Evaluating Websites Using a Practical Quality Model

MPhil Thesis

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Declaration

I declare that the work described in this thesis was originally carried out by me during the period of registration for the degree of Master of Philosophy at De Montfort University, from October 2006 to October 2009. Apart from the degree that this thesis is currently applying for, no other academic degree or award was applied for by me based on this work.

Zihou Zhou

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Abstract

Many of the existing website evaluation methods and criteria for evaluating website quality are not able to sufficiently assess the performance and quality of a website, and most of them focus on usability and accessibility. This thesis aims at proposing the website quality metrics and methods to measure the website interface and reputation quality factors. The evaluation metrics has a framework which can be viewed as a hierarchical tree with three levels. The first level is composed of five quality characteristics: Aesthetics, Ease of Use, Multimedia, Rich Content and Reputation. The second level breaks down the first level quality characteristics into sub-characteristics and the third level further breaks down the second level sub-characteristics into measurable criteria. This thesis is particularly concerned with two major quality characteristics: Aesthetics and Reputation, and also the several website measurable criteria (indicators) that now apply to almost all live websites.

A website evaluation tool is provided by this study to measure website quality automatically. It includes a traversal unit, parsing unit, data metrics unit and user interface unit. Also some effective algorithms are used in each unit: data crawler, recursive, parser and data transmission. According to relative issues in previous research about website evaluation metrics, there are only a few of them that use same methods as this study to completely measure the website metrics, and highlight the entire website quality scores that meet the users' requirements.

Table of Contents

Chapter 1

Introduction

1.1. Background and Motivation

A great number of new websites have been launched every day. Ones with similar content will not have the same degree of quality. If the quality is poor, the user will simply leave the website and go elsewhere. Generally, there is no second chance to get a user back to the website. Therefore, in order to improve the quality of a website. The quality of a website makes a website profitable, user friendly and accessible, and it also offers useful and reliable information, providing good design and visual appearance to meet the users' needs and expectations [22]. this can be done by defining the measurable website criteria [20, 72].

Website quality is dependent on the quality of the software. In the early years, quality of software provided effective support to develop the websites' performance. Nevertheless the quality assurance process became the challenges for the new discipline of website application. There were a number of experts or organizations who researched on different proposals to improve website quality, including quality frameworks, criteria, evaluation methodologies, approaches and metrics. In fact, since the website quality process became a particularly valuable topic which is ongoing and commercially researched, especially in website quality metrics. A set of metrics has been proposed for quantifying website quality attributes since the 1990s [9, 50]. Although quality of website has valuable background and been well developed in recent years, a big question is "why is the quality of websites still poor and lack of quality characteristics cause user dissatisfaction in most websites." [7, 6] There are some reasons shown below.

Website software technologies evolve extremely fast, possibly one hundred new software tools are developed each year. Websites blindly applied these software tools. Some of them support websites that have become very successful (e.g. Youtube, Blog and Ask.com), but some are not [55]. So these new websites technologies need to be verified and may or may not be used and some may even be eliminated (e.g. Auto-refresh, image ALT).

Website hardware technologies are continually upgraded. The main representative is network speed, the limitation of network speed is not considered as a reason affecting website quality. For example network services agents (BT, Virgin Media, etc) are providing broadband services up to 2 Mb speeds, even new wireless network (3G) is up to 1 Mb. In this case, a complicated website can contain multiple elements: “massive website” is no longer exists.

The application domains of websites are developing widely. Websites are becoming the preferred media instrument for information search, company presentation, shopping, entertainment, education, and social contacts. Traditional quality of websites issues does not fit the new multiple-technology websites application.

Based on the above factors, the new website quality features determine to establish a new website quality metrics which will have more practical measurement criteria and appropriate approaches for website quality evaluation needs.

1.2. Objectives

The aim of this project is to investigate the definition of website quality criteria, look for an approach to do the website evaluation that can relate to the user perspective. Especially developing the practical website quality metrics and identifies each quality characteristic, sub-characteristic and measurable measures. There are important to define the aesthetics and reputation characteristics, and implement the website evaluation approach. Finally, a website will be measured by a automated process tool.

In particular, this thesis aims to address the following:

- Analysing the current live websites, classifying new quality features or elements, defining the fresh website evaluation criteria.
- Proposing a new approach for website evaluation, that can measure a website step by step.
- Creating a special website evaluation tool, it able to measure many different types of website automatically.

However, some relevant quality criteria are deliberately ignored in this study (e.g. maintainability or time factors). Because this study focus on how well the website supports user tasks which are mainly related to user access requirements and expectation.

1.3. Contributions

The contributions of this project include:

- A set of new quality criteria (indicators) have been defined, which gather together some of the new website software technologies and new website quality rules. The new quality criteria include the words emphasis in the website documentation, rules of seven colours, avoid auto-refresh, and so on. These criteria are widely used in the current websites. However only few researchers have examined them.
- A website evaluation calculation method is used for the evaluation formulae. Several formulae are used to calculate each quality characteristic, quality sub-characteristic and measurable criteria (indicators). Different characteristics are assigned with different weights in this calculation. The results will be closer to the real live website's quality certification.
- Aesthetics and Reputation are used in main research topic in this website quality evaluation project. User interface and creditability become more and more important quality features in almost live website. For example users view an

e-commerce website because it has an interesting interface, and also they trust it.

- A specific evaluation issue is established by calculating the root page and children pages separately. It is well known that the root page carries more weight than the aggregately of all children pages.
- Advanced program design and implementation architecture have been established. Firstly, this study has built a website evaluation tool which has four layers; Tree-Traversal, Parsing, Data Metrics and Graphical User Interface. They provide a clear architecture and Object-Oriented mechanism which will make easily for future program reengineering. Secondly, certain specific technologies are used in the program design, such as Data Crawler, Traversal, Recursive algorithm, data analysis and transmission.
- A website evaluation tool has been established. It is able to evaluate a website which has “best” or “worst” quality by type or by pasting a URL into the text box.

1.4. Thesis Structure

Chapter 1 gives research background and motivation, objectives, contribution and thesis structure.

Chapter 2 introduces an overview of concepts of website quality, quality model, and website quality metrics from previous research experts or organisations. It also describes the limitations of existing website evaluation methods.

Chapter 3 provides a website quality metrics approach. It is classified by three stages: website quality frameworks, definition of quality criteria and rules and overall website evaluation.

Chapter 4 is the main part of this study. It will specifically represent website quality metrics according to the proposed approach in chapter 3.

Chapter 5 describes the implementation of the website evaluation tool and a case study.

Chapter 6 concludes this thesis and discusses possible future research.

Chapter 2

Related Work

There are many techniques and issues related to this study, selected research will be discussed in this section.

2.1. Website Quality and Quality Models

"What is quality?" Dr. Tom DeMarco [12] says *"Quality is the function of a product that changes the world for the better."*

Definition of website quality is how well a website is designed and how well the design meets with the user's satisfaction. Website Quality (or Quality of Websites) could be measured from two perspectives: Programmers, and End-users [37]. The aspects of website quality from programmers focus on the degree of Maintainability, Security, Functionality, etc. Whilst the end-users are paying more attentions to Usability, Efficiency, Creditability, etc.

Expanding these concepts, the usages of website quality may depend on

1. Task-related factors that affect end users such as presentation quality and contrast.
2. Performance-related factors that affect the efficiency for end users and the technologies of websites, for example, response time, transaction output and reliability.
3. Development-related factors that affect developers and maintainers of a website. For instance code complexity, code readability, portability and modifiability.

"How to clearly define these factors?" A concept (quality model) will be the leading factor in achieving website success and will apply to the majority of current live

websites. From previous research, the quality website is developed from quality of software. Gerald Weinberg [67] defined that the quality of software is inherently subjective and different people who will experience different quality even in the same software. It can also apply in a website as meaning that user satisfaction is more important than anything (This issue is reinforced in this study).

The ISO 9126 definition of quality for software products is [1]:

The totality of features and characteristics of a software product that bear on its ability to satisfy stated or implied needs.

Attributes of software may include a very large list of properties, possibly at the different levels of detail. Some attributes are internal (i.e. can be measured by examining the product, separate from its behavior); others are external (i.e. can be measured only with respect to how the product relates to its environment). For example, size is an internal attribute, whilst the user error rate is external.

A website is just like software (i.e. it applies to some entity, or some prototype, or its information architecture) defined in terms of a system of attributes, e.g. readability or coupling. Finally an assessment of the attributes that is a certain product possesses. These aspects taken together are called the Quality Model [48].

Luisa et.al [44], introduced a website quality model which shows an approach to the definition and measurement of website quality. It describes the trade-off between the user's needs to be well-established and flexible functions to permit the web application with diverse content.

Generally the website quality is prone to subjective interpretations unless it is quantified by a web quality model. A web quality model needs to define website quality requirements which are identified by a set of measurable attributes and meet the users' expectations. In other words, to evaluate the quality of website, the appropriate metrics have to be defined.

2.2. Existing Website Quality Models

2.2.1. ISO Quality Model

The first model identifying quality within software was in the mid 1970's. The International Organisation for Standardization (ISO) in cooperation with the International Electro-technical Commission (IEC) finished the development of the new standard "ISO 9126 - Information Technology – Software Product Evaluation – Quality characteristics and guidelines" [1]. It defined the quality model that can be applied to any kind of software product or service. In the process of standard revision, two series have been established: series ISO 9126 defined the quality model and series ISO 14598 described the quality evaluation process. This standard divided quality into six basic characteristics: functionality, usability, efficiency, reliability, maintainability and portability.

A subset of characteristics from the ISO model is part of the second level in the proposed model, where each characteristic is broken down into a set of sub-characteristics, which are in turn further broken down into a set of indicators at the third level. The choice of indicators is based on a set of web quality guidelines [20], W3C standards [65] and the analysis of the existing websites.

Figure 1 is represents the hierarchy of the proposed model. Looking from the top, the quality of characteristics depends on the quality of its sub-characteristics, which in turn depend on the quality of their indicators. However, looking from the perspective of the indicator, the quality of each indicator influences the quality of the appropriate sub-characteristic, which in turn influences the quality of the appropriate characteristic in the quality model.

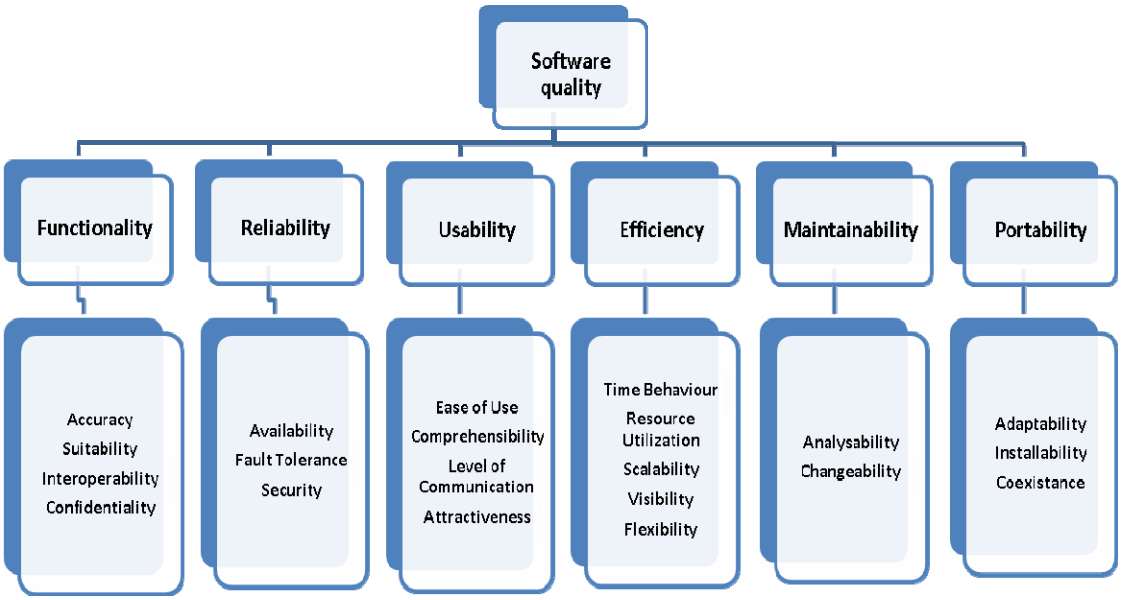


Figure 1. Quality Model Hierarchy [66]

In recent years, several experts have worked on different proposals to improve this website quality model, including methodologies [5, 6, 49, 54, 70], quality frameworks [10, 41, 69]， estimation models [36, 44], criteria [65], usability guidelines [46], metrics [7, 37, 47] and web evaluation tool [25, 27]. More information about website quality models will be described in the next section.

2.2.2. Other Web Quality Models

- Nakwichian and Sunetnanta [45] presented a user-centric web quality assessment model, which enabled them to evaluate website quality with respect to access by different end-user groups. They defined the common quality features as a guideline of website quality assessment. They designed a generalized assessment process that can be applied to diverse end-user domains. Their quality model is built on ISO/IEC 9126 and IEEE 1061 standards.
- Brajnik [6] stated that the quality model has to be defined. He suggested the adoption of Goal-Question-Metric paradigm as a useful framework to guide the

definition of the quality model.

- Fitzpatrick et al [15] looked at quality models with Human Computer Interaction standards. They defined a general set of 12 external and 5 internal quality factors. External factors included suitability, installability, functionality, adaptability, ease-of-use, learnability, interoperability, reliability, safety, security, correctness and efficiency. Internal attributes included maintainability, testability, flexibility, reusability and portability. Fitzpatrick later identified an additional 5 web site-specific characteristics: visibility, intelligibility, credibility, engagibility and differentiation [14]. For each of the characteristics they defined a set of “enablers” that reflect the existence and importance of the characteristic in question.
- Offut [50] analysed the quality attributes of web applications and identifies eight attributes: reliability, usability, security, availability, scalability, maintainability, performance and time-to-market.
- Olsina et al [41] described a Quality Evaluation Model which according to the same high-level quality characteristics, outlined a quality requirement tree containing more than 100 characteristics that refer to different website domains, e-commerce, academic sites and provide a descriptive framework to specify these quality characteristics. This requirement tree is rooted on ISO 9126 standard [39, 40, 42].

While there are many different theories and methods which can be used for internal and external evaluation, however they do not have any model which covers all quality aspects especially communication aspects such as theoretical and specific aspects and even more important, aesthetic aspects. The field of websites design mainly focused on the technical and functional aspects of web design, but ignoring the lack of aesthetic and reputation aspects.

A point of departure in Lisbeth Thorlacius’s [57, 58] visual, aesthetic communication model, she designed for use as a theoretical model in the construction and analysis of the visual and aesthetic aspects of all media products. The main

communication factors, such as the context, the addresser, the addressee, the consistency and the medium within the visual communication, have been thought through.

Just as described above, the quality model of a website is determined by the process of evaluation, design, implementation and validation involving a variety of methods and tools. In order to carry out on these processes, quality metrics need to be defined.

2.3. Websites Quality Metrics

A website quality metrics is defined by a measurement method and the measurement scale. In order to evaluate the number of measurable physical or abstract attributes for understanding and optimizing websites usage [2].

Web metrics is like a visitor's journey once on the website [68]. For example, the aesthetics characteristics will keep people on the website, reputation characteristics increase people’s trust, and encourage people to make a purchase. Website metrics assess a website in different domains which include e-commerce, academic, advertisement and so on. Each characteristic is compared against key performance indicators, and used to improve a website or marketing campaign's audience response.

In Websites Quality Metrics, Lilburne el al [37] proposed a Quality Compliance Framework (QCF) consisting of components such as quality measurement, quality characteristic, quality sub-characteristic and measurable indicator in Figure 2.

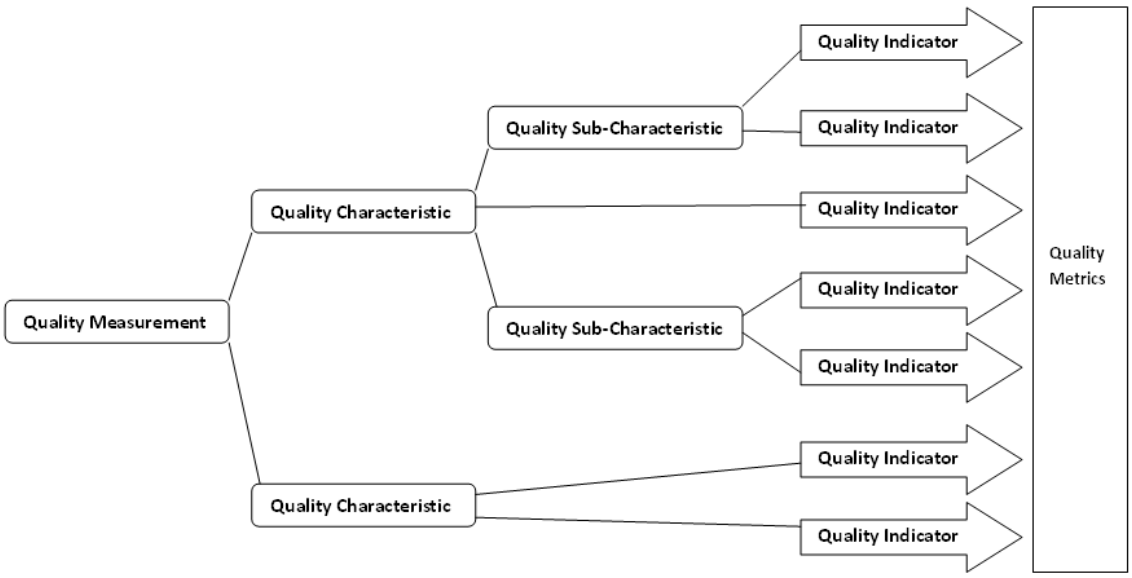


Figure 2. Quality Compliance Framework (QCF) [37]

- Quality measurement is the quality achievement in terms of a percentage value that indicates the degree of an overall quality compliance of the system.
- Quality Characteristics are the high level quality factors of a web application. A quality characteristic may have many levels of quality sub-characteristics.
- Quality sub-characteristics are the lower level quality criteria that break down its parent characteristic to more measurable criteria.
- Quality indicators (criteria) are the measurable units of quality in QCF. A quality attribute may belong to one or many quality characteristics or quality sub-characteristics.

QCF provides the quality measurement in a simple quality compliance scale. The scale starts from 0% and ends at 100%, where 0% indicates poor quality compliance and 100% indicates excellent quality compliance. This is the QCF score of the web application.

QCF works using bottom up approach. The metric for an attribute is converted to a 0% to 100% scale. Then the higher-level QCF score is calculated based on the QCF scores earned by the lower level children attributes, sub-characteristics, or indicators.

Final score is the quality measurement. The following formulas show how the quality measurement is calculated for different components of QCF:

- Quality measurement

$$\text{QualityMeasurement} = \frac{\sum \text{Childrens' QCF}}{\text{No.of children}}$$

- Characteristics and sub-characteristics QCF score

$$\text{Quality Characteristic Score} = \frac{\sum \text{Children'sQCF}}{\text{No.of children}}$$

- Attribute QCF score

$$\text{Quality indicator} = \frac{\text{Earned Score}}{\text{Possible Score}} \times 100\%$$

Here “Children” refers to the quality characteristics, quality sub-characteristics, or quality indicators in the hierarchy.

