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HYBRID APPROACH FOR WEBSITE QUALITY EVALUATION: LINEAR WEIGHTAGE MODEL AND FUZZY ANALYTICAL HIERARCHY PROCESS

by

HANDARU JATI

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BANDAR SERI ISKANDAR,

PERAK

MAY 2010

DECLARATION OF THESIS

Title of thesis	Hybrid Approach for Website Quality Evaluation: Linear Weightage Model and Analytical Hierarchy Process

I HANDARU JATI hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTP or other institutions.

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Handaru Jati

ABSTRACT

In recent years, many people have devoted their efforts to the issue of quality of website. The concept of quality is consisting of many criteria: quality of service perspective, a user perspective, a content perspective or indeed a usability perspective. The very special nature of the web applications and website pose unique software testing challenges. Webmasters, Web applications developers, and Website quality assurance managers need tools and methods that can match up to the new needs. The result of this study confirmed that criteria of website quality consist of eleven criteria (load time, response time, page rank, frequency of update, traffic, design optimization, size, nu

mber of items, accessibility error, markup validation, and broken link). Online diagnostic tools provided in the internet can be used to measure website quality related with criteria that was determined in this research. This decreases the economic and non-economic cost for conducting website evaluation. Online diagnostics tools allow the website designer or researcher to evaluate many websites and to detect potential problems as well as actual problems. This research conducts some tests to measure the quality website of Asian countries via web diagnostic tools online. The researcher proposes a methodology for determining and evaluating the best e-government, Asian airlines, and Malaysian universities sites based on many criteria of website quality. Applying Hybrid model between LWM and FAHP approach for website evaluation has resulted in significant acceleration of implementation, raised the overall effectiveness with respect to the underlying methodology and ultimately enabled more efficient procedure. The result of this study confirmed most of Asian websites are neglecting performance and airlines websites have the best quality performance based on Hybrid Model Evaluation. According to the results of the evaluation process, Airlines sector has the highest average score compare to e-government and university.

Keywords:—performance, quality, website, Hybrid model.

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ABBREVIATION

AHP	Analytic Hierarchy Process
FAHP	Fuzzy-Analytic Hierarchy Process
HM	Hybrid Model
HTTP	HyperText Markup Language
HTML	HyperText Transfer Protocol
LWM	Linear Weightage Model
TFN	Triangular Fuzzy Number
W3C	World Wide Web Consortium

LIST OF NOTATIONS

PR	page rank
$t_1 \ldots t_n$	are pages linking to page A
C	is the number of outbound links that a page has
d	is a damping factor, usually set to 0.85. $0 \leq d \leq 1$
ws_{max}	specific sample data value that has maximum type of threshold with respect to a particular attribute/criterion.
ws_{min}	specific sample data value that has minimum type of threshold with respect to a particular attribute/criterion.
$F(x)_{max}$	manimum threshold
$F(x)_{min}$	minimum treshold
W^t	weight vector
S_i	The value of fuzzy synthetic extent with respect to the i th Object
V	The degree possibility for a convex fuzzy number

CHAPTER 1

INTRODUCTION

1.1 Background of Study

The question of website quality has been defined by many disciplines in three distinct ways: the information value of the content provided (library and information science), the design of such a site (information systems and technology, media studies), and the usability of the interface (mediated communication). Each definition of quality leads to lists of criteria about what constitute a quality site. All of these criteria from many studies on web quality, form a comprehensive tool for evaluating the quality of a website that would serve to assess its trustworthiness [1]. There is a principle that 'if information can pass a test of quality, it is most likely to prove trustworthy' and because of this belief, higher quality website should have higher credibility. The Website Quality Evaluation Tool (WQET) is an interdisciplinary assessment instrument and this is an important instrument that has been produced from the analysis and synthesis of multiple web quality studies. The tool needs a lot of time and cautious consideration. It takes more than one hour to examine a website thoroughly and apply the criteria of the quality. This time dedication may be available to information professionals, but public users may not be willing to spend the same amount of time. Thus, the challenge is to create a method that will guide the Internet user to the same finding as the WQET without needing a lot of time.

The evaluation of a website in terms of quality lacks a single point definition. It is the combination of various factors: aesthetic, logic, technology and many other factors. There are many scope of quality, and each measure will pertain to a particular website in varying degrees. Here are some of them: the first factor is time; a credible site should be updated frequently. The information about the latest update should be included on the homepage. If the information in the website is not updated frequently, visitor could simply assume that the site manager has no time to update the site.

The second factor is structural; all website components should hold together and all website internal and external links should work well. Clear navigation, legible content, clean page layouts, simple instructions and easy search functions are factors that contribute to user-friendliness of a website. Broken links on the webpage is also another factor that can downgrade the website quality. Each page usually has references or links or connections to other pages, and these links are connected to the internal or external website. Users expect each link to be valid, meaning that it leads successfully to the intended page or other resources. In the year of 2003, it was discovered that about one out of every 200 links disappeared each week from the Internet [2].

The third factor is content or search engine friendliness; the number of links or link popularity is one of the off page factors that search engines are looking for to determine the value of the webpage. In emerging markets like Asian countries: Indonesia, Malaysia, Thailand, China, and India; the usage of the Internet is becoming very huge. Having a website, is just a requirement in today scenario. But, only having a website is not giving a good impact to the business if it cannot make good sales and revenue through the website. To generate income through merchandising sales, institutions need to have quality web traffic first. The advantages of a large number of links to a site are evident: first, the more sites that link to the website, the more traffic the website can expect to receive, and second, major search engines will improve website ranking when there are more sites that link to the website [3]. At the very least, website should be search engine friendly. Search engines should be able to easily extract the contents available for public and display the relevant pages to fulfill the search query. Higher search engines rankings convert into greater traffic to the site and therefore, increases its level of accessibility [4]. Major search engines have their own way of defining relevant search results for particular key-phrase. The three most popular search engines (Google, Yahoo, and MSN) have joined together to develop some standards related to the most effective way to crawl a website. This joint initiative is sitemaps.org which outlines the proocol for a website site map and instructs each engine on which pages to crawl, how relevant they are, and how often to crawl them. Approximately 85% of all traffics to website and 70% of all online business transactions originate from a search engine or directory (like Google, Yahoo, or MSN). Quality web traffics can be obtained by improving website ranking on most of the search engines. To improve website ranking, there are some steps to do, firstly by analyzing who are the target audiences and then analyzing what are the keywords or phrases the target audiences are using while searching the web. If the website has a very rich content with those keywords there will be a higher chance to improve the website ranking on any search engine. Secondly, by updating the content regularly and this action can improve the website ranking quite remarkably. This is because most of search engine algorithms give top ranking while indexing the website if the content is updated frequently. Search engines require a website to have at least two links pointing to the site before they will place it to their index. The idea is that when a website has increased its link popularity, then it has also proved that the website has high quality content. Number of links to a website improves access growth and helps to generate traffic [5]. Page-Rank is a link analysis algorithm used by the Google Internet search engine that assigns a numerical weighting to each element of a hyperlinked set of documents, such as the World Wide Web, with the purpose of measuring its relative importance within the set.

$$\mathrm{PR}(A) = (1-d) + d(\mathrm{PR}(t_1)/C(t_1) + \ldots + \mathrm{PR}(tn)/C(tn)) \tag{1.1}$$

PR = page rank

$t_1 \ldots t_n$ = are pages linking to page A

C = is the number of outbound links that a page has

d = is a damping factor, usually set to 0.85. $0 \leq d \leq 1$

Search engine such as Google makes a citation analysis to rank hits, and then a website which has many links to it will have a higher ranking compared to a website with a few links. This indicator can be used to measure the quality of website.

The fourth factor is response time; a website server should respond to a browser request within certain parameters. Popular sites averaged 52 objects per page, 8.1 of which were ads, served from 5.7 servers [6], and object overhead now dominates the latency of most webpage [7]. Following the recommendation of the HTTP 1.1 specification, browsers typically default to two simultaneous threads per hostname. As the number of HTTP requests required by a webpage increases from 3 to 23, the actual download time of objects as a percentage of the total page download time drops from 50% to only 14%.

The fifth factor is stickiness, which is the ability to ensure that the Internet user sticks on the website page for a longer period of time. A sticky website is a place that people will come to visit again. By having regular visitors, this strategy can increase exposure to product or service hence it can create more sales. The positive impacts to have a sticky website are: repeat traffic impact on increased sales, one-to-one relationships are created, and develop performance through feedback.

The sixth factor is design, a site does not only need to make sense visually, it should also appear the same on all web browsers (such as Internet Explorer, Opera, and Firefox) and across all computer platforms (PC and Mac). Good design should make a site easy to use and an effective site design should communicate a brand and help to accomplish the site's objectives and goals. Sites with known brands were also highly rated for both credibility and visual design [8]. However, creating website with a good design is subjective and it is only through repetitive efforts and testing that we can figure out what works best for the intended audience.

The seventh factor is performance. Technology continues to make important impact in service industries and fundamentally shapes how services are delivered [9]. There are also many factors that influence the performance of the web and most of them are outside the control of website designer. Download time of a website is determined by webpage design, web server, hardware of the client, software configuration, and characteristics of the Internet router which connects users and the website. It is found that extraneous content exists on the majority of popular pages, and that blocking this content buys a 25-30% reduction in objects downloaded and bytes, with a 33% decrease in page latency, from 2003 to 2008 the average webpage grew from 93.7K to over 312K [10]. One research finding mentioned that a website which has slow download time is less attractive compared to a website with faster download time [11]. Currently, the average connection speed is 5 Kbps (kilobytes per second), and this gives an implication that one webpage with 40 Kb page size will be downloaded within 8 seconds. This matter is in accordance with the 'eight second rule'. 8-second period is a normal time for loading a webpage and it is not tolerable by the user. This fact is supported by many research results mentioning that the mean of tolerable download time by the user is 8.57 seconds with standard deviation of 5.9 seconds [12]. A new study by Akamai and Jupiter proposed replacing the 8-second rule, claiming that today four seconds is the highest acceptable length of time an average online shopper will wait for a Web page to load before potentially abandoning a retail site [13]. This also shows that providing information related with waiting time is very important for the users. Therefore, for long download time, it is better to provide information about how many percent of the webpage already downloaded and how much time needed to complete this task. Another important aspect is information fit-to-task, which means that information presented on a website is accurate and appropriate for the task at hand [14]. Solid website engineering deals with planning on how the site will be tactically constructed and how all of website components will fit together to make it runs smoothly. Good architecture is fundamental to deal with a website's requirements, to ensure structural scalability, flexibility, security, and to fulfill performance demands currently and in the future. A completed site should comply with acknowledged programming standards. The World Wide Web Consortium (W3C) is an organization committed to create programming standards for HTML, XHTML and CSS. Other recognized web programming standard expands to accessibility compliance and security best practices. A website relies on infrastructure, server hardware, and software to have a good performance. All of these factors are supported by website's server or hosting environment that can contribute to the site's performance and security aspect. Website page optimization continues to provide significant improvements for website performance and can have a large impact on its quality. Despite the increasing broadband adoption, slow download time continues to be a cause of slow web browsing which can be one of the most frustrating experiences. The optimizations are organized into three basic categories including image, website design, and HTML code optimization. This optimization can be improved by improving the quality of website's images, reducing the complexity of the HTML coding, and increasing the overall usability.

The last factor is usability. As the web keeps on growing as a competitive tool for business applications, there is a need to comprehend the relationship between business performance and web usability. Most of the previous researches have discussed the website development from a set of usability factors [15-17]. Online accessibility test can be used to examine whether the web portals have accessibility errors on their respective webpages, and the World Wide Web Consortium (W3C) rules are divided into three priority levels which will influence the level of website accessibility. First Level (priority 1) is a requirement which has to be met by the website to make the website can be accessed by blind people [18]. Second Level (priority 2) includes some items that should be provided in the webpage for users with disability to be able to access more information in the web. Third Level (priority 3) requires more items than in the level priority 2 for users with disability to be able to access more complete information in the web. In other words, if the website cannot fulfill the first priority, then users with disability will not have an opportunity to access information in the web. If a website cannot satisfy second priority then users will have some problems to access the web, whereas if the website already satisfied the third criteria then users will have a little difficulty to access the web [19, 20].

1.2 Thesis Statement

Website quality is a new topic in the software quality. Web based application can be used and reached more users than non-web based application. Automation testing for website quality is a new chance and a new method. Consequently, an organized and disciplined deployment of engineering models, techniques, and methods for understanding, measuring, and developing of this kind of software should be considered a mandatory requirement. One of the main purposes for website evaluation is to recognize the scope with a given set of quality criteria fulfills a selected set of needs required by user. Website domains like electronic commerce, e-government, university, etc are becoming increasingly complex systems. For this reason, an integral quantitative evaluation process regarding all relevant quality criteria is also a complex topic. The evaluation complexity is caused by the big quantity of criteria and attributes; in addition, some relevant attributes to evaluate cannot objectively be measured by evaluators and are not included in the evaluation.

This research conducts some tests to measure the quality of website in Asian countries via web diagnostic tools online. We propose a new methodology for determining and evaluating the best Asian website based on many criteria of website quality. The criteria of website quality consists of eleven items : load time, response time, page rank, frequency of update, traffic, design optimization, size, number of items, accessibility error, markup validation, and broken link. The new evaluation model was implemented to evaluate website quality by using Linear Weightage Model and Fuzzy Analytical Hierarchy Process (FAHP) to generate the weights for the criteria.

1.3 Problem Statement

The importance of website creates a demand from users for the quality and fast delivery, unfortunately the complexities of the website and technology which support this application make testing and quality control more difficult to handle. The selection process of the most adequate method for a new problem is a complex task. This is an important issue, because many different evaluation methods are available. These methods originate from different areas like statistics, fuzzy logic and neural networks and their performance may vary considerably. Recent interest in combination of methods like combining and cascading have resulted in many new additional methods. We could decrease the problem of methods selection to the problem of method performance comparison by trying all the methods on the problem at hand. In practice this is not feasible in many situations, because there are too many methods to try out, some of which maybe quite complicated, especially with large amounts of data. An alternative solution would be to try to identify some of appropriate method, which could be used in all situations. There are some problems that will be explored:

1. In this research we are concerned with evaluation methods. These methods use experimental results obtained by a set of test available online test on the Internet to generate an appraisal of quality.

2. Method selection as an exploratory process is highly dependent on the analyst's knowledge of the methods and of the problem area, thus something lies somewhere on the border between engineering and art. All this implies that, referring to the problem at hand, specific recommendation should be given concerning which method should be utilized or tried out.

3. As it is generally difficult to recognize a single best method reliably, we believe that a good option is to provide a ranking. The ranking produced can be used to choose one or more suitable evaluation method for Asian website quality.

1.4 Research Objectives

This research pursues three objectives to be achieved.

1. To determine the factors influence website quality

2. To find available tools to generate an appraisal of quality.

3. To develop a new methodology for determining and evaluating the best Asian website based on many criteria of website quality.

1.5 Research Approach.

This research uses various evaluation techniques in order to find an effective method to identify the quality of website. First, a set of criteria used in quality of website was collected from the literature, and a test online provided in the Internet was done to refine the criteria. The criteria were then translated into terms appropriate for quality, and a test online was conducted that went to a specified website and collected aspects of the website that corresponded to the criteria. This data collection tool was used to gather information from three website sectors (e-government, airlines, and Malaysian universities) for the eleven criteria of the website quality. We address this issue by dividing the process into two distinct phases. At first, we identify and evaluate the quality for related website using three well known methods and one new proposed method. In the next phase, we proceed to create a ranking on the basis of the datasets identified. Our research aim is to examine four ranking methods and evaluate their ability to generate rankings which are consistent with the actual performance information, we also investigate the issue whether there are significant differences between them, and if there are, which method is preferable to the others. Whatever method we use to identify the appropriate approach, we still need to resolve the issue concerning which ranking method is the best one.

1.6 Research Questions

In responding to all of the problems stated above, this research attempt to address these questions:

1. What are the criteria that constitute the quality of a website and what is their significance and influence in the website quality evaluation?

2. Whether the performance among four proposed methods for evaluating website quality differs or not: Linear Weightage Model, Analytical Hierarchy Process, Fuzzy Analytical Hierarchy Process, and Hybrid Model?

3. Which of the following methods: LWM, AHP, FAHP, and HM are the best?

Here are the hypotheses:

H_0 : There is no difference in the mean average correlation coefficients for the four ranking methods.

H_1 : There are some differences in the mean average correlation coefficients for the four ranking methods.

H_0 : There is no difference in the mean average correlation coefficients between methods *i* and *j* (LWM, AHP, FAHP, and HM)

H_1 : There is some differences in the mean average correlation coefficients between methods *i* and *j* (LWM, AHP, FAHP, and HM)

1.7 Limitations and Key Assumptions

There are limitations for this analysis, one of the limitations in this research occurrs in the time factor. Websites are artifacts that can evolve dynamically and users always access the last on-line version. By the time of data collection (from March 3 to May 20, 2009), we did not perceive big changes in these websites that could affect the evaluation process despite the fact that the web is a highly dynamic and changeable medium. Similar studies at different times are likely to show different results. A second concern was the subjective nature of factors weightings, although are based on the results of previous studies and personal judgment as researcher, introduces subjectivity into our analysis.

1.8 Contribution of Study

The methodology based on hybrid model developed in this research can assist website user and developer for evaluating website quality. In other words, this methodology contributes to the website evaluation body of knowledge by adding a new method to measure website quality. Applying Hybrid model between LWM and FAHP approach for website evaluation has resulted in significant acceleration of implementation, raised the overall effectiveness with respect to the underlying methodology and ultimately enabled more efficient process. As the area of the research covers the domain of decision support system, multi criteria decision analysis, web engineering, evaluation system, and fuzzy system, the proposed model also contributes to the development of research on these areas.

1.9 Organization of Thesis

This thesis consists of six chapters.

Chapter 1: Introduction

Chapter one, gives an overview to the thesis research topic. This includes background of study, thesis statement, problem statement, research objectives, research approach, research question, hypothesis, limitation and key assumptions, contribution of the study, and organization of thesis.

Chapter 2: Literature review

In chapter two, a review of relevant literature related with this research is presented. The chapter presents website evaluation studies, website evaluation tool studies, non-automated website evaluation tools, automated website evaluation tools, factors influencing quality standard, past research on Linear Weightage Model, Analytical Hierarchy Process, and Fuzzy Analytical Hierarchy Process. The last section tries to explain the past research about ranking methods and ranking evaluation.

Chapter 3: Research Method

This chapter begins with research approach and design, research setting, study sample data, sampling criteria, data collection, instrument and procedure, also provides further discussion and detail explanation about reliability and validity. This chapter also discusses about statistical tools that were used to evaluate and rank a website using nonparametric statistical methods, especially chi square method (Friedman two-way analysis of rank) and Dunn test.

Chapter 4: Hybrid Linear Fuzzy Evaluation Method

Chapter four begins with discussion and detail explanation about Hybrid Linear Fuzzy Evaluation Model, research approach for Hybrid Linear Fuzzy Model that consists of design of evaluation setup, evaluation design, conducting the evaluation, and ended with Hybrid Linear Fuzzy evaluation Process.

Chapter 5: Analysis on Asian Website

Chapter five describes the result of analysis data and website evaluation using Linear Weightage Model, Analytical Hierarchy Process, Fuzzy Analytical Hierarchy Process, and Hybrid Model for e-government, airlines website in Asian country and universities in Malaysia. In the end of the chapter we conduct the analysis result for four methods proposed using non-parametric statistic approach. In this chapter research findings for comparison among three sectors were also discussed.

Chapter 6: Research Conclusion and Recommendation

The last chapter, chapter eight, highlights the summary of this research; then, concludes the research and gives recommendations and direction for future research.

CHAPTER 2

LITERATURE REVIEW

2.1 Website Evaluation Studies

The website evaluation can be approached from users, website designer/administrator or both [21]. From the user's perspective on the website evaluation, most of the studies on website evaluation focus on the factors for successful website. These researches concentrate on the development of a website evaluation tool. These studies search for design and content elements of a successful website using the exploratory study. The main areas for the website quality evaluation are: function, usability, efficiency, and reliability [22]. Website Quality Evaluation Method (QEM) is used to test six university sites from different countries [22]. Website architecture is classified into content and design [23], and each classification is specified into evaluation criteria according to the characteristics and perception of a website. Website evaluation model is developed to test university website in Spain [24]. The model, called Web Assessment Index has content, accessibility, and navigation at the major criteria. Website usability, design, and performance is developed using metrics and conducted a user test by using the metrics [25]. Through three consecutive tests, it is concluded that the success of a website is dependent on the website download delay (speed of access and display rate), navigation (organization, arrangement, layout, and sequencing), content (amount and variety of product information), interactivity (customization and interactivity), and response (feedback options and FAQs) [25]. Another research evaluates the performance of the present TV3 (a television station in Malaysia) website, this research identifies the website viewer requirements and their corresponding importance level. The Quality Function Deployment (QFD) exercise provides the prioritized technical requirements [26].

From the website designer or administrator's perspective the website evaluation focuses on the web usability and accessibility. The website evaluation model is based on the study of the user-centered development and evaluation approach. This study attempts to develop the methodology and tool for the website quality evaluation from the information systems and software engineering perspectives. Best websites are selected by experts and users are investigated in order to identify the common characteristics of them [27, 28]. To empirically determine whether the content is more important than the graphics, Webby Award 2000 data set is examined to differentiate the factors of the best website from the factors of other website [28]. Webby Award evaluators use 5 specific criteria. The criteria include structure, content, navigation, visual design, functionality, and interactivity. Although content was found to be more important than graphics, evaluation criteria cannot be considered independently [28].

2.2 Website Evaluation Tool Studies

In this literature, the survey summarizes the usability evaluation method and proposes a new methodology [29]. This new methodology, called WebTango, is introduced in previous research [30]. The WebTango is a quality checker tool, which proposes to help non-professional designers develop their sites using quantitative measures of the navigational, informational, and graphical aspects of a website. The usability evaluation approach is used in the field of the software engineering and adapted to the website usability evaluation [31]. The comparison of automated evaluation tools using consistency, adequate feedback, situational navigation, efficient navigation, and flexibility as the characteristics of usability is explored in this research [31]. Website evaluation model based on the stages of a transaction in the electronic market is another approach [32]. The three stages of the electronic commerce are: information stage, contract stage, and payment stage. These three stages are used as an evaluation model to evaluate Swissair website, and assume that all of these three stages in the cyber community play an important role [32]. A website evaluation model is developed by applying the software quality model [33]. The test method is proposed to determine whether an automated website evaluation tool uses the proper rules [33, 34].

The validity of a set of website evaluation criteria is verified using the Webby Award 2000 data set [27]. Development and evaluation of a model called Web-based Quality Function Deployment (WQFD) is a model to link among Total Quality Management (TQM), Information Technology (IT) and Web Engineering (WE) [35]. The Quality of Service (QoS) in the internet and richer understanding of Internet accounting taxonomy, such as attributes, parameters, protocols, records, and metering tools need to be updated or replaced [36]. The website designer or administrator evaluates a website design during the website life cycle so that the website becomes a successful one.

In general, the website evaluation can be done through the preliminary review, conformance evaluation, or ongoing monitoring. Preliminary review identifies general problems of a website, and conformance evaluation discovers major violations of guidelines during the website design stage. Conformance evaluation generally checks which level of Web Content Accessibility Guidelines (WCAG, W3C, WCAG 2.0) a website satisfies [37]. Ongoing monitoring tries to make sure that a website maintains a certain level of WCAG. There are two methods of website evaluation: automated evaluation and non-automated evaluation.

2.2.1 Non-Automated Website Evaluation Tools

Non-automated website evaluation can be done in two ways. The first approach is user testing. This approach allows website user groups to evaluate a website and collects opinions about evaluation criteria and analyzes them. The second approach is a heuristic testing. This method asks experts to identify the critical aspects and to offer managerial implications in order for designers to get an effective website [38]. Heuristic testing is costly since it asks experts to conduct an analysis and develop reports after the analysis. Thus, it is difficult for many organizations to employ website professionals for the regular evaluation. Both user testing and heuristic are equally efficient and effective in addressing different categories of usability problems. In fact, even there are significant differences found between these two methods. It is suggested that the two methods are complimentary and should not be competing [39]. User testing is required to make the evaluation criteria and environment very clear. To assess subjective features like usability, user testing needs a standard procedure to produce a repetitive and comparable result. For the majority of websites, heuristic testing and user testing are not practical due to two reasons. Firstly, quick development in the web technology makes the use of sophisticated tools and complex interaction of a website possible. Secondly, the life cycle of a website is very short. The website improvement has to be done faster than other software maintenance due to market pressure and the lack of barrier in website development. These characteristics of the website evaluation methods make an automated website evaluation tool a compulsory, not a choice. Automated website evaluation tools play a bigger role in supplementing or substituting non-automated website evaluation tool. Automated website evaluation tools can be used to detect potential usability problems before the real operation of a website and to select the best design through the comparison of alternative designs. This decreases the economic and non-economic cost for conducting non-automated website evaluations. Automated website evaluation tools also allow the website designer or administrator to evaluate many websites and to detect potential problems as well as actual problems.

2.2.2 Automated Website Evaluation Tool

The function of an automated website evaluation tool mostly consists of capture, analysis and critique of website data [29]. Capture activity records usage data. Analysis activity identifies potential usability problems. Critique activity proposes improvements for potential problems. One research proposes an automated web site evaluation approach using machine learning to cope with ranking problems [40]. This approach develops a method to obtain evaluation function using Ranking Support Vector Machine and automatically rank web sites with the learned classifier. Web Accessibility Initiative of W3C classifies automated website evaluation tools into evaluation tool, repair tool, and transformation tool. Analysis tools of automated website tools are divided into six types [33], which identify potential quality problems of a website. The first type of tools analyzes server log file data to identify potential problems in usage patterns. The second type of tools helps check whether the HTML code of a website follows the proper coding practice from a usability point of view. The second type of tools is most broadly used in practice and some of the examples including A-Prompt, WatchFire Bobby [[41], UsableNet LIFT, W3C HTML Validator [42], NIST (National Institute of Standards and Technology), and WebA. WebA is an application designed through modules with the objective of covering all of the evaluation and analysis phases [43]. A-Prompt, WatchFire Bobby, UsableNet LIFT, W3C HTML Validator, and NIST examine HTML to evaluate a website's usability. These tools check the conformance of WCAG or Section 508 guidelines [44]. In 1998, U.S. government enforced the Federal Law Rehabilitation Act 508, which requires all electronic information technologies to be accessible by handicaped people. Therefore every website is required to provide accessibility to all and this guideline becomes an evaluation criterion of automated website evaluation tools. The third type of tools evaluates a website's usability by collecting data through a simulation of a hypothetical user experience. The fourth type of tools monitors consistency, availability, and performance of a web server by stressing the server (e.g. TOPAZ). The fifth type of tools is security testing (e.g. iTrustPage), this is an anti-phishing tool that does not rely completely on automation to detect phishing. Instead, iTrustPage relies on user input and external repositories of information to prevent users from filling out phishing Web forms [45], and the last tools is classifying a website after learning the classification criteria from other website (e.g. WebTango [28]).

Max of WebCriteria, an automated website evaluation tool evaluates the usability of a website by gathering primary statistical data through the simulation model. The primary evaluation criteria include accessibility, load time, and content. NetRaker, another evaluation tool, develops an online survey which permits users to respond to the survey while using the website. NetRaker does not verify HTML code or evaluate statistical data. Instead, it gathers and evaluates user survey data of a website.

2.3 Quality Standard

Every webpage design has their own characteristics and these characteristic have drawbacks and benefits. There is a mechanism for measuring the effects of the webpage component toward the performance and quality of website. This mechanism will measure size, component, and time needed by the client for downloading a website. The main factors that will influence the download time are page size (bytes), number and types of component, number of server from the accessed web. Research conducted by IBM can be used as a standard for performance measurement of quality [46]. Table 2.1 describes all of the criteria and quality standard that should be fulfilled by a website to be a good quality website. Tested factors consist of: average server response time, number of component per page, webpage loading time, and webpage size in byte. A standard international download time for this performance can be used as a reference to categorize the tested webpage. Automation of the testing for website quality is a new chance and a new method, and should be applied for testing the quality of website. For leveraging the effectiveness of the continuous quality improvement, developer community has been aggressive in attaining Total Quality Management (TQM) strategies by implementing ISO 9001:2000 standard [47].

Table 2.1 Standard of the website performance [46]

Tested Factor	Quality Standard
Average server response time	< 0.5 second
Number of component per page	< 20 objects
Webpage loading time	< 30 second
Webpage size in byte	< 64 Kbytes

It is very important to update website weekly and use some interactive methods to attract regular customers [48]. This is giving a lot of positive effects because visitors want to see a fresh material and by updating the site more often, it will ensure that the information is current. Research reveals that between 25% and 75% of online shopping carts are abandoned by customers [49]. The quality of the website is discovered as one of the top reasons to explain these phenomena. Additionally, conversion rates for website are still low and vary from 2% to 5% [50-52]. Other study reveals that consumers abandoned their shopping carts for some reasons: poor site navigation, hard-to-find shopping carts, and time-consuming checkouts [49]. According to this research, it is obvious that many websites are not well customized to consumer's decision-making process. Consumers find it complicated to buy or find information online. In the best case scenario, they will keep trying and eventually find what they are looking for. In the worst case scenario, they will exit the website and find another service. In both cases, it may lead to frustration on the part of consumers and influence their perception of the website and consequently will have an impact toward brand image. The quality of website lies in its capability to generate the needed information with the least amount of frustration and dead-ends for the consumer side [53]. This assumption based on the fact that customers seek to become loyal to a website that make possible for them to work efficiently. In turn, this should give some guidances to website developer, how to design more usable website. There are many ways to measure the efficiency of a website. Conventional measures include the number of visitors attracted to a site, the number of pages read, the number of unique visitors, the conversion rate of consumers along with sales generated by the website. Closely related to the ergonomics factor of a website, various approaches have also been proposed [54]. Usability is defined as the "extent to which a computer system enables users, in the context of use, to accomplish specified objectives effectively and efficiently while promoting feelings of satisfaction" [29]. Usability is also defined as "how well and how easily a user, without formal training, can interact with an information system of a website" [55]. While there is no general accepted definition of usability, most definitions recommend that usability is a multidimensional factor that includes at least the two following dimensions: ease of use of the website and quality of information in order to effectively perform an online transaction and browsing.

Content of the website can determine whether the potential customer will stay on a website or leave the sites without completing their intended transaction [56]. Even though many companies are conscious that a well defined content of the website can contribute to the building of a good brand image which leads to improve the transaction, some of the companies still keep on developing an information dump in an effort to create an impressive content [57]. The majority of content should be free, because free content is a valuable feature [58]. But free content is likely to decrease for a commercial web as the web becomes more mature. The Wall Street Journal, Business Week, and others provide free information for months to attract customer then start to charge for it. Prospective customers are more likely to buy when website owners make sure that the free service provided is closely correlated to what is being sold [59]. Provide contact information in every page is another method to improve the quality of the website. A site without information of a person or address to contact may drive business overlook and it is recommended that website should include useful resources and tools [60]. Installing 'mail-to' links on every page [61], combining with a method which is displaying and posting threaded on-line discussions, on-line chat, message board or even interactions via real-time are other approaches [62]. A website should be evaluated at how well it markets their products and services, and also how well it keeps the customer stay in focus. During designing the content of website, basically, there are three goals that should be pursued: create awareness, generate traffic, and promote and make sales. Recommendations regarding this topic are: promote the website by listing keywords and then submitting the page to the important search engine like Yahoo and HotBot [59], create a page for each product and register each page with a search engine to improve the page rank, and arrange reciprocal links with other business websites.

Attract more visitors to a website and retain them to stay longer to browse and use the services or even buy the products, are goals that a website owner wishes to achieve. These goals will be hard to materialize if the system has poor performance, for example, with low response time to the user requests [63]. From the engineering and technical side, measuring website response time and understanding what is the contributing factors to a low response time are very important tasks. It is important to decompose response time into its constituting components in turn to provide a comprehensive analysis of response time. The problems related to the delayed response times are influenced by many factors, such as bottlenecks due to the route of a large amounts of information from the website to the user, the number of users, the server's connection to the Internet, and supported hardware for the server [64]. All of these problems have a cumulative effect on the speed of response time on the Internet and website performance and handling these issues requires considerable effort, time and money. In experimental computer science, analysis of performance can be thought in terms of measurement, interpretation, and communication of a computer system's speed or capacity [65]. This is the view adopted in this thesis, where the concept of performance is considered to refer to the speed with which a website serves and responds to its users. The speed, named as response time, is defined as the time elapsed from the user sends a request to a webpage until the intended page is displayed [66]. Response time is one of the performance issues in the web. Some studies have examined the users' tolerance of delay in webpage download time. User tolerance for delay ranging from 3 to 20 seconds [67, 68], and 10 seconds believes to be the general threshold for staying in a website [53]. According to a survey, page loading speed as part of performance of website is the number one complaint of web users (77%) [69]. One of the studies investigates the effect of webpage download delays on user performance and frustration. The results of the research indicate a minor effect of delay on lostness, with observed user being less lost in the 60 seconds delay conditions than the 1 or 30 seconds delay conditions [70]. Frustration is created by longer delay times, with the 60 and 30 seconds delay time which are significantly more frustrating than the 1 second delays. The quantity of tasks completed is also lower for the longer delay situations. Most customers do not want to wait for a seemingly endless page to load. Instead, they can search for other sites to find other services. Therefore, large, pretty graphic files and good animation may give negative impacts to the e-business service in terms of lost opportunity business [71].

Based on academic literature, several researchers have already defined the concept of stickiness. Stickiness can be defined from the user's side as repetitive visits and uses a preferred website because of a deeply held commitment to reuse the website consistently in the future, despite situational influences and advertising efforts that have the potential to cause switching behavior [72]. Stickiness is a word used to explain website ability to attract and retain users once they get there [73]. An ability of the company to retain users and drive them further into a site is another definition of stickiness [74]. Browsing a website in a user's normal activity or embedding a website within a user's routine, which is similar to the notion of continuous use, is another approach definition of stickiness [75]. When trying to compare these various definitions, two aspects appear to be the most important for stickiness: the duration and frequency of a user's visit. A site is categorized sticky when a user often visits a site or visits it for a long time. Of the definitions mentioned above, one researcher also stresses that stickiness drives a visitor deeper into a site. However, probably this is not included in the definition aspect of stickiness. This issue of stickiness is about increasing the time a visitor spends on a site within a specific time-period. Increasing the depth of a user's visit is only a means of achieving this. Stickiness is a positive characteristic of a website that maximizes duration, frequency and depth of a user's visit that will drive loyalty and loyalty is a key for success.

More and more companies are aware that the website design is becoming a very important issue for them [76]. Furthermore, the design of the website is able to help people browsing and exploring information efficiently and this factor will add the company's ability to achieve the profit [77]. Another feature that is also able to increase sales and therefore boosting company's revenue and profit is to have an easy to use website [78]. This is by far the most commonly prescribed recommendation in the literature, an opinion that competitive advantage is just another benefit that can be achieved by paying a lot of attention and having a well designed website [79]. There is a tendency that business website are ambiguous, one has no clue as to what the business is really about, what the company sells, or what its services should be provided. If icons are used in the webpage, it is wise to utilize the most important subjects. All the parts of the page: headings, subheadings, and text should contain only about one-half the words one would normally use in a paper document. Most of the Internet users, around 79 percent, only scan pages without spending the time to read what they find. The scan rate is high because it takes 25 percent longer to read from the computer screen than printing document [80]. Web users scan webpage rather than reading every word for two main reasons: reading from computer screens is tiring and they do not have time to read long-winded pages because they have a lot of things to do. The rewritten website scored

159% higher than the original in measured usability, which was measured in terms of task time, task errors, and memory [81]. Research indicates that for long webpage, scrolling down the computer screen three or more pages can cause a disorienting effect, one or two screens of information are enough for the average user [82]. Consistency is a requirement of any webpage. The general appearance and number of pages should remain consistent, an example for the consistency are by using the same icon as a metaphor for different concepts and make the same type of icon clickable in one place but not in another [83]. It is also important to add to this list are proper spelling and grammar [84]. There are five major factors that can be influence a website design and are displayed in Table 2.2 [56].

Table 2.2 Major Categories of Website Design [56]

Category	Number of citations	Percentage
Page loading	33	19.3
Business content	53	31.0
Navigation efficiency	29	17.0
Security	11	6.4
Marketing/customer focus	45	26.3

When creating a webpage that consists of HTML page text, background image, logo, navigation bar, navigation buttons, and award logos, it is recommended to limit total graphics and text for a single webpage to 60 KB [85]. A rule of thumb is to allocate about 5 KB (HTML page text), 5 KB (background image), 16 KB (logo), 8 KB (navigation bar), 16 KB (navigation button), and 10 KB (award logo) respectively. Some graphics are needed and necessary where it is crucial to display the product or service. When a designer thinks it is necessary to create animation inside webpage, it should be made to stop emerging after ten seconds to allow the user to scroll it off from display, because animation is one of the slow page loading factors [86]. Good webpage design will have information content which account for 80% of the site [87]. By allowing text to load first, followed by graphics and providing an option to load text only will increase speed and allow better choice variation of browsers [88]. This allows the user to read the content while the graphics are loading.

Website traffic is probably one of the most significant performance indicators for Internet service. When the website traffic has started to increase, the website popularity also increased, and traffic is a prerequisite for sparking on-line sales, and it provides a foundation for acquiring revenue from web-based business [89]. For all these reasons, many organizations create strategies to generate more website traffic [90]. Moreover, website updates are increasingly being evaluated in terms of the traffic changes that they induce [91]. The factor that influence website traffic is certainly not well discovered [92]. Indeed, obtaining and retaining visitors on a corporate website are extremely important as they have taken an interest and have built an amount of trust in the site and be one of the most elusive problems facing the average Internet firm with regular visitors

2.4 Linear Weightage Model

This model is very easy and mostly depending upon decision maker's judgment as they have to assign weights to the criteria that involve in decision-making process. First of all decision maker has to identify criteria that are involved in the certain process before performing any other steps. Decision makers should assigned weight to each individual criterion in order to determine the relative importance of each one. These weights play a vital role in decision-making process and extremely affect the final decision. After identifying all the criteria related to website selection decision, decision maker has to determine threshold for each criterion. In fact, threshold can be divided into two types, i.e. maximum and minimum. To establish a threshold to criterion, decision maker should classify all criteria into two groups. The first group is known as "larger is better" while the other one is known as "smaller is better".

In the linear weighted attribute model various functional relationships had been proposed [93, 94]. One of the Linear Weightage Models is maximax. In most cases there are some criteria considered as more important than others, such as load time, response time, traffic, page rank and broken link. The load time, response time, markup validation number error, and broken link can be categorized as "smaller is better" and the threshold for this type of criteria must be maximum. On the other hand, other criteria can be considered as "larger is better" such as traffic, page rank, frequency of update and design optimization where threshold must be minimum. Once the attribute is considered as maximum type of threshold, formula 1 [95] should be used.

$$ws_{max} = \frac{\max - \text{sample data}}{\max - \min} \tag{2.1}$$

$$ws_{max} = \frac{\text{sample data} - \min}{\max - \min} \tag{2.2}$$

where

ws_{max} = specific sample data value that has maximum type of threshold with respect to a particular attribute/criterion.

ws_{min} = specific sample data value that has minimum type of threshold with respect to a particular attribute/criterion.

sample data = specific sample data that is considered at the time.

max = maximum value of particular attribute/criteria among all atributes

min = minimum value of the same attribute among the whole atributes

The idea of using formula 1 and formula 2 is extremely valuable because they provide a method that enables the comparisons among decision criteria. Usually decision criteria have different units of measure so any comparisons among those criteria are not logically acceptable. By using the data normalization concept, which is represented in formula 1 and formula 2, all the criteria will be having weights instead of variety of measurement units and then the comparisons can simply be made. When all values of the criteria matrix are calculated, series of calculations should be achieved by multiplying weights W_i of criteria by the whole values X_i within the matrix. The total score should also be calculated using formula 2.3 for each specific website which represents the specific website' scores. The final decision table includes a total score for each website and the one who gains the highest score is recommended as the best website overall.

$$\text{Total Score} = \sum W_i X_i / \sum W_i \tag{2.3}$$

2.5 Analytical Hierarchy Process

Analytic Hierarchy Process (AHP) was originally designed by [96] to solve complicated multi-criteria decision problem, then this method is redesign that allows decision makers to model a complex problem in a hierarchical structure which consists of the goal, objectives (criteria), sub-objectives, and alternatives [97]. In AHP the problems are usually presented in a hierarchical structure and the decision maker is guided throughout a subsequent series of pairwise comparisons to express the relative strength of the elements in the hierarchy. In general the hierarchy structure encompasses of three levels, where the top level represents the goal, and the lowest level has the alternatives (in this thesis: website under consideration). The intermediate level contains the criteria under which each website is evaluated. Besides that, AHP is appropriate whenever a target is obviously declared and a set of relevant criteria and alternatives are offered [98]. Rather than prescribing a correct decision, the AHP helps the decision makers discover the one that best suits their needs and their comprehension of the problem, this technique is based on mathematics and psychology. The AHP technique offers a comprehensive and rational framework for representing and quantifying its elements, structuring a decision problem, connecting those elements to overall objectives, and evaluating alternative solutions. It is used broadly in a wide variety of decision situations and refined in fields such as business, government, industry, healthcare, and education. Software (commercial and free) is available to assist in using the process. AHP consists of three stages of problem-solving: principles of decomposition, comparative judgment, and priority synthesis [97]. The AHP methodology involves the decomposition of a complex problem into a multi-level hierarchical structure of characteristics and criteria to present the problem. The highest level of the hierarchy is the goal to be achieved in the decision problem, the middle levels contain the criteria that affect the goal and the lowest level represents decision alternatives which are to be evaluated in terms of the criteria in the upper levels. After the process creating hierarchy is built, the decision makers systematically evaluate its various elements by comparing them to one another two at a time. Comparative judgment is a pairwise comparison of the factors at the same level for measuring their comparative contribution to the overall objective, these judgments carried out through pairwise comparisons, are assigned numerical values. The decision makers can utilize real data about the elements, or they can use their own judgments about the importance of the element. It is the fundamental nature of the AHP technique that human judgments can be used in performing the evaluations. The AHP changes these evaluations process to numerical values that can be processed and compared over the entire range of the problem. This capability is one of AHP positive point which distinguishes from other decision-making techniques. Finally, in the synthesis of priority stage, it is done by computing a composite weight for each alternative, based on preferences identified through the comparison matrix. These numerical values represent the alternatives' relative ability to achieve the decision goal, so they allow an uncomplicated consideration of the various courses of action. In this thesis, based on the value of composite weight process, then relative priority of each alternative can be discovered. The final score obtained for each website across each criterion was calculated by multiplying the weight of each criterion with the weight of each website. Website which has the highest score is suggested as the best website and decision maker may consider that one as the best decision choice.

AHP has been proposed for determining the best website to support researcher through the decision-making activity [99], which aims to determine the best website among pool of e-commerece website. Generally, AHP has the following four steps:

1. Define an unstructured problem and determine its goal.
2. Structure the hierarchy from the top (objectives from a decision-maker's viewpoint) through intermediate levels (criteria on which subsequent levels depend) to the

lowest level, which typically contains a list of alternatives. Employ a pair-wise comparison approach. Fundamental scale for pair-wise comparisons developed to solve this problem [96]. The Fundamental Scale for judgments is shown in Table 2.3.

Table 2.3 The Fundamental Scale for Making Judgments [96]

1	Equal
2	Between Equal and Moderate
3	Moderate
4	Between Moderate and Strong
5	Strong
6	Between Strong and Very Strong
7	Very Strong
8	Between Very Strong and Extreme
9	Extreme
	Decimal judgments, such as 3.5, are allowed for fine tuning, and judgments greater than 9 may be entered, though it is suggested that they be avoided.

When a number greater than 9 is suggested by the inconsistency checking, this means that the elements you have grouped together are too disparate. We may input a number greater than 9, but perhaps you should re-organize your structure so that such a comparison is not required. It will do no great damage to allow numbers up to 12 or 13, but you should not go much beyond that.

3. The pair-wise comparison matrix A, in which the element a_{ij} of the matrix is the relative importance of the i^{th} factor with respect to the j^{th} factor, could be calculated as

$$A = \lfloor A_{ij} \rfloor = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix} \tag{2.4}$$

4. There are $n(n$-1)/judgments required for developing the set of matrices in step 3. Reciprocals are automatically assigned to each pair-wise comparison, where n is the matrix size.

