# Quality Assessment of E-Commerce Websites Using Bayesian Belief Networks

By

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# Abstract

This thesis raises the issue of quality in E-commerce websites and addresses methodologies and approaches to standardize their assessment. The thesis blends the knowledge of academic research with the opinions and insights from experts and practitioners in the field to provide a comprehensive view of the issues and their remedies.

The most experienced and successful E-commerce companies are beginning to realize that key determinants of success or failure are not merely a web presence or a low price but delivering a high quality website. Recent research shows that price and promotion are no longer the main draws for customers to make a decision on a purchase. More sophisticated online customers would rather pay a higher price to a provider with high quality service.

Given that the establishment of an E-commerce website is mainly a software development effort; there are several standards that apply in governing the quality of such development. There seems to be an almost overwhelming abundance of quality standards that lead to a high level of cynicism and skepticism surrounding them and the eventual lack of use. Furthermore, no standard can directly predict the quality a website under development is going to achieve.

Past approaches concerning the quality of E-commerce websites emphasize usability standards using techniques like feature inspection and collecting data about end-users' opinion by questionnaires. These methods provide important feedback and their results can be utilized as a useful background for future work, however, they do not contribute directly to a dynamic model that enables forecasting. The study of quality in the domain of the Internet in general, and E-commerce in particular, poses new challenges as technology evolves, including methods and metrics for estimating, managing quality during the product life cycle and quality-of-use measurement.

The solution proposed by this research is to use a Bayesian Belief Network model. This model provides a consistent and practical approach to assessing the quality of the

website. The assessment can be carried out before the completion of the website development, thus, providing insight on the trend and direction for correction and improvements. It can also be carried out on completed and operational work, providing analysis of areas for improvement. The model should be relatively quick and practical in providing an overall comprehensive assessment with root-cause analysis that would lead to corrective measures to improve the quality of the E-commerce website.

In this research idioms were applied in realizing a complete Bayesian Belief Network model. The conclusions are measured against comparative assessment to validate the practical benefits of the work accomplished. The WebQual method was utilized to validate the "belief" established by the model.

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# Chapter 1 – Introduction

## 1.1 Introduction

This chapter provides an overall context to the thesis. The chapter begins with an introduction to the concepts of E-commerce websites, starting with a background of the Internet that hosts E-commerce operations, and progressing onward to outlining issues and identifying root-causes that motivated the efforts and work of the thesis.

This thesis raises the issue of quality in E-commerce websites and addresses methodologies and approaches to standardize on their assessment. The thesis blends the knowledge of academic research with the opinions and insights from experts and practitioners in the field to provide a comprehensive view of the issues and their remedies. The focus is on regional opinions and input to make the thesis relevant to the author's locale and local environment.

## 1.2 History of the Internet

The Internet is named after the Internet Protocol, the popular and standard communications protocol used by every computer on the Internet. The essence of the Internet lies in its ability and power to find, manage, and share information between computing equipment and its users (Mowery and Simcoe, 2002).

The early Internet was used by computer experts, engineers, scientists, and librarians. There was nothing friendly about it. There were no home or office personal computers in those days, and anyone who used it, whether a computer professional or an engineer or scientist or librarian, had to learn to use a very complex system (Mowery and Simcoe, 2002).

The Internet was designed, in part, to provide a communications network that would work even if some of the sites were destroyed by nuclear attack. If the most direct route

was not available, routers would direct traffic around the network via alternate routes (Wikipedia, 2005).

According to the Massachusetts Institute of Technology Museum (Wikipedia, 2005), Licklider is one of the most influential people in the history of computer science and is considered the founding father of the Internet. Licklider, a professor at Massachusetts Institute of Technology (MIT), saw great potential value in allowing computers to share information on research and development in scientific and military fields. He first proposed a global network of computers in 1962, and moved over to DARPA (Defence Advanced Research Projects Agency) in late 1962 to head the work to develop it. Kleinrock of MIT developed the theory of packet switching, which was to form the basis of Internet connections (Wikipedia, 2005). Roberts of MIT connected a Massachusetts computer with a California computer in 1965 over dial-up telephone lines. It showed the feasibility of wide area networking, but also showed that the telephone line's circuit switching was inadequate (Mowery and Simcoe, 2002). Kleinrock's packet switching theory was confirmed. Roberts moved over to DARPA in 1966 and developed his plan for ARPANET an Advanced Research Projects Agency Network. The ARPANET was the foundation of the Internet network (Wikipedia, 2005).

Services like email found their first usage through the ARPANET system, and its obvious benefits were lauded by all who participated (Leiner et al, 1997). The bulletin-board system, Usenet, was developed in the mid to late 70s (Wikipedia, 2005). In the early 80s, all of the main universities in the United States were connected to the network and used it for transmitting experimental data and educational resources. It was found to be an excellent method of sharing information (Wikipedia, 2005). According to the Computer History Museum (2004), in 1973 the first international connection was made to the University College of London in England.

## 1.3 The World Wide Web

The introduction of personal computers in the late 80s brought a large new audience to the developing Internet. They used email and participated in discussions on networks

like Usenet. IRC (Internet Relay Chat) became available in 1988 and communities formed in Internet chat rooms (Leiner et al, 1997).

In 1991, the World Wide Web was introduced, developed by Berners-Lee (Berners-Lee, 2004), with assistance from Caillau during their work at CERN (Conseil Européen pour la Recherche Nucléaire, or in English, the European Organization for Nuclear Research) - the world's largest particle physics laboratory (Berners-Lee, 2004). Berners-Lee saw the need for a standard linked information system accessible across the range of different computers in use. It had to be simple to gain acceptance and popularity. He produced some pages and was able to access them with his 'browser' (Berners-Lee, 2004). Researchers became interested and started designing web sites and browsers. In 1993 the first proper web-browser, Mosaic, was available to the public effecting an immediate boom in the Web (Abbate, 1999).

The Web is an immense collection of web pages. Web pages are documents that contain knowledge content, images and links to other web pages. Every collection of web pages is hosted in what is called a web site. Services were set up for domain registration (Wikipedia, 2005) and web sites developed by educational institutions, commercial entities and even individuals started to emerge. According to Gray (Leiner et al, 1997) of MIT, the web grew from 130 sites in 1993 to over 650,000 in 1997. This number quadrupled by 2004 (Wikipedia, 2005).

## 1.4 E-commerce Foundation

The Internet and World Wide Web were a viable seed for E-commerce (Electronic Commerce). In 1995, a web site called Amazon.com was launched offering a service for book purchases over the Internet. This highly successful experimental venture by Amazon's founder, Bezos, ushered in the rise of E-commerce (Newmedia, 2006). According to Albuquerque and Belchior (2002), E-commerce is an excellent alternative for companies to reach new customers.

For a better understanding of the qualities of E-commerce websites, one should understand the essence of commerce itself. Commerce is about the trade transactions

(sales and purchases) with the objective of supplying commodities (goods and services). Commerce and merchandise are said in the Qur'an "to be of God." Surah xvii. 68: “It is your Lord who drives the ships for you in the sea that you may seek after plenty from Him; verily He is ever merciful to you. And when distress touches you in the sea, those whom you call upon, except Him, stray away from you; but when He has brought you safe to shore, you also turn away (from God); for man is ever ungrateful."

Tracking back to 2000 BC, the Phoenicians are a landmark in the history of commerce. They made commerce possible by building and riding ships that broke the bonds of geography and developed a flourishing trade with other peoples. The ability to connect is key in commerce and the facility to exchange is essential. Otherwise, with no trade transactions, there is no meaning to commerce (Rhodes Greece history, 2007).

The Greeks were able to dominate their Phoenician counterparts by introducing certain improvement elements to their commerce. Unlike the Phoenicians, the Greeks did not limit themselves to refined products like spices, jewels, precious cloths, but traded in items of basic necessity and low cost such as oil and wine, ceramic jars, metals, fabrics and utensils, and they traded these things in great quantities. It is easy to understand how this type of commerce established completely new exchange relationships between people when it was being addressed to the masses instead of merely the elite and monarchs. Attention was on both the quality the relationships established and the material itself. Trade not only served the rich and powerful, but the widest range of social classes. Every person, whether civilized or barbarian, or whether of the highest or lowest rank, is a potential buyer or seller of goods according to the Greeks, and this made trade a powerful tool of wealth and control for the Greeks (Rhodes Greece history, 2007).

Like the Greeks, the Internet in its technology breakthrough has enabled access to electronic trade for the masses allowing E-commerce to potentially expand relationships in large quantities. However, it is important to base any measure of an E-commerce website on the qualities of the basic elements of commerce itself – connection and trade. According to Albuquerque and Belchior (2002), many E-commerce websites have a short life because they do not meet the minimal software quality requirements. Wayne (2000) states that the new paradigm of E-commerce is built, not just on transactions, but

on building, sustaining and improving relationships, both existing and potential. A framework is needed to ensure quality is sustained in an E-commerce website to secure both the customer relationships and the service of goods.

The term E-commerce is loaded with meanings depending on the context in which the term is used. Kalakota and Whinston (1996) provide a four-perspective definition:

- **Communications perspective.** A delivery of information, products/services, or payments over telephone lines, computer networks or any other electronic means.
- **Business process perspective.** An application of technology towards the automation of business transactions and workflow.
- **Service perspective.** A tool to address the desire of firms, consumers, and management to cut service costs while improving the quality of goods and increasing the speed of service delivery.
- **Online perspective.** E-commerce provides the capability of buying and selling products and information on the Internet and other online services.

For the purpose of this thesis, E-commerce will be defined as:

> *"the technology and the implementation of specific software that facilitates conducting on-line retail purchases".*

E-commerce is one of the most misunderstood information technologies (Kalakota and Whinston, 1996). For instance, there is a tendency to categorize E-commerce in terms of two or three major types, such as electronic retailing or online shopping (U.S. Census Bureau, 2006). However, E-commerce is as old as the computer and software industries themselves and predates the Internet era of the 1990s (Kalakota and Whinston, 1996). There is no standard taxonomy of E-commerce technologies, but they do include major categories such as magnetic ink character recognition, automatic teller machines, electronic funds transfer, stock market automation, facsimiles, email, point of sale systems, Internet service providers, and electronic data interchange, as well as electronic retail trade and shopping websites (Kalakota and Whinston, 1996). Figure 1-1 shows the timeline and history of E-commerce.

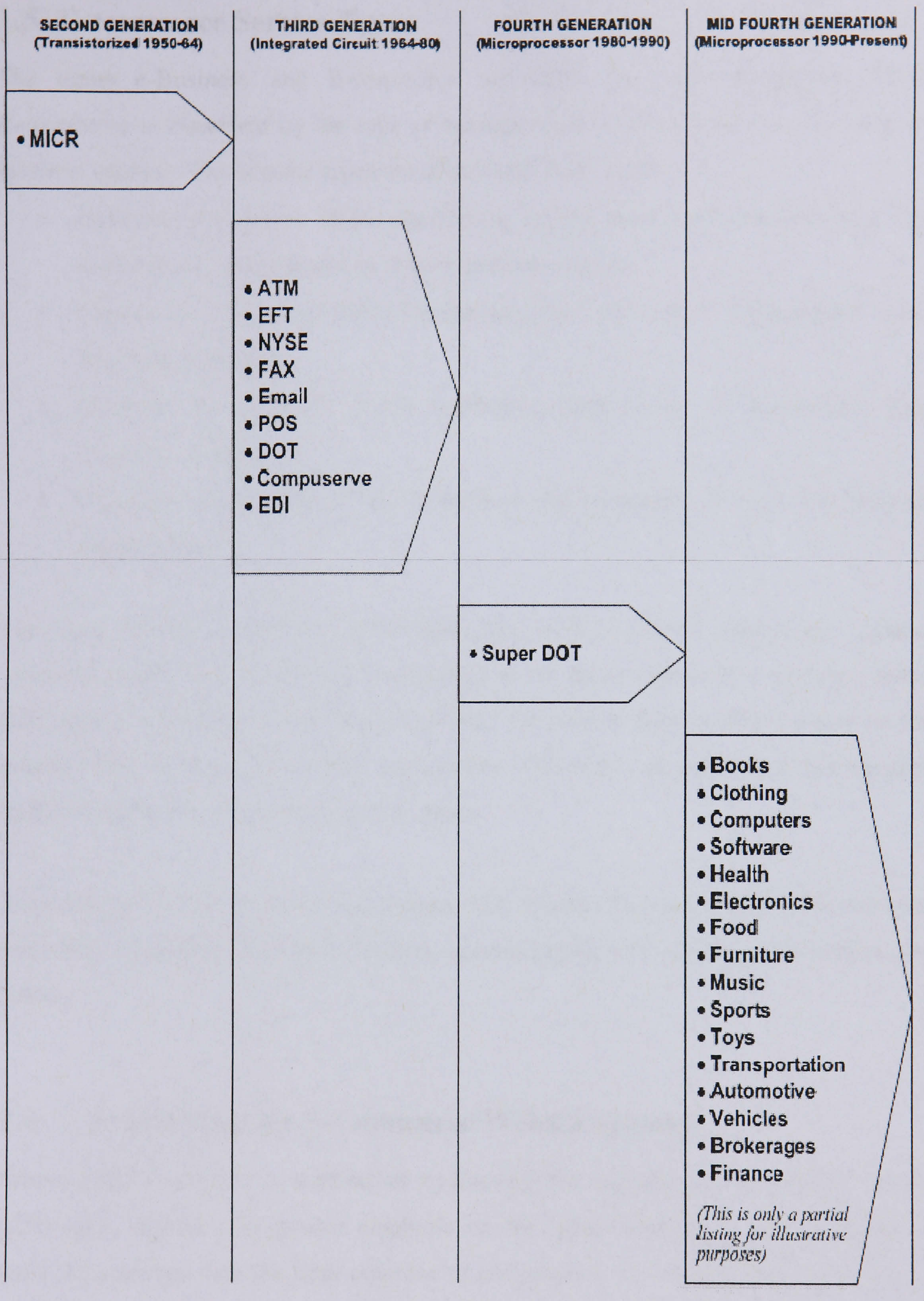



**Figure 1-1: Timeline and history of E-commerce (Frico, 2007a)**

## 1.5 E-commerce Service Types

The terms e-Business and E-commerce are often used interchangeably. Today E-commerce is classified by the type of business and involved parties conducting the business on-line. The popular types are (Pham and Tran, 2003):

- Business-to-Business (B2B) facilitating supply-chain and bid-fulfilment and marketplace type transaction among business entities.
- Business-to-Consumer (B2C) facilitating public consumers' engagement in on-line retail purchases.
- Consumer-to-Consumer (C2C) facilitating open-market or flea-market style trade transactions.
- Consumer-to-Business (C2B) facilitating freelance-type services for business organizations.

The focus of this research is on the B2C type of E-commerce operations. Unless otherwise stated, any reference to E-commerce in the thesis is actually a reference to the B2C type of E-commerce operation. However, the goal of this research focuses on the quality of the software behind such applications. The results obtained from this research could be applied to all above mentioned types.

According to United States Census Bureau (U.S. Census Bureau, 2006), 2004 revenues from B2C exceeded 130 Billion Dollars, accounting for 45% of the total trade on the Internet.

## 1.6 A Framework for E-Commerce Website Quality

Santos (1999) presents a method of evaluating the qualities of a website. In his publication, Santos puts greater emphasis on the methodology and process taken to build the software than the final outcome of the product, its reliability and capabilities. The process steps that the evaluators should follow when applying the method are:

1. Selecting a site, or a set of competitive sites, specific to a domain,
2. Specifying goals and the user view,
3. Specifying in a standard-compliant way, website quality characteristics and attributes,

4. Defining the evaluation criterion for each attribute, and applying attribute measurement,
5. Aggregating elementary attributes to yield the global quality preference.
   In this stage, an aggregation and scoring model should be selected and applied. The hierarchically grouped attributes, sub-characteristics, and characteristics will then be related by arithmetic or logic operators accordingly. According to Santos (1999), the core models and procedures for artifact evaluation are supported by a model known as the Logic Scoring of Preference (LSP) model. According to Santos (1999), in order to design the LSP aggregation schema, the following key basic questions should be answered: (1) what is the kind of relationship among this group of related attributes/sub-characteristic, etc.?, is it either a conjunctive, or disjunctive or neutral relationship?; (2) what is the relative importance or weight of each element into the group?
6. Analyzing, assessing, and comparing partial and global outcomes.

The process results may be useful to understand, control, and improve the Web artifacts' quality in small, medium and large-scale projects. Unfortunately this method is advocated without the requirement to put a standard in place. In following these procedures, anyone can use their own perception of the attributes and quality preferences. Furthermore, although Santos's method of aggregating attributes may be useful, it has been applied only on a relatively simple enumerating, qualifying, and quantifying of all the attributes, a process first used in the 1960s (see Section 2.9) that has now been superceded with the use of more web-oriented models of website quality.

According to Albuquerque and Belchior (2002), the quality of an E-commerce site can be attributed to a number of factors. Their research, based on a fuzzy logic model, identifies a hundred and sixteen quality sub-factors for E-commerce website developers to consider, contained in eighteen quality factors. The research, however, stops short of identifying the inter-relations and co-dependencies among these factors and sub-factors.

Pressman (2005) establishes a framework to effectively connect attributes of an E-commerce website quality with the efficient use of technology and the effective usability in the perspective of the end-user. To attain the desired quality of website software, it is necessary to produce a framework and model that enables evaluation of a

website's quality. According to the International Standards Organization (ISO, 2001) the main purpose of software quality evaluation is to supply referential quantitative results for software products that are reliable, understandable and produce user satisfaction and economic return.

Many of the metrics and quality models currently available for software analysis can be applied only after a product is complete or nearly complete (Bansiya and Davis, 2002). According to Stefani and Xenos (2001), there is a need for a model that can be applied in the early stages of website development to ensure that the analysis and design have favorable internal properties and to provide the opportunities for the developers to prevent problems, remove irregularities and non-conformance to standards and eliminate unwanted complexity early in the building effort. Furthermore, at the core of assessing quality is identification of the quality factors of a system and the identification of the cause-effect relations among them (Curtis et al., 1979).

## 1.7 Quality Perspectives of E-commerce

E-commerce represents a new way of conducting business transactions in the area of buying, selling or exchanging products, services and information. This represents a new perspective in consumer experience and customer satisfaction. A framework for assessing the qualities of an E-commerce website is the essence of this thesis. An E-commerce website, typically, consists of the following business functions:

- Electronic presentation of information, products and services for purchase and payment facilities
- Automation of business transactions and workflow to facilitate the business transaction at the consumer front-end from selection to tendering, and at the business back-end from inventory fulfilment to final shipment.

Quality has been identified as an emerging issue in the E-commerce technical community (Summers, 2001). According to Fenton and Pfleeger (1997), quality is a property of a product (i.e. it applies to some entity, like the website, or some prototype, or its information architecture), which is defined in terms of a system of attributes, like readability or coupling.

Quality is specified further as a composite property involving a set of interdependent factors such as functionality, reliability, efficiency, usability, maintainability, portability, presentation quality, appeal, content, function adequacy, navigability, code complexity, code readability, code flexibility, page coupling, modifiability, response time, transaction throughput and robustness. A number of measurement methods (metrics) have to be defined in order to assess the attributes that a certain product possesses. These aspects taken together are called the quality model of the particular product.

### 1.7.1 Quality Characteristics for E-commerce Applications

Businesses and individuals can use E-commerce to reduce transaction costs by improving the flow of information and increasing coordination of actions. It can be done by reducing the cost of searching for information about potential buyers and sellers and increasing the number of potential market participants. An ideal E-commerce system can result in reducing costs, improving product quality, reaching new customers or suppliers, and creating new ways of selling existing products. A quality E-commerce application has the following characteristics (Summers, 2001):

- Its Web site contents can attract customers.
- Its Web technology can efficiently process online transactions.
- Its supplementary services can facilitate online transactions and sales.
- Its security mechanisms assure transaction integrity against malicious actions and fraud.

The software behind any E-commerce website is, in essence, the virtual organization and business operation of that site. Having the right understanding and assessment of the qualities of that software is the key to formulating budgetary and contingency plans and activities in managing and maintaining the website and forecasting and predicting outcome and benefits from its operation. Having a working framework with an intelligent engine for evaluating E-commerce website qualities provides an effective mechanism for automating and standardizing such a process.

## 1.8 Aims and Objectives

The aim of this research is:

1. To provide a framework for assessing the quality attributes of an E-commerce website and their interrelations.
2. To provide an engine that automates quantification of E-commerce website quality levels.

In order to achieve this, the following objectives were set:

1. To study the published literature and case studies on the subject
2. To analyze and draw conclusions from these studies.
3. To establish the quality factors to measure a website using expert opinion on their interrelations and their level-of-importance.
4. To develop an intelligent measuring engine to quantify these quality factors.
5. To test the engine against live operating websites of public E-commerce organizations in the B2C domain.
6. To draw up a set of guidelines in the form of a framework for the application of the engine on E-commerce websites
7. To disseminate the findings through published papers and the publication of this thesis.

## 1.9 Thesis Layout

The following summarizes the remaining chapters of this thesis:

Chapter 2: Literature Review

This chapter reviews and analyses the relevant literature to identify the challenges faced in E-commerce software quality. The chapter provides the theoretical foundation on which the research is based.

Chapter 3: Methodology

This chapter describes the methodology used to develop the working model reported in this thesis and the statistical justification for it.

Chapter 4: Quality Factors

This chapter defines and categorizes the quality factors for measuring an E-commerce website.

Chapter 5: Quality Factors Interrelations

This chapter assesses and defines the interrelations among the quality factors identified in the previous chapter.

Chapter 6: Bayesian Belief Network

This chapter describes the development of the Bayesian Belief Network (BBN) domain and assessment model, "EWQPNet".

Chapter 7: Analysis of the Model

This chapter describes the application of the model in an E-commerce study and shows how the model can be usefully applied. The chapter examines the significant changes to the traditional processes of manually evaluating the quality of an E-commerce website with the introduction of the model developed in this research.

Chapters 8 - 10: Application of the Model

These chapters provide guidelines and exemplify the application of the model on actual websites to illustrate the usage and potential benefits of the model derived in this thesis.

Chapter 11: Conclusion and Recommendations for Further Work

This chapter summarizes the whole thesis, relating the achievement to the aims and objectives set out in this introductory chapter, and provides recommendations for future work.

The overall conclusion is that the research has been successful in satisfying its aims and objectives and that the working framework produced should be useful for any company to use in evaluating the qualities of E-commerce software.