It is worth remembering that the relative importance of some features changes depending on the specific purpose of the website, and also on the purpose of the page. Therefore, all the resulting values must be weighted.

2.4. Existing Evaluation Methods

Melody Y. Ivory [25, 26] proposed the Automated Usability Evaluation (AUE) method. The AUE method increases the number of usability terms evaluating the system, and increases the number of study participants. It provides the highest level of automation and requires no user testing or informal use.

Automated Usability Evaluation has several potential advantages over non-automated methods, including uncovering various types of errors more consistently, increasing the coverage of evaluated features, enabling comparisons between alternative

designs, and predicting time and error costs across an entire design. They should reduce the need for evaluation expertise among individual developers and reduce the cost of usability evaluation as compared to standard techniques. Some automated evaluation techniques can be embedded within the design phase of Usability Interfaces development, as opposed to being applied after implementation. This is important because evaluation of the more traditional methods can be done only after the interface has been built and changes are more costly.

Coral et al. [7] have created a web classification framework to determine how the classified web metrics can be applied to improve web information access and use. They have presented the web metrics classification that performed with 385 metrics using web quality model, a three-dimensional web quality model which includes Web Features Dimension, Quality Characteristics Dimension and Life-cycle Processes Dimension. As a result of this classification, they found that the triplet (usability, operation, presentation) with 149 metrics and the triplet (usability, maintenance, presentation) with 93 metrics are those with more defined metrics, and that most of the triplets that include reuse have no defined metrics.

Luis Olsina et al. [41] proposed a quantitative evaluation approach to assess the quality of websites called Website Quality Evaluation Method (QEM). In order to evaluate, compare, and rank the quality of Websites, Luis Olsina applies a set of activities regarding the proposed methodology. A high-level view of major phases and procedures required for quality assessment is shown below:

- The specification of goals and the user standpoint.

  The evaluators should define and refine the goals and scope of the evaluation process. They could evaluate a web development project or a web application, and could assess the quality of a set of characteristics of a component, a whole product, or compare characteristics and global preferences of selected ones.

- The definition of website quality requirements.

The evaluators should agree and specify the quality characteristics and quality criteria, grouping them in a requirement tree.

- The definition of elementary criteria and measurement procedures (also called the determination of the elementary quality preference).

  The evaluators should define the basis for elementary evaluation criteria and perform the measurement and rating process.

- The aggregation of elementary preferences to yield the global quality preferences.

  The evaluators should make decisions that prepare and perform the evaluation process to obtain a global preference indicator for each selected website.

- The analysis, the assessing, and comparison of partial and global quality preferences.

  The evaluators assess and compare elementary, partial and global quantitative results regarding the established goals and user standpoint.

This approach is valuable for general web quality metrics. However, it also has limitations. Because evaluating a website through website QEM firstly requires a quality requirement tree that is created by a specific assessor who has professional skills. Website QEM has to relocate in a different domain (e.g. e-commerce, academic). For this reason, people are looking for an automatic evaluation tool that can measure a website easily. The evaluation needs efficiency and be simple according to the most common quality indicators, for example the user can type a web address and then click a button; the result will appear in the user's interface.

2.5. Limitations of Existing Web Evaluation Methods

In order to create a new website quality evaluation method effectively, some limitation has to be considered according to existing website evaluation methods.

- Today web-based application is complex. Many of existing website evaluation methods evaluates a website's quality based on its domains (e.g. e-commerce, education, entertainment, etc). It is necessary to create a comprehensive website evaluation method that is applicable to all the websites. According to a standard ISO quality model, a comprehensive website evaluation method is required to address common quality elements of the web application, since the elements vary for different kinds of websites.
- A number of existing website evaluation methods generally requires the evaluator who has IT background to assess the qualities in a website. It is difficult to apply if the people do not have any IT skills. An easily used interface and auto-evaluation are necessary in new website evaluation methods.
- Many new website software technologies and rules are not considered in existing website quality evaluation methods. The web developer is confused by the overall picture of the evaluation criteria. A new website evaluation methods need to involve the all identified new software technologies as the numbers of new criteria.
- The specific quality criteria for a website's reputation are clarified in many existing website evaluation methods, however most creditable criteria are immeasurable. The measurable creditable criteria need to be defined in a comprehensive web evaluation method (e.g. customer feedback, traffic, etc).
- In the end, the strengths and weaknesses of the web evaluation results should be applied to the user's expectations, and ease of understanding

Chapter 3

Proposed Approach

In order to effectively assess the quality of a website, it is necessary to create a website evaluation approach. A well-defined approach will provide a structure for the website quality framework, website quality criteria and quality evaluation calculation. The results will be a group of scores which relate to a substantial range of “user needs” features and the appropriate to the advanced live-web quality requirements.

3.1. Website Evaluation Framework (WEF)

The main aim of this step is to elicit, classify, and group the characteristics, sub-characteristics and indicators into a web evaluation framework, and then it is further broken down through a quantitative evaluation and comparison process.

The quality characteristics are broken down into the lower levels of sub-characteristics, and a sub-characteristic can then be refined into a set of measurable indicators. However there are some quality characteristics such as maintainability and portability that are not selected in this study. The reason is this project focuses on the quality of the user interface relevant to meet user access expectation.

Figure 3 shows a particular web evaluation framework below.

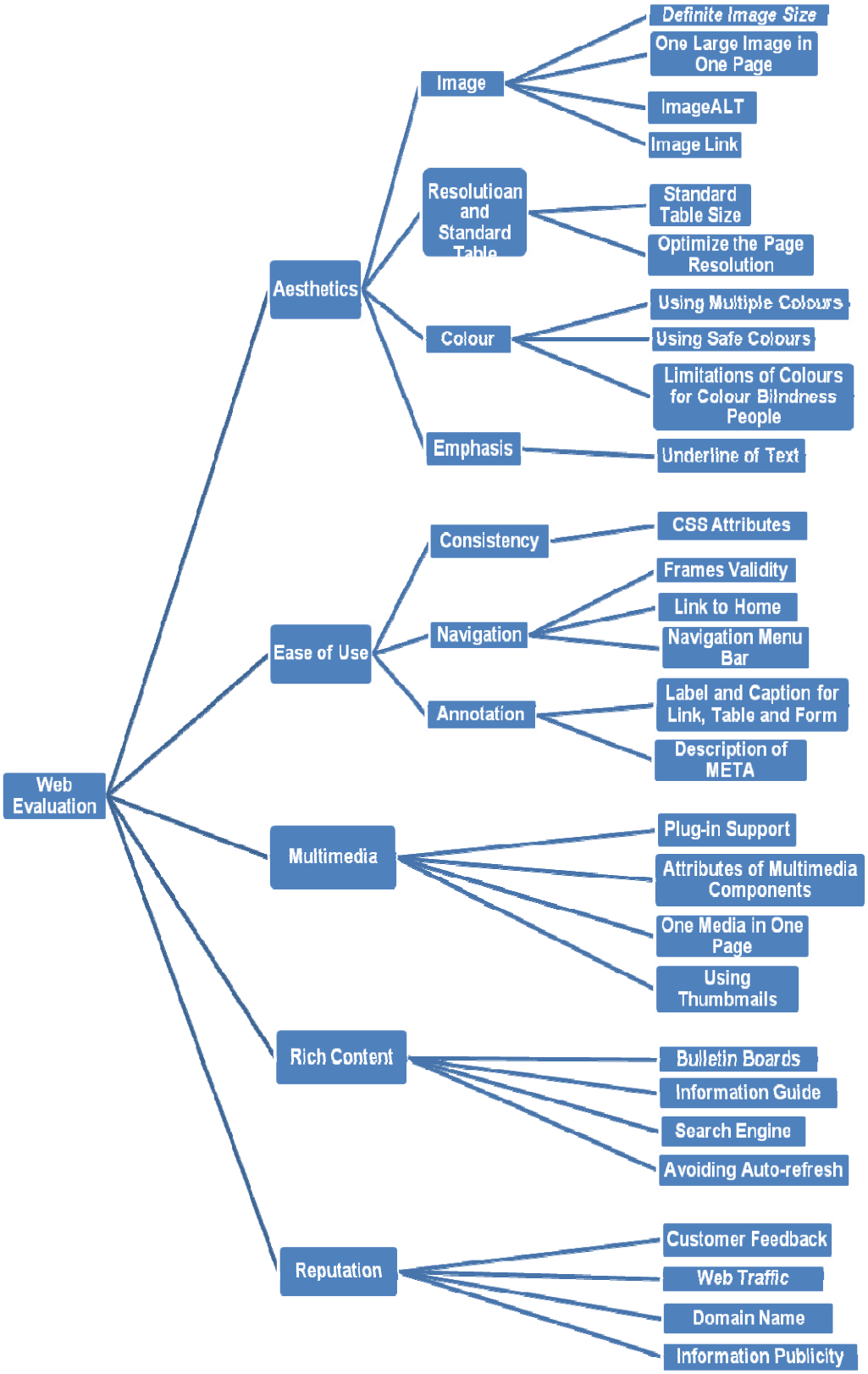


Figure 3. Web Evaluation Framework.

It is necessary to effectively classify the quality characteristics in WEF that should be suitable in the different types of websites. This is very important because one of the main aims in this study is to evaluate the any website automatically, regardless of different domains, types and language of design. There are 28 measurable measures and five quality characteristics, which may be widely covered by all the website's elements with regards to the user's viewpoint. Hence, the WEF function is to calculate the strength of the website and determine good or bad quality of the website through assessing the quality characteristics, sub-characteristics and indicators.

Based on the web evaluation framework, only Aesthetics and Ease of Use have a second level called quality sub-characteristic. Because these two specific quality characteristics both have multiple features, it is difficult to effectively classify the measurable criteria (indicators) directly. Comparing Aesthetics and Ease of use, the others characteristics such as Multimedia, Rich Content and Reputation are directly broken down into the measurable indicators. Because functional website elements can be established by the relative web criteria, they also can be easily detected through the web evaluation tool.

There are also two sub-characteristics which need to pay more attention: Emphasis and Consistency. They are represented by strong evaluation criteria and only a few researchers have done the same research as this study. Also Emphasis and Consistency both have only one indicator. If these features are missed then a website is possibly not able to get a high degree of quality of evaluation.

3.2. Definition of Website Quality Criteria

According to the well-defined web evaluation framework, defining the web quality criteria is the real challenge in this study. The quality criteria (indicators) are the bottom level in the framework. They are defined through in depth analysis of the effects on the new website technologies used in a website, which have not been fully researched to

replace the older quality criteria. So these effects and inflections are selected in this study, and constituted by several new web quality criteria, which will be found automatically by a web evaluation tool.

Each quality criterion can take a real value - the measurable and computable value, this value represents the outcome quality criteria, which can be interpreted as the degree of satisfaction required. For example the "*Search Engine"* quantifiable indicator is derived from the ease of use characteristic. It defines a measurable score 0 or 1 that will result afterwards in an indicator value. 0 is poor quality, 1 means excellent quality.

How to identify the measurable indicators? A web evaluation tool effectively analyses the HTML source codes and extract the codes according to the relative definition for the each quality criteria. Also a website quality criterion will be selected by a specific variable. A simple example of a website quality criterion "No. of images" is derived from the aesthetics characteristic, and it is easily detected by web evaluation tool and checked through a semantic code "<img>" and "</img>".

3.3. Overall Website Evaluation

In this stage the web quality metrics will calculate the quality indicators through the evaluation formulae, and provide a set of web quality scores.

Firstly, the criteria values and scoring formulae should be defined, also every relative indicator will be considered by means of weights. Using formulae they can make the evaluation process is comprehensible and accurate. The results will be calculated from 0 to 1. 0 is poor quality and 1 is excellent quality. Following the definition of the structure of the web evaluation framework, the evaluation is calculated from bottom to top. Quality characteristics scores represent the degree of web quality for the each characteristic (e.g. aesthetics, ease of use, and so on). Finally, assessing and comparing the complete quantitative results regarding the established goals and user standpoint.

3.4. Summary

The proposed approach provided a blueprint which recorded the components of the website quality framework, website quality criteria, the definition of quality criteria and quality calculation formulae.

Chapter 4

Website Quality Metrics

According to the approaches in Chapter 3, the web quality evaluation process is implemented by a specification for the web quality criteria (indicators), characteristics, sub-characteristics and formulae of calculation that will be shown in the following section. Olsina [42] defined a particular structure in which she considered the six basic aspects to measure a website. Following this idea, a website quality framework is purposed, which includes Aesthetics, Ease of Use, Multimedia, Richness of Content and Reputation. Finally, all the resulting values must be weighted.

4.1. Aesthetics

4.1.1. Background of Aesthetics

Since the websites began to be used popularly in the early 1990's, the aesthetics has become a topic of heated discussion. As the role of aesthetics in the websites increasingly became an issue of contention, different opinions regarding the relationship between the aesthetics and web application were expressed.

One of the proponents Jakob Nielsen [47], has contributed some of the most important research regarding software development and Human-Computer-Interaction (HCI) in his book "Usability Engineering". Nielsen argued against using Flash, because more and more web designers realised that the use of elements such as the Flash on the websites created too many images on the screen. This resulted in messy websites with the Flash elements that blinked and moved across the page without creating an aesthetic experience for the user. Many users could not even open the pages, or the downloading time was too long, this reduced the usability of the website.

However, at the beginning of the 21st century there has been a renewed tendency for more functional websites with multiple elements of aesthetics which replaced the traditional features [11]. On the one hand, the fast development in IT-technology and the speediness of broadband have made it possible to accommodate the users who wish to receive their information in a more aesthetic way, without necessarily sacrificing content and function. Just as people today are increasingly expected to be up to date on the IT technology development, it will also be expected that people who work with the website access not only have the knowledge of the technologies, but also the attractive aesthetics.

On the other hand, according to the issue from Lisbeth Thorlacius [58], “In a world where a picture means more than words, no one has the time or bothers to read lengthy information advertising.” It means visual symbols such as images, video, animation images, etc have become an integral part of web application.

The major research in this study focused on the aesthetic characteristics of the quality evaluation. The main reason is visual aesthetics can play an important quality role in the measurement of websites and this can be identified in the different ways [66]:

- The aesthetics have an important role for the all types of websites which are concerned with how the users are perceived. For example the professional aesthetics layout that convey information of the worth of the organisation or the individual behind the website.
- The aesthetics supports the content and the functional aspects. Websites are user-friendly when they viewed aesthetically with the navigation and interactive functions.
- The aesthetic characteristics adapt to any kinds of websites. For example, people expect the entertainment websites to offer a reasonable amount of aesthetic content, whereas people also expect the educational websites to have aesthetic appeal.
- The aesthetic classifies the suitable target audience. The presentation of a website

providing services to the young audiences must be designed with visual aesthetics in accordance with contemporary ideas and this is different from a website that targets the general adult population.

Well-defined aesthetics have been used in the most successful websites. The aesthetic characteristics have been created in accordance with the above-mentioned issues.

4.1.2. Aesthetics Metrics

Aesthetic characteristic is a high level quality element of a website's measurement. It has two levels which include the sub-characteristics and indicators. The sub-characteristics were established by treating them as a set of components, classifying the visual effects including the Resolution & Standard Table Size, Colours, Images and Emphasis.

The reason these characteristics have been selected is because this study is interested in the attractive user interfaces [35]. This includes design with the users' frames, tables, fonts and without being confused by complex colours or layout when they appear on the websites. Specifying these sub-characteristics are in reality like a word framework, a colour choice, or text displayed on the screen, and any visual expression, whether it is intentional or not.

The main objective of aesthetic evaluation is to calculate the different score of the sub–characteristics which indicate the result of indicator measurement by using an aggregation formula. The importance of sub-characteristics is considered by means of weights. Based on the research [37], following formula shows aesthetics calculated with "Children" components:

$$\text{Aes} = 0.3 \times \text{Img} + 0.2 \times \text{T \& S} + 0.3 \times \text{Col} + 0.2 \times \text{Emp}$$

- Img – the total number of sub-characteristic of Images in whole websites,

0 <= Img <=1.

- T&S – the sub-characteristic of Resolution & Standard Table Size, 0 <= T&S <=1.
- Col – the sub-characteristic of Colour in quality of websites, 0 <= Col <=1.
- Emp – the sub-characteristic of Emphasis, 0 <= Emp <= 1.
- 0.3, 0.2, 0.3, 0.2 mean the number of weights of each sub-characteristic, Sum of weights = 1, and 0< weights < 1.
- Aes – the characteristic of aesthetics, 0 < Aes <= 1

These are the four aesthetic characteristics that enhance the quality of a website interface, however they have different values. Considering the proportion of each sub-characteristic, image and colour (0.3 weights) pay more attention than others, because people look at the images first when they view a web page. Both Resolution & Standard Table Size and Emphasis have the same weight (0.2).

Obviously, the quality of sub-characteristics is immeasurable, and they have to be calculated through the quality criteria. The following introduction is to specify the sub-characteristics and indictors in order to clarify the website evaluation process.

4.1.2.1. Images

Traditional rules of the quality of measurement that define the graphics do not add value to a page's aesthetics. The main reason is the websites tend to be complicated when it comes to graphics, such as the blinking, flashing, animation and other special effects.

However, the fast development of web-technology and the broadband in present times has created a revolution in the website design. It is possible to create the different web applications with the multiple-technologies to satisfy the user expectations.

Images are the most frequently displayed characteristic in the web entity. Images that include the Graphics Interchange Format (GIF), Joint Photographic Experts Group

(JPEG), and Flash are popular in the most live-websites, and there also have different formats such as BMP, TIFF, PNG and so on [43].

GIF, JPEG and Flash are only discussed in this study. GIF formats support up to the 256 colour chosen from the 24 bits per pixel RGB colour space. In general, GIF is best for the images that are used in the line drawings, black and white images and small text (e.g. logo). JPEG images are best suited for the photographs and complex graphics. However GIF does not work well on the photographs as the images lose clarity and sharpness. Flash is a program by macromedia for creating interactive, animated online content [18]. In addition, images have also been used in the websites that combine the text and hyperlinks to increase the quality of aesthetics.

The Sub-characteristic of Images is a lower level quality element called the Upper Level Sub-group. It has four measurable indictors. An average formula is used for calculating these four measurable indicators to implement the images evaluation process.

$$\text{Images} = \frac{\text{ISize} + \text{IinOne} + \text{IALT} + \text{ILink}}{4}$$

- ISize – The measurable indicator names Image Size, it has a scoring 0 or 1. 0 expresses as poor quality and 1 is excellent quality.
- IinOne – The measurable indicator names One Larger Image in One Page, it has a scoring 0 or 1. 0 expresses as poor quality and 1 is excellent quality.
- IALT - The measurable indicator names Image ALT, it has a scoring 0 or 1. 0 expresses as poor quality and 1 is excellent quality.
- ILink – The measurable indicator names Image Link, it has a scoring 0 or 1. 0 expresses as poor quality and 1 is excellent quality.
- Images –The sub-characteristic of images, the final result of images is 0<=images<=1.

The Measurable indicators are well established according to the contemporary website quality criteria and interactive user interfaces that suit the user's expectations. Each indicator is specifically described below.