Based on pairwise comparison judgments, AHP is aimed at integrating both criteria importance and alternative preference measures into a single overall score for ranking decision alternatives [100]. The AHP model provides a framework to assist managers view complex relationships in the problem and helps the decision maker to judge whether the evaluation criteria are of the same order of magnitude, so the decision maker can compare such identical alternatives accurately. A sensitivity analysis is followed to investigate how criteria weighting changes can affect the changes in the rankings of alternatives. The consistency of the results is measured using a consistency ratio (CR). A consistency ratio below than 10% is considered valid to interpret the results [101]. AHP has been effectively used by researchers to enhance the evaluation, choice, and resource allocation phase of decision-making. For that reasons, AHP is considered as a method that effectively measures the impact of factors determining possible outcomes and also predicts outcomes. The predictions are useful inputs for evaluating alternative solutions of action. AHP has been applied successfully to a wide variety of decision problems such as project selection [102], car purchasing [103], diagnostic technology [101], manufacturing systems [104], telecommunication systems vendors [105], software selection [106], but has not been widely applied to the quality of website. Only a few studies (e.g., [107]) have been conducted.

2.6 FAHP

In 1965 Lotfi A. Zadeh introduced a new approach to a precise theory of approximation and vagueness based on generalization of standard set theory to fuzzy sets [108]. Fuzzy sets and fuzzy logic are powerful mathematical tools for modeling: nature and humanity, uncertain systems in industry, and facilitators for common-sense reasoning in decision-making in the absence of complete and precise information. Their role is significant when applied to complex phenomena not easily described by traditional mathematical methods, especially when the goal is to find a good approximate solution [109]. The values of fuzzy logic are ranging from 0 to 1 for showing the membership of the objects in a fuzzy set. Complete non-membership is represented by 0, and complete membership as 1. Values between 0 and 1 represent intermediate degrees of membership. A fuzzy approach for tackling qualitative multi-criteria analysis problems is approached by using a simple and straightforward manner [110]. The basic theory of the triangular fuzzy number and the comparison formulation of triangular fuzzy number's size are discovered, on this basis, a practical example was introduced on petroleum prospecting case [111]. The fuzzy ratios of relative importance and consistency, allowing certain tolerance deviation, were formulated as constraints on the membership values of the local priorities [112].

Fuzzy numbers are the special classes of fuzzy quantities. A fuzzy number is a fuzzy quantity *M* that represents a generalization of a real number *r*. Intuitively, *M*(*x*), should be a measure of how better *M*(*x*) "approximates" *r*. A fuzzy number *M* is a convex normalized fuzzy set. A fuzzy number is characterized by a given interval of real numbers, each with a grade of membership between 0 and 1 [110]. A triangular fuzzy number (TFN), M is shown in Figure 2.1.

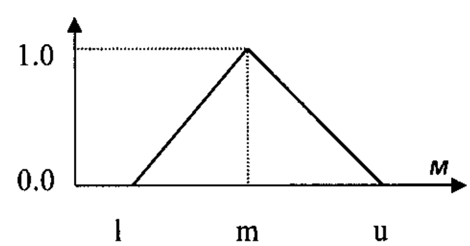

Figure 2.1 A Triangular fuzzy number, $\tilde{M}$

Triangular fuzzy numbers are described by three real numbers, expressed as (*l,m,u*). The parameters *l, m,* and *u* indicate the smallest possible value, the most promising value, and the largest possible value respectively that describe a fuzzy event. Their membership functions are described as [110];

$$\mu(x/\tilde{M}) = \begin{cases} 0, & x < l \\ (x-l)/(m-l), & l \le x \le m \\ (u-x)/(u-m), & m \le x \le u \\ 0, & x > u \end{cases} \tag{2.5}$$

In applications it is easy to work with TFNs because of their simple computation, and they are useful in promoting representation and information processing in a fuzzy environment. In this research, implementation of TFNs in the Fuzzy-AHP is adopted. The Fuzzy-AHP methodology extends Saaty's AHP by combining it with the fuzzy set theory. In the Fuzzy-AHP, fuzzy ratio scales are used to indicate the relative strength of the factors in the corresponding criteria, therefore mixing of fuzzy set and AHP provides a much better and more exact representation of relationship between criteria and alternatives. Since fuzziness and vagueness are common characteristics in many decision-making problems, a Fuzzy-AHP (FAHP) method should be able to tolerate vagueness or ambiguity [113]. The final scores of alternatives are also represented by fuzzy numbers. The optimum alternative is obtained by ranking the fuzzy numbers using special algebra operators. Triangular fuzzy numbers were used with pair-wise comparisons in order to compute the weights of importance of the decision criteria [114, 115]. Thus, all elements in the judgment matrix and weight vectors are represented by triangular fuzzy numbers. Trapezoidal fuzzy numbers is used to express the decision maker's evaluation on alternatives with respect to each criterion [116]. Prioritized estimation is accomplished by using the extend analysis method for estimating the synthetic degree value [117]. This is a new approach for handling Fuzzy-AHP with the use of triangular fuzzy numbers for pair-wise comparison scale of Fuzzy-AHP.

Dealing with fuzzy numbers is a must when using fuzzy sets in applications. In this section, three important operations used in this study are illustrated [118]. If two TFNs A and B by the triplets A = (l_1, m_1, u_1) and B = (l_2, m_2, u_2), then

Addition: $A + B = (l_1,m_1,u_1) + (l_2,m_2,u_2) = (l_1+l_2,\ m_1+m_2,\ u_1+u_2)$ (2.6)

Multiplication: $A.B = A.B = (l_1,m_1,u_1) \,.\, (l_2,m_2,u_2) = (l_1.l_2,\ m_1.m_2,\ u_1.u_2)$ (2.7)

Inverse: $(l_1,m_1,u_1)^1 \approx (1/u_1, 1/m_1, 1/l_1)$ (2.8)

In this study the extent FAHP is utilized, which was originally introduced by Chang (1996). Let $x = \{x_1, x_2, x_3, \ldots, x_n\}$ and object set, and $g = \{g_1, g_2, g_3, \ldots, g_n\}$ be a goal set. According to the method of Chang's extent analysis, each object is taken and extent analysis for each goal performed respectively. Therefore, m extent analysis values for each object can be obtained, with the following signs: $M_{gi}^1, M_{gi}^2, \ldots, M_{gi}^m$

$i = 1, 2, \ldots, n$

where M_{gi}^j ($j = 1, 2, \ldots, m$) all are TFNs. The steps of Chang's extent analysis can be given as in the following [117]:

Step 1: The value of fuzzy synthetic extent with respect to the i th object is defined as

$$S_i = \sum_{j=1}^{m} M_{gi}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1} \tag{2.9}$$

To obtain $\sum_{j=1}^{m} M_{gi}^j$, perform the fuzzy addition operation of m extent analysis values for a particular matrix such as:

$$\sum_{j=1}^{m} M_{gi}^j = \left[\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right] \tag{2.10}$$

and to obtain $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1}$ perform the fuzzy addition operation of M_{gi}^j ($j=1,2,\ldots,m$) values such as:

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1} = \left[\sum_{j=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right] \qquad 2.11)$$

and then compute the inverse of the vector above, such that:

$$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} = \left[1/\sum_{j=1}^{n} l_i, 1/\sum_{i=1}^{n} m_i, 1/\sum_{i=1}^{n} l_i\right] \quad . \tag{2.12}$$

Step 2: As $\widetilde{M} = (l_1,m_1,u_1)$ and $\widetilde{M} = (l_2,m_2,u_2)$ are two triangular fuzzy numbers, the degree of possibility of $M_2 = (l_2,m_2,u_2) \geq M_1 = (l_1,m_1,u_1)$ defined as:

$$V(\widetilde{M}_2 \geq \widetilde{M}_1) = \sup_{y \geq x}\left[\min(\mu_{\widetilde{M}}(x), \mu_{\widetilde{M}}(y)\right] \tag{2.13}$$

and can be equivalently expressed as follows:

$$V(\widetilde{M}_2 \geq \widetilde{M}_1) = hgt(\widetilde{M}_1 \cap \widetilde{M}_2) = \mu_{M_2}(d) \tag{2.14}$$

$$= \begin{cases} 1, & m_2 \geq m_1 \\ 0, & if\ l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{otherwise} \end{cases} \tag{2.15}$$

Step 3: The degree possibility for a convex fuzzy number to be greater than k convex fuzzy M_i ($i = 1,2,k$) numbers can be defined by

$V(M \geq M_1, M_2, \ldots M_k) \quad = V[(M \geq M_1)$ and $(M \geq M_2)$ and $(M \geq M_K)]$

$$= \min V(M \geq M_i), I = 1,2,\ldots,k \tag{2.16}$$

Assume that $d(A_i) = \min V(S_i \geq S_k)$ for $k = 1,2,\ldots,n$; $k \neq 1$. Then the weight vector is given by

$$W' = (d'(A_1), d'(A_2),\ldots,d'(A_n))^T \tag{2.17}$$

where A_i = (i=1,2……n) are n elements

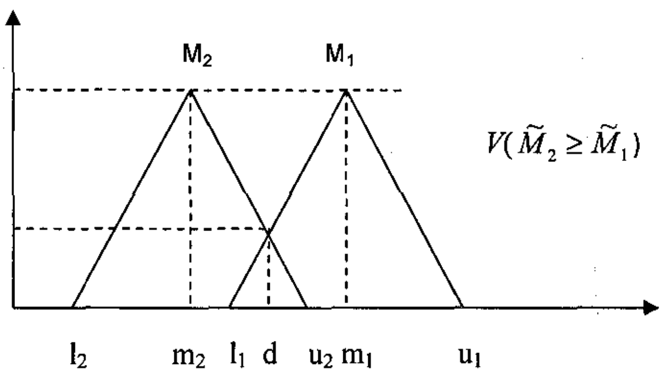

Figure 2.2 The intersection between M_1 and M_2 (Kahraman et al., 2004)

Figure 2.2 illustrates Eq. (11) where d is the ordinate of the highest intersection point D between μ_{M_1} and μ_{M_2} to compare M_1 and M_2, both the values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$ are needed.

Step 4: Via normalization, the normalized weight vectors are

$$W = (d(A_1), d(A_2), \ldots, d(A_n))^T \qquad 2.18)$$

where W is a non-fuzzy number.

FAHP has been applied successfully to a wide variety of decision problems such as project selection [119]. This problem focused on the constraints that have to be considered within Fuzzy-AHP. A model for providing a framework for an organization to select the global supplier by considering risk factors is another problem trying to be solved by using Fuzzy-AHP [120]. They used fuzzy extended Analytic Hierarchy Process in the selection of global supplier in the current business scenario. The economic part of the decision process had been developed by fuzzy replacement analysis. Non-economic factors and financial figures had been combined by using a Fuzzy-AHP approach. Other researchers used the Fuzzy-AHP for comparing catering firms in Turkey [121], for the application and development of a capital investment study by trying to select the type of fleet car to be adopted by a car rental company (Tang and

Beynon (2005)). Fuzzy replacement analysis and Analytic Hierarchy Process were also being implemented in the selection of operating system [122]. An analytical tool was developed based on FAHP to select the best software providing the most customer satisfaction [123].

2.7 Ranking Method

Ranking items of a given set has been widely studied in the literature. In classical Information Retrieval systems, results ranking was based mainly on term frequency and verse document frequency (it can be used to measure the term frequency of a word in a document relative to the entire collection of document) [124]. Most often, each item is assigned a score which denotes how early the item appears in the list, and the items are arranged by sorting the scores in descending order. Several different scoring systems may have the same ranking of the items. Comparing such scoring schemes is generally conducted by comparing the induced ranking on the set of items [125]. To test whether the ranking methods have significantly different performance, a research can use a distribution-free hypothesis test on the difference between more than two population means, such as the Friedman's test [126]. In general, the optimal test may rely on the number of experimental methods being compared. For instance, both Friedman and ANOVA have different forms where there are only two methods [127], and that there is a more powerful alternative to Friedman test for cases when three or four methods are being compared [128]. The "No free lunch" theorem [129] demonstrates that it is not possible to find one algorithm being better in behaviour for any problem. On the other hand, knowing that working with different degrees of knowledge about the problem which can be solved, and that it is not the same to work without knowledge about the problem (hypothesis of the "no free lunch" theorem) than to work with partial knowledge about the problem, knowledge that allows us to design algorithms with specific characteristics which can make them more suitable for the solution of the problem. Once situated in this field, the partial knowledge of the problem and the necessity of having disposals of algorithms for its solution, the question about deciding when an algorithm is better than another is suggested. In the case of the use of evolutionary algorithms, the later may be done attending to the efficiency and/or effectiveness criteria. When theoretical results are not available in order to allow the comparison of the behaviour of the algorithms, focus is on the analysis of empirical results.

During several years, there has been a growing interest in the analysis of experiments in the field of evolutionary algorithms. The work of Hooker is pioneer in this line and it shows an interesting study on what must be done and not be done when suggesting the analysis of the behaviour of a metaheuristic about a problem [130]. In relation to the analysis of experiments, there are three types of works: the study and design of test problems, experimental design and the statistical analysis of experiments. A number of researchers have focused their interest in the design of test problems which could be appropriate to do a comparative study among the algorithms. Focusing our attention to find the best solution deals with optimization problems, which will be used in this thesis, the pioneer papers of Whitley and co-authors for the design of complex test functions for continuous optimization will be pointed [131-133]. In the same way, there are papers that present test cases for different types of problems. Centred on the statistical analysis of the results, if the published papers in specialized journals are analyzed, there are majority of articles making comparison of results based on average values of a set of executions over a concrete case. In proportion, a little set of works use statistical procedures in order to compare results, although their usage is recently growing and it is being suggested as a need for many reviewers. When finding statistical studies, they are usually based on the average and variance by using parametric tests (ANOVA, t-test) [134-136]. Recently, non-parametric statistical procedures have been considered for being used in analysis of results [137, 138]. A similar situation can be found in the machine learning community [139]. The experimental design consists of a set of techniques which comprise methodologies for adjusting the parameters of the algorithms depending on the settings used and results obtained [140, 141].

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

As the organizations have become more conscious in their use of website, the website has also become more complex. For most organizations especially commercial organization, the website is an important channel to communicate with the users, and therefore the quality of the website design is decisive. During the past decade user-centered design has grown to be a central and important part of the development process. There is, however, no consensus definition of a website quality, which remains a complex concept with multiple dimensions. In this research methodology chapter, multiple dimensions of website quality and procedure to evaluate the quality are described. The study design and sample are also explained. The instruments used to collect data, including methods implemented to test the consistency and to get the best method are described.

3.2 Research Approach and Design

Quantitative research is a formal, objective, systematic process to describe and test relationship and to examine cause and effect of interaction among variables [142]. Survey may be used for descriptive, explanatory and exploratory research. A descriptive survey design was used in this thesis, and a survey used to collect original data. The relevance of the problem has been addressed in the introduction and the previous section. Summarised, our research purpose have three aims: 1) to determine the factors influence website quality 2) to find available tools to generate an appraisal of quality and 3) to develop a new methodology for determining and evaluating the best Asian website based on many criteria of website quality consist of three sectors: e-government, airlines, and Malaysian university, namely to increase efficiency and reliability of the evaluation process. If the process can be executed with lower cost but with increased reliability, more organizations and companies could afford to do it, thus increasing the overall quality of website.

Identification of several formal heuristic frameworks of usability evaluation of a website was first done to provide the foundation of the application. The development process was iterative. Concept is outlined based on literature review and have a result that the quality of website consists of eleven criteria. In previous research, content has been identified as the most important characteristics which contribute to usability of website, and as one of the key reasons that users return to website. Measures such as ease of use and useful content of the website are widely used as evaluation criteria. In the research literature, there was a general agreement that the most important aspect of website evaluation is usability, but there were also other important attributes, including such criteria as specific content requirements and W3C compliance (Web Assessment Index). The International Organization for Standardization (ISO) definition of usability is "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" [143]. The two main approaches used were usability testing and expert evaluations. Usability testing usually involves a number of representative users to imitate real use of a website or application. Expert (heuristic) evaluations usually build on a framework of guidelines or criteria which are considered relevant for all website or a subset of them [64]. While usability testing is subjective, expert evaluation aim is an objective assessment, in the sense that the assessment in principle could be replicated. An initiative has been launched to speed up and/or automate this evaluation process. The approaches include:

- Manual guidelines (i.e. heuristics and theoretical framework)
- Online guides (heuristic online guides, which may include automatic testing)
- Automatic tests (i.e. W3C compliance, download time and searching for "dead links")

Some attributes can be partially automated evaluation using software tools to acquire information on site file types and links, discover when a site was last updated, number of links, count broken link and so on. Examples of these tools include

Watchfire's Linkbot (http://www.watchfire.com), and Bobby (Center for Applied Special Technology, http://www.cast.org). These tools signal instructions incompatible with a certain HTML version or browser and determine the degree of accessibility for disabled users. Some JavaScript routines were used to obtain useful data rapidly when analyzing update of a site. The details of website quality assessment process, which consists of the following eight steps in figure 3.1:

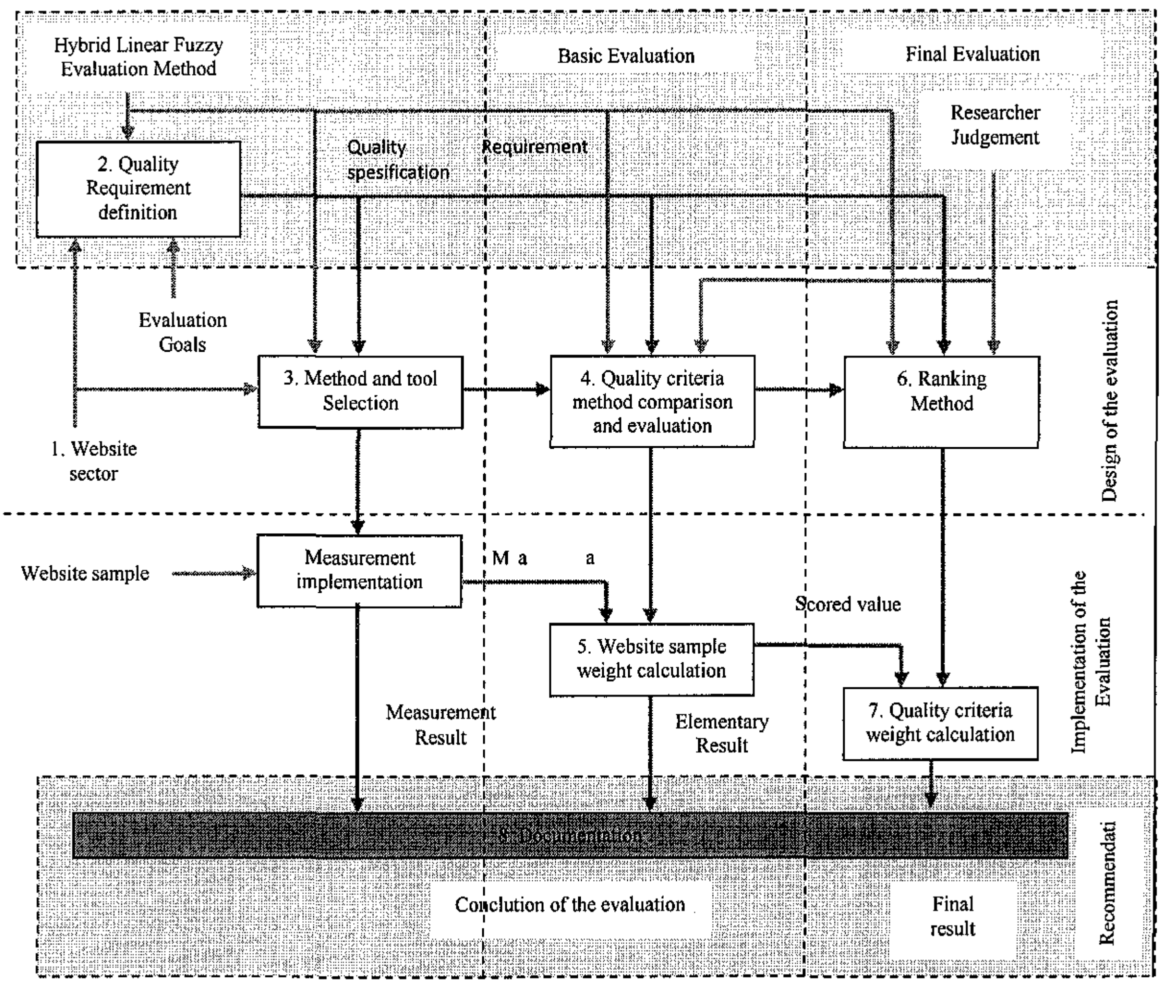

Figure 3.3 Quality Assesment Design

The details of website quality assessment process, which consists of the following eight steps:

Step 1: Selecting a site or a set of candidate sites to evaluate or compare

Step 2: Specifying evaluation goals and defining the website quality characteristics and attributes requirement: reliability (time), structural, content/search engine friendliness, latency, stickiness, design, performance, and efficiency.

Step 3: Defining a method and assigning tools, which are provided in the Internet for collecting data from Asian website (e-government, airlines, and Malaysian university) and data related with quality of website.

Step 4: Defining the evaluation method

Step 5: Assigning weight, which are obtained from literature review and researcher judgment.

Step 6: For all the criteria, we use four methods to evaluate website quality (LinearWeightage Model, Analytical Hierarchy Process, Fuzzy Analytical Hierarchy Process, and Hybrid Model).

Step 7: Determining website score for evaluation and comparison and analyze of website quality by ranking it through consistency of its result.

Step 8: Analyzing, assessing, and determining the best multicriteria decision-making method applied in website evaluation.

3.3 Sampling Unit

The study was conducted at Universiti Teknologi PETRONAS Malaysia, This data of quality website from Asian websites (e-government, airlines, and Malaysia university) were taken more than 30 trails on various occasions on different period of time. This data has been taken from 3/29/2009 until 5/20/2009. All of the data for this research was taken using PC with specification: Processor Pentium Mobile 740, using Local Area Network Internet connection with average bandwidth 60 kbps.

3.4 The study sample

This research examined the national e-government and airlines website of a selected number of countries in Asia: Singapore, Korean, Japan, Hongkong and Malaysia and also five Malaysian universities. The e-government, airlines, and university website were not randomly selected, but a careful process was undertaken. Rather than selecting any generic Asian website this research attempted to evaluate the e-government website that was considered to be leaders in the area of information technology implementation based on result of a survey conducted by Economist Intelligent Unit for Country E-readiness in 2009 and United Nation for e-government in 2008, pingdom and skytrax company for Airlines website, and Webometric for university. Given the intensive nature of the website evaluation, a relatively small sample size (about 15 subjects) is often sufficient in eliciting a comprehensive list of constructs for the purpose of a study (Ginsberg, 1989, Dunn et al., 1986, Tan and Hunter, 2002). By doing such approach it was felt that measures of 'best practices' could emerge because this entire sample was among the best website.

3.5 Sampling criteria

Since it was generally not practical to test all pages of a site (from within the scope) against all evaluation criteria using the current guidelines, a subset or "sample" of pages was identified. The pages were sampled from within the scope. Every tested website was represented by index page that usually appeared as a website address page.

3.6 Data Collection

This research consisted of several stages, started with problem identification followed by research procedure and data collection, and ended with analysis of data. This research examined the e-government, airlines, and Malaysian university website of a selected number of countries in Asia: Singapore, Korean, Japan, Hongkong, and Malaysia. The primary target audience for this normative document consisted of professional evaluators of website. The secondary target audience was defined as policy makers and managers who want to use the web guidelines as a basis for procurement. The tertiary target audience was defined as web designers and developers who want to validate their website against a quality model.

3.6.1 Data Collection Instrument

In order to achieve the above-mentioned goals, we needed an empirical design that would allow us to account for individual variability, situational variability and register variability by employing the quantitative study. In order to ensure reliability and credibility of this study, it is decided that the data was to be obtained by a multiple prescriptive test.

A number of widely available web diagnostic tools online was used, thus widely available website performance tool and webpage speed analyzer online service were used (http://www.websiteoptimization.com). List of performance measured and reported by this service include total size, number of objects (HTML, images, CSS, scripts), and download times on a 56.6 kbps connection. Another available webpage online tool that was used for testing quality was: http://validator.w3.org/checklink which was utilised in order to monitor broken links in the HTML code of the portals. The W3C's HTML validator website (http://validator.w3.org) was used to validate the HTML code of the portals. This standard was set up by the World Wide Web Consortium (W3C), the main international standards organization for the World Wide Web. Link popularity website (www.linkpopularity.com) was used to determine the amount and quality of links that are made to a single website from many websites, based on the page-rank analysis.

This research was also conducted using accessibility software for testing whether the webpage tested already fulfill the criteria to be accessed by people with disabilities. This software has an ability to conduct an online test for webpage refering to the criteria setup by W3C-WCAG. Web Content Accessibility Guidelines (WCAG) is part of a series of web accessibility guidelines published by the W3C's Web Accessibility Initiative. The guidelines were consisted of a set of guidelines on making content accessible, primarily for disabled users, but also for all user agents, including highly limited devices, such as mobile phones. Accessibility software can be downloaded from www.tawdis.net. Testing using accessibility software consists of test for HTML code to know whether the webpage can be read by screen reader, and testing to know if there is any alternative text for every single picture, animation, video, and audio in the webpage. Tawdis software tester can cover almost 90% of the item demanded by WCAG. Accessibility software used will give a report about an item, which does not meet with the requirement, how many mistakes in every item, and line error of the HTML code.

3.6.2 Data Collection Procedure

This data of quality website from Asian website: e-government, airlines, and university websites were taken more than 30 trails on various occasions on different period of time. All of the data for this research were taken using PC with specification: Processor Pentium Mobile 740, using Local Area Network Internet connection with an average bandwidth of 60 kbps. This data has been taken from 3/29/2009 until 5/20/2009. Using website diagnostic tools and four selected methods (LWM, AHP, FAHP, HM) the aims of this research were explored. Data was analyzed by using non-parametric statistical test. In order to analyze whether there are differences among the ranking composition methods, the Friedman test was used. When the null-hypothesis was rejected by the Friedman test, we can proceed with a post-hoc test to detect which differences among the methods are significant using Bonferroni's/Dunn's multiple comparison technique.

3.7 Reliability and Validity

3.7.1 Reliability

Reliability can also be ensured by minimizing sources of measurement error like data collector bias. Data collector bias was minimized by the researcher being the only one to administer the collecting data, and standardizing conditions such as exhibiting similar attributes to all research subjects. Content reliability refers to the extent to which data represent the factor under study. The approach in this research for analyzing website reliability is to look at the web address or URL (uniform resource locator) of the website. The URL/domain can tell the researcher about the organization that published the web site. The organizational source of the website will reflect its content type [144].

Commercial websites that have been developed for the purpose of selling or promoting a product or product line often include '.com'. Websites maintained by the government include '.gov'. Many educational institutions in Asian will include '.edu'. The reliability and validity of websites published by established educational institutions have been closely scrutinized which means the information will likely be objective.

3.7.2 Validity

The validity of an instrument is the degree to which the instrument measures what it is intended to measure (Polit. 1993). Content validity refers to the extent to which an instrument represents the factor under study. Most website quality testings concerned with usability of websites, extremely are simple and straightforward rules (like checking that the markup language used conforms to the HTML 4.0 standard, accessibility conforms to WCAG 2.0). The first thing to have a validity result is by running comparative experiments. During evaluation of website, an alternative evaluation tool and technique (eg. user testing) is used and the set of results found respectively and the automatic tool are compared. If a result found by a tool is confirmed by findings through the other tools and technique, then the result is correct. For example, the measurement of accessibility not only being measured by http://www.tawdis.net but also compared by http://wave.webaim.org. In addition, a statistical characterization of result correctness can be given by using average result found by a tool/technique then confirmed by the other tool technique.

3.8 Data Analysis

After the data were collected they were then organized and analyzed. The data were analyzed by using mathematical models and statistical tools. All of the statistical tests have been based on the assumption that the data are normally distributed. Implicitly it is estimating the parameters of this distribution, the mean and variance. These are sufficient statistics for this distribution, that is, specifying the mean and variance of a normal distribution specifies it completely. The central limit theorem provides a justification for the normality assumption in many cases, and in still other cases the robustness of the tests with respect to normality provides a justification. Parametric statistics deal with the estimation of parameters (e.g., means, variances) and testing hypotheses for continuous normally distributed variables. The parametric tests are called "parametric" because, when it calculates the p-value, it uses the "parameters" of the normal distribution: mean and standard deviation. The p-values estimated by t-tests and analysis of variance can be influenced greatly by extreme observations (outliers). The t-test and ANOVA p-values will also be inaccurate if the sample size is small and the parent population is not normally distributed. Comparison of parametric test and non-parametric test is shown in Table 3.1. In many real experiments, there are outliers in the data or the data are clearly not normally distributed. In these cases, non-parametric tests can be used based on ranks:

Table 3.4 Comparison statistical test

Parametric test	Non-parametric analog
T-test (unpaired)	Wilcoxon rank sum test
Paired t-test	Wilcoxon signed rank test
ANOVA	Kruskal-Wallis test
Repeated measures ANOVA	Friedman test

In cases where the assumption of normality cannot be employed, however, non-parametric, or distribution-free methods may be appropriate. Non-parametric statistics do not relate to specific parameters (the broad definition). They maintain their distributional properties irrespective of the underlying distribution of the data and for this reason they are called distribution-free methods. Non-parametric statistics compare distributions rather than parameters. The non-parametric tests do not estimate these parameters, but instead are based on ranks. To perform the non-parametric tests, it can replace the actual observations with their ranks. Therefore, non-parametric statistics are less restrictive in terms of the assumptions compared to parametric techniques. Although some assumptions, for example, samples are random and independent, they are still required. In cases involving ranked data, i.e. data that can be put in the order, and/or categorical data non-parametric statistics are necessary. Non-parametric statistics are not generally as powerful (sensitive) as parametric statistics if the assumptions regarding the distribution are valid for the parametric test. That is, type II errors (false null hypothesis is accepted) are more likely.

There is no universal agreement among statisticians as to when to use the alternative tests. Some statisticians believe that the fewest possible assumptions should be made about the data, and therefore non-parametric tests are better. Other statisticians suggest that parametric tests are acceptable because they are: more powerful if the data are normally distributed, available in widely used software (such as Excel), and better known and understood and nonparametric test used because: they are appropriate when only weak assumptions can be made about the distribution, they can be used with categorical data when no adequate scale of measurement is available, for data that can be ranked, non-parametric test using ranked data maybe the best option, they are relatively quick and easy to pply and to learn since they involve counts, ranks and signs. In this research, we will later look at power and sample size for non-parametric tests versus parametric tests, but to summarize: Parametric tests are slightly more powerful (by a few percent) when the data are normally distributed. Non-parametric tests are more powerful (by a few or many percent) when the data are not normally distributed. There are various tests for normality, but they are not very sensitive to deviations from normality. There are no more useful than just graphing the data, which is a very good thing to do in any case. The calculations for the non-parametric statistical tests were performed through the construction of calculation worksheets in Microsoft Excel. The Bonferroni/Dunn test is used as a non-parametric test as an alternative to the parametric paired t-test. This is a non-parametric test that compares two paired groups. It calculates the difference between each set of pairs and analyses the differences between n pairs of observations, assuming that the differences are distributed symmetrically around their mean. The differences are ranked, from the smallest to the largest, without any regard to sign. Once the ranks are computed, the original sign of each difference is assigned to the corresponding rank.

3.8.1 More than two sample tests (Friedman Test)

It sometimes happens that the data collected are only in rank form within each block or normality cannot be assumed in the randomized block design. In these situations, a non-parametric approach called the Friedman rank test can be utilized. The Friedman rank test is primarily used to test whether c sample groups (i.e., the treatment levels) have been selected from populations having equal medians. That is;

H_0: M.1 = M.2 =…= M.c , against the alternative

H_1: Not all M.j are equal, (where j = 1, 2, . . . , c)

To develop the test, first replace the data by their ranks on a block-to-block basis. In each of the r independent blocks, the c observations are replaced by their corresponding ranks such as rank 1 is given to the smallest observation in the block and rank c to the largest. If any values in a block are tied, they are assigned the average of the ranks that they would otherwise have been given. Thus, R_{ij} is the rank (from 1 to c) associated with the j^{th} group (where j = 1, 2, . . . ,c) in the ith block (where i = 1, 2, . . . , r). Under the null hypothesis of no differences in the c groups, each ranking within a block is equally likely. There are c! possible ways of ranking within a particular block and (c!)r possible arrangements of ranks over all r independent blocks. If the null hypothesis is true, there will be no real differences among the average ranks for each group (taken over all r blocks). From the above, the following test statistic FR is obtained.

The procedure of Friedman's test is the following:

1. Change every value in each row to its rank, from the lowest to the highest
2. Calculate the mean rank (r_i) for every column
3. Estimate the critical value χ^2_F :

$$\chi^2_F = \left[\frac{12}{rc(c+1)}\sum_i (SR_i^2)\right] - 3r(c+1)$$

where r is the number of the rows, and c is the number f the columns

4. if χ_F^2 is 95% statistically meaningful according to the χ_{k-1}^2 distribution the different options of the feature are statistically different and the comparison is meaningful.

3.8.2 Post Hoc Test

The Bonferroni t statistic is used to investigate dependent comparisons among means. This test is only good for investigating the difference between two means. The Bonferroni t test is the same as a normal pairwise comparison (t-test), but the critical value is different. As making many comparisons are allowed, familywise error has to be controlled by reducing the per comparison level. The overall level will be set to 0.05, and the individual per comparison level will be equalled to 0.05 divided by the total number of possible comparisons. The seven step procedure leads to the following results:

Parameter of interest: the parameter of interest are $\mu_1 = \mu_2 = \ldots = \mu_c$

Null hypothesis, H_0: $\mu_1 = \mu_2 = \ldots = \mu_c = 0$

Alternative Hypothesis, H_1: $\mu_i \neq 0$ for at least one i

Procedure to do test statistic

1. Calculate the t' statistics.

$$\text{General formula: } t^1 = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{MS_{error}}{n} + \frac{MS_{error}}{n}}} = \frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{2(MS_{error})}{n}}}$$

$$SS_T = \sum_{i=1}^{4}\sum_{j=1}^{5} y_{ij}^2 - \frac{y^2}{N}$$

$$SS_{Treatment} = \sum_{i=1}^{4} \frac{y_i^2}{n} - \frac{y^2}{N}$$

$$SS_E = SS_T - SS_{treatment}$$

$$MS_{treatment} = \frac{SS_{treatment}}{a-1}$$

$$MS_E = \frac{SS_E}{[a(n-1)]}$$

2. Set to the appropriate level.

$$\alpha = \frac{\alpha_{FW}}{k}$$

$df = dfMS_{error}$

3. Determine significance of comparisons.(the Dunn/Bonferroni table)

3.9 Summary of the Chapter

This chapter has reviewed and discussed the study design, procedures, sample population, and methods for collecting and analyzing data that were used to produce the results of this research and to inform the answers to the research questions initially posed in Chapter 1. This chapter provided a template for studies with similar research purposes. This paper presented and discussed an application to increase efficiency and reliability of a website evaluation, in a web quality context. The researcher found that the application was clearly an improvement and a new concept. In a web quality context this application contributed to a significant increase in web evaluation efficiency, and it gave the researcher an opportunity to rank the companies by a total score, on the same objective basis.

CHAPTER 4

EVALUATION METHOD

4.1 Introduction

This chapter evaluates the model of website quality evaluation and select a method for a given classification problem. Firstly, a research approach was determined to form the methodology for website quality evaluation. The quality aspect of website is investigated and select a method for a given classification problem. When testing for website quality, the first step is to weigh the advantages and disadvantages of the new proposed model. Factors that help make the right decision are cost, time, and accuracy. In the following table 4.1, comparison of six Quality Models proposed in the last few years and one new model proposed in this research that covers various points of view in observing, gauging and evaluating a website are summarized. Trying to abstract the high level concepts which the characteristics of the presented Quality Models refer to, it seems possible to identify a few of them, namely: Usability (efficient, effective, and satisfactory use of the website), content (a component that identifies what is contained in the site, and has its further characterizations), navigability (the ability to exploit the relationships among the elements (pages, images) which compose a site, management (set of the activities that allow full operability of the site and that include the maintenance finalized to stability and evolution, good operation of the site, including protection of privacy and security) and relationality (process through which two or more entities act to reciprocally modifying their state, and is used as Identification and as Interactivity).

Table 4.5 Website Quality Model and Their Characteristic

Model	Usability	Content	Navigability	Management	Relationality
2QCV3Q [145]	V	V		V	V
Comprehensive [146]		V	V		V
Minerva [147]	V	V	V	V	V
QEM [22]	V	V	V	V	V
QWEB [148]	V	V		V	V
Hybrid Model	V	V	V	V	V

4.2 Hybrid Linear Fuzzy Evaluation Model

Hybrid method combines two previous methods used in website evaluation. This model is a combination between LWM and FAHP and assigns weights to the criteria using FAHP process. Quantitative research is a formal, objective, systematic process to describe and test relationship and to examine cause and effect of interaction among variables [142]. Survey may be used for descriptive, explanatory and exploratory research. A descriptive survey design was used in this thesis, and a survey used to collect original data.

4.3 Research Approach for Hybrid Linear Fuzzy Model

The Hybrid Linear Fuzzy Model provides a conceptual framework for identifying aspects that determine website quality. Applying the model to a site doesn't require a particular evaluation process, but followed some general guidelines for adopting a problem solving approach to quality evaluation. In short, the evaluation process requires: an initial setup phase that includes evaluation requirements analysis and specification, design phase that defines the evaluation plan and techniques, and realization phase that applies survey techniques and measurement modalities specified in the evaluation plan.

4.3.1 Design of Evaluation Setup

The quality requirements definition and specification must consider certain elements, including the evaluation's purpose,

- the type and domain of the website(s) to be evaluated,
- the researcher's objectives

An evaluation can arise from very diverse needs, for example to design a site that satisfy customer or make a classification scheme of websites for every sector. Based on the information gathered in this first phase, we can then define the evaluation requirements in detail. The researcher describes quality requirements using Hybrid Model dimensions. In particular, for each dimension the analysis' degree of detail is established, structured as a hierarchy of attributes to consider and their relevance.

4.3.2 Evaluation design

Next identification of the appropriate assessment modalities for the Hybrid Model attributes is accounting for the quality requirements defined during setup. In this phase determining survey modalities is a must, which can vary depending on the techniques and tools adopted and on evaluators' number, roles, and competencies. When choosing a technique, evaluators might refer to a classification proposed in the website quality literature, which distinguishes empirical and analytical techniques. The decision to use one method over another depends on such factors such as the project's stage of advancement, data requested, availability of and access to users, and available time and resources. Nonetheless, evaluators should employ diverse techniques, and to further integrate the results. The trade-off of quantitative and qualitative evaluation can be critical and must be managed with extreme attention, keeping in mind the effectiveness and cost of the techniques used. For some characteristics the adoption of quantitative metrics is fixed based on literature. Furthermore, even for attributes of which identifiers linked to physical parameters (such as average time to download a site's homepage) it can establish absolute reference values, researcher needs to determine suitable download time. Also relevant are the network characteristics and mode of entry, whether via modem from home or high-speed network. Relatively sophisticated statistical-mathematical techniques can also be adopted to consider the relative importance of the model's attributes. For example, see the Hybrid method, and the use of fuzzy logic to associate judgments expressed with linguistic labels.

4.3.3 Conducting the evaluation

To evaluate a site, survey techniques and the measurement modalities specified in the evaluation plan are applied. Normally the evaluation is based on one or more visits to the site. Using appropriate methods, comparing the results with the quality profile is defined in the first phase. Whatever the site evaluation's purpose, the results in a report where the structure reflects evaluation objectives with the content organized according to Hybrid model items can be grouped. Partially automate evaluation of some attributes using software tools can be done. Search engines are used to assess the reachability attributes. Moreover, some JavaScript routines are used to obtain useful data rapidly when visiting a site.

4.4 Hybrid Linear Fuzzy Evaluation Process

Figure 4.1 shows a high-level view of major steps required for quality evaluation and specification. In addition, it depicts the website quality component and evaluation, basic evaluation and final evaluation, and analysis, conclusions and documentation phases. Next, the major process steps that evaluators should be followed by applying the Hybrid Evaluation Model, namely:

Step one. Selecting a site or a set of candidate sites to evaluate or compare. In this task, decision-makers should know what the evaluation domain is and select the systems to assess. This research examined the national e-government and airlines website of a selected number of countries in Asia: Singapore, Korean, Japan, Hongkong and Malaysia and also five Malaysian universities. The e-government, airlines, and university website were not randomly selected, but a careful process was undertaken. Rather than selecting any generic Asian website this research attempted to evaluate the e-government website that were considered to be leaders in the area of information technology implementation based on the result of a survey conducted by Economist Intelligent Unit for Country E-readiness in 2009 and United Nation for e-government in 2008, pingdom and skytrax company for Airlines website, and Webometric for university. In addition, if the purpose of the assessment is the comparison of competitive sites, it should be selected based on appropriate sample in order to be successful throughout the evaluation process.

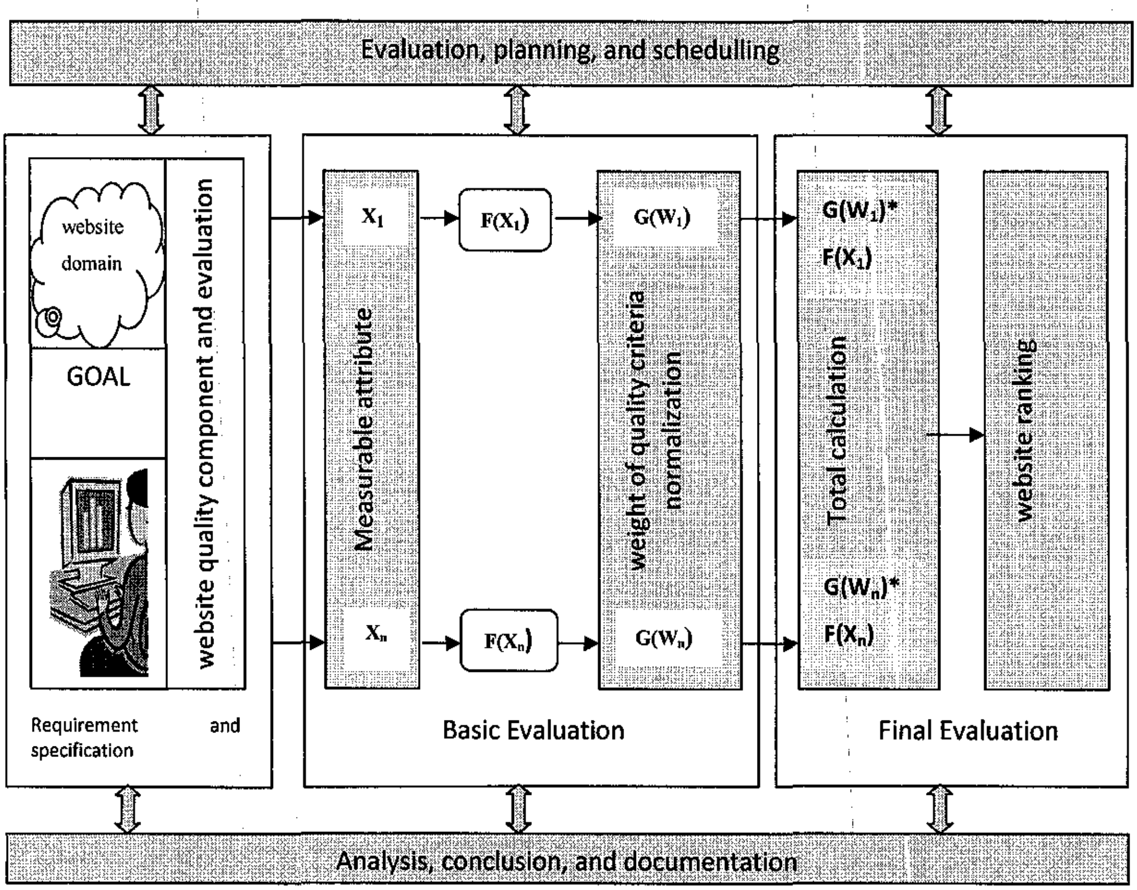

Figure 4.4 Hybrid Linear Fuzzy Model Evaluation Process

Step two. Specifying evaluation goals and defining the Web-site quality characteristics and attributes requirement. In this step, evaluators should define the goals and scope of the evaluation process. The research purpose are: to determine the factors influence website quality, to find available tools to generate an appraisal of quality and to develop a new methodology for determining and evaluating the best Asian website based on many criteria of website quality. The quality of a set of attributes or sub-characteristics, a sub-system, and an overall system could be evaluated. Well-known standards of high level website quality characteristics are followed like usability, functionality, reliability, efficiency, portability, and maintainability. These characteristics give evaluators a conceptual and general description of website quality and provide a baseline for further decomposition. From these characteristics, subcharacteristics could be derived, and from these, specify measurable attributes and variables could be specified. These subcharacteristics consist of: reliability (time), structural, content/search engine friendliness, latency, stickiness, design, performance, and efficiency. This is foolowed by discussing some characteristics and attributes and the decomposition mechanism. The usability characteristic is decomposed in subfactors such as design, and search engine friendliness/link popularity. The functionality characteristic is decomposed in stickiness and performance issues. The same decomposition mechanism is applied to reliability and efficiency factors, for example regarding reliability factor, the degree to which artifacts do not contain undetected errors. In this category, and considering link errors, attributes like broken links are found. The broken links attribute counts dangling links out of the total site links leading to absent destination nodes. The higher the detected number of links errors, the lower the site Reliability. The results might be useful to understand, assess, control, forecast, or improve the quality of websites.