# Chapter 2 – Literature Review

## 2.1 Introduction

This chapter explores the subject of E-commerce, and in particular, the role quality plays in influencing the success of an E-commerce website. It is based on material gathered from various books, journals and newspapers. The chapter examines quality standards, measures and models that help in assessing E-commerce websites.

The available published work is evaluated in order to properly determine why this research project is needed and the areas it compliments. By identifying the gaps in existing published material on the subject, this chapter forms a justification for the aims and objectives of the research stated in Chapter One.

## 2.2 E-commerce

E-commerce can be defined as a forum for sharing business information, maintaining business relationships and conducting business transactions by the means of telecommunication networks (Zwass, 1996).

With the increasing development of new technology, the studies in the field of E-commerce have become more and more attractive. Many research efforts and journals have been written on the value and the business impact E-commerce poses in our lives (e.g.: Kalakota and Whinston, 1996; Advocate, 2001; Schneider and Perry, 2000; and Pham and Tran, 2003). Today E-commerce is growing. Data confirms that an increasing number of enterprises are investing in the creation of E-commerce systems for their organization and the continuous expansion of economic and commercial transactions through the Internet (Stefani et al., 2003). At one point both the CNN and the BBC claimed that there were about 20 million web-based businesses in existence (Pather et al., 2003).

The presence of E-commerce has managed to overcome the barriers to conducting global commerce (Wang, 2003). According to Wang (2003), consumers accessing

websites today are insensitive to the country of origin and the legal structure behind E-commerce and the services offered. Customer loyalty has become a challenge for business (Zwass, 1996).

E-commerce websites are becoming increasingly complex systems. Hence, an integral quantitative evaluation process regarding all relevant quality characteristics is also a complex issue (Santos, 1999). According to Pressman (2005), the duality of roles an E-commerce website plays between a store front that displays merchandise goods for purchasing and a system that facilitates and automates the business process from purchasing to fulfilment, makes it a challenge to establish a framework that guarantees quality and user satisfaction.

## 2.3 Quality Defined

There are many different definitions of quality (Crosby, 1995; Deming, 1982; Feigenbaum, 1991; Ishikawa, 1985, Juran, 1993; Oakland, 1995; Shingo, 1986; Taguchi et al, 1989). Table 2-1 shows a number of acknowledged definitions.

**- Table 2-1 – Definitions of Quality -**

| Reference | Definition or Interpretation of quality |
|---|---|
| Crosby, 1995. | Conformance to requirements. |
| Deming, 1982 | Defined only in terms of the agent who is the judge of quality. |
| Feigenbaum, 1991 | The composite product characteristics of engineering and manufacture that determine the degree to which the product in use will meet the expectations of the customer. |
| Juran, 1993 | Product performance, freedom from defects, and fitness for use. |
| Oakland. 1995 | Meeting customers' requirements. |
| Shingo, 1986 | Zero defects. |
| Taguchi et al., 1989 | Quality is the totality of losses suffered by society due to deviations of product performance characteristics from their ideal target values. |

International standards organizations also define quality. A selection of International definitions is shown in Table 2-2.

**- Table 2-2 – International standards definitions of Quality -**

| Reference | Definition or Interpretation of quality |
|---|---|
| Oxford, 2002 | Degree of excellence |
| German Industry Standard DIN 55350 Part 11 | Quality comprises all characteristics and significant features of a product or an activity which relate to the satisfying of given requirements. |
| ANSI Standard (ANSI/ASQC A3/197B) | Quality is the totality of features and characteristics of a product or a service that bears on its ability to satisfy the given needs. |
| IEEE Standard (IEEE Std 729-1 GG3) | The totality of features and characteristics of a software product that bear on its ability to satisfy given needs: for example, A) Conform to specifications. B) The degree to which software possesses a desired combination of attributes. C) The degree to which a customer or user perceives that software meets his or her composite expectations. D) The composite characteristics of software that determine the degree to which the software in use will meet the expectations of the customer. |
| ISO/IEC 9126 (1991) | The totality of features and characteristics of a software product that bear on its ability to satisfy stated or implied needs. |

Quality in terms of E-commerce may be hard to define (Fitzpatrick et al., 2004). However, several successful attempts have been made to give it a clear definition. Gefen (2002) defines E-commerce quality as a type of service quality. According to Gefen (2002), service quality is the subjective comparison that customers make between the quality of the service that they experience against what they perceived and initially expected. This definition is also reflected in work by Watson et al (1998).

Zeithaml et al (2000) define quality for E-commerce in terms of seven dimensions consisting of:

1. Efficiency: referring to the ability of the customer to get to the Web site, find their desired product and information associated with it and to check it out with minimal effort.
2. Fulfillment: incorporating accuracy of service promises, having products in stock and delivering the product within the promised time.
3. Reliability: associated with the technical functioning of the site, particularly the extent to which it is available and functioning properly.
4. Privacy: including assurances that shopping behavior data are not shared and that credit card information is securely held.
5. Responsiveness: measuring the ability of a company to provide appropriate information to customers when a problem occurs, and the mechanism for handling returns and an arrangement for online guarantees.
6. Compensation: facilitating the refunds and the return of goods.
7. Contact points: enabling customers to be able speak to a live customer service agent online or by phone.

According to Zeithaml et al (2000), quality plays a pivotal role to attracting and retaining customers of E-commerce operations, and a high rating in these seven aspects assures this. However, there is no guidance on to how to measure and attain a high rating in each dimension.

The study of quality in the domain of the Internet in general, and E-commerce in particular, poses new challenges as technology evolves (Fitzpatrick et al., 2004). According to Fitzpatrick et al. (2004), challenges include methods and metrics for estimating, managing quality during the product life cycle and quality-of-use measurement.

## 2.4 The Importance of Quality on E-commerce

The most experienced and successful E-commerce companies are beginning to realize that key determinants of success or failure are not merely web presence or low price but

delivering on a high quality website. Recent research shows that price and promotion are no longer the main draws for customers to make a decision on a purchase. More sophisticated online customers would rather pay a higher price to a provider with high quality service (Schneider & Perry, 2000).

According to Schellhese et al (2000), when consumers conduct a purchase across the border, they will have concern as to whether they will receive quality services from a "foreign" E-commerce website. It concludes that attention to quality is of paramount importance for E-commerce success. This has been the trigger motivation for the author in formulating this thesis.

Quality has been established as a key factor in ensuring the success of E-commerce in attracting and retaining customers (Stefani et al., 2003). To this end, it is necessary to define what constitutes a high-quality E-commerce website and a methodology for evaluating the quality of E-commerce websites (Burrows, 1999).

## 2.5 Overview of Website Evaluation

The common issues found in the literature relating to website evaluation are quality (e.g. Dran et al., 1999, Cox and Dale, 2002, Mich et al., 2003), Web design (e.g. Gehrke and Turban, 1999, Thelwall, 2003), and usability (e.g. Nielsen, 1995, Palmer, 2002, Agarwal and Venkatesh, 2002, Konradt et al., 2003). Researchers have adopted the Web quality concept from the quality of product or service (e.g. Cox and Dale, 2002, Day, 1997). For example, Dran, Zhang, and Small (1999) adopted Kano's Model of Quality as a theoretical framework to evaluate the quality of websites. This model separated product and service quality into three levels according to customer expectations: expected, normal, and exciting. The entry level, "expected", refers to the minimum level of qualities, properties, or attributes that must exist for the system to function. These expectations are also known as the dissatisfiers because by themselves they are unable to fully satisfy a customer. The next higher level, "normal" identifies the "wants" or the satisfiers because they are the ones that customers will specify as though from a list. They can either satisfy or dissatisfy the customer depending on their presence or absence. The highest level, "exciting", as described by Kano, identifies the "wow" level

qualities, properties, or attributes. These are also known as the "delighters" or "exciters" because they go well beyond anything the customer might imagine and ask for.

These researchers believe that quality in a product or service is not what the provider or seller put into it, but what the client or customer receives from it. Thus, a website should try to satisfy its customers' needs in order to ensure repeat visits from them, and gain their loyalty.

In regard to Web design, Shneiderman (1997) provided an Objects/Actions Interface (OAI) model for Website design. This encourages designers of a website to focus on analyzing the relationship between the task and Web interface. Wan and Chung (1998) looked at problems in Web design from the perspective of network analysis. They suggested that care must be taken when designing the homepage, which is the entrance to the website. Gehrke and Turban (1999) suggested five major categories that should be considered when designing a website for a business: page loading, business content, navigation efficiency, and security and marketing/consumer focus. They argued that page loading is the most important factor in website design. Thelwall (2003) suggested shifting the focus on evaluating Web design from individual pages to aggregated collections based upon Web directories, domains, and the entire site.

Undertaking a usability study usually needs high consumer or user involvement, and sometimes the study needs to be conducted in an experimental environment. Nielsen (1993, 1995) provided guidelines and criteria to evaluate the usability of website design and suggested that every design project, including website development, should be subjected to usability testing and other validation methods. Toh and Pendse (1997) also suggested that Web pages should be designed for usability and understanding. However, a website with good usability cannot guarantee users' preference (Tullis, 1998).

## 2.6 Measuring and Analyzing E-commerce Quality

The measurement of quality in information technologies has been an issue of concern for a long period of time. This issue has had a great deal of attention from many researchers in the academic world (Remenyi et al., 1993; Seddon et al, 1999; and Delone and Mclean, 1997).

Lehman and Belady (1985) established a simple classification for information systems, being either E-type or S-type. An S-type system is one that is completely and totally defined, and is required to be correct with respect to a mathematically defined specification. An E-type system, on the other hand, resolves to expectations of the system. An E-type system is correct when it satisfies the user expectations. These expectations can be from any aspect of the system, such as quality, performance, user-friendliness, or any measure of system functionality or capability.

A classification of information systems in terms of its quality indicators, categorized quality to three perspectives as shown in Table 2-3 (Whyte and Bytheway, 1996).

Various studies related to the three perspectives outlined in Table 2-3 have produced a number of measures for evaluating informational systems such as E-commerce websites. These include system usage (Srinivasan 1985; Trice and Treacy, 1986), information value (Gallagher, 1974) and user satisfaction (Bailey and Pearson, 1983).

The diversity of these various measures was initially a cause for concern, so Delone and McLean (1997) attempted to synthesize them into a unified model. The Delone and McLean (1997) Model of "Information Services Success" has been regarded by many authors as a major contribution (Molla and Licker, 2001) and has been the focus of several studies (e.g. Seddon et al., 1999). Pitt and Watson (1997) proposed a modification of this model to include a "Service Quality" component. This modification was endorsed by Delone (2003) together with other modifications integrated to the updated Information Services Success Model (Delone, 2003).

Some researchers have highlighted the problem of inadequate measures for assessing the benefits of investments in Information Technology (Miller and Doyle, 1987; Molla and Licker, 2001). There is a considerable difficulty in measuring the quality of informational systems and there lies some difficulty in searching for appropriate metrics (Arnold, 1995).

Notwithstanding the literature review concerning the difficulty in developing measures, there is still a need for an indicator of the success of a company's E-commerce website. One possible indicator is that of user satisfaction. Various sources have argued that measuring satisfaction of users is useful as a surrogate indicator of information system quality. The utilization of user satisfaction for measuring quality is discussed in the next section.

**Table 2-3 - Perspectives on IS Effectiveness Adapted from Whyte and Bytheway (1996: 75-77)**

| Product | Process | Service |
|---|---|---|
| The product which is delivered to the users e.g. actual software | The process that creates the system e.g. RAD approach, end-user approach. | Deals with softer issues e.g. answering questions, dealing with problems, addressing concerns of users. |
| It is argued that early IS research has chosen to deal with the product viewpoint, focusing on the more tangible attributes and characteristics of systems products, such as response times, data volumes and extent of system usage. | Increased systems complexity, the increasing number of unsuccessful systems and a growing systems development backlog led to a shift in attention from the product perspective to the process viewpoint. The studies once again concentrated on the more tangible attributes such as the number of errors occurring within the process, the level of user involvement and the milestones at which user approval is given. | The emergence of a service perspective introduces the idea of user satisfaction as a means of assessing effectiveness. |

## 2.7 User Satisfaction as an Effective Measure

User satisfaction gradually became a measure of software quality during the 1950s, 1960s, and 1970s (Thayer, 1958; Hardin, 1960; Kaufman, 1966; Lucas, 1974). User satisfaction is defined as "the sum of one's feelings or attitudes toward a variety of

factors affecting that situation," e.g., computer use and adoption by end users (Bailey and Pearson, 1983).

Most studies up until 1980 focused on the end user's satisfaction toward software developers; but one study squarely focused on the end user's satisfaction with the software itself (Lyons, 1980). Pearson and Bailey (1980) produced one of the first studies to address a variety of software attributes such as software accuracy, timeliness, precision, reliability, currency, and flexibility.

Studies throughout the 1980s addressed user satisfaction with both designers and software (Walsh, 1982; Bailey and Pearson, 1983; Ives et al., 1983; Joshi et al.,1986; Baroudi and Orlikowski, 1988). The late 1980s marked a turning point with studies focusing entirely on user satisfaction with the software itself and attributes such as content, accuracy, format, ease of use, and timeliness of the software (Doll and Torkzadeh, 1988).

A study of user satisfaction at IBM was based on reliability, capability, usability, installability, maintainability, performance, and documentation factors (Kekre, et al., 1995). Throughout the 1990s, IBM used a family of user satisfaction models called UPRIMD, UPRIMDA, CUPRIMDA, and CUPRIMDSO, which referred variously to factors of capability, usability, performance, reliability, installability, maintainability, documentation, availability, service, and overall satisfaction (Kan, 1995).

User satisfaction, now commonly referred to as customer satisfaction, is no doubt related to earlier measures of software attributes, usability or user friendliness of software, and more recently, web quality.

In E-commerce, interaction with the end-user is conducted through web-based applications including both server and client-side applications commonly referred to as a website. All user-system communication is realized through the interface, so it is self evident that the quality of an E-commerce system is directly related to the quality of the user interaction experience (Zwass, 1996).

Research efforts by Wang (2003) have directly tied the assessment of an E-commerce website to customer satisfaction. A survey carried out by Wang (2003) on 35 E-commerce companies in the United States identified three proponent methods for assessing quality. All three were actually an assessment of the satisfaction of the customer. In broad terms, the assessment addressed the following:

1. General feedback on the web site design
2. The competitive price of the product
3. Merchandise availability
4. Merchandise condition
5. On-time delivery
6. Merchandise return policy
7. Customer support
8. E-mail confirmation of customer orders
9. Promotion activities

The three major assessment methods are text comments, categorized rating and overall rating. Text comment allows customers to write their own comments in 500 to 1000 characters on the "where"s and "why"s they did their shopping. Categorized rating is achieved with a questionnaire that asks online shoppers to rate a number of quality determinants using a scale of 1 to N where N is the best rating. The overall satisfaction rating uses an ordinal rating system with a scale of 1 to N where N is the best rating.

User satisfaction is a combination of experience and perception (Gefan, 2002). It has been shown that several factors can positively or negative influence a user's experience and their perception of a website experience (Stefani et al., 2003).

## 2.8 Evaluating E-commerce Websites: A review of Evaluation Criteria

Website quality models - appearing in the late 1990s, following the user satisfaction movement - appeared as important measures of software quality (Lindroos, 1997). One of the first models of website quality identified background, image size, sound file display, and celebrity endorsement as important factors of software quality (Dreze and Zufryden, 1997). The web assessment method or WAM quickly followed with quality factors of external bundling, generic services, customer specific services, and emotional

experience (Selz and Schubert, 1997). In what promised to be the most prominent web quality model, attitude toward the site had quality factors of, informativeness, and entertainment (Chen and Wells, 1999). The next major model was the e-satisfaction model with its five factors of convenience, product offerings, product information, website design, and financial security (Szymanski and Hise, 2000). The website quality model or WebQual for business school portals was based on factors of ease-of-use, experience, information, and communication and integration (Barnes and Vidgen, 2000). An adaptation of the service quality or ServQual model, WebQual 2.0 measured quality factors such as tangibles, reliability, responsiveness, assurance, and empathy (Barnes and Vidgen, 2001).

Although some researchers have tried to provide ways of evaluating E-commerce website specifically (e.g. Boyd, 2002, van der Merwe and Bekker, 2003), the selection of evaluation criteria still requires more theoretical justification. A selection of evaluation criteria is shown in Table 2-4, each of these has their points of strengths and weaknesses.

Studies on E-commerce website quality also focus on more specific quality characteristics such as issues that warrant successful transactions (Bidgoli, 2002), maximize the perceived trustworthiness (Egger, 1998; Slyke et al., 2004), or ensure E-commerce website reliability (Dustin et al.,, 2001).

Although, all the above factors affect the quality of E-commerce websites and are prerequisites for their success, they are not the only ones that relate to E-commerce website quality. Farthing and Stocking (2005) jumped to a conclusion that there is no fully integrated approach after their review of the literature. From these previous studies, it can be inferred that a global approach, such as the one discussed in this thesis, is required combining all factors affecting quality.

**Table 2-4 - A review of evaluation criteria**

| Reference | Perspective | Strengths | Weaknesses |
|---|---|---|---|
| Kramer, 2000 Evaluating E-commerce servers | Evaluating E-commerce servers | Practical advice for system managers | Evaluates E-commerce server technology not web sites or customer service |
| (Barnes & Vidgen, 2002) WebQual | HCI framework: Five factors identified: Usability, design, information, trust & empathy | Based on customer perceptions of quality weighted by importance | Very narrow focus |
| (Schubert & Dettling, 2002) EWAM | EWAM (Extended web assessment method ) is a tool specifically created for the evaluation of E-commerce sites | Considers sites from the customers' perception | Concentrates on generic web issues with little consideration of issues important to selling |
| Akhter, et al., 2005 Evaluating consumer trust | Compares customers' trust with their familiarity with the site, and objective measures of security. | Identifies how important these are in encouraging trust | Intended solely to evaluate trust, not other factors important to selling |
| Lightener, 2004 | Evaluation from a customer service perspective | Consideration of the design is subordinate to the functions actually provided | Doesn't cover the whole selling life cycle, e.g. customer finding the site, generating repeat business |
| Hahn et al., 2002 | Evaluation from an investment perspective | Management focus | Identifies problem areas but not solutions |

## 2.9 E-commerce Website quality

Early definitions of software quality included fitness for use, conformance to requirements, or degree to which software satisfied its specified requirements. These classical definitions of software quality imply one must gather customer requirements, develop a software product, and then determine how many requirements have been satisfied (e.g., if four out of five requirements have been satisfied, then the quality is 80%).

Since the 1960s, increasingly sophisticated views of software quality have emerged: (a) software size, (b) software errors, (c) software attributes, (d) software defect models, (e) software complexity, (f) software reliability, (g) user satisfaction, and (h) website quality, to name a few. One of the earliest approaches for measuring software quality was the practice of quantifying and assessing attributes or characteristics of computer programs. Software attributes are traits, characteristics, features, or other properties of software products. Early studies attempted to enumerate, qualify, and quantify all of the attributes of software products. One such study (Boehm et al., 1978) identified the following attributes: (a) correctness, (b) efficiency, (c) flexibility, (d) integrity, (e) interoperability, (f) maintainability, (g) portability, (h) reliability, (i) reusability, (j) testability, and (k) usability.

Throughout the 1970s and 1980s the practice of measuring software attributes waned in favor of statistical models of software quality and reliability, which estimated defects and mean time to failure. However, during the 1990s, the practice of measuring software attributes began to take a foothold once again in the form of user satisfaction and website quality models. User satisfaction models were used to measure end user attitudes towards software products. One such model (Barnes and Vidgen, 2002) measured user attitudes about the following attributes of software quality: (a) usability, (b) design, (c) information, (d) trust, and (e) empathy.

Models of user satisfaction were eventually overtaken by models of website quality by the end of the 1990s. Basic website quality is defined as a "customer's judgment about the website's overall excellence or superiority, which is an attitude that comes from a comparison of expectations and perceived performance" (Arambewela and Hall, 2006).

Within the context of E-commerce, website quality refers to "the extent to which a website facilitates efficient and effective shopping, purchasing, and delivery of products and services" (Gounaris et al., 2005). According to Frico (2007b), over 45 scholarly models of website quality have appeared in the last 10 years. A small sample of those studies had been tested on over 436,000 data points from 16,000 respondents (Frico, 2007b). What this indicates is that the application and use of scholarly models of website quality is a very-well established discipline. However, many of these models have numerous factors and sub-factors, as well as unusually large measurement instruments, which are economically prohibitive to apply. Also, many of these models have not proven very robust, and exhibit low levels of reliability and validity (Frico, 2007b).

Most of the tools that have been developed for the assessment of E-commerce websites give emphasis on the web applications of the system and they are based on surveys (Molla and Licker, 2001; Offut, 2002). This process provides significant results but demands extra time for data collection and data analysis in each measurement phase. The work presented in this thesis, differs from questionnaire-based surveys in that it uses a process aiming to limit subjectivity and frequent errors in similar surveys and provides a flexible way to define the quality of E-commerce websites, as users perceive it, in a short period of time.

## 2.10 Predicting E-commerce Quality

Given that the establishment of an E-commerce website is mainly a software development effort; there are several standards that apply in governing the quality of such development. According to de Chazal (2005), there seems to be an almost overwhelming abundance of quality standards that lead to a high level of cynicism and skepticism surrounding them and the eventual lack of use. Website developers need to use standards and best practices to ensure that websites are functional, accessible and interoperable. However many websites fail to achieve such goals and no standard can directly predict the quality a website under development is going to achieve.

The software behind any E-commerce website is, in essence, the virtual organization and business operation of that site. It is thus reasonable to conclude that the quality and

evaluation methods of E-commerce systems will always be dependant on the quality of applications they contain and their ability to meet end-user requirements.

An E-commerce website can be assessed by the quality factors of its software. Having these quality factors enables the measured specification of attributes and variables. Such quality factors should be seriously considered during the development of E-commerce websites (Stefani et al., 2003). Past approaches concerning the quality of E-commerce websites emphasized the usability standards, using techniques like feature inspection methods and collecting data about end-users' opinion by questionnaires. These methods provide an important feedback and their results are of useful background for future work, however, they do not contribute directly to a dynamic model that enables forecasting (Chan et al., 2001).

In this thesis, a model is proposed where the attributes are of a dynamic character. The results derived from the application of the proposed model are utilized to predict E-commerce website quality and to direct the development of a website to increase the quality measures, producing a site that gives an E-commerce experience with high service quality and user satisfaction. Furthermore, the results derived from its application are utilized for the model's constant improvement, thus contributing to a continuous evolvement and upgrading.