A. Metric Name: Image Size

Name of Variable: ISize

Higher Level Metric Group: Aesthetics

Upper Level Sub-Group: Images

Description: Image size is restricting the width and height of the images that display in a web page. Most websites use images to improve their aesthetics, using width and height attributes on the images can ensure the fast web page display, and limiting the size of image appearance. However not all web pages apply width and height to the size of their graphics.

Proposed Evaluation Aspects: Every image should be coded by width and height tags.

Algorithms: It is a binary criterion: if the images have width and height in a page then. ISize = 1, otherwise ISize = 0.

B. Metric Name: One Larger Image in One Page

Name of Variable: IinOne

Higher Level Metric Group: Aesthetics

Upper Level Sub-Group: Images

Description: One web page should have only one large image. If a page needs to display more than one, it should instead show the images on the web page by using a link to display in a new browser window. Another choice is to display a thumbnail

or a smaller version of the image which can be made by a clickable link and the larger image can load in a new browser window.

Proposed Evaluation Aspects: One web page is only allowed to have only one larger image, the maximum size is width = 360, height = 360.

Algorithms: Checking every size of image in a page,

If X and Y >= 360 then Larger One= Large One + 1.

If Larger <=1 then IonOne = 1, otherwise IonOne = 0.

C. Metric Name: Image ALT (Alternative Text)

Name of Variable: IALT

Higher Level Metric Group: Aesthetics

Upper Level Sub-Group: Images

Description: Image ALT attribute is applicable when a web page cannot display the images, forms, or applets, this attribute will specify the alternative text [60]. In general it assigns the text to the images alternative needs, because sometimes the website users cannot understand the images, but they would rather read aloud the alternative text assigned to them. Every user can see this ALT text, simply by pointing over the image and looking at the yellow tooltip that appears.

Proposed Evaluation Aspects: Every image should code in image ALT attribute.

Algorithms: Checking every image code,

If alt <> " " then ImageALT = ImageALT + 1, If ImageALT = Total Images then IALT = 1, otherwise IALT = 0.

D. Metric Name: Image Link

Name of Variable: ILink

Higher Level Metric Group: Aesthetics

Upper Level Sub-Group: Images

Description: An image link is a hyperlink which interacts with a specific image, and the user can click this image to point it at the relevant link destinations. More and more people are accustomed to clicking the images to seek the hyperlink. This is an easy way to link an object but without a specification.

Proposed Evaluation Aspects: Images should have image link attribute.

Algorithms: Checking image code,

If X <> " " then ImageLink = ImageLink+ 1. If ImageLink = Total Images then ILink = 1, otherwise ILink = 0.

4.1.2.2. Page's Resolution and Standard Table Size

In order to identify the page resolution and standard table size as the important criteria in the evaluation of aesthetics, a definition of appearance has to be specified. Appearance is the main quality element for a visual web interface. Apple's iMac advertised as the "aesthetic revolution in computing," a criterion of appearance that has become a major consideration for purchasing computers [33]. This issue can also be used in the web application domain.

However, the traditional websites have enforced their appearance across the different browsers. This is an example of how previous ideas in the quality of website design are now out of date. Early websites insisted that appearance should be identical across the all browsers, to ensure they provided the similar resolution, font sizes, table, etc on the every browser. The question today is "why?" Do users benefit from identical

appearance? Not really. The most users are used to a single browser and rarely change to others. It does not matter to them how the website looks in other browsers.

Traditional appearances are now simplified and changed to meet the new quality criteria used in this study to evaluate the aesthetics. Page's resolution and standard table size emphasize the page display that should have the fixed table and higher resolution, focusing readability onto the monitor. For example a flexible table and lower resolution will change the page size, it will become too wide or too long, meaning that it is necessary to scroll up and down.

An average formula is proposed by computing this rate of sub-characteristic, which have two measurable indictors: Optimise the Page Resolution and Standard Table Size.

$$PR\ \&\ RT = \frac{STable + PResolution}{2}$$

- STable – The measurable indicator names Standard Table Size, it has a scoring 0 or 1. 0 expresses as poor quality, and 1 is excellent quality.
- PResolution – The measurable indicator names Optimise the Page Resolution, it has a scoring 0 or 1. 0 expresses as poor quality, and 1 is excellent quality.
- PR&RT means Page's Resolution & Standard Table Size sub-characteristic, the final result: 0 <= PR&RT <= 1.

Each measurable indictor is further clarified by the following attributes.

A. Metric Name: Standard Table Size

Name of Variable: STable

Higher Level Metric Group: Aesthetics

Upper Level Sub-Group: Page's Resolution & Standard Table Size

Description: Some websites have a settable width at 100%. The reason is the table is able to fit in with any size of browsers whatever the resolution of the screen.

This makes it easy for the users, because the users can view the information on the screen without scrolling horizontally.

However, does the resizable table actually satisfy the user's expectation? It does according to the relative researches on the 100 most popular websites such as IBM.com, Microsoft.com, uk.yahoo.com and so on. A lot of websites still set the table width as pixels. Because resizable table can avoid horizontal move scroll, but the layout of content (e.g. text) are also changed. Users will be confused by looking for the same information or words because they are not always in the same position once browser size has been charged.

Proposed Evaluation Aspects: The width attribute should set fixed number in the table code.

Rules of Scoring: Checking attribute of every image,

If every width <> 100% then STable = 1, otherwise STable = 0.

B. Metric Name: Optimise the Page Resolution

Name of Variable: PResolution

Higher Level Metric Group: Aesthetics

Upper Level Sub-Group: Page's Resolution & Standard Table Size

Description: The most common computer display the resolution is 1024 x 768 [18]. The optimisation resolution from the previous 800 x600 format to the higher 1024x768 that the many websites and multimedia products were re-designed. However there are so many higher resolutions released such as inexpensive LCD monitors which have made 1280x1024 resolution more popular for the desktop user, 1400x1050 SXGA+, 1280x720 WXGA, 1920x1200 WUXGA and so on. Old monitors such as 800 x600 are thrown away in the real computer market.

Proposed Evaluation Aspects: The resolution of a page should be higher than

1024x768.

Algorithms: If the page resolution is higher than 1024x768 then PResolution = 1 otherwise PResolution =0.

4.1.2.3. Colour

Visually appealing web pages need a consistent colour scheme. Colour is a very salient stimulus, which is known to affect the visual appeal of websites. When opening a website the background colours are usually displayed well before the content appears [29]. Without colour, a page can be lacking aesthetically. For this reason, website quality should show a consistent and balanced colour scheme. Too much colour, or erratic colour, gives the page confused aesthetics.

Estimating the quality of colour can be very difficult. However, according to research from a thousand relative studies, three measurable indictors are selected within the sub-characteristic of colour, which include Using Multiple Colours, Using Safe Colours and Limitation of Colours. They typically affect the quality of visual colours and few researchers have mentioned them. More information about each indictor is shown below.

Colour is a lower level characteristic within the website quality framework. Its evaluation is calculated by the three measurable indicators, and the result of the calculation will be an average rate of the total number of indicators. The following formula has shows the expression for the calculation:

$$\text{Colour} = \frac{\text{CMultiple} + \text{CSafe} + \text{CLimitation}}{3}$$

- CMultiple – The Measurable indicator names Using Multiple Colours, it has a scoring 0 or 1. 0 expresses as poor quality and 1 is excellent quality.
- CSafe – The Measurable indicator names Using Safe Colours, it has a scoring 0 or 1.

0 expresses as poor quality, and 1 is excellent quality.

- CLimitation – The Measurable indicator names Limitations of Colours for Colour Blindness People, it has a scoring 0 or 1. 0 expresses as poor quality, and 1 is excellent quality.
- Colour – Means colour sub-characteristic, the final result: 0 <= Colour <= 1.

The following information is specifies each measurable indicator and the important rules. They are automatically calculated by the web evaluation tools.

A. Metric Name: Using Multiple Colours

Name of Variable: CMultiple

Higher Level Metric Group: Aesthetics

Upper Level Sub-Group: Colour

Description: A web page using too little colour looks boring or inert, whereas too much colour can be garish. Colour is good way for identifying, grouping or differentiating the website's elements. Evaluating a web page that uses simple or complex colour, it may not be able to clearly represent the meaning of website's elements and draw user's eyes, and is a poor aesthetics quality website.

Proposed Evaluation Aspects: The recommendation for a web page is that it uses no more than seven colors [18].

Algorithms: Checking code of colour, calculating the number of colour

If Colour > = 7 then CMultiple = 1, otherwise CMultiple = 0.

B. Metric Name: Using Safe Colour

Name of Variable: CSafe

Higher Level Metric Group: Aesthetics

Upper Level Sub-Group: Colour

Description: The safe colour palette of websites commonly applies a set of 216 colour values [60]. It developed at a time when many computer displays were only 256 colours. As of 2009, company and personal PCs typically have at least the 32 Deep Colours, even mobile devices have at least the 16-bit colour. The application of web safe colours has reduced, however it is still an important feature for the most website designs.

Proposed Evaluation Aspects: Each web page should specify the number of colour components according to RGB triplet, such as read: FF0000.

Algorithms: Checking colour code, if the colour code matches the list of RGB value then CSafe = 1, otherwise CSafe = 0.

C. **Metric Name** : Limitations of Colours for Colour Blindness People

Name of Variable: CLimitation

Higher Level Metric Group: Aesthetics

Upper Level Sub-Group: Colour

Description: Some people (mainly males) have impaired ability to tell the certain colours apart. There are several types of colour-blindness, the most common affecting red & green (they appear very much the same).

Proposed Evaluation Aspects: A web page should not use colour (particularly red and green) to build the important elements such as titles, documentations, fonts, links in a website because the user needs to differentiate the colours to be able to use the interface successfully [51].

Algorithms: Checking the colour code, if background and font colour is 008000, 00FF00 and FF0000 then CLimitation = 0, otherwise CLimitation = 1.

4.1.2.4. Emphasis

A web page made up entirely of text is hard for people's eyes to scan. An on-line document adds focal points that will provide the landmarks to direct the reader through the content structure. Focal points must determine the most important part of the page and give it the greatest emphasis.

Emphasis is to provide a way of making the element that is most important stand out in the web design [31]. Emphasis contains Italics, Bold, Underline, Color, Size, Capitals, even Space and Indentation. If a website tries to emphasise everything on a page, the reader would get confused and lose the interest. The most important content of the page should be prioritised and presented accordingly. A good rule when working with the website content is to add the different emphasis one at the time. For example if a section has the same size of text, the headings within this section should be increased or made bold. Only a small variation is required to establish a visual contrast.

Fortunately, W3C has well established the relevant criteria about the emphasising structure of text in a web page, with the criteria such as EM (emphasis), STRONG (stronger emphasis), white space, line and so on. This aspect will not be discussed in this study.

However, an argument has been proposed about using the underlining of text to emphasise the web content. More information discussing this particular issue is shown below.

A. Metric Name: Underline of Text

Name of Variable: Underline

Higher Level Metric Group: Aesthetics

Upper Level Sub-Group: Emphasis

Description: Underlining is used for emphasising the important points of web content and also acts for the highlighting hyperlinks (whether visited or not) [63].

However a question is whether the underlining is needed to emphasis. According to the correlative researches, the thirty five popular websites have been analysed, which include IBM.com, Microsoft.com, Wikipedia.org, BBC.co.uk, etc. these websites do not use the underlining to emphasise the focal points within them.

Today's computer users are used to looking for a hyperlink by moving the cursor onto the text which has been underlined. They can be confused if an underline is not a hyperlink. Underline of text has lost the function of emphasis. For this reason, an Underline means and only means a hyperlink.

Proposed Evaluation Aspects: Avoid mixing the underlined text for the emphasis, it only appears as a hyperlink.

Algorithms: If the texts have underline, they must be hyperlinks， then Underline = 1, otherwise Underline = 0.

Sub-characteristic of emphasis is an immeasurable criterion, and it has only one measurable indicator: underline of text. The goal of an indicator directly indicates its parent level. Therefore the sub-characteristic only has as a calculation score. Emphasis = 1, or Emphasis = 0.

4.2. Ease of Use

4.2.1. Background of Ease of Use

In the early days of web applications, people realized that using the most websites were really difficult, therefore the diffusive quality issues "usability" are researched. Usability has been proposed as a concept by watching real people using the websites which meet their expectations.

Hong Xie reedited a brand-new definition of usability – ease of use from website quality: "ease of use recommends a clear definition for the web-credible usability but it is more explicit and tangible, and researches from other authors have also mentioned

that the ease of use is the capability of the website to be used with ease by the users [20, 24, 53].

According to well-defined the aspects of ease of use and comparing the usability, ease of use is the common feature for website quality evaluation. It is more specifically focused on user satisfaction, offering visitors a good user experience with a quick accessible website. Then they are more likely to feel good about the organisation behind the website.

4.2.2. Ease of Use Metrics

A definition by Whitney Quesenbery [52] about evaluation of ease of use is:

"Ease of use can be used to understand user requirements, formulate characteristic goals and decide on the best techniques for ease of use evaluations".

The characteristic of ease of use is a high level web quality element. It has a children level – three sub-characteristics, and each of them has one or more measurable indicators. Sub-characteristics contain Consistency, Navigation and Annotation. The reason for choosing these factors is because they are more suited to the user friendly aspects of interfaces and Human Computer Interaction (HCI) and also to analyse effective websites where the users are able to quickly and efficiently access the desired pieces of information.

Furthermore in order to effectively measure the quality of ease of use, a formula is proposed by calculating the aggregation of sub-characteristics and considering the means of weights for each of them.

The following formula shows the calculation of ease of use:

$$EoU = 0.4 \times Consis + 0.4 \times Nav + 0.2 \times Anno$$

- Consis – the sub-characteristic of Consistency, 0 <= Consis <= 1.

- Nav – the sub-characteristic of Navigation, 0 <= Nav <=1.
- Anno – the sub-characteristic of Annotation, 0 <= Anno <= 1.
- 0.4, 0.4 and 0.2 represent the weights of each number of sub-characteristics. Sum of weights = 1 and 0< each weights <1.
- EoU – the characteristic of Ease of Use, 0 < EoU < 1.

Each sub-characteristic has a different value. The Consistency and Navigation pay more attention than annotation because technically they are designed to be a flexible web interface that allows people to use it as easily as they can.

Also each sub-characteristic has one or more measurable indicators, they provide an average formula to calculate the result of the evaluation of a sub-characteristic. The following information is an introduction for sub-characteristics and measurable indictors.

4.2.2.1. Consistency

The simple idea about consistency is that people can move around the website from page to page and find the similar content or information displayed in the similar ways. All pages should provide the consistent user interfaces that present the same options in the same way over the whole website. When it comes to website design, people need consistency so they can find the things much quicker.

Further discussion about the importance of consistency in a website is necessary. Everyone agrees that well-defined consistency which keeps the same design style across the entire website makes the easier and more comfortable to the users.

Generally the evaluation of a sub-characteristic is calculated through a formula that is the average of a number of measurable indicators. However, consistency only has one indicator, which is Cascading Style Sheets (CSS) Attributes. So the result of

consistency is directly defined by 0 or 1. 0 represents poor quality of consistency and 1 represents excellent quality of consistency. This is a way to prove that CSS attribute is an essential element of web quality. A website missing CSS attributes means it has a strong chance of losing a large score for quality.

A. Metric Name: CSS Attributes

Name of Variable: CSSA

Higher Level Metric Group: Ease of Use

Description: One well-defined web page interface, must have a consistent layout to allow the users easy navigation [61]. The number of attributes should all remain the consistent throughout a website. They include Mouse over effects, Colour, Layout, Style and Font. When a user navigates from one page to another page in a website, he/she should see a page layout similar to the previous one. For example, Microsoft's Download website has a very good consistent page layout that makes it easy for the user to find the information they need.

One of the most common methods of ensuring consistency in the website is to use Cascading Style Sheets. The CSS attribute is able to define the page layout for each element in the entire website and helps to keep the similar features and behaviours for each web page that uses the same style sheet.

Proposed Evaluation Aspects: A website should have a well-defined CSS attribute, and this CSS attribute should have Mouse over effects, Colour, Layout, Style and Font elements.

Algorithms: If the CSS attribute is exists and CSS has defined the above elements, then CSSA = 1, otherwise CSSA= 0.

4.2.2.2. Navigation

Many features come together to create a quality website. One of the integral components is the website navigation. The website navigation is the act of moving around from the page to page within a website, and a good website provides people with the easy ways to navigate through to access the web content. If the navigation has not been designed well it can also easily hinder the users and they will not use the website again.

Website navigation is very important as it creates the flow for the website's user to travel around the website. A good website should include the prominent and clear navigation elements, which contain the menu bar, images, text content, and so on. They are composed of the internal links and external links grouped together and provide a guiding of a user's location within the website at all times.

Navigation is a sub-characteristic under the Ease of Use called Up Level. It has three measurable indicators. Obviously navigation is an immeasurable characteristic. An average formula is calculated by using these three indicators and is shown below.

$$\text{Navigation} = \frac{\text{Frames} + \text{Lhome} + \text{Menubar}}{3}$$

- Frames – The indicator of Use of Frames, Frames = 0 or 1, 0 expresses as poor quality, and 1 is excellent quality.
- Lhome – The indicator of Link to Home, Lhome = 0 or 1, 0 expresses as poor quality, and 1 is excellent quality.
- Menubar – The indicator of Navigation Menu Bar, Menubar = 0 or 1, 0 expresses as poor quality, and 1 is excellent quality.
- Navigation – The sub-characteristic of navigation. The final result: 0 <= Navigation <= 1.

The information below includes more discussion about the each indicator and their

metric. A website evaluation tool is used by computing them automatically.

A. Metric Name: Use of Frames

Name of Variable: Frames

Higher Level Metric Group: Ease of Use

Upper Level Sub-Group: Navigation

Description: Frames is the use of multiple, independently, controllable windows or sub-windows on a website. This effect is achieved by building a number of sections as a separate HTML file and having a master indentify all of the sections. For example, in the same window it should have three frames, they include first frame which is a display static banner, second frame which is a navigation menu, and third frame represents the main document that can be scrolled and replaced by a second navigational frame [63].

Proposed Evaluation Aspects: The frames should be designed in a website and each element (e.g. Frameset, Frame, NoFrames) should contain the equivalent navigation options.

Algorithms: If Frame attribute is used and its relevant elements are well defined then Frames = 1, otherwise Frames = 0.

B. Metric Name: Link to Home

Name of Variable: Lhome

Higher Level Metric Group: Ease of Use

Upper Level Sub-Group: Navigation

Description: This is the most essential link for the every web page. The homepage should be the central hub which connects to all the other parts of the website.

Proposed Evaluation Aspects: Each web page should contain a link to the home page.

Algorithms: If a home link or several home links are used in every web page then Lhome = 1, otherwise Lhome= 0.

C. Metric Name: Navigation Menu Bar

Name of Variable: Menubar

Higher Level Metric Group: Ease of Use

Upper Level Sub-Group: Navigation

Description: The navigation menu bar is aggregated by a number of links together. It is commonly placed on the top of the page. It is important because once the page has loaded from top to bottom, the user can see the page content without having to scroll down [64].