Step three. Defining a method and tool used for collecting data from Asian website (e-government, airlines, and Malaysian university). Once all criteria were agreed, and data collected, then the variable value and the elementary quality preference can be computed for each attribute of each system. This activity should be performed for each characteristic (such as load time, etc.) for each website. Finally, some considerations should be made with regard to data collection. Data collection activity can be done manually, semi-automatically, and automatically. Most of the attributes values were collected automatically because there are widely available web diagnostic tools online.

Table 4.6 Web diagnostics tools online

Attribute of quality	Tools	Alternative tools for validation
load time	www.websiteoptimization.com	Tools.pingdom.com
response time	www.websitepulse.com	Webhosting.candidinfo.com
page rank	www.pageranktool.com	www.prchecker.info
frequency of update	javascript	manual user testing
Traffic	www.alexa.com	www.metricsmarket.com
design optimization	www.webpagetest.org	Tools.pingdom.com
Size	www.websiteoptimization.com	Tools.pingdom.com
number of items	www.websiteoptimization.com	Tools.pingdom.com
accessibility error	www.tawdis.net	www.cast.org
markup validation	Validator.w3org	www.validome.org
Broken link	Validator.w3org/checklink	www.dead-links.com

Step four. Defining the evaluation method

This research proposed a new model of website quality evaluation by applying Hybrid model between LWM and FAHP approach with the goal to have significant acceleration of implementation, raised the overall effectiveness with respect to the underlying methodology and ultimately enabled more efficient process.

Step five. Assigning weights for website sample data which are obtained from survey measurement based on Linear Weightage Model [95]. Threshold can be divided into two types: maximum and minimum. The first group known as "smaller is better" such as load time, response time, traffic, page rank and broken link and the threshold for this type of criteria must be maximum. On the other hand other criteria can be considered as "larger is better" such as traffic, page rank, frequency of update and design optimization where threshold must be minimum where thresholds must be minimum.

$$F(x)_{max} = \frac{max - website}{max - min} \tag{4.1}$$

$$F(x)_{min} = \frac{website - min}{max - min} \tag{4.2}$$

where

$F(x)_{max}$= specific website value that has maximum type of threshold with respect to a particular attribute/criterion.

$F(x)_{min}$ = specific website value that has minimum type of threshold with respect to a particular attribute/criterion.

website = specific website that is considered at the time.

max = maximum value of particular attribute/criteria among all website

min = minimum value of the same attribute among the whole website.

The idea of using formula 4.1 and formula 4.2 in this research is extremely valuable because they provide a method that enables the comparisons among decision criteria. Usually decision criteria have different units of measure so any comparisons among those website criteria are not logically acceptable. Table 4.3 shows result example of assigning weight process by using e-government sample.

Table 4.7 Maximum minimum criteria of e-government website based on LWM

Criteria	Singapore	Korea	Japan	Hongkong	Malaysia
A max	30.77	0.30	68.93	41.94	77.51
B max	1.94	1.17	1.73	1.03	4.84
C min	2870.00	430.00	2020.00	9690.00	2470.00
D min	60.00	60.00	60.00	1.00	60.00
E min	62000.00	39800.00	223200.00	499600.00	228200.00
F min	37.50	57.00	36.50	33.00	22.00
G max	128305.00	511.00	285645.00	195384.00	366825.00
H max	26.00	1.00	60.00	15.00	22.00
I max	37.00	0.00	2.00	0.00	15.00
J max	79.00	5.00	21.00	3.00	80.00
K max	4.00	0.00	1.00	1.00	9.00

By implementing equations (4.1) and (4.2) every cell in the Table 4.3 will be converted into normalized data and depicted in Table 4.4.

Table 4.8 Normalized data of e-government website based on LWM

Criteria	Singapore	Korea	Japan	Hongkong	Malaysia
A	0.605	1.000	0.111	0.461	0.000
B	0.759	0.962	0.815	1.000	0.000
C	0.263	0.000	0.172	1.000	0.220
D	1.000	1.000	1.000	0.000	1.000
E	0.048	0.000	0.399	1.000	0.410
F	0.443	1.000	0.414	0.314	0.000
G	0.651	1.000	0.222	0.468	0.000
H	0.576	1.000	0.000	0.763	0.644
I	0.000	1.000	0.946	1.000	0.595
J	0.013	0.974	0.766	1.000	0.000
K	0.556	1.000	0.889	0.889	0.000

By using the data normalization concept, which is represented in formula 4.1 and formula 4.2, all the criteria will be having weights instead of variety of measurement units and then the comparisons can simply be made.

Step six. Defining criterion function for each attribute, and applying attribute measurement. When all values of the criteria matrix are calculated, series of calculations should be achieved by performing a comparison of each attributes by using Fuzzy-Analytic Hierarchy Process.

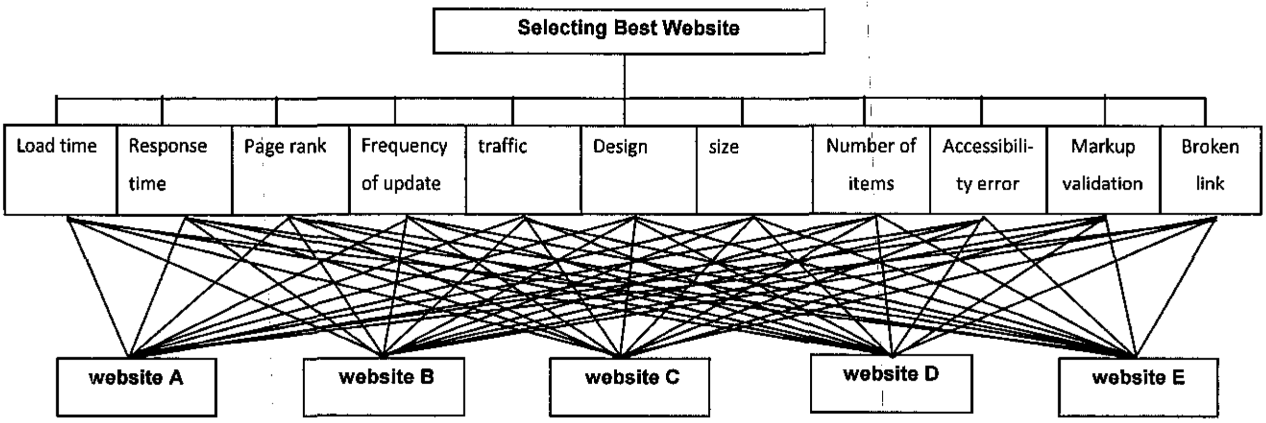

Figure 4.2 FAHP Model of Website

The hierarchical decomposition of measurable attributes could be also considered in this process framework. Criteria involves in the website selection process using proposed FAHP model are load time (A), response time (B), page rank (C), frequency of update (D), traffic (E), design optimization (F), size (G), number of items (H), accessibility error (I), markup validation (J, and broken link (K). All of the data is displayed in Figure 4.2. After determining the attributes and performance results, the next step in the Fuzzy-Analytic Hierarchy Process is to perform a comparison of each attribute. The preference criteria matrix was obtained which compare each criterion to the others based on membership function parameter [97] and this criteria is displayed in Table 4.5.

Table 4.9 Each of membership functions' parameter [97].

Linguistic Expressions	Fuzzy AHP		
	a_1	a_2	a_3
Equal	1	1	2
Equal –Moderate	1	2	3
Moderate	2	3	4
Moderate- Fairly Strong	3	4	5
Fairly Strong	4	5	6
Fairly Strong- Very Strong	5	6	7
Very Strong	6	7	8
Very Strong- Absolute	7	8	9
Absolute	8	9	9

Load time is more important than response time so the weight which represents load time should be bigger than response time, in this case weight for load time (8,9,9), response time (7,8,9), page rank (6,7,8), frequency of update (5,6,7), traffic (5,6,7), design optimization (5,6,7), size (4,5,6), number of items (3,4,5), accessibility error (2,3,4), markup validation (1,2,3), and broken link (1,1,2). The preference criteria matrix was obtained which compare each criterion to the others and Table 4.6 depicts the preference criteria matrix in a form of pairwise comparisons.

Table 4.10 Preference Criteria of Quality Website with FAHP matrix

	A	B	C	D	E	F	G	H	I	J	K
A	1,1,1	1,2,3	2,3,4	3,4,5	4,5,6	5,6,7	5,6,7	5,6,7	6,7,8	7,8,9	8,9,9
B	1/3, 1/2, 1	1,1,1	1,2,3	2,3,4	3,4,5	4,5,6	4,5,6	4,5,6	5,6,7	6,7,8	7,8,9
C	1/4, 1/3, ½	1/3, 1/2, 1	1,1,1	1,2,3	2,3,4	3,4,5	4,5,6	4,5,6	4,5,6	5,6,7	6,7,8
D	1/5, 1/4, 1/3	1/4, 1/3, ½	1/3, ½, 1	1,1,1	1,2,3	2,3,4	3,4,5	3,4,5	3,4,5	4,5,6	5,6,7
E	1/6, 1/5, ¼	1/5, 1/4, 1/3	¼ 1/3, ½	1/3, ½, 1	1,1,1	1,2,3	2,3,4	2,3,4	2,3,4	3,4,5	4,5,6
F	1/7, 1/6, 1/5	1/6, 1/5, ¼	1/5, 1/4, 1/3	¼, 1/3, ½	1/3, ½, 1	1,1,1	1,2,3	1,2,3	1,2,3	2,3,4	3,4,5
G	1/7, 1/6, 1/5	1/6, 1/5, ¼	1/6, 1/5, ¼	1/5, ¼, 1/3	¼, 1/3, ½	1/3, ½, 1	1,1,1	1,1,2	1,2,3	2,3,4	3,4,5
H	1/7, 1/6, 1/5	1/6, 1/5, ¼	1/6, 1/5, ¼	1/5, ¼, 1/3	¼, 1/3, ½	1/3, ½, 1	½, 1, 1	1,1,1	1,2,3	2,3,4	3,4,5
I	1/8, 1/7, 1/6	1/7, 1/6, 1/5	1/6, 1/5, ¼	1/5, ¼, 1/3	¼, 1/3, ½	1/3, ½, 1	1/3, ½, 1	1/3, ½, 1	1,1,1	1,2,3	2,3,4
J	1/9, 1/8, 1/7	1/8, 1/7, 1/6	1/7, 1/6, 1/5	1/6, 1/5, ¼	1/5, ¼, 1/3	¼, 1/3, ½	¼, 1/3, ½	¼, 1/3, ½	1/3, ½, 1	1,1,1	1,2,3
K	1/9, 1/9, 1/8	1/9, 1/8, 1/7	1/8, 1/7, 1/6	1/7, 1/6, 1/5	1/6, 1/5, ¼	1/5, ¼, 1/3	1/5, ¼ 1/3	1/5, ¼, 1/3	¼ 1/3, ½	1/3, ½, 1	1,1,1
Σ	2.726, 3.162, 4.118	3.662, 5.118, 7.093	5.551, 7.993, 10.950	8.493, 11.950, 15.950	12.450, 16.950, 22.083	17.450, 23.083, 29.833	21.283, 28.083, 34.833	21.783, 28.083, 35.833	24.583, 32.833, 41.500	33.333, 42.500, 52.000	43.000 53.000, 62.000,

Load time is as important as or slightly more important than response time, so the cells which represent load time across response time in the second row of the first column is 1,2,3 according to the FAHP measure scale, and when comparing response time to load time it will be 1/3,1/2,1 because TFN inverse calculation. The same calculation is followed to calculate all criteria pairwise comparison. The next step is to get the weight for every criterion by normalized the data in Table 4.7. The steps applied to the criteria matrix and weights will be calculated by using Chang's extent analysis [117]:

1. Sum every element in each row (*l*,*m*,*u*).
2. Sum total element in each column.
3. Divide 1 with the sum of the total element in every column (*l*,*m*,*u*).
4. Multiply every element in each row with the inverse of the total element

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} \tag{4.3}$$

5. By using equation

$$V(\widetilde{M}_2 \geq \widetilde{M}_1) = \sup_{y \geq x} \left[\min(\mu_{\widetilde{M}}(x), \mu_{\widetilde{M}}(y) \right] \tag{4.4}$$

$$V(\widetilde{M}_2 \geq \widetilde{M}_1) = hgt(\widetilde{M}_1 \cap \widetilde{M}_2) = \mu_{M_2}(d) \tag{4.5}$$

determine the value of *V*.

6. Determine the minimum value on every row.
7. Find the normalized weight vector by using Transpose operation for step no 6.

Table 4.11 Normalized data for e-government website criteria

Criteria	L	M	U	Weight l	Weight m	Weight U
A	47.000	57.000	66.000	0.149	0.226	0.340
B	37.333	46.500	56.000	0.118	0.184	0.288
C	30.583	38.833	47.500	0.097	0.154	0.244
D	22.783	30.083	37.833	0.072	0.119	0.195
E	15.950	22.283	29.083	0.050	0.088	0.150
F	10.093	15.450	21.283	0.032	0.061	0.110
G	9.260	12.650	17.533	0.029	0.050	0.090
H	8.760	12.650	16.533	0.028	0.050	0.085
I	5.885	8.593	12.450	0.019	0.034	0.064
J	3.829	5.385	7.593	0.012	0.021	0.039
K	2.840	3.329	4.385	0.009	0.013	0.023

Calculation yields the normalized matrix of criteria as illustrated in Table 4.7. The average weights of rows are computed in the last column to indicate the weights of the criteria. Sum of *l*, *m*, and *u* for this table is 194.315, 252.756, 316.194 and 0.005, 0.004, 0.003 are 1 divided by l, u, and u. Weight for l, m, and u is taken by multiplying every cell with inverse of the total l, m, u. The Fuzzy values of V for those criteria will be displayed in the Table 4.8, where numerical calculation for this value is using equation 4.4.

Table 4.12 Fuzzy values for website criteria

fAB	1.00	fAC	1.00	fAD	1.00	fAE	1.00	fAF	1.00	fAG	1.00	fAH	1.00	fAI	1.00	fAJ	1.00	fAK	1.00
fBA	0.77	fBC	1.00	fBD	1.00	fBE	1.00	fBF	1.00	fBG	1.00	fBH	1.00	fBI	1.00	fBJ	1.00	fBK	1.00
fCA	0.57	fCB	0.81	fCD	1.00	fCE	1.00	fCF	1.00	fCG	1.00	fCH	1.00	fCI	1.00	fCJ	1.00	fCK	1.00
fDA	0.30	fDB	1.38	fDC	0.74	fDE	1.00	fDF	1.00	fDG	1.00	fDH	1.00	fDI	1.00	fDJ	1.00	fDK	1.00
fEA	0.01	fEB	0.25	fEC	0.45	fED	0.72	fEF	1.00	fEG	1.00	fEH	1.00	fEI	1.00	fEJ	1.00	fEK	1.00
fFA	0.00	fFB	0.00	fFC	0.12	fFD	0.39	fFE	0.69	ffG	1.00	ffH	1.00	fFI	1.00	fFJ	1.00	fFK	1.00
fGA	0.00	fGB	0.00	fGC	0.00	fGD	0.21	fGE	0.51	fGF	0.84	fGH	1.00	fGI	1.00	fGJ	1.00	fGK	1.00
fHA	0.00	fHB	0.00	fHC	0.00	fHD	0.16	fHE	0.48	fHF	0.83	fHG	1.00	fHI	1.00	fHJ	1.00	fHK	1.00
fIA	0.00	fIB	0.00	fIC	0.00	fID	0.00	fIE	0.20	fIF	0.54	fIG	0.68	fIH	0.69	fIJ	1.00	fIK	1.00
fJA	0.00	fJB	0.00	fJC	0.00	fJD	0.00	fJE	0.00	fJF	0.15	fJG	0.25	fJH	0.28	fJI	0.62	fJK	1.00
fKA	0.00	fKB	0.00	fKC	0.00	fKD	0.00	fKE	0.00	fKF	0.00	fKG	0.00	fKH	0.00	fKI	0.16	fKJ	0.56

Priority weights from Table 4.8 are calculated using equation 4.5 will give a result of:
W' = (1.000, 0.771, 0.571, 0.302, 0.007, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000)
After the normalization of these values, the priority weight with respect to criteria of website is calculated as
G(W) = (0.377, 0.291, 0.216, 0.114, 0.003, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000)
Calculation continued to determine fuzzy value for each alternative depends on the category of quality website.

Step seven. Determining website score for evaluation and comparison and analyze of website quality ranking result consistency. Multiplying weights W_i of criteria by the whole values X_i within the matrix. The total score should also be calculated using formula 4.5 for each specific e-government website as a sample, which represents the specific website' scores. The final decision table includes a total score for each website and the one who gains the highest score is recommended as the best website overall.

$$\text{Total Score} = \sum_{i}^{n} G(W_i)F(X_i) / \sum G(W_i) \tag{4.6}$$

$G(W_i)$ = value of the criteria weight (W_i) based on Fuzzy AHP process

$F(W_i)$ = the measured value of website sample, which can take a proporsional based on Linear Weightage Model.

The final result of Hybrid Model for website quality and ranking will be displayed in Table 4.9

Table 4.13 Final Result for e-government website based on LWM

website	Singapore	Korea	Japan	Hongkong	Malaysia	Weight
A	0.605	1.000	0.111	0.461	0.000	0.158
B	0.759	0.962	0.815	1.000	0.000	0.140
C	0.263	0.000	0.172	1.000	0.220	0.123
D	1.000	1.000	1.000	0.000	1.000	0.105
E	0.048	0.000	0.399	1.000	0.410	0.105
F	0.443	1.000	0.414	0.314	0.000	0.105
G	0.651	1.000	0.222	0.468	0.000	0.088
H	0.576	1.000	0.000	0.763	0.644	0.070
I	0.000	1.000	0.946	1.000	0.595	0.053
J	0.013	0.974	0.766	1.000	0.000	0.035
K	0.556	1.000	0.889	0.889	0.000	0.018
Sum	0.499	0.766	0.456	0.672	0.252	1
Rank	3	1	4	2	5	

Step eight. Analyze of website quality ranking result consistency. In this final step, the evaluators analyze, assess, and compare the website, website based partial and total quantitative results regarding the established goals. At the end of the evaluation and comparison process a global indicator using the scale from 1 to 5, is obtained for each competitive system.

4.5 Summary of the Chapter

In this chapter a new methodology has been proposed for determining and evaluating the best websites based on many criteria of website quality. To get results on the quality of a website, sample data are measured from e-government website in five Asian countries and calculate load time, response time, page rank, frequency of update, traffic, design optimization, page size, number of item, accessibility error, markup validation, and broken link. Using a series of online diagnostic tolls, many dimensions of quality are examined, and each dimension are measured by a specific test online. This new hybrid model has been implemented using Linear Weightage Model and Fuzzy Analytical Hierarchy Process (FAHP) to generate the weights for the criteria which are much better and guaranteed more fairly preference of the criteria and consist of the eight steps.

CHAPTER 5

ANALYSIS ON ASIAN WEBSITE

5.1 Introduction

The quality aspect of websites is investigated and select a method for a given classification problem. Four ranking methods are presented for that purpose: LWM, AHP, FAHP, and HM. The problem of evaluating and comparing these methods are also analyzed. The evaluation technique used is based on a leave-one-out procedure. On each calculation, the method generates a ranking using the results obtained by the algorithms on the datasets. To compare ranking methods, a combination of Friedman's test and Dunn's multiple comparison procedure is adopted. The selection of the most adequate algorithm for a new problem is a difficult task. This is an important issue, because many different methods are available. These methods originate from different areas like statistics, fuzzy logics, and mathematics and their performance may vary considerably. Recent interests in combination of methods like combining and cascading have resulted in many new additional methods. The problem of method selection could be rduced to the problem of method performance comparison by trying all the methods on the problem at hand. In practice this is not feasible in many situations, because there are too many methods to try out. An alternative solution would be to try to identify the single best method, which could be used in all situations. However, the No Free Lunch (NFL) algorithms [129] state that if algorithm A outperforms algorithm B on some cost functions, then there must exist exactly as many other functions where B outperforms A. All this implies that, according to the problem at hand, specific recommendation should be given concerning which algorithm should be used or tried out.

Method selection as an exploratory process, is highly dependent on the analyst's knowledge of the methods and of the problem domain, thus something which lies somewhere on the border between engineering and art. Considering the NFL theorem if cannot be expected that a single best ranking of algorithms could be found and be valid for all datasets. Whatever method used to identify the relevant datasets, we still need to resolve the issue concerning which ranking method is the best one. The aim is to examine four ranking methods and evaluate their ability to generate rankings which are consistent with the actual performance information of the algorithms on an unseen dataset. The issue whether there are significant differences between them, and, if there are, which method is preferable to the others are investigated.

Table 5.1 showed that in term of ranking, link popularity of the e-government website are different with the result of the Waseda University World e-government Ranking in 2008 and e-government ranking survey published by center for public policy Brown University [149]. Based on Waseda University World e-government, the ranking are Singapore, Korean, Japan, Hongkong, and Malaysia, while based on e-government ranking survey published by Brown University: Korea, Singapore, Hong Kong, Malaysia, and the last Japan. Evaluation based on link popularity using Google search engine the sequence are: Hongkong, Singapore, Malaysia, Japan, and the last ranking is Korea. Similar result has occurred by using yahoo search engine with ranking number one is Malaysia, followed by Singapore, Japan, Hongkong, and Korea as the last ranking.

Table 5.14 Ranking of the e-government website based on search engine

e-government	Waseda University	Gobal e-government	Google	Yahoo
www.gov.sg	1`	2	2 (2650 links)	2 (105914 links)
www.korea.go.kr	2	1	5 (454 links)	5 (49005 links)
www.kantei.go.jp	3	40	4 (1810 links)	3 (91038 links)
www.gov.hk	4	22	1 (8180 links)	4 (59876 links)
www.gov.my	5	25	3 (2190 links)	1 (132804 links)

5.2 E-Government Website Evaluation

Information and Communication Technology (ICT) has become one of the important tools for organizational success. The phenomenon of the Internet and web has changed the way that people work and communicate. This rapid development of ICT raises concerns among government agencies to figure out how to deal with technology in order to enhance the government services to the public and to improve the internal progress of the organization [150]. They have started to deploy the World Wide Web for delivering information and services to all citizens and residents. Many governments around the world are moving toward embracing Internet technology. Recently, integrated web based government services have begun to be provided in developed countries such as the US, UK, Australia, Japan, Korea, Singapore and Malaysia. Digital government or well known as electronic e-government has huge potential benefits. Government provides service to all sectors of society, not only legal, political, and economic infrastructure, but also exercises substantial influence on the social factors that support to their development [151]. The aims of using ICT are to enhance the effectiveness and efficiency of the government agencies' processes [152, 153]. It is also to transform government to be more citizen-oriented. E-government thus has the potential function as a bridge to transform people's perceptions of civil and political interactions with their governments. Through the web and Internet, expectations of the service levels that e-government sites provide have been raised considerably [154]. In accordance with the technology development, it can be seen further convergence of e-commerce and e-government services [155]. Unlike e-commerce, e-government services must be accessible to all. The implementation case of e-government in developing countries is significantly more problematic, even in developed countries where a better environment is available for such development [156]. Two crucial requirements for successful e-government implementation are availability and accessibility. Firstly, e-government services and transactions have to be available full time, meaning that should be available during 24 hours a day and 7 days a week. This provides citizens, partners, and government employees with the flexibility to process transactions outside standard government office hours. This is in turn will increase the performance of services provided by the government. Therefore, an e-government website needs to satisfy this high-availability requirement [157]. Secondly, the e-government endeavor is critically dependent on the accessibility of its integral website. If the website is not accessible to the intended target users it will not be categorized as successful website.

First column in Table 5.2 shows the criteria of the quality website. The criteria involve in the website selection process using proposed model are load time (A), response time (B), page rank (C), frequency of update (D), traffic (E), design optimization (F), size (G), number of items (H), accessibility error (I), markup validation (J), and broken link (K). The second column shows the measurement unit, and the rest of the columns represent the country e-government performance value.

Table 5.15 Original data of Asian e-government website

Criteria	Measurement unit	Singapore	Korea	Japan	Hongkong	Malaysia
A(load time)	Second	30.77	0.30	68.93	41.94	77.51
B(response time)	Second	1.94	1.17	1.73	1.03	4.84
C(page rank)	Number	2870.00	430.00	2020.00	9690.00	2470.00
D(frequency of update)	Number	60.00	60.00	60.00	1.00	60.00
E(traffic)	Number	62000.00	39800.00	223200.00	499600.00	228200.00
F(design optimization)	Percentage	37.50	57.00	36.50	33.00	22.00
G(size)	Number	128305.00	511.00	285645.00	195384.00	366825.00
H(number of items)	Number	26.00	1.00	60.00	15.00	22.00
I(accessibility error)	Number	37.00	0.00	2.00	0.00	15.00
J(markup validation)	Number	79.00	5.00	21.00	3.00	80.00
K(broken link)	Number	4.00	0.00	1.00	1.00	9.00

The results of the website quality test based on load time, response time, page rank, frequency of update, traffic, design optimization, size, number of items, accessibility error, markup validation, and broken link are also displayed in Table 5.2. The data in Table 5.2 show that most of the e-government website in Asian countries cannot fulfill the criteria as a high quality website. Most server response, load times, size, and number of items exceeded the value standardized by IBM, except Korean e-government website in load time, size, and number of items criteria. Implementation of the W3C's HTML validator highlighted that none of e-government website had HTML 4.01 valid entry page, most of them did not have DOCTYPE declarations. Consequences of this problem will be on the portability and development of the website. In term of broken link, four e-government websites or 80% of the sample had a broken link. After determining the attributes and performance results, the next step in the evaluation process was to perform a comparison of each attribute. The preference criteria matrix was obtained to compare each criterion against the others. There are four models used in this research, Linear Weightage Model (LWM), Analytical Hierarchy Process (AHP), Fuzzy-Analytical Hierarchy Process (FAHP) and Hybrid Model Linear Fuzzy (HM, a combination between LWM and FAHP).

5.2.1 E-government LinearWeightage Model Website Evaluation

Table 5.3 presents the original data and maximum minimum criteria of e-government website associated with each of the website quality criteria based on the evaluation of their contribution toward overall quality using LWM model.

Table 5.16 Maximum minimum criteria of e-government website based on LWM

Criteria	Singapore	Korea	Japan	Hongkong	Malaysia
A max	30.77	0.30	68.93	41.94	77.51
B max	1.94	1.17	1.73	1.03	4.84
C min	2870.00	430.00	2020.00	9690.00	2470.00
D min	60.00	60.00	60.00	1.00	60.00
E min	62000.00	39800.00	223200.00	499600.00	228200.00
F min	37.50	57.00	36.50	33.00	22.00
G max	128305.00	511.00	285645.00	195384.00	366825.00
H max	26.00	1.00	60.00	15.00	22.00
I max	37.00	0.00	2.00	0.00	15.00
J max	79.00	5.00	21.00	3.00	80.00
K max	4.00	0.00	1.00	1.00	9.00

By implementing equations (4.1) and (4.2) every cell in the Table 5.4 will be converted into normalized data and depicted in Table 5.4.

Table 5.17 Normalized data of e-government website based on LWM

Criteria	Singapore	Korea	Japan	Hongkong	Malaysia
A	0.605	1.000	0.111	0.461	0.000
B	0.759	0.962	0.815	1.000	0.000
C	0.263	0.000	0.172	1.000	0.220
D	1.000	1.000	1.000	0.000	1.000
E	0.048	0.000	0.399	1.000	0.410
F	0.443	1.000	0.414	0.314	0.000
G	0.651	1.000	0.222	0.468	0.000
H	0.576	1.000	0.000	0.763	0.644
I	0.000	1.000	0.946	1.000	0.595
J	0.013	0.974	0.766	1.000	0.000
K	0.556	1.000	0.889	0.889	0.000

Load time is more important than response time so the weight which represents load time should be bigger than response time, in this case we give weight for load time (9), response time (8), page rank (7), frequency of update (6), traffic (6), design optimization (6), size (5), number of items (4), accessibility error (3), markup validation (2), and broken link (1). Total sum of the weight criteria is 57 (9 + 8 +7 + 6 + 6 + 6 + 5 + 4 + 3 + 2 + 1), and then all of the weights of criteria are divided by total sum. The next step is to get the weight for every criterion by normalized the data in Table 5.5.

Table 18.5 Final Result for e-government website based on LWM

Website	Singapore	Korea	Japan	Hongkong	Malaysia	Weight
A	0.605	1.000	0.111	0.461	0.000	0.158
B	0.759	0.962	0.815	1.000	0.000	0.140
C	0.263	0.000	0.172	1.000	0.220	0.123
D	1.000	1.000	1.000	0.000	1.000	0.105
E	0.048	0.000	0.399	1.000	0.410	0.105
F	0.443	1.000	0.414	0.314	0.000	0.105
G	0.651	1.000	0.222	0.468	0.000	0.088
H	0.576	1.000	0.000	0.763	0.644	0.070
I	0.000	1.000	0.946	1.000	0.595	0.053
J	0.013	0.974	0.766	1.000	0.000	0.035
K	0.556	1.000	0.889	0.889	0.000	0.018
Sum	0.499	0.766	0.456	0.672	0.252	1
Rank	3	1	4	2	5	

After conducting some calculations during this evaluation process, the last step in this procedure was computing the final score of each website. Then the sum of each column represents the score of each single website. Table 5.5 depicts the final scores of e-government website based on LWM evaluation method. The most important thing with regards to the final results, the website which has the highest score is suggested as the best website for LWM model. In accordance with the results generated by the proposed model, Korea e-government website has the highest score of 0.77 in comparison with the rest of e-government website. As a result, the proposed LWM model rank for e-government website is: Korea (score: 0.77), Hongkong (score: 0.67), Singapore (score: 0.50), Japan (score: 0.46), and the last rank is Malaysia (score: 0.25).

5.2.2 E-government Analytical Hierarchy Process Website Evaluation

Load time is more important than response time so the cells which represent load time across response time in the second row third column is 2 according to the AHP measure scale, and when comparing response time to load time it will be 1/2 or 0.5 because of the opposite calculation. The same calculation is followed to calculate all criteria pairwise comparison and displayed in Table 5.6.

Table 5.19 Preference Criteria Matrix of website based on AHP

Criteria	A	B	C	D	E	F	G	H	I	J	K
A	1.000	2.000	3.000	4.000	5.000	6.000	6.000	6.000	7.000	8.000	9.000
B	0.500	1.000	2.000	3.000	4.000	5.000	5.000	5.000	6.000	7.000	8.000
C	0.333	0.500	1.000	2.000	3.000	4.000	5.000	5.000	5.000	6.000	7.000
D	0.250	0.333	0.500	1.000	2.000	3.000	4.000	4.000	4.000	5.000	6.000
E	0.200	0.250	0.333	0.500	1.000	2.000	3.000	3.000	3.000	4.000	5.000
F	0.167	0.200	0.250	0.333	0.500	1.000	2.000	2.000	2.000	3.000	4.000
G	0.167	0.200	0.200	0.250	0.333	0.500	1.000	1.000	2.000	3.000	4.000
H	0.167	0.200	0.200	0.250	0.333	0.500	1.000	1.000	2.000	3.000	4.000
I	0.143	0.167	0.200	0.250	0.333	0.500	0.500	0.500	1.000	2.000	3.000
J	0.125	0.143	0.167	0.200	0.250	0.333	0.333	0.333	0.500	1.000	2.000
K	0.111	0.125	0.143	0.167	0.200	0.250	0.250	0.250	0.333	0.500	1.000
Sum	3.162	5.118	7.993	11.950	16.950	23.083	28.083	28.083	32.833	42.500	53.000

The next step is to get the weight for every criterion by normalized the data in Table 5.7. The steps applied to the criteria matrix and weights will be calculated.

1. Sum the elements in each column.
2. Divide each value by its column total.
3. Calculate row averages.

Table 5.20 Weights of e-government website criteria based on AHP

norm	A	B	C	D	E	F	G	H	I	J	K	Priority vector	Weight
A	0.316	0.391	0.375	0.335	0.295	0.260	0.214	0.214	0.213	0.188	0.170	2.971	0.270
B	0.158	0.195	0.250	0.251	0.236	0.217	0.178	0.178	0.183	0.165	0.151	2.162	0.197
C	0.105	0.098	0.125	0.167	0.177	0.173	0.178	0.178	0.152	0.141	0.132	1.627	0.148
D	0.079	0.065	0.063	0.084	0.118	0.130	0.142	0.142	0.122	0.118	0.113	1.176	0.107
E	0.063	0.049	0.042	0.042	0.059	0.087	0.107	0.107	0.091	0.094	0.094	0.835	0.076
F	0.053	0.039	0.031	0.028	0.029	0.043	0.071	0.071	0.061	0.071	0.075	0.573	0.052
G	0.053	0.039	0.025	0.021	0.020	0.022	0.036	0.036	0.061	0.071	0.075	0.457	0.042
H	0.053	0.039	0.025	0.021	0.020	0.022	0.036	0.036	0.061	0.071	0.075	0.457	0.042
I	0.045	0.033	0.025	0.021	0.020	0.022	0.018	0.018	0.030	0.047	0.057	0.335	0.030
J	0.040	0.028	0.021	0.017	0.015	0.014	0.012	0.012	0.015	0.024	0.038	0.234	0.021
K	0.035	0.024	0.018	0.014	0.012	0.011	0.009	0.009	0.010	0.012	0.019	0.173	0.016
Sum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	11.000	1.000

From Table 5.7, the weight of the load time (A) is 0.270, response time (B) is 0.197, page rank (C) is 0.148, frequency of update is (D) 0.107, traffic (E) is 0.076, design optimization (F) is 0.052, size (G) is 0.042, number of items (H) is 0.042, accessibility error (I) is 0.030, markup validation (J) is 0.021, and broken link (K) is 0.016. The next step is to compute the criteria value matrix for alternatives (e-government website). All of this procedure is located in Appendix A1, then multiply each column in Table 5.7 by the corresponding weights of attributes. The results of the criteria values matrix are displayed in Table 5.8.

Table 5.21 Weight of criteria and e-government website based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia	Weight
A(load time)	0.260	0.503	0.068	0.134	0.035	0.270
B(response time)	0.082	0.282	0.147	0.456	0.032	0.197
C(page rank)	0.218	0.033	0.075	0.547	0.127	0.148
D(frequency of update)	0.307	0.184	0.184	0.141	0.184	0.107
E(traffic)	0.057	0.031	0.179	0.507	0.226	0.076
F(design optimization)	0.203	0.522	0.130	0.096	0.049	0.052
G(size)	0.221	0.562	0.063	0.120	0.034	0.042
H(number of items)	0.096	0.494	0.031	0.250	0.129	0.042
I(accessibility error)	0.030	0.342	0.194	0.342	0.092	0.030
J(markup validation)	0.047	0.336	0.139	0.445	0.033	0.021
K(broken link)	0.101	0.394	0.237	0.237	0.031	0.016

The last step in this method is to compute the final score of each website. Then the sum of each column represents the score of each single website. Table 5.9 depicts the final scores of website. The most important thing with regards to the final results, the website which has the highest score is suggested as the best website for AHP model.

Table 5.22 Final Result of e-government website based on AHP evaluation

Criteria	Singapore	Korea	Japan	Hongkong	Malaysia
A(load time)	0.070	0.136	0.018	0.036	0.009
B(response time)	0.016	0.056	0.029	0.090	0.006
C(page rank)	0.032	0.005	0.011	0.081	0.019
D(frequency of update)	0.033	0.020	0.020	0.015	0.020
E(traffic)	0.004	0.002	0.014	0.039	0.017
F(design optimization)	0.011	0.027	0.007	0.005	0.003
G(size)	0.009	0.024	0.003	0.005	0.001
H(number of items)	0.004	0.021	0.001	0.011	0.005
I(accessibility error)	0.001	0.010	0.006	0.010	0.003
J(markup validation)	0.001	0.007	0.003	0.009	0.001
K(broken link)	0.002	0.006	0.004	0.004	0.000
Sum	0.183	0.313	0.115	0.305	0.085
Rank	3	1	4	2	5

In accordance with the results generated by the proposed model, Hongkong website has the highest score of 0.305 in comparison with the rest of e-government website. As a result, the proposed AHP model rank for e-government website is: Korea (score: 0.313), Hongkong (score: 0.305), Singapore (score: 0.183), Japan (score: 0.115), and the last rank is Malaysia (score: 0.085).

5.2.3 E-government Fuzzy Analytical Hierarchy Process Model Website Evaluation

The Criteria involves in the website selection process using proposed FAHP model are load time (A), response time (B), page rank (C), frequency of update (D), traffic (E), design optimization (F), size (G), number of items (H), accessibility error (I), markup validation (J, and broken link (K). All of the data is displayed in Table 5.10.

After determining the attributes and performance results, the next step in the Fuzzy-Analytic Hierarchy Process is to perform a comparison of each attribute. The preference criteria matrix was obtained in Table 4.6 which compares each criterion to the others. Calculation of the e-government website samples based on FAHP are listed in Appendix A1. The last step in this method is to compute the final score of each website in Table 5.10. Then the sum of each column represents the score of each single website

Table 5.23 Weight criteria and e-government website based on FAHP

Website quality Criteria	Singapore	Korea	Japan	Hongkong	Malaysia	Weight
A(load time)	0.289	0.711	0.000	0.000	0.000	0.377
B(response time)	0.000	0.347	0.024	0.628	0.000	0.291
C(page rank)	0.092	0.000	0.000	0.908	0.000	0.216
D(frequency of update)	0.819	0.181	0.000	0.000	0.000	0.114
E(traffic)	0.000	0.000	0.093	0.454	0.454	0.003
F(design optimization)	0.171	0.829	0.000	0.000	0.000	0.000
G(size)	0.042	0.958	0.000	0.000	0.000	0.000
H(number of items)	0.000	1.000	0.000	0.000	0.000	0.000
I(accessibility error)	0.000	0.500	0.000	0.500	0.000	0.000
J(markup validation)	0.000	0.427	0.000	0.573	0.000	0.000
K(broken link)	0.000	0.598	0.402	0.000	0000	0.000

Table 5.11 depicts the final scores of website. The most important thing with regards to the final results, the website which has the highest score is suggested as the best website for the FAHP model.

Table 5.24 E-government final result website based on FAHP

Website quality Criteria	Singapore	Korea	Japan	Hongkong	Malaysia
A(load time)	0.109	0.268	0.000	0.000	0.000
B(response time)	0.000	0.101	0.007	0.183	0.000
C(page rank)	0.020	0.000	0.000	0.196	0.000
D(frequency of update)	0.093	0.021	0.000	0.000	0.000
E(traffic)	0.000	0.000	0.000	0.001	0.001
F(design optimization)	0.000	0.000	0.000	0.000	0.000
G(size)	0.000	0.000	0.000	0.000	0.000
H(number of items)	0.000	0.000	0.000	0.000	0.000
I(accessibility error)	0.000	0.000	0.000	0.000	0.000
J(markup validation)	0.000	0.000	0.000	0.000	0.000
K(broken link)	0.000	0.000	0.000	0.000	0.000
Total	0.222	0.390	0.007	0.380	0.001
Rank	3	1	4	2	5

5.2.4 E-government Hybrid Linear Fuzzy Model Website Evaluation

Hybrid method combines two previous evaluation methods used before. This model is a combination between LWM and FAHP. This method assigns weights of samples using LWM and weights of criteria using FAHP process. This model result is shown in Table 5.12

Table 5.25 Maxium minimum criteria based on HM

Criteria	Type	Singapore	Korea	Japan	Hongkong	Malaysia	Weight
A	Max	0.605	1.000	0.111	0.461	0.000	0.377
B	max	0.759	0.962	0.815	1.000	0.000	0.291
C	min	0.263	0.000	0.172	1.000	0.220	0.216
D	min	1.000	1.000	1.000	0.000	1.000	0.114
E	min	0.048	0.000	0.399	1.000	0.410	0.003
F	min	0.443	1.000	0.414	0.314	0.000	0.000
G	max	0.651	1.000	0.222	0.468	0.000	0.000
H	max	0.576	1.000	0.000	0.763	0.644	0.000
I	max	0.000	1.000	0.946	1.000	0.595	0.000
J	max	0.013	0.974	0.766	1.000	0.000	0.000
K	Max	0.556	1.000	0.889	0.889	0.000	0.000

By applying Hybrid model between FAHP and LWM approach for website evaluation has resulted in significant reducing of computation, raised the overall speed and effectiveness with respect to the underlying methodology and ultimately enabled more efficient and significantly procedure compared with other methods.

Table 5.26 Final result for e-government website

Criteria	Type	Singapore	Korea	Japan	Hongkong	Malaysia
A	Max	0.228	0.377	0.042	0.174	0.000
B	Max	0.221	0.280	0.237	0.291	0.000
C	Min	0.057	0.000	0.037	0.216	0.047
D	Min	0.114	0.114	0.114	0.000	0.114
E	Min	0.000	0.000	0.001	0.003	0.001
F	Min	0.000	0.000	0.000	0.000	0.000
G	Max	0.000	0.000	0.000	0.000	0.000
H	Max	0.000	0.000	0.000	0.000	0.000
I	Max	0.000	0.000	0.000	0.000	0.000
J	Max	0.000	0.000	0.000	0.000	0.000
K	Max	0.000	0.000	0.000	0.000	0.000
Final result		0.620	0.771	0.431	0.683	0.162
Rank		3	1	4	2	5

Table 5.13 depicts the final scores of website. The most important thing with regards to the final results, the website which has the highest score is suggested as the best website for the proposed hybrid model. In accordance with the results generated by the proposed model, Korea e-government website has the highest score of 0.771 in comparison with the rest of e-government website. As a result, the proposed Hybrid model rank for e-government website is: Korea (score: 0.771), Hongkong (score: 0.683), Singapore (score: 0.620), Japan (score: 0.431), and the last rank is Malaysia (score: 0.162).

Table 5.27 Final result for e-government website performance based on evaluation

Method	Singapore	Korea	Japan	Hongkong	Malaysia
LWM	0.499(3)	0.766(1)	0.456(4)	0.672(2)	0.252(5)
AHP	0.183(3)	0.313(1)	0.115(4)	0.305(2)	0.085(5)
FAHP	0.222(3)	0.390(1)	0.007(4)	0.380(2)	0.001(5)
Hybrid	0.620(3)	0.771(1)	0.431(4)	0.683(2)	0.162(5)

Table 5.14 depicts the final ranking of e-government website based on four specific methods. In accordance with the results generated by the proposed model, Korea website has the highest in comparison with the rest of e-government website. As a result, in overall ranking for the proposed model rank for e-government website is:

Korea, Hongkong, Singapore, Japan, and Malaysia and the the rank is consistent using all the evaluation methods.

5.3 Airlines Website Evaluation

Similar with e-government websites, the first column in Table 5.15 shows the criteria of the airlines website quality. The criteria involves in the website selection process using proposed model consisting of eleven criteria. The second column and the rest of the columns represent the airlines website performance value.

Table 5.28 Original data of Asian airlines website

Criteria	SIA	KAL	JAL	CATHAY	MAS
A(load time)	91.91	5.16	35.50	42.23	0.32
B(response time)	1.35	1.92	1.56	1.10	1.52
C(page rank)	1180.00	919.00	326.00	1310.00	765.00
D(frequency of update)	60.00	60.00	60.00	60.00	60.00
E(traffic)	971100.00	533000.00	410400.00	868200.00	861500.00
F(design optimization)	25.00	27.00	61.00	92.00	89.00
G(size)	408003.00	21865.00	123919.00	145666.00	582.00
H(number of items)	53.00	4.00	54.00	66.00	1.00
I(accessibility error)	2.00	12.00	0.00	26.00	0.00
J(markup validation)	141.00	25.00	0.00	444.00	1.00
K(broken link)	2.00	0.00	0.00	28.00	0.00

After determining the attributes and performance results, the next step in the evaluation process is to perform a comparison of each attribute. The preference criteria matrix was obtained comparing each criterion to the others. There are four models used in this research, Linear weightage Model (LWM), Analytical Hierarchy Process (AHP), Fuzzy Analytical Hierarchy Process (FAHP) and Hybrid Model (combination between LWM and FAHP).