## 2.11 Applying Bayesian Belief Networks

Having a metric for quality makes matters easier for a business, as it can then measure whether quality is being attained. Seddon et al (1999) define quality as "a relative value that is meaningful only when compared to postulated values that are defined by the user or by standards organizations." Several researchers such as McCall et al. (1977) and Boehm et al. (1978) have since proposed holistic quality models incorporating a wide array of measures, in order to define a quality system. According to de Chazal (2005), holistic models such as these often require substantial infrastructure in order to capture and analyze the data gathered. Consequently, many companies look for easier alternatives, such as a single measure of quality, as opposed to process-driven quality.

Niedermayer (1998) describes a Bayesian Belief Network (BBN) as a model that defines various events, the dependencies between them, and the conditional probabilities involved in those dependencies. The mathematical model on which Bayesian Belief Networks are based is the theorem developed by the mathematician and theologian, Thomas Bayes (Stigler, 1982). The BBN is a special category of graphic models where nodes represent variables and the directed arrows represent the relations between them. Therefore, a BBN is a graphical network that describes the relations of probabilities between the variables (Agena, 2006). This information can then be used to calculate the probabilities of various possible causes being the actual cause of an event.

A framework for assessing the qualities of an E-commerce website is the essence of this thesis. Now, the question which arises is: 'Can a Bayesian Belief Network be applied to anticipate the level of quality of the site and the factors behind that level of quality?' According to Advocate.com (Advocate, 2001), in applying a Bayesian Belief Network, a single model can be used for both diagnostic and causal reasoning. That is, the same model can be used to reason from effects to causes and from causes to effects. This suggests that a Bayesian Belief Network could be used to systematically predict the qualities of an E-commerce website under development and to determine the reasons for the predicted quality.

In this thesis, a model is proposed based on the notation and formation of Causal Probabilistic Networks, also called Belief Networks (BN) and Bayesian Networks (Jensen, 1996).

According to the literature reviewed in this section the use of a BN should provide:

1. A way to define the relation between the various nodes (variables), but also to estimate consistently the way in which the initial probabilities influence uncertain conclusions, such as the quality of an E-commerce system.
2. A single conclusive indicator on the state of quality an E-commerce website has or will probably have.
3. A mechanism to establish future estimation, (also known as "forward prediction").
4. Assessment of the state of initial work on a website based on a given final and some intermediate variables (also known as "backward assessment").

## 2.12 Reviews and Summary of Aim

Quality is needed as a means of assessment of E-commerce website. Effort and complexity stems from defining the quality attributes that determine such an assessment in a consistent, repetitive way. This chapter has reviewed some of these methods and measures used to assess E-commerce quality. It also evaluated the effort involved in using such methods and the conclusion is that quality is needed to assess and manage risk. No tools have yet been developed that enable the prediction and forecast of quality that satisfies the needs of quality standards. Developing such tools is a challenging task. Yet, the tools available and that have been reviewed are only viable at the completion of the website development effort.

The solution proposed by this thesis is the creation of a Bayesian Belief Network model. The reviews of literature given in this chapter suggest that this tool will be most useful in providing a consistent and practical approach to assessing the quality of a website. Furthermore, the assessment could be conducted before the completion of the website development, thus, providing insight on the development trend which would enable the direction of the development to be altered to improve the quality. If it is conducted on a completed and operational website it would provide the necessary analysis to enable the website to be revised and improved.

This review of the literature suggests the development of a Bayesian Belief Network model for the quality assessment of E-commerce websites as an easy-to-use alternative to the previous range of models and metrics. The expected performance of the model should be relatively quick and practical in providing overall comprehensive assessment with root-cause analysis that could lead to corrective measures to improve the quality of the E-commerce websites. The research effort described in this thesis is based on a hypothesis that the quality attributes in the Bayesian Belief Network model would directly influence the E-commerce user satisfaction rating and, therefore, its popularity and economic growth.

The literature review in this chapter has established the need for this research project as there is no fully integrated evaluation approach and no practical, effective means of

assessing the quality of an E-commerce website in advance of its completion. This review has also identified a means by which the aims of this research can be achieved. A Bayesian Belief Network has the properties reported in the literature to provide the required model for predicting E-commerce website quality and for identifying the attributes that need further development to improve the overall website quality.

## 2.13 Conclusions

This chapter covered a literature review of E-commerce quality and the evaluation of quality in E-Commerce in terms of methods explored, devised and deployed to measure the E-commerce performance. The chapter defined E-commerce from the perspective of a user service built mainly by software. The chapter progressed in exploring the quality standards and measures available and the complexity involved in defining and using them. The closure was a summary to the review dovetailed with the aimed goals of the thesis and the contribution it can make to the knowledge in the public domain.

# Chapter 3 – Methodology

## 3.1 Introduction

This chapter outlines the selection of the appropriate approaches used to achieve the research objectives. The chapter starts by discussing the different methodologies available and the process of picking the most appropriate set to accomplish the underlying research. The chapter continues to describe the methodology used to collect data, analyze it and apply it to achieve the research aims given in Chapter One.

## 3.2 Background to Methodologies

There are prominently two research methodologies, Positivism and Interpretivism. An analysis of these two fundamental research approaches was made to uncover the differences in their process of collecting, compiling and analyzing research observations and based on what paradigm and philosophy.

According to Berntsen et al (2000), the Positivist approach builds on the premise that knowledge is acquired through an objective process based on measurable and repeatable observations. According to Weber (2004), Positivists believe that the objects they research have qualities that exist independent of the researcher. Thus in Positivism, reasoning is based on the analysis of data. Positivists consider the researcher and the phenomena to be two separate, independent things. Weber (2004) continues on to state that Positivists believe that research is reliable if results can be replicated by the researcher herself/himself and other researchers. According to Weber (2004), the lack of reliability is attributed to factors such as researcher biases, inconsistencies in the research processes used, differences in the context in which the research was conducted, and measurement errors. Positivists tend to use laboratory experiments, field experiments and surveys as their preferred research methods. They seek large amounts of empirical data that they can analyze statistically to detect underlying regularities (Berntsen et al, 2000).

On the other hand, Interpretivism is based on the belief that reality and the individual who observes it cannot be separated (Weber, 2004). Interpretivists believe that the qualities they describe in the objects under research are socially constructed and products of their worlds (Berntsen et al, 2000). Interpretivists build on the premise that there can be many different perceptions of reality, and none of them may actually describe reality in extremis (Berntsen et al, 2000). In the Interpretive approach, the assumption is made that knowledge is gained only through social constructions such as language, consciousness, shared meanings, documents and other artifacts (Berntsen et al. 2000). According to Weber (2004), in Interpretivism, the subjective characteristics reflect researchers' perceptions about the meaning of some world. The objective's characteristics reflect the constant negotiation this meaning has with others the researchers has had interaction with.

Interpretivists believe that research is reliable if researchers can demonstrate interpretive awareness (Weber, 2004). So, the Interpretive researcher needs to show and acknowledge the subjectivity the researcher brings to the research process, and hence, steps have to be taken to address the implications of this subjectivity. According to Berntsen et al, (2000), the very nature of Interpretivists' research means that researchers themselves in effect become "measurement instruments." The researchers interpret the phenomena they observe. In this regard, Interpretive researchers understand that their research actions affect the research objects they are studying. Thus, Interpretive research often involves using qualitative methods with the aim to understand the data collected and analyzed during the research process (Berntsen et al, 2000). Interpretivists tend to use case studies, ethnographic studies, phenomenological studies, and ethno methodological studies as their preferred research methods.

The Table 3-1 identifies key differences between the two philosophies. In his analysis, Weber (2004) points out that the core difference is rooted in the beliefs behind conducting the research.

**Table 3-1 – Difference between Interpretive and Positivist**

**Source: MIS Quarterly Vol. 28 No. 1/March 2004**

| Theoretical Assumptions | Positivism | Interpretivism |
|---|---|---|
| Ontology | Person (researcher) and reality are separate. | Person (researcher) and reality are inseparable (life-world). |
| Epistemology | Objective reality exists beyond the human mind. | Knowledge of the world is intentionally constituted through a person's lived experience. |
| Research Object | Research object has inherent qualities that exist independently of the researcher. | Research object is interpreted in light of meaning structure of person's (researcher's) lived experience. |
| Method | Statistics, content analysis. | Hermeneutics, phenomenology. |
| Theory of Truth | Correspondence theory of truth: one-to-one mapping between research statements and reality. | Truth as intentional fulfillment: interpretations of research object match lived experience of object. |
| Validity | Certainty where data truly measures reality. | Defensible knowledge claims. |
| Reliability | Repeatability, where research results can be reproduced. | Interpretive awareness: researchers recognize and address implications of their subjectivity. |

## 3.3 Methodology Selection and Approach

In this thesis, the author followed the Interpretivism approach to conduct the research under study. Several authors (Hirschheim et al, 1985; Bjørn-Andersen, 1985; and Remenyi and Williams, 1996) have argued that the Positivist approach is inappropriate for the social sciences due to inconsistency of results and lack of identifying measures

for important phenomena. Walsham (1993) states that in software, interpretive research is more effective since it aims at producing an understanding of the context of the information system and the process whereby the Information System influences and is influenced by its context.

Building on the hypothesis presented in Chapter Two that the quality of an E-commerce site is best measured from a user satisfaction framework, this research relied on the Kuutti (1991) principles of Activity Theory to study the quality factors that contribute to assessing the overall quality of an underlying website.

**Table 3-2 – Main Concepts of Activity theory (AT)**

**Source: Berntsen, et al (2000)**

| **Binding Concepts** |
|---|
| 1. An activity has an active subject (individual or collective) who understands the motive of the activity – the object. |
| 2. The transformation of the object towards some desired state is what motivates the existence of an activity. |
| 3. An activity exists in a material environment and transforms it. (the term material comes from Marxist philosophy and signifies not only "touchable" things but everything conscious which exists outside the individual). |
| 4. An activity is a historically developing phenomenon. |
| 5. An activity is a collective phenomenon. |
| 6. An activity is realized through the conscious and purposeful actions of participants. |
| 7. Individuals can participate in several activities |
| 8. Activities temporarily merge. Actions are usually poly-motivated, that is they are simultaneously part of separate "overlapping" activities. |
| 9. Contradictions are the force behind the development of an activity |
| 10. Primary contradictions between the objects or outcomes of two separate activities may introduce secondary contradictions into the activities. |
| 11. Relationships within an activity are culturally mediated. |

According to Kuutti (1991), Activity Theory is a philosophical framework for studying different forms of human praxis as processes of development, where both the individual and the social levels are interlinked. In this framework, an activity is seen as a minimal meaningful context for individual actions and a suitable basic unit for analysis. The main concepts for activity theory are listed in Table 3-2.

According to Berntsen et al (2000), experimental software engineering is based on a hypothetic-deductive research model. In conducting the research, the author relied on the five step approach of Wohlin et al. (2000) as it was considered to be suitable for the study of software. The steps are:

1. Experiment definition. In this step the hypothesis is defined, along with the objectives and goals of the experiment.
2. Experiment planning. At this stage, the hypothesis is formalized including a null hypothesis. Input/independent variables and output/dependent variables are determined. A suitable experiment design is chosen, and the potential validity problems with the results are discussed.
3. Experiment operation. Subjects and the materials needed (for data collection forms) for the experiments are prepared, before executing the experiment. The primary objective of this stage is to gather data for the next step.
4. Analysis and interpretation. Descriptive statistics are used to understand the data gathered during step three. A possible reduction of the data set must be considered. After the data have been reduced, a hypothesis test is performed by using statistical techniques.
5. Presentation and package. The main concern here is in presenting and packaging the findings. It is important that the experiment design is clear, to allow replication as this is an important mechanism for validating the findings.

## 3.4 Qualitative & Quantitative Analysis Considered

Researchers use questionnaires as a qualitative research tool to study the phenomenon (Barnes, 1997). The research approach to this thesis started with qualitative analysis to the subject domain under study. According to Patton (1990), a research-oriented learning experience includes a formal and informal process of gaining, utilizing and

systematically applying knowledge to an area of interest in order to make sense of the interrelationships between what one knows and what one learns. This was motivational as a methodology to follow in the early stages of the model development, where it helped organize and prioritize factors and sub-factors involved in assessing the qualities of E-commerce websites.

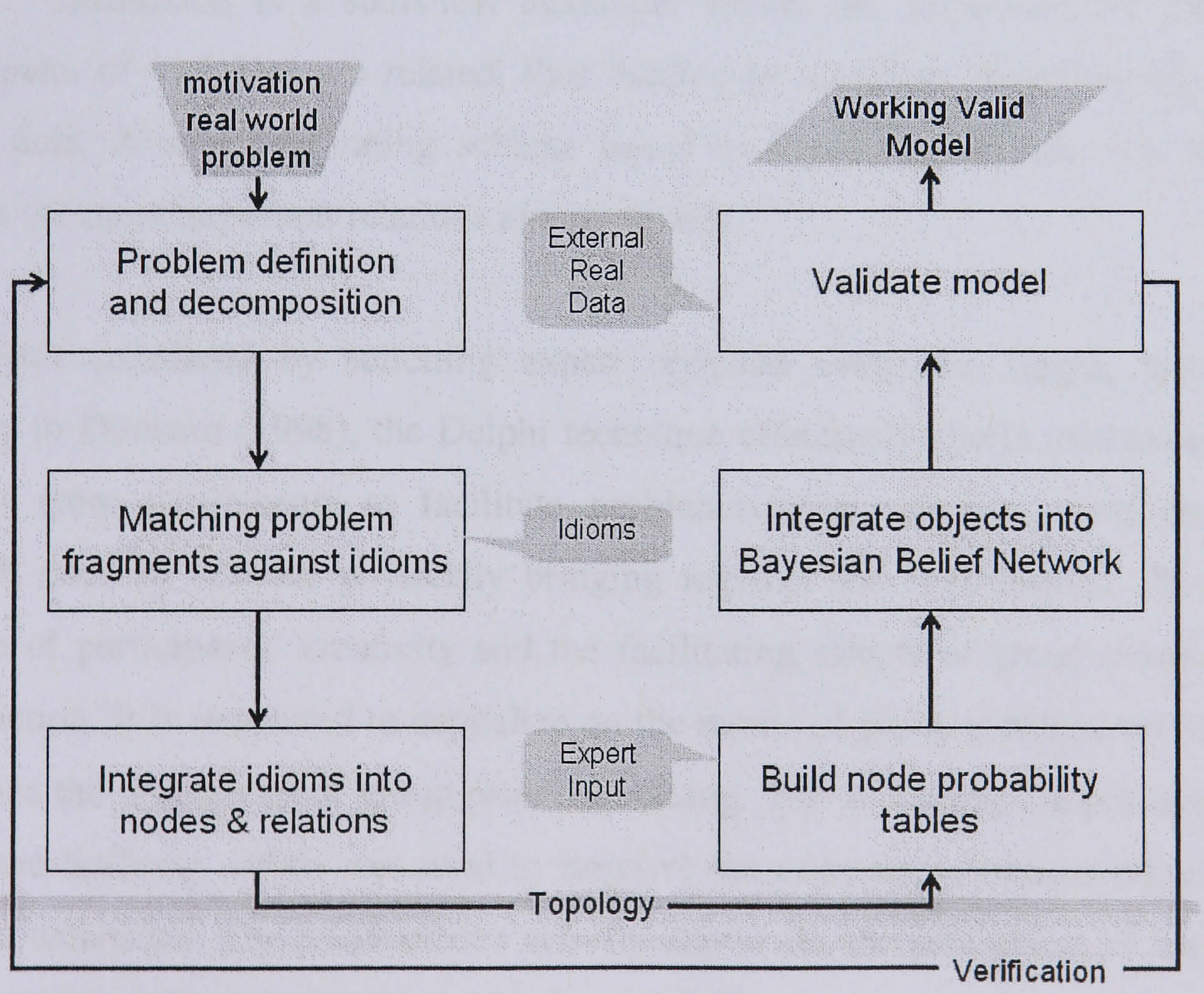
Observations collected from the questionnaires were put through quantitative reasoning to integrate the identified factors into a relationship framework. The transformation to quantitative research was led by a drive for explanatory investigation of the relationships between the identified inter-factor relations and their probabilistic intra-influences. The establishment of these inter-factor relations led to the realization of the totality of the model.

Quantitative strategies use normal distributions based on statistical or regression analysis (Patton et al, 1990). Statistical techniques, such as correlation, were used to deduce approximation to normality that would produce tangible evidence for the assertions that the inference influence a factor has on the total quality of the website. Following this, a probabilistic model based on Bayesian theory was applied to complete the model.

After the completion of the model, empirical evidence was derived by the way of case study analysis to validate the model in practical use. According to Dockrell and Hamilton (1980), case studies are a fairly intensive examination of what has happened in a single bounded context. This helps to explore, unravel and validate problems, issues and relationships in a particular situation. Case studies involve an in-depth, descriptive record taken by an outside observer, based on collecting and examining various observations and records of a targeted experience (Aha, 1992). According to Aha (1992), case studies are useful when researchers want to get a detailed contextual view of a particular phenomenon. However, the limitation of observing behaviour is that it can only be described, not completely explained. To circumvent such limitations, case studies were applied to validate the model but not to build it.

## 3.5 The Use of Idioms

According to Yu and Johnson (2002) idioms are best applied in realizing a complete Bayesian Belief Network where they act as building blocks that can be joined together to compose the system's totality. While personal experiences in building networks are the basis of generating idioms, idioms can help people to decide the direction of arcs addressing the more difficult step of building the network. Fenton et al. (2001) suggests the use of an idiom framework to build a network using expertise, which would be a reusable network structure that represents generic patterns. These authors use the term idiom in this context to represent clearly identifiable conceptual aspects that contribute to a problem, such "security" or "reliability". The idioms are typically instantiated by matching them against pieces of the real world problem at hand, for example reliability may be matched against the mean time between system breakdowns. Figure 3-1 illustrates the procedure recommended by Fenton et al. (2001) and adopted for the research effort in this thesis.




**- Figure 3-1: The use of an idiom framework to build a BBN (from Fenton et al, 2001)-**

Once the model was produced, guidelines were developed to guide the process of utilizing the model, affirming hypotheses and extrapolating findings into a working

apparatus that can be applied for practical benefits.

## 3.6 Research Participation and Procedures

In conducting the study to create the domain final model, the research involved the solicitation and compilation of eighty-four quality factors from previously published research. This set was analyzed and qualified by conducting a comprehensive questionnaire to a representative sample set of twelve qualified E-commerce users. The recruitment of participants for the present research proved to be difficult, as is often the case with Internet populations in the Middle East where the research was undertaken. Increasing the sample size proved not to be possible within the resources available.

The normal distribution of the data for all the quality factors and sub-factors were checked in order to ensure their validity. Statistical correlation was used in analyzing the data obtained from the responses to the questionnaire to derive initial inter-factor relations. Correlation is a statistical technique which can show whether and how strongly pairs of variables are related, thus leading to a greater understanding of the acquired data. A statistical rating scheme based on frequency of rate was used to determine the most important relations among factors.

The analysis continued by soliciting expert opinions using the Delphi technique. According to Dunham (1998), the Delphi technique effectively elicits information and judgments from participants to facilitate problem-solving, planning, and decision-making. It does so without physically bringing together the contributors. This takes advantage of participants' creativity and the facilitating effects of group involvement and interaction. It is structured to capitalize on the merits of group problem-solving and to minimize the difficulties of group problem-solving. The Wideband Delphi Approach (Boehm and Sullivan, 2000) was used to improve the estimate consensus obtained by the Delphi technique. The result of this activity allows for the refinement of the target model. A detailed description of how the Delphi technique was used in the case studies in this thesis is described in Section 9.4.

The Hugin Expert A/S (Hugin, 2006) was employed to program the Bayesian Belief

Network model to use. The Hugin Expert A/S provides a comprehensive and flexible interface to model networks. Once modeled, the software's decision engine is leveraged graphically with ease. Furthermore, the application allows easy modification and editing of existing models. Several available tools were considered, such as Microsoft's MSBNx, B.net of Charles River Analytics, and Netica from Norsys before finding Hugin Expert A/S the tool of choice.

The Hugin Expert A/S was also used to apply the resultant network model in three selected case studies. The results of the studies are documented within this thesis in Chapters 8, 9, and 10. The developed software file that represents the model is publicly available and can be requested from The Knowledge Management Research Group at Loughborough University by contacting the supervisor of this research, Ray Dawson.

## 3.7 Conclusion

After evaluating different methodology alternatives, this chapter presents the methodology undertaken in this research to produce reliable results and conclusions serving the intended aims and objectives described in Chapter One. According to Miles and Huberman. (1994), trustworthiness emerges through the efforts of the researcher to provide credible, confirmable and dependable findings. This chapter describes how this trustworthiness has been achieved in this research project.

# Chapter 4 – E-commerce Quality Attributes

## 4.1 Introduction

An E-commerce website can be assessed by the quality factors of its software. The presence of these quality factors allows the measurable specification of attributes and variables. This chapter defines and categorizes the quality factors for measuring an E-commerce website. The primary goals are identifying, qualifying, categorizing and rating these factors and thus formulating the baseline for the work in this thesis.

The software is an essential part of the E-commerce website. The ISO 9126-1 standard for software engineering product quality (ISO, 2001) states that the main purpose of software quality evaluation is to supply referential quantitative results for software products that are reliable, understandable and acceptable. According to Larsson (2004), quality factors are primarily attributes of the software that are often labelled as "non-functional requirements." The key challenge of these attributes is the lack of a formal specification of a means of measurement. This thesis provides a framework to establish quality factors in terms of attributes, in addition to their level of importance based on the opinion of highly-skilled professionals.

## 4.2 Categorizing

The quality of a website is a property difficult to define and capture in an operational way, yet everybody feels it when it is missing. In fact, for a website there can be as many views of its quality as there are usages. Quality may depend on task-related factors affecting end users such as presentation quality and appeal, content and function adequacy, and navigability. It may also depend on performance-related factors that affect the efficiency of end users and the economics of the website within the company running it. These factors include response time, transaction throughput, reliability and robustness. It may depend on development-related factors that affect developers and maintainers of a website. These include code complexity, code readability, code flexibility, portability, page coupling and modifiability.

The foundation model used to identifying quality factors and attributes is based on research by Albuquerque and Belchior (2002). The model is extended with further research investigation and expert reviews and interviews.

Albuquerque and Belchior have organized a comprehensive set of software quality attributes into objectives where each objective is composed of a set of quality factors. Each quality factor is further decomposed into sub-factors. According to Albuquerque and Belchior (2002), three broad objectives formulate the model, as illustrated below which enables the evaluation of an E-commerce website's quality.