Proposed Evaluation Aspects: A website should have a navigation bar and it should be placed at the top of the page.

Algorithms: If a navigation bar is used and it is placed at the top of the page then Menubar = 1, otherwise Menubar= 0.

4.2.2.3. Annotation

Annotation is generally used in the newspapers or magasines, for example where another reader has written down the notes about the quality of a document, or annotated information which give a description about a paper or argument. An annotation can also be prominent in a lot of features in a website domain.

The website annotation can be described as an aggregation of text attributes for a key element in a web page. These attributes include tag, caption, label, summary, etc.

This study proposes the idea that the website should provide annotations for the every element, which contain the links, forms, tables, images, or other web elements, these elements are important attributes for the interaction between the users and web interface, Well-defined annotations can help users to understand the functions of a website, they can see what they like, and support user access behaviours.

Annotation is a sub-characteristic under the ease of use characteristic. It has two measurable indicators. An average formula is calculated by using the indicators.

$$\text{Annotation} = \frac{\text{LabelLTF} + \text{META}}{2}$$

- LabelLTF represents the indicator of Label and Caption for Link and Form, LabelLTF = 0 or 1, 0 expresses as poor quality, and 1 is excellent quality.
- META - The indicator of Description of META, META = 0 or 1, 0 expresses as poor quality, and 1 is excellent quality.
- Annotation means the annotation sub-characteristic, the final result:

  0 <= Annotation <=1

A. Metric Name: Label of Link and Form

Name of Variable: LabelLTF

Higher Level Metric Group: Ease of Use

Upper Level Sub-Group: Annotation

Description: Links associated with the web resources (e.g., an image, HTML document, a video clip, etc.). Users frequently identify what they want to visit before clicking the link resources. Well-defined links must be very specific with their instructions.

Tables include a group of attributes of which the most important is “caption” that provides the short description of the tables’ purpose. A longer description may

also need to be provided (via the “summary” attribute) for the benefit of people using the speech or Braille-based software in a web page [63].

The form is a section of a document which contains the mark-up, normal content and a number of special elements such as the checkboxes, buttons, menus, etc. Generally users need to modify or complete the whole thing (e.g., entering text, clicking button, etc), before they submit the form. In order to help users understand what they are about to do, a form should specify the label and description on each element, for example text input fields should have the labels and summary.

Proposed Evaluation Aspects:

The links should specify the titles of the link attributes.

The tables in web pages must have the “caption” elements.

The form elements should have the well-defined Labels and Summary.

Algorithms: Checking source code,

If X = “LINK”, Y= “TABLE”, Z = “FORM” then Total = Total +1

If Link = “title”, Table= “caption”, Form = “label” and “summary” then

Attrib = Attrib +1

If Total = Attrib then LabelLTF = 1 otherwise LabelLTF = 0.

B. Metric Name: Description of META

Name of Variable: META

Higher Level Metric Group: Ease of Use

Upper Level Sub-Group: Annotation

Description: META is information about a website specified in a variety of ways [63]. For example, specifying information of author or a short description of website. A website should have the appropriate META information to be searchable by

search engines, and this information must contain “author”, “copyright”, “keywords” and “date”.

Proposed Evaluation Aspects: Every web page should involve a META element, and be well-defined by the attributes (“author”, “copyright”, “keywords” and “date”).

Algorithms: If every page has a META element and the key attributes <> “ ” then META = 1, otherwise META = 0.

4.3. Multimedia

4.3.1. Background of Multimedia

In July 2009 it was reported by the Pew Internet Life Study [59] that some 57 percent of adults were internet users in the U.K. They are watching or downloading the video content, 19 percent do so on a typical day, primarily at the YouTube, news and internet TV websites. These numbers swell to 75 percent and 31 percent for the young adult (18 to 29 year old) market, clearly painting a picture of the importance of video and multimedia content in both today and future.

In the past five years, the bandwidth to the customers has expanded. Web multimedia has been receiving near exponentially increasing attention. The explosion of YouTube, and the emergence of Internet TV are creating enormous interest in the use of online communication such as video and advertising medium [21]. More and more users expect the dynamic and interactive content. Multimedia creates an outlet for this demand. This is why it is so important to incorporate an effective multimedia design scheme.

According to these reasons, multimedia has become an important characteristic for the quality of websites. The elements of multimedia contain the animation images – the user can hear or see: music, sounds, videos, flash, and more. Without this integration of

web attributes, the quality of website to connect with the customers will ultimately suffered.

4.3.2. Multimedia Metrics

In order to evaluate multimedia, the components of multimedia must be distinguished by what are essential. An important article by Gibbs et al. [19] conveyed a study looking at how the quality of video or sounds are enriching the pages and making the web pages more attractive. The quality characteristic should be carefully selected, and each characteristic must be defined by representing a specific value of web multimedia that satisfies the users' requirements.

Multimedia is a high level quality characteristic and it is directly calculated from the measurable indicators through an aggregation formula. This is different from Aesthetics and Ease of Use. The main aim of multimedia evaluation is to show the degree of multimedia quality in the live website and important indicators are considered by the means of weights. The formula can be expressed as follows:

$$\text{Media} = 0.2 \times \text{Plugin} + 0.2 \times \text{Attri} + 0.3 \times \text{MinOne} + 0.3 \times \text{Thum}$$

- Plugin represents the measurable indicator called Plug-in Support, its scoring is 0 or 1. 0 means poor quality and 1 is excellent quality.
- Attri represents the measurable indicator called Attributes of Multimedia Components, its scoring is 0 or 1. 0 means poor quality and 1 is excellent quality.
- MinOne represents the measurable indicator called One Media in One Page, its scoring is 0 or 1. 0 means poor quality and 1 is excellent quality.
- Thum represents the measurable indicator called Using Thumbnails, its scoring is 0 or 1. 0 means poor quality and 1 is excellent quality.
- The weights proposed for each indicator are 0.2, 0.2, 0.3 and 0.3. Sum of weights =

1 and 0< each weights <1.

- Media produces Multimedia characteristic, 0 <= Media <=1.

Considering the differences between the degrees of each indicator, One Media in One Page and Using Thumbnails take more weights than others, because they strongly affect the quality of a website. A website may lose the customers if they are poor.

The information below includes more discussion about each indicator and their algorithms.

A. Metric Name: Plug-in Support

Name of Variable: Plugin

Higher Level Metric Group: Multimedia

Description: Plug-in (add-in, plugin or snap-in) is a program that interacts with a web browser to extend the web browser's specific functional supports. There are a lot of different presentation formats (e.g., Flash, QuickTime, Microsoft Silverlight, 3DMLW, etc) and they all interact with the web browsers by using plug-in support.

Proposed Evaluation Aspects: A website with a multimedia element should provide appropriate browser plug-in support.

Algorithms: If multimedia components are involved and plug-in = true, then Plugin = 1, otherwise Plugin = 0.

B. Metric Name: Attributes of Multimedia Components

Name of Variable: Attri

Higher Level Metric Group: Multimedia

Description: Multimedia components (e.g. video, audio, and flash) are becoming increasingly common elements on the websites. They are widely used in entertainments, newscasts, distance learning materials and so on. However, there are

number of challenges when presenting the dynamic multimedia, especially for people misunderstands a multimedia element that has no description. For this reason a well-defined description is necessary for the every multimedia component, and this description includes “title”, “alt” and “abstract”.

Proposed Evaluation Aspects: Every multimedia component such as flash animation, video, and audio must have a well-defined description.

Algorithms: If multimedia components are involved then “title”, “alt” and “abstract” = true, Attri = 1, otherwise Attri = 0.

C. Metric Name: One Media in One Page

Name of Variable: MinOne

Higher Level Metric Group: Multimedia

Description: Each web page should have only one multimedia component. Unprofessional websites normally have more animation components which can cause the page disturbance and confuse the users.

Proposed Evaluation Aspects: A web page should have only one multimedia element.

Algorithms: If X = video or flash or audio, then Multimedia = Multimedia + 1. If Multimedia <=1 then MinOne = 1, otherwise MinOne = 0.

D. Metric Name: Using Thumbnails

Name of Variable: Thum

Higher Level Metric Group: Multimedia

Description: A thumbnail is a small image preview on a web page. It usually contains a hyperlink to a full-size version of the multimedia components or images.

According to the issue (One media in one page) in this study, only one multimedia can be used in a page and therefore any others should be represented with a number of thumbnails, so that the users can view other relevant multimedia components by clicking the thumbnails. Also using thumbnails can speed up the page load time. Thumbnail should be well-defined by using the “title” and “alt” attributes and specifying the size equivalent with “width” and “height”.

Proposed Evaluation Aspects: Every thumbnail should have “title” and “alt” attributes and maximum size is 240x240 pixels.

Algorithms: If thumbnail = true then Total = Total+1

If “title”, “alt” <> “ ” and size < = 240 then attribute = attribute +1

If Total = attribute then Thum = 1, otherwise Thum = 0.

4.4. Rich Content

4.4.1. Background of Rich Content

Generally content aims to benefit the reader by providing the information, relevant to their search query, whether it be educational, objective entertaining, amusing or exciting information.

Rich content can be described as a gathering of many elements such as a search engine, bulletin board, information guide, Graphics and so on. These complete the website’s functionality and accessibility requirements to meet the user’s expectation. Today web content is the best tool for building relations between the potential customers and suppliers. For this reason, content is selected as an important characteristic in this study

The growing importance of content can be best judged from the following indicators, and they can add positive features to the quality of a website.

4.4.2. Rich Content Metrics

The rich content characteristic can be classified into the various elements and each element should have its own purpose and target. Some elements increase the quality of website, whilst others do not. It is very important to know which elements of content can add the high marks for the websites quality evaluation.

Rich content is a high level characteristic which has four measurable indicators in this study. In order to evaluate the quality of content, the rich content characteristic is calculated through an average formula by using the four measurable indicators. Comparing the difference for each indicator, important is considered by means of weights.

The following formula shows the regular expression.

$$\text{Rcontent} = 0.2 \times \text{Bulletin} + 0.2 \times \text{Guide} + 0.4 \times \text{SeEngine} + 0.2 \times \text{AutoRefsh}$$

- Bulletin represents the measurable indicator called Bulletin Boards, its scoring is 0 or 1. 0 means poor quality and 1 is excellent quality.
- Guide represents the measurable indicator called Information Guide, its scoring is 0 or 1. 0 means poor quality and 1 is excellent quality.
- SeEngine represents the measurable indicator called Search Engine, its scoring is 0 or 1. 0 means poor quality and 1 is excellent quality.
- AutoRefsh represents the measurable indicator called Avoiding Auto-refresh, its scoring is 0 or 1. 0 means poor quality and 1 is excellent quality.
- The weights proposed for each indicator are 0.2, 0.2, 0.4 and 0.2. Sum of weights = 1 and 0< each weights <1.
- Rcontent produces Rich Content characteristic, 0 <= Rcontent <=1.

The search engine has a higher weighting than others, because it is an essential element in page content and using a search engine is second nature to users.

The Measurable indicators are well established and more information about each indicator is described below.

A. Metric Name: Bulletin Boards

Name of Variable: Bulletin

Higher Level Metric Group: Rich Content

Description: The bulletin board has become a common feature in the most of live website and it provides the quickest way to establish online interaction between the user's interests and the community's events or news. A bulletin board can be used to satisfy the numerous web applications. The most common uses are for the discussion forums, but it is also used quite successfully for the applications such as the community websites, customer service and technical support websites, University websites and even newsletter websites.

From a book "Community Building on the Web" by Amy Jo Kim [28], adding a bulletin board to the website is only about 10% of the battle, the other 90% deals with promoting the bulletin board and building a community around it.

Proposed Evaluation Aspects: A quality website should use a bulletin board.

Algorithms: If bulletin board are used or =true then Bulletin = 1, otherwise Bulletin = 0.

B. Metric Name: Information Guide

Name of Variable: Guide

Higher Level Metric Group: Rich Content

Description: An information guide provides the assistances for people wishing to navigate a website. It must include all the information about the entire website's domain and be able to be used by the people with different knowledge levels,

backgrounds, etc. They should contain the information about the summary, stretchable text, customisable information and a guided tour for the first time visitors.

Proposed Evaluation Aspects: A well-defined information guide can benefit a website by providing the good quality of service that meets user's requirement.

Algorithms: If information guide are used or information guide = true then Bulletin = 1, otherwise Bulletin = 0.

C. Metric Name: Search Engine

Name of Variable: SeEngine

Higher Level Metric Group: Rich Content

Description: A web search engine is a tool for searching information on the World Wide Web. The search results present the information from both internal and external websites. Comparing a general website (excluding global search engine providers such as Google, Yahoo, Bing, etc) gives an internal search which is often more specific than an external search service. When people use a search engine on a website they want very specific information from that website, and usually do not need the external information.

Currently people are used to searching for specific information by using a search engine. It is the easiest and quickest way to find whatever the information they want.

Proposed Evaluation Aspects: A quality website should have a search engine.

Algorithms: If search engine = true then SeEngine = 1, otherwise SeEngine = 0.

D. Metric Name: Avoiding Auto-refresh

Name of Variable: AutoRefrsh

Higher Level Metric Group: Rich Content

Description: Auto-refresh is a web technology that prompts a web browser to automatically refresh the current web page or specific frame according to a given time interval. Auto-refresh makes it easier for the users especially when the users expect the information instantly (e.g., stocks and shares, exchange rate, etc).

However, the auto-refresh has weaknesses and should not be used, because when a page reloads without the user's request, it can be confusing to the users [62].

Proposed Evaluation Aspects: A website should avoid auto-refresh function.

Algorithms: If the X<> "refresh" then OthersB = 1, otherwise OthersB= 0.

4.5. Reputation

A website's reputation is much like that of an individual or organisation. It validates through the positive previous experiences, through the third-party endorsements such as the ranking services that are shown on the websites, or indirectly through the recommendation from another websites' link.

For example the potential customer wants to shop on an e-commerce website which has a well-known or established domain name and he/she will always be asking themselves the question "Can I trust this website and its products/services?" [8] On the other hand, reputation is an important personal/company asset for protecting a strategic value of public and the private organisations [17, 71].

Why is reputation important in website evaluation? Firstly reputation is an essential feature to make people purchase, register, download and so on. Secondly when people talk about the reputation of websites, its value is a general term concerned with

many factors e.g. security, usability, efficiency, search engine ranking etc [56]. Therefore, website reputation can be identified to some extent with the criterion of a successful web application. Reputation is the most important key to make the users return.

Very few people have researched reputation to the any degree of websites. Some issues are represented in the next section.

4.5.1. Background of Reputation

A recent study from Stanford University [16] indicates that the primary contributors to the website reputation are not the traditional factors, e.g. Privacy Policies, third party endorsements, awards and so on.

The Stanford study goes on to describe that the average consumer now pays far more attention to the superficial aspects of a website, such as visual cues, than to its content. For example, nearly half of all consumers (46.1%) in the study assessed the reputation of websites based on the appeal of the overall visual design of a website, including the layout, typography, font size and colour schemes. The others factors, according to the study, were Information Design/Structure (28.5%) and Information Focus (25.1%).

Here are some other application methods particular to individual websites that have been developed on the internet to judge and evaluate the reputation; eBay provides a system of ranking users, whereby buyers and sellers provide the customer feedback on those from whom they buy and sell. Here, buyers and sellers develop the reputation that each can use when considering whether to engage in the transactions. Amazon provides a service whereby book and other product reviews can be scrutinised by other users, thereby providing a reputation system for the reviewers.

According to the relative research about the quality of reputation, they are

proposed the eight guidelines for contributing and collecting the features of website reputation from other researchers. They determine how reputable a website is perceived.

1. Information should easily verify the accuracy on the website.

   Resources (e.g. source materials, references and citations) indicate the trust worthiness of information on the website. Websites use references to persuade and achieve their purposes.

2. Updating websites on a regular basis.

   People trust a website because it updates regularly. Adding some new information or icons with signs “new”, shows the user that this website is actually controlled by the author behind it.

3. Highlight the expertise of web supplier and services details.

   The website has to be sure to give the credentials from experts and authorities and make clear it is affiliated with a respected organisation. Conversely, don't link to the outside websites that are not credible. A website becomes less credible by the association.

4. Publish photos of real people behind the website.

   The website provides photos, name, email address, etc from real people to convey their trustworthiness to the customers [38].

5. Ease of contact.

   A simple way to boost a website's reputation is by making the contact information clear in a sub-webpage or sub-section, such as phone number, physical address, and public email address.

6. Design the website so it looks professional (or is appropriate for website’s purpose).

   Stanford study presented that people quickly evaluate the reputation by visual the design alone. A professional website layout indicates the strong organisation

behind it.

7. People are visiting high-reputation websites more than once.

   Re-visit is an indicator of loyalty. If a user is willing to re-visit a website, then it can be argued that the website has good creditability. Especially in the e-commerce, repeat visits to a website directly affect the value of the business. [34].

8. People will recommend a creditable website to others.

   Recommendation is an indicator of reputation. People will only recommend a website which they are already trusted. Otherwise they might lose their personal reputation.

The reason that these guidelines were specifically described is because the measurable indicators are concluded and summarised from these issues in this study. They were accepted by almost the research organisations. However some issues are so difficult to measure, some only stayed as the theory and hardly made it into practice. In order to automatically evaluate the quality of reputation, these issues have been carefully abstraction. This is important because the criteria of reputation evaluation cannot be proposed without these issues. More discussions about indicators are specified in the future information.

The quality of reputation is one of the major features in this study, the website quality metrics produce the new reputable indicators which have been mentioned in only few researchers. On the other hand, the evaluation process for doing this study has created a metric to measure the user perceptions of reputation, one that could be used for other studies.

4.5.2. Reputation Metrics

From previous work examined, evaluation of reputation can be classified in to five measurable criteria (indicators), which are Customer Feedback, Web Traffic, Domain

Name and Information Publicity respectively.

The reason these criteria are selected, because they have been used in a number of good reputations websites (e.g. IBM.com, Microsoft, Wikipedia, etc), and also according to the studies at Stanford University previously noted. Optimising these immeasurable issues need transforming into the measurable criteria aspects. For example people recommendation is impossible using the web evaluation software. However Customer Feedback was used in almost all websites especially in e-commerce as it can be measured easily. Well-defined Customer Feedback was proved to be one of the most important features in the quality of reputation.

Reputation is a high level quality characteristic to calculate the score of indicators through an aggregation formula. The important indicators are considered by adding weights. This calculation is given by the following formula:

$$\text{Reputation} = 0.3 \times \text{Feedback} + 0.3 \times \text{Traffic} + 0.2 \times \text{Domain} + 0.2 \times \text{Publicity}$$

- Feedback represents the measurable indicator called Customer Feedback, its scoring is 0 or 1; 0 means poor quality and 1 is excellent quality.
- Traffic represents the measurable indicator called Web Traffic, its scoring is 0 or 1; 0 means poor quality and 1 is excellent quality.
- Domain represents the measurable indicator called Domain Name, its scoring is 0 or 1; 0 means poor quality and 1 is excellent quality.
- Publicity represents the measurable indicator called Information Publicity, its scoring is 0 or 1; 0 means poor quality and 1 is excellent quality.
- The weights are proposed for each indicator they are 0.2, 0.2, 0.3 and 0.3. Sum of weights = 1 and 0< each weights <1.
- Reputation produces reputation characteristic, 0 <= Reputation <=1.