5.3.1 Airlines Website LinearWeightage Model Website Evaluation

Table 5.16 presents the original data and maximum minimum criteria of airlines website associated with each of the website quality criteria based on the evaluation of their contribution toward overall quality using LWM model.

Table 5.29 Maxium minimum criteria of Asian airlines website based on LWM

Criteria	SIA	KAL	JAL	CATHAY	MAS
A max	91.91	5.16	35.50	42.23	0.32
B max	1.35	1.92	1.56	1.10	1.52
C min	1180.00	919.00	326.00	1310.00	765.00
D min	60.00	60.00	60.00	60.00	60.00
E min	971100.00	533000.00	410400.00	868200.00	861500.00
F min	25.00	27.00	61.00	92.00	89.00
G max	408003.00	21865.00	123919.00	145666.00	582.00
H max	53.00	4.00	54.00	66.00	1.00
I max	2.00	12.00	0.00	26.00	0.00
J max	141.00	25.00	0.00	444.00	1.00
K max	2.00	0.00	0.00	28.00	0.00

By implementing equations (4.1) and (4.2) every cell in the Table 5.16 will be converted into normalized data and depicted in Table 5.17.

Table 5.30 Normalized data of Asian airlines website based on LWM

Criteria	SIA	KAL	JAL	CATHAY	MAS
A	0.000	0.947	0.616	0.542	1.000
B	0.693	0.000	0.437	1.000	0.490
C	0.868	0.603	0.000	1.000	0.446
D	1.000	1.000	1.000	1.000	1.000
E	1.000	0.219	0.000	0.816	0.805
F	0.000	0.030	0.537	1.000	0.955
G	0.000	0.948	0.697	0.644	1.000
H	0.200	0.954	0.185	0.000	1.000
I	0.923	0.538	1.000	0.000	1.000
J	0.682	0.944	1.000	0.000	0.998
K	0.93	1.00	1.00	0.00	1.00

The weight which represents criteria in this website is designed similar with e-government website. The next step is to get the weight for every criterion by normalized the data in Table 5.18. The steps applied to the criteria matrix and weights will be calculated.

Table 5.31 Final Result for Asian airlines website based on LWM

Website	SIA	KAL	JAL	CATHAY	MAS	Weight
A	0.000	0.947	0.616	0.542	1.000	0.16
B	0.693	0.000	0.437	1.000	0.490	0.14
C	0.868	0.603	0.000	1.000	0.446	0.12
D	1.000	1.000	1.000	1.000	1.000	0.11
E	1.000	0.219	0.000	0.816	0.805	0.11
F	0.000	0.030	0.537	1.000	0.955	0.11
G	0.000	0.948	0.697	0.644	1.000	0.09
H	0.200	0.954	0.185	0.000	1.000	0.07
I	0.923	0.538	1.000	0.000	1.000	0.05
J	0.682	0.944	1.000	0.000	0.998	0.04
K	0.93	1.00	1.00	0.00	1.00	0.02
Sum	0.517	0.584	0.500	0.702	0.835	
Rank	4	3	5	2	1	

After conducting some calculations during this evaluation process, the last step in this procedure was computing the final score of each website. Then the sum of each column represents the score of each website. Table 5.18 depicts the final scores of airlines website based on LWM evaluation method. In accordance with the results generated by the proposed model, Malaysia Airlines website has the highest score of 0.84 in comparison with the rest of the airlines website. As a result, the proposed LWM model rank for the airlines website is: Malaysia Airlines (score: 0.835), Cathay Pacific Airlines (score: 0.702), Korea Airlines (score: 0.584), Singapore Airlines (score: 0.517), and the last rank is Japan Airlines (score: 0.500).

5.3.2 Airline Analytical Hierarchy Process Model Website Evaluation

Table 5.19 presents the weights of airlines website associated with each of the website quality criteria, based on the evaluation of their contribution toward overall quality using AHP model. Weights of airlines website associated with each of the website quality criteria are taken from table 5.7, while weight for criteria based on AHP is calculated in Appendix A2.

Table 5.32 Weight of criteria and Asian airline website based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS	Weight
A(load time)	0.030	0.286	0.157	0.095	0.433	0.270
B(response time)	0.259	0.058	0.110	0.413	0.159	0.197
C(page rank)	0.253	0.136	0.033	0.506	0.071	0.148
D(frequency of update)	0.200	0.200	0.200	0.200	0.200	0.107
E(traffic)	0.418	0.101	0.055	0.253	0.172	0.076
F(design optimization)	0.040	0.058	0.183	0.410	0.309	0.052
G(size)	0.074	0.285	0.117	0.085	0.439	0.042
H(number of items)	0.085	0.308	0.064	0.035	0.509	0.042
I(accessibility error)	0.211	0.116	0.313	0.048	0.313	0.030
J(markup validation)	0.069	0.172	0.416	0.029	0.313	0.021
K(broken link)	0.147	0.272	0.272	0.036	0.272	0.016

The last step in this method is to compute the final score of each website. Then the sum of each column represents the score of each website. Table 5.20 depicts the final scores of website. The most important thing with regards to the final results, the website which has the highest score is suggested as the best website for AHP model.

Table 5.33 Final Result of Asian airlines website based on AHP evaluation

Criteria	SIA	KAL	JAL	CATHAY	MAS
A(load time)	0.008	0.077	0.042	0.026	0.117
B(response time)	0.051	0.011	0.022	0.081	0.031
C(page rank)	0.037	0.020	0.005	0.075	0.011
D(frequency of update)	0.021	0.021	0.021	0.021	0.021
E(traffic)	0.032	0.008	0.004	0.019	0.013
F(design optimization)	0.002	0.003	0.010	0.021	0.016
G(size)	0.003	0.012	0.005	0.004	0.018
H(number of items)	0.004	0.013	0.003	0.001	0.021
I(accessibility error)	0.006	0.003	0.009	0.001	0.009
J(markup validation)	0.001	0.004	0.009	0.001	0.007
K(broken link)	0.002	0.004	0.004	0.001	0.004
Sum	0.169	0.177	0.134	0.252	0.269
Rank	4	3	5	2	1

In accordance with the results generated by the proposed model, Malaysia Airlines website has the highest score of 0.269 in comparison with the rest of Asian airlines website. As a result, the proposed AHP model rank for Asian airlines website is: Malaysia Airlines (score: 0.269), Cathay Pacific (score: 0.252), Korea Airlines (score:

0.177), Singapore Airlines (score: 0.169), and the last rank is Japan Airlines (score: 0.134).

5.3.3 Airline Fuzzy Analytical Hierarchy Process Model Website Evaluation

The preference criteria matrix was obtained in Table 4.6 which compares each criterion to the others. Table 5.21 displays weight criteria of Asian Airlins website based on AHP. Calculation of the airlines website samples based on FAHP are listed in Appendix A2.

Table 5.34 Weight Criteria and Asian airlines website based on FAHP

Website quality Criteria	SIA	KAL	JAL	CATHAY	MAS	Weight
A(load time)	0.000	0.364	0.107	0.000	0.529	0.377
B(response time)	0.284	0.000	0.167	0.401	0.148	0.291
C(page rank)	0.276	0.000	0.000	0.724	0.000	0.216
D(frequency of update)	0.200	0.200	0.200	0.200	0.200	0.114
E(traffic)	0.498	0.000	0.000	0.316	0.186	0.003
F(design optimization)	0.000.	0.000	0.207	0.417	0.376	0.000
G(size)	0.000	0.428	0.000	0.000	0.572	0.000
H(number of items)	0.000	0.389	0.000	0.000	0.611	0.000
I(accessibility error)	0.264	0.103	0.316	0.000	0.316	0.000
J(markup validation)	0.000	0.132	0.460	0.000	0.408	0.000
K(broken link)	0.144	0.285	0.285	0.000	0.285	0.000

The last step in this method is to compute the final score of each website. Then the sum of each column represents the score of each website. Table 5.22 depicts the final scores of website. The most important thing with regards to the final results, the website which has the highest score is suggested as the best website for the FAHP model.

Table 5.35 Asian airlines final result website based on FAHP

Website quality Criteria	SIA	KAL	JAL	CATHAY	MAS
A(load time)	0.000	0.137	0.040	0.000	0.199
B(response time)	0.083	0.000	0.049	0.117	0.043
C(page rank)	0.060	0.000	0.000	0.156	0.000
D(frequency of update)	0.023	0.023	0.023	0.023	0.023
E(traffic)	0.001	0.000	0.000	0.001	0.001
F(design optimization)	0.000	0.000	0.000	0.000	0.000
G(size)	0.000	0.000	0.000	0.000	0.000
H(number of items)	0.000	0.000	0.000	0.000	0.000
I(accessibility error)	0.000	0.000	0.000	0.000	0.000
J(markup validation)	0.000	0.000	0.000	0.000	0.000
K(broken link)	0.000	0.000	0.000	0.000	0.000
Total	0.167	0.160	0.112	0.297	0.266
Rank	3	4	5	1	2

In accordance with the results generated by the proposed model, Cathay Pacific website has the highest score of 0.297 in comparison with the rest of airlines website. As a result, the proposed FAHP model rank for airlines website is: Cathay Pacific (score: 0.297), Malaysia Airlines (score: 0.266), Singapore Airlines (score: 0.167), Korea Airlines (score: 0.167), and the last rank is Japan Airlines (score: 0.112).

5.3.4 Airlines Hybrid Linear Fuzzy Model Website Evaluation

Table 5.23 presents the weights of airlines website associated with each of the website quality criteria, based on the evaluation of their contribution toward overall quality using Hybrid model.

Table 5.36 Maxium Minimum Criteria

Criteria	Type	SIA	KAL	JAL	CATHAY	MAS	Weight
A	Max	0.000	0.947	0.616	0.542	1.000	0.377
B	Max	0.693	0.000	0.437	1.000	0.490	0.291
C	Min	0.868	0.603	0.000	1.000	0.446	0.216
D	Min	1.000	1.000	1.000	1.000	1.000	0.114
E	Min	1.000	0.219	0.000	0.816	0.805	0.003
F	Min	0.000	0.030	0.537	1.000	0.955	0.000
G	Max	0.000	0.948	0.697	0.644	1.000	0.000
H	Max	0.200	0.954	0.185	0.000	1.000	0.000
I	Max	0.923	0.538	1.000	0.000	1.000	0.000
J	Max	0.682	0.944	1.000	0.000	0.998	0.000
K	Max	0.929	1.000	1.000	0.000	1.000	0.000

Table 5.23 depicts the final scores of website. The most important thing with regards to the final results, the website which has the highest score is suggested as the best website for the proposed Hybrid model.

Table 5.37 Final result for Asian airlines website based on HM

Criteria	Type	SIA	KAL	JAL	CATHAY	MAS
A	Max	0.000	0.357	0.232	0.205	0.377
B	Max	0.201	0.000	0.127	0.291	0.142
C	Min	0.187	0.130	0.000	0.216	0.096
D	Min	0.114	0.114	0.114	0.114	0.114
E	Min	0.003	0.001	0.000	0.002	0.002
F	Min	0.000	0.000	0.000	0.000	0.000
G	Max	0.000	0.000	0.000	0.000	0.000
H	Max	0.000	0.000	0.000	0.000	0.000
I	Max	0.000	0.000	0.000	0.000	0.000
J	Max	0.000	0.000	0.000	0.000	0.000
K	Max	0.000	0.000	0.000	0.000	0.000
Final result		0.505	0.602	0.473	0.827	0.732
Rank		4	3	5	1	2

Cathay Pacific website has the highest score of 0.827 in comparison with the rest of airlines website. As a result, the proposed hybrid model rank for the airlines website is: Cathay Pacific (score: 0.827), Malaysia Airlines (score: 0.732), Korea Airlines (score: 0.602), Singapore Airlines (score: 0.505), and the last rank is Japan Airlines (score: 0.473). Table 5.25 presents the ranking weight of airlines website associated with each of the website quality criteria, based on the evaluation of their contribution toward overall quality using LWM, AHp, FAHP and HM.

Table 5.38 Final result for Asian airlines Website Performance

Method	SIA	KAL	JAL	CATHAY	MAS
LWM	0.517(4)	0.584(3)	0.500(5)	0.702(2)	0.835(1)
AHP	0.169(4)	0.177(3)	0.134(5)	0.252(2)	0.269(1)
FAHP	0.166(3)	0.160(4)	0.112(5)	0.297(1)	0.266(2)
Hybrid	0.505(4)	0.602(3)	0.473(5)	0.827(1)	0.732(2)

Table 5.25 depicts the final ranking of Asian airlines website based on four specific methods. Malaysia Airlines website has the highest in comparison with the rest of airlines website for LWM and AHP methods. As a result, the evaluation model ranking

(LWM and AHP) for the airlines website is: Malaysian Airlines, Cathay Pacific, Korea Airlines, Singapore Airlines, and Japan Airlines. Inconsistency occurred for the FAHP and hybrid model, because the ranking list for FAHP method is: Cathay Pacific, Malaysia Airlines, Singapore Airlines, Korea Airlines and Japan Airlines, while using Hybrid model the ranking list are : Cathay Pacific, Malaysia Airlines, Korea Airlines, Singapore Airlines and Japan Airlines.

5.4 Malaysian University Website Evaluation

University portal and website are sites that serve as a gateway to a large amount of information related with all academic activities. University portal webpages are often divided into subsections called portlets, or channels, and are accessible to both public and inside campus audiences. For example, google.com serves as a public point of access to a multitude of information ranging from news and mail to blog reviews and document. Universities sometimes use portal website as secure points of access for employee or student to get information and also give services to support academic activities. Through this portal, faculty staff may access student class lists and enter grades, and students may access course materials, grades, and job placement information. One important benefit of a university portal at the institutional level is the ability to access all of the information using only a single sign-on [158, 159]. There are many tools that are being used to build university portals. One of the examples for these tools is open source. Open source allowed educational institutions to use this services and avoid redundant work in developing a user interface and navigation [160]. Recently, a review of 23 educational portals, there is a stable growth in portal usage, increased numbers of features offered and increased collaboration within organizations [159]. While the idea of a single point of access for quick and easy access to critical academic information sounds idyllic, designers of such interfaces are faced with the challenges of presenting the material in a good performance and high quality website. This factor becomes especially challenging as access to more information from university becomes available and the size of the portal or website interface increases.

The first column in Table 5.26 shows the criteria of the quality website. The criteria involve in the website selection process using proposed model are load time (A), response time (B), page rank (C), frequency of update (D), traffic (E), design optimization (F), size (G), number of items (H), accessibility error (I), markup validation (J), and broken link (K) and shows the measurement unit, and the rest of the columns represent the country airlines performance value.

Table 5.39 Original data of Malaysian university website

Criteria	USM	UPM	UKM	UUM	UTP
A(load time)	95.51	85.23	3.59	12.04	97.58
B(response time)	2.40	2.05	2.33	0.73	1.85
C(page rank)	778.00	844.00	377.00	313.00	152.00
D(frequency of update)	60.00	60.00	30.00	60.00	30.00
E(traffic)	185700.00	377300.00	359000.00	174600.00	90400.00
F(design optimization)	29.50	39.00	30.00	26.50	63.50
G(size)	456135.00	381465.00	16025.00	41366.00	478578.00
H(number of items)	23.00	46.00	2.00	19.00	11.00
I(accessibility error)	26.00	42.00	9.00	0.00	5.00
J(markup validation)	158.00	234.00	20.00	2.00	86.00
K(broken link)	1.00	19.00	3.00	0.00	1.00

The results of the website quality test based on load time, response time, page rank, frequency of update, traffic, design optimization, size, number of items, accessibility error, markup validation, and broken link are also displayed in Table 5.26. The data in Table 5.26 shows that most of the Malaysian University websites cannot fulfill the criteria as a high quality website. Most of server response, load times, size, and number of items exceed the value standardized by IBM, except University Kebangsaan Malaysia website in load time, size, and number of items criteria. Implementation of the W3C's HTML validator highlighted that none of the university website had HTML 4.01 valid entry page, most of them did not have DOCTYPE declarations. Consequences of this problem will be on the portability and development of the website. In terms of broken link, four Malaysian university websites or 80% of the sample had a broken link. After determining the attributes and performance results, the next step in the evaluation process was to perform a comparison of each attribute. The preference criteria matrix was obtained which compare each criterion against the others, then continue by analyzing this data using Linear weightage Model (LWM), Analytical Hierarchy Process (AHP), Fuzzy-Analytical Hierarchy Process (FAHP) and Hybrid Model (combination between LWM and FAHP).

5.4.1 Malaysian University Linear Weightage Model Website Evaluation

Table 5.27 presents the original data and maximum and minimum criteria of Malaysian university websites associated with each of the website quality criteria based on the evaluation of their contribution toward overall quality using LWM model.

Table 5.40 Maxium minimum criteria of Malaysian university website based on LWM

Criteria	USM	UPM	UKM	UUM	UTP
A max	95.51	85.23	3.59	12.04	97.58
B max	2.40	2.05	2.33	0.73	1.85
C min	778.00	844.00	377.00	313.00	152.00
D min	60.00	60.00	30.00	60.00	30.00
E min	185700.00	377300.00	359000.00	174600.00	90400.00
F min	29.50	39.00	30.00	26.50	63.50
G max	456135.00	381465.00	16025.00	41366.00	478578.00
H max	23.00	46.00	2.00	19.00	11.00
I max	26.00	42.00	9.00	0.00	5.00
J max	158.00	234.00	20.00	2.00	86.00
K max	1.00	19.00	3.00	0.00	1.00

By implementing equations (4.1) and (4.2) every cell in the Table 5.27 will be converted into normalized data and depicted in Table 5.28.

Table 5.41 Normalized data of Malaysian university website based on LWM

Criteria	USM	UPM	UKM	UUM	UTP
A	0.02	0.13	1.00	0.91	0.00
B	0.00	0.21	0.04	1.00	0.33
C	0.90	1.00	0.33	0.23	0.00
D	1.00	1.00	0.00	1.00	0.00
E	0.33	1.00	0.94	0.29	0.00
F	0.08	0.34	0.09	0.00	1.00
G	0.05	0.21	1.00	0.95	0.00
H	0.52	0.00	1.00	0.61	0.80
I	0.38	0.00	0.79	1.00	0.88
J	0.33	0.00	0.92	1.00	0.64
K	0.95	0.00	0.84	1.00	0.95

Based on previous calculation in e-government and airlines websites, total weight criteria is 57, and then all of the weights of the criteria are divided by the total sum. The next step is to get the weight for every criterion by normalized the data in Table 5.29. The steps applied to the criteria matrix and weights will be calculated.

Table 5.42 Final Result for Malaysian university website based on LWM

Criteria	USM	UPM	UKM	UUM	UTP	Weight
A	0.022	0.131	1.000	0.910	0.000	0.158
B	0.000	0.206	0.038	1.000	0.328	0.140
C	0.905	1.000	0.325	0.233	0.000	0.123
D	1.000	1.000	0.000	1.000	0.000	0.105
E	0.332	1.000	0.936	0.293	0.000	0.105
F	0.081	0.338	0.095	0.000	1.000	0.105
G	0.049	0.210	1.000	0.945	0.000	0.088
H	0.523	0.000	1.000	0.614	0.795	0.070
I	0.381	0.000	0.786	1.000	0.881	0.053
J	0.328	0.000	0.922	1.000	0.638	0.035
K	0.947	0.000	0.842	1.000	0.947	0.018
Sum	0.352	0.437	0.558	0.680	0.293	1
Rank	4	3	2	1	5	

After conducting some calculations during this evaluation process, the last step in this procedure was computing the final score of each website. Then the sum of each column represents the score of each website. Table 5.29 depicts the final scores of website based on LWM evaluation method. Related with the results generated by the proposed model, Universiti Utara Malaysia website has the highest score of 0.680 in comparison with the rest of the other websites. As a result, the proposed LWM model rank for the university website is: Universiti Utara Malaysia (score: 0.680), Univesiti Kebangsaan Malaysia (score: 0.558), Universiti Putra Malaysia (score: 0.437), Universiti Sains Malaysia (score: 0.352), and the last rank is Universiti Teknologi PETRONAS (score: 0.293).

5.4.2 Malaysian University Analytical Hierarchy Process Model Website Evaluation

Calculation yields the normalized matrix of criteria as illustrated in Table 5.30. Weights of airlines website associated with each of the website quality criteria is taken from Table 5.7.

Table 5.43 Weight of criteria and Malaysian university website based on AHP

Website	USM	UPM	UKM	UUM	UTP	Weight
A(load time)	0.053	0.095	0.508	0.307	0.037	0.270
B(response time)	0.042	0.128	0.064	0.553	0.212	0.197
C(page rank)	0.275	0.475	0.121	0.092	0.038	0.148
D(frequency of update)	0.286	0.286	0.095	0.286	0.047	0.107
E(traffic)	0.116	0.464	0.303	0.080	0.037	0.076
F(design optimization)	0.076	0.254	0.119	0.049	0.502	0.052
G(size)	0.053	0.102	0.505	0.305	0.036	0.042
H(number of items)	0.077	0.033	0.489	0.141	0.260	0.042
I(accessibility error)	0.080	0.032	0.193	0.443	0.252	0.030
J(markup validation)	0.071	0.032	0.260	0.480	0.156	0.021
K(broken link)	0.237	0.029	0.124	0.373	0.237	0.016

The last step in this method is to compute the final score of each website. Then sum of each column represents the score of each website. Table 5.31 depicts the final scores of website. The most important thing with regards to the final results, the website which has the highest score is suggested as the best website for AHP model.

Table 5.44 Final Result of Malaysian university website based on AHP

Criteria	USM	UPM	UKM	UUM	UTP
A(load time)	0.014	0.026	0.137	0.083	0.010
B(response time)	0.008	0.025	0.013	0.109	0.042
C(page rank)	0.041	0.070	0.018	0.014	0.006
D(frequency of update)	0.031	0.031	0.010	0.031	0.005
E(traffic)	0.009	0.035	0.023	0.006	0.003
F(design optimization)	0.004	0.013	0.006	0.003	0.026
G(size)	0.002	0.004	0.021	0.013	0.002
H(number of items)	0.003	0.001	0.021	0.006	0.011
I(accessibility error)	0.002	0.001	0.006	0.013	0.008
J(markup validation)	0.001	0.001	0.005	0.010	0.003
K(broken link)	0.004	0.000	0.002	0.006	0.004
Sum	0.120	0.208	0.262	0.293	0.118
Rank	4	3	2	1	5

In accordance with the results generated by the proposed model, Universiti Utara Malaysia website has the highest score of 0.293 in comparison with the rest of the other websites. As a result, the proposed AHP model rank for the university website is: Universiti Utara Malaysia (score: 0.293), Univesiti Kebangsaan Malaysia (score: 0.262), Universiti Putra Malaysia (score: 0.208), Universiti Sains Malaysia (score: 0.120), and the last rank is Universiti Teknologi PETRONAS (score: 0.118).

5.4.3 Malaysian University Fuzzy Analytical Hierarchy Process Model Website Evaluation

Criteria involve in the website selection process using proposed FAHP model are displayed in Table 4.6. The preference criteria matrix which compare each criterion to the others was obtained and displayed in Table 4.8. After determining the attributes and performance results, the next step in the Fuzzy-Analytic Hierarchy Process is to perform a comparison of each attributes. Calculation of the Malaysian university website samples based on FAHP are listed in Appendix A3. The last step in this method is to compute the final score of each website in Table 5.32. Then the sum of each column represents the score of each single website

Table 5.45 Weight criteria and Malaysian university website based on FAHP

Website quality Criteria	USM	UPM	UKM	UUM	UTP	Weight
A(load time)	0.000	0.000	0.613	0.387	0.000	0.377
B(response time)	0.000	0.000	0.000	0.933	0.067	0.291
C(page rank)	0.000	1.000	0.000	0.000	0.000	0.216
D(frequency of update)	0.333	0.333	0.333	0.333	0.333	0.114
E(traffic)	0.000	0.549	0.451	0.000	0.000	0.003
F(design optimization)	0.000	0.000	0.000	0.000	1.000	0.000
G(size)	0.000	0.000	0.843	0.157	0.000	0.000
H(number of items)	0.000	0.000	0.683	0.000	0.317	0.000
I(accessibility error)	0.000	0.000	0.176	0.488	0.337	0.000
J(markup validation)	0.000	0.000	0.314	0.686	0.000	0.000
K(broken link)	0.257	0.000	0.000	0.524	0.219	0.000

Table 5.33 depicts the final scores of website. The most important thing is regarding the final results, the website which has the highest score is suggested as the best website for the FAHP model.

Table 5.46 Malaysian university final result website based on FAHP

Website quality Criteria	USM	UPM	UKM	UUM	UTP
A(load time)	0.000	0.000	0.231	0.146	0.000
B(response time)	0.000	0.000	0.000	0.272	0.019
C(page rank)	0.000	0.216	0.000	0.000	0.000
D(frequency of update)	0.038	0.038	0.038	0.038	0.038
E(traffic)	0.000	0.002	0.001	0.000	0.000
F(design optimization)	0.000	0.000	0.000	0.000	0.000
G(size)	0.000	0.000	0.000	0.000	0.000
H(number of items)	0.000	0.000	0.000	0.000	0.000
I(accessibility error)	0.000	0.000	0.000	0.000	0.000
J(markup validation)	0.000	0.000	0.000	0.000	0.000
K(broken link)	0.000	0.000	0.000	0.000	0.000
Total	0.038	0.256	0.270	0.455	0.057
Rank	5	3	2	1	4

Universiti Utara Malaysia website has the highest score of 0.455 in comparison with the rest of the university websites. As a result, the proposed FAHP model rank for the university website is: Universiti Utara Malaysia (score: 0.455), Univesiti Kebangsaan Malaysia (score: 0.270), Universiti Putra Malaysia (score: 0.256), Universiti Teknologi PETRONAS (score: 0. 057), and the last rank is Universiti Sains Malaysia (score: 0.038).

5.4.4 Malaysian University Hybrid Linear Fuzzy Model Website Evaluation

Table 5.34 presents the weights of Malaysian university websites associated with each of the website quality criteria, based on the evaluation of their contribution toward overall quality using Hybrid model.

Table 5.47 Maxium minimum criteria based on HM

Criteria	Type	USM	UPM	UKM	UUM	UTP	Weight
A	Max	0.02	0.13	1.00	0.91	0.00	0.270
B	Max	0.00	0.21	0.04	1.00	0.33	0.197
C	Min	0.90	1.00	0.33	0.23	0.00	0.148
D	Min	1.00	1.00	0.00	1.00	0.00	0.107
E	Min	0.33	1.00	0.94	0.29	0.00	0.076
F	Min	0.08	0.34	0.09	0.00	1.00	0.052
G	Max	0.05	0.21	1.00	0.95	0.00	0.042
H	Max	0.52	0.00	1.00	0.61	0.80	0.042
I	Max	0.38	0.00	0.79	1.00	0.88	0.030
J	Max	0.33	0.00	0.92	1.00	0.64	0.021
K	Max	0.95	0.00	0.84	1.00	0.95	0.016

Table 5.35 depicts the final scores of website. The most important thing with regards to the final results, the website which has the highest score is suggested as the best website for the proposed Hybrid model. By applying Hybrid model between FAHP and LWM approach for website evaluation has resulted in significant reducing of computation, raised the overall speed and effectiveness with respect to the underlying methodology and ultimately enabled more efficient and significantly procedure compared with other methods.

Table 5.48 Final result for university website based on HM

Criteria	Type	USM	UPM	UKM	UUM	UTP
A	Max	0.008	0.050	0.377	0.343	0.000
B	Max	0.000	0.060	0.011	0.291	0.095
C	Min	0.195	0.216	0.070	0.050	0.000
D	Min	0.114	0.114	0.000	0.114	0.000
E	Min	0.001	0.003	0.003	0.001	0.000
F	Min	0.000	0.000	0.000	0.000	0.000
G	Max	0.000	0.000	0.000	0.000	0.000
H	Max	0.000	0.000	0.000	0.000	0.000
I	Max	0.000	0.000	0.000	0.000	0.000
J	Max	0.000	0.000	0.000	0.000	0.000
K	Max	0.000	0.000	0.000	0.000	0.000
Final result		0.318	0.441	0.461	0.799	0.095
Rank		4	3	2	1	5

In accordance with the results generated by the proposed model, Universiti Utara Malaysia website has the highest score of 0.799 in comparison with the rest of the university websites. As a result, the proposed Hybrid model rank for the university website is: Univesiti Utara Malaysia (score: 0.799), Universiti Kebangsaan Malaysia (score: 0.461), Universiti Putra Malaysia (score: 0.441), Universiti Sains Malaysia (score: 0.318), and the last rank is Universiti Teknologi PETRONAS (score: 0.095).

Table 5.49 Final result for Malaysian university website performance

Method	USM	UPM	UKM	UUM	UTP
LWM	0.35(4)	0.44(3)	0.56(2)	0.68(1)	0.29(5)
AHP	0.120(4)	0.208(3)	0.262(2)	0.293(1)	0.118(5)
FAHP	0.038(5)	0.256(3)	0.270(2)	0.455(1)	0.057(4)
Hybrid	0.318(4)	0.441(3)	0.461(2)	0.799(1)	0.095(5)

Table 5.36 depicts the final scores of Malaysian university websites based on four evaluation methods, Universiti Utara Malaysia has the highest in score in all four methods: LWM, AHP, FAHP, and HM. Inconsistency occurred for the FAHP model, different with the other three models, because there is an exchange rank position for Universiti Sains Malaysia rank 5, and Universiti Teknologi PETRONAS rank 4.

5.5 Statistical Test

In order to analyze whether there are differences among the ranking composition methods, the Friedman test was done [139]. When the null-hypothesis is rejected by the Friedman test, a post-hoc can be done to detect which differences among the methods are significant.

5.5.1 More than two sample tests (Friedman Test)

Friedman test procedures are based on e-government website ranking for four evaluation method in table 5.37.

Table 5.50 E-government website ranking based on method

Original Data						Ranked Data					
	Country	LWM	AHP	FAHP	Hybrid		country	LWM	AHP	FAHP	Hybrid
1	Singapore	0.499	0.183	0.222	0.620	1	Singapore	3	1	2	4
2	Korea	0.766	0.313	0.39	0.771	2	Korea	3	1	2	4
3	Japan	0.456	0.115	0.007	0.431	3	Japan	4	2	1	3
4	Hongkong	0.672	0.305	0.380	0.683	4	Hongkong	3	1	2	4
5	Malaysia	0.252	0.085	0.001	0.162	5	Malaysia	4	2	1	3
							SR_i	17	7	8	18

To check the ranking, note that the sum of the four rank sums is 17 + 7 + 8 + 18 = 50, and the sum of the c numbers in a row is $\frac{c(c+1)}{2}$. However, there are r rows, so multiply the expression by r. So $\sum SR_i = \frac{rc(c+1)}{2} = \frac{5(4)(5)}{2} = 50$. Similar procedures also applied for the airlines websites ranking in Table 5.38.

Table 5.51 Airlines website ranking based on method

Original Data						Ranked Data					
		LWM	AHP	FAHP	Hybrid			LWM	AHP	FAHP	Hybrid
1	SIA	0.517	0.169	0.166	0.505	1	SIA	4	2	1	3
2	KAL	0.584	0.177	0.160	0.602	2	KAL	3	2	1	4
3	JAL	0.500	0.134	0.112	0.473	3	JAL	4	2	1	3
4	CATHAY	0.702	0.252	0.297	0.827	4	CATHAY	3	1	2	4
5	MAS	0.835	0.269	0.266	0.732	5	MAS	4	2	1	3
							SR_i	18	9	6	17

Last ranking based on four evaluation method for Malaysian university is displayed in Table 5.39.

Table 5.52 Malaysian university websites ranking based on method

Original Data						Ranked Data					
		LWM	AHP	FAHP	Hybrid			LWM	AHP	FAHP	Hybrid
1	USM	0.352	0.120	0.038	0.318	1	USM	4	2	1	3
2	UPM	0.437	0.208	0.256	0.441	2	UPM	3	1	2	4
3	UKM	0.558	0.262	0.270	0.461	3	UKM	4	1	2	3
4	UUM	0.680	0.293	0.455	0.799	4	UUM	3	1	2	4
5	UTP	0.293	0.118	0.057	0.095	5	UTP	4	3	1	2
							SRi	18	8	8	16

Now compute the Friedman statistic,

$$\chi_F^2 = \left[\frac{12}{rc(c+1)}\sum_j (SR_j^2)\right] - 3r(c+1)$$

$$\chi^2(\text{e}-\text{government}) = \left[\frac{12}{(5)(4)(5)}((17)^2 + (7)^2 + (8)^2 + (18)^2\right] - 3(5)(5) =$$

$$\left[\frac{12}{100}(726)\right] - 75 = 12.12$$

$$\chi^2(\text{airlines}) = \left[\frac{12}{(5)(4)(5)}((18)^2 + (9)^2 + (6)^2 + (17)^2\right] - 3(5)(5) = \left[\frac{12}{100}(730)\right] - 75 = 12.60$$

$$\chi^2(\text{university}) = \left[\frac{12}{(5)(4)(5)}((18)^2 + (8)^2 + (8)^2 + (16)^2\right] - 3(5)(5) =$$

$$\left[\frac{12}{100}(708)\right] - 75 = 9.96$$

In the Friedman table, the p-value for four columns and 5 rows with $\chi_F^2 = 12.12$ is 0.007, $\chi_F^2 = 12.6$ is 0.0056, and $\chi_F^2 = 9.96$ is 0.0185. Since all of the p-value is below $\alpha = .05$, the null hypothesis is rejected. Since the computed FR statistic is greater than 7.815, the upper-tail critical value under the chi-square distribution having $c - 1 = 3$ degrees of freedom (Friedman Table), the null hypothesis is rejected at the 0.05 level of significant. It can be concluded that there are significant differences (as perceived by the raters) with respect to the rating produced at the four evaluation model.

5.5.2 Post Hoc Test

After there are significant differences among four evaluation model, determining which methods are different from one another must be done. To answer this question Bonferroni/Dunn's multiple comparison technique is used [161]. Using this method $p = 12k\,(k-1)$ hypotheses of the form:

$H(i,j)_0$: There is no difference in the mean average correlation coefficients between methods i and j.

$H(i,j)_1$: There are some differences in the mean average correlation coefficients between methods i and j.

The Bonferroni t statistic is used to investigate dependent comparisons among means. This test is only good for investigating the difference between two means (i.e. it can't compare Groups LWM and AHP vs. Groups FAHP and HM). The Bonferroni t test is the same as a normal pairwise comparison (t-test), but the critical value is different. As making many comparisons are allowed, familywise error has to be controlled by reducing the per comparison level. The overall level will be set to 0.05, and the individual per comparison levels will be equalled to 0.05 divided by the total number of possible comparisons. A total of 4C2 = 6 different pairwise comparisons between the four means can be made. In practice, not all of these comparisons can be done, but remember that the error rate will always have to be set according to the total number of possible comparisons.

Step 1: Calculate the t' statistics.

General formula: : $t^1 = \dfrac{\overline{x_1} - \overline{x_2}}{\sqrt{\dfrac{MS_{error}}{n} + \dfrac{MS_{error}}{n}}} = \dfrac{\overline{x_1} - \overline{x_2}}{\sqrt{\dfrac{2(MS_{error})}{n}}}$

$$SS_T = \sum_{i=1}^{4}\sum_{j=1}^{5} y_{ij}^2 - \frac{y^2}{N}$$

e-government = $(3)^2 + (3)^2 + (4)^2 + (3)^2 + (4)^2 + (1)^2 + (1)^2 + (2)^2 + (1)^2 + (2)^2 + (2)^2 + (2)^2 + (1)^2 + (2)^2 + (1)^2 + (4)^2 + (4)^2 + (3)^2 + (4)^2 + (3)^2 - \dfrac{(50)^2}{20} = 150 - 125 = 25$

airlines = $(4)^2 + (3)^2 + (4)^2 + (3)^2 + (4)^2 + (2)^2 + (2)^2 + (2)^2 + (1)^2 + (2)^2 + (1)^2 + (1)^2 + (1)^2 + (2)^2 + (1)^2 + (3)^2 + (4)^2 + (3)^2 + (4)^2 + (3)^2 - \dfrac{(50)^2}{20} = 150 - 125 = 25$

Malaysian university = $(4)^2 + (3)^2 + (4)^2 + (3)^2 + (4)^2 + (2)^2 + (1)^2 + (1)^2 + (1)^2 + (3)^2 + (1)^2 + (2)^2 + (2)^2 + (2)^2 + (1)^2 + (3)^2 + (4)^2 + (3)^2 + (4)^2 + (2)^2 - \frac{(50)^2}{20} = 150 - 125 = 25$

$$SS_{Treatment} = \sum_{i=1}^{4} \frac{y_i^2}{n} - \frac{y^2}{N}$$

e-government= $\frac{(17)^2 + (7)^2 + (8)^2 + (18)^2}{5} - \frac{(50)^2}{5} = \frac{726}{5} - \frac{(50)^2}{5} = 145.2 - 125 = 20.2$

airlines = $\frac{(18)^2 + (9)^2 + (6)^2 + (17)^2}{5} - \frac{(50)^2}{5} = \frac{730}{5} - \frac{(50)^2}{5} = 146 - 125 = 21$

Malaysian University = $\frac{(18)^2 + (8)^2 + (8)^2 + (16)^2}{5} - \frac{(50)^2}{5} = \frac{708}{5} - \frac{(50)^2}{5} = 141.6 - 125$

$= 16.6$

$SS_E \quad = SS_T - SS_{treatment}$

e-government = $25 - 20.2 = 4.8$

airlines = $25 - 21 = 4$

Malaysian university = = $25 - 16.6 = 8.4$

$$MS_{treatment} = \frac{SS_{treatment}}{a-1}$$

e-goverment = $\frac{20.2}{3} = 6.733$, airlines = $\frac{21}{3} = 7$, Malaysian university = $\frac{16.6}{3} = 5.53$

$$MS_E = \frac{SS_E}{[a(n\text{-}1)]}$$

e-government = $\frac{4.8}{[4(4)]} = 0.3$, airlines = $\frac{4}{[4(4)]} = 0.25$, Malaysian university = $\frac{8.4}{[4(4)]} =$

0.525

Table 5.53 Significance of difference between two means methods

	LWM vs AHP	LWM vs FAHP	LWM vs Hybrid	AHP vs FAHP	AHP vs Hybrid	FAHP vs Hybrid
General formula	$\frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{2(MS_{error})}{n}}}$	$\frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{2(MS_{error})}{n}}}$	$\frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{2(MS_{error})}{n}}}$	$\frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{2(MS_{error})}{n}}}$	$\frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{2(MS_{error})}{n}}}$	$\frac{\overline{x_1} - \overline{x_2}}{\sqrt{\frac{2(MS_{error})}{n}}}$
e-government	$\frac{3.4-1.4}{\sqrt{\frac{2(0.3)}{5}}}$	$\frac{3.4-1.6}{\sqrt{\frac{2(0.3)}{5}}}$	$\frac{3.4-3.6}{\sqrt{\frac{2(0.3)}{5}}}$	$\frac{1.4-1.6}{\sqrt{\frac{2(0.3)}{5}}}$	$\frac{1.4-3.6}{\sqrt{\frac{2(0.3)}{5}}}$	$\frac{1.6-3.6}{\sqrt{\frac{2(0.3)}{5}}}$
Result	= 5.780	= 5.202	= - 0.578	= -0.578	= - 6.358	= - 5.780
Airlines	$\frac{3.6-1.8}{\sqrt{\frac{2(0.25)}{5}}}$	$\frac{3.6-1.2}{\sqrt{\frac{2(0.25)}{5}}}$	$\frac{3.6-3.4}{\sqrt{\frac{2(0.25)}{5}}}$	$\frac{1.8-1.2}{\sqrt{\frac{2(0.25)}{5}}}$	$\frac{1.8-3.4}{\sqrt{\frac{2(0.25)}{5}}}$	$\frac{1.2-3.4}{\sqrt{\frac{2(0.25)}{5}}}$
Result	= 5.69	= 7.59	= 0.633	= 1.89	= - 5.06	= - 6.96
Malaysian university	$\frac{3.6-1.6}{\sqrt{\frac{2(0.525}{5}}}$	$\frac{3.6-1.6}{\sqrt{\frac{2(0.525}{5}}}$	$\frac{3.6-3.2}{\sqrt{\frac{2(0.525}{5}}}$	$\frac{1.6-1.6}{\sqrt{\frac{2(0.525}{5}}}$	$\frac{1.6-3.2}{\sqrt{\frac{2(0.525}{5}}}$	$\frac{1.6-3.2}{\sqrt{\frac{2(0.525}{5}}}$
Result	= 4.367	= 4.367	= 0.873	= 0	= - 3.493	= -3.493

Step 2: Set to the appropriate level.

so per comparison will be:

$$\alpha = \frac{\alpha_{FW}}{k}$$

$$= \frac{0.05}{4} = 0.0125,\ df = dfMS_{error} = 16$$

Step 3: Determine significance of comparisons.

Student's t tables do not contain a critical value for α=0.0125 so we have to look it up in the Dunn/Bonferroni t' table. The degrees of freedom = 16, and the number of comparison = 6. This gives a t' value: 3.008. Thus, the result for this test for e-government sector is ; LWM vs AHP: t' = 5.780 (significant), LWM vs. FAHP: t' = 5.202 (significant), LWM vs. Hybrid: t' = -0.578 (insignificant), AHP vs. FAHP : t' = -0.578 (insignificant), AHP vs. Hybrid : t' = -6.358 (significant), FAHP vs. Hybrid : t' = -5.780 (significant). Whereas, the result for airlines website sector for this significance test is; LWM vs AHP: t' = 5.69 (significant), LWM vs. FAHP: t' = 7.59 (significant), LWM vs. Hybrid: t' = 0.633 (insignificant), AHP vs. FAHP : t' = 1.89 (insignificant), AHP vs. Hybrid : t' = - 5.06 (insignificant), FAHP vs. Hybrid : t' = - 6.96 (significant). Finally, the result for Malaysian university sector for this significant test is; LWM vs AHP: t' = 4.367 (significant), LWM vs. FAHP: t' = 4.367 (significant), LWM vs. Hybrid: t' = 0.873 (insignificant), AHP vs. FAHP : t' = 0.00 (insignificant), AHP vs. Hybrid : t' = - 3.493 (significant), FAHP vs. Hybrid : t' = - 3.493 (significant). Therefore, it can be concluded that HM ranking method is significantly better than AHP and FAHP, and Hybrid ranking method are not significantly different with LWM.

5.5.3 Website Sector Performance

In this website quality evaluation step, the evaluators can analyze, assess, and compare final outcomes regarding stated goals. At this moment, final results shown in graphic diagrams (as illustrated in figure 5.1), and schemas depicting comparison of website sector based on their total score in four methods. This picture is a useful tool and source of information to analyze and draw conclusions about the quality of website based on sector.

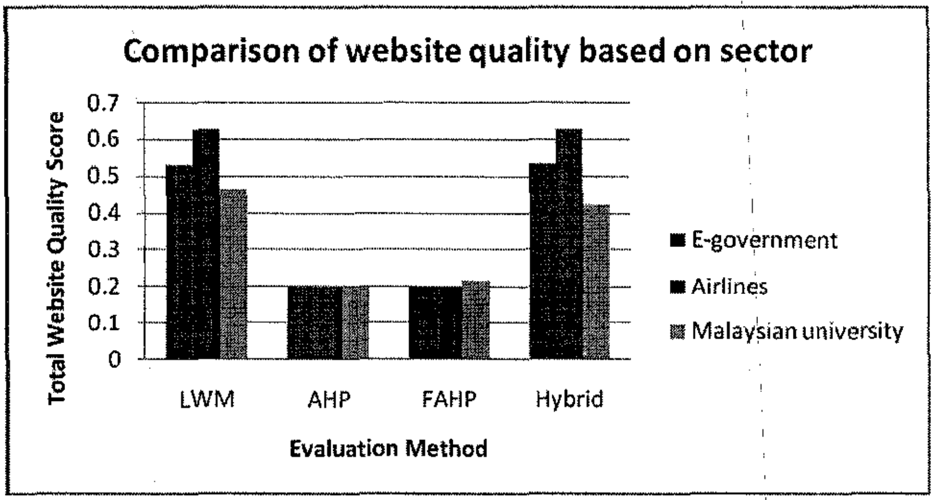

Figure 5.1 Comparison of Website Quality Based on Sector

The colored quality bars of fig. 5.1 indicate the total score based on sector observed in this research, defined as: e-government (blue), airlines (red), and Malaysian university (green). According to the results of the evaluation process of websites quality based on Hybrid method, Airlines sector has the highest average score compare to e-government and university, followed by e-government and Malaysian university as the last rank.