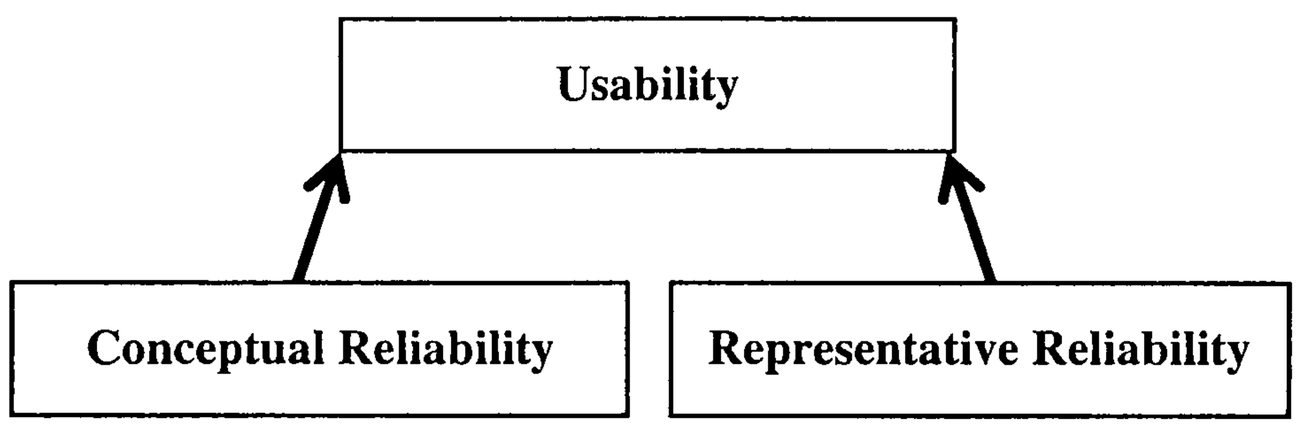



**Figure 4-1: E-commerce quality objectives (Albuquerque and Belchior, 2002)**

Usability is a quality objective that refers to the characteristics that allow the use of the E-commerce site in the most diverse situations, not only during its development process, but also during its operation and maintenance. This objective builds on the reliability of the web site. Reliability is composed of two aspects, according to Albuquerque and Belchior (2002). Conceptual reliability is concerned with the E-commerce site's capacity to implement, satisfactorily, what was specified and designed. Representative reliability refers to the E-commerce site's representation characteristics that affect its understanding and manipulation through its lifecycle.

Albuquerque and Belchior's identification of the factors under these objectives was derived from their extensive questionnaires to both the user and developer communities in E-commerce.

## 4.3 Identifying

Further quality factors and attributes were researched to ensure having a comprehensive list of quality factors. In particular, scalability and availability were added as, according

to Firesmith (2003), E-commerce website software is large and complex, but quality requirements demand the key performance of factors such as availability, performance, scalability, and security. This, in essence, provides the biggest influence on the effective implementation of a website.

Scalability is the website readiness to meet rising demands of users and usage. Thus, website software applications must be prepared to grow quickly both in terms of users serviced and in terms of services offered. According to Firesmith (2003), the need for scalability has been a driver for much of the technology innovations in the past few years. Industry has developed new software languages, new design strategies, and new communication and data transfer protocols, in part to allow web sites to grow as needed.

According to Firesmith (2003), availability is of two parts. The first relates to the website accessibility and being up and running 24 hours a day, 7 days a week and 365 days a year. The second relates to the web software and it accessibility by diverse types of web browsers. Using the common denominator of features among all browsers as the baseline and removing any use of features unique to a particular browser ensures cross-browser availability. To be available in this sense requires significantly more knowledge and effort on the part of the software engineers.

Further, the scope of Albuquerque and Belchior quality factors extend beyond the technical and operational aspects of a website to its economics and business viabilities. However, in aligning with the goals of the thesis, factors relating to such attributes were removed from the list. Table 4-1 lists the factors used with a short explanation of each factor.

At this stage, and based on the academic research exercised, it was felt that a list of sixteen factors within three objectives satisfy an assessment of the quality of the operational software of an E-commerce website. The next step was to extend the factors with sub-factors that allow measurement to qualify the assessment. Table 4-2 displays the complete set of those quality attributes. They are a total of eighty four sub-factors organized within the quality factors.

**- Table 4-1: E-commerce Quality Factors -**

| **Usability** | |
|---|---|
| Efficiency | The timeliness of which the website responds to the user. |
| User-Friendliness | The user interface capabilities to which the website provides a supportive experience to the user. |
| Navigability | The browsing extensibility which the website's software allows. |
| Maintainability | The reduced effort which the website's software requires for its upkeep, enhancing its ability to be kept up to date and usable |
| Involvement Capacity | The measure of which the website can adapt to and attract each user's individuality. |
| **Conceptual Reliability** | |
| Functionality | The extent of the operational aspects of the website software and its fitness of use. |
| Security | The extent of safety assured against malicious or accidental intrusion of unauthorized users when using the website. |
| Reliability | The extent of which the website remains available and working. |
| Integrity | The reliability, consistency and correctness of stored data. |
| Trustworthiness | The extent to which the user perceives the website to behave consistently, reliability and correctly, building a trusting relationship. |
| Content Adequacy | The extent to which the information presented is contextually applicable to the user and sufficient for the user's needs. |
| Scalability | The website readiness to meet rising demands in users and usage. |
| Availability | The extent of website accessibility to users through different browsers in differing times. |
| **Representative Reliability** | |
| Readability | The appropriate application of the written language within the website |
| Standards Conformance | The extent of consistency applied within the user interface of the website. |
| Ease Of Manipulation | The extent of help provided to operate the website and the software underneath it. |

**- Table 4-2: Identified Quality Sub-Factors -**

| Quality Sub-Factors | Reference |
|---|---|
| **1. Usability** | |
| **1.1 Efficiency** | |
| 1.1.1 Time Behavior | Albuquerque and Belchior (2002) |
| 1.1.2 Purchase Process Performance | Albuquerque and Belchior (2002) |
| 1.1.3 Page Generation Speed | Albuquerque and Belchior (2002) |
| **1.2 User-Friendliness** | |
| 1.2.1 Understandability | Albuquerque and Belchior (2002) |
| 1.2.2 Products Information Availability | Albuquerque and Belchior (2002) |
| 1.2.3 Interactivity | Albuquerque and Belchior (2002) |
| 1.2.4 Learn-ability | Albuquerque and Belchior (2002) |
| 1.2.5 Information Localizability | Albuquerque and Belchior (2002) |
| 1.2.6 Response Time Uniformity | Albuquerque and Belchior (2002) |
| 1.2.7 Forms Of Payment Availability | Albuquerque and Belchior (2002) |
| 1.2.8 Storage Of Purchase List | Albuquerque and Belchior (2002) |
| 1.2.9 Help Availability | Albuquerque and Belchior (2002) |
| 1.2. 10 Products Comparison | Albuquerque and Belchior (2002) |
| 1.2.11 "Shopping Cart" Metaphor | Albuquerque and Belchior (2002) |
| 1.2.12 Printing Facilities | Albuquerque and Belchior (2002) |
| 1.2.13 Download Facilities | Albuquerque and Belchior (2002) |
| **1.3 Navigability** | |
| 1.3.1 Absence Of Navigation Errors | Albuquerque and Belchior (2002) |
| 1.3.2 Minimal Path & Shortcut Facility | Albuquerque and Belchior (2002) |
| 1.3.3 Drawback | Albuquerque and Belchior (2002) |
| 1.3.4 Navigation Structure Taxonomy | Albuquerque and Belchior (2002) |
| 1.3.5 Links Visibility | Albuquerque and Belchior (2002) |
| 1.3.6 Links Visualization Consistence | Albuquerque and Belchior (2002) |
| 1.3.7 Alternative Paths | Albuquerque and Belchior (2002) |
| 1.3.8 Navigational Prediction | Albuquerque and Belchior (2002) |
| 1.3.9 User Level Adaptability | Albuquerque and Belchior (2002) |
| 1.3.10 Interaction Storage Capacity | Albuquerque and Belchior (2002) |
| 1.3.11 Mobile Devices Accessibility | Albuquerque and Belchior (2002) |
| **1.4 Maintainability** | |
| 1.4.1 Stability | Albuquerque and Belchior (2002) |
| 1.4.2 Testability | Albuquerque and Belchior (2002) |
| 1.4.3 Analyzability | Albuquerque and Belchior (2002) |
| 1.4.4 Changeability | Albuquerque and Belchior (2002) |
| **1.5 Involvement Capacity** | |
| 1.5.1 Attractiveness | Albuquerque and Belchior (2002) |
| 1.5.2 Aesthetic Attributes | Albuquerque and Belchior (2002) |
| 1.5.3 Client Profile Identification | Albuquerque and Belchior (2002) |
| 1.5.4 Simulation | Albuquerque and Belchior (2002) |
| 1.5.5 Additional Services Availability | Albuquerque and Belchior (2002) |
| **2. Conceptual Reliability** | |
| 2.1 **Functionality** | |
| 2.1.1 Accuracy | Albuquerque and Belchior (2002) |
| 2.1.2 Client Support | Albuquerque and Belchior (2002) |
| 2.1.3 Information On Product Delivery | Albuquerque and Belchior (2002) |
| 2.1.4 Suitability | Albuquerque and Belchior (2002) |
| 2.1.5 Flexibility | Albuquerque and Belchior (2002) |
| 2.1.6 Interoperability | Albuquerque and Belchior (2002) |

| Quality Sub-Factors | Reference |
|---|---|
| **2.2 Security** | |
| 2.2.1 Payment Systems Security | Albuquerque and Belchior (2002) |
| 2.2.2 Vulnerability | Albuquerque and Belchior (2002) |
| 2.2.3 Site Authentication | Albuquerque and Belchior (2002) |
| 2.2.4 Access Control | Albuquerque and Belchior (2002) |
| 2.2.5 Confidentiality | Albuquerque and Belchior (2002) |
| 2.2.6 Privacy | Albuquerque and Belchior (2002) |
| **2.3 Reliability** | |
| 2.3.1 Recoverability | Albuquerque and Belchior (2002) |
| 2.3.2 Maturity | Albuquerque and Belchior (2002) |
| 2.3.3 Fault Tolerance | Albuquerque and Belchior (2002) |
| **2.4 Integrity** | |
| 2.4.1 Data Integrity | Albuquerque and Belchior (2002) |
| 2.4.2 Data Entry Signalizing | Albuquerque and Belchior (2002) |
| 2.4.3 Robustness | Albuquerque and Belchior (2002) |
| 2.4.4 Audit Trail | Albuquerque and Belchior (2002) |
| **2.5 Trustworthiness** | |
| 2.5.1 Correctness | Albuquerque and Belchior (2002) |
| 2.5.2 Completeness | Albuquerque and Belchior (2002) |
| 2.5.3 Necessity | Albuquerque and Belchior (2002) |
| **2.6 Content Adequacy** | |
| 2.6.1 Updated Content | Albuquerque and Belchior (2002) |
| 2.6.2 Correctness | Albuquerque and Belchior (2002) |
| 2.6.3 Intelligibility | Albuquerque and Belchior (2002) |
| 2.6.4 User Oriented | Albuquerque and Belchior (2002) |
| 2.6.5 Respectability | Albuquerque and Belchior (2002) |
| 2.6.6 Concise Content | Albuquerque and Belchior (2002) |
| 2.6.7 Completeness | Albuquerque and Belchior (2002) |
| 2.6.8 Compatibility With Real Store | Albuquerque and Belchior (2002) |
| **2.7 Scalability** | |
| 2.7.1 Multiprocessor handling | Larsson (2004) |
| 2.7.2 Farming capabilities | Larsson (2004) |
| **2.8 Availability** | |
| 2.8.1 24/7/365 Readiness | Larsson (2004) |
| 2.8.2 Partial Availability | Larsson (2004) |
| 2.8.3 Browser version compatibility | Larsson (2004) |
| 2.8.4 Cross Browser Support | Larsson (2004) |
| **3. Representation Reliability** | |
| **3.1 Readability** | |
| 3.1.1 Language Correctness | Albuquerque and Belchior (2002) |
| 3.1.2 Style Uniformity | Albuquerque and Belchior (2002) |
| 3.1.3 Clarity | Albuquerque and Belchior (2002) |
| 3.1.4 Conciseness | Albuquerque and Belchior (2002) |
| 3.1.5 Terminology Uniformity | Albuquerque and Belchior (2002) |
| 3.1.6 Abstraction Uniformity | Albuquerque and Belchior (2002) |
| **3.2 Standards Conformance** | |
| 3.2.1 Interface Standards | Albuquerque and Belchior (2002) |
| 3.2.2 Programming Standards | Albuquerque and Belchior (2002) |
| 3.2.3 Navigation Standards | Albuquerque and Belchior (2002) |
| **3.3 Ease Of Manipulation** | |
| 3.3.1 Up-To-Date | Albuquerque and Belchior (2002) |
| 3.3.2 Ability To Trace | Albuquerque and Belchior (2002) |

| Quality Sub-Factors | Reference |
|---|---|
| 3.3.3 Documentation Availability | Albuquerque and Belchior (2002) |
| 3.3.4 Structure | Albuquerque and Belchior (2002) |

## 4.4 Qualifying

To establish a rating system for the factors, a standard statistical rating scheme based on frequency of expert rating was used to reflect the relative importance of the different sub-factors within a factor. The weighting system was generated based on questionnaire results from expert specialists in E-commerce development and representative consumers of E-commence.

Participants in the questionnaires were selected based on meeting qualifying criteria detailed in Appendix A. Each person was required to obtain a score based on answering the questions stated in Appendix A. The qualifying criteria were derived from the industry best practices. The selection of the sampled participants was based on the following:

- ✓ The number of E-commerce websites developed by the expert / respondent (at least 5 websites to be considered).
- ✓ The level of experience for each expert / respondent
- ✓ The complexity and size of the developed E-commerce websites.

A total of twenty experts were surveyed from largest IT companies in Jordan. The questionnaires were administered by the author visiting these companies and interviewing the respondents. Each question gave the respondents the option to select one answer from multiple answers. Each answer was assigned a score from 0 to 7 depending on the question as shown in Appendix A. The answers were recorded by the author.

A score of 20 or above was used as the qualification to be considered as an expert (A score of 20 was chosen for convenience to get a range of experience of building websites with several different companies). The author was able to define 13 experts/respondents out of 20 sampled, most of whom used to be software engineers and developers. These experts represented a range of seven companies, including the largest IT companies in Jordan, and have a wide experience in building E-commerce websites

in the Middle East, working on web applications or desktop applications. They have a solid technical background and a wide experience in designing and developing E-commerce websites. Table 4-3 shows the list of Companies represented and the role of each expert.

**- Table 4-3: Companies list and the role of each expert -**

| Expert Role | Company Name | Web address |
|---|---|---|
| The principle owner and Chief Architect of ePageCafe | IT Matrix | www.epagecafe.com |
| Lead designers | Integrated Technology Group | http://www.itgsolutions.com/ |
| Senior programmers | AlliedSoft | www.alliedsoft.com.jo |
| Test researchers | CNS - Primus | http://www.cns.com.jo/ |
| Project managers | Mozaiic | http://www.mozaiic.com/index.cfm |
| Senior Director of the Innovation Centre at Estarta | Estarta Solutions | www.estartasolutions.com |
| Chief Technology Architect of Softact | Softact | http://www.Softact.com/ |

Once identified as an expert, the participants were asked to respond to the questionnaire that asked them to rate each of the sub-factors in order of importance of their contribution to the factor. The questionnaire is available in Appendix B. The questionnaire listed in Appendix B also provides an explanation of how each sub-factor influences the factor it belongs to.

Initially, one randomly selected expert was identified for a pilot run to validate the content and style of the questionnaire. When the answers had been received from the pilot run, they were verified to make sure that the questions were clear, complete and unambiguous; the questionnaire was then distributed to the remaining twelve participants. Data generated from the pilot run was excluded from the final results.

100% of the twelve respondents gave back their responses to the questionnaire. However, some of those who were given the questionnaire did not answer all parts of the questionnaire as highlighted in Appendix C.

The questionnaire was administered during a face-to-face interview with the experts. For each interview engagement, an introduction orientation was given on the questionnaire followed by a one-on-one question and answers session to gain the answers and clarified any ambiguities. The answers were recorded by the author to assure accuracy and consistency, which follows the guidelines of the Delphi method described in Chapter 3. In general, the process of soliciting answers followed the standard Delphi method (Dunham, 1998) in soliciting expert opinions.

## 4.5 Rating

The rating of sub-factors was done within each factor. The rating is sequentially based on the order of the importance of the sub-factors in their influence on the factor. So, for factor *S* having six sub-factors of *SS1 to SS6,* each participant rated each sub-factor according to its importance in influencing *S,* where 1 was the most important and 6 was the least.

In handling missing values for sub-factors, the average of received responses was calculated to fill in the gaps of missing observations. It was intended that sub-factors that had six or fewer responses would be removed from the analysis, but this did not prove to be necessary as each sub-factor had at least ten responses as shown in Appendix C.

Once all results were collected, a weighting scheme was applied to reflect the relative importance (rating) of the different sub-factors based on the following formula:

$$\textit{Sub-factor Percent Importance} = 100 - (M / N)*100$$

Where *M* represents the average rating received on a sub-factor and N represents the total number of sub-factors attributes for a given factor. The subtraction from 100 is to reverse the rating scale of the questionnaire so that the questionnaire rating of "1" has

the highest percentage importance. The final rating achieved has the highest percentage given to the most important sub-factor, proceeding to the least important in a descending fashion. One drawback to this method is that the final rating obtained for each sub-factor is dependant on the number of sub-factors in each group (e.g. for four factors the with an average score of 1, the maximum is 100 - (1/4)*100 = 75 and for 3 factors the maximum is 100 - (1/3)*100 = 66.7). So, this rating is affected by the number of sub-factors in a factor and consequently this affects inter-factor correlations. To compensate for this problem, a second expert panel of experts was used to assess the appropriateness of the correlations as explained in the next chapter.

## 4.6 Results

The final rating achieved has the highest percentage given to the most important sub-factor as the key factors to assessing the qualities of an E-commerce website, proceeding to the least important in a descending fashion. Table 4-3 shows the rating received by each sub factor. Appendix C provides the full calculations for this effort.

**- Table 4-4: Identified Quality Sub-Factors -**

| Quality Sub-Factors | Rating |
|---|---|
| **Usability** | |
| **Efficiency** | |
| Time Behavior | 53 |
| Page Generation Speed | 53 |
| Purchase Process Performance | 33 |
| **User-Friendliness** | |
| Understandability | 76 |
| Response Time Uniformity | 74 |
| Interactivity | 73 |
| Learn-ability | 68 |
| Help Availability | 52 |
| “Shopping Cart” Metaphor | 52 |
| Products Comparison | 48 |
| Forms Of Payment Availability | 33 |
| Storage Of Purchase List | 27 |
| Localizability | 26 |
| Printing Facilities | 26 |
| Download Facilities | 24 |
| Products Information Availability | 23 |
| **Navigability** | |
| Minimal Path & Shortcut Facility | 80 |
| Links Visibility | 72 |

| Quality Sub-Factors | Rating |
|---|---|
| Absence Of Navigation Errors | 67 |
| Navigation Structure Taxonomy | 66 |
| Links Visualization Consistence | 48 |
| User Level Adaptability | 45 |
| Interaction Storage Capacity | 29 |
| Alternative Paths | 28 |
| Navigational Prediction | 17 |
| Mobile Devices Accessibility | 17 |
| Drawback | 16 |
| **Maintainability** | |
| Stability | 60 |
| Changeability | 52 |
| Testability | 27 |
| Analyzability | 10 |
| **Involvement Capacity** | |
| Attractiveness | 63 |
| Client Profile Identification | 55 |
| Aesthetic Attributes | 53 |
| Simulation | 20 |
| Additional Services Availability | 10 |
| **Conceptual Reliability** | |
| **Functionality** | |
| Accuracy | 67 |
| Suitability | 58 |
| Client Support | 53 |
| Information On Product Delivery | 44 |
| Flexibility | 18 |
| Interoperability | 10 |
| **Security** | |
| Payment Systems Security | 58 |
| Site Authentication | 57 |
| Access Control | 51 |
| Privacy | 51 |
| Confidentiality | 18 |
| Vulnerability | 14 |
| **Reliability** | |
| Recoverability | 53 |
| Fault Tolerance | 47 |
| Maturity | 0 |
| **Integrity** | |
| Data Integrity | 58 |
| Audit Trail | 25 |
| Robustness | 22 |
| **Trustworthiness** | |
| Correctness | 50 |
| Completeness | 0 |
| **Content Adequacy** | |

| Quality Sub-Factors | Rating |
|---|---|
| Updated Content | 68 |
| Correctness | 61 |
| User Oriented | 55 |
| Completeness | 52 |
| Concise Content | 39 |
| Intelligibility | 26 |
| Respectability | 25 |
| Compatibility With Real Store | 24 |
| **Scalability** | |
| Farming capabilities | 54 |
| Multiprocessor handling | 21 |
| **Availability** | |
| Browser version compatibility | 57 |
| 24/7/365 Readiness | 53 |
| Cross Browser Support | 53 |
| Partial Availability | 38 |
| Notification Integrity | 13 |
| **Representation Reliability** | |
| **Readability** | |
| Language Correctness | 75 |
| Clarity | 67 |
| Style Uniformity | 38 |
| Conciseness | 33 |
| Terminology Uniformity | 24 |
| Abstraction Uniformity | 14 |
| **Standards Conformance** | |
| Interface Standards | 61 |
| Programming Standards | 42 |
| Navigation Standards | 31 |
| **Ease Of Manipulation** | |
| Up-To-Date | 44 |
| Ability To Trace | 38 |
| Structure | 35 |
| Documentation Availability | 33 |

## 4.7 Conclusion

This chapter has determined the factors that assess the quality of an E-commerce website, identifying and rating the main quality attributes to this application domain. The list of attributes was derived from the specialized literature. The survey and analysis described in this chapter enabled a greater understanding of the inter-relations and influences these sub-factors have on the main quality factors and this forms the basis for the E-commerce prediction model derived in the next chapters

# Chapter 5 – Relationships between Factors

## 5.1 Introduction

In continuing the process of shaping the quality assessment model for E-commerce websites, this chapter defines the interrelations among the quality factors identified in the previous chapter. The relationships are identified from the results of the questionnaire described in the last chapter and by using statistical analysis and expert opinion.