Considering the different weights of each indicators; Customer Feedback and Web Traffic have the strong quality of reputation (0.3 Weights), People accept these criteria

which indicate the good reputation from both the subjective web designers and users' objective acceptation. They expressed the user tends to trust the objective descriptions from others. Domain Name and Information Publicity are defined by less reputation (0.2 Weights). The reason is they are generally provided by the web designers, and lack authentication from other users. People do not trust a website if it does not have any contact details, name of organisation or date of upgrade.

More discussion about each measurable indicator and the rules of scoring is shown below:

A. Metric Name: Customer Feedback

Name of Variable: Feedback

Higher Level Metric Group: Reputation

Description: Customer feedback is "a general term describing direct contact with the users (or information about the result) and covering many events or approaches" and lays on the "continuum from informative, through consultative to participative" [32].

Customer feedback refers to the user participation in all reputation activities (e.g., information creditability, product quality check, feature driven, etc). It will influence the same activities in the present or future. Considering the qualified reputation issues above, feedback is more like a recommendation. However recommendation is impossible to evaluate by using the web evaluation software. A website recommends the external links or web addresses but the users do not trust them because nobody knows whether they are safe or have good reputation. However, Customer Feedback is like a platform to provide the information interaction between the users. It is free speech; the user can leave neutral, positive or negative feedback, in which positive feedback increases the trust, negative feedback reduces the trust.

A successful website that uses the feedback mechanism is eBay. Reputation

attributes complete the customer's feedback score. High percentage positive feedback means a good reputation. It makes selling or buying easier.

Currently, more and more websites are designing the feedback mechanism which is generally placed at the end of a page, and the user can write a response which comments on the website and is open for others to see. Figure 4 shows an example where a number of users have left their feedback on the web page.

However some websites do not require the feedback element, for example if it has a URL address which is defined by an institution of learning or research, government, state abbreviation (ex. .gov, .edu, .uk, etc).

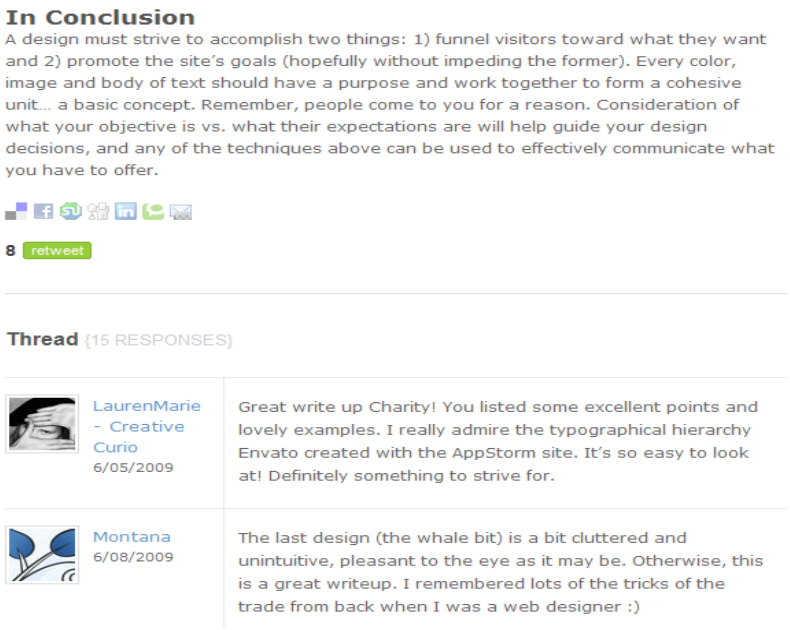


Figure 4. Shows a feedback mechanism in Design & Adaptations website.

Proposed Evaluation Aspects: A good reputation website should have the customer feedback mechanism, if its URL address is not an institution of learning or research or government.

Algorithms: If Domain = 1 then Feedback = 1,

If Domain = 0 then if feedback is used in the website, then

Feedback = 1, otherwise Feedback = 0.

B. Metric Name: Web Traffic

Name of Variable: Traffic

Higher Level Metric Group: Reputation

Description: Web traffic is the amount of data viewed by the visitors to a website. It represents the number of visitors and the number of pages accessed.

Web traffic is a very important criteria to indicate the good or bad reputation and it has been researched since 1995 [23]. More than fifty million results appeared when a person typed “Web traffic” on the Google. There are thousands of website companies providing the services, tools or approaches to increase the web traffic, some of them have more than ten years experience with a lot of clients. This means web traffic is a key element to proving that a website has many loyal paying customers and the strong reputation. Although someone could lie about their sources, it is relatively easy to generate at least some information about the source.

Also web traffic is essential to ranking services. Website ranking assesses a website at some point and relies on the data of web traffic.

Proposed Evaluation Aspects: A website should show the data of web traffic, or a result is measured by an evaluation tool. The amount of data of traffic will have to be larger than 10,000 hits.

Algorithms: If a website has traffic element and the data of traffic >= 10,000, or the result of traffic measurement >= 10,000 then Traffic = 1, otherwise Traffic = 0.

C. Metric Name: Domain Name

Name of Variable: Domain

Higher Level Metric Group: Reputation

Description: Here expertise was identified as a mark of reputation. Barry &

Schamber [3] state that generally a document from an institution of learning or research (e.g. .edu or .gov in the URL) would tend to have more credibility than others from a commercial enterprise (e.g. .com or .net). The URL address which starts with “http://.”And ending in “.gov”, “.edu”, and “.uk” (state abbreviation) are reliable [4]. However if a URL address contains tildes (~) it usually mean that an individual published website. Individual publishers only have the few credible criteria.

Proposed Evaluation Aspects: If a URL address is an institution of learning or research, government, state abbreviation, and if it does not have “~” then this website should have good reputation.

Algorithms: If X = “.edu” or “.org” or “.mil” or “state abbreviation” and X <> “~”, then Domain = 1, otherwise Domain = 0.

D. Metric Name: Information Publicity

Name of Variable: Publicity

Higher Level Metric Group: Reputation

Description: Information Publicity is represented by a group of links or information which is published on the websites. It includes contact details, privacy policy, and date of update.

According to the qualified issues have been mentioned in the eight guidelines. Easy Contact is an important criterion in the web reputation. An interesting case is that the small website owners are often not happy to make the available contact information on the website, because anyone can find the information about them. It all comes back to making a decision about including the contact information if web owners wish to be contacted. They lose an opportunity to prove their creditability, and then they lose clients.

The legitimate contact information should contain: Phone number, A physical address, A business email address (e.g., yahoo, hotmail, etc is not credible).

A privacy policy is a legal document that represents how a party retains, processes, discloses, and purges customer's data. For example, a privacy policy can be described by whether the website uses cookies and/or bugs, what personal information is collected, how the personal information is used, who discloses the personal information and what security issues are taken to protect the personal information. A website that has a very good privacy policy provides the good credible services.

A website should update regularly. New information always attracts the new customers. For example, adding some icons, special signs with the inscription "new" can be a good way to show the website actually has organisation behind and does not stand still. In addition, a website that has been published more recently is more credible.

Contact details, privacy policy and date of update represent the information to indicate the credibility of a website in the different ways, and some of them such as contact details are defined by individual criteria in the eight guidelines study.

Proposed Evaluation Aspects: A good reputation website has to have well-defined information publicity element.

Algorithms: Checking the source code,

If email <> "Yahoo, Hotmail, Gmail, and so on",

If X = "phone number", "address" and email

If Y = privacy policy and date of update then Publicity = 1, otherwise

Publicity = 0.

4.6. Overall Evaluation Calculation

An official website may have many web pages, and each web page will have a different quality. Previous definitions of web quality metrics have been represented as an evaluation on one particular page. However this section will propose a collation to evaluating the whole website through the specific formulae.

According to the important research about the web quality metrics from Lilburne et al [37], they proposed the web measurement formulae which is able to compute the full web quality characteristics for the final score or sub-score of the websites. Following these ideas the more practiced the web evaluation process is defined as below:

1. Total children quality characteristics evaluation. This evaluation is to calculate the quality metrics for the five quality characteristics in the total children web pages.

$$\text{SubTotalAesthetics} = \frac{\sum \text{Aes}}{\text{No.of pages}}$$

- Aes represents an aesthetics value for one children page.
- No. of pages is the number of children pages in a website.
- Subtotal Aesthetics means an aesthetic value for total children web pages, except for root page.

Other four quality characteristics are same as aesthetics. The formula can be expressed as follows:

$$\text{SubTotalEoU} = \frac{\sum \text{EoU}}{\text{No.of pages}} \qquad \text{SubTotalMultimedia} = \frac{\sum \text{Media}}{\text{No.of pages}}$$

$$\text{SubTotalRcontent} = \frac{\sum \text{Rcontent}}{\text{No.of pages}} \qquad \text{SubTotalReputation} = \frac{\sum \text{Reputation}}{\text{No.of pages}}$$

2. Total quality characteristics evaluation. It provides the total values for the each

quality characteristics in the whole website evaluation.

$$\text{TotalAesthetics} = 0.5 \times \text{RootAes} + 0.5 \times \text{SubTotalAesthetics}$$

- RootAes is an aesthetics value for the root page of a website.
- SubTotalAesthetics means an aesthetics value for the total children web pages, except for root page.
- TotalAesthetics represents the total aesthetics value of a website.

Other four quality characteristics are same as aesthetics. The formula can be expressed as follows:

$$\text{TotalEoU} = 0.5 \times \text{RootEoU} + 0.5 \times \text{SubTotalEoU}$$

$$\text{TotalMultimedia} = 0.5 \times \text{RootMedia} + 0.5 \times \text{SubTotalMultimedia}$$

$$\text{TotalRcontent} = 0.5 \times \text{RootRcontent} + 0.5 \times \text{SubTotalRcontent}$$

$$\text{TotalReputation} = 0.5 \times \text{RootReputation} + 0.5 \times \text{SubTotalReputation}$$

A root page is considered by calculating individually and taken half percentage than other children pages. Because that everyone would agree that a root page is the most important part of a website. Web designer spends the most of their time in the root page design, which means the failure of root page design will lead to the failure of the website. On the other hand, the root page is always the first thing seen by the users, and generally speaking users access the root page more than the children pages. Users will stay in a website if they feel the root page is interesting.

For the above reasons, the total quality characteristics have been assigned with the same weights (0.5) in both root page and the total children pages. Considering that the root page should be paid more attention to than others, all the children pages are only assigned 0.5, but it does not mean they are not important.

3. Complete websites quality evaluation. It provides the final score for the whole website quality evaluation.

$$\text{FinalWeb} = 0.3 \times \text{TotalAesthetics} + 0.2 \times \text{TotalEoU} + 0.1 \times \text{TotalMultimedia} + 0.1 \times \text{TotalRcontent} + 0.3 \times \text{TotalReputation}$$

- TotalAesthetics, TotalEoU, TotalMultimedia, TotalRcontent and TotalReputation are respectively represented the total value for five main quality characteristics: Aesthetics, Ease of Use, Multimedia, Rich Content and Reputation.
- 0.3, 0.2, 0.1, 0.1 and 0.3 mean the quality weights for each web characteristics.
- FinalWeb represents the final score of a website.

Considering weights given aesthetics and reputation are the main characteristics in this study and should take more weight than others. In fact, users pay more attention on the web interface view and worthiness trust. Also ease of use is second highest weight because it may help users with quick and friendly access to a website.

Finally the scales of website quality have been defined in this study. Figure 5 shows the five levels which represent the different degree of evaluation. People can directly figure out which websites are more interesting.

Level	Scale
★★★★★	0.9~1
★★★★☆	0.7~0.89
★★★☆☆	0.5~0.69
★★☆☆☆	0.3~0.49
★☆☆☆☆	0.1~0.29

Figure 5. Scale for Website Evaluation

4.7. Summary

Chapter 4 is major part of this study. It introduces the five main quality characteristics, which includes Aesthetics, Ease of use, Multimedia, Rich Content and Reputation.

Firstly, the evaluation of aesthetics is calculated by four sub-characteristics and ten measurable indicators. Sub-characteristics are immeasurable values. The results of sub-characteristics are calculated through their average formulae that are provided from measurable indicators. Quality goals are established by measurable indicators. Each of them has one value 0 or 1, where 0 indicates poor quality attribute and 1 means excellent quality attribute.

Secondly, the quality of ease of use focuses on users being satisfied with website access and understanding at all times. According to this issue, the ease of use characteristic has separated three independent sub-characteristics and each sub-characteristic is extended by detecting what they attribute into one or more measurable indicators.

Thirdly, the quality of multimedia is indicated by a website that can satisfy users' expectations for media access, understanding, and appearance. Some factors are not considered by this metrics, for example the network speed can affect the quality of multimedia. The reason is broadband has already became the most popular network connection and even in a 3G wireless network it has a minimum 2 Mb speed. The network services providers (e.g. BT, Virgin media) no longer provide less than 1 Mb broadband speed to the customers. The lower speed network is not considered in this study.

Fourthly, quality content on a website will add value for users. The purpose of this evaluation is to assess the common elements of content used in the "best" and "worst" rated websites. Each element is careful selected with scoring preferences, which typically represent the degree of satisfaction of all the requirements of quality of content.

Fifthly, Aspects of reputation are gathered and selected from the "eight guidelines" research, and calculated from four measurable indicators by using an aggregation formula. Measurable indicators are defined with the simple quality scoring and each

them has one value 0 or 1, as same as aesthetics characteristic, 0 indicates poor quality attribute and 1 means excellent quality attribute.

Finally, several effective formulae have been defined. They are able to calculate the overall website quality characteristics automatically through website evaluation tool. The quality values for five quality characteristics and the final quality score of website evaluation will appear in the user interface of website evaluation tool.

Chapter 5

Website Evaluation Implementation and Case Study

In this chapter, the website evaluation must be implemented by using the formulae, aggregation and mapping process, which take real values that define the level of a website and satisfy the user's expectation for access.

5.1. Toolset Implementation

5.1.1. Architecture of Website Evaluation Tool

In the stage of implementation, the web evaluation tool is designed in the four levels, Tree-Traversal Layer, Parse Layer, Data Metrics Layer, and User Interface Layer respectively. The architecture of design is shown in Figure 6. Whole values can be obtained automatically by using the web evaluation tool.

In order to achieve high performance of program standard, the implementation architecture suitable evaluation is based on the four layers. The proposed implementation architecture should have flexibility, modularity and weak coupling between each layer. A number of rules for system design which have applied. It includes avoiding data repetitive copy in interlayer communications, minimising the necessary retransmission, and so on.

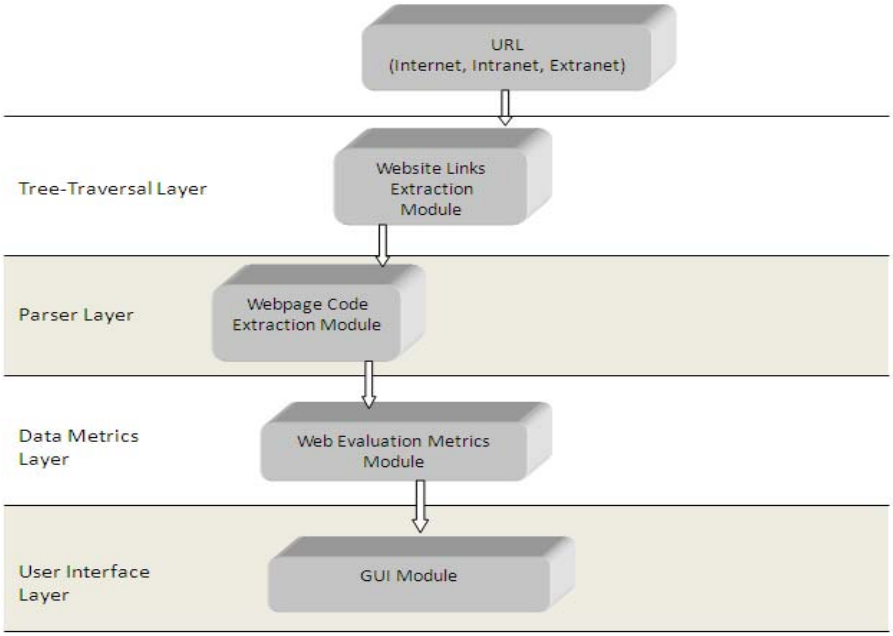


Figure 6. Architecture of Website Evaluation Tool

Once the effective web evaluation framework and metrics are defined, the structure of the program design is established. The website evaluation tool assesses the websites automatically, achieving the website evaluation process.

5.1.1.1. Tree-Traversal Layer

Tree-Traversal will examine, update and process each node in a tree data structure. Such traversals are classified by the order in which the nodes are visited in a systematic way. Tree-Traversal Layer has a Website Links Traversal (WLTraversal) module which is established by using a web crawler which has been proposed in the program design. Web crawler is a program or automated script which browses the websites in a methodical and automated manner [13, 30]. It is mainly used to extract the whole web URLs and create a copy of all the web pages for later Webpage Code Extraction (WCExtraction) process. It exports a number of web URLs, and the links are unique.

In this web crawler, an algorithm structure is established by the following steps:

Step1. Obtaining a root page (User can type or paste a web address into a text box).

Step2. Extracting all the links in a root page, and enclosing these links into a variable "lstLinks".

Step3. Extracting the whole websites' URLs from "lstLinks", by using the recursive algorithm, and then enclosing into "lstLinks". This recursive algorithm only runs two levels in the web structure.

Step4. For the URLs which have been traversed, they are recorded into a temporary variable "trvLinks". Program compares these URLs, if one link is already exist then the program traverses next URL, return to Step 3.

Step5. Classifying the total URLs in "lstLinks", holding internal URLs, and deleting external URLs.

Following Figure 7 shows a small web crawler which will crawl through all the links in the given URL.

```
Private Sub getLinks(strURL As String, iParentChild As Integer, Optional iParentNo As Integer)
    '
    Dim objLink As mshtml.HTMLLinkElement
    Dim objMSHTML As New MSHTML.HTMLDocument
    Dim objDocument As New mshtml.HTMLDocument
    Dim objNode As Node
    Dim iCount As Integer
    '
    objDocument = objMSHTML.createDocumentFromUrl(txtURL.Text, vbNullString)
    '
    While objDocument.readyState <> "complete"
        DoEvents()
    End While
    ' get all Links
    For Each objLink In objDocument.links
        '
        If iParentChild = 1 Then
            '
            lstLinks.AddItem(objLink)
            '
        ElseIf iParentChild = 2 Then
            '
            'lstInnerLinks.AddItem objLink

            objNode = trvLinks.Nodes.Add(iParentNo, tvwChild)
            objNode.Text = objLink
            'objNode.Image = "leaf"
            '
            iCount = 0

            While iCount <= lstLinks.ListCount - 1

                If lstLinks.Selected(iCount) Then

                    trvLinks.Nodes.Add , , , lstLinks.List(iCount)
                    getLinks(lstLinks.List(iCount), 2, trvLinks.Nodes.Count)
                    lstLinks.RemoveItem(iCount)
                    lstLinks.Refresh()
                Else

                End If
                iCount = iCount + 1

            End While
            'Next

        End If
        '
    Next

End Sub
```

Figure 7. VB codes for extracting whole web URLs.