5.6 Summary of the chapter

In this chapter we evaluate the quality of Asian e-government websites. Using a series of online diagnostic tolls, we examined many dimensions of quality, and each dimension was measured by a specific test online. The result of this study confirmed that the website presence of Asian e-government website is neglecting performance and quality criteria. It is clear in the research that more effort is required to meet these criteria in the context of website design. This suggests that web developers responsible for e-government website should follow and encourage the use of recognised guidelines when designing website. To get results on the quality of a website, sample data from e-government website in five Asian countries are measured and load time, response time, page rank, frequency of update, traffic, design optimization, page size, number of item, accessibility error, markup validation, and broken link are calculated. Some methodologies for determining and evaluating the best e-government sites are used based on many criteria of website quality, consist of: Linear Weightage Model, Analytical Hierarchy Process, Fuzzy Analytical Hierarchy Process, and one Hybrid Model. This new hybrid model has been implemented using Linear Weightage Model and Fuzzy Analytical Hierarchy Process (FAHP) to generate the weights for the criteria which are much better and guaranteed more fairly preference of criteria.

CHAPTER 6

CONCLUSION

6.1 Summary

6.1.1 Purpose of the study

This dissertation was written with the objective of determining the factors influence website quality, finding available tools to generate an appraisal of quality and developing a new methodology for determining and evaluating the best Asian website based on many criteria of website quality consist of three sectors: e-government, airlines, and Malaysian university, namely to increase efficiency and reliability of the evaluation process. More specifically, this research determines quality factors that can be measured using online diagnostic tools in Asian website (e-government, airlines, and Malaysian university). Based on the criteria proposed, the researcher proposes the a new methodology for evaluating the quality of Asian website. With the data gathered and analyzed, this research also tries to determine the best ranking used by comparing four available methods (LWM, AHP, FAHP, and Hybrid Model).

6.1.2 Research Design

Using a series of online diagnostic tolls, the researcher examined many dimensions of quality, and each dimension will be measured by specific test online. Sample data from e-government website in five Asian countries, carrier flag of Asian airlines website from five countries and five Malaysian universities were measured then load time, response time, page rank, frequency of update, traffic, design optimization, page size, number of item, accessibility error, markup validation, and broken link were calculated as a website criteria. This research adopted the survey method for some reasons. Online test website evaluation tools play a bigger role in supplementing or substituting non-automated website evaluation tool. This decreases economic and non-economic cost for conducting non-automated website evaluations. Online website evaluation tools also allow the website designer or administrator to evaluate many websites and to detect potential problems as well as actual problems. This research uses various evaluation techniques in order to find an effective method to identify the quality of website. First, a set of criteria used in quality of website was collected from the literature, and an online test provided in the Internet was done to refine the criteria. The criteria were then translated into terms appropriate for quality, and a test online was conducted that went to a specified website and collected aspects of the website that correspond to the criteria. Our research aim is to examine four ranking methods (LWM, AHP, FAHP, and HM) and evaluate their ability to generate rankings which are consistent with the actual performance information, the issue whether there are significant differences between them is also investigated, and if there are, which method is preferable to the others.

6.2 Conclusion

The result of this study confirmed that criteria of website quality consist of eleven criteria (load time, response time, page rank, frequency of update, traffic, design optimization, size, number of items, accessibility error, markup validation, and broken link). This eleven criteria already represent high level concepts of Quality Models refer to, namely: usability (load time, response time, size, and accessibility), content (design optimization, markup validation, and number of items), navigability (broken link), management (frequency of update) and relationality (Hybrid model for evaluation). Online diagnostic tools provided in the Internet can be used to measure website quality related to criteria that was determined in this research. This decreases the economic and non-economic cost for conducting website evaluations. Online diagnostics tools also allow the website designer or researcher to evaluate many website and to detect potential problems as well as actual problems.

The website presence of Asian e-government website is neglecting performance and quality criteria. Most server response, load times, size, and number of items exceed the value standardized by IBM [46]. It is clear in the research more effort is required to meet with these criteria in the context of website design. This suggests that web developers responsible for Asian website should follow and encourage the use of recognised guidelines when designing website. Some methodologies for determining and evaluate the Asian website based on many criteria of website quality are proposed; consist of Linear Weightage Model, Analytical Hierarchy Process, Fuzzy Analytical Hierarchy Process, and one Hybrid Model. Based on statistical it can be concluded that LWM and HM ranking method are significantly better than AHP and FAHP ranking method, while comparison between LWM to HM and AHP to FAHP ranking method are insignificantly different. This hybrid model has been implemented using Linear Weightage Model and Fuzzy Analytical Hierarchy Process (AHP) to generate the weights for the criteria which are much better and guarantee more fairly preference of criteria. By applying Hybrid model between LWM and FAHP approach for website evaluation has resulted in significant acceleration of implementation, raised the overall effectiveness with respect to the underlying methodology and ultimately enabled more efficient and significantly equal or better procedure compared with other methods. According to the results of the evaluation process of websites quality based on Hybrid Method, Airlines sector has the highest average score compare to e-government and Malaysian university.

6.3 Recommendations for Further Study

Over the period of conducting this research, the researcher found some limitations and has come up with recommendations for further study of the Asian website quality. Future directions for this research are added criteria for evaluating website quality, such as availability and security aspect, also from the cultural perspective, since culture has an impact upon a website. Moreover, because the ultimate determinant of quality website is the users, future directions for this research also involve the objective and subjective views from user's perspective and other practitioner. This research could be repeated every year in order to gather time based data (longitudinal study). For example, the progress of the initiatives and its quality level could be plotted against time to measure the progress on year-to-year basis. Best practices that could be applied from other region that are already soaring in implementation of website application (e-government, e-commerce, and university) like European and North America need to be highlighted. This would benefit emerging economical power such as Asian countries and eliminates the need to reinvent the wheel.

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Appendix 1 E-goverment

AHP

Calculation yields the normalized matrix of criteria is illustrated in Table A1.1. The average weights of rows are computed in the last column to indicate the weights of the criteria.

Table A1.1 Original data of e-government load time matrix based on AHP

website	Singapore	Korea	Japan	Hongkong	Malaysia
Singapore	1.000	0.333	5.000	3.000	7.000
Korea	3.000	1.000	7.000	5.000	9.000
Japan	0.200	0.143	1.000	0.333	3.000
Hongkong	0.333	0.200	3.000	1.000	5.000
Malaysia	0.143	0.111	0.333	0.200	1.000
Sum	4.676	1.787	16.333	9.533	25.000

From the Table A1.1, the sum of Singapore load time is 4.676, Korea is 1.787, Japan is 16.333, Hongkong is 9.533, while Malaysia is 25.000. The next step is computing the value matrix by dividing all of the pairwise value with the sum of the column. The result of the criteria values matrix is displayed in Table A1.2.

Table A1.2 Normalize matrix for e-government load time based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia	Sum	Priority vector
Singapore	0.214	0.187	0.306	0.315	0.280	1.301	0.260
Korea	0.642	0.560	0.429	0.524	0.360	2.514	0.503
Japan	0.043	0.080	0.061	0.035	0.120	0.339	0.068
Hongkong	0.071	0.112	0.184	0.105	0.200	0.672	0.134
Malaysia	0.031	0.062	0.020	0.021	0.040	0.174	0.035
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A1.2 added two new columns, which are: row summation of the value based on country and priority vector column (sum column divide by total). In this table, Singapore has priority vector value of 0.260, Korea has 0.503, Japan has 0.068. Hongkong has 0.134, and Malaysia has 0.035. The highest weights (priority vector)

0.503 and 0.260 belong to the attributes Korea and Singapore respectively. The attribute Malaysia has the lowest weight 0.035.

Table A1.3 Original data of e-government response time matrix based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia
Singapore	1.000	0.200	0.333	0.167	5.000
Korea	5.000	1.000	3.000	0.500	7.000
Japan	3.000	0.333	1.000	0.200	7.000
Hongkong	6.000	2.000	5.000	1.000	9.000
Malaysia	0.200	0.143	0.143	0.111	1.000
Sum	15.200	3.676	9.476	1.978	29.000

From the Table A1.3, the sum of Singapore response time is 15.200, Korea is 3.676, Japan is 9.476, Hongkong is 1.978 while Malaysia is 29.000. The next step is computing the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A1.4.

Table A1.4 Normalize matrix for e-government response time based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia	Sum	Priority vector
Singapore	0.066	0.054	0.035	0.084	0.172	0.412	0.082
Korea	0.329	0.272	0.317	0.253	0.241	1.412	0.282
Japan	0.197	0.091	0.106	0.101	0.241	0.736	0.147
Hongkong	0.395	0.544	0.528	0.506	0.310	2.282	0.456
Malaysia	0.013	0.039	0.015	0.056	0.034	0.158	0.032
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A1.4 added two new columns, which are: row summation of the value based on country and priority vector column (sum column divide by total). In this table, Singapore has priority vector value of 0.082, Korea has 0.282, Japan has 0.147. Hongkong has 0.456, and Malaysia has 0.032. The highest weights (priority vector) 0.456 and 0.282 belong to the attributes Hongkong and Korea respectively. The attribute Malaysia has the lowest weight, 0.032.

Table A1.5 Original data of e-government page rank matrix based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia
Singapore	1.000	7.000	4.000	0.200	3.000
Korea	0.143	1.000	0.250	0.111	0.200
Japan	0.250	4.000	1.000	0.143	0.333
Hongkong	5.000	9.000	7.000	1.000	6.000
Malaysia	0.333	5.000	3.000	0.167	1.000
Sum	6.726	26.000	15.250	1.621	10.533

From the Table A1.5, the sum of Singapore page rank is 6.726, Korea is 26.000, Japan is 15.250, Hongkong is 1.621 while Malaysia is 10.533. The next step in the step is to compute the value matrix by divided all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A1.6.

Table A1.6 Normalize matrix for e-government page rank based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia	Sum	Priority vector
Singapore	0.149	0.269	0.262	0.123	0.285	1.088	0.218
Korea	0.021	0.038	0.016	0.069	0.019	0.164	0.033
Japan	0.037	0.154	0.066	0.088	0.032	0.376	0.075
Hongkong	0.743	0.346	0.459	0.617	0.570	2.735	0.547
Malaysia	0.050	0.192	0.197	0.103	0.095	0.636	0.127
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A1.6 added two new columns, which are: row summation of the value based on country and priority vector column (sum column divide by total). In this Table, Singapore has priority vector value of 0.218, Korea has 0.033, Japan has 0.075. Hongkong has 0.547, and Malaysia has 0.127. The highest weights (priority vector) 0.547 and 0.218 belong to the attributes Hongkong and Singapore respectively. The attribute Japan has the lowest weight, 0.075.

Table A1.7 Original data of e-government frequency of update matrix based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia
Singapore	1.000	1.000	1.000	9.000	1.000
Korea	1.000	1.000	1.000	1.000	1.000
Japan	1.000	1.000	1.000	1.000	1.000
Hngkong	0.111	1.000	1.000	1.000	1.000
Malaysia	1.000	1.000	1.000	1.000	1.000
Sum	4.111	5.000	5.000	13.000	5.000

From the Table A1.7, the sum of Singapore frequency of update is 4.111, Korea is 5.000, Japan is 5.000, Hongkong is 13.000 while Malaysia is 5.000. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A1.8.

Table A1.8 Normalize matrix for e-government frequency of update based in AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia	Sum	Priority vector
Singapore	0.243	0.200	0.200	0.692	0.200	1.536	0.307
Korea	0.243	0.200	0.200	0.077	0.200	0.920	0.184
Japan	0.243	0.200	0.200	0.077	0.200	0.920	0.184
Hongkong	0.027	0.200	0.200	0.077	0.200	0.704	0.141
Malaysia	0.243	0.200	0.200	0.077	0.200	0.920	0.184
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A1.8 added two new columns, which are: row summation of the value based on country and priority vector column (sum column divide by total). In this table, Singapore has priority vector value of 0.307, Korea has 0.184, Japan has 0.184. Hongkong has 0.141, and Malaysia has 0.184. The highest weights (priority vector) 0.307 belongs to the attributes Singapore and Hongkong has the lowest weight, 0.141.

Table A1.9 Original data of e-government traffic matrix based on AHP

Website	Singapore	Korea	Japan	hongkong	Malaysia
Singapore	1.000	3.000	0.167	0.143	0.167
Korea	0.333	1.000	0.125	0.111	0.125
Japan	6.000	8.000	1.000	0.200	0.500
Hongkong	7.000	9.000	5.000	1.000	4.000
Malaysia	6.000	8.000	2.000	0.250	1.000
Sum	20.333	29.000	8.292	1.704	5.792

From the Table A1.9, the sum of Singapore traffic is 20.333, Korea is 29.000, Japan is 8.292, Hongkong is 1.704 while Malaysia is 1.000. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A1.10.

Table A1.10 Normalize matrix for e-government traffic based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia	Sum	Priority vector
Singapore	0.049	0.103	0.020	0.084	0.029	0.285	0.057
Korea	0.016	0.034	0.015	0.065	0.022	0.153	0.031
Japan	0.295	0.276	0.121	0.117	0.086	0.895	0.179
Hongkong	0.344	0.310	0.603	0.587	0.691	2.535	0.507
Malaysia	0.295	0.276	0.241	0.147	0.173	1.132	0.226
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A1.10 added two new columns, which are: row summation of the value based on country and priority vector column (sum column divide by total). In this table, Singapore has priority vector value of 0.057, Korea has 0.031, Japan has 0.179, Hongkong has 0.507, and Malaysia has 0.226. The highest weights (priority vector) 0.507 and 0.226 belong to the attributes Hongkong and Malaysia respectively. The attribute Korea has the lowest weight, 0.031.

Table A1.11 Original data of e-government design optimization matrix based on AHP

Website	Singapore	Korea	Japan	hongkong	Malaysia
Singapore	1.000	0.250	2.000	3.000	4.000
Korea	4.000	1.000	5.000	5.000	7.000
Japan	0.500	0.200	1.000	2.000	3.000
Hongkong	0.333	0.200	0.500	1.000	3.000
Malaysia	0.250	0.143	0.333	0.333	1.000
Sum	6.083	1.793	8.833	11.333	18.000

From the Table A1.11, the sum of Singapore design optimization is 6.083, Korea is 1.793, Japan is 8.833, Hongkong is 11.333 while Malaysia is 18.000. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A1.12.

Table A1.12 Normalize matrix for e-government design optimization based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia	Sum	Priority vector
Singapore	0.164	0.139	0.226	0.265	0.222	1.017	0.203
Korea	0.658	0.558	0.566	0.441	0.389	2.611	0.522
Japan	0.082	0.112	0.113	0.176	0.167	0.650	0.130
Hongkong	0.055	0.112	0.057	0.088	0.167	0.478	0.096
Malaysia	0.041	0.080	0.038	0.029	0.056	0.243	0.049
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A1.12 added two new columns, which are: row summation of the value based on country and priority vector column (sum column divide by total). In this table, Singapore has priority vector value of 0.203, Korea has 0.522, Japan has 0.130, Hongkong has 0.096, and Malaysia has 0.049. The highest weights (priority vector) 0.522 and 0.203 belong to the attributes Korea and Singapore respectively. The attribute Malaysia has the lowest weight, 0.049.

Table A1.13 Original data of e-government size matrix based on AHP

Website	Singapore	Korea	Japan	hongkong	Malaysia
singapore	1.000	0.200	5.000	3.000	7.000
Korea	5.000	1.000	8.000	7.000	9.000
Japan	0.200	0.125	1.000	0.333	3.000
hongkong	0.333	0.143	3.000	1.000	5.000
malaysia	0.143	0.111	0.333	0.200	1.000
Sum	6.676	1.579	17.333	11.533	25.000

From the Table A1.13, the sum of Singapore size is 6.676, Korea is 1.579, Japan is 17.333, Hongkong is 11.533 while Malaysia is 25.000. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A1.14.

Table A1.14 Normalize matrix for e-government size based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia	Sum	Priority vector
Singapore	0.150	0.127	0.288	0.260	0.280	1.105	0.221
Korea	0.749	0.633	0.462	0.607	0.360	2.811	0.562
Japan	0.030	0.079	0.058	0.029	0.120	0.316	0.063
Hongkong	0.050	0.090	0.173	0.087	0.200	0.600	0.120
Malaysia	0.021	0.070	0.019	0.017	0.040	0.168	0.034
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A1.14 added two new columns, which are: row summation of the value based on country and priority vector column (sum column divide by total). In this table, Singapore has priority vector value of 0.221, Korea has 0.562, Japan has 0.063, Hongkong has 0.120, and Malaysia has 0.034. The highest weights (priority vector) 0.562 and 0.221 belong to the attributes Korea and Singapore respectively. The attribute Malaysia has the lowest weight, 0.034.

Table A1.15 Original data of e-government number of items matrix based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia
singapore	1.000	0.167	6.000	0.250	0.500
Korea	6.000	1.000	9.000	3.000	5.000
Japan	0.167	0.111	1.000	0.143	0.167
Hongkong	4.000	0.333	7.000	1.000	3.000
Malaysia	2.000	0.200	6.000	0.333	1.000
Sum	13.167	1.811	29.000	4.726	9.667

From the Table A1.15, the sum of Singapore number of items is 13.167, Korea is 1.811, Japan is 29.000, Hongkong is 4.726 while Malaysia is 9.667. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A1.16.

Table A1.16 Normalize matrix for e-government number of items based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia	Sum	Priority vector
Singapore	0.076	0.092	0.207	0.053	0.052	0.479	0.096
Korea	0.456	0.552	0.310	0.635	0.517	2.470	0.494
Japan	0.013	0.061	0.034	0.030	0.017	0.156	0.031
Hongkong	0.304	0.184	0.241	0.212	0.310	1.251	0.250
Malaysia	0.152	0.110	0.207	0.071	0.103	0.643	0.129
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A1.16 added two new columns, which are: row summation of the value based on country and priority vector column (sum column divide by total). In this table, Singapore has priority vector value of 0.096, Korea has 0.494, Japan has 0.031, Hongkong has 0.250, and Malaysia has 0.129. The highest weights (priority vector) 0.494 and 0.250 belong to the attributes Korea and Singapore respectively. The attribute Japan has the lowest weight, 0.031.

Table A1.17 Original data of e-government accessibility matrix based on AHP

Website	Singapore	Korea	Japan	hongkong	Malaysia
Singapore	1.000	0.111	0.143	0.111	0.167
Korea	9.000	1.000	2.000	1.000	5.000
Japan	7.000	0.500	1.000	0.500	3.000
Hongkong	9.000	1.000	2.000	1.000	5.000
Malaysia	6.000	0.200	0.333	0.200	1.000
Sum	32.000	2.811	5.476	2.811	14.167

From the Table A1.17, the sum of Singapore accessibility is 32.000, Korea is 2.811, Japan is 5.476, Hongkong is 2.811 while Malaysia is 14.167. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A1.18.

Table A1.18 Normalize matrix for e-government accessibility based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia	Sum	Priority vector
Singapore	0.031	0.040	0.026	0.040	0.012	0.148	0.030
Korea	0.281	0.356	0.365	0.356	0.353	1.711	0.342
Japan	0.219	0.178	0.183	0.178	0.212	0.969	0.194
hongkong	0.281	0.356	0.365	0.356	0.353	1.711	0.342
Malaysia	0.188	0.071	0.061	0.071	0.071	0.461	0.092
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A1.18 added two new columns, which are: row summation of the value based on country and priority vector column (sum column divide by total). In this table, Singapore has priority vector value of 0.030, Korea has 0.342, Japan has 0.194, Hongkong has 0.342, and Malaysia has 0.092. The highest weights (priority vector) 0.342 together belong to the attributes Korea and Hongkong. The attribute Singapore has the lowest weight, 0.030.

Table A1.19 Original e-government markup validation matrix based on AHP

Website	Singapore	Korea	Japan	hongkong	Malaysia
Singapore	1.000	0.125	0.200	0.125	2.000
Korea	8.000	1.000	5.000	0.500	9.000
Japan	5.000	0.200	1.000	0.200	6.000
Hongkong	8.000	2.000	5.000	1.000	9.000
Malaysia	0.500	0.111	0.167	0.111	1.000
Sum	22.500	3.436	11.367	1.936	27.000

From the Table A1.19, the sum of Singapore markup validation is 22.500, Korea is 3.436, Japan is 11.367, Hongkong is 1.936 while Malaysia is 27.000. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A1.20.

Table A1.20 Normalize matrix for e-government markup validation

Website	Singapore	Korea	Japan	Hongkong	Malaysia	Sum	Priority vector
Singapore	0.044	0.036	0.018	0.065	0.074	0.237	0.047
Korea	0.356	0.291	0.440	0.258	0.333	1.678	0.336
Japan	0.222	0.058	0.088	0.103	0.222	0.694	0.139
Hongkong	0.356	0.582	0.440	0.516	0.333	2.227	0.445
Malaysia	0.022	0.032	0.015	0.057	0.037	0.164	0.033
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A1.20 added two new columns, which are: row summation of the value based on country and priority vector column (sum column divide by total). In this table, Singapore has priority vector value of 0.047, Korea has 0.336, Japan has 0.139, Hongkong has 0.445, and Malaysia has 0.033. The highest weights (priority vector) 0.445 and 0.336 belong to Hongkong and Korea respectively. The attribute Malaysia has the lowest weight, 0.033.

Table A1.21 Original e-government broken link matrix based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia
Singapore	1.000	0.250	0.333	0.333	5.000
Korea	4.000	1.000	2.000	2.000	9.000
Japan	3.000	0.500	1.000	1.000	8.000
Hongkong	3.000	0.500	1.000	1.000	8.000
Malaysia	0.200	0.111	0.125	0.125	1.000
Sum	11.200	2.361	4.458	4.458	31.000

From the Table A1.21, the sum of Singapore broken link is 11.200, Korea is 2.361, Japan is 4.458, Hongkong is 4.458 while Malaysia is 31.000. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A1.22.

Table A1.22 Normalize matrix for e-government broken link based on AHP

Website	Singapore	Korea	Japan	Hongkong	Malaysia	Sum	Priority vector
Singapore	0.089	0.106	0.075	0.075	0.161	0.506	0.101
Korea	0.357	0.424	0.449	0.449	0.290	1.968	0.394
Japan	0.268	0.212	0.224	0.224	0.258	1.186	0.237
Hongkong	0.268	0.212	0.224	0.224	0.258	1.186	0.237
Malaysia	0.018	0.047	0.028	0.028	0.032	0.153	0.031
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A1.22 added two new columns, which are: row summation of the value based on country and priority vector column (sum column divide by total). In this table Singapore has priority vector value of 0.101, Korea has 0.394, Japan has 0.237, Hongkong has 0.237, and Malaysia has 0.031. The highest weights (priority vector) 0.394 belong to Korea and the attribute Malaysia has the lowest weight, 0.031.

FAHP

Table A1.23 Evaluation of the e-government attributes with respect to load time

Load time	Singapore			Korea			Japan			Hongkong			Malaysia		
Singapore	1	1	1	1/4	1/3	1/2	4	5	6	2	3	4	6	7	8
Korea	2	3	4	1	1	1	6	7	8	4	5	6	8	9	9
Japan	1/6	1/5	1/4	1/8	1/7	1/6	1	1	1	1/4	1/3	1/2	2	3	4
Hongkong	1/4	1/3	1/2	1/6	1/5	1/4	2	3	4	1	1	1	4	5	6
Malaysia	1/8	1/7	1/6	1/9	1/9	1/8	1/4	1/3	1/2	1/6	1/5	1/4	1	1	1

From Table A1.23, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sg} = (13.250, 16.333, 19.500) \otimes (1/67.208, 1/57.330, 1/46.861) = (0.197, 0.285, 0.416)$$
$$S_{kor} = (21.000, 25.000, 28.000) \otimes (1/67.208, 1/57.330, 1/46.861) = (0.312, 0.436, 0.598)$$
$$S_{jp} = (3.542, 4.676, 5.917) \otimes (1/67.208, 1/57.330, 1/46.861) = (0.053, 0.082, 0.126)$$
$$S_{hk} = (7.417, 9.533, 11.750) \otimes (1/67.208, 1/57.330, 1/46.861) = (0.110, 0.166, 0.251)$$
$$S_{my} = (1.653, 1.787, 2.042) \otimes (1/67.208, 1/57.330, 1/46.861) = (0.025, 0.031, 0.044)$$

These fuzzy values are compared by using equation (2.15) and

$$V(S_{sg} \geqslant S_{kor}) = 0.407,\ V(S_{sg} \geqslant S_{jp}) = 1.000,\ V(S_{sg} \geqslant S_{hk}) = 1.000,\ V(S_{sg} \geqslant S_{my}) = 1.000$$
$$V(S_{kr} \geqslant S_{sg}) = 1.000,\ V(S_{kr} \geqslant S_{jp}) = 1.000,\ V(S_{kr} \geqslant S_{hk}) = 1.000,\ V(S_{kr} \geqslant S_{my}) = 1.000$$
$$V(S_{jp} \geqslant S_{sg}) = 0.000,\ V(S_{jp} \geqslant S_{kr}) = 0.000,\ V(S_{jp} \geqslant S_{hk}) = 0.158,\ V(S_{jp} \geqslant S_{my}) = 1.000$$

$V(S_{hk} \geqslant S_{sg}) = 0.311$, $V(S_{hk} \geqslant S_{kr}) = 0.000$, $V(S_{hk} \geqslant S_{jp}) = 1.000$, $V(S_{hk} \geqslant S_{my}) = 1.000$
$V(S_{my} \geqslant S_{sg}) = 0.000$, $V(S_{my} \geqslant S_{kr}) = 0.000$, $V(S_{my} \geqslant S_{jp}) = 0.000$, $V(S_{my} \geqslant S_{hk}) = 0.000$

are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sg) = \min(0.407,\ 1.000,\ 1.000,\ 1.000) = 0.407$,

$d'(kr) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000$,

$d'(jp) = \min(0.000,\ 0.000,\ 0.158,\ 1.000) = 0.000$,

$d'(hk) = \min(0311,\ 0.000,\ 1.000,\ 1.000) = 0.000$,

$d'(my) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000$

Priority weights form $W' = (0.407,\ 1.000,\ 0.000,\ 0.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.289,\ 0.711,\ 0.000,\ 0.000,\ 0.000)$. According to this result the Korea gives importance to load time, then Singapore in selecting the best e-government.

Table A1.24 Evaluation of the e-government attributes with respect to response time

Response	Singapore			Korea			Japan			Hongkong			malaysia		
Singapore	1	1	1	1/6	1/5	1/4	1/4	1/3	½	1/7	1/6	1/5	4	5	6
Korea	4	5	6	1	1	1	2	3	4	1/3	1/2	1	6	7	8
Japan	2	3	4	1/4	1/3	1/2	1	1	1	1/6	1/5	¼	6	7	8
Hongkong	5	6	7	1	2	3	4	5	6	1	1	1	8	9	9
Malaysia	1/6	1/5	1/4	1/8	1/7	1/6	1/8	1/7	1/6	1/9	1/9	1/8	1	1	1

From Table A1.24, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sg} = (5.560, 6.700, 7.950) \otimes (1/69.408, 1/59.330, 1/48.837) = (0.080, 0.113, 0.163)$$
$$S_{kor} = (13.333, 16.500, 20.000) \otimes (1/69.408, 1/59.330, 1/48.837) = (0.192, 0.278, 0.410)$$
$$S_{jp} = (9.417, 11.533, 13.750) \otimes (1/69.408, 1/59.330, 1/48.837) = (0.136, 0.194, 0.282)$$
$$S_{hk} = (19.000, 23.000, 26.000) \otimes (1/69.408, 1/59.330, 1/48.837) = (0.274, 0.388, 0.532)$$
$$S_{my} = (1.528, 1.597, 1.708) \otimes (1/69.408, 1/59.330, 1/48.837) = (0.022, 0.027, 0.035)$$

These fuzzy values are compared by using equation (2.15) and $V(S_{sg} \geqslant S_{kor}) = 0.000$, $V(S_{sg} \geqslant S_{jp}) = 0.226$, $V(S_{sg} \geqslant S_{hk}) = 0.000$, $V(S_{sg} \geqslant S_{my}) = 1.000$

$V(S_{kr} \geq S_{sg}) = 1.000,\ V(S_{kr} \geq S_{jp}) = 1.000,\ V(S_{kr} \geq S_{hk}) = 0.553,\ V(S_{kr} \geq S_{my}) = 1.000$
$V(S_{jp} \geq S_{sg}) = 1.000,\ V(S_{jp} \geq S_{kr}) = 0.517,\ V(S_{jp} \geq S_{hk}) = 0.039,\ V(S_{jp} \geq S_{my}) = 1.000$
$V(S_{hk} \geq S_{sg}) = 1.000,\ V(S_{hk} \geq S_{kr}) = 1.000,\ V(S_{hk} \geq S_{jp}) = 1.000,\ V(S_{hk} \geq S_{my}) = 1.000$
$V(S_{my} \geq S_{sg}) = 0.000,\ V(S_{my} \geq S_{kr}) = 0.000,\ V(S_{my} \geq S_{jp}) = 0.000,\ V(S_{my} \geq S_{hk}) = 0.000$
, are obtained.

Then priority weights are calculated by using equation (2.16):

$$d'(sg) = \min(0.000,\ 0.226,\ 0.000,\ 1.000) = 0.000,$$

$$d'(kr) = \min(1.000,\ 1.000,\ 0.553,\ 1.000) = 0.553,$$

$$d'(jp) = \min(1.000,\ 0.517,\ 0.039,\ 1.000) = 0.039,$$

$$d'(hk) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$$

$$d'(my) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000$$

Priority weights form $W' = (0.000,\ 0.553,\ 0.039,\ 1.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.347,\ 0.024,\ 0.628,\ 0.000)$. According to this result the Hongkong gives importance to response time, then Korea in selecting the best e-government.

Table A1.25 Evaluation of the e-government attributes with respect to page rank

Page rank	Singapore			Korea			Japan			Hongkong			Malaysia		
Singapore	1	1	1	6	7	8	3	4	5	1/6	1/5	1/4	2	3	4
Korea	1/8	1/7	1/6	1	1	1	1/5	1/4	1/3	1/9	1/9	1/4	1/6	1/5	¼
Japan	1/5	1/4	1/3	3	4	5	1	1	1	1/8	1/7	1/6	1/4	1/3	½
Hongkong	4	5	6	8	9	9	6	7	8	1	1	1	5	6	7
Malaysia	1/4	1/3	1/2	4	5	6	2	3	4	1/7	1/6	1/5	1	1	1

From Table A1.25, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sg} = (12.167, 15.200, 18.250) \otimes (1/69.950, 1/60.130, 1/49.737) = (0.174, 0.253, 0.367)$$
$$S_{kor} = (1.603, 1.704, 2.000) \otimes (1/69.950, 1/60.130, 1/49.737) = (0.023, 0.028, 0.040)$$
$$S_{jp} = (4.575, 5.726, 7.000) \otimes (1/69.950, 1/60.130, 1/49.737) = (0.065, 0.095, 0.141)$$
$$S_{hk} = (24.000, 28.000, 31.000) \otimes (1/69.950, 1/60.130, 1/49.737) = (0.343, 0.466, 0.623)$$
$$S_{my} = (7.393, 9.500, 11.700) \otimes (1/69.950, 1/60.130, 1/49.737) = (0.106, 0.158, 0.253)$$

These fuzzy values are compared by using equation (2.15) and

$V(S_{sg} \geq S_{kor}) = 1.000$, $V(S_{sg} \geq S_{jp}) = 1.000$, $V(S_{sg} \geq S_{hk}) = 0.101$, $V(S_{sg} \geq S_{my}) = 1.000$
$V(S_{kr} \geq S_{sg}) = 0.000$, $V(S_{kr} \geq S_{jp}) = 0.000$, $V(S_{kr} \geq S_{hk}) = 0.000$, $V(S_{kr} \geq S_{my}) = 0.000$
$V(S_{jp} \geq S_{sg}) = 0.000$, $V(S_{jp} \geq S_{kr}) = 1.000$, $V(S_{jp} \geq S_{hk}) = 0.000$, $V(S_{jp} \geq S_{my}) = 0.358$
$V(S_{hk} \geq S_{sg}) = 1.000$, $V(S_{hk} \geq S_{kr}) = 1.000$, $V(S_{hk} \geq S_{jp}) = 1.000$, $V(S_{hk} \geq S_{my}) = 1.000$
$V(S_{my} \geq S_{sg}) = 0.393$, $V(S_{my} \geq S_{kr}) = 1.000$, $V(S_{my} \geq S_{jp}) = 1.000$, $V(S_{my} \geq S_{hk}) = 0.000$
are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sg) = \min(1.000,\ 1.000,\ 0.101,\ 1.000) = 0.101,$

$d'(kr) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

$d'(jp) = \min(0.000,\ 1.000,\ 0.000,\ 0.358) = 0.000,$

$d'(hk) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(my) = \min(0.393,\ 1.000,\ 1.000,\ 0.000) = 0.000,$

Priority weights form $W' = (0.101,\ 0.000,\ 0.000,\ 1.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.092,\ 0.000,\ 0.000,\ 0.908,\ 0.000)$. According to this result the Hongkong gives importance to page rank, then Singapore in selecting the best e-government.

Table A1.26 Evaluation of the e-government attributes with respect to frequency

Frequency	Singapore			Korea			Japan			Hongkong			Malaysia		
Singapore	1	1	1	1/2	1	1	1/2	1	1	8	9	9	1	1	2
Korea	1	1	2	1	1	1	1	1	2	1	1	2	1	1	2
Japan	1	1	2	1/2	1	1	1	1	1	1/2	1	1	1	1	2
Hongkong	1/9	1/9	1/8	1/2	1	1	1	1	2	1	1	1	1	1	2
Malaysia	1	1	2	1/2	1	1	1/2	1	1	1/2	1	1	1	1	1

From Table A1.26, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sg} = (11.000, 13.000, 14.000) \otimes (1/42.125, 1/32.111, 1/27.111) = (0.261, 0.405, 0.516)$$
$$S_{kor} = (5.000, 5.000, 9.000) \otimes (1/42.125, 1/32.111, 1/27.111) = (0.119, 0.156, 0.332)$$
$$S_{jp} = (4.000, 5.000, 7.000) \otimes (1/42.125, 1/32.111, 1/27.111) = (0.095, 0.156, 0.258)$$

$S_{hk} = (3.611, 4.111, 6.125) \otimes (1/42.125, 1/32.111, 1/27.111) = (0.086, 0.128, 0.226)$

$S_{my} = (3.500, 5.000, 6.000) \otimes (1/42.125, 1/32.111, 1/27.111) = (0.083, 0.156, 0.221)$

These fuzzy values are compared by using equation (2.15) and

$V(S_{sg} \geq S_{kor}) = 1.000,\ V(S_{sg} \geq S_{jp}) = 1.000,\ V(S_{sg} \geq S_{hk}) = 0.101,\ V(S_{sg} \geq S_{my}) = 1.000$
$V(S_{kr} \geq S_{sg}) = 0.221,\ V(S_{kr} \geq S_{jp}) = 1.000,\ V(S_{kr} \geq S_{hk}) = 1.000,\ V(S_{kr} \geq S_{my}) = 1.000$
$V(S_{jp} \geq S_{sg}) = 0.000,\ V(S_{jp} \geq S_{kr}) = 1.000,\ V(S_{jp} \geq S_{hk}) = 1.000,\ V(S_{jp} \geq S_{my}) = 1.000$
$V(S_{hk} \geq S_{sg}) = 1.000,\ V(S_{hk} \geq S_{kr}) = 0.795,\ V(S_{hk} \geq S_{jp}) = 0.826,\ V(S_{hk} \geq S_{my}) = 0.838$
$V(S_{my} \geq S_{sg}) = 0.000,\ V(S_{my} \geq S_{kr}) = 1.000,\ V(S_{my} \geq S_{jp}) = 1.000,\ V(S_{my} \geq S_{hk}) = 1.000$
are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sg) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(kr) = \min(0.221,\ 1.000,\ 1.000,\ 1.000) = 0.221,$

$d'(jp) = \min(0.000,\ 1.000,\ 1.000,\ 1.000) = 0.000,$

$d'(hk) = \min(0.000,\ 0.795,\ 0.826,\ 0.838) = 0.000,$

$d'(my) = \min(0.000,\ 1.000,\ 1.000,\ 1.000) = 0.000,$

Priority weights form $W' = (1.000,\ 0.221,\ 0.000,\ 0.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.819,\ 0.181,\ 0.000,\ 0.000,\ 0.000)$. According to this result the Singapore gives importance to frequency of update, then Korea in selecting the best e-government.

Table A1.27 Evaluation of the attributes with respect to traffic

Traffic	Singapore			Korea			Japan			Hongkong			Malaysia		
Singapore	1	1	1	2	3	4	1/7	1/6	1/5	1/8	1/7	1/6	1/7	1/6	1/5
Korea	1/4	1/3	1/2	1	1	1	1/9	1/8	1/7	1/9	1/9	1/8	1/9	1/8	1/7
Japan	5	6	7	7	8	9	1	1	1	1/6	1/5	1/4	1/3	1/2	1
Hongkong	6	7	8	8	9	9	4	5	6	1	1	1	3	4	5
Malaysia	5	6	7	7	8	9	1	2	3	1/5	1/4	1/3	1	1	1

From Table A1.27, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$S_{sg} = (3.411, 4.476, 5.567) \otimes (1/75.061, 1/65.121, 1/54.694) = (0.045, 0.069, 0.102)$
$S_{kor} = (1.583, 1.694, 1.911) \otimes (1/75.061, 1/65.121, 1/54.694) = (0.021, 0.026, 0.035)$

$S_{jp} = (13.500, 15.700, 108.250) \otimes (1/75.061, 1/65.121, 1/54.694) = (0.180, 0.241, 0.334)$

$S_{hk} = (22.000, 26.000, 20.000) \otimes (1/75.061, 1/65.121, 1/54.694) = (0.293, 0.339, 0.530)$

$S_{my} = (14.200, 17.250, 75.061) \otimes (1/75.061, 1/65.121, 1/54.694) = (0.189, 0.265, 0.372)$

These fuzzy values are compared by using equation (2.15) and

$V(S_{sg} \geqslant S_{kor}) = 1.000,\ V(S_{sg} \geqslant S_{jp}) = 0.000,\ V(S_{sg} \geqslant S_{hk}) = 0.000,\ V(S_{sg} \geqslant S_{my}) = 0.000$

$V(S_{kr} \geqslant S_{sg}) = 0.000,\ V(S_{kr} \geqslant S_{jp}) = 0.000,\ V(S_{kr} \geqslant S_{hk}) = 0.000,\ V(S_{kr} \geqslant S_{my}) = 0.000$

$V(S_{jp} \geqslant S_{sg}) = 1.000,\ V(S_{jp} \geqslant S_{kr}) = 1.000,\ V(S_{jp} \geqslant S_{hk}) = 0.204,\ V(S_{jp} \geqslant S_{my}) = 0.859$

$V(S_{hk} \geqslant S_{sg}) = 1.000,\ V(S_{hk} \geqslant S_{kr}) = 1.000,\ V(S_{hk} \geqslant S_{jp}) = 1.000,\ V(S_{hk} \geqslant S_{my}) = 1.000$

$V(S_{my} \geqslant S_{sg}) = 1.000,\ V(S_{my} \geqslant S_{kr}) = 1.000,\ V(S_{my} \geqslant S_{jp}) = 1.000,\ V(S_{my} \geqslant S_{hk}) = 1.650$

, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sg) = \min(1.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

$d'(kr) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

$d'(jp) = \min(1.000,\ 1.000,\ 0.204,\ 0.859) = 0.204,$

$d'(hk) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(my) = \min(1.000,\ 1.000,\ 1.000,\ 1.650) = 1.000,$

Priority weights form $W' = (0.000,\ 0.000,\ 0.204,\ 1.000,\ 1.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.000,\ 0.093,\ 0.454,\ 0.454)$. According to this result the Hongkong, Malaysia gives importance to traffic, then Japan in selecting the best e-government.

Table A1.28 Evaluation of the attributes with respect to design optimization

Design	Singapore			Korea			Japan			Hongkong			Malaysia		
Singapore	1	1	1	1/5	1/4	1/3	1	2	3	2	3	4	3	4	5
Korea	3	4	5	1	1	1	4	5	6	4	5	6	6	7	8
Japan	1/3	½	1	1/6	1/5	1/4	1	1	1	1	2	3	2	3	4
Hongkong	¼	1/3	½	1/6	1/5	1/4	1/3	½	1	1	1	1	2	3	4
Malaysia	1/5	¼	1/3	1/8	1/7	1/6	1/4	1/3	1/2	1/4	1/3	1/2	1	1	1

From Table A1.28, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$S_{sg} = (7.200, 10.250, 13.333) \otimes (1/57.883, 1/46.043, 1/35.275) = (0.124, 0.223, 0.378)$

$S_{kor} = (18.000, 22..000, 26.000) \otimes (1/57.883, 1/46.043, 1/35.275) = (0.311, 0.478, 0.737)$

$S_{jp} = (4.500, 6.700, 9.250) \otimes (1/57.883, 1/46.043, 1/35.275) = (0.078, 0.146, 0.262)$

$S_{hk} = (3.750, 5.033, 6.750) \otimes (1/57.883, 1/46.043, 1/35.275) = (0.065, 0.109, 0.191)$

$S_{my} = (1.825, 2.060, 2.500) \otimes (1/57.883, 1/46.043, 1/35.275) = (0.032, 0.045, 0.071)$

These fuzzy values are compared by using equation (2.15) and

$V(S_{sg} \geqslant S_{kor}) = 0.207,\ V(S_{sg} \geqslant S_{jp}) = 1.000,\ V(S_{sg} \geqslant S_{hk}) = 1.000,\ V(S_{sg} \geqslant S_{my}) = 1.000$
$V(S_{kr} \geqslant S_{sg}) = 1.000,\ V(S_{kr} \geqslant S_{jp}) = 1.000,\ V(S_{kr} \geqslant S_{hk}) = 1.000,\ V(S_{kr} \geqslant S_{my}) = 1.000$
$V(S_{jp} \geq S_{sg}) = 0.641,\ V(S_{jp} \geq S_{kr}) = 0.000,\ V(S_{jp} \geq S_{hk}) = 1.000,\ V(S_{jp} \geq S_{my}) = 1.000$
$V(S_{hk} \geqslant S_{sg}) = 0.371,\ V(S_{hk} \geqslant S_{kr}) = 0.000,\ V(S_{hk} \geqslant S_{jp}) = 0.758,\ V(S_{hk} \geqslant S_{my}) = 1.000$
$V(S_{my} \geqslant S_{sg}) = 0.000,\ V(S_{my} \geqslant S_{kr}) = 0.000,\ V(S_{my} \geqslant S_{jp}) = 0.000,\ V(S_{my} \geqslant S_{hk}) = 0.085$
are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sg) = \min(0.207,\ 1.000,\ 1.000,\ 1.000) = 0.000,$

$d'(kr) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(jp) = \min(0.641,\ 0.000,\ 1.000,\ 1.000) = 0.000$

$d'(hk) = \min(0.371,\ 0.000,\ 0.758,\ 1.000) = 1.000,$

$d'(my) = \min(0.000,\ 0.000,\ 0.000,\ 0.085) = 0.000,$

Priority weights form $W' = (0.207,\ 1.000,\ 0.000,\ 0.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.171,\ 0.829,\ 0.000,\ 0.000,\ 0.000)$. According to this result the Korea gives importance to design optimization, then Singapore in selecting the best e-government.