An understanding of the inferences and causal relations the quality factors have amongst them is essential for a reliable model (Loiacono et al., 1999). According to the Survey System (2002), correlation is a statistical technique which can show whether and how strongly pairs of variables are related, thus leading to a greater understanding of the acquired data. Correlation is most meaningful when used for quantities of some sort and may be controversial when used otherwise. Rating scales is a middle case according to the Survey System (2002). The numbers in rating scales have meanings, but these meanings are not very precise.

The key issue of using correlation with the rating scales, according to the Survey System (2002), is that they are not like-quantities in terms of distance along the rating scale. With a quantity (such as Pounds), the difference between 1 and 2 is exactly the same as between 2 and 3. But with the rating scale, that might not be the case, and it is subject to the perspectives and perceptions of the survey takers.

Nevertheless, and according to Falk (1997), many survey researchers do use correlations with rating scales, because the results usually reflect the real world. In this thesis, correlations are used with rating scales, but with care. After the completion of identifying the factors' significant inter-relations, the results were reviewed by a panel

of experts to ensure they were satisfied that the results were acceptable. This chapter elaborates on the process and approach taken.

## 5.2 Assessment

According to StatSoft (2005), the main result of a correlation is called the correlation coefficient (or "r"). It ranges from -1.0 to +1.0. The closer r is to +1 or -1, the more closely the two variables are related. A reading of r close to "0" means there is no relationship between the variables. When r is positive, this means that the variables are synchronized in their movement such that as one variable gets larger the other gets larger as well. A negative value of r means that the two variables move in opposite directions such that as one variable get larger the other gets smaller. This latter case is often called an "inverse" correlation.

Table 5-1 shows the correlation report drawn from assessing the interdependencies between every two pairs in the Quality Sub-Factors list derived in the previous chapter and the resultant high mark correlations are identified. Table 5-2 identifies the high ranked correlations of 0.51 or greater among sub-factors.

**-Table 5-1: The correlation report drawn from assessing the interdependencies between every two pairs in the Quality Sub-Factors-**

| S | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | QF | | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 4 | 5 | 5 | 5 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 4 | 6 | 6 | 6 | 6 | 7 | 8 | 8 | 8 | 1 | 1 | 2 |
| | | SF | 1 | 3 | 1 | 3 | 4 | 6 | 11 | 13 | 1 | 2 | 4 | 5 | 1 | 4 | 1 | 2 | 3 | 1 | 2 | 4 | 1 | 3 | 4 | 6 | 1 | 1 | 1 | 2 | 4 | 7 | 2 | 1 | 4 | 5 | 1 | 3 | 1 |
| 1 | 1 | 1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 3 | -0.22 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2 | 1 | -0.05 | -0.05 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2 | 3 | -0.10 | -0.17 | -0.41 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2 | 4 | -0.35 | 0.31 | -0.25 | 0.40 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2 | 6 | 0.06 | -0.56 | 0.01 | 0.25 | -0.42 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2 | 11 | 0.16 | 0.12 | -0.35 | -0.03 | 0.23 | -0.54 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 2 | 13 | 0.31 | 0.07 | -0.41 | -0.48 | -0.06 | -0.17 | 0.15 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 3 | 1 | -0.04 | 0.04 | -0.43 | 0.46 | 0.25 | -0.45 | 0.17 | -0.02 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 3 | 2 | 0.41 | -0.22 | 0.62 | -0.17 | -0.24 | 0.10 | -0.21 | -0.12 | -0.19 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 3 | 4 | -0.49 | 0.31 | 0.03 | -0.33 | -0.17 | 0.37 | -0.33 | 0.03 | -0.55 | -0.30 | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 3 | 5 | 0.49 | -0.03 | -0.42 | -0.15 | 0.09 | -0.44 | 0.47 | 0.36 | 0.29 | -0.30 | -0.32 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 4 | 1 | -0.16 | 0.16 | -0.63 | 0.22 | 0.53 | -0.27 | 0.52 | 0.32 | 0.21 | -0.39 | -0.19 | 0.11 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 4 | 4 | 0.06 | -0.26 | 0.70 | -0.12 | -0.28 | 0.40 | -0.85 | -0.35 | -0.31 | 0.42 | 0.13 | -0.30 | -0.75 | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 5 | 1 | 0.19 | 0.02 | 0.05 | 0.13 | 0.16 | -0.03 | -0.63 | -0.03 | 0.37 | 0.15 | -0.12 | 0.18 | -0.27 | 0.57 | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 5 | 2 | -0.36 | -0.19 | 0.05 | 0.19 | 0.14 | 0.18 | 0.32 | -0.33 | -0.40 | 0.00 | -0.02 | -0.29 | 0.41 | -0.23 | -0.58 | | | | | | | | | | | | | | | | | | | | | | |
| 1 | 5 | 3 | -0.36 | 0.38 | 0.29 | -0.58 | -0.26 | -0.21 | 0.24 | -0.12 | -0.41 | -0.14 | 0.60 | 0.09 | -0.33 | -0.05 | -0.38 | 0.09 | | | | | | | | | | | | | | | | | | | | | |
| 2 | 1 | 1 | 0.10 | -0.64 | -0.19 | 0.61 | 0.32 | 0.56 | -0.26 | -0.14 | -0.05 | 0.16 | -0.23 | -0.22 | 0.26 | 0.15 | 0.19 | 0.39 | -0.69 | | | | | | | | | | | | | | | | | | | | |
| 2 | 1 | 2 | 0.67 | -0.17 | 0.09 | -0.26 | 0.29 | -0.10 | 0.09 | 0.54 | -0.34 | 0.33 | -0.28 | 0.26 | 0.13 | 0.05 | 0.05 | -0.03 | -0.28 | 0.27 | | | | | | | | | | | | | | | | | | | |
| 2 | 1 | 4 | -0.08 | 0.46 | 0.00 | -0.24 | -0.26 | -0.07 | 0.23 | -0.22 | -0.17 | -0.47 | 0.48 | 0.15 | -0.16 | -0.15 | -0.30 | -0.16 | 0.64 | -0.66 | -0.49 | | | | | | | | | | | | | | | | | | |
| 2 | 2 | 1 | -0.30 | 0.71 | 0.14 | -0.24 | 0.13 | -0.38 | -0.30 | 0.02 | 0.06 | -0.12 | 0.02 | 0.10 | 0.11 | 0.26 | 0.50 | -0.05 | 0.02 | -0.23 | -0.04 | -0.04 | | | | | | | | | | | | | | | | | |
| 2 | 2 | 3 | -0.17 | 0.22 | -0.06 | -0.52 | -0.39 | -0.06 | 0.11 | 0.32 | -0.04 | -0.19 | 0.57 | -0.06 | -0.11 | -0.25 | -0.27 | -0.40 | 0.54 | -0.63 | -0.36 | 0.58 | -0.26 | | | | | | | | | | | | | | | | |
| 2 | 2 | 4 | -0.16 | -0.47 | -0.44 | 0.27 | 0.20 | 0.23 | 0.09 | 0.31 | 0.08 | -0.35 | 0.04 | 0.12 | 0.06 | -0.24 | -0.21 | 0.03 | -0.14 | 0.35 | 0.20 | -0.31 | -0.54 | -0.03 | | | | | | | | | | | | | | | |
| 2 | 2 | 6 | 0.43 | -0.55 | 0.25 | 0.32 | -0.39 | 0.42 | -0.05 | -0.37 | -0.04 | 0.46 | -0.56 | -0.21 | -0.11 | 0.23 | -0.13 | 0.33 | -0.46 | 0.42 | -0.01 | -0.23 | -0.24 | -0.45 | -0.22 | | | | | | | | | | | | | |
| 2 | 3 | 1 | 0.70 | -0.57 | 0.17 | 0.07 | 0.21 | -0.03 | 0.17 | -0.06 | 0.10 | 0.50 | -0.46 | 0.16 | 0.02 | 0.06 | 0.16 | -0.13 | -0.35 | 0.34 | 0.39 | -0.20 | -0.41 | -0.12 | -0.10 | 0.36 | | | | | | | | | | | | |
| 2 | 4 | 1 | 0.22 | -0.51 | 0.11 | 0.33 | 0.07 | 0.55 | -0.55 | -0.21 | 0.02 | 0.34 | 0.12 | -0.22 | -0.38 | 0.53 | 0.55 | -0.33 | -0.35 | 0.56 | 0.06 | -0.28 | -0.34 | -0.08 | 0.18 | 0.11 | 0.50 | | | | | | | | | | | |
| 2 | 6 | 1 | 0.02 | -0.20 | 0.10 | -0.23 | -0.37 | -0.10 | -0.46 | 0.19 | 0.43 | 0.17 | -0.17 | 0.22 | -0.39 | 0.42 | 0.66 | -0.54 | -0.12 | -0.15 | -0.15 | -0.29 | 0.38 | 0.07 | -0.07 | -0.04 | -0.09 | 0.18 | | | | | | | | | | |
| 2 | 6 | 2 | 0.21 | -0.38 | 0.19 | 0.14 | 0.50 | -0.23 | -0.32 | 0.04 | 0.35 | 0.36 | -0.47 | 0.08 | -0.03 | 0.38 | 0.69 | -0.29 | -0.54 | 0.42 | 0.45 | -0.68 | 0.20 | -0.45 | 0.08 | -0.02 | 0.51 | 0.50 | 0.41 | | | | | | | | | |
| 2 | 6 | 4 | 0.45 | 0.12 | -0.02 | 0.37 | 0.03 | -0.16 | 0.40 | -0.14 | 0.24 | 0.29 | -0.53 | 0.05 | -0.11 | -0.25 | -0.27 | -0.10 | -0.22 | -0.05 | 0.16 | -0.03 | -0.46 | -0.20 | 0.04 | 0.38 | 0.27 | -0.08 | -0.34 | -0.07 | | | | | | | | |
| 2 | 6 | 7 | -0.14 | -0.22 | 0.08 | -0.49 | -0.68 | 0.22 | 0.00 | 0.37 | -0.32 | -0.06 | 0.09 | -0.10 | 0.01 | -0.04 | -0.45 | 0.25 | 0.16 | -0.19 | -0.04 | 0.00 | 0.04 | 0.24 | 0.07 | 0.24 | -0.41 | -0.49 | 0.21 | -0.44 | -0.29 | | | | | | | |
| 2 | 7 | 2 | 0.18 | -0.40 | -0.12 | 0.20 | -0.31 | 0.04 | 0.41 | -0.36 | 0.32 | -0.11 | -0.38 | 0.15 | 0.20 | -0.27 | -0.25 | 0.21 | -0.12 | -0.03 | -0.49 | 0.42 | -0.22 | 0.07 | -0.39 | 0.68 | 0.33 | -0.16 | -0.05 | -0.29 | 0.09 | 0.21 | | | | | | |
| 2 | 8 | 1 | 0.71 | -0.12 | 0.10 | 0.11 | 0.20 | -0.21 | 0.32 | 0.07 | 0.03 | 0.53 | -0.75 | 0.12 | 0.34 | -0.12 | -0.03 | 0.25 | -0.52 | 0.32 | 0.58 | -0.45 | 0.04 | -0.57 | -0.31 | 0.57 | 0.55 | -0.14 | -0.21 | 0.32 | 0.47 | -0.09 | 0.21 | | | | | |
| 2 | 8 | 4 | 0.29 | -0.24 | -0.25 | -0.07 | 0.08 | -0.04 | -0.25 | 0.36 | 0.34 | -0.01 | 0.04 | 0.50 | -0.34 | 0.21 | 0.61 | -0.70 | -0.12 | 0.05 | 0.23 | -0.24 | -0.10 | 0.11 | 0.45 | -0.46 | 0.20 | 0.54 | 0.57 | 0.50 | -0.17 | -0.31 | -0.41 | -0.33 | | | | |
| 2 | 8 | 5 | -0.14 | -0.60 | -0.15 | 0.31 | -0.23 | 0.82 | -0.20 | -0.26 | -0.31 | -0.26 | 0.41 | -0.34 | -0.03 | 0.07 | -0.29 | 0.26 | -0.06 | 0.42 | -0.32 | 0.24 | -0.56 | 0.17 | 0.34 | 0.28 | 0.04 | 0.41 | -0.33 | -0.37 | -0.20 | 0.16 | 0.34 | -0.37 | -0.15 | | | |
| 3 | 1 | 1 | 0.55 | 0.55 | -0.08 | 0.11 | 0.00 | 0.00 | 0.04 | 0.01 | -0.09 | 0.30 | 0.04 | 0.05 | -0.09 | -0.05 | 0.12 | -0.26 | -0.05 | -0.11 | 0.18 | 0.17 | 0.00 | -0.04 | -0.40 | 0.03 | 0.11 | 0.09 | -0.29 | -0.18 | 0.54 | -0.46 | -0.20 | 0.32 | -0.02 | -0.24 | | |
| 3 | 1 | 3 | 0.00 | 0.35 | -0.77 | 0.05 | 0.42 | -0.41 | 0.39 | 0.42 | 0.35 | -0.79 | 0.06 | 0.66 | 0.57 | -0.57 | 0.10 | -0.21 | 0.00 | -0.18 | 0.00 | 0.29 | 0.25 | 0.14 | 0.19 | -0.57 | -0.19 | -0.31 | -0.05 | -0.08 | -0.21 | -0.17 | 0.05 | -0.18 | 0.27 | -0.13 | 0.00 | |
| 3 | 2 | 1 | -0.46 | 0.11 | 0.20 | 0.20 | -0.07 | 0.05 | -0.11 | -0.41 | -0.05 | 0.30 | -0.08 | -0.33 | -0.09 | 0.13 | -0.03 | 0.64 | 0.10 | 0.20 | -0.21 | -0.45 | 0.30 | -0.46 | -0.09 | 0.17 | -0.49 | -0.20 | 0.18 | -0.05 | -0.04 | 0.16 | -0.20 | 0.05 | -0.50 | -0.25 | -0.08 | -0.42 |

**- Table 5-2: Topmost Sub-Factor Correlations –**

| S | QF | SF | Factor | R | $r^2$ | S | QF | SF | Factor |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 8 | 1 | 24/7/365 Readiness | 0.71 | 50% | 1 | 1 | 1 | Time Behavior |
| 2 | 2 | 1 | Payment Systems Security | 0.71 | 50% | 1 | 1 | 3 | Page Generation Speed |
| 2 | 3 | 1 | Recoverability | 0.70 | 49% | 1 | 1 | 1 | Time Behavior |
| 1 | 4 | 4 | Changeability | 0.70 | 49% | 1 | 2 | 1 | Understandability |
| 2 | 6 | 2 | Correctness | 0.69 | 48% | 1 | 5 | 1 | Attractiveness |
| 2 | 7 | 2 | Farming capabilities | 0.68 | 46% | 2 | 2 | 6 | Privacy |
| 2 | 1 | 2 | Client Support | 0.67 | 45% | 1 | 1 | 1 | Time Behavior |
| 3 | 1 | 3 | Clarity | 0.66 | 44% | 1 | 3 | 5 | Links Visibility |
| 2 | 6 | 1 | Updated Content | 0.66 | 44% | 1 | 5 | 1 | Attractiveness |
| 3 | 2 | 1 | Interface Standards | 0.64 | 41% | 1 | 5 | 2 | Aesthetic Attributes |
| 2 | 1 | 4 | Suitability | 0.64 | 41% | 1 | 5 | 3 | Client Profile Identification |
| 1 | 3 | 2 | Minimal Path & Shortcut Facility | 0.62 | 38% | 1 | 1 | 1 | Time Behavior |
| 1 | 3 | 2 | Minimal Path & Shortcut Facility | 0.62 | 38% | 1 | 2 | 1 | Understandability |
| 2 | 1 | 1 | Accuracy | 0.61 | 37% | 1 | 2 | 3 | Interactivity |
| 2 | 8 | 4 | Browser version compatibility | 0.61 | 37% | 1 | 5 | 1 | Attractiveness |
| 1 | 5 | 3 | Client Profile Identification | 0.60 | 36% | 1 | 3 | 4 | Navigation Structure Taxonomy |
| 2 | 8 | 1 | 24/7/365 Readiness | 0.58 | 34% | 2 | 1 | 2 | Client Support |
| 2 | 2 | 3 | Site Authentication | 0.58 | 34% | 2 | 1 | 4 | Suitability |
| 2 | 2 | 3 | Site Authentication | 0.57 | 32% | 1 | 3 | 4 | Navigation Structure Taxonomy |
| 3 | 1 | 3 | Clarity | 0.57 | 32% | 1 | 4 | 1 | Stability |
| 1 | 5 | 1 | Attractiveness | 0.57 | 32% | 1 | 4 | 4 | Changeability |
| 2 | 8 | 1 | 24/7/365 Readiness | 0.57 | 32% | 2 | 2 | 6 | Privacy |
| 2 | 8 | 4 | Browser version compatibility | 0.57 | 32% | 2 | 6 | 1 | Updated Content |
| 2 | 1 | 1 | Accuracy | 0.56 | 31% | 1 | 2 | 6 | Response Time Uniformity |
| 2 | 4 | 1 | Data Integrity | 0.56 | 31% | 2 | 1 | 1 | Accuracy |
| 3 | 1 | 1 | Language Correctness | 0.55 | 30% | 1 | 1 | 3 | Page Generation Speed |

| S | QF | SF | Factor | R | $r^2$ | S | QF | SF | Factor |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 4 | 1 | Data Integrity | 0.55 | 30% | 1 | 5 | 1 | Attractiveness |
| 2 | 8 | 1 | 24/7/365 Readiness | 0.55 | 30% | 2 | 3 | 1 | Recoverability |
| 3 | 1 | 1 | Language Correctness | 0.55 | 30% | 1 | 1 | 1 | Time Behavior |
| 2 | 1 | 2 | Client Support | 0.54 | 29% | 1 | 2 | 13 | "Shopping Cart" Metaphor |
| 2 | 2 | 3 | Site Authentication | 0.54 | 29% | 1 | 5 | 3 | Client Profile Identification |
| 2 | 8 | 4 | Browser version compatibility | 0.54 | 29% | 2 | 4 | 1 | Data Integrity |
| 3 | 1 | 1 | Language Correctness | 0.54 | 29% | 2 | 6 | 4 | User Oriented |
| 1 | 4 | 1 | Stability | 0.53 | 28% | 1 | 3 | 4 | Navigation Structure Taxonomy |
| 2 | 8 | 1 | 24/7/365 Readiness | 0.53 | 28% | 1 | 3 | 2 | Minimal Path & Shortcut Facility |
| 2 | 4 | 1 | Data Integrity | 0.53 | 28% | 1 | 4 | 4 | Changeability |
| 1 | 4 | 1 | Stability | 0.52 | 27% | 1 | 2 | 11 | Help Availability |
| 2 | 6 | 2 | Correctness | 0.51 | 26% | 2 | 3 | 1 | Recoverability |
| 2 | 4 | 1 | Data Integrity | -0.51 | 26% | 1 | 1 | 3 | Page Generation Speed |
| 2 | 2 | 3 | Site Authentication | -0.52 | 27% | 1 | 2 | 3 | Interactivity |
| 2 | 6 | 4 | User Oriented | -0.53 | 28% | 1 | 3 | 4 | Navigation Structure Taxonomy |
| 1 | 2 | 11 | Help Availability | -0.54 | 29% | 1 | 2 | 6 | Response Time Uniformity |
| 2 | 6 | 1 | Updated Content | -0.54 | 29% | 1 | 5 | 2 | Aesthetic Attributes |
| 2 | 2 | 4 | Access Control | -0.54 | 29% | 2 | 2 | 1 | Payment Systems Security |
| 2 | 2 | 6 | Privacy | -0.55 | 30% | 1 | 1 | 3 | Page Generation Speed |
| 1 | 3 | 4 | Navigation Structure Taxonomy | -0.55 | 30% | 1 | 3 | 1 | Absence Of Navigation Errors |
| 1 | 2 | 6 | Response Time Uniformity | -0.56 | 31% | 1 | 1 | 3 | Page Generation Speed |
| 2 | 2 | 6 | Privacy | -0.56 | 31% | 1 | 3 | 4 | Navigation Structure Taxonomy |
| 2 | 8 | 5 | Cross Browser Support | -0.56 | 31% | 2 | 2 | 1 | Payment Systems Security |

| S | QF | SF | Factor | R | $r^2$ | S | QF | SF | Factor |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 3 | 1 | Recoverability | -0.57 | 32% | 1 | 1 | 3 | Page Generation Speed |
| 3 | 1 | 3 | Clarity | -0.57 | 32% | 1 | 4 | 4 | Changeability |
| 2 | 8 | 1 | 24/7/365 Readiness | -0.57 | 32% | 2 | 2 | 3 | Site Authentication |
| 3 | 1 | 3 | Clarity | -0.57 | 32% | 2 | 2 | 6 | Privacy |
| 1 | 5 | 3 | Client Profile Identification | -0.58 | 34% | 1 | 2 | 3 | Interactivity |
| 2 | 4 | 1 | Data Integrity | -0.59 | 35% | 1 | 2 | 1 | Help Availability |
| 2 | 8 | 5 | Cross Browser Support | -0.60 | 36% | 1 | 1 | 3 | Page Generation Speed |
| 1 | 4 | 1 | Stability | -0.63 | 40% | 1 | 2 | 1 | Understandability |
| 1 | 5 | 1 | Attractiveness | -0.63 | 40% | 1 | 2 | 1<br>1 | Help Availability |
| 2 | 2 | 3 | Site Authentication | -0.63 | 40% | 2 | 1 | 1 | Accuracy |
| 2 | 1 | 1 | Accuracy | -0.64 | 41% | 1 | 1 | 3 | Page Generation Speed |
| 2 | 1 | 4 | Suitability | -0.66 | 44% | 2 | 1 | 1 | Accuracy |
| 2 | 6 | 7 | Completeness | -0.68 | 46% | 1 | 2 | 4 | Learn-ability |
| 2 | 6 | 2 | Correctness | -0.68 | 46% | 2 | 1 | 4 | Suitability |
| 2 | 1 | 1 | Accuracy | -0.69 | 48% | 1 | 5 | 3 | Client Profile Identification |
| 2 | 8 | 4 | Browser version compatibility | -0.70 | 49% | 1 | 5 | 2 | Aesthetic Attributes |
| 2 | 8 | 1 | 24/7/365 Readiness | -0.75 | 56% | 1 | 3 | 4 | Navigation Structure Taxonomy |
| 1 | 4 | 4 | Changeability | -0.75 | 56% | 1 | 4 | 1 | Stability |
| 3 | 1 | 3 | Clarity | -0.77 | 59% | 1 | 2 | 1 | Understandability |
| 3 | 1 | 3 | Clarity | -0.79 | 62% | 1 | 3 | 2 | Minimal Path & Shortcut Facility |
| 1 | 4 | 4 | Changeability | -0.85 | 72% | 1 | 2 | 1<br>1 | Help Availability |

Where:

S: Represents quality objective number.