Finally, the whole internal web URLs is available for the further parser process in the next layer.

5.1.1.2. Parsing Layer

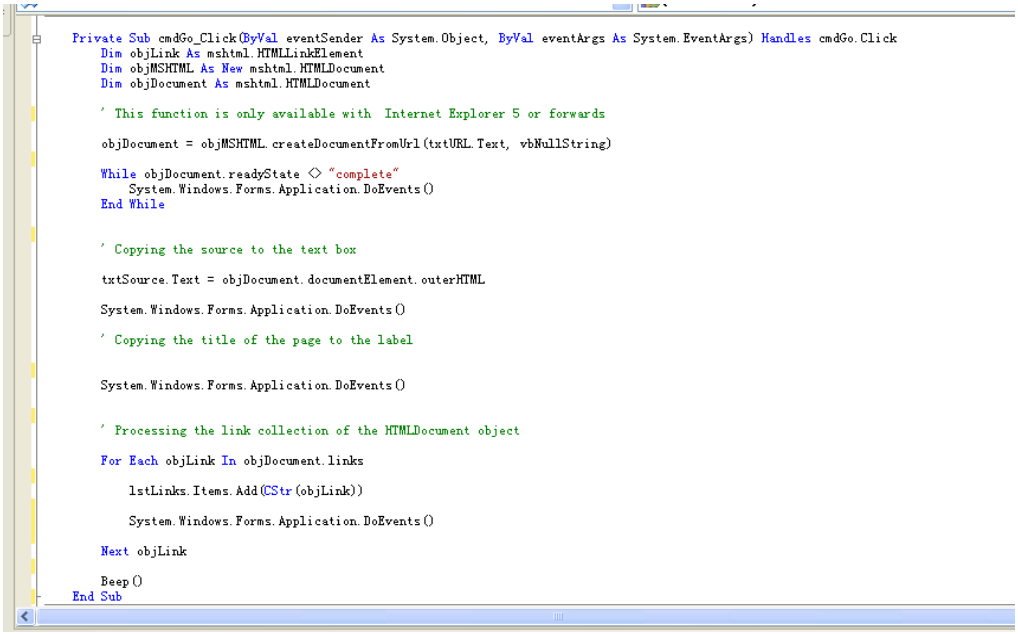
Parsing is another term used for website's "Interpreting". In most cases, it means to extract information from the source codes. In this case study, the parsing layer has a Webpage Code Extraction module, it is able to extract the HTML source codes and analyse the HTML sources providing evaluation support to the next web evaluation tool layer. It exports the HTML source codes.

HTML source codes are taken into account by major materials for the web quality evaluation. The reason is most data on the web is stored in the HTML format. This means extracting and analysing the HTML source codes which will be well enough to represent the whole quality aspects of a website.

It is hard to parsing because most of websites are designed by using many classes (Object-Oriented function). However, after the effectively practices are completed, a lot of HTML source codes have been successfully extracted.

Following figure 8 is shown as an example for the extraction of HTML source code from a website:

HTML source codes are extracted into a "variable". They are then ready for data analysis in the next layer. This is an example for how the parser works. Parser codes will become a "class" in the website evaluation tool, which is similar than figure 8 but more handing in the program design.



```
Private Sub cmdGo_Click(ByVal eventSender As System.Object, ByVal eventArgs As System.EventArgs) Handles cmdGo.Click
    Dim objLink As mshtml.HTMLLinkElement
    Dim objMSHTML As New mshtml.HTMLDocument
    Dim objDocument As mshtml.HTMLDocument

    ' This function is only available with  Internet Explorer 5 or forwards

    objDocument = objMSHTML.createDocumentFromUrl(txtURL.Text, vbNullString)

    While objDocument.readyState <> "complete"
        System.Windows.Forms.Application.DoEvents()
    End While


    ' Copying the source to the text box

    txtSource.Text = objDocument.documentElement.outerHTML

    System.Windows.Forms.Application.DoEvents()

    ' Copying the title of the page to the label


    System.Windows.Forms.Application.DoEvents()


    ' Processing the link collection of the HTMLDocument object

    For Each objLink In objDocument.links

        lstLinks.Items.Add(CStr(objLink))

        System.Windows.Forms.Application.DoEvents()

    Next objLink

    Beep()
End Sub
```

Figure 8. Parsing HTML source in VB code

5.1.1.3. Data Metrics Layer

Data metrics layer is a calculation layer to process the data which is extracted from the parsing layer, according to the rules of the web evaluation metrics which have been described in the previously. The algorithms of web evaluation criteria are basically a logic written for program designs for the intended target (websites). In order to analyse and compute the quality of a website in the different quality characteristics, the evaluation is calculated through a number of formulae to determine the quality of a website.

The algorithm structure is established by the following steps:

Step1. Analysing the sources code according to the logic algorithms of web evaluation criteria.

Step2. Calculating the scores for each quality characteristics in the every web page.

For example: A web page was calculated: Aesthetics = 0.7, Ease of Use = 0.8, Multimedia = 0.6, Rich Content = 0.6 and Reputation = 0.8.

Step3. Averaging scores of whole web pages, if a web page is root page, then it is considered by computing its value individually.

Step4. Calculating final score.

Well-defined algorithms and criteria for each quality characteristic have been established in the Chapter 4. Here it is not necessary to specifically describe the data metrics activities.

5.1.1.4. Graphical User Interface

A graphical user interface is a type of interface that allows users to interact with the multiple activities, such as typing, computer, media play, gaming and so on. The web evaluation tool only has one main user work interface. It offers graphical icons, text labels, buttons with fully represent the information of website quality to a user. The information includes the score of each quality characteristic, final score for quality of website, a graphical chart it relates to each quality characteristics, and these functions are performed through click buttons.

Following figure 9 shows the main interface for web evaluation tool.

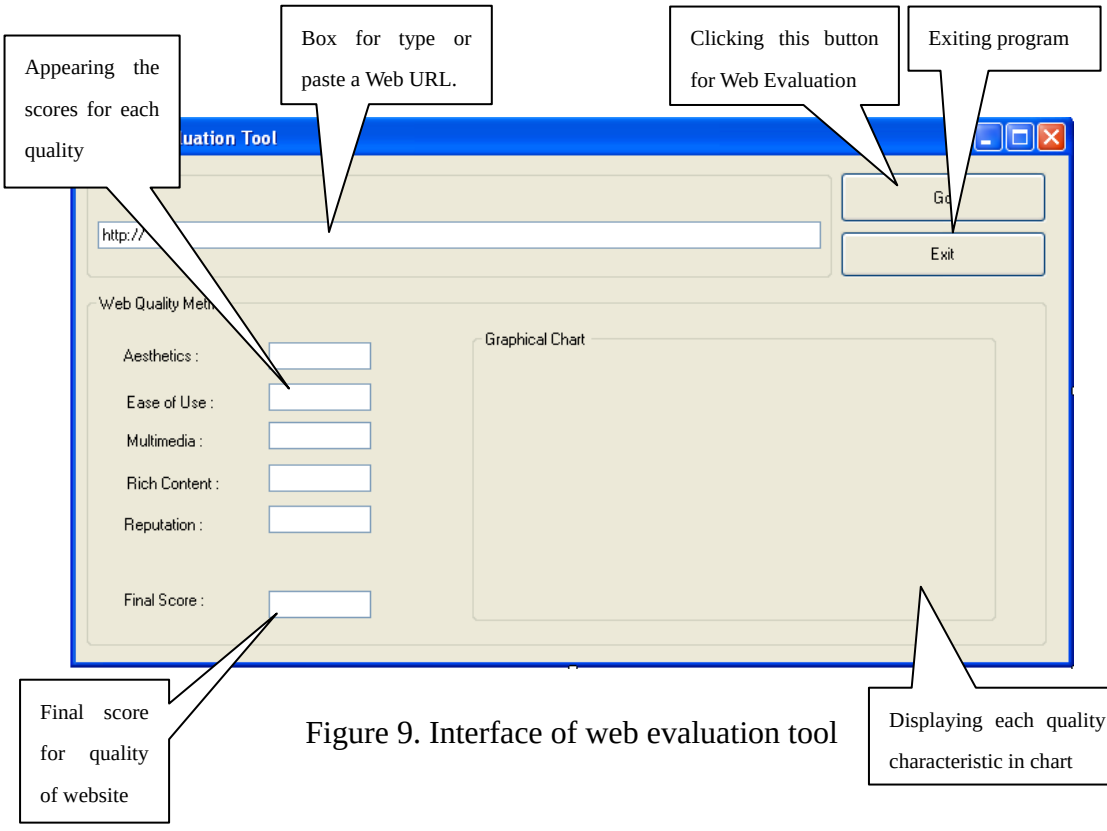


Figure 9. Interface of web evaluation tool

User can type or paste a web address into the URL text box, and then click the Go button. The results of each quality characteristics and final score of a website will show on the screen. In addition, a chart is appeared by representing the graphical visual for each quality characteristic. An example of a result is shown in figure 10.

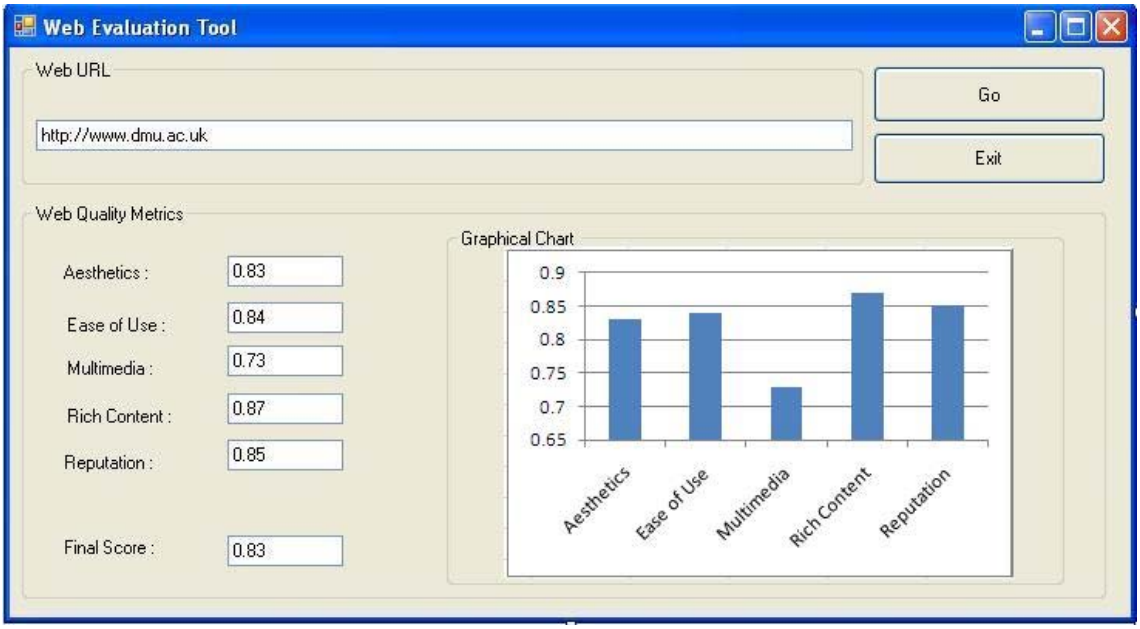


Figure 10. Interface of web evaluation tool

5.1.2. Implementation

Web evaluation tool is designed by using VB.net. The reason for using it to build this tool is because VB.net is one of easiest programming language that creates the visual element – the point and click interface. The design of the evaluation tool is mainly attached to specific parts of the user interface, and easily executed and evaluated at the time when the user interacts with the tool. Also VB.net is very quick and easy to put together with different applications especially Microsoft applications, such as SQL Server 2005.

5.2. Case Study

In order to perform a real test, the web evaluation tool examined a real website: www.dmu.ac.uk, which is the official website of De Montfort University (DMU). The websites of De Montfort University have been established since 1994. Since then it has developed more than 1200 pages with a number of different components. In order to evaluate a fully functional website, the DMU official website is a real challenge for the implementing practices of this study. The root page shows in figure 11.

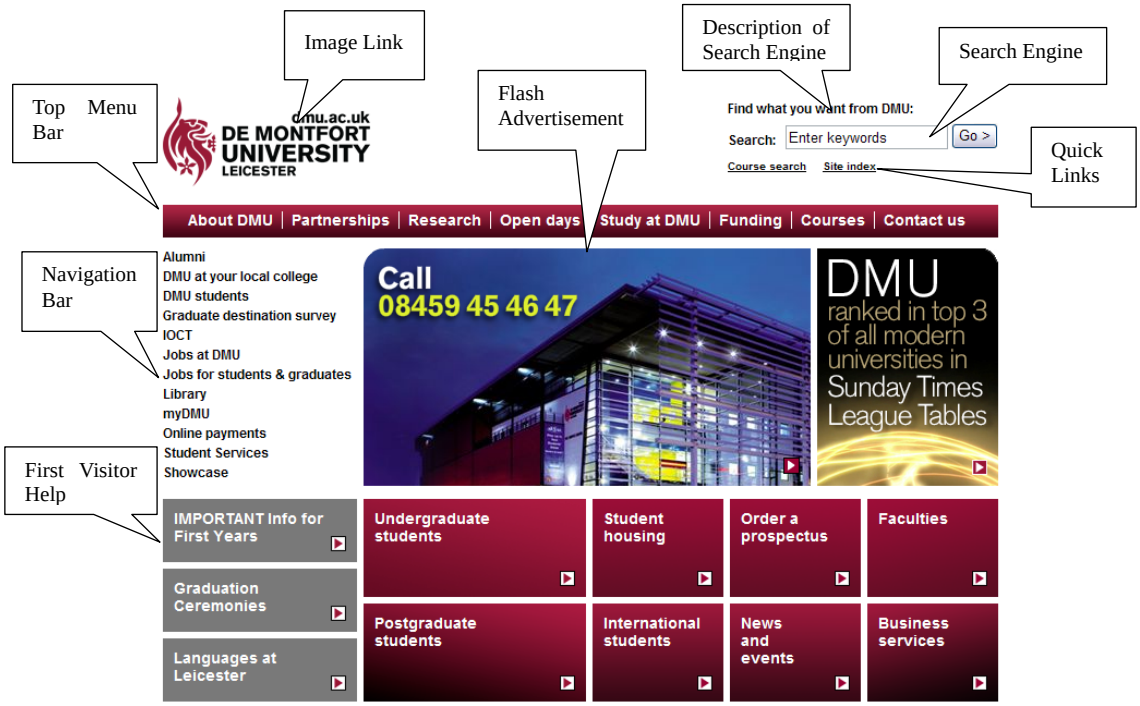


Figure 11. A screenshot of DMU home page.

Figure 11 shows where some measurable indicators are highlighted and these indicators are automatically analysed through the web evaluation tool from the root page.

In order to specifically describe how to evaluate the DMU website step by step, the website evaluation tool will calculate the five quality characteristics in the DMU's root page, and the average results of each page will be figured out.

5.2.1. Quality Characteristics Evaluation

A particular DMU's root page is measured as an example in this section. Parser analyses the source code and groups the proposed quality criteria (indictors) which are then defined in the website evaluation framework. Website evaluation module calculates the measurable indicators through specific formulae.

5.2.1.1. Aesthetics Evaluation

The results of the aesthetic evaluation are shown in Figure 12.

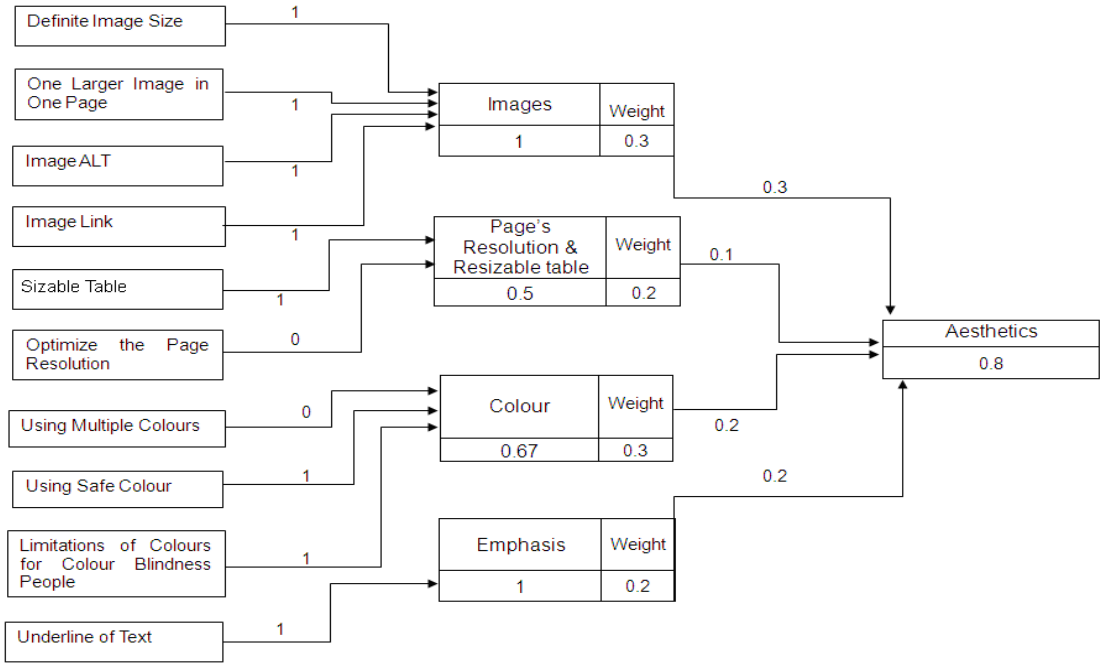


Figure 12. A summary of aesthetics characteristic for a root page of DMU website in October, 2009.

In order to fairly evaluate the degree of aesthetics in a website, each sub-characteristic has to define the weight. Sub-characteristics in Images and Colour attract more attention than others, they both weigh 0.3, Emphasis, Page's resolution and Standard Table Size each weigh the same at 0.2. According to the formula of evaluation and relative criteria, the final result of aesthetics is 0.8.

5.2.1.2. Ease of Use Evaluation

Ease of use characteristic and its "children" sub-characteristics are both immeasurable factors as they have to calculate the measurable indicators through the formulae to evaluate their quality rate. For example, the ease of use characteristic from DMU's root page has been evaluated by this metrics and shown in Figure 13.