Table A1.29 Evaluation of the attributes with respect to size

Size	Singapore			Korea			Japan			Hongkong			Malaysia		
Singapore	1	1	1	1/6	1/5	1/4	4	5	6	2	3	4	6	7	8
Korea	4	5	6	1	1	1	7	8	9	6	7	8	8	9	9
Japan	1/6	1/5	1/4	1/9	1/8	1/7	1	1	1	1/4	1/3	½	2	3	4
Hongkong	1/4	1/3	1/2	1/8	1/7	1/6	2	3	4	1	1	1	4	5	6
Malaysia	1/8	1/7	1/6	1/9	1/9	1/8	1/4	1/3	1/2	1/6	1/5	¼	1	1	1

From Table A1.29, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$S_{sg} = (13.167, 16.200, 19.250) \otimes (1/71.851, 1/62.122, 1/51.722) = (0.183, 0.261, 0.372)$

$S_{kor} = (26.000, 30..000, 33.000) \otimes (1/71.851, 1/62.122, 1/51.722) = (0.362, 0.483, 0.638)$

$S_{jp} = (3.528, 4.658, 5.893) \otimes (1/71.851, 1/62.122, 1/51.722) = (0.049, 0.075, 0.014)$

$S_{hk} = (7.375, 9.476, 11.667) \otimes (1/71.851, 1/62.122, 1/51.722) = (0.103, 0.153, 0.226)$

$S_{my} = (1.653, 1.787, 2.042) \otimes (1/71.851, 1/62.122, 1/51.722) = (0.023, 0.029, 0.039)$

These fuzzy values are compared by using equation (2.15) and

$V(S_{sg} \geqslant S_{kor}) = 0.044,\ V(S_{sg} \geqslant S_{jp}) = 1.000,\ V(S_{sg} \geqslant S_{hk}) = 1.000,\ V(S_{sg} \geqslant S_{my}) = 1.000$

$V(S_{kr} \geqslant S_{sg}) = 1.000,\ V(S_{kr} \geqslant S_{jp}) = 1.000,\ V(S_{kr} \geqslant S_{hk}) = 1.000,\ V(S_{kr} \geqslant S_{my}) = 1.000$

$V(S_{jp} \geqslant S_{sg}) = 0.000,\ V(S_{jp} \geqslant S_{kr}) = 0.000,\ V(S_{jp} \geqslant S_{hk}) = 0.127,\ V(S_{jp} \geqslant S_{my}) = 1.000$

$V(S_{hk} \geqslant S_{sg}) = 0.281,\ V(S_{hk} \geqslant S_{kr}) = 0.000,\ V(S_{hk} \geqslant S_{jp}) = 1.000,\ V(S_{hk} \geqslant S_{my}) = 1.000$

$V(S_{my} \geqslant S_{sg}) = 0.000,\ V(S_{my} \geqslant S_{kr}) = 0.000,\ V(S_{my} \geqslant S_{jp}) = 0.000,\ V(S_{my} \geqslant S_{hk}) = 0.000$

are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sg) = \min(0.044,\ 1.000,\ 1.000,\ 1.000) = 0.044,$

$d'(kr) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(jp) = \min(0.000,\ 0.000,\ 0.127,\ 1.000) = 0.000,$

$d'(hk) = \min(0.281,\ 0.000,\ 1.000,\ 1.000) = 0.000,$

$d'(my) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

Priority weights form $W' = (0.044,\ 1.000,\ 0.000,\ 0.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.042,\ 0.958,\ 0.000,\ 0.000,\ 0.000)$. According to this result the Korean gives importance to size, then Singapore in selecting the best e-government.

Table A1.30 Evaluation of the attributes with respect to number of items

Number of items	Singapore			Korea			Japan			Hongkong			Malaysia		
Singapore	1	1	1	1/7	1/6	1/5	5	6	7	1/5	1/4	1/3	1/3	1/2	1
Korea	5	6	7	1	1	1	8	9	9	2	3	4	4	5	6
Japan	1/7	1/6	1/5	1/9	1/9	1/8	1	1	1	1/8	1/7	1/6	1/7	1/6	1/5
Hongkong	3	4	5	1/4	1/3	1/2	6	7	8	1	1	1	2	3	4
Malaysia	1	2	3	1/6	1/5	1/4	5	6	7	1/4	1/3	1/2	1	1	1

From Table A1.30, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$S_{sg} = (6.676, 7.917, 9.533) \otimes (1/68.475, 1/58.371, 1/47.865) = (0.097, 0.136, 0.139)$

$S_{kor} = (26.000, 30..000, 33.000) \otimes (1/68.475, 1/58.371, 1/47.865) = (0.292, 0.411, 0.394)$

$S_{jp} = (1.522, 1.587, 1.692) \otimes (1/68.475, 1/58.371, 1/47.865) = (0.022, 0.027, 0.025)$

$S_{hk} = (12.250, 15.333, 18.500) \otimes (1/68.475, 1/58.371, 1/47.865) = (0.179, 0.263, 0.270)$

$S_{my} = (7.417, 9.533, 11.750) \otimes (1/68.475, 1/58.371, 1/47.865) = (0.108, 0.163, 0.172)$

These fuzzy values are compared by using equation (2.15) and

$V(S_{sg} \geqslant S_{kor}) = 0.000,\ V(S_{sg} \geqslant S_{jp}) = 1.000,\ V(S_{sg} \geqslant S_{hk}) = 0.000,\ V(S_{sg} \geqslant S_{my}) = 0.527$

$V(S_{kr} \geqslant S_{sg}) = 1.000,\ V(S_{kr} \geqslant S_{jp}) = 1.000,\ V(S_{kr} \geqslant S_{hk}) = 1.000,\ V(S_{kr} \geqslant S_{my}) = 1.000$

$V(S_{jp} \geqslant S_{sg}) = 0.000,\ V(S_{jp} \geqslant S_{kr}) = 0.000,\ V(S_{jp} \geqslant S_{hk}) = 0.000,\ V(S_{jp} \geqslant S_{my}) = 0.000$

$V(S_{hk} \geqslant S_{sg}) = 1.000,\ V(S_{hk} \geqslant S_{kr}) = 0.000,\ V(S_{hk} \geqslant S_{jp}) = 1.000,\ V(S_{hk} \geqslant S_{my}) = 1.000$

$V(S_{my} \geqslant S_{sg}) = 1.000,\ V(S_{my} \geqslant S_{kr}) = 0.000,\ V(S_{my} \geqslant S_{jp}) = 1.000,\ V(S_{my} \geqslant S_{hk}) = 0.000$

, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sg) = \min(0.000,\ 1.000,\ 0.000,\ 0.527) = 0.000,$

$d'(kr) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(jp) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

$d'(hk) = \min(1.000,\ 0.000,\ 1.000,\ 1.000) = 0.000,$

$d'(my) = \min(1.000,\ 0.000,\ 1.000,\ 0.000) = 0.000,$

Priority weights form $W' = (0.000,\ 1.000,\ 0.000,\ 0.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as

(0.000, 1.000, 0.000, 0.000, 0.000). According to this result the Korea gives importance to number of items in selecting the best e-government.

Table A1.31 Evaluation of the attributes with respect to accessibility

Accessibility	Singapore			Korea			Japan			Hongkong			Malaysia		
Singapore	1	1	1	1/9	1/9	1/8	1/8	1/7	1/6	1/9	1/9	1/8	1/7	1/6	1/5
Korea	8	9	9	1	1	1	1	2	3	1	1	2	4	5	6
Japan	6	7	8	1/3	½	1	1	1	1	1/3	1/2	1	2	3	4
Hongkong	8	9	9	1	1	1/2	1	2	3	1	1	1	4	5	6
Malaysia	5	6	7	1/3	½	1	1/4	1/3	1/2	1/6	1/5	1/4	1	1	1

From Table A1.31, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sg} = (1.490, 1.532, 1.617) \otimes (1/66.867, 1/57.565, 1/47.907) = (0.022, 0.027, 0.024)$$
$$S_{kor} = (15.000, 18.000, 21.000) \otimes (1/66.867, 1/57.565, 1/47.907) = (0.224, 0.313, 0.314)$$
$$S_{jp} = (9.667, 12.000, 15.000) \otimes (1/66.867, 1/57.565, 1/47.907) = (0.145, 0.208, 0.224)$$
$$S_{hk} = (15.000, 18.000, 19.500) \otimes (1/66.867, 1/57.565, 1/47.907) = (0.224, 0.313, 0.292)$$
$$S_{my} = (6.750, 8.033, 9.750) \otimes (1/66.867, 1/57.565, 1/47.907) = (0.101, 0.140, 0.146)$$

These fuzzy values are compared by using equation (2.15) and

$$V(S_{sg} \geqslant S_{kor}) = 0.000, \quad V(S_{sg} \geqslant S_{jp}) = 0.000, \quad V(S_{sg} \geqslant S_{hk}) = 0.000, \quad V(S_{sg} \geqslant S_{my}) = 0.000$$
$$V(S_{kr} \geqslant S_{sg}) = 1.000, \quad V(S_{kr} \geqslant S_{jp}) = 1.000, \quad V(S_{kr} \geqslant S_{hk}) = 1.000, \quad V(S_{kr} \geqslant S_{my}) = 1.000$$
$$V(S_{jp} \geqslant S_{sg}) = 1.000, \quad V(S_{jp} \geqslant S_{kr}) = 0.000, \quad V(S_{jp} \geqslant S_{hk}) = 0.000, \quad V(S_{jp} \geqslant S_{my}) = 1.000$$
$$V(S_{hk} \geqslant S_{sg}) = 1.000, \quad V(S_{hk} \geqslant S_{kr}) = 1.000, \quad V(S_{hk} \geqslant S_{jp}) = 1.000, \quad V(S_{hk} \geqslant S_{my}) = 1.000$$
$$V(S_{my} \geqslant S_{sg}) = 1.000, \quad V(S_{my} \geqslant S_{kr}) = 0.000, \quad V(S_{my} \geqslant S_{jp}) = 0.018, \quad V(S_{my} \geqslant S_{hk}) = 0.000$$

, are obtained.

Then priority weights are calculated by using equation (2.16):

$$d'(sg) = \min(0.000, \ 0.000, \ 0.000, \ 0.000) = 0.000,$$

$$d'(kr) = \min(1.000, \ 1.000, \ 1.000, \ 1.000) = 1.000,$$

$$d'(jp) = \min(1.000, \ 0.000, \ 0.000, \ 1.000) = 0.000,$$

$$d'(hk) = \min(1.000, \ 1.000, \ 1.000, \ 1.000) = 1.000,$$

$$d'(my) = \min(1.000, \ 0.000, \ 0.018, \ 0.000) = 0.000,$$

Priority weights form $W' = (0.000,\ 1.000,\ 0.000,\ 1.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.500,\ 0.000,\ 0.500,\ 0.000)$. According to this result the Korean and japan give importance to accessibility in selecting the best e-government.

Table A1.32 Evaluation of the attributes with respect to markup language

Markup	Singapore			Korea			Japan			Hongkong			Malaysia		
Singapore	1	1	1	1/9	1/8	1/7	1/6	1/5	1/4	1/9	1/8	1/7	1	2	3
Korea	7	8	9	1	1	1	4	5	6	1/3	1/2	1	8	9	9
Japan	4	5	6	1/6	1/5	1/4	1	1	1	1/6	1/5	1/4	5	6	7
Hongkong	7	8	9	1	2	3	4	5	6	1	1	1	8	9	9
Malaysia	1/3	1/2	1	1/9	1/9	1/8	1/7	1/6	1/5	1/9	1/9	1/8	1	1	1

From Table A1.32, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sg} = (2.389, 3.450, 4.536) \otimes (1/75.486, 1/66.239, 1/55.754) = (0.032, 0.052, 0.060)$$
$$S_{kor} = (20.333, 23.500, 26.000) \otimes (1/75.486, 1/66.239, 1/55.754) = (0.269, 0.355, 0.344)$$
$$S_{jp} = (10.333, 12.400, 14.500) \otimes (1/75.486, 1/66.239, 1/55.754) = (0.137, 0.187, 0.192)$$
$$S_{hk} = (21.000, 25.000, 28.000) \otimes (1/75.486, 1/66.239, 1/55.754) = (0.278, 0.377, 0.371)$$
$$S_{my} = (1.698, 1.889, 2.450) \otimes (1/75.486, 1/66.239, 1/55.754) = (0.022, 0.029, 0.032)$$

These fuzzy values are compared by using equation (2.15) and

$$V(S_{sg} \geqslant S_{kor}) = 0.000,\ V(S_{sg} \geqslant S_{jp}) = 0.000,\ V(S_{sg} \geqslant S_{hk}) = 0.000,\ V(S_{sg} \geqslant S_{my}) = 1.000$$
$$V(S_{kr} \geqslant S_{sg}) = 1.000,\ V(S_{kr} \geqslant S_{jp}) = 1.000,\ V(S_{kr} \geqslant S_{hk}) = 0.745,\ V(S_{kr} \geqslant S_{my}) = 1.000$$
$$V(S_{jp} \geqslant S_{sg}) = 1.000,\ V(S_{jp} \geqslant S_{kr}) = 0.000,\ V(S_{jp} \geqslant S_{hk}) = 0.000,\ V(S_{jp} \geqslant S_{my}) = 1.000$$
$$V(S_{hk} \geqslant S_{sg}) = 1.000,\ V(S_{hk} \geqslant S_{kr}) = 1.000,\ V(S_{hk} \geqslant S_{jp}) = 1.000,\ V(S_{hk} \geqslant S_{my}) = 1.000$$
$$V(S_{my} \geqslant S_{sg}) = 0.000,\ V(S_{my} \geqslant S_{kr}) = 0.000,\ V(S_{my} \geqslant S_{jp}) = 0.000,\ V(S_{my} \geqslant S_{hk}) = 0.000$$

, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sg) = \min(0.000,\ 0.000,\ 0.000,\ 1.000) = 0.000$,

$d'(kr) = \min(1.000,\ 1.000,\ 0.745,\ 1.000) = 0.745$,

$d'(jp) = \min(1.000,\ 0.000,\ 0.000,\ 1.000) = 0.000$,

$d'(hk) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000$,

$d'(my) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000$,

Priority weights form $W' = (0.000,\ 0.745,\ 0.000,\ 1.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.427,\ 0.000,\ 0.573,\ 0.000)$. According to this result the Hongkong gives importance to markup validation, then Korea in selecting the best e-government.

Table A1.33 Evaluation of the attributes with respect to broken link

Broken link	Singapore			Korea			Japan			Hongkong			Malaysia		
Singapore	1	1	1	1/5	1/4	1/3	1/4	1/3	1/2	1/4	1/3	1/2	4	5	6
Korea	3	4	5	1	1	1	1	2	3	1	2	3	8	9	9
Japan	2	3	4	1/3	1/2	1	1	1	1	1	1	2	7	8	9
Hongkong	2	3	4	1/3	½	1	1/2	1	1	1	1	1	7	8	9
Malaysia	1/6	1/5	1/4	1/9	1/9	1/8	1/9	1/8	1/7	1/9	1/8	1/7	1	1	1

From Table A1.33, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sg} = (5.700, 6.917, 8.333) \otimes (1/63.994, 1/53.478, 1/43.367) = (0.089, 0.129, 0.192)$$
$$S_{kor} = (14.000, 18.000, 21.000) \otimes (1/63.994, 1/53.478, 1/43.367) = (0.219, 0.337, 0.484)$$
$$S_{jp} = (11.333, 13.500, 17.000) \otimes (1/63.994, 1/53.478, 1/43.367) = (0.177, 0.252, 0.392)$$
$$S_{hk} = (10.833, 13.500, 16.000) \otimes (1/63.994, 1/53.478, 1/43.367) = (0.169, 0.252, 0.369)$$
$$S_{my} = (1.500, 1.561, 1.661) \otimes (1/63.994, 1/53.478, 1/43.367) = (0.023, 0.029, 0.038)$$

These fuzzy values are compared by using equation (2.15) and

$$V(S_{sg} \geq S_{kor}) = 0.000,\ V(S_{sg} \geq S_{jp}) = 0.109,\ V(S_{sg} \geq S_{hk}) = 0.157,\ V(S_{sg} \geq S_{my}) = 1.000$$
$$V(S_{kr} \geq S_{sg}) = 1.000,\ V(S_{kr} \geq S_{jp}) = 1.000,\ V(S_{kr} \geq S_{hk}) = 1.000,\ V(S_{kr} \geq S_{my}) = 1.000$$
$$V(S_{jp} \geq S_{sg}) = 1.000,\ V(S_{jp} \geq S_{kr}) = 0.673,\ V(S_{jp} \geq S_{hk}) = 1.000,\ V(S_{jp} \geq S_{my}) = 1.000$$
$$V(S_{hk} \geq S_{sg}) = 1.000,\ V(S_{hk} \geq S_{kr}) = 0.000,\ V(S_{hk} \geq S_{jp}) = 1.000,\ V(S_{hk} \geq S_{my}) = 1.000$$
$$V(S_{my} \geq S_{sg}) = 0.000,\ V(S_{my} \geq S_{kr}) = 0.000,\ V(S_{my} \geq S_{jp}) = 0.000,\ V(S_{my} \geq S_{hk}) = 0.000$$

, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sg) = \min(0.000,\ 0.109,\ 0.157,\ 1.000) = 0.000$,

$d'(kr) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000$,

$d'(jp) = \min(1.000,\ 0.673,\ 1.000,\ 1.000) = 0.673$,

$d'(hk) = \min(1.000,\ 0.000,\ 1.000,\ 1.000) = 0.000$,

$d'(my) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000$,

Priority weights form $W' = (0.000,\ 1.000,\ 0.673,\ 0.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.598,\ 0.402,\ 0.000,\ 0.000)$. According to this result the Korea gives importance to broken link, then japan in selecting the best e-government.

Appendix 2 Airlines

AHP

Calculation yields the normalized matrix of criteria is illustrated in Table A2.1. The average weights of rows are computed in the last column to indicate the weights of the criteria.

Table A2.1 Original data of Asian airlines load time matrix based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS
SIA	1.000	0.125	0.143	0.167	0.111
KAL	8.000	1.000	3.000	4.000	0.500
JAL	7.000	0.333	1.000	3.000	0.250
CATHAY	6.000	0.250	0.333	1.000	0.200
MAS	9.000	2.000	4.000	5.000	1.000
Sum	31.000	3.708	8.476	13.167	2.061

From the Table A2.1, the sum of Singapore Airlines load time is 31.000, Korea Airlines is 3.708, Japan Airlines is 8.476, Cathay Pacific is 13.167 and Malaysia Airlines is 2.061. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A2.2.

Table A2.2 Normalize matrix for Asian airlines load time based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS	Sum	Priority vector
SIA	0.032	0.034	0.017	0.013	0.054	0.149	0.030
KAL	0.258	0.270	0.354	0.304	0.243	1.428	0.286
JAL	0.226	0.090	0.118	0.228	0.121	0.783	0.157
CATHAY	0.194	0.067	0.039	0.076	0.097	0.473	0.095
MAS	0.290	0.539	0.472	0.380	0.485	2.166	0.433
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A2.2 added two new columns, which are: row summation of the value based on airlines and priority vector column (sum column divide by total). In this table, Singapore Airlines has priority vector value of 0.030, Korea Airlines has 0.286, Japan Airlines has

0.157, Cathay Pacific has 0.095, and Malaysia Airlines has 0.433. The highest weights (priority vector) 0.433 and 0.286 belong to the attributes Malaysia Airlines and Korean Airlines respectively. The attribute Singapore Airlines has the lowest weight, 0.030.

Table A2.3 Original data Asian airlines response time matrix based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS
SIA	1.000	4.000	3.000	0.500	2.000
KAL	0.250	1.000	0.333	0.200	0.333
JAL	0.333	3.000	1.000	0.250	0.500
CATHAY	2.000	5.000	4.000	1.000	3.000
MAS	0.500	3.000	2.000	0.333	1.000
Sum	4.083	16.000	10.333	2.283	6.833

From the Table A2.3, the sum of Singapore Airlines response time is 4.083, Korea Airlines is 16.000, Japan Airlines is 10.333, Cathay Pacific is 2.283 and Malaysia Airlines is 6.833. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A2.4.

Table A2.4 Normalize matrix for Asian airlines response time based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS	Sum	Priority vector
SIA	0.245	0.250	0.290	0.219	0.293	1.297	0.259
KAL	0.061	0.063	0.032	0.088	0.049	0.292	0.058
JAL	0.082	0.188	0.097	0.109	0.073	0.549	0.110
CATHAY	0.490	0.313	0.387	0.438	0.439	2.066	0.413
MAS	0.122	0.188	0.194	0.146	0.146	0.796	0.159
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A2.4 added two new columns, which are: row summation of the value based on airlines and priority vector column (sum column divide by total). In this table, Singapore Airlines has priority vector value of 0.259, Korea Airlines has 0.058, Japan Airlines has 0.110, Cathay Pacific has 0.413, and Malaysia Airlines has 0.159. The highest weights (priority vector) 0.413 and 0.259 belong to the attributes Cathay Pacific and Singapore Airlines respectively. The attribute Korea Airlines has the lowest weight, 0.058.

Table A2.5 Original data for Asian airline page rank matrix based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS
SIA	1.000	4.000	7.000	0.250	5.000
KAL	0.250	1.000	5.000	0.200	4.000
JAL	0.143	0.200	1.000	0.111	0.250
CATHAY	4.000	5.000	9.000	1.000	7.000
MAS	0.200	0.250	4.000	0.143	1.000
Sum	5.593	10.450	26.000	1.704	17.250

From the Table A2.5, the sum of Singapore Airlines page rank is 5.593, Korea Airlines is 10.450, Japan Airlines is 26.000, Cathay Pacific is 1.704, and Malaysia Airlines is 17.250. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A2.6.

Table A2.6 Normalize matrix for Asian airlines page rank based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS	Sum	Priority vector
SIA	0.179	0.383	0.269	0.147	0.290	1.267	0.253
KAL	0.045	0.096	0.192	0.117	0.232	0.682	0.136
JAL	0.026	0.019	0.038	0.065	0.014	0.163	0.033
CATHAY	0.715	0.478	0.346	0.587	0.406	2.532	0.506
MAS	0.036	0.024	0.154	0.084	0.058	0.355	0.071
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A2.6 added two new columns, which are: row summation of the value based on airlines and priority vector column (sum column divide by total). In this table, Singapore Airlines has priority vector value of 0.253, Korea Airlines has 0.136, Japan Airlines has 0.033, Cathay Pacific has 0.506, and Malaysia Airlines has 0.071. The highest weights (priority vector) 0.506 and 0.253 belong to the attributes Cathay Pacific and Singapore Airlines respectively. The attribute Japan Airlines has the lowest weight, 0.033.

Table A2.7 Original data Asian airlines frequency of update matrix based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS
SIA	1.000	1.000	1.000	1.000	1.000
KAL	1.000	1.000	1.000	1.000	1.000
JAL	1.000	1.000	1.000	1.000	1.000
CATHAY	1.000	1.000	1.000	1.000	1.000
MAS	1.000	1.000	1.000	1.000	1.000
Sum	5.000	5.000	5.000	5.000	5.000

From the Table A2.7, the sum of all Asian airlines frequency of update is 5. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A2.8.

Table A2.8 Normalize matrix for Asian ailines frequency of update based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS	Sum	Priority vector
SIA	0.200	0.200	0.200	0.200	0.200	1.000	0.200
KAL	0.200	0.200	0.200	0.200	0.200	1.000	0.200
JAL	0.200	0.200	0.200	0.200	0.200	1.000	0.200
CATHAY	0.200	0.200	0.200	0.200	0.200	1.000	0.200
MAS	0.200	0.200	0.200	0.200	0.200	1.000	0.200
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A2.8 added two new columns, which are: row summation of the value based on airlines and priority vector column (sum column divide by total). In this table, all Asian airlines have priority vector value of 0.200.

Table A2.9 Original data of Asian airlines traffic matrix based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS
SIA	1.000	4.000	6.000	2.000	3.000
KAL	0.250	1.000	3.000	0.333	0.333
JAL	0.167	0.333	1.000	0.250	0.333
CATHAY	0.500	3.000	4.000	1.000	2.000
MAS	0.333	3.000	3.000	0.500	1.000
Sum	2.250	11.333	17.000	4.083	6.667

From the Table A2.9, the sum of Singapore Airlines traffic is 2.250, Korea Airlines is 11.333, Japan Airlines is 17.000, Cathay Pacific is 4.083 and Malaysia Airlines is 6.667. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A2.10.

Table A2.10 Normalize matrix for Asian airlines traffic based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS	Sum	Priority vector
SIA	0.444	0.353	0.353	0.490	0.450	2.090	0.418
KAL	0.111	0.088	0.176	0.082	0.050	0.507	0.101
JAL	0.074	0.029	0.059	0.061	0.050	0.274	0.055
CATHAY	0.222	0.265	0.235	0.245	0.300	1.267	0.253
MAS	0.148	0.265	0.176	0.122	0.150	0.862	0.172
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A2.10 added two new columns, which are: row summation of the value based on airlines and priority vector column (sum column divide by total). In this table, Singapore Airlines has priority vector value of 0.253, Korea Airlines has 0.136, Japan Airlines has 0.033, Cathay Pacific has 0.506, and Malaysia Airlines has 0.071. The highest weights (priority vector) 0.506 and 0.253 belong to the attributes Cathay Pacific and Singapore Airlines respectively. The attribute Japan Airlines has the lowest weight, 0.033.

Table A2.11 Original data of Asian airlines design optimization Matrix based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS
SIA	1.000	0.500	0.167	0.143	0.143
KAL	2.000	1.000	0.200	0.167	0.167
JAL	6.000	5.000	1.000	0.333	0.333
CATHAY	7.000	6.000	3.000	1.000	2.000
MAS	7.000	6.000	3.000	0.500	1.000
Sum	23.000	18.500	7.367	2.143	3.643

From the Table A2.11, the sum of Singapore Airlines design optimization is 23.000, Korea Airlines is 18.500, Japan Airlines is 7.367, Cathay Pacific is 2.143 and Malaysia Airlines is 3.643. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A2.12.

Table A2.12 Normalize matrix for Asian airlines design optimization based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS	Sum	Priority vector
SIA	0.043	0.027	0.023	0.067	0.039	0.199	0.040
KAL	0.087	0.054	0.027	0.078	0.046	0.292	0.058
JAL	0.261	0.270	0.136	0.156	0.092	0.914	0.183
CATHAY	0.304	0.324	0.407	0.467	0.549	2.052	0.410
MAS	0.304	0.324	0.407	0.233	0.275	1.544	0.309
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A2.12 added two new columns, which are: row summation of the value based on airlines and priority vector column (sum column divide by total). In this table, Singapore Airlines has priority vector value of 0.040, Korea Airlines has 0.058, Japan Airlines has 0.183, Cathay Pacific has 0.410, and Malaysia Airlines has 0.309. The highest weights (priority vector) 0.410 and 0.309 belong to the attributes Cathay Pacific and Malaysia Airlines respectively. The attribute Singapore Airlines has the lowest weight, 0.040.

Table A2.13 Original data of Asian airlines size matrix based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS
SIA	1.000	1.000	1.000	0.167	0.111
KAL	8.000	1.000	5.000	6.000	0.333
JAL	7.000	0.200	1.000	2.000	0.200
CATHAY	6.000	0.167	0.500	1.000	0.167
MAS	9.000	3.000	5.000	6.000	1.000
Sum	31.000	5.367	12.500	15.167	1.811

From the Table A2.13, the sum of Singapore Airlines size is 31.000, Korea Airlines is 5.367, Japan Airlines is 12.500, Cathay Pacific is 15.167 and Malaysia Airlines is 1.811. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A2.14.

Table A2.14 Normalize matrix for Asian airlines size based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS	Sum	Priority vector
SIA	0.032	0.186	0.080	0.011	0.061	0.371	0.074
KAL	0.258	0.186	0.400	0.396	0.184	1.424	0.285
JAL	0.226	0.07	0.080	0.132	0.110	0.585	0.117
CATHAY	0.194	0.031	0.040	0.066	0.092	0.423	0.085
MAS	0.290	0.559	0.400	0.396	0.552	2.197	0.439
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A2.14 added two new columns, which are: row summation of the value based on airlines and priority vector column (sum column divide by total). In this table, Singapore Airlines has priority vector value of 0.074, Korea Airlines has 0.285, Japan Airlines has 0.117, Cathay Pacific has 0.085, and Malaysia Airlines has 0.439. The highest weights (priority vector) 0.439 and 0.285 belong to the attributes Malaysia Airlines and Korea Airlines respectively. The attribute Singapore Airlines has the lowest weight, 0.074.

Table A2.15 Original data of Asian airlines number of items matrix based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS
SIA	1.000	0.167	2.000	3.000	0.143
KAL	6.000	1.000	7.000	8.000	0.333
JAL	0.500	0.143	1.000	3.000	0.125
CATHAY	0.333	0.125	0.333	1.000	0.111
MAS	7.000	3.000	8.000	9.000	1.000
Sum	14.833	4.435	18.333	24.000	1.712

From the Table A2.15, the sum of Singapore Airlines number of items is 0.143, Korea Airlines is 0.333, Japan Airlines is 0.125, Cathay Pacific is 0.111 and Malaysia Airlines is 1.000. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A2.16.

Table A2.16 Normalize matrix for Asian airlines number of items based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS	Sum	Priority vector
SIA	0.067	0.038	0.109	0.125	0.083	0.423	0.085
KAL	0.404	0.226	0.382	0.333	0.195	1.540	0.308
JAL	0.034	0.032	0.055	0.125	0.073	0.318	0.064
CATHAY	0.022	0.028	0.018	0.042	0.065	0.175	0.035
MAS	0.472	0.677	0.436	0.375	0.584	2.544	0.509
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A2.16 added two new columns, which are: row summation of the value based on airlines and priority vector column (sum column divide by total). In this table, Singapore Airlines has priority vector value of 0.085, Korea Airlines has 0.308, Japan Airlines has 0.064, Cathay Pacific has 0.035, and Malaysia Airlines has 0.509. The highest weights (priority vector) 0.509 and 0.308 belong to the attributes Malaysia Airlines and Korea Airlines respectively. The attribute Cathay Pacific has the lowest weight, 0.035.

Table A2.17 Original data of Asian airlines accessibility matrix based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS
SIA	1.000	3.000	0.500	5.000	0.500
KAL	0.333	1.000	0.333	4.000	0.333
JAL	2.000	3.000	1.000	5.000	1.000
CATHAY	0.200	0.250	0.200	1.000	0.200
MAS	2.000	3.000	1.000	5.000	1.000
Sum	5.533	10.250	3.033	20.000	3.033

From the Table A2.17, the sum of Singapore Airlines accessibility is 5.533, Korea Airlines is 10.250, Japan Airlines is 3.033, Cathay Pacific is 20.000 and Malaysia Airlines is 3.003. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A2.18.

Table A2.18 Normalize matrix for Asian airlines accessibility based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS	Sum	Priority vector
SIA	0.181	0.293	0.165	0.250	0.165	1.053	0.211
KAL	0.060	0.098	0.110	0.200	0.110	0.578	0.116
JAL	0.361	0.293	0.330	0.250	0.330	1.563	0.313
CATHAY	0.036	0.024	0.066	0.050	0.066	0.242	0.048
MAS	0.361	0.293	0.330	0.250	0.330	1.563	0.313
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A2.18 added two new columns, which are: row summation of the value based on airlines and priority vector column (sum column divide by total). In this table, Singapore Airlines has priority vector value of 0.211, Korea Airlines has 0.116, Japan Airlines has 0.313, Cathay Pacific has 0.048, and Malaysia Airlines has 0.313. The highest weights (priority vector) 0.313 belong together to the attributes Japan Airlines and Malaysia

Airlines because they have the same number. The attribute Cathay Pacific has the lowest weight, 0.033.

Table A2.19 Original data for Asian airline markup validation matrix based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS
SIA	1.000	0.200	0.143	5.000	0.143
KAL	5.000	1.000	0.333	7.000	0.333
JAL	7.000	3.000	1.000	9.000	2.000
CATHAY	0.200	0.143	0.111	1.000	0.111
MAS	7.000	3.000	0.500	9.000	1.000
Sum	20.200	7.343	2.087	31.000	3.587

From the Table A2.19, the sum of Singapore Airlines markup validation is 20.200, Korea Airlines is 7.343, Japan Airlines is 2.087, Cathay Pacific is 31.000 and Malaysia Airlines is 3.587. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A2.20.

Table A2.20 Normalize matrix for Asian airlines markup validation based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS	Sum	Priority vector
SIA	0.050	0.027	0.068	0.161	0.040	0.346	0.069
KAL	0.248	0.136	0.160	0.226	0.093	0.862	0.172
JAL	0.347	0.409	0.479	0.290	0.558	2.082	0.416
CATHAY	0.010	0.019	0.053	0.032	0.031	0.146	0.029
MAS	0.347	0.409	0.240	0.290	0.279	1.564	0.313
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A2.20 added two new columns, which are: row summation of the value based on airlines and priority vector column (sum column divide by total). In this table, Singapore Airlines has priority vector value of 0.069, Korea Airlines has 0.172, Japan Airlines has 0.416, Cathay Pacific has 0.029, and Malaysia Airlines has 0.313. The highest weights (priority vector) 0.416 and 0313 belong to the attributes Japan Airlines and Malaysia Airlines respectively. The attribute Cathay Pacific has the lowest weight, 0.029.

Table A2.21 Original data for Asian airline broken link matrix based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS
SIA	1.000	0.500	0.500	5.000	0.500
KAL	2.000	1.000	1.000	7.000	1.000
JAL	2.000	1.000	1.000	7.000	1.000
CATHAY	0.200	0.143	0.143	1.000	0.143
MAS	2.000	1.000	1.000	7.000	1.000
Sum	7.200	3.643	3.643	27.000	3.643

From the Table A2.21, the sum of Singapore Airlines broken link is 7.200, Korea Airlines is 3.643, Japan Airlines is 3.643, Cathay Pacific is 27.000 and Malaysia Airlines is 3.643. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A2.22.

Table A2.22 Normalize matrix for Asian airlines broken link based on AHP

Website	SIA	KAL	JAL	CATHAY	MAS	Sum	Priority vector
SIA	0.139	0.137	0.137	0.185	0.137	0.736	0.147
KAL	0.278	0.275	0.275	0.259	0.275	1.361	0.272
JAL	0.278	0.275	0.275	0.259	0.275	1.361	0.272
CATHAY	0.028	0.039	0.039	0.037	0.039	0.182	0.036
MAS	0.278	0.275	0.275	0.259	0.275	1.361	0.272
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A2.22 added two new columns, which are: row summation of the value based on airlines and priority vector column (sum column divide by total). In this table Singapore Airlines has priority vector value of 0.147, Korea Airlines has 0.272, Japan Airlines has 0.272, Cathay Pacific has 0.036, and Malaysia Airlines has 0.272. The highest weights (priority vector) 0.272 belong to three attributes: Korea Airlines, Japan Airlines, And Malaysia Airlines. The attribute Cathay Pacific has the lowest weight, 0.036.

Table A2.23 Evaluation of the Asian airlines attributes with respect to load time

Load time	SIA			KAL			JAL			CATHAY			MAS		
SIA	1	1	1	1/9	1/8	1/7	1/8	1/7	1/6	1/7	1/6	1/5	1/9	1/9	1/8
KAL	7	8	9	1	1	1	2	3	4	3	4	5	1/3	1/2	1
JAL	6	7	8	1/4	1/3	1/2	1	1	1	2	3	4	1/5	1/4	1/3
CATHAY	5	6	7	1/5	¼	1/3	1/4	1/3	1/2	1	1	1	1/6	1/5	¼
MAS	8	9	9	1	2	3	3	4	5	4	5	6	1	1	1

FAHP

Table A2.24 Evaluation of the Asian airlines attributes with respect to load time

Load time	SIA			KAL			JAL			CATHAY			MAS		
SIA	1	1	1	1/9	1/8	1/7	1/8	1/7	1/6	1/7	1/6	1/5	1/9	1/9	1/8
KAL	7	8	9	1	1	1	2	3	4	3	4	5	1/3	1/2	1
JAL	6	7	8	1/4	1/3	1/2	1	1	1	2	3	4	1/5	1/4	1/3
CATHAY	5	6	7	1/5	¼	1/3	1/4	1/3	1/2	1	1	1	1/6	1/5	¼
MAS	8	9	9	1	2	3	3	4	5	4	5	6	1	1	1

From Table A2.24, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sia} = (1.490, 1.546, 1.635) \otimes (1/68.551, 1/58.412, 1/47.890) = (0.022, 0.026, 0.034)$$
$$S_{kal} = (13.333, 16.500, 20.000) \otimes (1/68.551, 1/58.412, 1/47.890) = (0.195, 0.282, 0.418)$$
$$S_{jal} = (9.450, 11.583, 13.833) \otimes (1/68.551, 1/58.412, 1/47.890) = (0.138, 0.198, 0.289)$$
$$S_{cathay} = (6.617, 7.783, 9.083) \otimes (1/68.551, 1/58.412, 1/47.890) = (0.097, 0.133, 0.190)$$
$$S_{mas} = (17.000, 21.000, 24.000) \otimes (1/68.551, 1/58.412, 1/47.890) = (0.248, 0.360, 0.501)$$

These fuzzy values are compared by using equation (2.15) and

$$V(S_{sia} \geqslant S_{kal}) = 0.000,\ V(S_{sia} \geqslant S_{jal}) = 0.000,\ V(S_{sia} \geqslant S_{cathay}) = 0{,}000,\ V(S_{sia} \geqslant S_{mas}) = 0.000$$
$$V(S_{kal} \geqslant S_{sia}) = 1.000,\ V(S_{kal} \geqslant S_{jal}) = 1.000,\ V(S_{kal} \geqslant S_{cathay}) = 1.000,\ V(S_{kal} \geqslant S_{mas}) = 0.688$$
$$V(S_{jal} \geqslant S_{sia}) = 1.000,\ V(S_{jal} \geqslant S_{kal}) = 0.529\ V(S_{jal} \geqslant S_{cathay}) = 1.000,\ V(S_{jal} \geqslant S_{mas}) = 0.202$$
$$V(S_{cathay} \geqslant S_{sia}) = 1.000, V(S_{cathay} \geqslant S_{kal}) = 0.000, V(S_{cathay} \geqslant S_{jal}) = 0.443, V(S_{cathay} \geqslant S_{mas}) = 0.000$$
$$V(S_{mas} \geqslant S_{sia}) = 1.000,\ V(S_{mas} \geqslant S_{kal}) = 1.000,\ V(S_{mas} \geqslant S_{jal}) = 1.000,\ V(S_{mas} \geqslant S_{cathay}) = 1.000$$

are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sia) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

$d'(kal) = \min(1.000,\ 1.000,\ 1.000,\ 0.688) = 0.688,$

$d'(jal) = \min(1.000,\ 0.529,\ 1.000,\ 0.202) = 0.202,$

$d'(cathay) = \min(1.000,\ 0.000,\ 0.443,\ 0.000) = 0.000,$

$d'(mas) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

Priority weights form $W' = (0.000,\ 0.688,\ 0.202,\ 0.000,\ 1.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as

(0.000, 0.364, 0.107, 0.000, 0.529). According to this result the Malaysia airlines gives importance to load time, then Korea airlines in selecting the best airlines website.

Table A2.25 Evaluation of the Asian airlines attributes with respect to response time

Response time	SIA			KAL			JAL			CATHAY			MAS		
SIA	1	1	1	3	4	5	2	3	4	1/3	/2	1	1	2	3
KAL	1/5	1/4	1/3	1	1	1	1/4	1/3	1/2	/6	1/5	1/4	1/4	1/3	½
JAL	1/4	1/3	1/2	2	3	4	1	1	1	1/5	1/4	1/3	1/3	½	1
CATHAY	1	2	3	4	5	6	3	4	5	1	1	1	2	3	4
MAS	1/3	1/2	1	2	3	4	1	2	3	1/4	1/3	1/2	1	1	1

From Table A2.25, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sia} = (7.333, 10.500, 14.000) \otimes (1/51917, 1/39.533, 1/28.567) = (0.141, 0.266, 0.490)$$
$$S_{kal} = (1.867, 2.117, 2.583) \otimes (1/51917, 1/39.533, 1/28.567) = (0.036, 0.054, 0.090)$$
$$S_{jal} = (3.783, 5.083, 6.833) \otimes (1/51917, 1/39.533, 1/28.567) = (0.073, 0.129, 0.239)$$
$$S_{cathay} = (11.000, 15.000, 19.000) \otimes (1/51917, 1/39.533, 1/28.567) = (0.212, 0.379, 0.665)$$
$$S_{mas} = (4.583, 6.833, 9.500) \otimes (1/51917, 1/39.533, 1/28.567) = (0.088, 0.173, 0.333)$$

These fuzzy values are compared by using equation (2.15) and

$$V(S_{sia} \geqslant S_{kal}) = 1.000,\ V(S_{sia} \geqslant S_{jal}) = 1.000,\ V(S_{sia} \geqslant S_{cathay}) = 0.710,\ V(S_{sia} \geqslant S_{mas}) = 1.000$$
$$V(S_{kal} \geqslant S_{sia}) = 0.000,\ V(S_{kal} \geqslant S_{jal}) = 0.190,\ V(S_{kal} \geqslant S_{cathay}) = 0.000,\ V(S_{kal} \geqslant S_{mas}) = 0.018$$
$$V(S_{jal} \geqslant S_{sia}) = 0.417,\ V(S_{jal} \geqslant S_{kal}) = 1.000\ \ V(S_{jal} \geqslant S_{cathay}) = 0.098,\ V(S_{jal} \geqslant S_{mas}) = 0.773$$
$$V(S_{cathay} \geqslant S_{sia}) = 1.000,\ V(S_{cathay} \geqslant S_{kal}) = 1.000, V(S_{cathay} \geqslant S_{jal}) = 1.000, V(S_{cathay} \geqslant S_{mas}) = 1.000$$
$$V(S_{mas} \geqslant S_{sia}) = 0.673,\ V(S_{mas} \geqslant S_{kal}) = 1.000,\ V(S_{mas} \geqslant S_{jal}) = 1.000,\ V(S_{mas} \geqslant S_{cathay}) = 0.369$$

are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sia) = \min(1.000,\ 1.000,\ 0.710,\ 1.000) = 0.710$,

$d'(kal) = \min(0.000,\ 0.190,\ 0.000,\ 0.018) = 0.000$,

$d'(jal) = \min(0.417,\ 1.000,\ 0.098,\ 0.773) = 0.417$,

$d'(cathay) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000$,

$d'(mas) = \min(0.673,\ 1.000,\ 1.000,\ 0.369) = 0.369$, Priority weights form $W' = (0.710,\ 0.000,\ 0.417,\ 1.000,\ 0.369)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.284,\ 0.000,\ 0.167,\ 0.401,\ 0.148)$. According to this result the Cathay Pacific airlines gives importance to response time, then Singapore airlines in selecting the best airlines website.

Table A2.26 Evaluation of the Asian airlines attributes with respect to page rank

Page rank	SIA			KAL			JAL			CATHAY			MAS		
SIA	1	1	1	3	4	5	6	7	8	1/5	1/4	1/3	4	5	6
KAL	1/5	1/4	1/3	1	1	1	4	5	6	1/6	1/5	1/4	3	4	5
JAL	1/8	1/7	1/6	1/6	1/5	1/4	1	1	1	1/9	1/9	1/8	1/5	1/4	1/3
CATHAY	3	4	5	4	5	6	8	9	9	1	1	1	6	7	8
MAS	1/4	1/5	1/6	1/5	1/4	1/3	3	4	5	1/8	1/7	1/6	1	1	1

From Table A2.26, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sia} = (14.200, 17.250, 20.333) \otimes (1/70.458, 1/60.997, 1/50.744) = (0.202, 0.283, 0.401)$$
$$S_{kal} = (8.367, 10.450, 12.583) \otimes (1/70.458, 1/60.997, 1/50.744) = (0.119, 0.171, 0.248)$$
$$S_{jal} = (1.603, 1.704, 1.875) \otimes (1/70.458, 1/60.997, 1/50.744) = (0.023, 0.028, 0.037)$$
$$S_{cathay} = (22.000, 26.000, 29.000) \otimes (1/70.458, 1/60.997, 1/50.744) = (0.312, 0.426, 0.571)$$
$$S_{mas} = (4.575, 5.593, 6.667) \otimes (1/70.458, 1/60.997, 1/50.744) = (0.065, 0.092, 0.131)$$

These fuzzy values are compared by using equation (2.15) and

$$V(S_{sia} \geqslant S_{kal}) = 1.000,\ V(S_{sia} \geqslant S_{jal}) = 1.000,\ V(S_{sia} \geqslant S_{cathay}) = 0.381,\ V(S_{sia} \geqslant S_{mas}) = 1.000$$
$$V(S_{kal} \geqslant S_{sia}) = 0.294,\ V(S_{kal} \geqslant S_{jal}) = 1.000,\ V(S_{kal} \geqslant S_{cathay}) = 0.000,\ V(S_{kal} \geqslant S_{mas}) = 1.000$$
$$V(S_{jal} \geqslant S_{sia}) = 0.000,\ V(S_{jal} \geqslant S_{kal}) = 0.000\ \ V(S_{jal} \geqslant S_{cathay}) = 0.000,\ V(S_{jal} \geqslant S_{mas}) = 0.000$$
$$V(S_{cathay} \geqslant S_{sia}) = 1.000, V(S_{cathay} \geqslant S_{kal}) = 1.000, V(S_{cathay} \geqslant S_{jal}) = 1.000, V(S_{cathay} \geqslant S_{mas}) = 1.000$$
$$V(S_{mas} \geqslant S_{sia}) = 0.000,\ V(S_{mas} \geqslant S_{kal}) = 2.289,\ V(S_{mas} \geqslant S_{jal}) = 1.000, V(S_{mas} \geqslant S_{cathay}) = 0.000$$

are obtained.