QF: Represents quality factor number.

SF: Represents quality sub-factor number.

While correlation coefficients are normally reported as r (a value between -1 and +1), squaring them makes it easier to understand. The square of the coefficient (or r squared) is equal to the proportion of the variation in one variable that is related to the variation in the other.

## 5.3 Cause and Effect Analysis

Correlation is not an indication of cause-and-effect relationships (StatSoft, 2005) where changes in one variable impacts and is the direct cause of changes in the correlated variable. Correlations merely indicate whether two variables are in unison in terms of movement. However, a harmony in movement in either the same direction or opposite (inverse) direction provides insight to the possibility of cause-and-effect relations.

The validation of this possibility was exercised by using a panel of experts to analyze the results of the correlation analysis to draw conclusions about which viable inter-dependencies to include in the assessment model. The selected panel members were the three topmost experienced professionals in E-commerce website development from the original participant group for the questionnaire, Basil Qubain (BQ), Osamah Telfah (OT) and Dawsar Zghoul (DZ). Appendix D provides a summary of their profiles.

The panel members were invited to a group discussion on what would be the relevant and important relationships among the sub-factors. Using Martin's (2003) approach, a stepwise model selection technique combining forward selection and backwards elimination was used. Every panel member was asked to select the best causal relationship, in their view, from the Topmost Correlations table, Table 5-2.

**- Table 5-3: Sequenced Selection of Sub-Factors -**

| Sub Factor | Sub Factor | Selector | Selection Sequence |
|---|---|---|---|
| Attractiveness | Help Availability | BQ | 1 |
| Minimal Path & Shortcut Facility | Time Behavior | DZ | 1 |
| Stability | Understandability | OT | 1 |
| Client Support | "Shopping Cart" Metaphor | BQ | 2 |
| Navigation Structure Taxonomy | Absence Of Navigation Errors | DZ | 2 |
| Site Authentication | Suitability | OT | 2 |
| Data Integrity | Changeability | BQ | 3 |
| Changeability | Help Availability | DZ | 3 |
| Recoverability | Time Behavior | OT | 3 |
| Clarity | Minimal Path & Shortcut Facility | BQ | 4 |
| 24/7/365 Readiness | Client Support | DZ | 4 |
| Correctness | Suitability | OT | 4 |
| Stability | Help Availability | BQ | 5 |
| Access Control | Payment Systems Security | DZ | 5 |
| Data Integrity | Accuracy | OT | 5 |
| Client Profile Identification | Interactivity | BQ | 6 |
| Response Time Uniformity | Page Generation Speed | DZ | 6 |
| Correctness | Attractiveness | OT | 6 |
| Suitability | Client Profile Identification | BQ | 7 |
| Recoverability | Page Generation Speed | DZ | 7 |
| Changeability | Understandability | OT | 7 |
| Clarity | Links Visibility | BQ | 8 |
| Data Integrity | Attractiveness | DZ | 8 |
| Clarity | Changeability | OT | 8 |
| Clarity | Understandability | BQ | 9 |
| Accuracy | Page Generation Speed | DZ | 9 |
| Updated Content | Attractiveness | BQ | 10 |
| Privacy | Navigation Structure Taxonomy | DZ | 10 |
| Correctness | Recoverability | BQ | 11 |
| User Oriented | Navigation Structure Taxonomy | DZ | 11 |
| Completeness | Learn-ability | DZ | 12 |
| Browser version compatibility | Updated Content | DZ | 13 |
| Minimal Path & Shortcut Facility | Understandability | DZ | 14 |
| Clarity | Stability | DZ | 15 |
| Accuracy | Response Time Uniformity | DZ | 16 |

**- Table 5-4: Sequence Discarding Sub-Factors Inter-relations –**

| Sub Factor | Sub Factor | Selector | Discard Sequence |
|---|---|---|---|
| Data Integrity | Changeability | BQ | -1 |
| Minimal Path & Shortcut Facility | Time Behavior | DZ | -1 |
| Changeability | Understandability | OT | -1 |
| Correctness | Recoverability | BQ | -2 |
| Navigation Structure Taxonomy | Absence Of Navigation Errors | DZ | -2 |
| Clarity | Changeability | OT | -2 |
| Suitability | Client Profile Identification | BQ | -3 |
| Changeability | Help Availability | DZ | -3 |
| Data Integrity | Accuracy | OT | -3 |
| Client Profile Identification | Interactivity | BQ | -4 |
| Accuracy | Page Generation Speed | DZ | -4 |
| Correctness | Attractiveness | OT | -4 |
| Stability | Help Availability | BQ | -5 |
| User Oriented | Navigation Structure Taxonomy | DZ | -5 |
| Correctness | Suitability | OT | -5 |
| Browser version compatibility | Updated Content | DZ | -6 |
| Accuracy | Response Time Uniformity | DZ | -7 |

**- Table 5-5: Finalized Selection of Sub-Factors Interdependencies -**

| Sub Factor | | Sub Factor |
|---|---|---|
| "Shopping Cart" Metaphor | Influences | Client Support |
| 24/7/365 Readiness | Influences | Client Support |
| Access Control | Influences | Payment Systems Security |
| Clarity | Influences | Understandability |
| Completeness | Influences | Learn-ability |
| Data Integrity | Influences | Attractiveness |
| Help Availability | Influences | Attractiveness |
| Links Visibility | Influences | Clarity |
| Minimal Path & Shortcut Facility | Influences | Clarity |
| Minimal Path & Shortcut Facility | Influences | Understandability |
| Navigation Structure Taxonomy | Influences | Privacy |
| Page Generation Speed | Influences | Response Time Uniformity |
| Page Generation Speed | Influences | Recoverability |
| Recoverability | Influences | Time Behavior |
| Site Authentication | Influences | Suitability |
| Stability | Influences | Clarity |
| Stability | Influences | Understandability |
| Updated Content | Influences | Attractiveness |

The selection was iterated one relationship at a time in a round-robin approach. Not knowing when a cessation would reach in this process, the members continued till their own point of satisfaction was reached and no further selection was added to their list. At that point a reversal elimination process started where each member was asked to return the least desired relation from their possession. The process continued in a round-robin fashion until the panel collectively retained 50% of the initially selected relations. The exercise was concluded at that point. Tables 5-3, 5-4 and 5-5 show the results of the selection process.

## 5.4 Factors Relationship Analysis

The same panel of three experts was invited to another exercise to perform interrelations analysis at the quality factors level. All the possible factors relations as shown in Table 5-6 were projected at a display wall. The panel members were asked to assess the relation "cells" and provide a score of 0 to 2 whereas "2" indicates the presence of strong causal relations and a "0" the lack of such a relationship. Table 5-6 lists possible relations among factors and the rating results received. The results are shown in Table 5-7. The most significant relationships were chosen to be those that achieved a rating of more than 3. This figure was chosen because:

- It is an intuitive value as it selects those relationships above the half-way point. A value of 4 or more could only be achieved by at least one of the experts rating the relation as being strong. Even if one expert thought the there was no relationship he would have been outvoted by the other two who believed the relationship to be strong.
- The three experts themselves agreed this should be the criterion to select the most significant factors relationships.
- This value produces a good balanced network that is neither too simple with too few factors relations or too complex with too many relations.

**- Table 5-6: Factors' Polled Relations -**

| | Usability | Efficiency | User-Friendliness | Navigability | Maintainability | Involvement Capacity | Conceptual Reliability | Functionality | Security | Reliability | Integrity | Trustworthiness | Content Adequacy | Scalability | Availability | Representation Reliability | Readability | Standards Conformance | Ease Of Manipulation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Usability** | | | | | | | | | | | | | | | | | | | |
| **Efficiency** | | | | | | | | | | | | | | | | | | | |
| **User Friendliness** | | 1 | | | | | | | | | | | | | | | | | |
| **Navigability** | | 3 | 3 | | | | | | | | | | | | | | | | |
| **Maintainability** | | 1 | 0 | 0 | | | | | | | | | | | | | | | |
| **Involvement Capacity** | | 0 | **5** | 2 | 0 | | | | | | | | | | | | | | |
| **Conceptual Reliability** | | | | | | | | | | | | | | | | | | | |
| **Functionality** | | 3 | 3 | 3 | 2 | 0 | | | | | | | | | | | | | |
| **Security** | | 0 | 0 | 0 | **4** | 0 | | 3 | | | | | | | | | | | |
| **Reliability** | | 0 | 0 | 0 | **4** | 0 | | 3 | **5** | | | | | | | | | | |
| **Integrity** | | 0 | 0 | 0 | **4** | 0 | | **4** | **6** | **6** | | | | | | | | | |
| **Trustworthiness** | | 0 | 0 | 0 | 0 | 0 | | **3** | **6** | **6** | **6** | | | | | | | | |
| **Content Adequacy** | | **5** | **4** | 1 | 2 | 0 | | **4** | 0 | 0 | 0 | **5** | | | | | | | |
| **Scalability** | | 3 | 0 | 0 | **5** | 3 | | 0 | 0 | 3 | 0 | 0 | 0 | | | | | | |
| **Availability** | | 0 | 0 | 0 | 0 | 0 | | 3 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | |
| **Representation Reliability** | | | | | | | | | | | | | | | | | | | |
| **Readability** | | 3 | **5** | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| **Standards Conformance** | | 0 | 0 | 0 | **5** | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | | |
| **Ease Of Manipulation** | | 0 | 0 | 0 | 0 | 0 | | **4** | 0 | 0 | 0 | 0 | 0 | 3 | 1 | | 0 | 0 | |

**- Table 5-7: Factor Relations' Polling Results –**

| | |
|---|---|
| Highest and Highest Possible Score | 6.0 |
| Lowest and Lowest Possible Score | 0.0 |
| Total Score | 150 |
| Total Count | 120 |
| Average (Mean) | 1.25 |
| Median | 0.0 |
| Threshold | 4.0 |

Table 5-8 shows the resultant relations inferred.

**- Table 5-8: Finalized Selection of Factors' Interdependencies -**

| **Sub Factor** | | **Sub Factor** |
|---|---|---|
| Involvement Capacity | Influences | User-Friendliness |
| Security | Influences | Maintainability |
| Reliability | Influences | Maintainability |
| Reliability | Influences | Security |
| Integrity | Influences | Security |
| Integrity | Influences | Reliability |
| Integrity | Influences | Maintainability |
| Integrity | Influences | Functionality |
| Trustworthiness | Influences | Security |
| Trustworthiness | Influences | Reliability |
| Trustworthiness | Influences | Integrity |
| Content Adequacy | Influences | Efficiency |
| Content Adequacy | Influences | Integrity |
| Content Adequacy | Influences | User-Friendliness |
| Content Adequacy | Influences | Functionality |
| Scalability | Influences | Maintainability |
| Readability | Influences | User-Friendliness |
| Standards Conformance | Influences | Maintainability |
| Ease Of Manipulation | Influences | Functionality |

## 5.5 Conclusion

This chapter has finalized the causal interrelations among the identified quality factors and sub-factors in preparation for setting up the quality assessment model. The research in this chapter set the stage for a Bayesian Belief Network for assessing the probability of an E-commerce website quality as explained in the following chapter.

# Chapter 6 – Creating a Bayesian Belief Network

## 6.1 Introduction

This chapter describes the development of the Bayesian Belief Network, called EWQPNet (E-commerce Website Quality Prediction Network) that facilitates assessing the quality of E-commerce websites. The chapter first provides an overview of Bayesian Belief Networks, and then continues with the steps and processes taken to produce the target model of this thesis.

According to Jensen (2002), Bayesian Belief Networks are often called decision support systems, where the factors affecting a decision, are modeled in terms of their elements and inter-dependencies. The aims of this thesis, stated in Chapter One, can be regarded as just that – to create a decision support system to aid in the assessment and decision making with regard to the quality assessment of E-commerce websites. The challenge is to identify the elements required to build the appropriate Bayesian Belief Network.

## 6.2 Bayesian Belief Networks

A Bayesian Belief Network is a graph composed of variables (also known as nodes) connected by arrows (also known as arcs and edges) indicating an influencing relationship between the connected nodes. Each node has a fixed number of states, and a table of probabilities indicating its relationship with another node. Edges reflect cause-effect relationships within the domain. These effects are normally not completely deterministic. The strength of an effect is modeled as a probability, according to Jensen (2002). Mathematically, and according to Jensen (2002), a Bayesian Belief Network is a probabilistic network that helps model and measures valuations and assessments.

A Bayesian network is used to model a domain containing uncertainty in some manner. The technology with which a system handles uncertain information forms is a crucial component of its overall performance. The technologies for modeling uncertainty

include Bayesian probability, Dempster-Shafer theory, Fuzzy Logic, and Certainty Factor. Bayesian probability uses probability theory to manage uncertainty by explicitly representing the conditional dependencies between the different knowledge components. It offers a language and calculus for reasoning about the beliefs in the presence of uncertainty. Prior probabilities are thus updated, after new events are observed to produce posterior probabilities. By repeating this process, the implications of multiple source of evidence can be calculated in a consistent way, and the uncertainties are exploited explicitly to reach an objective conclusion. A Bayesian Belief Network provides an intuitive graphical visualization of the knowledge including the interactions among the various sources of uncertainty.

According to Niedermayer (1998), Bayesian Networks have become an important tool for research and applications. They are useful for both inferential exploration of previously undetermined relationships among variables and for descriptions of the relationships discovered. A Bayesian Network can be viewed as a "story" (Friedman, 1998) of causes that lead to the effects that influenced the outcome of the end-node in the network.

Producing a Bayesian Belief Network is a two stage approach (Friedman, 1998). Qualitative analysis is the first stage, followed by quantitative analysis.

## 6.3 Qualitative Analysis

Qualitative analysis entails representing the Bayesian Belief Networks in the form of an acyclic graph consisting of nodes and directed arcs. The quality factors map to the nodes and their inter-relationships are represented by the arcs.

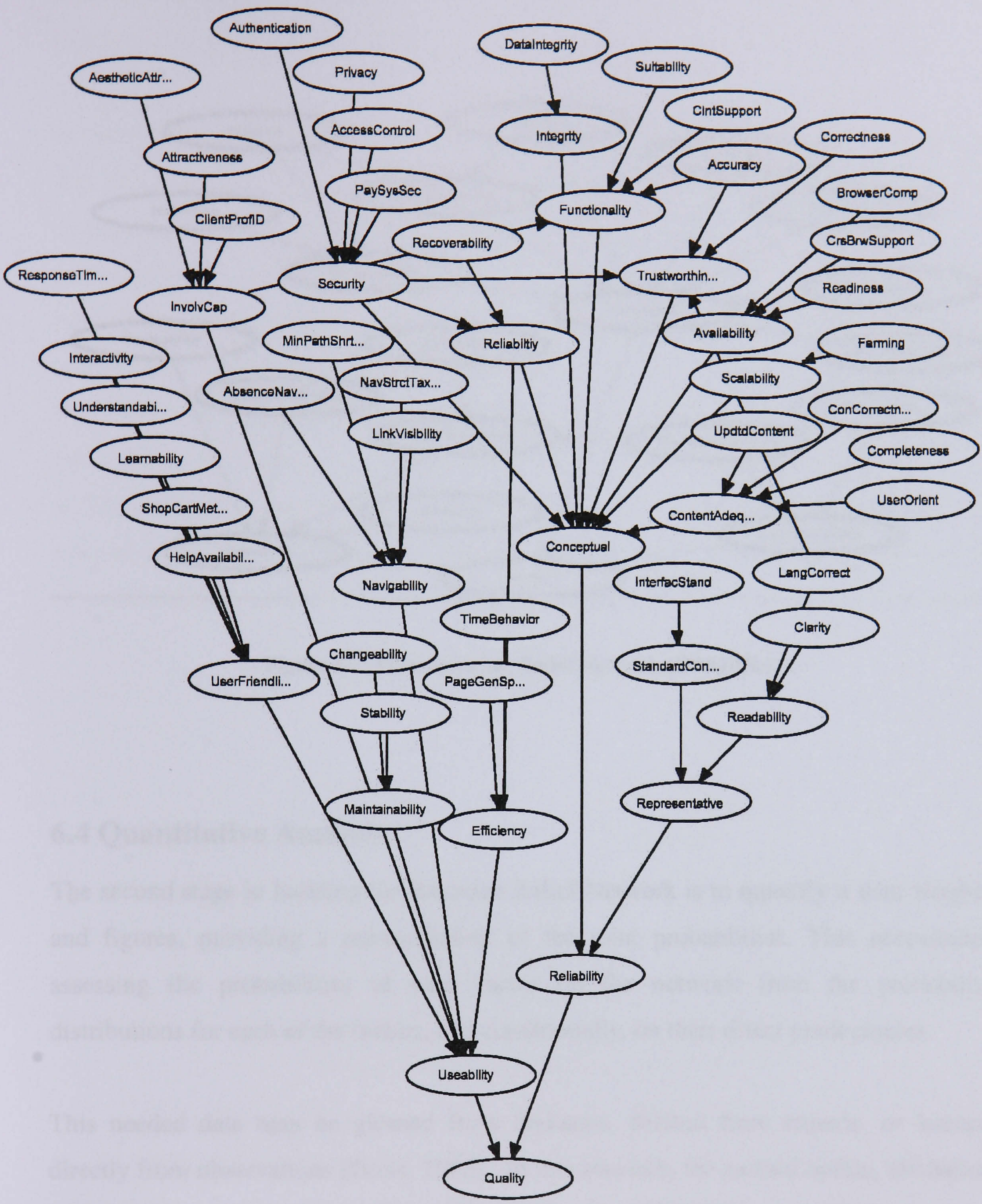
Identifying the factors, sub-factors and their inter-relationships was completed in the previous chapters. Figure 6-1 illustrates the efforts in a graphical representation.

The target Bayesian Belief Network was built using the tool, Hugin Expert A/S (Hugin, 2006). Only quality factors and sub-factors having multiple inter-relationships with other factors are required in the network. Sub-factors with single direct feed into a

quality factor were removed from the model since their influence is already factored-in the probability of their factor. Furthermore, applying the concepts of divorcing and d-separation and arc representation (Yu and Johnson, 2002) reduced the complexity of the network to a level of practical effectiveness. These concepts are explained in Appendix K. The resultant Bayesian Belief Network is shown in Figure 6.2.

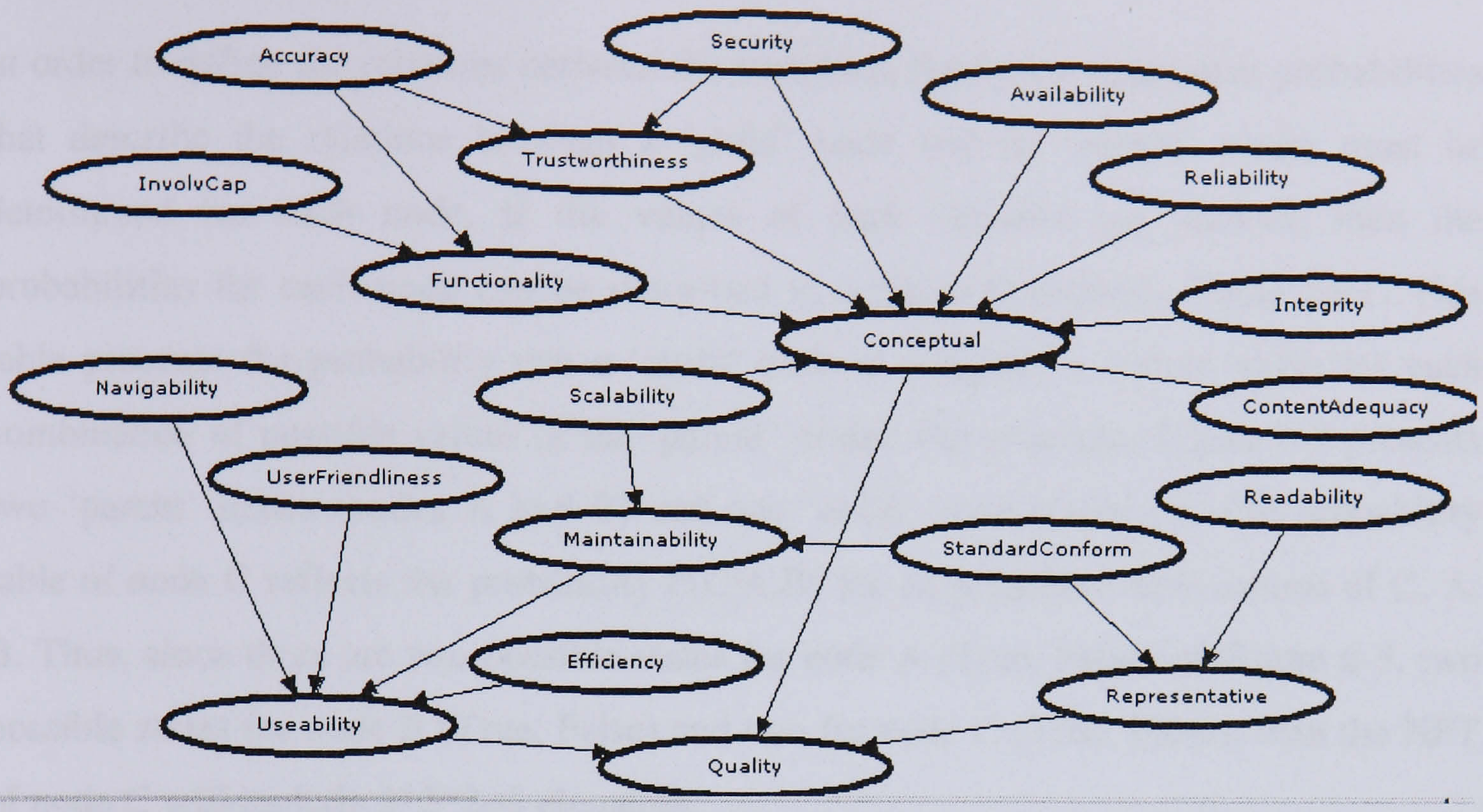
As Figure 6.2 illustrates, there are three types of nodes in the EWQPNet:

1. Target nodes, the nodes about which the objective of the network is to make an assessment. In this network, Quality is the target node. This assessment is expressed with a quantifiable target variable for quality.
2. Intermediate nodes, which are nodes for which there is limited information, or only "beliefs". The associated variables are the hidden variables. In this network, Functionality, Trustworthiness, Maintainability, Usability, Conceptual Reliability and Representative Reliability are intermediate nodes.
3. Observable nodes, which can be directly observed with associated observable variables that are measurable or quantifiable, even though this measurement may not be exact and objective. All remaining nodes in the network are observable nodes that can be quantified, based on the findings gathered from their sub-factors.




