software before able to assess and evaluate them [7].

A. Software Quality and Certification

In general, software certification is defined as an official document of a good quality. It is also a written assurance by third party organization that a product or services conforms to specified characteristics [6]. Previous work by Voas [9] indicated that software certification can be viewed in three different perspectives which are through the development process, the end product quality and the people that involve in development. Software certification offers benefits and values to several groups include the developer, producer (stakeholder and vendor) as well as the end users. In user perspective, certification is a mechanism to guarantee that the software is good at certain level of quality standard.

In certification process, quality model is the necessary benchmark and standard needed to be embedded and integrated in the whole processes. There are several software product quality models available in the literature and the well-known are McCall, Boehm, FURPS, ISO9126, Dormey, SQuaRE and Pragmatic Quality Model or PQF [10]-[12]. However, these models mainly focus on technical perspective and limited concern with user's or human's perspective in assessment of software products. For example, ISO/IEC 15504 is the reference model for the process assessment and ISO9126 is the reference model for product assessment. Both reference models focus on technical aspects in development and product quality. K-Model is a software process improvement and certification for small and medium size business and is implemented in Korea [13]. At current trend, software quality models are still in the scope of technology, and behavioral views of assessment [14]. Therefore, in our research, we focus on development of software quality factors and metrics that rely on user's perspective and views or sometimes we refer to user-perceived quality. Furthermore, software certification model by user centric approach is proposed to improve the existing software certification model that meets user's needs and demands.

B. User Centric Issues

Today, software is not only vital to the businesses to excel, compete and remain competitiveness locally and globally but to the social society as a whole. It has become parts of everyone in everyday life. The emergence of social network application such as Facebook, Twitter, Friendster and many more show the relevance and influential of software and computers in today's people's life. The integration of human's activities and ICT appliances connects people anytime and anywhere through software applications. Thus, this situation creates the user centricity paradigm where people and users are the key actors in the scenarios.

User centric approach has been discussed in several domains and areas especially in software development. It has been highlighted the necessities of user involvement in design or development decisions [8], [15]. Jeff Patton argued on developer's productivity that been focused without considering user's perspective in software development [8]. He suggested that the target of producing software should be building something useful for the people. Normally, in many circumstances, users don't have much concern about the design of the software as long as they can access and use it. Therefore, as a developer they need to understand the wants and needs of user through what they build, who will use it and how to use it. He stated that "user centricity isn't just caring about users or asking them what they want. It's understanding them and collaborating effectively with them to help make informed choices about what software to build." This relates to how to ensure the software meets this target. Thus, the assessment and measurement of software quality must align to this approach as well.

Khan et al. [16] studied the assessment of web-based systems using user-centric quality approach. He defined user-perceived quality into Factor–Criteria-Attributes-Metric or FCAM tree. The main criteria are text, structure, general quality, non-textual and physical properties. Each of these criteria is broken down further into applicable attributes. The proposed model by Khan et al mainly focuses on subjective metrics and measures by web-users. It does not evaluate the quality from other's perspective such as designers and developers view. The model is intended to be used in conjunction with other models that focus on complementing objectives metrics.

Previous certification studies by our research group have indicated that certification process demands for self-certifying approach [6]. In this new paradigm, users should be able to assess and certify their products within their own environment. In addition, user-centricity approach can be defined as a new paradigm where the requirements and limitations of end-users of software products are given extensive attention at each stage of the processes and user has a control through her involvement in using the product [22]. This relates back to the general definition of quality, where quality is defined as "fitness for use" and "conformance to requirements". The term "fitness of use" usually means characteristics such as functionality, usability, maintainability, and reusability and "conformance to requirements" means that software has value to the users [23], [2].

A related work conducted by IBM Switzerland and European Commission IST Project PRIME studied the user centricity concept in federated identity management (FIM) as to provide stronger user control and privacy. In this recent

paradigm, two main focuses and being explore are the security and privacy, and the user-control. Under the structure of user control there are properties that relevant to it. The properties such as confidentiality, integrity, revocability, unlinkability, policy, user-chosen IP, verifiability, generated tokens, illegal sharing prevention, non-transferability, and non-replay are identified and used. There are such attributes that considered as high level properties such as accountability, notification, anonymity, data minimization, attribute security, and privacy [22].