Then priority weights are calculated by using equation (2.16):

$$d'(sia) = \min(1.000,\ 1.000,\ 0.381,\ 1.000) = 0.381,$$
$$d'(kal) = \min(0.294,\ 1.000,\ 0.000,\ 1.000) = 0.000,$$
$$d'(jal) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$$
$$d'(cathay) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$$

$d'(mas) = \min(0.000,\ \ 2.289,\ \ 1.000,\ \ 0.000) = 0.000$,

Priority weights form $W' = (0.381,\ 0.000,\ 0.000,\ 1.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.276,\ 0.000,\ 0.000,\ 0.724,\ 0.000)$. According to this result the Cathay Pacific airlines gives importance to page rank, then Singapore airlines in selecting the best airlines website.

Table A2.27 Evaluation of the Asian airlines attributes with respect to frequency of update

Frequency of update	SIA			KAL			JAL			CATHAY			MAS		
SIA	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
KAL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
JAL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
CATHAY	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MAS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

From Table A2.27, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sia} = (5.000, 5.000, 5.000) \otimes (1/24.000, 1/25.000, 1/25.000) = (0.208, 0.200, 0.200)$$
$$S_{kal} = (5.000, 5.000, 5.000) \otimes (1/24.000, 1/25.000, 1/25.000) = (0.208, 0.200, 0.200)$$
$$S_{jal} = (5.000, 5.000, 5.000) \otimes (1/24.000, 1/25.000, 1/25.000) = (0.208, 0.200, 0.200)$$
$$S_{cathay} = (5.000, 5.000, 5.000) \otimes (1/24.000, 1/25.000, 1/25.000) = (0.208, 0.200, 0.200)$$
$$S_{mas} = (5.000, 5.000, 5.000) \otimes (1/24.000, 1/25.000, 1/25.000) = (0.208, 0.200, 0.200)$$

These fuzzy values are compared by using equation (2.15) and

$$V(S_{sia} \geqslant S_{kal}) = 1.000,\ \ V(S_{sia} \geqslant S_{jal}) = 1.000,\ \ V(S_{sia} \geqslant S_{cathay}) = 1.000,\ \ V(S_{sia} \geqslant S_{mas}) = 1.000$$
$$V(S_{kal} \geqslant S_{sia}) = 1.000,\ \ V(S_{kal} \geqslant S_{jal}) = 1.000,\ \ V(S_{kal} \geqslant S_{cathay}) = 1.000,\ \ V(S_{kal} \geqslant S_{mas}) = 1.000$$
$$V(S_{jal} \geqslant S_{sia}) = 1.000,\ \ V(S_{jal} \geqslant S_{kal}) = 1.000\ \ V(S_{jal} \geqslant S_{cathay}) = 1.000,\ \ V(S_{jal} \geqslant S_{mas}) = 1.000$$
$$V(S_{cathay} \geqslant S_{sia}) = 1.000,\ \ V(S_{cathay} \geqslant S_{kal}) = 1.000, V(S_{cathay} \geqslant S_{jal}) = 1.000,\ \ V(S_{cathay} \geqslant S_{mas}) = 1.000$$
$$V(S_{mas} \geqslant S_{sia}) = 1.000,\ \ V(S_{mas} \geqslant S_{kal}) = 1.000,\ \ V(S_{mas} \geqslant S_{jal}) = 1.000,\ \ V(S_{mas} \geqslant S_{cathay}) = 1.000$$

are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sia) = \min(1.000,\ \ 1.000,\ \ 1.000,\ \ 1.000) = 1.000,$

$d'(kal) = \min(1.000,\ \ 1.000,\ \ 1.000,\ \ 1.000) = 1.000,$

$d'(jal) = \min(1.000,\ \ 1.000,\ \ 1.000,\ \ 1.000) = 1.000,$

$d'(cathay) = \min(1.000,\ \ 1.000,\ \ 1.000,\ \ 1.000) = 1.000,$

$d'(mas) = \min(1.000,\ \ 1.000,\ \ 1.000,\ \ 1.000) = 1.000,$

Priority weights form $W' = (1.000,\ 1.000,\ 1.000,\ 1.000,\ 1.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.200,\ 0.200,\ 0.200,\ 0.200,\ 0.200)$. According to this result the all of the airlines gives importance to frequency of update. .

Table A2.28 Evaluation of the Asian airlines attributes with respect to traffic

Traffic	SIA			KAL			JAL			CATHAY			MAS		
SIA	1	1	1	3	4	5	5	6	7	1	2	3	2	3	4
KAL	1/5	1/4	1/3	1	1	1	2	3	4	1/4	1/3	1/2	¼	1/3	½
JAL	1/3	1/4	1/5	1/4	1/3	½	1	1	1	1/5	1/4	1/3	¼	1/3	½
CATHAY	1/3	1/2	1	2	3	4	3	4	5	1	1	1	1	2	3
MAS	1/4	1/3	1/2	2	3	4	2	3	4	1/3	1/2	1	1	1	1

From Table A2.28, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sia} = (12.000, 16.000, 20.000) \otimes (1/53.367, 1/41.417, 1/30.650) = (0.225, 0.386, 0.653)$$
$$S_{kal} = (3.700, 4.917, 6.333) \otimes (1/53.367, 1/41.417, 1/30.650) = (0.069, 0.119, 0.207)$$
$$S_{jal} = (2.033, 2.167, 2.533) \otimes (1/53.367, 1/41.417, 1/30.650) = (0.038, 0.052, 0.083)$$
$$S_{cathay} = (7.333, 10.500, 14.000) \otimes (1/53.367, 1/41.417, 1/30.650) = (0.137, 0.254, 0.457)$$
$$S_{mas} = (5.583, 7.833, 10.500) \otimes (1/53.367, 1/41.417, 1/30.650) = (0.105, 0.189, 0.343)$$

These fuzzy values are compared by using equation (2.15) and

$V(S_{sia} \geq S_{kal}) = 1.000,\ \ V(S_{sia} \geq S_{jal}) = 1.000,\ \ V(S_{sia} \geq S_{cathay}) = 1.000,\ \ V(S_{sia} \geq S_{mas}) = 1.000$

$V(S_{kal} \geq S_{sia}) = 0.000,\ \ V(S_{kal} \geq S_{jal}) = 1.000,\ \ V(S_{kal} \geq S_{cathay}) = 0.339,\ \ V(S_{kal} \geq S_{mas}) = 0.592$

$V(S_{jal} \geq S_{sia}) = 0.000,\ \ V(S_{jal} \geq S_{kal}) = 0.167\ \ V(S_{jal} \geq S_{cathay}) = 0.000,\ \ V(S_{jal} \geq S_{mas}) = 0.000$

$V(S_{cathay} \geq S_{sia}) = 0.636, V(S_{cathay} \geq S_{kal}) = 1.000, V(S_{cathay} \geq S_{jal}) = 1.000, V(S_{cathay} \geq S_{mas}) = 1.000$

$V(S_{mas} \geq S_{sia}) = 0.374,\ \ V(S_{mas} \geq S_{kal}) = 1.000, V(S_{mas} \geq S_{jal}) = 1.000,\ \ V(S_{mas} \geq S_{cathay}) = 0.761$

are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sia) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(kal) = \min(0.000,\ 1.000,\ 0.339,\ 0.592) = 0.000,$

$d'(jal) = \min(0.000,\ 0.167,\ 0.000,\ 0.000) = 0.000,$

$d'(cathay) = \min(0.636,\ 1.000,\ 1.000,\ 1.000) = 0.636,$

$d'(mas) = \min(0.374,\ 1.000,\ 1.000,\ 0.761) = 0.374,$

Priority weights form $W' = (1.000,\ 0.000,\ 0.000,\ 0.636,\ 0.374)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.498,\ 0.000,\ 0.000,\ 0.316,\ 0.186)$. According to this result the Singapore airlines gives importance to traffic, then Cathay Pacific in selecting the best airlines website.

Table A2.29 Evaluation of the Asian airlines attributes with respect to design optimization

Design optimization	SIA			KAL			JAL			CATHAY			MAS		
SIA	1	1	1	1/3	1/2	1	1/7	1/6	1/5	1/8	1/7	1/6	1/8	1/7	1/6
KAL	1	2	3	1	1	1	1/6	1/5	1/4	1/7	1/6	1/5	1/7	1/6	1/5
JAL	5	6	7	4	5	6	1	1	1	¼	1/3	½	¼	1/3	1/2
CATHAY	6	7	8	5	6	7	2	3	4	1	1	1	1	2	3
MAS	6	7	8	5	6	7	2	3	4	1/3	1/2	1	1	1	1

From Table A2.29, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sia} = (1.726, 1.952, 2.533) \otimes (1/66.183, 1/54.652, 1/44.012) = (0.026, 0.036, 0.058)$$
$$S_{kal} = (2.452, 3.533, 4.650) \otimes (1/66.183, 1/54.652, 1/44.012) = (0.037, 0.065, 0.106)$$
$$S_{jal} = (10.500, 12.667, 15.000) \otimes (1/66.183, 1/54.652, 1/44.012) = (0.159, 0.232, 0.341)$$
$$S_{cathay} = (15.000, 19.000, 23.000) \otimes (1/66.183, 1/54.652, 1/44.012) = (0.227, 0.348, 0.523)$$
$$S_{mas} = (14.333, 17.500, 21.000) \otimes (1/66.183, 1/54.652, 1/44.012) = (0.217, 0.320, 0.477)$$

These fuzzy values are compared by using equation (2.15) and

$$V(S_{sia} \geqslant S_{kal}) = 0.415,\ V(S_{sia} \geqslant S_{jal}) = 0.000,\ V(S_{sia} \geqslant S_{cathay}) = 0{,}000,\ V(S_{sia} \geqslant S_{mas}) = 0.000$$
$$V(S_{kal} \geqslant S_{sia}) = 1.000,\ V(S_{kal} \geqslant S_{jal}) = 0.000,\ V(S_{kal} \geqslant S_{cathay}) = 0.000,\ V(S_{kal} \geqslant S_{mas}) = 0.000$$
$$V(S_{jal} \geqslant S_{sia}) = 1.000,\ V(S_{jal} \geqslant S_{kal}) = 1.000,\ V(S_{jal} \geqslant S_{cathay}) = 0.496,\ V(S_{jal} \geqslant S_{mas}) = 0.584$$

$V(S_{cathay} \geqslant S_{sia}) = 1.000, V(S_{cathay} \geqslant S_{kal}) = 1.000, V(S_{cathay} \geqslant S_{jal}) = 1.000, V(S_{cathay} \geqslant S_{mas}) = 1.000$
$V(S_{mas} \geqslant S_{sia}) = 1.000, \quad V(S_{mas} \geqslant S_{kal}) = 1.000, V(S_{mas} \geqslant S_{jal}) = 1.000, \quad V(S_{mas} \geqslant S_{cathay}) = 1.000$
, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sia) = \min(0.415, \; 0.000, \; 0.000, \; 0.000) = 0.000,$

$d'(kal) = \min(1.000, \; 0.000, \; 0.000, \; 0.000) = 0.000,$

$d'(jal) = \min(1.000, \; 1.000, \; 0.496, \; 0.584) = 0.496,$

$d'(cathay) = \min(1.000, \; 1.000, \; 1.000, \; 1.000) = 1.000,$

$d'(mas) = \min(1.000, \; 1.000, \; 1.000, \; 0.901) = 0.901,$

Priority weights form $W' = (0.000, \; 0.000, \; 0.496, \; 1.000, \; 0.901)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000, \; 0.000, \; 0.207, \; 0.417, \; 0.376)$. According to this result the Cathay pacific gives importance to design optimization, then Malaysia airlines in selecting the best airlines website.

Table A2.30 Evaluation of the Asian airlines attributes with respect to size

Size	SIA			KAL			JAL			CATHAY			MAS		
SIA	1	1	1	1	1	2	1	1	2	1/7	1/6	1/5	1/9	1/9	1/8
KAL	7	8	9	1	1	1	4	5	6	5	6	7	1/4	1/3	½
JAL	6	7	8	1/6	1/5	1/4	1	1	1	1	2	3	1/6	1/5	¼
CATHAY	5	6	7	1/7	1/6	1/5	1/3	1/2	1	1	1	1	1/7	1/6	1/5
MAS	8	9	9	2	3	4	4	5	6	5	6	7	1	1	1

From Table A3.30, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sia} = (3.254, 3.278, 5.325) \otimes (1/77.725, 1/65.844, 1/55.456) = (0.042, 0.050, 0.096)$$
$$S_{kal} = (17.250, 20.333, 23.500) \otimes (1/77.725, 1/65.844, 1/55.456) = (0.022, 0.309, 0.424)$$
$$S_{jal} = (8.333, 10.400, 12.500) \otimes (1/77.725, 1/65.844, 1/55.456) = (0.107, 0.158, 0.225)$$
$$S_{cathay} = (6.619, 7.833, 9.400) \otimes (1/77.725, 1/65.844, 1/55.456) = (0.085, 0.119, 0.170)$$
$$S_{mas} = (20.000, 24.000, 27.000) \otimes (1/77.725, 1/65.844, 1/55.456) = (0.257, 0.364, 0.487)$$

These fuzzy values are compared by using equation (2.15) and $V(S_{sia} \geqslant S_{kal}) = 0.000$, $V(S_{sia} \geqslant S_{jal}) = 0.000$, $V(S_{sia} \geqslant S_{cathay}) = 0{,}136$, $V(S_{sia} \geqslant S_{mas}) = 0.000$
$V(S_{kal} \geqslant S_{sia}) = 1.000$, $V(S_{kal} \geqslant S_{jal}) = 1.000$, $V(S_{kal} \geqslant S_{cathay}) = 1.000$, $V(S_{kal} \geqslant S_{mas}) = 0.749$
$V(S_{jal} \geqslant S_{sia}) = 1.000$, $V(S_{jal} \geqslant S_{kal}) = 0.022$, $V(S_{jal} \geqslant S_{cathay}) = 1.000$, $V(S_{jal} \geqslant S_{mas}) = 0.000$
$V(S_{cathay} \geqslant S_{sia}) = 1.000$, $V(S_{cathay} \geqslant S_{kal}) = 0.000$, $V(S_{cathay} \geqslant S_{jal}) = 0.615$, $V(S_{cathay} \geqslant S_{mas}) = 0.000$
$V(S_{mas} \geqslant S_{sia}) = 1.000$, $V(S_{mas} \geqslant S_{kal}) = 1.000$, $V(S_{mas} \geqslant S_{jal}) = 1.000$, $V(S_{mas} \geqslant S_{cathay}) = 1.000$
, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(\text{sia}) = \min(0.000,\ 0.000,\ 0.136,\ 0.000) = 0.000,$

$d'(\text{kal}) = \min(1.000,\ 1.000,\ 1.000,\ 0.749) = 0.749,$

$d'(\text{jal}) = \min(1.000,\ 0.022,\ 1.000,\ 0.000) = 0.000,$

$d'(\text{cathay}) = \min(1.000,\ 0.000,\ 0.615,\ 0.000) = 0.000,$

$d'(\text{mas}) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

Priority weights form $W' = (0.000,\ 0.749,\ 0.000,\ 0.000,\ 1.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.428,\ 0.000,\ 0.000,\ 0.572)$. According to this result the Malaysia airlines gives importance to size, then Korea airlines in selecting the best airlines website.

Table A2.31 Evaluation of the Asian airlines attributes with respect to number of items

Number of items	SIA			KAL			JAL			CATHAY			MAS		
SIA	1	1	1	1/7	1/6	1/5	1	2	3	2	3	4	1/8	1/7	1/6
KAL	5	6	7	1	1	1	6	7	8	7	8	9	1/4	1/3	½
JAL	1/3	1/2	1	1/8	1/7	1/6	1	1	1	2	3	4	1/9	1/8	1/7
CATHAY	1/4	1/3	1/2	1/9	1/8	1/7	1/4	1/3	1/2	1	1	1	1/9	1/9	1/8
MAS	6	7	8	2	3	4	7	8	9	8	9	9	1	1	1

From Table A2.31, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sia} = (4.268, 6.310, 8.367) \otimes (1/73.444, 1/63.313, 1/52.810) = (0.058, 0.100, 0.158)$$
$$S_{kal} = (19.250, 22.333, 25.500) \otimes (1/73.444, 1/63.313, 1/52.810) = (0.262, 0.353, 0.483)$$
$$S_{jal} = (3.569, 4.768, 6.310) \otimes (1/73.444, 1/63.313, 1/52.810) = (0.049, 0.075, 0.119)$$

$$S_{cathay} = (1.722, 1.903, 2.268) \otimes (1/73.444, 1/63.313, 1/52.810) = (0.023, 0.030, 0.043)$$

$$S_{mas} = (24.000, 28.000, 31.000) \otimes (1/73.444, 1/63.313, 1/52.810) = (0.327, 0.442, 0.587)$$

These fuzzy values are compared by using equation (2.15) and

$V(S_{sia} \geqslant S_{kal}) = 0.000$, $V(S_{sia} \geqslant S_{jal}) = 1.000$, $V(S_{sia} \geqslant S_{cathay}) = 1,000$, $V(S_{sia} \geqslant S_{mas}) = 0.000$

$V(S_{kal} \geqslant S_{sia}) = 1.000$, $V(S_{kal} \geqslant S_{jal}) = 1.000$, $V(S_{kal} \geqslant S_{cathay}) = 1.000$, $V(S_{kal} \geqslant S_{mas}) = 0.636$

$V(S_{jal} \geqslant S_{sia}) = 0.716$, $V(S_{jal} \geqslant S_{kal}) = 0.000$, $V(S_{jal} \geqslant S_{cathay}) = 1.000$, $V(S_{jal} \geqslant S_{mas}) = 0.000$

$V(S_{cathay} \geqslant S_{sia}) = 0.000$, $V(S_{cathay} \geqslant S_{kal}) = 0.000$, $V(S_{cathay} \geqslant S_{jal}) = 0.000$, $V(S_{cathay} \geqslant S_{mas}) = 0.000$

$V(S_{mas} \geqslant S_{sia}) = 1.000$, $V(S_{mas} \geqslant S_{kal}) = 1.000$, $V(S_{mas} \geqslant S_{jal}) = 1.000$, $V(S_{mas} \geqslant S_{cathay}) = 1.000$

, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sia) = \min(0.000,\ 1.000,\ 1.000,\ 0.000) = 0.000,$

$d'(kal) = \min(1.000,\ 1.000,\ 1.000,\ 0.636) = 0.636,$

$d'(jal) = \min(0.716,\ 0.000,\ 1.000,\ 0.000) = 0.000,$

$d'(cathay) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

$d'(mas) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

Priority weights form $W' = (0.000,\ 0.636,\ 0.000,\ 0.000,\ 1.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.389,\ 0.000,\ 0.000,\ 0.611)$. According to this result the Malaysia airlines gives importance to number of items, then Korea airlines in selecting the best airlines website.

Table A2.32 Evaluation of the Asian airlines attributes with respect to accessibility

Accessibility	SIA			KAL			JAL			CATHAY			MAS		
SIA	1	1	1	2	3	4	1/3	1/2	1	4	5	6	1/3	½	1
KAL	1/4	1/3	1/2	1	1	1	1/4	1/3	1/2	3	4	5	1/4	1/3	½
JAL	1	2	3	2	3	4	1	1	1	4	5	6	1/2	1	1
CATHAY	1/6	1/5	1/4	1/5	1/4	1/3	1/6	1/5	1/4	1	1	1	1/6	1/5	¼
MAS	1	2	3	2	3	4	1	1	2	4	5	6	1	1	1

From Table A3.32, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sia} = (7.667, 10.000, 13.000) \otimes (1/53.583, 1/41.850, 1/31.617) = (0.143, 0.239, 0.411)$$
$$S_{kal} = (4.750, 6.000, 7.500) \otimes (1/53.583, 1/41.850, 1/31.617) = (0.089, 0.143, 0.237)$$
$$S_{jal} = (8.500, 12.000, 15.000) \otimes (1/53.583, 1/41.850, 1/31.617) = (0.159, 0.287, 0.474)$$
$$S_{cathay} = (1.700, 1.850, 2.083) \otimes (1/53.583, 1/41.850, 1/31.617) = (0.032, 0.044, 0.066)$$
$$S_{mas} = (9.000, 12.000, 16.000) \otimes (1/53.583, 1/41.850, 1/31.617) = (0.168, 0.287, 0.506)$$

These fuzzy values are compared by using equation (2.15) and

$$V(S_{sia} \geqslant S_{kal}) = 1.000,\ V(S_{sia} \geqslant S_{jal}) = 0.841,\ V(S_{sia} \geqslant S_{cathay}) = 1{,}000,\ V(S_{sia} \geqslant S_{mas}) = 0.836$$
$$V(S_{kal} \geqslant S_{sia}) = 0.496,\ V(S_{kal} \geqslant S_{jal}) = 0.354,\ V(S_{kal} \geqslant S_{cathay}) = 1.000,\ V(S_{kal} \geqslant S_{mas}) = 0.326$$
$$V(S_{jal} \geqslant S_{sia}) = 1.000,\ V(S_{jal} \geqslant S_{kal}) = 1.000,\ V(S_{jal} \geqslant S_{cathay}) = 1.000,\ V(S_{jal} \geqslant S_{mas}) = 1.000$$
$$V(S_{cathay} \geqslant S_{sia}) = 0.000,\ V(S_{cathay} \geqslant S_{kal}) = 0.000, V(S_{cathay} \geqslant S_{jal}) = 0.000, V(S_{cathay} \geqslant S_{mas}) = 0.000$$
$$V(S_{mas} \geqslant S_{sia}) = 1.000,\ V(S_{mas} \geqslant S_{kal}) = 1.000,\ V(S_{mas} \geqslant S_{jal}) = 1.000,\ V(S_{mas} \geqslant S_{cathay}) = 1.000$$

, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sia) = \min(1.000,\ 0.841,\ 1.000,\ 0.836) = 0.836,$

$d'(kal) = \min(0.496,\ 0.354,\ 1.000,\ 0.326) = 0.326,$

$d'(jal) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(cathay) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

$d'(mas) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

Priority weights form $W' = (0.836,\ 0.326,\ 1.000,\ 0.000,\ 1.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.264,\ 0.103,\ 0.316,\ 0.000,\ 0.316)$. According to this result the Malaysia airlines and Japan Airlines gives importance to accessibility, then Singapore airlines in selecting the best airlines website.

Table A2.33 Evaluation of the Asian airlines attributes with respect to markup validation

Markup validation	SIA			KAL			JAL			CATHAY			MAS		
SIA	1	1	1	1/6	1/5	1/4	1/8	1/7	1/6	4	5	6	1/8	1/7	1/6
KAL	4	5	6	1	1	1	¼	1/3	1/2	6	7	8	1/4	1/3	½
JAL	6	7	8	2	3	4	1	1	1	8	9	9	1	2	3
CATHAY	1/6	1/5	1/4	1/8	1/7	1/6	1/9	1/9	1/8	1	1	1	1/9	1/9	1/8
MAS	6	7	8	2	3	4	1/3	½	1	8	9	9	1	1	1

From Table A2.33, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sia} = (5.417, 6.486, 7.583) \otimes (1/73.250, 1/64.217, 1/53.764) = (0.074, 0.101, 0.141)$$
$$S_{kal} = (11.500, 13.667, 16.000) \otimes (1/73.250, 1/64.217, 1/53.764) = (0.157, 0.213, 0.298)$$
$$S_{jal} = (18.000, 22.000, 25.000) \otimes (1/73.250, 1/64.217, 1/53.764) = (0.246, 0.343, 0.465)$$
$$S_{cathay} = (1.514, 1.565, 1.667) \otimes (1/73.250, 1/64.217, 1/53.764) = (0.021, 0.024, 0.031)$$
$$S_{mas} = (17.333, 20.500, 23.000) \otimes (1/73.250, 1/64.217, 1/53.764) = (0.237, 0.319, 0.428)$$

These fuzzy values are compared by using equation (2.15) and

$V(S_{sia} \geqslant S_{kal}) = 0.000$, $V(S_{sia} \geqslant S_{jal}) = 0.000$, $V(S_{sia} \geqslant S_{cathay}) = 1{,}000$, $V(S_{sia} \geqslant S_{mas}) = 0.000$
$V(S_{kal} \geqslant S_{sia}) = 1.000$, $V(S_{kal} \geqslant S_{jal}) = 0.286$, $V(S_{kal} \geqslant S_{cathay}) = 1.000$, $V(S_{kal} \geqslant S_{mas}) = 0.364$
$V(S_{jal} \geqslant S_{sia}) = 1.000$, $V(S_{jal} \geqslant S_{kal}) = 1.000$, $V(S_{jal} \geqslant S_{cathay}) = 1.000$, $V(S_{jal} \geqslant S_{mas}) = 1.000$
$V(S_{cathay} \geqslant S_{sia}) = 0.000$, $V(S_{cathay} \geqslant S_{kal}) = 0.000$, $V(S_{cathay} \geqslant S_{jal}) = 0.000$, $V(S_{cathay} \geqslant S_{mas}) = 0.000$
$V(S_{mas} \geqslant S_{sia}) = 1.000$, $V(S_{mas} \geqslant S_{kal}) = 1.000$, $V(S_{mas} \geqslant S_{jal}) = 0.886$, $V(S_{mas} \geqslant S_{cathay}) = 1.000$
, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sia) = \min(0.000,\ 0.000,\ 1.000,\ 0.000) = 0.000,$

$d'(kal) = \min(1.000,\ 0.286,\ 1.000,\ 0.364) = 0.286,$

$d'(jal) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000$
$d'(cathay) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

$d'(mas) = \min(1.000,\ 1.000,\ 0.886,\ 1.000) = 0.886,$

Priority weights form $W' = (0.000,\ 0.286,\ 1.000,\ 0.000,\ 0.886)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.132,\ 0.460,\ 0.000,\ 0.408)$. According to this result the Japan airlines gives importance to markup validation, then Malaysia airlines in selecting the best airlines website.

Table A2.34 Evaluation of the Asian airlines attributes with respect to broken link

Broken link	SIA			KAL			JAL			CATHAY			MAS		
SIA	1	1	1	1/3	½	1	1/3	1/2	1	4	5	6	1/3	½	1
KAL	1	2	3	1	1	1	1	1	2	6	7	8	1/2	1	1
JAL	1	2	3	1/2	1	1	1	1	1	6	7	8	1/2	1	1
CATHAY	1/6	1/5	1/4	1/8	1/7	1/6	1/8	1/7	1/6	1	1	1	1/8	1/7	1/6
MAS	1	2	3	1	1	2	1	1	2	6	7	8	1	1	1

From Table A2.34, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{sia} = (6.000, 7.500, 10.000) \otimes (1/56.750, 1/45.129, 1/36.042) = (0.106, 0.166, 0.277)$$
$$S_{kal} = (9.500, 12.000, 15.000) \otimes (1/68.551, 1/58.412, 1/47.890) = (0.167, 0.266, 0.416)$$
$$S_{jal} = (9.000, 12.000, 14.000) \otimes (1/68.551, 1/58.412, 1/47.890) = (0.159, 0.266, 0.388)$$
$$S_{cathay} = (1.542, 1.629, 1.750) \otimes (1/68.551, 1/58.412, 1/47.890) = (0.027, 0.036, 0.049)$$
$$S_{mas} = (10.000, 12.000, 16.000) \otimes (1/68.551, 1/58.412, 1/47.890) = (0.176, 0.266, 0.444)$$

These fuzzy values are compared by using equation (2.15) and

$$V(S_{sia} \geqslant S_{kal}) = 0.525,\ V(S_{sia} \geqslant S_{jal}) = 0.544,\ V(S_{sia} \geqslant S_{cathay}) = 1{,}000,\ V(S_{sia} \geqslant S_{mas}) = 0.504$$
$$V(S_{kal} \geqslant S_{sia}) = 1.000,\ V(S_{kal} \geqslant S_{jal}) = 1.000,\ V(S_{kal} \geqslant S_{cathay}) = 1.000,\ V(S_{kal} \geqslant S_{mas}) = 1.000$$
$$V(S_{jal} \geqslant S_{sia}) = 1.000,\ V(S_{jal} \geqslant S_{kal}) = 1.000,\ V(S_{jal} \geqslant S_{cathay}) = 1.000,\ V(S_{jal} \geqslant S_{mas}) = 1.000$$
$$V(S_{cathay} \geqslant S_{sia}) = 0.000,\ V(S_{cathay} \geqslant S_{kal}) = 0.000\ V(S_{cathay} \geqslant S_{jal}) = 0.000, (S_{cathay} \geqslant S_{mas}) = 0.000$$
$$V(S_{mas} \geqslant S_{sia}) = 1.000,\ V(S_{mas} \geqslant S_{kal}) = 1.000,\ V(S_{mas} \geqslant S_{jal}) = 1.000,\ V(S_{mas} \geqslant S_{cathay}) = 1.000$$

, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(sia) = \min(0.525,\ 0.544,\ 1.000,\ 0.504) = 0.504$,

$d'(kal) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000$,

$d'(jal) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000$,

$d'(\text{cathay}) = \min(0.000,\ \ 0.000,\ \ 0.000,\ \ 0.000) = 0.000$,

$d'(\text{mas}) = \min(1.000,\ \ 1.000,\ \ 1.000,\ \ 1.000) = 1.000$,

Priority weights form $W' = (0.504,\ 1.000,\ 1.000,\ 0.000,\ 1.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.144,\ 0.285,\ 0.285,\ 0.000,\ 0.285)$. According to this result Malaysia airlines, Japan airlines, and Korea airlines give the same importance to broken link in selecting the best airlines website.

Appendix 3 Malaysian University

AHP

Calculation yields the normalized matrix of criteria is illustrated in Table A3.1. The average weights of rows are computed in the last column to indicate the weights of the criteria.

Table A3.1 Normalize matrix for Malaysian university load time based on AHP

Website	USM	UPM	UKM	UUM	UTP	Sum	Priority vector
USM	0.051	0.023	0.073	0.032	0.087	0.266	0.053
UPM	0.154	0.068	0.083	0.038	0.130	0.473	0.095
UKM	0.410	0.477	0.584	0.677	0.391	2.539	0.508
UUM	0.359	0.409	0.195	0.226	0.348	1.536	0.307
UTP	0.026	0.023	0.065	0.028	0.043	0.185	0.037
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A3.1 added two new columns, which are: row summation of the value based on university website and priority vector column (sum column divide by total). In this table, Universiti Sains Malaysia has priority vector value of 0.053, Universiti Putra Malaysia has 0.095, Universiti Kebangsaan Malaysia has 0.508, Universiti Utara Malaysia has 0.307, and Universiti Teknologi PETRONAS has 0.037. The highest weights (priority vector) 0.508 and 0.307 belong to the attributes of Universiti Kebangsaan Malaysia and Universiti Utara Malaysia respectively. The attribute of Universiti Teknologi PETRONAS has the lowest weight, 0.037.

Table A3.2 Original data for Malaysian university respose time matrix based on AHP

Website	USM	UPM	UKM	UUM	UTP
USM	1.000	0.250	0.500	0.125	0.200
UPM	4.000	1.000	3.000	0.167	0.333
UKM	2.000	0.333	1.000	0.143	0.250
UUM	8.000	6.000	7.000	1.000	5.000
UTP	5.000	3.000	4.000	0.200	1.000
Sum	20.000	10.583	15.500	1.635	6.783

From the Table A3.2, the sum of Universiti Sains Malaysia response time is 20.000, Universiti Putra Malaysia is 10.583, Universiti Kebangsaan Malaysia is 15.500, Universiti Utara Malaysia is 1.635 and Universiti Teknologi PETRONAS is 6.783. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A3.3.

Table A3.3 Normalize matrix for Malaysian university response time time based on AHP

Website	USM	UPM	UKM	UUM	UTP	Sum	Priority vector
USM	0.050	0.024	0.032	0.076	0.029	0.212	0.042
UPM	0.200	0.094	0.194	0.102	0.049	0.639	0.128
UKM	0.100	0.031	0.065	0.087	0.037	0.320	0.064
UUM	0.400	0.567	0.452	0.612	0.737	2.767	0.553
UTP	0.250	0.283	0.258	0.122	0.147	1.061	0.212
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A3.3 added two new columns, which are: row summation of the value based on university website and priority vector column (sum column divide by total). In this table, Universiti Sains Malaysia has priority vector value of 0.042, Universiti Putra Malaysia has 0.128, Universiti Kebangsaan Malaysia has 0.064, Universiti Utara Malaysia has 0.553, and Universiti Teknologi PETRONAS has 0.212. The highest weights (priority vector) 0.553 and 0.212 belong to the attributes of Universiti Utara Malaysia and Universiti Teknologi PETRONAS respectively. The attribute of Universiti Sains Malaysia has the lowest weight, 0.042.

Table A3.4 Original data for Malaysian university page rank matrix based on AHP

Website	USM	UPM	UKM	UUM	UTP
USM	1.000	0.333	4.000	5.000	6.000
UPM	3.000	1.000	5.000	6.000	7.000
UKM	0.250	0.200	1.000	2.000	5.000
UUM	0.200	0.167	0.500	1.000	5.000
UTP	0.167	0.143	0.200	0.200	1.000
Sum	4.617	1.843	10.700	14.200	24.000

From the Table A3.4, the sum of Universiti Sains Malaysia page rank is 4.617, Universiti Putra Malaysia is 1.843, Universiti Kebangsaan Malaysia is 10.700, Universiti Utara Malaysia is 14.200 and Universiti Teknologi PETRONAS is 24.000. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A3.5.

Table A3.5 Normalize matrix for Malaysian university page rank based on AHP

Website	USM	UPM	UKM	UUM	UTP	Sum	Priority vector
USM	0.217	0.181	0.374	0.352	0.250	1.373	0.275
UPM	0.650	0.543	0.467	0.423	0.292	2.374	0.475
UKM	0.054	0.109	0.093	0.141	0.208	0.605	0.121
UUM	0.043	0.090	0.047	0.070	0.208	0.459	0.092
UTP	0.036	0.078	0.019	0.014	0.042	0.188	0.038
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A3.5 added two new columns, which are: row summation of the value based on university website and priority vector column (sum column divide by total). In this table, Universiti Sains Malaysia has priority vector value of 0.275, Universiti Putra Malaysia has 0.475, Universiti Kebangsaan Malaysia has 0.121, Universiti Utara Malaysia has 0.092, and Universiti Teknologi PETRONAS has 0.038. The highest weights (priority vector) 0.475 and 0.275 belong to the attributes of Universiti Putra Malaysia and Universiti Sains Malaysia respectively. The attribute of Universiti Teknologi PETRONAS has the lowest weight, 0.038.

Table A3.6 Original data of Malaysian university frequency of update Matrix based on AHP

Website	USM	UPM	UKM	UUM	UTP
USM	1.000	1.000	5.000	1.000	5.000
UPM	1.000	1.000	5.000	1.000	5.000
UKM	0.200	0.200	1.000	0.200	5.000
UUM	1.000	1.000	5.000	1.000	5.000
UTP	0.200	0.200	0.200	0.200	1.000
Sum	3.400	3.400	16.200	3.400	21.000

From the Table A3.6, the sum of Universiti Sains Malaysia frequency of update is 3.400, Universiti Putra Malaysia is 3.400, Universiti Kebangsaan Malaysia is 16.200, Universiti Utara Malaysia is 3.400 and Universiti Teknologi PETRONAS is 21.000. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A3.7.

Table A3.7 Normalize matrix for Malaysian university frequency of update based on AHP

Website	USM	UPM	UKM	UUM	UTP	Sum	Priority vector
USM	0.294	0.294	0.309	0.294	0.238	1.429	0.286
UPM	0.294	0.294	0.309	0.294	0.238	1.429	0.286
UKM	0.059	0.059	0.062	0.059	0.238	0.476	0.095
UUM	0.294	0.294	0.309	0.294	0.238	1.429	0.286
UTP	0.059	0.059	0.012	0.059	0.048	0.236	0.047
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A3.7 added two new columns, which are: row summation of the value based on university website and priority vector column (sum column divide by total). In this table, Universiti Sains Malaysia has priority vector value of 0.286, Universiti Putra Malaysia has 0.286, Universiti Kebangsaan Malaysia has 0.095, Universiti Utara Malaysia has 0.286, and Universiti Teknologi PETRONAS is 0.047. The highest weights (priority vector) 0.286 belongs together to the attributes of Universiti Sains Malaysia, Universiti Putra Malaysia and Universiti Utara Malaysia. The attribute of Universiti Teknologi PETRONAS has the lowest weight, 0.047.

Table A3.8 Original data of Malaysian university traffic matrix based on AHP

Website	USM	UPM	UKM	UUM	UTP
USM	1.000	0.200	0.200	2.000	5.000
UPM	5.000	1.000	3.000	6.000	7.000
UKM	5.000	0.333	1.000	6.000	7.000
UUM	0.500	0.167	0.167	1.000	4.000
UTP	0.200	0.143	0.143	0.250	1.000
Sum	11.700	1.843	4.510	15.250	24.000

From the Table A3.8, the sum of Universiti Sains Malaysia traffic is 11.700, Universiti Putra Malaysia is 1.843, Universiti Kebangsaan Malaysia is 4.510, Universiti Utara Malaysia is 15.250 and Universiti Teknologi PETRONAS is 24.000. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A3.9.

Table A3.9 Normalize matrix for Malaysian university traffic based on AHP

Website	USM	UPM	UKM	UUM	UTP	Sum	Priority vector
USM	0.085	0.109	0.044	0.131	0.208	0.578	0.116
UPM	0.427	0.543	0.665	0.393	0.292	2.320	0.464
UKM	0.427	0.181	0.222	0.393	0.292	1.515	0.303
UUM	0.043	0.090	0.037	0.066	0.167	0.402	0.080
UTP	0.017	0.078	0.032	0.016	0.042	0.184	0.037
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A3.9 added two new columns, which are: row summation of the value based on university website and priority vector column (sum column divide by total). In this table, Universiti Sains Malaysia has priority vector value of 0.116, Universiti Putra Malaysia has 0.464, Universiti Kebangsaan Malaysia has 0.303, Universiti Utara Malaysia has 0.080, and Universiti Teknologi PETRONAS has 0.037. The highest weights (priority vector) 0.464 and 0.303 belong to the attributes of Universiti Putra Malaysia and Universiti Kebangsaan Malaysia respectively. The attribute of Universiti Teknologi PETRONAS has the lowest weight, 0.037.

Table A3.10 Original data of Malaysian university design optimization matrix based on AHP

Website	USM	UPM	UKM	UUM	UTP
USM	1.000	0.250	0.500	2.000	0.167
UPM	4.000	1.000	3.000	5.000	0.333
UKM	2.000	0.333	1.000	3.000	0.200
UUM	0.500	0.200	0.333	1.000	0.143
UTP	6.000	3.000	5.000	7.000	1.000
Sum	13.500	4.783	9.833	18.000	1.843

From the Table A3.10, the sum of Universiti Sains Malaysia design optimization is 13.500, Universiti Putra Malaysia is 4.783, Universiti Kebangsaan Malaysia is 9.833, Universiti Utara Malaysia is 18.000 and Universiti Teknologi PETRONAS is 1.843. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A3.11.

Table A3.11 Normalize matrix for Malaysian university design optimization based on AHP

Website	USM	UPM	UKM	UUM	UTP	Sum	Priority vector
USM	0.074	0.052	0.051	0.111	0.090	0.379	0.076
UPM	0.296	0.209	0.305	0.278	0.181	1.269	0.254
UKM	0.148	0.070	0.102	0.167	0.109	0.595	0.119
UUM	0.037	0.042	0.034	0.056	0.078	0.246	0.049
UTP	0.444	0.627	0.508	0.389	0.543	2.512	0.502
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A3.11 added two new columns, which are: row summation of the value based on university website and priority vector column (sum column divide by total). In this table, Universiti Sains Malaysia has priority vector value of 0.076, Universiti Putra Malaysia has 0.254, Universiti Kebangsaan Malaysia has 0.119, Universiti Utara Malaysia has 0.049, and Universiti Teknologi PETRONAS has 0.502. The highest weights (priority vector) 0.502 and 0.254 belong to the attributes of Universiti Teknologi PETRONAS and Universiti Putra Malaysia respectively. The attribute of Universiti Utara Malaysia has the lowest weight, 0.049.

Table A3.12 Original data of Malaysian university size matrix based on AHP

Website	USM	UPM	UKM	UUM	UTP
USM	1.000	0.333	0.125	0.143	2.000
UPM	3.000	1.000	0.143	0.167	4.000
UKM	8.000	7.000	1.000	3.000	9.000
UUM	7.000	6.000	0.333	1.000	8.000
UTP	0.500	0.250	0.111	0.125	1.000
Sum	19.500	14.583	1.712	4.435	24.000

From the Table A3.12, the sum of Universiti Sains Malaysia size is 19.500, Universiti Putra Malaysia is 14.583, Universiti Kebangsaan Malaysia is 1.712, Universiti Utara Malaysia is 4.435 and Universiti Teknologi PETRONAS is 24.000. The next step in the step is to compute the value matrix by dividing all of the pairwise value with sum of the column. The result of the criteria values matrix is displayed in Table A3.13.

Table A.3.13 Normalize matrix for Malaysian university size based on AHP

Website	USM	UPM	UKM	UUM	UTP	Sum	Priority vector
USM	0.051	0.023	0.073	0.032	0.083	0.263	0.053
UPM	0.154	0.069	0.083	0.038	0.167	0.510	0.102
UKM	0.410	0.480	0.584	0.677	0.375	2.526	0.505
UUM	0.359	0.411	0.195	0.226	0.333	1.524	0.305
UTP	0.026	0.017	0.065	0.028	0.042	0.178	0.036
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A3.13 added two new columns, which are: row summation of the value based on university website and priority vector column (sum column divide by total). In this table, Universiti Sains Malaysia has priority vector value of 0.053, Universiti Putra Malaysia has 0.102, Universiti Kebangsaan Malaysia has 0.505, Universiti Utara Malaysia has 0.305, and Universiti Teknologi PETRONAS is 0.036. The highest weights (priority vector) 0.505 and 0.305 belong to the attributes of Universiti Kebangsaan Malaysia and Universiti Utara Malaysia respectively. The attribute of Universiti Teknologi PETRONAS has the lowest weight, 0.036.

Table A3.14 Original data for Malaysian university number of items matrix based on AHP

Website	USM	UPM	UKM	UUM	UTP
USM	1.000	4.000	0.167	0.333	0.200
UPM	0.250	1.000	0.111	0.167	0.143
UKM	6.000	9.000	1.000	5.000	3.000
UUM	3.000	6.000	0.200	1.000	0.333
UTP	5.000	7.000	0.333	3.000	1.000
Sum	15.250	27.000	1.811	9.500	4.676

From the Table A3.14, the sum of Universiti Sains Malaysia number of items is 15.250, Universiti Putra Malaysia is 27.000, Universiti Kebangsaan Malaysia is 1.811, Universiti Utara Malaysia is 9.500 and Universiti Teknologi PETRONAS is 4.676. The next step in the step is to compute the value matrix by dividing all of the pairwise value

with sum of the column. The result of the criteria values matrix is displayed in Table A3.15.

Table A3.15 Normalize matrix for Malaysian university number of items based on AHP

Website	USM	UPM	UKM	UUM	UTP	Sum	Priority vector
USM	0.066	0.148	0.092	0.035	0.043	0.384	0.077
UPM	0.016	0.037	0.061	0.018	0.031	0.163	0.033
UKM	0.393	0.333	0.552	0.526	0.642	2.447	0.489
UUM	0.197	0.222	0.110	0.105	0.071	0.706	0.141
UTP	0.328	0.259	0.184	0.316	0.214	1.301	0.260
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A3.15 added two new columns, which are: row summation of the value based on university website and priority vector column (sum column divide by total). In this table, Universiti Sains Malaysia has priority vector value of 0.077, Universiti Putra Malaysia has 0.033, Universiti Kebangsaan Malaysia has 0.489, Universiti Utara Malaysia has 0.141, and Universiti Teknologi PETRONAS has 0.260. The highest weights (priority vector) 0.489 and 0.260 belong to the attributes of Universiti Kebangsaan Malaysia and Universiti Teknologi PETRONAS respectively. The attribute of Universiti Putra Malaysia has the lowest weight, 0.033.

Table A3.16 Original data of Malaysian university accessibility matrix based on AHP

Website	USM	UPM	UKM	UUM	UTP
USM	1.000	6.000	0.200	0.143	0.167
UPM	0.167	1.000	0.143	0.111	0.125
UKM	5.000	7.000	1.000	0.333	0.500
UUM	7.000	9.000	3.000	1.000	2.000
UTP	6.000	8.000	2.000	0.200	1.000
Sum	19.167	31.000	6.343	1.787	3.792

From the Table A3.16, the sum of Universiti Sains Malaysia accessibility is 19.167, Universiti Putra Malaysia is 31.000, Universiti Kebangsaan Malaysia is 6.343, Universiti Utara Malaysia is 1.787 and Universiti Teknologi PETRONAS is 3.792. The next step in the step is to compute the value matrix by dividing all of the pairwise value

with sum of the column. The result of the criteria values matrix is displayed in Table A3.17.