**- Figure 6-1 -**

**- Network Representations of Quality Causes (Factors & Sub Factors) in E-commerce Websites -**




**- Figure 6-2: Final Bayesian Belief Network (EWQPNet) -**

## 6.4 Quantitative Analysis

The second stage in building the Bayesian Belief Network is to quantify it with weights and figures, providing a representation of the joint probabilities. This necessitates assessing the probabilities of each factor on the network from the probability distributions for each of the factors, and conditionally, on their direct predecessors.

This needed data may be gleaned from literature, elicited from experts, or learned directly from observations (Grois, 1995). In this research, the second option, elicitation from experts, was used for building EWQPNet. Once EWQPNet was finalized, it was tested against actual collected observations of selected case studies to justify its validity.

The expert panel, used previously and described in the previous chapter, was asked again to help derive an effective mechanism for quantifying the relations. Unanimously, the three experts agreed to limit quantifiable assessment of each variable to 3 values: (+1) means the variable has positive influence within the website, (-1)

indicates an absence of evidence of the variable's attribute in the website and (0) indicates neutrality in the decision about the variable's influence within the website.

In order to define the relations between the variables, firstly the dependent probabilities that describe the relations between a 'child' node and its 'parent' nodes must be determined for each node. If the values of each variable are distinct, then the probabilities for each node can be described in a Node Probability Table NPT. This table presents the probability that a 'child' node is assigned a certain value for each combination of possible values of the 'parent' nodes. For example, Figure 6-3 presents two 'parent' nodes (nodes A and B) and one 'child' node (node C). The probability table of node C reflects the probability P(C|A,B) for all possible combinations of C, A, B. Thus, since there are two possible states for node A (True, False) of Figure 6-3, two possible states for node B (True, False) and two for node C (True, False), then the NPT of node C will include 2*2*2=8 elements.

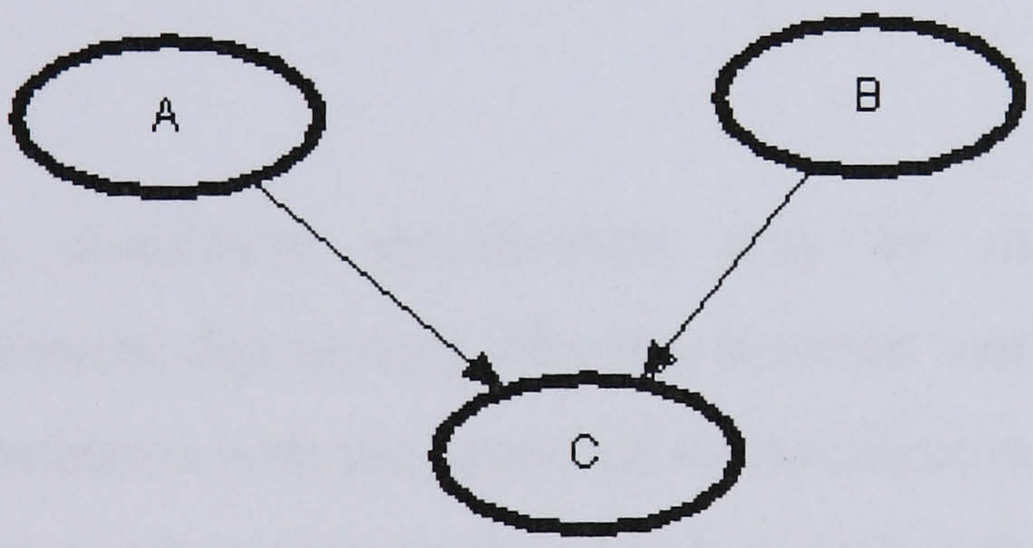



**Figure 6-3: BBN: qualitative specification**

A conditional probability is associated with each of these states for each combination of states of their direct predecessors (see Figure 6-4 for an example). A complete listing of the conditional probability tables is found in Appendix E.

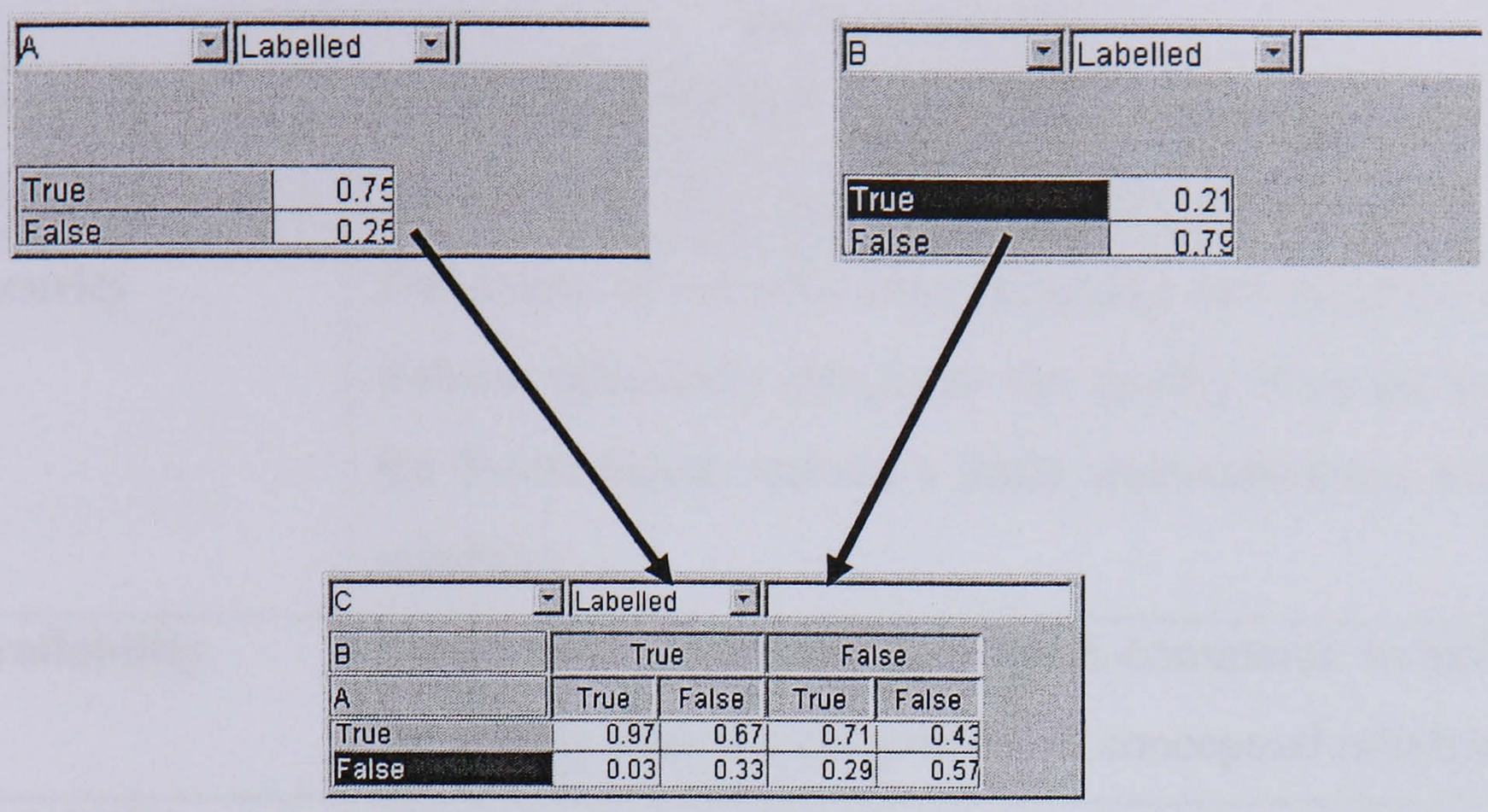



**Figure 6-4: A BBN: quantitative specification**

The network can be relied upon to deliver mathematical correct probabilities given correct qualitative and quantitative specifications of the BBN. If a BBN doesn't give correct output, it may be an indication that the probabilistic information in the network is wrong or that there is something wrong with the qualitative specification of the network.

Problems with the qualitative specification may be missing variables (over-simplification) or incorrect dependency relations between variables (missing arrows or too many arrows). Problems with the quantitative specification are caused by incorrect conditional probabilities. Most of these errors only manifest themselves in very specific situations (Yu and Johnson, 2002). Therefore, a network has to be tested to make sure the output of it is correct under all circumstances and this is done for EWQPNet in the next chapters.

## 6.5 Insight on Nodes Influences

The resultant model produced is shown in Figure 6-2. Table 6-1 lists how the factors acting as the Bayesian Belief Network nodes influence the EWQPNet from a business domain perspective.

- **Table 6-1: How the factors acting as BBN nodes influence the EWQPNet from a business domain perspective. –**

| Observable Nodes | Influence Described |
|---|---|
| **Security** | The extent of security when accessing and using the E-commerce website ultimately influences the quality from the perspective of the E-commerce website's basic trustworthiness and conceptual reliability. |
| **Availability** | The extent of availability of the E-commerce website influences the quality from the perspective of conceptual reliability. |
| **Scalability** | The extent of scalability of the E-commerce website to consistently match growing demand on its services influences the quality from the perspective of the E-commerce website's basic Maintainability and conceptual reliability. |
| **Integrity** | The extent that stored and processed data can be relied on influences the website quality from the perspective of the conceptual reliability. |
| **Content Adequacy** | Ensuring the right amount and appropriate type of information is presented within context influences the quality from the perspective of the conceptual reliability. |
| **Trustworthiness** | The extent that the user can trust the consistency in performance, data and processing of data influences the quality from the perspective of the overall conceptual reliability |
| **Accuracy** | The correctness in performing calculations and measurements influences the quality from the perspective of the functionality of operations and the overall conceptual reliability. |
| **Involved Capacity** | The measure of which the E-commerce website can adapt to each user's individuality influences the quality from the perspective of the functionality of operations and the overall conceptual reliability. |
| **Maintainability** | The ease of adapting and changing the underlying software of the E-commerce website to meet user changes and growing requirements influences the quality from the perspective of |

| Observable Nodes | Influence Described |
|---|---|
| | usability. |
| **User-Friendliness** | The ease of matching users' expectations and the minimization of users' efforts to achieve objectives when using the E-commerce website influences the quality from the perspective of usability. |
| **Navigability** | The ease of traversing the E-commerce website pages influences the quality from the perspective of usability. |
| **Reliability** | The fundamental reliability of basic operations and execution of functions influences the quality from the perspective of the overall conceptual reliability. |
| **Efficiency** | The reduction in time consumed to achieve goals and objectives by the user when using the E-commerce website influences the quality from the perspective of the overall conceptual reliability. |
| **Readability** | The ease of reading and comprehending the content of the E-commerce website influences the quality from the perspective of the overall representative reliability. |
| **Standard Conformance** | The consistency of implementation of the E-commerce website and its adherence to the standards influences the quality from the perspective of the E-commerce website's basic maintainability and overall representative reliability. |
| **Functionality** | The level of richness and practicality of the functional features the E-commerce website offers influences the quality from the perspective of the overall conceptual reliability. |

## 6.6 Conclusion

This chapter has described the development of the Bayesian Belief Network, EWQPNet, based on qualitative and quantitative analysis and fed into a modelling and a simulation tool, Hugin Expert A/S. This Bayesian network model is analysed from the perspective of the modelling tool and, in later chapters, is put through an exercise to validate the viability of the model created.

# Chapter 7 – Analysis of the Model

## 7.1 Introduction

This chapter analyzes the Bayesian Belief Network developed in the previous chapter in terms of its functionality, use and viability. This step is a prelude to putting the model to use by applying it to case studies of E-commerce websites.

According to Yu and Johnson (2002), a Bayesian Belief Network is based on probability and provides a sound mathematical basis for reasoning under uncertainty since:

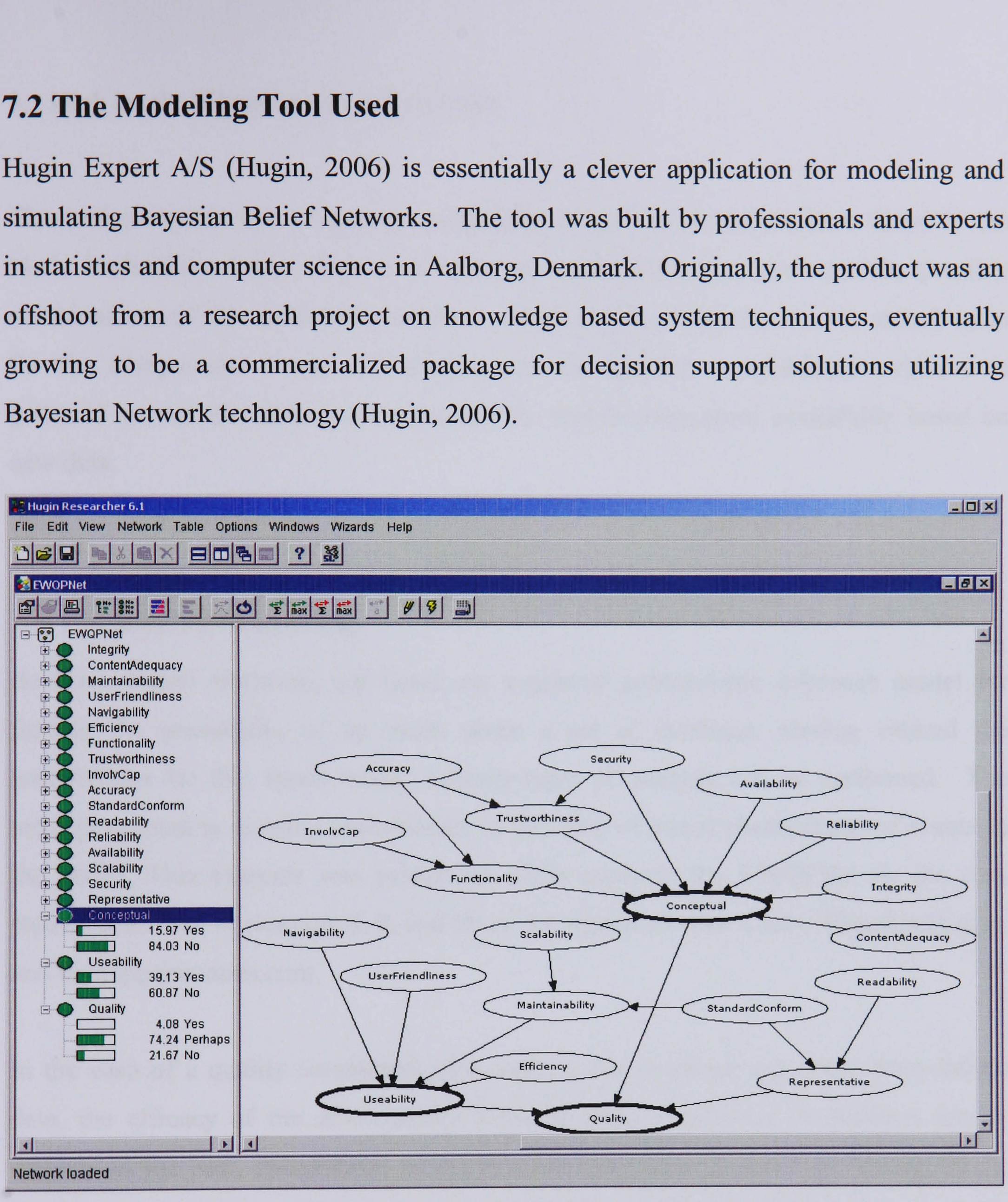
- It allows the user to envisage multiple possible states of the world with different degrees of likelihood.
- It allows the user to incorporate multiple pieces of evidence obtained from various sensors in a coherent way.

This allows the user to make optimal decisions that lead to the maximum expected utility.

The key feature of Bayesian Belief Networks is that they enable us to model and reason about uncertainty. The developed EWQPNet model involved setting the key factors that influence qualities of E-commerce websites, their inter-relationships and the probability distributions for each quality factor within the network. The expert panel was solicited to validate assumptions about the inferential relationship among the factors and sub-factors (nodes) enabling a practical probability framework to be developed. Once this model is completed, it can be deployed to assess quality by computing the probabilities of the component variables from the given evidence.

## 7.2 The Modeling Tool Used

Hugin Expert A/S (Hugin, 2006) is essentially a clever application for modeling and simulating Bayesian Belief Networks. The tool was built by professionals and experts in statistics and computer science in Aalborg, Denmark. Originally, the product was an offshoot from a research project on knowledge based system techniques, eventually growing to be a commercialized package for decision support solutions utilizing Bayesian Network technology (Hugin, 2006).




**- Figure 7-1: Screen shot to Hugin software with model loaded –**

Figure 7.1 is a screen shot of the model as it was loaded and run in the system. The right pane in the figure displays the graphical representation of the model. The left pane displays the node list, with each node expanded to show its state.

The model describes three types of key factors (Variables) to achieve quality:

1. High level of Usability attributes
2. High level of Conceptual Reliability

3. High level of Representative Reliability

The tool computes the component availability based on the information found in the Node Probability Table. This is a table for each node that holds all the possible combinations of this availability number, which can be interpreted as the initial value for the component. These availabilities can be updated as additional evidence is gathered so that the tool can re-compute the overall component availability based on new data.

## 7.3 Parametric Learning

Bayesian Belief Networks are based on a general probabilistic inference model for finding the probability of an event given a set of evidence. Having entered the probabilities for this thesis model, various types of analysis can be performed. The most prominent is revising probabilities in the light of actual observations of events in the nodes. This exercise was performed while applying the EWQPNet on the case studies described in chapters 8, 9, and 10 on the websites Softact.com, RingaDong.com, and Iconopportunities.com.

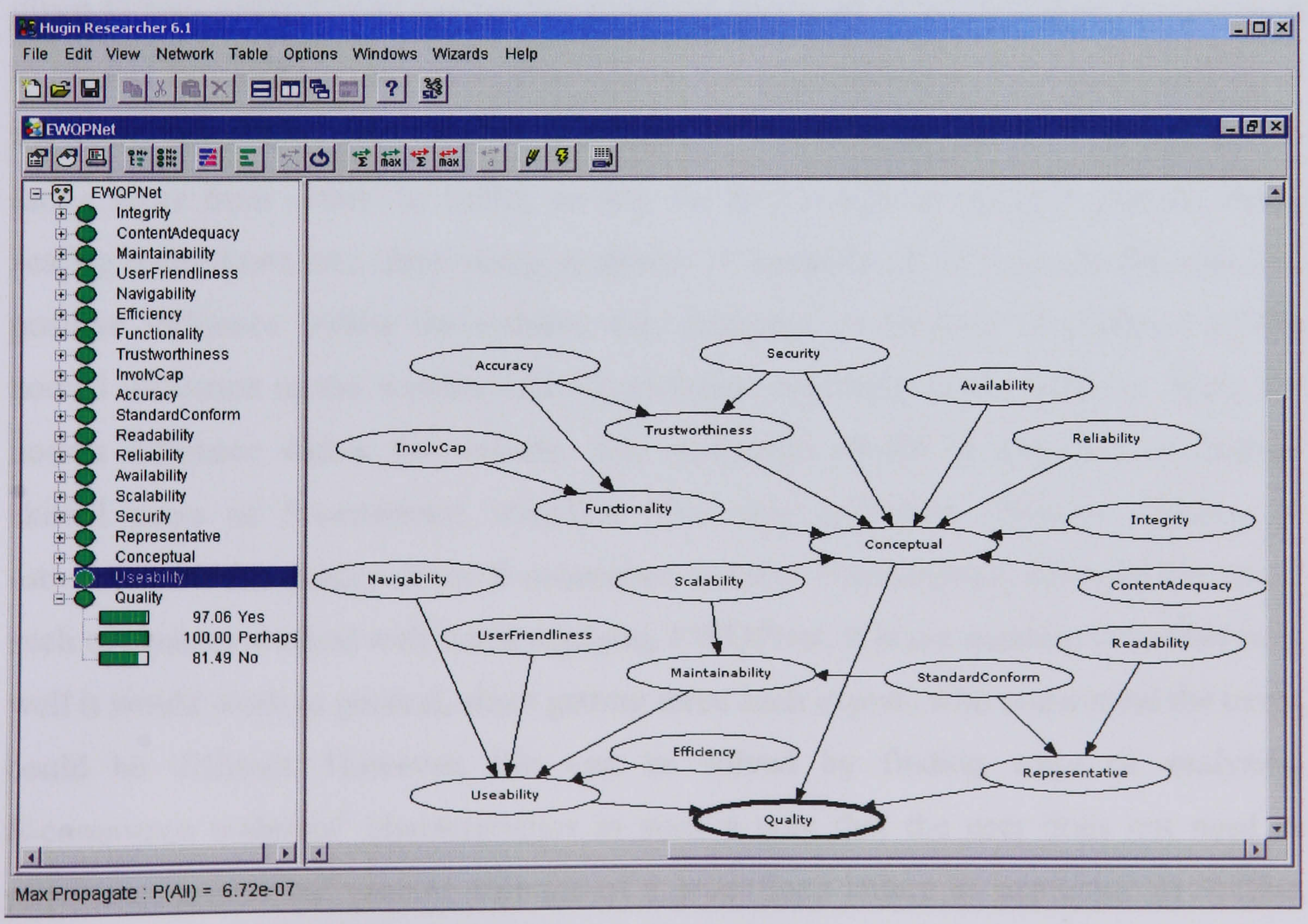
In the case of a quality assessment of a website, the evidence can come from failure data, the efficacy of the development methods used, experience in building similar systems in the past, competence of the development team, architectural details of the design, etc. The more case-specific evidence that was gathered, the more accurately the EWQPNet was able to predict the quality level for the E-commerce web site and to discover the factors that determined the calculated quality level.

The determination of the conditional probability, given the evidence, is called the "query" (Yu and Johnson, 2002). Entering evidence to update the probabilities is called "propagation" (Yu and Johnson, 2002).

In the Hugin tool, the Node List is used to enter evidence and retrieve beliefs. By doing this, the model helps in the forward-looking assessment of the probability that a website

will be considered to be a quality site with a considerable level of confidence, and it traces backwards, looking for causes for the quality level the website is currently at.

Further, the Hugin tool provides two types of propagation: Sum and Max. The Sum normal propagation is the most commonly used propagation method where it updates all probabilities, distribution functions, and expected utilities of the discrete chance nodes respectively, according to entered evidence. In the Max normal propagation, the tool searches for states in the network belonging to the most probable configuration of all nodes in the network. If a state of a node belongs to the most probable configuration it is given the value 100. All other states are given the relative value of the probability of the most probable configuration they are found in comparison with the most probable configuration. When running this propagation on the default settings of the network, the results yielded a 100% "Perhaps of Quality". Figure 7.2 is a screen shot of the model run under Max propagation.