According to Quasthoff & Meinel [15] "User centricity in identity management systems does not only refer to design processes leading to better usability, customer satisfaction or something similar". Ahn et al. [24] have studied the user centric approach in identity management which focused on user perspective related to managing private and critical attributes. User is able to control their rights and responsibility over the identity information. Thus, the user's private information is better protection by user itself. In this approach, user is an important element to put them into the middle of transaction between identity providers and relying parties. Furthermore, user centricity in healthcare identity management is introduced to for improvement of healthcare and services and the reduction of costs. Patient is the real users of an electronic healthcare infrastructure. While, health professional such medical practitioners and pharmacists are users of the system. Thus, it will be user centric with health infrastructure, patients, health professional, and administrative personnel [15].

The evolution of software product and software quality and assessment methods can be summarized from year 1970s to years 2000s. It showed the development of software assessment method from measuring through complexity, estimation, internal measurements, and later moved to the development of software quality model such as McCall and Boehm model. In year 1990s, ISO 9126 was developed which demanded from the industry to measure software based on end-product quality approach and more specifically the quality in-use factors [17]. During this period of time, Software Engineering Institute through its Quality Subgroup of the Software Metrics Definition Working Group and the Software Process Measurement Project Team had proposed a framework for discovery, reporting and measurements of problems and defects of software. Mechanisms for describing and specifying the software measures used to understand and predict software quality and software process efficiency. The attributes used were size, defects, effort and time [18]. Later in year 2000 onward, we saw the emergence of cloud computing, social network software and user involvement in software development such as agile method, where the evolution of software certification was getting more relevant for assurance of quality. Furthermore, with the domination of users in software development and application, there is a paradigm shift that demand for user based quality assessment and certification in software industry as well as in the design and development activity [19], [20]. In this paradigm and ecosystem, the effectiveness of the assessment and evaluation of applications depends on the metrics collected during the process. For a model that focuses on user-centric assessment quality model, the metrics are collected by a group of users defined in the model.

III. User Centric Software Certification (ucSoftC): the Conceptual Model

The aim of this research is to develop a certification model that focuses on user-perceived quality in web-based system product. This section presents the design of user centric software certification or ucSoftC model. It is designed, developed and enhanced from current model of software certification which is the SCM-Prod model. The first component is the quality factor. The second component is certification assessor that involve in the assessment. In this model only user will do the assessment of the software product. The third component is certification process which includes the procedures, formulas and algorithms to implement the model. In this model, the computation of quality score then will mapped into the certification level which determine as excellent, good, basic and acceptable or poor. The basic algorithm and formulas are derived from our previous works [6], [25].

The user centric approach in this research refers to the concept of assessment carried out by users only, based on users perceive and therefore the quality attributes of assessment mainly focuses on the user centric approach and perspective. In the previous SCM-Prod model, the assessment is carried out by three different groups collaboratively which are the developer, independent assessor and user [6]. The development of user centric software certification model is an alternative mechanism to enhance and improve the SCM-Prod model for software product certification process based on user centric approach for web-based applications. In contrast to certification model developed by Laboratory for Quality Software (or LaQuSo) where LaQuSo model emphasizes not only on software as end product but considering other software artifacts such as context description, user requirements, detailed design, implementation and testing [26]

Fig. 1 shows that depending on the category of users, the certification process which includes the quality factors can be customized to make the certification more practical and reliable to the organization.

A. Certification Assessor

In this model, the main participants in the assessment and certification are the users of the system software. The identified and potential users of system software are the management, technical, public and expert. The classified users above have a personalized quality factors relevant and appropriate for the groups. There is a possibility of customized process of certification and assessment based on user's groups as shown Fig. 1 The classification of users and the attributes associated with them will be discussed in the following section.

B. The Certification Process

The second component is the process. In this research, the formulas and algorithms for user-centric certification and assessments are introduced. These formulas and algorithms are used to measure the quality status of each attributes defined ucSoftC as well as the certification level of the product. The quality score obtained in this model is then mapped into a certification level of excellent, good, basic and acceptable, and poor as defined in previous works. The basic algorithms and formulas of certification has been validated and applied in various exercises conducted in Malaysia [6], [21] and thus, needs to be customized and enhanced for user centric approach. This will be carried out further in this research.

The attributes identified and selected in this proposed model together with the processes need to be documented and stated either through hardcopy or softcopy kits and instruments. The assessment instruments need to be checked for verification and validation through expert review and case study. The support system will be developed to assist in the processes and assessment. The proposed technique is through online assessment which will be developed using android programming and handheld technology. This is to provide the appropriate mechanism where users are able to assess and certify the products in their own ecosystem and environment (self-certification) and within their own sufficient time. With this capability, the method of assessment and certification will be different from other approaches.