Table A3.17 Normalize matrix for Malaysian university accessibility based on AHP

Website	USM	UPM	UKM	UUM	UTP	Sum	Priority vector
USM	0.052	0.194	0.032	0.080	0.044	0.401	0.080
UPM	0.009	0.032	0.023	0.062	0.033	0.159	0.032
UKM	0.261	0.226	0.158	0.187	0.132	0.963	0.193
UUM	0.365	0.290	0.473	0.560	0.527	2.215	0.443
UTP	0.313	0.258	0.315	0.112	0.264	1.262	0.252
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A3.17 added two new columns, which are: row summation of the value based on university website and priority vector column (sum column divide by total). In this table, Universiti Sains Malaysia has priority vector value of 0.080, Universiti Putra Malaysia has 0.032, Universiti Kebangsaan Malaysia has 0.193, Universiti Utara Malaysia has 0.443, and Universiti Teknologi PETRONAS is 0.252. The highest weights (priority vector) 0.443 and 0.252 belong to the attributes of Universiti Utara Malaysia and Universiti Teknologi PETRONAS respectively. The attribute of Universiti Putra Malaysia has the lowest weight, 0.032.

Table A3.18 Original data for Malaysian university markup validation Matrix based on AHP

Website	USM	UPM	UKM	UUM	UTP
USM	1.000	4.000	0.200	0.143	0.250
UPM	0.250	1.000	0.143	0.111	0.167
UKM	5.000	7.000	1.000	0.333	3.000
UUM	7.000	9.000	3.000	1.000	4.000
UTP	4.000	6.000	0.333	0.250	1.000
Sum	17.250	27.000	4.676	1.837	8.417

From the Table A3.18, the sum of Universiti Sains Malaysia markup validation is 17.250, Universiti Putra Malaysia is 27.000, Universiti Kebangsaan Malaysia is 4.676, Universiti Utara Malaysia is 1.837 and Universiti Teknologi PETRONAS is 8.417. The next step in the step is to compute the value matrix by dividing all of the pairwise value

with sum of the column. The result of the criteria values matrix is displayed in Table A3.19.

Table A3.19 Normalize matrix for Malaysian university markup validation based on AHP

Website	USM	UPM	UKM	UUM	UTP	Sum	Priority vector
USM	0.058	0.148	0.043	0.078	0.030	0.356	0.071
UPM	0.014	0.037	0.031	0.060	0.020	0.162	0.032
UKM	0.290	0.259	0.214	0.181	0.356	1.301	0.260
UUM	0.406	0.333	0.642	0.544	0.475	2.400	0.480
UTP	0.232	0.222	0.071	0.136	0.119	0.780	0.156
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A3.19 added two new columns, which are: row summation of the value based on university website and priority vector column (sum column divide by total). In this table, Universiti Sains Malaysia has priority vector value of 0.071, Universiti Putra Malaysia has 0.032, Universiti Kebangsaan Malaysia has 0.260, Universiti Utara Malaysia has 0.480, and Universiti Teknologi PETRONAS has 0.156. The highest weights (priority vector) 0.480 and 0.260 belong to the attributes of Universiti Utara Malaysia and Universiti Kebangsaan Malaysia respectively. The attribute of Universiti Putra Malaysia has the lowest weight, 0.032.

Table A3.20 Original data for Malaysian university broken link matrix based on AHP

Website	USM	UPM	UKM	UUM	UTP
USM	1.000	8.000	3.000	0.500	1.000
UPM	0.125	1.000	0.125	0.111	0.125
UKM	0.333	8.000	1.000	0.333	0.333
UUM	2.000	9.000	3.000	1.000	2.000
UTP	1.000	8.000	3.000	0.500	1.000
Sum	4.458	34.000	10.125	2.444	4.458

From the Table A3.20, the sum of Universiti Sains Malaysia broken link is 4.458, Universiti Putra Malaysia is 34.000, Universiti Kebangsaan Malaysia is 10.125, Universiti Utara Malaysia is 2.444 and Universiti Teknologi PETRONAS is 4.458. The next step in the step is to compute the value matrix by dividing all of the pairwise value

with sum of the column. The result of the criteria values matrix is displayed in Table A3.21.

Table A3.21 Normalize matrix for Malaysian university broken link based on AHP

Website	USM	UPM	UKM	UUM	UTP	Sum	Priority vector
USM	0.224	0.235	0.296	0.205	0.224	1.185	0.237
UPM	0.028	0.029	0.012	0.045	0.028	0.143	0.029
UKM	0.075	0.235	0.099	0.136	0.075	0.620	0.124
UUM	0.449	0.265	0.296	0.409	0.449	1.867	0.373
UTP	0.224	0.235	0.296	0.205	0.224	1.185	0.237
Sum	1.000	1.000	1.000	1.000	1.000	5.000	1.000

Table A3.21 added two new columns, which are: row summation of the value based on university website and priority vector column (sum column divide by total). In this table, Universiti Sains Malaysia has priority vector value of 0.237, Universiti Putra Malaysia has 0.029, Universiti Kebangsaan Malaysia has 0.124, Universiti Utara Malaysia has 0.373, and Universiti Teknologi PETRONAS is 0.237. The highest weights (priority vector) 0.373 belongs to the attributes of Universiti Utara Malaysia. The attribute of Universiti Putra Malaysia has the lowest weight, 0.029.

FAHP

Table A3.22 Evaluation of the Malaysian university attributes with respect to load time

Load time	USM			UPM			UKM			UUM			UTP		
USM	1	1	1	1/4	1/3	1/2	1/9	1/8	1/7	1/8	1/7	1/6	1	2	3
UPM	2	3	4	1	1	1	1/8	1/7	1/6	1/7	1/6	1/5	2	3	4
UKM	7	8	9	6	7	8	1	1	1	2	3	4	8	9	9
UUM	6	7	8	5	6	7	¼	1/3	1/2	1	1	1	7	8	9
UTP	1/3	1/2	1	1/2	1/3	1/4	1/9	1/9	1/8	1/9	1/8	1/7	1	1	1

From Table A3.22, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{usm} = (2.486, 3.601, 4.810) \otimes (1/73.194, 1/63.313, 1/53.060) = (0.034, 0.057, 0.091)$$
$$S_{upm} = (5.268, 7.310, 9.367) \otimes (1/73.194, 1/63.313, 1/53.060) = (0.072, 0.115, 0.177)$$
$$S_{ukm} = (24.000, 28.000, 31.000) \otimes (1/73.194, 1/63.313, 1/53.060) = (0.328, 0.442, 0.584)$$

$S_{uum} = (19.250, 22.333, 25.500) \otimes (1/73.194, 1/63.313, 1/53.060) = (0.263, 0.353, 0.481)$
$S_{utp} = (2.056, 2.069, 2.518) \otimes (1/73.194, 1/63.313, 1/53.060) = (0.028, 0.033, 0.047)$

These fuzzy values are compared by using equation (2.15) and $V(S_{usm} \geqslant S_{upm}) = 0.242$, $V(S_{usm} \geqslant S_{ukm}) = 0.000$, $V(S_{usm} \geqslant S_{uum}) = 0{,}000$, $V(S_{usm} \geqslant S_{utp}) = 1.000$, $V(S_{upm} \geqslant S_{usm}) = 1.000$, $V(S_{upm} \geqslant S_{ukm}) = 0.000$, $V(S_{upm} \geqslant S_{uum}) = 0.000$, $V(S_{upm} \geqslant S_{utp}) = 1.000$, $V(S_{ukm} \geqslant S_{usm}) = 1.000$, $V(S_{ukm} \geqslant S_{upm}) = 1.000$, $V(S_{ukm} \geqslant S_{uum}) = 1.000$, $V(S_{ukm} \geqslant S_{utp}) = 1.000$, $V(S_{uum} \geqslant S_{usm}) = 1.000$, $V(S_{uum} \geqslant S_{upm}) = 1.000$, $V(S_{uum} \geqslant S_{ukm}) = 0.630$, $V(S_{uum} \geqslant S_{utp}) = 1.000$, $V(S_{mas} \geqslant S_{sia}) = 0.358$, $V(S_{mas} \geqslant S_{kal}) = 0.000$, $V(S_{mas} \geqslant S_{jal}) = 0.000$, $V(S_{mas} \geqslant S_{cathay}) = 0.000$, , are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(usm) = \min(0.242,\ 0.000,\ 0.000,\ 1.000) = 0.000,$

$d'(upm) = \min(1.000,\ 0.000,\ 0.000,\ 1.000) = 0.000,$

$d'(ukm) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(uum) = \min(1.000,\ 1.000,\ 0.630,\ 1.000) = 0.630,$

$d'(utp) = \min(0.358,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

Priority weights form $W' = (0.000,\ 0.000,\ 1.000,\ 0.630,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.000,\ 0.613,\ 0.387,\ 0.000)$. According to this result the Universiti Kebangsaan Malaysia website gives importance to load time, then Universiti Utara Malaysia in selecting the best website.

Table A3.23 Evaluation of the Malaysian university attributes with respect to response time

Response time	USM			UPM			UKM			UUM			UTP		
USM	1	1	1	1/5	1/4	1/3	1/3	1/2	1	1/9	1/8	1/7	1/6	1/5	¼
UPM	3	4	5	1	1	1	2	3	4	1/7	1/6	1/5	¼	1/3	½
UKM	1	2	3	¼	1/3	1/2	1	1	1	1/8	1/7	1/6	1/5	1/4	1/3
UUM	7	8	9	5	6	7	6	7	8	1	1	1	4	5	6
UTP	4	5	6	2	3	4	3	4	5	1/6	1/5	1/4	1	1	1

From Table A3.23, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{usm} = (1.811, 2.075, 2.726) \otimes (1/65.676, 1/54.501, 1/43.946) = (0.028, 0.038, 0.062)$$
$$S_{upm} = (6.393, 8.500, 10.700) \otimes (1/65.676, 1/54.501, 1/43.946) = (0.097, 0.038, 0.062)$$
$$S_{ukm} = (2.575, 3.726, 5.000) \otimes (1/65.676, 1/54.501, 1/43.946) = (0.039, 0.068, 0.114)$$
$$S_{uum} = (23.000, 27.000, 31.000) \otimes (1/65.676, 1/54.501, 1/43.946) = (0.350, 0.495, 0.705)$$
$$S_{utp} = (10.167, 13.200, 16.250) \otimes (1/65.676, 1/54.501, 1/43.946) = (0.155, 0.242, 0.370)$$

These fuzzy values are compared by using equation (2.15) and $V(S_{usm} \geqslant S_{upm}) = 0.000$, $V(S_{usm} \geqslant S_{ukm}) = 0.430$, $V(S_{usm} \geqslant S_{uum}) = 0{,}000$, $V(S_{usm} \geqslant S_{utp}) = 1.000$, $V(S_{upm} \geqslant S_{usm}) = 1.000$, $V(S_{upm} \geqslant S_{ukm}) = 1.000$, $V(S_{upm} \geqslant S_{uum}) = 0.000$, $V(S_{upm} \geqslant S_{utp}) = 0.507$, $V(S_{ukm} \geqslant S_{usm}) = 1.000$, $V(S_{ukm} \geqslant S_{upm}) = 0.158$, $V(S_{ukm} \geqslant S_{uum}) = 0.000$, $V(S_{ukm} \geqslant S_{utp}) = 0.000$, $V(S_{uum} \geqslant S_{usm}) = 1.000$, $V(S_{uum} \geqslant S_{upm}) = 1.000$, $V(S_{uum} \geqslant S_{ukm}) = 1.000$, $V(S_{uum} \geqslant S_{utp}) = 1.000$, $V(S_{mas} \geqslant S_{sia}) = 1.000$, $V(S_{mas} \geqslant S_{kal}) = 1.000$, $V(S_{mas} \geqslant S_{jal}) = 1.000$, $V(S_{mas} \geqslant S_{cathay}) = 0.072$,
, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(usm) = \min(0.000,\ 0.430,\ 0.000,\ 0.000) = 0.000$,

$d'(upm) = \min(1.000,\ 1.000,\ 0.000,\ 0.507) = 0.000$,

$d'(ukm) = \min(1.000,\ 0.158,\ 0.000,\ 0.000) = 0.000$,

$d'(uum) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000$,

$d'(utp) = \min(1.000,\ 1.000,\ 1.000,\ 0.072) = 0.072$,

Priority weights form $W' = (0.000,\ 0.000,\ 0.000,\ 1.000,\ 0.072)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.000,\ 0.000,\ 0.933,\ 0.067)$. According to this result the Universiti Utara Malaysia website gives importance to response time, then Universiti Teknologi PETRONAS in selecting the best website.

Table A3.24 Evaluation of the Malaysian university attributes with respect to page rank

Page rank	USM			UPM			UKM			UUM			UTP		
USM	1	1	1	1/4	1/3	1/2	3	4	5	4	5	6	5	6	7
UPM	2	3	4	1	1	1	4	5	6	5	6	7	6	7	8
UKM	1/5	1/4	1/3	1/6	1/5	1/4	1	1	1	1	2	3	4	5	6
UUM	1/5	1/5	1/4	1/7	1/6	1/5	1/3	½	1	1	1	1	4	5	6
UTP	1/7	1/6	1/5	1/8	1/7	1/6	1/6	1/5	1/4	1/6	1/5	1/4	1	1	1

From Table A3.24, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{usm} = (13.250, 16.333, 19.500) \otimes (1/66.400, 1/55.360, 1/44.894) = (0.200, 0.295, 0.434)$$
$$S_{upm} = (18.000, 22.000, 26.000) \otimes (1/66.400, 1/55.360, 1/44.894) = (0.271, 0.397, 0.579)$$
$$S_{ukm} = (6.367, 8.450, 10.583) \otimes (1/66.400, 1/55.360, 1/44.894) = (0.096, 0.153, 0.236)$$
$$S_{uum} = (5.676, 6.867, 8.450) \otimes (1/66.400, 1/55.360, 1/44.894) = (0.085, 0.124, 0.188)$$
$$S_{utp} = (1.601, 1.710, 1.867) \otimes (1/66.400, 1/55.360, 1/44.894) = (0.024, 0.031, 0.042)$$

These fuzzy values are compared by using equation (2.15) and
$V(S_{usm} \geqslant S_{upm}) = 0.000$, $V(S_{usm} \geqslant S_{ukm}) = 1.000$, $V(S_{usm} \geqslant S_{uum}) = 1,000$, $V(S_{usm} \geqslant S_{utp}) = 1.000$,
$V(S_{upm} \geqslant S_{usm}) = 1.000$, $V(S_{upm} \geqslant S_{ukm}) = 1.000$, $V(S_{upm} \geqslant S_{uum}) = 1.000$, $V(S_{upm} \geqslant S_{utp}) = 1.000$,
$V(S_{ukm} \geqslant S_{usm}) = 0.203$, $V(S_{ukm} \geqslant S_{upm}) = 0.000$, $V(S_{ukm} \geqslant S_{uum}) = 1.000$, $V(S_{ukm} \geqslant S_{utp}) = 1.000$,
$V(S_{uum} \geqslant S_{usm}) = 0.000$, $V(S_{uum} \geqslant S_{upm}) = 0.000$, $V(S_{uum} \geqslant S_{ukm}) = 0.746$, $V(S_{uum} \geqslant S_{utp}) = 1.000$,
$V(S_{mas} \geqslant S_{sia}) = 0.000$, $V(S_{mas} \geqslant S_{kal}) = 0.000$, $V(S_{mas} \geqslant S_{jal}) = 0.000$, $V(S_{mas} \geqslant S_{cathay}) = 0.000$,
, are obtained.

Then priority weights are calculated by using equation (2.16):

$$d'(usm) = \min(0.000,\ 1.000,\ 1.000,\ 1.000) = 0.000,$$

$$d'(upm) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$$

$$d'(ukm) = \min(0.203,\ 0.000,\ 1.000,\ 1.000) = 0.000,$$

$$d'(uum) = \min(0.000,\ 0.000,\ 0.746,\ 1.000) = 0.000,$$

$$d'(utp) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$$

Priority weights form $W' = (0.000,\ 1.000,\ 0.000,\ 0.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 1.000,\ 0.000,\ 0.000,\ 0.000)$. According to this result the Universiti Putra Malaysia website gives importance to page rank in selecting the best website.

Table A3.25 Evaluation of the Malaysian university attributes with respect to frequency of update

Frequency of Update	USM			UPM			UKM			UUM			UTP		
USM	1	1	1	1/2	1	1	4	5	6	1/2	1	1	4	5	6
UPM	1	1	2	1	1	1	4	5	6	1/2	1	1	4	5	6
UKM	1/6	1/5	1/4	1/6	1/5	1/4	1	1	1	1/6	1/5	1/4	4	5	6
UUM	1	1	2	1	1	2	4	5	6	1	1	1	4	5	6
UTP	1/6	1/5	1/4	1/6	1/5	1/4	1/6	1/5	1/4	1/6	1/5	1/4	1	1	1

From Table A3.25, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{usm} = (10.000, 13.000, 15.000) \otimes (1/57.750, 1/47.400, 1/38.667) = (0.173, 0.274, 0.260)$$
$$S_{upm} = (10.500, 13.000, 16.000) \otimes (1/57.750, 1/47.400, 1/38.667) = (0.182, 0.274, 0.277)$$
$$S_{ukm} = (5.500, 6.600, 7.750) \otimes (1/57.750, 1/47.400, 1/38.667) = (0.095, 0.139, 0.134)$$
$$S_{uum} = (11.000, 13.000, 17.000) \otimes (1/57.750, 1/47.400, 1/38.667) = (0.190, 0.274, 0.294)$$
$$S_{utp} = (1.667, 1.800, 2.000) \otimes (1/57.750, 1/47.400, 1/38.667) = (0.029, 0.038, 0.035)$$

These fuzzy values are compared by using equation (2.15) and $V(S_{usm} \geqslant S_{upm}) = 1.000$, $V(S_{usm} \geqslant S_{ukm}) = 1.000$, $V(S_{usm} \geqslant S_{uum}) = 1{,}000$, $V(S_{usm} \geqslant S_{utp}) = 1.000$, $V(S_{upm} \geqslant S_{usm}) = 1.000$, $V(S_{upm} \geqslant S_{ukm}) = 1.000$, $V(S_{upm} \geqslant S_{uum}) = 1.000$, $V(S_{upm} \geqslant S_{utp}) = 1.000$, $V(S_{ukm} \geqslant S_{usm}) = 0.000$, $V(S_{ukm} \geqslant S_{upm}) = 0.000$, $V(S_{ukm} \geqslant S_{uum}) = 0.000$, $V(S_{ukm} \geqslant S_{utp}) = 1.000$, $V(S_{uum} \geqslant S_{usm}) = 1.000$, $V(S_{uum} \geqslant S_{upm}) = 1.000$, $V(S_{uum} \geqslant S_{ukm}) = 1.000$, $V(S_{uum} \geqslant S_{utp}) = 1.000$, $V(S_{mas} \geqslant S_{sia}) = 0.000$, $V(S_{mas} \geqslant S_{kal}) = 0.000$, $V(S_{mas} \geqslant S_{jal}) = 0.000$, $V(S_{mas} \geqslant S_{cathay}) = 0.000$, , are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(usm) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(upm) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(ukm) = \min(0.000,\ 0.000,\ 0.000,\ 1.000) = 0.000,$

$d'(uum) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(utp) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

Priority weights form $W' = (1.000,\ 1.000,\ 0.000,\ 1.000,\ 1.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as

(0.333, 0.333, 0.000, 0.333, 0.000). According to this result the three universities have the same importance to frequency of update, then USM, UPM, and UUM in selecting the best website.

Table A3.26 Evaluation of the Malaysian university attributes with respect to traffic

Traffic	USM			UPM			UKM			UUM			UTP		
USM	1	1	1	1/6	1/5	1/4	1/6	1/5	1/4	1	2	3	4	5	6
UPM	4	5	6	1	1	1	2	3	4	5	6	7	6	7	8
UKM	4	5	6	1/4	1/3	1/2	1	1	1	5	6	7	6	7	8
UUM	1/3	1/2	1	1/7	1/6	1/5	1/7	1/6	1/5	1	1	1	3	4	5
UTP	1/6	1/5	1/4	1/8	1/7	1/6	1/8	1/7	1/6	1/5	1/4	1/3	1	1	1

From Table A3.26, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{usm} = (6.333, 8.400, 10.500) \otimes (1/68.317, 1/57.302, 1/46.819) = (0.093, 0.147, 0.224)$$
$$S_{upm} = (18.000, 22.000, 26.000) \otimes (1/68.317, 1/57.302, 1/46.819) = (0.263, 0.384, 0.555)$$
$$S_{ukm} = (16.250, 19.333, 22.500) \otimes (1/68.317, 1/57.302, 1/46.819) = (0.238, 0.337, 0.481)$$
$$S_{uum} = (4.619, 5.833, 7.400) \otimes (1/68.317, 1/57.302, 1/46.819) = (0.068, 0.102, 0.158)$$
$$S_{utp} = (1.617, 1.736, 1.917) \otimes (1/68.317, 1/57.302, 1/46.819) = (0.024, 0.030, 0.041)$$

These fuzzy values are compared by using equation (2.15) and $V(S_{usm} \geqslant S_{upm}) = 0.000$, $V(S_{usm} \geqslant S_{ukm}) = 0.000$, $V(S_{usm} \geqslant S_{uum}) = 1{,}000$, $V(S_{usm} \geqslant S_{utp}) = 1.000$, $V(S_{upm} \geqslant S_{usm}) = 1.000$, $V(S_{upm} \geqslant S_{ukm}) = 1.000$, $V(S_{upm} \geqslant S_{uum}) = 1.000$, $V(S_{upm} \geqslant S_{utp}) = 1.000$, $V(S_{ukm} \geqslant S_{usm}) = 1.000$, $V(S_{ukm} \geqslant S_{upm}) = 0.823$, $V(S_{ukm} \geqslant S_{uum}) = 1.000$, $V(S_{ukm} \geqslant S_{utp}) = 1.000$, $V(S_{uum} \geqslant S_{usm}) = 0.593$, $V(S_{uum} \geqslant S_{upm}) = 0.000$, $V(S_{uum} \geqslant S_{ukm}) = 0.000$, $V(S_{uum} \geqslant S_{utp}) = 1.000$, $V(S_{mas} \geqslant S_{sia}) = 0.000$, $V(S_{mas} \geqslant S_{kal}) = 0.000$, $V(S_{mas} \geqslant S_{jal}) = 0.000$, $V(S_{mas} \geqslant S_{cathay}) = 0.000$, , are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(usm) = \min(0.000,\ 0.000,\ 1.000,\ 1.000) = 0.000,$

$d'(upm) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(ukm) = \min(1.000,\ 0.823,\ 1.000,\ 1.000) = 0.823,$

$d'(uum) = \min(0.593,\ 0.000,\ 0.000,\ 1.000) = 0.000,$

$d'(utp) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

Prioristy weights form $W' = (0.000,\ 1.000,\ 0.823,\ 0.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.549,\ 0.451,\ 0.000,\ 0.000)$. According to this result the universiti Putra Malaysia website gives importance to traffic, then universiti Kebangsaan Malaysia in selecting the best website.

Table A3.27 Evaluation of the Asian airlines attributes with respect to design optimization

Design Optimization	USM			UPM			UKM			UUM			UTP		
USM	1	1	1	1/5	1/4	1/3	1/3	½	1	1	2	3	1/7	1/6	1/5
UPM	3	4	5	1	1	1	2	3	4	4	5	6	1/4	1/3	½
UKM	1	2	3	1/4	1/3	1/2	1	1	1	2	3	4	1/6	1/5	¼
UUM	1/3	1/2	1	1/6	1/5	1/4	¼	1/3	1/2	1	1	1	1/8	1/7	1/6
UTP	5	6	7	2	3	4	4	5	6	6	7	8	1	1	1

From Table A3.27, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{usm} = (2.676, 3.917, 5.533) \otimes (1/59.700, 1/47.960, 1/37.218) = (0.045, 0.082, 0.093)$$
$$S_{upm} = (10.250, 13.333, 16.500) \otimes (1/59.700, 1/47.960, 1/37.218) = (0.172, 0.278, 0.276)$$
$$S_{ukm} = (4.417, 6.533, 8.750) \otimes (1/59.700, 1/47.960, 1/37.218) = (0.074, 0.136, 0.147)$$
$$S_{uum} = (1.875, 2.176, 2.917) \otimes (1/59.700, 1/47.960, 1/37.218) = (0.031, 0.353, 0.481)$$
$$S_{utp} = (18.000, 22.000, 26.000) \otimes (1/59.700, 1/47.960, 1/37.218) = (0.302, 0.459, 0.436)$$

These fuzzy values are compared by using equation (2.15) and $V(S_{usm} \geqslant S_{upm}) = 0.000$, $V(S_{usm} \geqslant S_{ukm}) = 0.299$, $V(S_{usm} \geqslant S_{uum}) = 1{,}000$, $V(S_{usm} \geqslant S_{utp}) = 0.000$, $V(S_{upm} \geqslant S_{usm}) = 1.000$, $V(S_{upm} \geqslant S_{ukm}) = 1.000$, $V(S_{upm} \geqslant S_{uum}) = 1.000$, $V(S_{upm} \geqslant S_{utp}) = 0.000$, $V(S_{ukm} \geqslant S_{usm}) = 1.000$, $V(S_{ukm} \geqslant S_{upm}) = 0.000$, $V(S_{ukm} \geqslant S_{uum}) = 1.000$, $V(S_{ukm} \geqslant S_{utp}) = 0.000$, $V(S_{uum} \geqslant S_{usm}) = 0.100$, $V(S_{uum} \geqslant S_{upm}) = 0.000$, $V(S_{uum} \geqslant S_{ukm}) = 0.000$, $V(S_{uum} \geqslant S_{utp}) = 0.000$, $V(S_{mas} \geqslant S_{sia}) = 1.000$, $V(S_{mas} \geqslant S_{kal}) = 1.000$, $V(S_{mas} \geqslant S_{jal}) = 1.000$, $V(S_{mas} \geqslant S_{cathay}) = 1.000$, , are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(usm) = \min(0.000,\ 0.299,\ 1.000,\ 0.000) = 0.000$,

$d'(upm) = \min(1.000,\ 1.000,\ 1.000,\ 0.000) = 0.000$,

$d'(ukm) = \min(1.000,\ 0.000,\ 1.000,\ 0.000) = 0.000,$

$d'(uum) = \min(1.000,\ 0.000,\ 0.630,\ 0.000) = 0.000,$

$d'(utp) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

Priority weights form $W' = (0.000,\ 0.000,\ 0.000,\ 0.000,\ 1.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.000,\ 0.000,\ 0.000,\ 1.000)$. According to this result the Universiti Teknologi PETRONAS website gives importance to design optimization then it becomes the best website.

Table A3.28 Evaluation of the Malaysian university attributes with respect to size

Size	USM			UPM			UKM			UUM			UTP		
USM	1	1	1	1/4	1/3	½	1/9	1/8	1/7	1/8	1/7	1/6	1	2	3
UPM	2	3	4	1	1	1	1/8	1/7	1/6	1/7	1/6	1/5	3	4	5
UKM	7	8	9	6	7	8	1	1	1	2	3	4	8	9	9
UUM	6	7	8	5	6	7	¼	1/3	1/2	1	1	1	7	8	9
UTP	1/3	1/2	1	1/5	1/4	1/3	1/9	1/8	1/7	1/9	1/8	1/7	1	1	1

From Table A3.28, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{usm} = (2.486, 3.601, 4.810) \otimes (1/74.295, 1/64.244, 1/53.760) = (0.033, 0.056, 0.065)$$
$$S_{upm} = (6.268, 8.310, 10.367) \otimes (1/74.295, 1/64.244, 1/53.760) = (0.084, 0.129, 0.140)$$
$$S_{ukm} = (24.000, 28.000, 31.000) \otimes (1/74.295, 1/64.244, 1/53.760) = (0.323, 0.436, 0.417)$$
$$S_{uum} = (19.250, 22.333, 25.500) \otimes (1/74.295, 1/64.244, 1/53.760) = (0.259, 0.348, 0.343)$$
$$S_{utp} = (1.756, 2.000, 2.619) \otimes (1/74.295, 1/64.244, 1/53.760) = (0.024, 0.031, 0.035)$$

These fuzzy values are compared by using equation (2.15) and

$$V(S_{usm} \geqslant S_{upm}) = 0.000,\ V(S_{usm} \geqslant S_{ukm}) = 0.000,\ V(S_{usm} \geqslant S_{uum}) = 0.000, V(S_{usm} \geqslant S_{utp}) = 1.000,$$
$$V(S_{upm} \geqslant S_{usm}) = 1.000,\ V(S_{upm} \geqslant S_{ukm}) = 0.000,\ V(S_{upm} \geqslant S_{uum}) = 0.000, V(S_{upm} \geqslant S_{utp}) = 1.000,$$
$$V(S_{ukm} \geqslant S_{usm}) = 1.000,\ V(S_{ukm} \geqslant S_{upm}) = 1.000,\ V(S_{ukm} \geqslant S_{uum}) = 1.000, V(S_{ukm} \geqslant S_{utp}) = 1.000,$$
$$V(S_{uum} \geqslant S_{usm}) = 1.000,\ V(S_{uum} \geqslant S_{upm}) = 1.000,\ V(S_{uum} \geqslant S_{ukm}) = 0.186, V(S_{uum} \geqslant S_{utp}) = 1.000,$$
$$V(S_{mas} \geqslant S_{sia}) = 0.067,\ V(S_{mas} \geqslant S_{kal}) = 0.000,\ V(S_{mas} \geqslant S_{jal}) = 0.000, V(S_{mas} \geqslant S_{cathay}) = 0.000,$$

, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(usm) = \min(0.000,\ 0.000,\ 0.000,\ 1.000) = 0.000,$

$d'(upm) = \min(1.000,\ 0.000,\ 0.000,\ 1.000) = 0.000,$

$d'(ukm) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(uum) = \min(1.000,\ 1.000,\ 0.186,\ 1.000) = 0.186,$

$d'(utp) = \min(0.067,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

Priority weights form $W' = (0.000,\ 0.000,\ 1.000,\ 0.186,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.000,\ 0.843,\ 0.157,\ 0.000)$. According to this result the university Kebangsaan Malaysia website gives importance to size, then university utara Malaysia in selecting the best website.

Table A3.29 Evaluation of the Malaysian university attributes with respect to number of items

Number of items	USM			UPM			UKM			UUM			UTP		
USM	1	1	1	3	4	5	1/7	1/6	1/5	1/4	1/3	1/2	1/6	1/5	¼
UPM	1/5	1/4	1/3	1	1	1	1/9	1/9	1/8	1/7	1/6	1/5	1/8	1/7	1/6
UKM	5	6	7	8	9	9	1	1	1	4	5	6	2	3	4
UUM	2	3	4	5	6	7	1/6	1/5	1/4	1	1	1	1/4	1/3	1/2
UTP	4	5	6	6	7	8	¼	1/3	½	2	3	4	1	1	1

From Table A3.29, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{usm} = (4.560, 5.700, 6.950) \otimes (1/68.025, 1/58.237, 1/47.805) = (0.067, 0.098, 0.145)$$
$$S_{upm} = (1.579, 1.671, 1.825) \otimes (1/68.025, 1/58.237, 1/47.805) = (0.023, 0.029, 0.038)$$
$$S_{ukm} = (20.000, 24.000, 27.000) \otimes (1/68.025, 1/58.237, 1/47.805) = (0.294, 0.412, 0.565)$$
$$S_{uum} = (8.417, 10.533, 12.750) \otimes (1/68.025, 1/58.237, 1/47.805) = (0.124, 0.181, 0.267)$$
$$S_{utp} = (13.250, 16.333, 19.500) \otimes (1/68.025, 1/58.237, 1/47.805) = (0.195, 0.280, 0.408)$$

These fuzzy values are compared by using equation (2.15) and

$V(S_{usm} \geqslant S_{upm}) = 1.000,\ V(S_{usm} \geqslant S_{ukm}) = 0.000,\ V(S_{usm} \geqslant S_{uum}) = 0,207, V(S_{usm} \geqslant S_{utp}) = 0.000,$
$V(S_{upm} \geqslant S_{usm}) = 0.000,\ V(S_{upm} \geqslant S_{ukm}) = 0.000,\ V(S_{upm} \geqslant S_{uum}) = 0.000, V(S_{upm} \geqslant S_{utp}) = 0.000,$
$V(S_{ukm} \geqslant S_{usm}) = 1.000,\ V(S_{ukm} \geqslant S_{upm}) = 1.000,\ V(S_{ukm} \geqslant S_{uum}) = 1.000, V(S_{ukm} \geqslant S_{utp}) = 1.000,$
$V(S_{uum} \geqslant S_{usm}) = 1.000,\ V(S_{uum} \geqslant S_{upm}) = 1.000,\ V(S_{uum} \geqslant S_{ukm}) = 0.000, V(S_{uum} \geqslant S_{utp}) = 0.419,$

$V(S_{mas} \geqslant S_{sia}) = 1.000$, $V(S_{mas} \geqslant S_{kal}) = 1.000$, $V(S_{mas} \geqslant S_{jal}) = 0.464$, $V(S_{mas} \geqslant S_{cathay}) = 1.000$, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(usm) = \min(1.000,\ 0.000,\ 0.207,\ 0.000) = 0.000,$

$d'(upm) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

$d'(ukm) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(uum) = \min(1.000,\ 1.000,\ 0.000,\ 0.419) = 0.000,$

$d'(utp) = \min(1.000,\ 1.000,\ 0.464,\ 1.000) = 0.464,$

Priority weights form $W' = (0.000,\ 0.000,\ 1.000,\ 0.000,\ 0.464)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.000,\ 0.683,\ 0.000,\ 0.317)$. According to this result the university Kebangsaan Malaysia website gives importance to number of items, then university Teknologi PETRONAS in selecting the best website.

Table A3.30 Evaluation of the Malaysian university attributes with respect to accessibility

Accessibility	USM			UPM			UKM			UUM			UTP		
USM	1	1	1	5	6	7	1/6	1/5	1/4	1/8	1/7	1/6	1/7	1/6	1
UPM	1/7	1/6	1/5	1	1	1	1/8	1/7	1/6	1/9	1/9	1/8	1/9	1/8	1/7
UKM	4	5	6	6	7	8	1	1	1	1/4	1/3	1/2	1/3	1/2	1
UUM	6	7	8	8	9	9	2	3	4	1	1	1	1	2	3
UTP	5	6	7	7	8	9	1	2	3	1/3	½	1	1	1	1

From Table A3.30, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{usm} = (6.435, 7.510, 9.417) \otimes (1/73.551, 1/62.388, 1/51.841) = (0.087, 0.120, 0.182)$$
$$S_{upm} = (1.490, 1.546, 1.635) \otimes (1/73.551, 1/62.388, 1/51.841) = (0.020, 0.025, 0.032)$$
$$S_{ukm} = (11.583, 13.833, 16.500) \otimes (1/73.551, 1/62.388, 1/51.841) = (0.157, 0.222, 0.318)$$
$$S_{uum} = (18.000, 22.000, 25.000) \otimes (1/73.551, 1/62.388, 1/51.841) = (0.245, 0.353, 0.482)$$
$$S_{utp} = (14.333, 17.00, 21.000) \otimes (1/73.551, 1/62.388, 1/51.841) = (0.195, 0.281, 0.405)$$

These fuzzy values are compared by using equation (2.15) and $V(S_{usm} \geqslant S_{upm}) = 1.000$, $V(S_{usm} \geqslant S_{ukm}) = 0.192$, $V(S_{usm} \geqslant S_{uum}) = 0,000$, $V(S_{usm} \geqslant S_{utp}) = 0.000$,

$V(S_{upm} \geq S_{usm}) = 0.000$, $V(S_{upm} \geq S_{ukm}) = 0.000$, $V(S_{upm} \geq S_{uum}) = 0.000$, $V(S_{upm} \geq S_{utp}) = 0.000$, $V(S_{ukm} \geq S_{usm}) = 1.000$, $V(S_{ukm} \geq S_{upm}) = 1.000$, $V(S_{ukm} \geq S_{uum}) = 0.360$, $V(S_{ukm} \geq S_{utp}) = 0.677$, $V(S_{uum} \geq S_{usm}) = 1.000$, $V(S_{uum} \geq S_{upm}) = 1.000$, $V(S_{uum} \geq S_{ukm}) = 1.000$, $V(S_{uum} \geq S_{utp}) = 1.000$, $V(S_{mas} \geq S_{sia}) = 1.000$, $V(S_{mas} \geq S_{kal}) = 1.000$, $V(S_{mas} \geq S_{jal}) = 1.000$, $V(S_{mas} \geq S_{cathay}) = 0.690$, , are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(usm) = \min(1.000,\ 0.192,\ 0.000,\ 0.000) = 0.000$,

$d'(upm) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000$,

$d'(ukm) = \min(1.000,\ 1.000,\ 0.360,\ 0.677) = 0.360$,

$d'(uum) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000$,

$d'(utp) = \min(1.000,\ 1.000,\ 1.000,\ 0.690) = 0.690$,

Priority weights form $W' = (0.000,\ 0.000,\ 0.360,\ 1.000,\ 0.690)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.000,\ 0.176,\ 0.488,\ 0.337)$. According to this result the Universiti Utara Malaysia website gives importance to accessibility error, then Universiti Teknologi PETRONAS in selecting the best website.

Table A3.31 Evaluation of the Malaysia university attributes with respect to markup validation

Markup validation	USM			UPM			UKM			UUM			UTP		
USM	1	1	1	3	4	5	1/6	1/5	1/4	1/8	1/7	1/6	1/5	1/4	1/3
UPM	1/5	1/4	1/3	1	1	1	1/8	1/7	1/6	1/9	1/9	1/8	1/7	1/6	1/5
UKM	4	5	6	6	7	8	1	1	1	1/4	1/3	½	2	3	4
UUM	6	7	8	8	9	9	2	3	4	1	1	1	3	4	5
UTP	3	4	5	5	6	7	1/4	1/3	1/2	1/5	1/4	1/3	1	1	1

From Table A3.31, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$$S_{usm} = (4.492, 5.593, 6.750) \otimes (1/68.908, 1/59.180, 1/48.771) = (0.034, 0.057, 0.091)$$
$$S_{upm} = (1.579, 1.671, 1.825) \otimes (1/68.908, 1/59.180, 1/48.771) = (0.023, 0.028, 0.037)$$
$$S_{ukm} = (13.250, 16.333, 19.500) \otimes (1/68.908, 1/59.180, 1/48.771) = (0.192, 0.276, 0.400)$$

$S_{uum} = (20.000, 24.000, 27.000) \otimes (1/68.908, 1/59.180, 1/48.771) = (0.290, 0.406, 0.554)$
$S_{utp} = (9.450, 11.583, 13.833) \otimes (1/68.908, 1/59.180, 1/48.771) = (0.137, 0.196, 0.284)$

These fuzzy values are compared by using equation (2.15) and
$V(S_{usm} \geq S_{upm}) = 1.000,\ V(S_{usm} \geq S_{ukm}) = 0.000,\ V(S_{usm} \geq S_{uum}) = 0{,}000, V(S_{usm} \geq S_{utp}) = 0.012,$
$V(S_{upm} \geq S_{usm}) = 0.000,\ V(S_{upm} \geq S_{ukm}) = 0.000,\ V(S_{upm} \geq S_{uum}) = 0.000, V(S_{upm} \geq S_{utp}) = 0.000,$
$V(S_{ukm} \geq S_{usm}) = 1.000,\ V(S_{ukm} \geq S_{upm}) = 1.000,\ V(S_{ukm} \geq S_{uum}) = 0.458, V(S_{ukm} \geq S_{utp}) = 1.000,$
$V(S_{uum} \geq S_{usm}) = 1.000,\ V(S_{uum} \geq S_{upm}) = 1.000,\ V(S_{uum} \geq S_{ukm}) = 1.000, V(S_{uum} \geq S_{utp}) = 1.000,$
$V(S_{mas} \geq S_{sia}) = 1.000,\ V(S_{mas} \geq S_{kal}) = 1.000,\ V(S_{mas} \geq S_{jal}) = 0.532, V(S_{mas} \geq S_{cathay}) = 0.000,$
, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(usm) = \min(1.000,\ 0.000,\ 0.000,\ 0.012) = 0.000,$

$d'(upm) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

$d'(ukm) = \min(1.000,\ 1.000,\ 0.458,\ 1.000) = 0.458,$

$d'(uum) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(utp) = \min(1.000,\ 1.000,\ 0.532,\ 0.000) = 0.000,$

Priority weights form $W' = (0.000,\ 0.000,\ 0.458,\ 1.000,\ 0.000)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.000,\ 0.000,\ 0.314,\ 0.686,\ 0.000)$. According to this result the Universiti Utara Malaysia website gives importance to markup validation, then Universiti Kebangsaan Malaysia in selecting the best website.

Table A3.32 Evaluation of the Malaysia university attributes with respect to broken link

Broken link	USM			UPM			UKM			UUM			UTP		
USM	1	1	1	7	8	9	2	3	4	1/3	½	1	1	1	2
UPM	1/9	1/8	1/7	1	1	1	1/9	1/8	1/7	1/9	1/9	1/8	1/9	1/8	1/7
UKM	¼	1/3	1/2	7	8	9	1	1	1	1/4	1/3	1/2	1/4	1/3	½
UUM	1	2	3	8	9	9	2	3	4	1	1	1	1	2	3
UTP	½	1	1	7	8	9	2	3	4	1/3	1/2	1	1	1	1

From Table A3.32, according to extent analysis synthesis values respect to main goal are calculated like in equation (2.9):

$S_{usm} = (11.333, 13.500, 17.000) \otimes (1/66.054, 1/55.486, 1/45.361) = (0.172, 0.243, 0.257)$
$S_{upm} = (1.444, 1.486, 1.554) \otimes (1/66.054, 1/55.486, 1/45.361) = (0.022, 0.027, 0.024)$
$S_{ukm} = (8.750, 10.000, 11.500) \otimes (1/66.054, 1/55.486, 1/45.361) = (0.132, 0.180, 0.174)$
$S_{uum} = (13.000, 17.000, 20.000) \otimes (1/66.054, 1/55.486, 1/45.361) = (0.197, 0.306, 0.303)$
$S_{utp} = (10.833, 13.500, 16.000) \otimes (1/66.054, 1/55.486, 1/45.361) = (0.164, 0.243, 0.242)$

These fuzzy values are compared by using equation (2.15) and

$V(S_{usm} \geq S_{upm}) = 1.000,\ V(S_{usm} \geq S_{ukm}) = 1.000,\ V(S_{usm} \geq S_{uum}) = 0.490,\ V(S_{usm} \geq S_{utp}) = 1.000,$
$V(S_{upm} \geq S_{usm}) = 0.000,\ V(S_{upm} \geq S_{ukm}) = 0.000,\ V(S_{upm} \geq S_{uum}) = 0.000,\ V(S_{upm} \geq S_{utp}) = 0.000,$
$V(S_{ukm} \geq S_{usm}) = 0.038,\ V(S_{ukm} \geq S_{upm}) = 1.000,\ V(S_{ukm} \geq S_{uum}) = 0.000,\ V(S_{ukm} \geq S_{utp}) = 0.138,$
$V(S_{uum} \geq S_{usm}) = 1.000,\ V(S_{uum} \geq S_{upm}) = 1.000,\ V(S_{uum} \geq S_{ukm}) = 0.630,\ V(S_{uum} \geq S_{utp}) = 1.000,$
$V(S_{mas} \geq S_{sia}) = 1.000,\ V(S_{mas} \geq S_{kal}) = 1.000,\ V(S_{mas} \geq S_{jal}) = 1.000,\ V(S_{mas} \geq S_{cathay}) = 0.419,$
, are obtained.

Then priority weights are calculated by using equation (2.16):

$d'(usm) = \min(1.000,\ 1.000,\ 0.490,\ 1.000) = 0.490,$

$d'(upm) = \min(0.000,\ 0.000,\ 0.000,\ 0.000) = 0.000,$

$d'(ukm) = \min(0.038,\ 1.000,\ 0.000,\ 0.138) = 0.000,$

$d'(uum) = \min(1.000,\ 1.000,\ 1.000,\ 1.000) = 1.000,$

$d'(utp) = \min(1.000,\ 1.000,\ 1.000,\ 0.419) = 0.419,$

Priority weights form $W' = (0.490,\ 0.000,\ 0.000,\ 1.000,\ 0.419)$ vector. After the normalization of these values priority weight respect to main goal is calculated as $(0.257,\ 0.000,\ 0.000,\ 0.524,\ 0.219)$. According to this result the universiti Utara Malaysia website gives importance to broken link, then Universiti Sains Malaysia in selecting the best website.