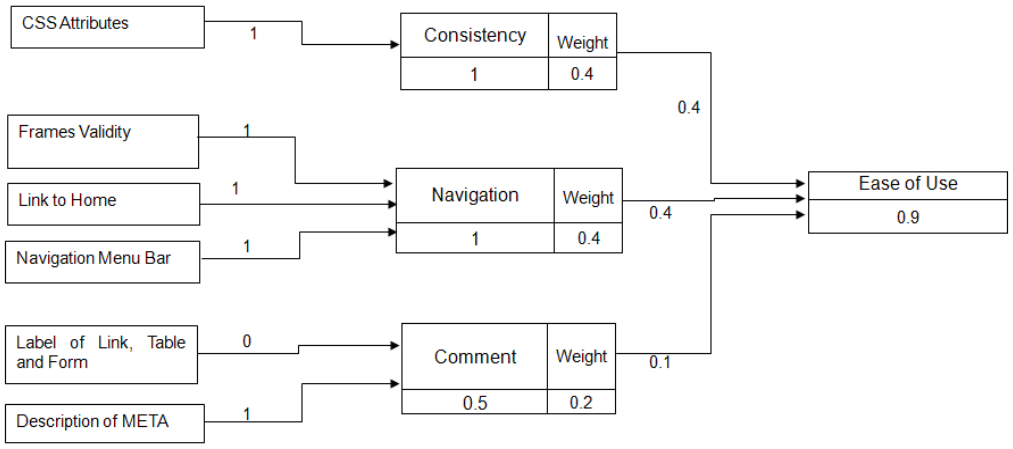


Figure 13. A summary of Ease of Use characteristic for a root page of DMU website in October, 2009.

Figure 13 shows evaluation of the root page of DMU website. The results indicate the scoring for each measurable indicator, the rate of sub-characteristics and the final value for the ease of use characteristic. The evaluator can easily see the quality grade for each level. For instance, Consistency and Navigation received full marks, Annotation needs improvement, and the satisfactory quality for ease of use is 0.9. Excellent quality of ease of use being 1, dmu.ac.uk has a high score in this evaluation.

5.2.1.3. Multimedia Evaluation

Multimedia has the factors as they have to calculate the measurable indicators through the formulae to evaluate their quality rate. The DMU website has been measured as an example below.

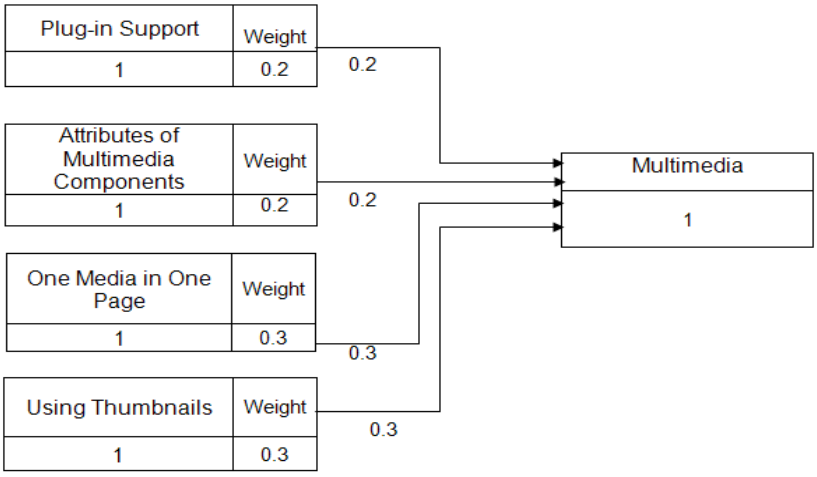


Figure 14. A summary of Multimedia characteristic for the main video page of the DMU website in October, 2009.

The evaluation of multimedia has been calculated in figure 14, and shown every measurable indicator with into the excellent quality score. The final result of multimedia is 1, which means the quality of multimedia is excellent quality in the DMU website.

5.2.1.4. Rich Content Evaluation

The evaluation process is carried on through an average formula to calculate the final scores and then the relative weights need to be computed. A root page from the DMU website has been assessed as an example. Figure 15 shows the results of the content evaluation process. The quality of metrics classified in each value of indicator, and sum of these values shows greater quality in the DMU website.

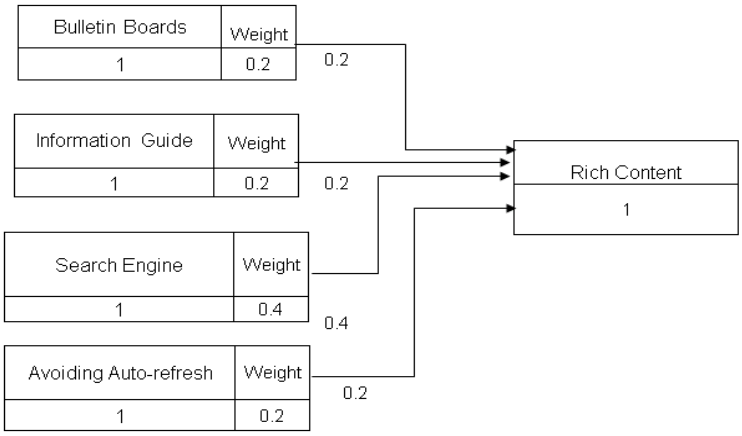


Figure 15. A summary of Rich Content characteristic for a root page of DMU website in October, 2009.

5.2.1.5. Reputation Evaluation

An evaluation of reputation has been calculated by a particularly example in the DMU website. The process of evaluation has been showed in figure 16.

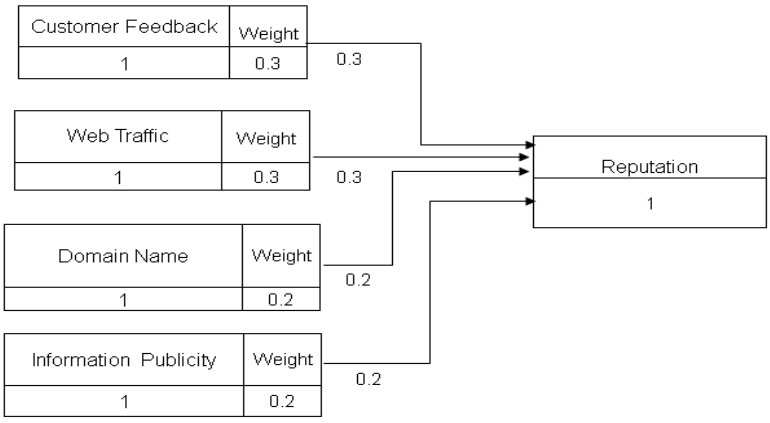


Figure 16. A summary of Reputation characteristic for the DMU website in October, 2009.

In order to evaluate the quality of the reputation of the DMU website, that completely satisfies the user. The reputation metrics have taken a fairly calculated the scoring of each measurable indicator (criterion) by the meaning of the weights. This is an important feature needs to be paid more attention, because the DMU's URL address

has state abbreviation (.ac.uk) in the end. The indicator of web feedback is valued as excellent quality 1 automatically according to the definition of web feedback criterion.

5.2.1.6. Overall Evaluation

According to the formulae which have been mentioned in Chapter 4, the five total quality characteristics are calculated. The results are shown in below:

Quality Characteristic	Aesthetics	Ease of Use	Multimedia	Rich Content	Reputation	Final Score
DMU	0.83	0.84	0.73	0.87	0.85	

Figure 17. Final rankings for each quality characteristics in the root page of DMU website.

After the each quality characteristics have been calculated, a formula is used by computing the final quality score of DMU website.

$$\text{FinalWeb} = 0.3 \times \text{TotalAesthetics} + 0.2 \times \text{TotalEoU} + 0.1 \times \text{TotalMultimedia} + 0.1 \times \text{TotalRcontent} + 0.3 \times \text{TotalReputation}$$

According to this formula, the final quality score is: 0.83

$$0.83 = 0.3 \times 0.83 + 0.2 \times 0.84 + 0.1 \times 0.73 + 0.1 \times 0.87 + 0.3 \times 0.85$$

Figure 17 shows the total values for aesthetics, ease of use, multimedia, rich content and reputation characteristics in De Montfort University websites. Considering the evaluation in the best and worst quality characteristics, the rich content is highest quality characteristic and multimedia is lowest characteristic. Using this method the user can see which quality characteristic need to improvement and which are satisfactory. In the end, a final quality score has been calculated, which shows the complete websites quality evaluation.

5.2.2. Validation of Web Evaluation Tool

In order to verify the results of the web evaluation tool to achieve practical values close to people's real opinion, the validation of questionnaires is used in this study.

There are 20 PHD and Master students who are studying in the faculty of Computing Science Engineering (CSE) at the DMU have been employed by doing this task. They all have professional IT skills and most of them generally spend more than five hours to research and surf on the internet. They complete the questionnaires and evaluate the ten specific university websites according to the requirements on the questionnaires and provide honest answers. These results are carefully analyzed and compared at the end of the experiment. More information is shown below.

Figure 18 shows an example of the questionnaires. The five quality aspects are listed on the sheets. Evaluators should scan every page especially the root page and assess the websites whether or not they feel satisfaction about each quality aspect. There are ten checkboxes which represent different level of scores for each quality aspect. The scores are rated from the lower to the higher, 0.1 produces dissatisfaction and 1 means satisfaction. The evaluators have to tick the box according to how they feel after they have evaluated the websites.

Web Quality Evaluation Questionnaires

University Websites / Quality Aspects	University of Cambridge									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Aesthetics										
Ease of Use										
Multimedia										
Rich Content										
Reputation										

Comments:
The scores of each quality aspect are between 0.1 to 1 that from low quality to high quality.

Instructions:
1. Evaluators should carefully assess the websites according to 5 quality Aspects.
2. Evaluators should traverse every single page in a website.
3. Evaluators should honestly provide the true values.

Final Score: _____

Evaluator Name: _____
Date of Measurement: _____

Figure 18. Web Quality Evaluation Questionnaires.

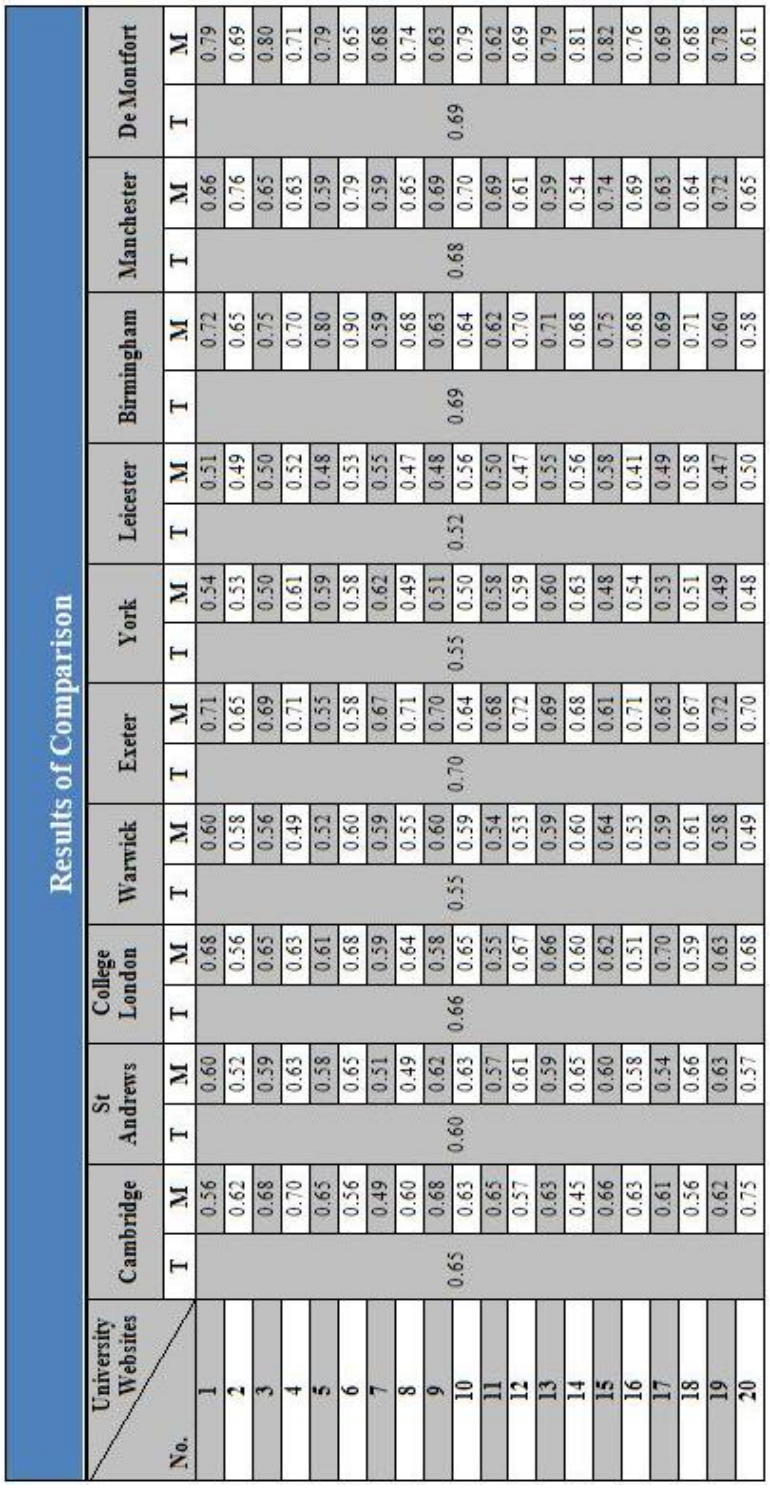
Ten university websites have been selected in this evaluation process, including Cambridge, St Andrews, College London, Warwick, Exeter, York, Leicester, Birmingham, Manchester, and De Montfort. The reasons, firstly they are belonging to the same website domains. The quality of websites evaluation should be in the same domain, otherwise they would lose comparability. For example e-commerce websites may not able to compare with academic websites. Secondly they all have been established more than 15 years and also have larger numbers of loyal visitors. Lastly they belong to the social universities with strong creditability and having no problems with funding support. For above factors, the ten websites are having same condition of background or foundation. The evaluator can assess the user access quality of websites as the main goal in this project without any other effects.

After the evaluators have finished the website evaluation manually, the final score for each website has been calculated by using the same formulae used in the web evaluation tool. These final scores are achieved from questionnaires the tool and they are collected into a form shown in Figure 19.

Figure 19 lists the numbers of final scores for ten university websites which were provided by 20 evaluators, and also the final scores were assessed by the web evolution tool. Comparing the different scores from the web evaluation tool and the evaluators, there are 13 evaluators that have estimated the scores similar to the tool's score in website of Cambridge column, and this situation is the same on other websites, they displayed 15, 12, 11, 13, 13, 12, 12, 14 and 12 similar scores respectively. These results prove that the tool's scores are very close to the evaluators' scores. However, there are also differences, for example four evaluators' scores are lower than the tool's scores in Cambridge University's website, and five scores are higher than the tool's scores in the De Montfort University's website.

Finally, according to the analysis of figure 19, these questionnaires' scores can validate that web evaluation tool is qualified, because more than 50% of evaluators provided similar scores. It means the scores estimated by using the web evaluation tool

are close to users' access expectations, and the web evaluation tool is not only suitable for a university website, it also can evaluate different types of website. The final score is the standard of websites in same domain.



Results of Comparison																											
University Websites / No.	Cambridge		St Andrews		College London		Warwick		Exeter		York		Leicester		Birmingham		Manchester		De Montfort	
	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M
1	0.65	0.56	0.60	0.60	0.66	0.68	0.55	0.60	0.70	0.71	0.55	0.54	0.52	0.51	0.69	0.72	0.68	0.66	0.69	0.79
2		0.62		0.52		0.56		0.58		0.65		0.53		0.49		0.65		0.76		0.69
3		0.68		0.59		0.65		0.56		0.69		0.50		0.50		0.75		0.65		0.80
4		0.70		0.63		0.63		0.49		0.71		0.61		0.52		0.70		0.63		0.71
5		0.65		0.58		0.61		0.52		0.55		0.59		0.48		0.80		0.59		0.79
6		0.56		0.65		0.68		0.60		0.58		0.58		0.53		0.90		0.79		0.65
7		0.49		0.51		0.59		0.59		0.67		0.62		0.55		0.59		0.59		0.68
8		0.60		0.49		0.64		0.55		0.71		0.49		0.47		0.68		0.65		0.74
9		0.68		0.62		0.58		0.60		0.70		0.51		0.48		0.63		0.69		0.63
10		0.63		0.63		0.65		0.59		0.64		0.50		0.56		0.64		0.70		0.79
11		0.65		0.57		0.55		0.54		0.68		0.58		0.50		0.62		0.69		0.62
12		0.57		0.61		0.67		0.53		0.72		0.59		0.47		0.70		0.61		0.69
13		0.63		0.59		0.66		0.59		0.69		0.60		0.55		0.71		0.59		0.79
14		0.45		0.65		0.60		0.60		0.68		0.63		0.56		0.68		0.54		0.81
15		0.66		0.60		0.62		0.64		0.61		0.48		0.58		0.75		0.74		0.82
16		0.63		0.58		0.51		0.53		0.71		0.54		0.41		0.68		0.69		0.76
17		0.61		0.54		0.70		0.59		0.63		0.53		0.49		0.69		0.63		0.69
18		0.56		0.66		0.59		0.61		0.67		0.51		0.58		0.71		0.64		0.68
19		0.62		0.63		0.63		0.58		0.72		0.49		0.47		0.60		0.72		0.78
20		0.75		0.57		0.68		0.49		0.70		0.48		0.50		0.58		0.65		0.61

Figure 19. Comparison of Website Evaluation Results

5.3. Summary

This section analyses the main ideas behind the web evaluation process and performs a case study involving five quality characteristics in real live websites. The implementation has four layers of structure. First tree-traversal layer uses a web crawler to enclose the whole website's internal URLs. Second parsing layer is to extract HTML source codes in every web page according to the internal URLs enclosed from above the layer. Third data metrics layer is to analyse the source codes and calculate the quality scores through the particular formulae defined in Chapter 4. The results of the calculation will be displayed on the user interface. Last the graphical user interface layer is to provide a program interface on which appears the scores for each quality characteristic and final score of web evaluation. In addition, a graphical chart is also displayed on the interface. The user is able to view the degree of each characteristic visually, and directly recognises which characteristic needs improvement and which are satisfactory.

A case study is performed by using the website evaluation tool to evaluate a real website. De Montfort University's website is chosen for this practice. This case mainly includes two steps: one step is to evaluate the five quality characteristics respectively. The five quality values consist of Aesthetics, Ease of Use, Multimedia, Rich Content, and Reputation. The other step is to calculate the overall quality of the DMU website through averaging five quality values.

Finally, a validation process is applied by using the questionnaires to verify the web evaluation tool is accurate for different types of websites.

Chapter 6

Conclusions and Future work

6.1. Conclusions

From the outcomes of this investigation, the research work has taken a new angle. It proposed a website quality metrics which included a website evaluation framework, definition of each website quality criteria and website evaluation calculation. Finally a website evaluation tool is established to automatically analyse and calculate the quality of a website.

Initially, web evaluation must clarify the evaluation goals and the intended user viewpoint, and then define a web evaluation framework. For instance, the ISO quality model prescribed characteristics and attributes that customise different web applications. The importance of the web evaluation framework has been proposed by three-level structures, which are quality characteristics, quality sub-characteristics and measurable criteria (indicators). In the first level, the web evaluation framework proposed five quality characteristics which included Aesthetics, Ease of Use, Multimedia, Rich Content and Reputation. Aesthetics and Reputation are the main parts of this study. The second level characteristic is broken down by several Sub-characteristics. Each Sub-characteristic is inherited from parental quality characteristics, however only Aesthetics and Ease of Use have Sub-characteristics, and others such as Multimedia, Rich Content and Reputation are directly divided into the third level – measurable indicators. The third level has twenty eight measurable criteria (indicators) which overlap very little. Each measurable criterion is defined specifically in this study.