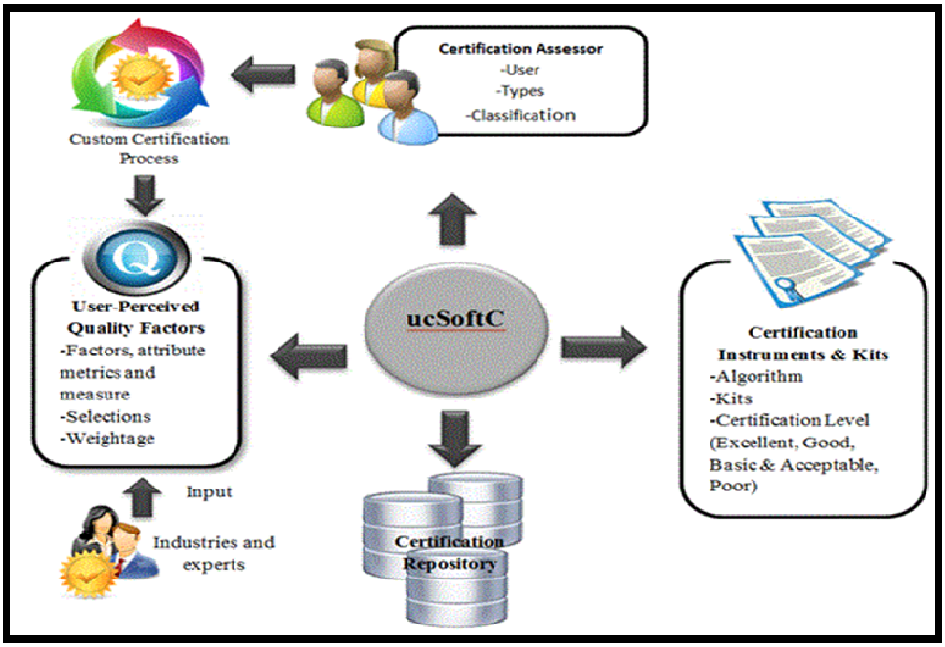

Fig. 1 The conceptual model for user centric software certification approach

C. The Quality Attributes Based On User Centric Approach (ucSoftC)

User-perceived quality attributes are derived from the user classifications. Using brainstorming approach and expert review sessions, four main classifications have been identified and defined in this model. The classifications are expert, management, technical and public users. The attributes or factors are structured in a tree like structure or normally call classical Factor-Criteria-Metric (FCM) model [27]. The same concept and approach was introduced by IEEE (2005) of software quality framework [28]. In this framework, quality aspect of software is broken down into several factors or attributes, and further decomposed into sub factors or also known as sub attributes and metrics. The metrics, which are the third level of the software quality framework, are the direct attributes that are used to estimate quality factor of software. In this model, we modify FCM and IEEE structure to form the Factor-Attribute-Metric-Measure (FAME) where in this model metric is the third level and measure is the fourth level which is scaled into a Likert value of 1 to 5. The classification and FAME model will be discussed in following section.

D. The Certification Level

The last component of ucSoftC model is the certification level. The quality score calculated is mapped into a certification level of excellent, good, intermediate or poor. The level represents the quality status of the particular product. The detail of the assessment will be kept in a repository for future use.

IV. Classification and FAME Quality Factors

From an extensive study on software quality, software certification and software maintenance, we discover that there are four main categories of users for web-based application software. The categories are: management, expert, public and

technical. Management users are users who involve in managing software in the organizations. Examples are project manager, manager of computer center and financial controller of the software. Public users are the novice users who normally use software for their own interest and benefits. While expert users are the users who are the expert in using the system in their environment. Technical users are the system administration, database administration and person who involve administrating technical aspect of the system. Our proposed method in software quality and assessment measures factors, attributes and metrics by employing a questionnaire type of assessment form which users answer the question based on metrics with the measures defined in each factor and attributes. Fig. 2 demonstrates the example of FAME structure for web-based system software assessment according to user classification. Example in Fig. 2 is the user-perceived quality factors for management user.

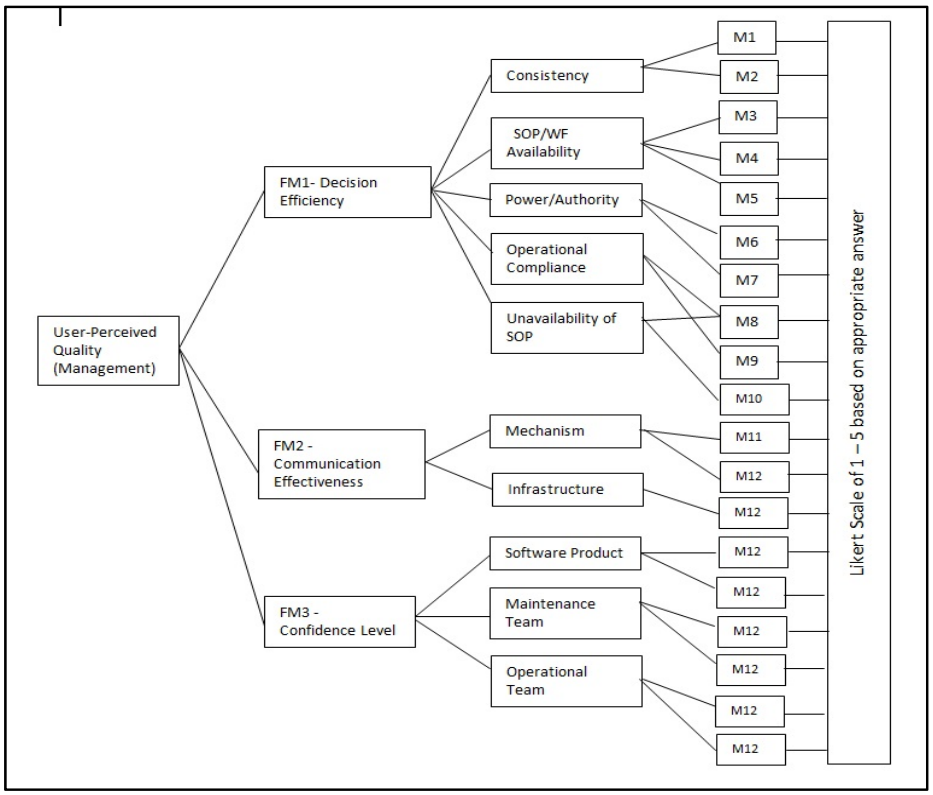

Fig. 2 User perceived quality FAME structure for management user

In this structure three main factors contribute to user-perceive quality by management users are decision efficiency, communication effectiveness and confidence level. Each of these factors is broken down further into applicable attributes or sub factors. Each attribute is then broken down into several metrics and then will be measured by appropriate values and scales. The similar structure will apply to the other user classifications which are public, expert and technical as shown in Table I.

V. Conclusion and Future Work

This paper has presented the issues of software certification practices related to software quality assessment. Before advancement of internet technology, most of the researchers focused on software complexity measures which would determine the software quality. With the current development of internet applications and technologies, software applications are more transparent and much closer to the end-users. Software development cycle is also shorter which demand more active user involvement in the process. With the current scenarios in software development and implementation, users are more critical in various functional and non-functional characteristics of the software. For numbers of years, our research group has focused on software quality from different perspective which is through external or quality in-use which is via certification. We have successfully developed and implemented two certification models as discussed in previous publications.

TABLE I
SOFTWARE QUALITY FACTORS

User's Classification	Factor	Sub-Factors
Public	Navigability	Guided navigation, process structure, screen and data based input, multi directional navigation,
	Recoverability	Ability to return, minimum input
	Usability	Understandability, learnability, operability, content
	Security	Feel safe, support
Expert	Reliability	Maturity, fault tolerance, recoverability, intermittent disruption
	Efficiency	Time behavior
	Future potential	Room for improvement
	Impact	User and society, economic, environment
Technical	Integrity	Access controllability, access restriction, access auditability, preventing data corruption, data corruption, data encryption
	Maintainability	Effortless failure analysis, failure case finding, readiness diagnostic function, activity recording, execution monitoring, design documentation, effortless changeability, readiness of parameterization, change recordability, readiness for change, built-in-test function, test restartability, effortless testing
	Portability	Environmental software adaptability, environmental hardware adaptability, adaptability, user effortless adaptation, effortless installation, installation easiness, operational installation flexibility, easiness of user's manual , easiness of setup re-try, standard conformability, function inclusion, data continuation.
	Functionality	Implementation coverage, specification stability, implementation completeness, incomplete result, incorrect result, unexpected results issued, data format, data exchange

We further our research to focus on user based software certification model. The components and factors of software certification model based on user-centric approach have been presented. The user centric software certification (ucSoftC) model is a new model to enhance previous software product certification and assessment models explained in this paper. Generally, user centric approach focuses in user perspective and user-perceived assessment and certification software product operating in their environments. Therefore, the developments of user centric software certification process and ucSoftC model are able to fulfill the requirement of organization according to demands and constraints in software product quality and assessment. The proposed ucSoftC model and FAME quality factors and structure explained in this paper will enhanced the certification process which enables software users to assess and certify their own products in their own environment and ecosystem. The FAME quality factors defined in this research is applicable for web-based system software.

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