Next, in order to identify the web quality aspects meet the user access requirements, the twenty eight quality criteria have been defined. The selection of each quality criteria is concluded by in depth research based on the disadvantages of live websites, and also

according to the relative rules from previous study. The following shows the particular principles for selecting website quality criteria:

1. The definition of quality criteria are selected based on the debates. It means some users agree with a quality criterion used in live websites and some users are not. An example is the Auto-refresh attribute.
2. The definition of quality criteria is chose based on the disadvantages. It means some quality criteria have not been defined according to the previous researches. An example is Information Publicity.
3. The definition of quality criteria is concluded based on practical study. Some quality criteria have been researched within more than one hundred different websites. An example is Underline of Text.

The website quality criteria are the foundation of the website quality metrics, the criteria are established based on the user's perspectives and designed for a possible automatic website evaluation process.

Last, the website quality metrics calculates the quality criteria through several evaluation formulae giving results with the meaningful quality scores. After the quality criteria have been analysed, the average formulae are computed based on the aggregate of each quality criteria. The results will from 0 to 1, also the means of weights is considered in the evaluation process. Following the main aim for evaluating a website quality, means the website quality metrics need to calculate the whole web pages: one root page and a total numbers children pages. Obviously, the root page is more important than others, so the calculation for the whole quality of the website is defined by the root page has the same weight (0.5) as the total children pages (0.5). The result is also from 0 to 1, 0 represents poor quality and 1 means excellent quality.

Finally, an advanced program has been designed as a website evaluation tool. Its implementation architecture has four layers, which includes Tree-Traversal, Parsing, Data Metrics and Graphical User Interface. The functions in Tree-Traversal are designed

for examining the whole website and extracting all internal web addresses. The Parsing layer extracts the web page's source codes based on the internal web addresses which have been produced in front layer. Data Metrics layer is to analyse and calculate the web page's source codes and provide visual numbers as quality scores of a website. Graphical User Interface provides a main interface for interacting between the program and the users. User can type or paste a website address into a text box and then click the "Go" button, the scores will be shown on the screen.

The advantages of this website quality metrics are very specific:

- Firstly, Website quality metrics focuses on the users need to be comfortable with the pleasant web design, good creditability, ease to use etc; these objectives incorporate advanced web technology and the user's perspective.
- Secondly, the websites quality metrics provides an evaluation blueprint and resource to inform visitors that they can access the websites confidently.
- Thirdly, the website quality metrics is different than traditional web measurement methods, some reasons such as it provides a quality evaluation tool which can analyse and calculate the quality of website automatically.
- Fourthly, website quality framework has different quality measurement criteria.

The proposed website quality metrics can be used as a website evaluation framework to evaluate existing websites and allocate quality scores, but also can be help to improving website quality through re-engineering. Data collected in the analysis phase can support update the website.

6.2. Future Work

Regarding the website quality metrics described in this study, the website quality criteria of a website that may not have been completely defined. It is necessary to make an even more exhaustive study for example in aesthetics or reputation quality

characteristics, the definition of new quality criteria it is likely that poor quality criteria will be detected. One of priorities is the Layout characteristic, which is a particularly valuable feature when taking into account the new kinds of website quality characteristic.

Since websites are continually developing as mentioned previously, although many end users are still using PCs or Macs as just choice, the new web applications are necessary for mobile devices that could result in changes to website design. In the future, the website quality metrics will be adjusted to adapt this new challenge.

In order to automatically evaluate the quality of a website by using a web evaluation tool, there are still several problems. For example, some defined quality criteria are not analysed completely by the web evaluation tool, because most of websites are designed by many classes (object-oriented function). It is difficult to extract the HTML source codes from a website. On the other hand, currently website evaluation tool is a Windows application. In the future it should be run on-line.

Finally, evaluating the quality of website is a very interesting research topic. This study proposed an important issue and a software tool which focused on meeting the user's access expectations. However, it is not the end, improving the research of websites quality metrics and website evaluation tools will be continued in future study.

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Appendix A

Selected Code of Website Evaluation Tool

A.1 HTML Source Codes Extraction

```
Public Class WebEvaluationTool

    Private Sub btnGo_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles
btnGo.Click
        WebBrowser1.Navigate(Me.txtUrl.Text)

    End Sub
```

A.2 Log off Function of the Website Evaluation Tool

```
Private Sub btnExit_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles
btnExit.Click
        Me.Close()

    End Sub
```

A.3 Evaluation of the Aesthetics Quality Characteristic

```
Private Sub WebBrowser1_DocumentCompleted(ByVal sender As System.Object, ByVal e As
System.Windows.Forms.WebBrowserDocumentCompletedEventArgs) Handles
WebBrowser1.DocumentCompleted
        Dim objDocument As HtmlDocument
        Dim objImg As System.Windows.Forms.HtmlElement
        Dim objTable As System.Windows.Forms.HtmlElement
        Dim objBody As System.Windows.Forms.HtmlElement
        Dim imgSize As Integer = 0
        Dim imgOnlyOne As Integer = 1
        Dim imgAlt As Integer = 0
        Dim imgSrc As Integer = 0
        Dim tableSize As Integer = 0
        Dim multiple As Integer = 0
        Dim htmlResolution As Integer = 0
        Dim imgSizeCount As Integer = 0
        Dim imgOnlyOneCount As Integer = 0
```

```
            Dim imgAltCount As Integer = 0
            Dim imgSrcCount As Integer = 0
            Dim tableSizeCount As Integer = 0
            Dim htColor As Hashtable = New Hashtable
            Dim alNamesColor As ArrayList = New ArrayList()
            Dim alColor As ArrayList = New ArrayList()
            Dim safeColor As Integer = 0
            Dim safeCount As Integer = 0
            Dim underlineCount As Integer = 0
            Dim limitation As Integer = 1
            Dim underline As Integer = 0
            Dim aesthetic As Double = 0
            objDocument = WebBrowser1.Document
            alColor = GetSystemColorCollection()
            alNamesColor = GetSystemColorNameCollection()
            For Each objImg In objDocument.Images
                Dim str As String = objImg.OuterHtml
                'Defining image size
                If str.ToLower().Contains("width") And str.ToLower().Contains("height") Then
                    imgSizeCount = imgSizeCount + 1
                    'If a image is not defined, then extracting CSS
                ElseIf objImg.Style IsNot Nothing AndAlso (objImg.Style.ToLower().Contains("width")
And objImg.Style.ToLower().Contains("height")) Then
                    imgSizeCount = imgSizeCount + 1
                End If
                'One page one image
                If objImg.ClientRectangle.Width > 360 And objImg.ClientRectangle.Height > 360 Then
                    imgOnlyOneCount = imgOnlyOneCount + 1
                End If
                'ALT attributes
                If str.ToLower().Contains("alt=") Then
                    imgAltCount = imgAltCount + 1
                End If
                'Image Links
                If str.ToLower().Contains("src=") Then
                    imgSrcCount = imgSrcCount + 1
                End If
            Next
            'Image size > 50%, = 1
            If (imgSizeCount = 0 Or imgSizeCount / objDocument.Images.Count > 0.5) Then
                imgSize = 1
            End If
            'image > 360x360, = 0
```

```
        If (imgOnlyOneCount > 1) Then
            imgOnlyOne = 0
        End If
        'Image ALT attributes > 50%, =1
        If (imgAltCount = 0 Or imgAltCount / objDocument.Images.Count > 0.5) Then
            imgAlt = 1
        End If
        'Image links > 50%, =1
        If (imgSrcCount = 0 Or imgSrcCount / objDocument.Images.Count > 0.5) Then
            imgSrc = 1
        End If

        For Each objTable In objDocument.GetElementsByTagName("table")
            'Defining Table size
            Dim str As String = objTable.OuterHtml.Substring(0, objTable.OuterHtml.Length -
objTable.InnerHtml.Length)
            If str.ToLower().Contains("width") And str.ToLower().Contains("height") Then
                tableSizeCount = tableSizeCount + 1
            ElseIf objTable.Style IsNot Nothing AndAlso
(objTable.Style.ToLower().Contains("width") And objTable.Style.ToLower().Contains("height"))
Then
                tableSizeCount = tableSizeCount + 1
            End If
        Next
        'Defining the table size > 50%, =1
        If (tableSizeCount = 0 Or tableSizeCount /
objDocument.GetElementsByTagName("table").Count > 0.5) Then
            tableSize = 1
        End If

        For Each objBody In objDocument.GetElementsByTagName("body")
            'Optimizing Resolution
            If objBody.ClientRectangle.Width > 1024 And objBody.ClientRectangle.Height > 768 Then
                htmlResolution = 1
                Return
            End If
        Next
        'Using multip colour
        Try
            htColor = GetColorsIsMultiple(objDocument.Body.Children, htColor)
        Catch ex As Exception
        End Try
```

```
        For Each objStyle As HtmlElement In objDocument.All
            'Extracting tags between body
            If (objStyle.TagName.ToLower() = "body") Then
                Exit For
            Else
                If (objStyle.TagName.ToLower() = "style") Then
                    GetColorsIsMultiple(objStyle.OuterHtml, htColor)
                End If
                If (objStyle.TagName.ToLower() = "link") Then
                    Dim strUrl As String = GetStylebyAttribute(objStyle.OuterHtml, "href")
                    Dim strStyle As String
                    strUrl = String.Format("http://[21]", objDocument.Domain +
strUrl.Substring(strUrl.IndexOf("/")))
                    Try
                        strStyle = DownFile(strUrl, "temp.css")
                        GetColorsIsMultiple(strStyle, htColor)
                    Catch ex As Exception
                    End Try
                End If
            End If
        Next
        If (htColor IsNot Nothing AndAlso htColor.Count > 7) Then
            multiple = 1
        Else
        End If
        'Using Safe Colour
        For Each cor As String In htColor.Values
            If alColor.Contains(cor) Or alNamesColor.Contains(cor) Then
                safeCount = safeCount + 1
            End If
        Next

        'Using Safe Colour > 50%, = 1
        If (safeCount = 0 Or safeCount / htColor.Count > 0.5) Then
            safeColor = 1
        End If

        'The limitations of Colour blindness
        If objDocument.BackColor = Color.Red Or objDocument.BackColor = Color.Green Or
objDocument.BackColor = Color.Lime _
           Or objDocument.ForeColor = Color.Red Or objDocument.ForeColor = Color.Green Or
objDocument.ForeColor = Color.Lime Then
            limitation = 0
```

```
        End If
        'Underline of Text
        Try
            underlineCount = Me.GetUnderline(objDocument.Body.Children, 0)
            If underlineCount = 0 Then
                underline = 1
            End If
        Catch ex As Exception

        End Try

        aesthetic = (imgSize + imgOnlyOne + imgAlt + imgSrc) / 4 * 0.3 + 0.2 * (tableSize +
htmlResolution) / 2 + (multiple + safeColor + limitation) / 3 * 0.3 + 0.2 * underline
        Me.TextBox1.Text = aesthetic
        Me.ChartControl1.BeginInit()
        Dim series As DevExpress.XtraCharts.Series = Me.ChartControl1.Series(0)
        series.Points.Clear()
        series.Points.AddRange(New DevExpress.XtraCharts.SeriesPoint() New
DevExpress.XtraCharts.SeriesPoint("Aesthetic"), New DevExpress.XtraCharts.SeriesPoint("Ease of
Use"), New DevExpress.XtraCharts.SeriesPoint("Multimedia"), New
DevExpress.XtraCharts.SeriesPoint("Rich Content"), New
DevExpress.XtraCharts.SeriesPoint("Reputation"))
        series.Points(0).Values = New Double() 1aesthetic1
        series.Points(1).Values = New Double() 0.9
        series.Points(2).Values = New Double() 0.15
        series.Points(3).Values = New Double() 1.1
        series.Points(4).Values = New Double() 1.03
        Me.ChartControl1.EndInit()
    End Sub
```

A.4 Recursive Invocation for the Extraction of Colour Codes.

```
    ''' </summary>
    ''' <param name="objDocument"></param>
    ''' <param name="htColor"></param>
    ''' <returns></returns>
    ''' <remarks></remarks>
    Private Function GetColorsIsMultiple(ByVal objDocument As HtmlElementCollection, ByVal
htColor As Hashtable) As Hashtable
        Dim objElements As HtmlElement
        Dim guid As Guid
        If htColor Is Nothing Then
```

```
            htColor = New Hashtable
        End If
        For Each objElements In objDocument
            Dim attributeValue As String
            attributeValue = GetStylebyCSSAttribute(objElements.Style, "color")
            If (Not String.IsNullOrEmpty(attributeValue) AndAlso Not
htColor.ContainsValue(attributeValue)) Then
                guid = New Guid()
                guid = guid.NewGuid()
                htColor.Add(guid, attributeValue)
            End If
            GetColorsIsMultiple(objElements.Children, htColor)
        Next
        Return htColor
    End Function
```

A.5 Recursion Invocation for the Extraction of Text-Decoration Codes.

```
    ''' </summary>
    ''' <param name="objDocument"></param>
    ''' <param name="underlineCount"></param>
    ''' <returns></returns>
    ''' <remarks></remarks>
    Private Function GetUnderline(ByVal objDocument As HtmlElementCollection, ByRef
underlineCount As Integer) As Integer
        Dim objElements As HtmlElement
        For Each objElements In objDocument
            Dim attributeValue As String
            If objElements.TagName.ToLower() <> "a" Then
                attributeValue = GetStylebyCSSAttribute(objElements.Style, "text-decoration")
                If (Not String.IsNullOrEmpty(attributeValue) AndAlso
attributeValue.ToLower().Equals("underline")) Then
                    underlineCount = underlineCount + 1
                End If
                GetUnderline(objElements.Children, underlineCount)
            End If
        Next
        Return underlineCount
    End Function
```

A.6 Judgement of the Existence of CSS Attributes

```
Private Function CheckCSSAttributeIsExistence(ByVal strStyle As String, ByVal attribute As String)
As Boolean
        Dim attributeIsExistence As Boolean = False
        Dim strStyles As String() = Nothing
        If Not String.IsNullOrEmpty(strStyle) Then
            strStyles = strStyle.Split(";")
            For Each str As String In strStyles
                If (str.ToLower().Contains(attribute)) Then
                    attributeIsExistence = True
                    Exit For
                End If
            Next
        End If
        Return attributeIsExistence
    End Function
```

A.7 Downloading CSS files

```
Public Shared Function DownFile(ByVal URL As String, ByVal Filename As String) As String
        Dim Myrq As HttpWebRequest = HttpWebRequest.Create(URL)
        Dim myrp As HttpWebResponse = Myrq.GetResponse
        Dim st As Stream = myrp.GetResponseStream
        Dim totalBytes As Long = myrp.ContentLength
        Dim so As Stream = New FileStream(Filename, FileMode.Create)
        Dim totalDownloadedByte As Long = 0
        Dim by(totalBytes - 1) As Byte
        Dim osize As Integer = st.Read(by, 0, by.Length)
        While osize > 0
            totalDownloadedByte = osize + totalDownloadedByte
            Application.DoEvents()
            so.Write(by, 0, osize)
            osize = st.Read(by, 0, by.LongLength)
        End While
        so.Close()
        st.Close()
        Return Encoding.Default.GetString(by)

    End Function
End Class
```

A.8 Extraction of the Quality Characteristics Codes within entire CSS Attributes

```
Private Function GetStylebyCSSAttribute(ByVal strStyle As String, ByVal attribute As String) As
String
        Dim attributeValue As String = Nothing
        If (Not String.IsNullOrEmpty(strStyle) AndAlso strStyle.ToLower().Contains(attribute))
Then
            attributeValue = (strStyle.Split(":"))(1)
        End If
        Return attributeValue
    End Function
```

A.9 Extraction of the Colours Codes within entire CSS Attributes

```
   Private Function GetColorsIsMultiple(ByVal objDocument As HtmlElementCollection, ByVal htColor
As Hashtable) As Hashtable
        Dim objElements As HtmlElement
        Dim guid As Guid
        If htColor Is Nothing Then
            htColor = New Hashtable
        End If
        For Each objElements In objDocument
            Dim attributeValue As String
            attributeValue = GetStylebyCSSAttribute(objElements.Style, "color")
            If (Not String.IsNullOrEmpty(attributeValue) AndAlso Not
htColor.ContainsValue(attributeValue)) Then
                guid = New Guid()
                guid = guid.NewGuid()
                htColor.Add(guid, attributeValue)
            End If
            GetColorsIsMultiple(objElements.Children, htColor)
        Next
        Return htColor
    End Function
```

A.10 Assessment of the Safe Colour Codes

```
Private Function GetSystemColorNameCollection() As ArrayList
        Dim alColor As ArrayList = New ArrayList()
        Dim colorCollection As Type
        colorCollection = GetType(System.Drawing.KnownColor)
```

```
        For Each colorName As String In [Enum].GetNames(colorCollection)
            alColor.Add(colorName)
        Next
        Return alColor
    End Function

Private Function GetSystemColorCollection() As ArrayList
        Dim alColor As ArrayList = New ArrayList()
        For i As Integer = 0 To 5
            For j As Integer = 0 To 5
                For k As Integer = 0 To 5
                    Dim safecolor As String = "#"
                    Select Case i
                        Case 0
                            safecolor = safecolor + "00"
                        Case 1
                            safecolor = safecolor + "33"
                        Case 2
                            safecolor = safecolor + "66"
                        Case 3
                            safecolor = safecolor + "99"
                        Case 4
                            safecolor = safecolor + "CC"
                        Case 5
                            safecolor = safecolor + "FF"
                    End Select
                    Select Case j
                        Case 0
                            safecolor = safecolor + "00"
                        Case 1
                            safecolor = safecolor + "33"
                        Case 2
                            safecolor = safecolor + "66"
                        Case 3
                            safecolor = safecolor + "99"
                        Case 4
                            safecolor = safecolor + "CC"
                        Case 5
                            safecolor = safecolor + "FF"
                    End Select
                    Select Case k
                        Case 0
                            safecolor = safecolor + "00"
```

```
                    Case 1
                        safecolor = safecolor + "33"
                    Case 2
                        safecolor = safecolor + "66"
                    Case 3
                        safecolor = safecolor + "99"
                    Case 4
                        safecolor = safecolor + "CC"
                    Case 5
                        safecolor = safecolor + "FF"
                End Select
                alColor.Add(safecolor)
            Next
        Next
    Next
    Return (alColor)
End Function
```

Appendix B

List of Publications by Author

- Zihou Zhou, Hong Zhou and Hongji Yang, “Evaluating Websites using A Practical Quality Model” *14th International Conference on Automation &Computing Society in the UK (ICAC’08)*, West London, England, Sept. 2008. pp. 114-119.

- Jianjun Pu, Jian Kang, Zihou Zhou and Hongji Yang, “Combining MDE and UML to Reverse Engineer Web-Based Legacy Systems with UML”, *Agent-Oriented Software Development Methodology (AOSDM’ 2008)*, Glasgow, UK, July 2008.