**- Figure 7-2: Screen shot of Hugin software with the model run under Max propagation –**

## 7.4 The EWQPNet Application Process

EWQPNet can be used both forwards and backwards. Backward use of EWQPNet provides assessments regarding the child nodes (e.g. nodes of E-commerce characteristics) when the value of a parent node (e.g. node of 'Conceptual Reliability' characteristic) is defined.

In the forward use, the values of each node are the inputs that are gathered from the evaluators' answers. These answers have only three possible states: 'positive', 'negative' and 'neutral'. In this way, EWQPNet estimates the website's quality providing the probabilities for the possible states of the nodes that represent the quality characteristics and the overall quality of the website. This process, which is also represented in Figure 7-3, is illustrated in detail in the following paragraphs.

In the first step of the process, the evaluation sheet of the E-commerce website will be given to two evaluators to answer the proposed questions. Two evaluators are assigned to answer the questions to avoid errors due to some carelessness or misunderstanding of the questions. The sheet is simply a questionnaire that gives the evaluator the option of a rating score from -100% to 100%, so that the third evaluator can then process these, scaling them down into three states as shown in appendix G: (+1) means the node has positive influence within the website, (-1) indicates an absence of evidence of the node's influence in the website and (0) indicates neutrality in the decision about the node's influence within the website. The evaluators should be experienced, highly-skilled users of E-commerce websites. This may guarantee objective judging or estimating for the quality of the E-commerce website. Nevertheless, although the use of such evaluators worked well while applying EWQPNet, it is not possible to predict how well it would work in general, since getting three such experts who understand the terms could be difficult. However, this can be solved by finding ways of analyzing E-commerce websites' characteristics in such a way that the user does not need to provide estimates but precise answers of a predefined nature as explained in Section 11.5.

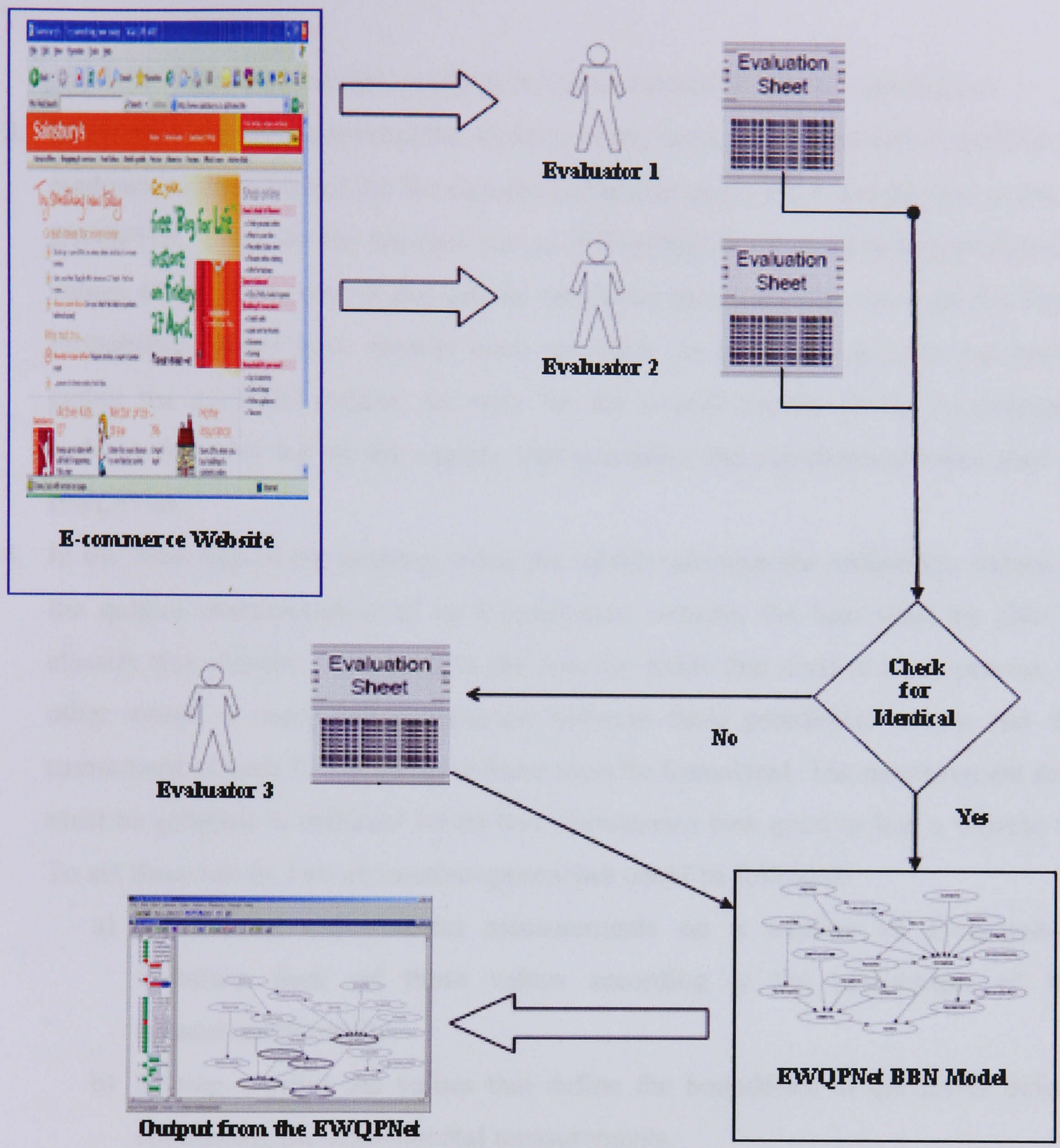



**Figure 7-3: EWQPNet Application Process**

2. In the second step of the process, a third evaluator checks whether the evaluators gave the same evaluation. The third evaluator acts as a judge after reviewing and analyzing the answers of the previous two evaluators. His role is as follows:
    - As the two evaluators may answer the questions differently, they may not be able to reach a stage of complete agreement unless the judge gives his point of view.
    - If there is any discrepancy between the evaluators, he will aid in solving the individual differences to reach a stage of complete objective

evaluation.

- He must conduct analysis on items warranting further elaboration.

3. In the next step of the process the answers of the sheet are entered into EWQPNet as evidence to the nodes of the E-commerce characteristics, which are the leaf nodes of EWQPNet. Thus, by the forward use of EWQPNet, the corresponding probability values of all the parent nodes can be estimated automatically, since all the Node Probability Tables have already been specified. In this way, the user can easily gather the provided results, not only for the overall quality of the E-commerce website, but also for all the quality characteristics and sub-characteristics used in EWQPNet.
4. In the final step of the process, when the model estimates the probability values of the quality characteristics of an E-commerce website, the user must be able to classify this website and ascertain the specific fields that need to be improved. In other words, a comparative approach between these probability values and the assessment of each E-commerce website must be formulated. The measurement data must be grouped in different levels that characterize how good or bad a website is. To set these levels, two alternative approaches could be followed:
   a) Conducting experimental measurements on a number of E-commerce websites, then set these values according to the percentages of the measurement results.
   b) Setting a priori the values that define the boundaries of the levels before conducting the experimental measurements.

These levels can be set as shown in the Table 7-2 below based on the second point mentioned above.

**- Table 7-1: Scale Levels -**

| Scale Levels | |
|---|---|
| Good | x>=0.80 |
| Average | 0.65= < x < 0.80 |
| Poor | x<0.65 |

Where x, represent the probability values of the quality factors.

## 7.5 EWQPNet Uses

It is important to realize that any model is a simplification of reality. Therefore, the output of a BBN is also a simplification of reality. The design of EWQPNet was aimed to get useful output to aid developers to determine the quality of a website, and the factor elements that caused the website to reach its current state. The benefit and application expected from EWQPNet is to support the decision making process regarding the next developmental steps appropriate for the website.

The output of a BBN consists of prior probabilities for each state in each variable (quality factor). The idea is that a user enters probabilities for some of the variables, for instance P(Content Adequacy)=1.0. This information is then used together with the quantitative specification of the network to re-calculate all the other probabilities. Furthermore, probabilities other than 1.0 can be entered, so the user is able to enter information that is uncertain. Though the output of the network in itself is quantitative, the user can use this output to make qualitative statements based on the quantitative output.

Sometimes the output of a BBN contradicts what is expected from the given input. Contradicting output can always be traced back to either errors in the BBN, lack of input for the BBN, unrealistic input, confusion about terminology in the BBN or a mistake by the user.

In other cases the BBN will give neutral output i.e. the probabilities for each state in a certain variable are more or less equal. The cause is attributed to the lack of information in the BBN to favor any of the states or that the variable has no incoming arrows.

If the output is correct, the structure of the BBN can be used to find a proper argument for the probabilities of the variables. If, for instance, the BBN gives "unsatisfactory" quality for the website due to usability issues, the variable predecessors of Usability in the BBN and their predecessors can be examined to find out why the usability is at a

low level. This analysis may also suggest solutions for problems. For example, a low level of Usability can be traced back to Navigability and Efficiency - any solutions for the low level of Usability will have to address the low levels of Navigability and Efficiency.

Though the ways in which a BBN can be used is unlimited, four types of usage strategies for EWQPNet have been identified:

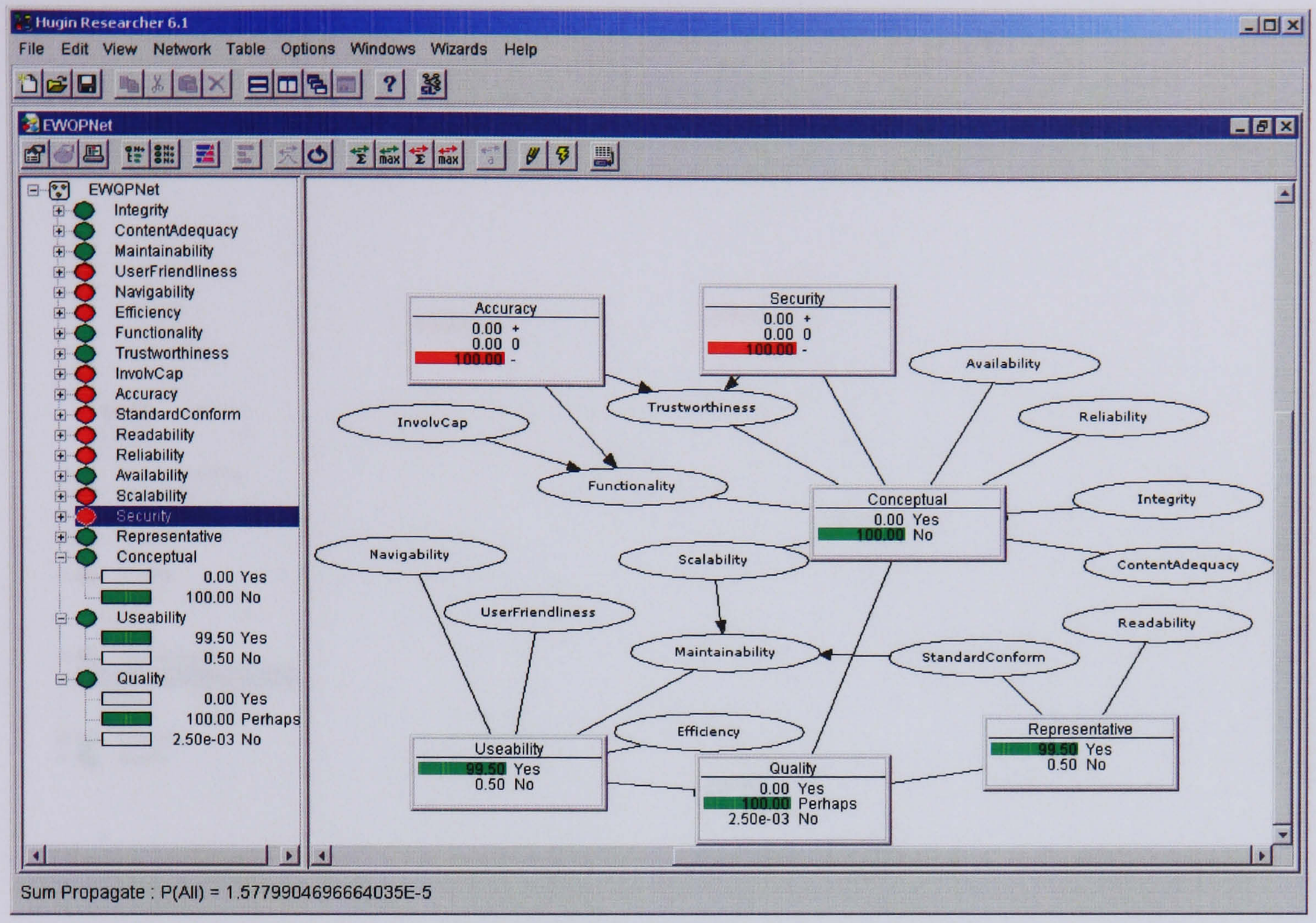
### 7.5.1 Quality attributes prediction

In this type of use, as much information as possible is collected and put into EWQPNet. EWQPNet can calculate all the variables that have not been entered. This can give an impression of the quality level and reveal problems, if any, in the website. For example, given that the user has the information in Table 7.2 about some observable nodes, the user then can plug this information into EWQPNet to predict the quality level and reveal problems, if any, in the website.

**- Table 7-2: An example of observable node assessment -**

| Nodes | Assessment |
|---|---|
| User-Friendliness | Positive |
| Navigability | Positive |
| Efficiency | Positive |
| Involved Capacity | Neutral |
| Scalability | Positive |
| Reliability | Positive |
| Security | Negative |
| Accuracy | Negative |
| Readability | Positive |
| Standard Conformance | Positive |

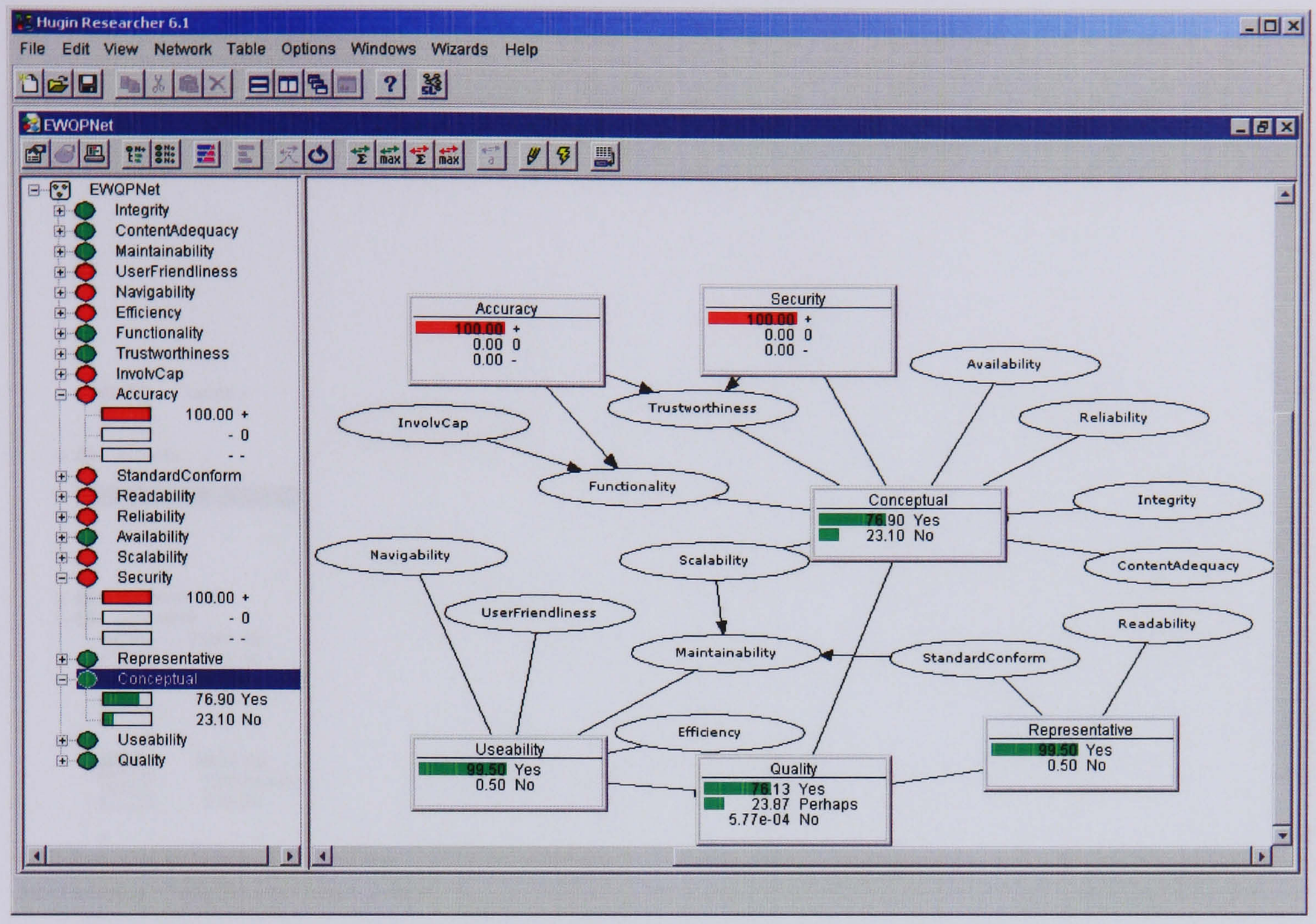
According to EWQPNet, the results provided a forecast, with a 100% probability that the site would be lacking of Conceptual Reliability, giving a 99.5% high level of Usability and an "unsatisfactory" Quality for the website.




**- Figure 7-4: Using EWQPNet as a prediction tool -**

### 7.5.2 Diagnostic Use

One of the possible uses of EWQPNet is as a diagnostic tool. When using EWQPNet in this way, the user is trying to find possible causes for problems. For example, Figure 7-4 shows that the Conceptual Reliability is at a low level. Using EWQPNet as a diagnosing tool, the user can find that Accuracy and Security are the causes of this problem – by moving Accuracy and Security to a positive state this will promote the Conceptual Reliability to a positive state as highlighted in Figure 7.5.

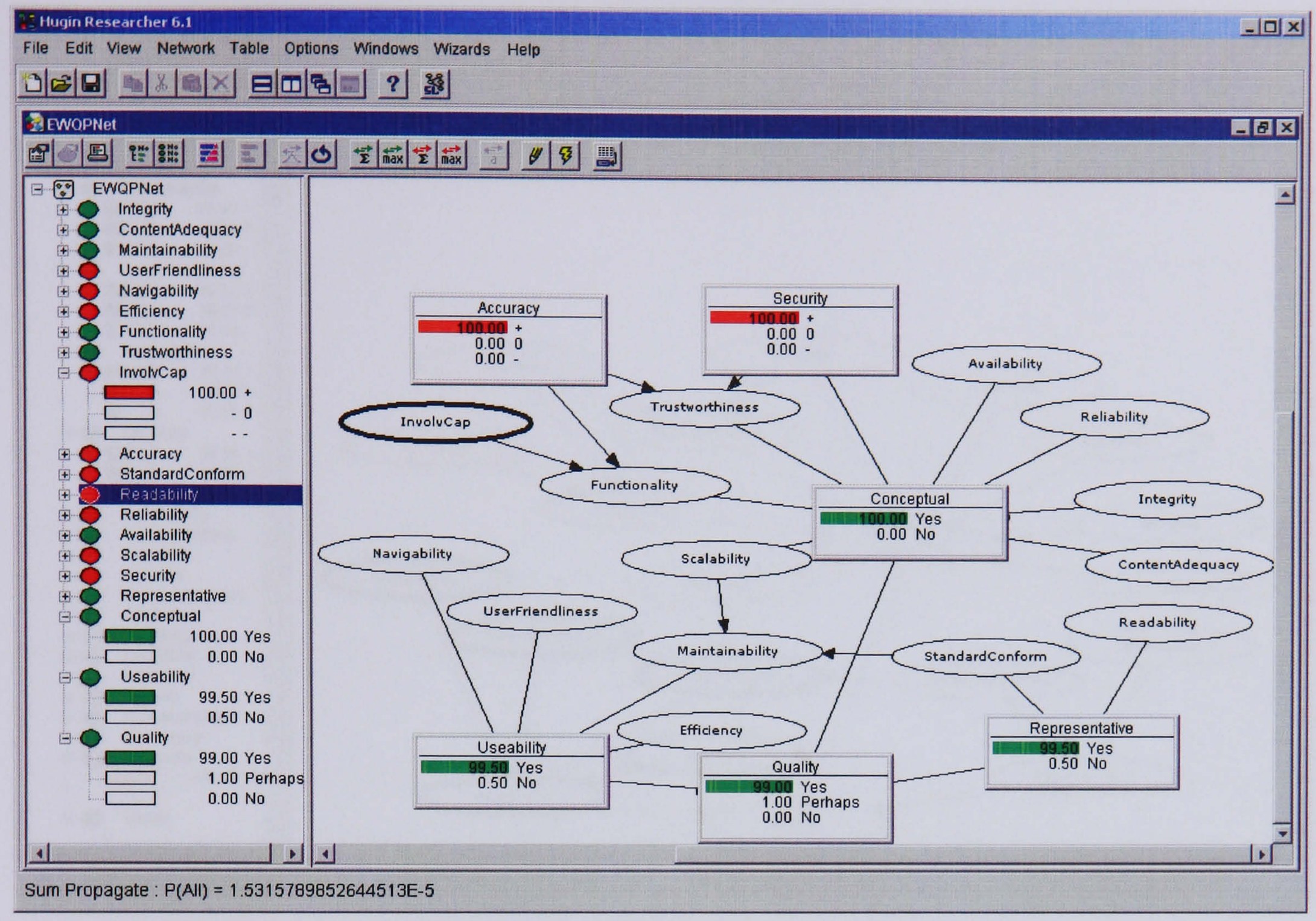



**- Figure 7-5: Using EWQPNet as a diagnostic tool –**

### 7.5.3 Impact Analysis

Another way to use EWQPNet is to evaluate the consequences of the future changes in the observable nodes on the intermediate nodes as well as the target node (Quality). To do so, the potential future states that the observable nodes are entered. The EWQPNet then calculates the intermediate nodes as well as the target node (Quality) that is likely for such changes on the observable node. In Figure 7-5, the user can investigate what will happen if the state of Involved Capacity changed from Neutral to Positive as shown in Figure 7.6.

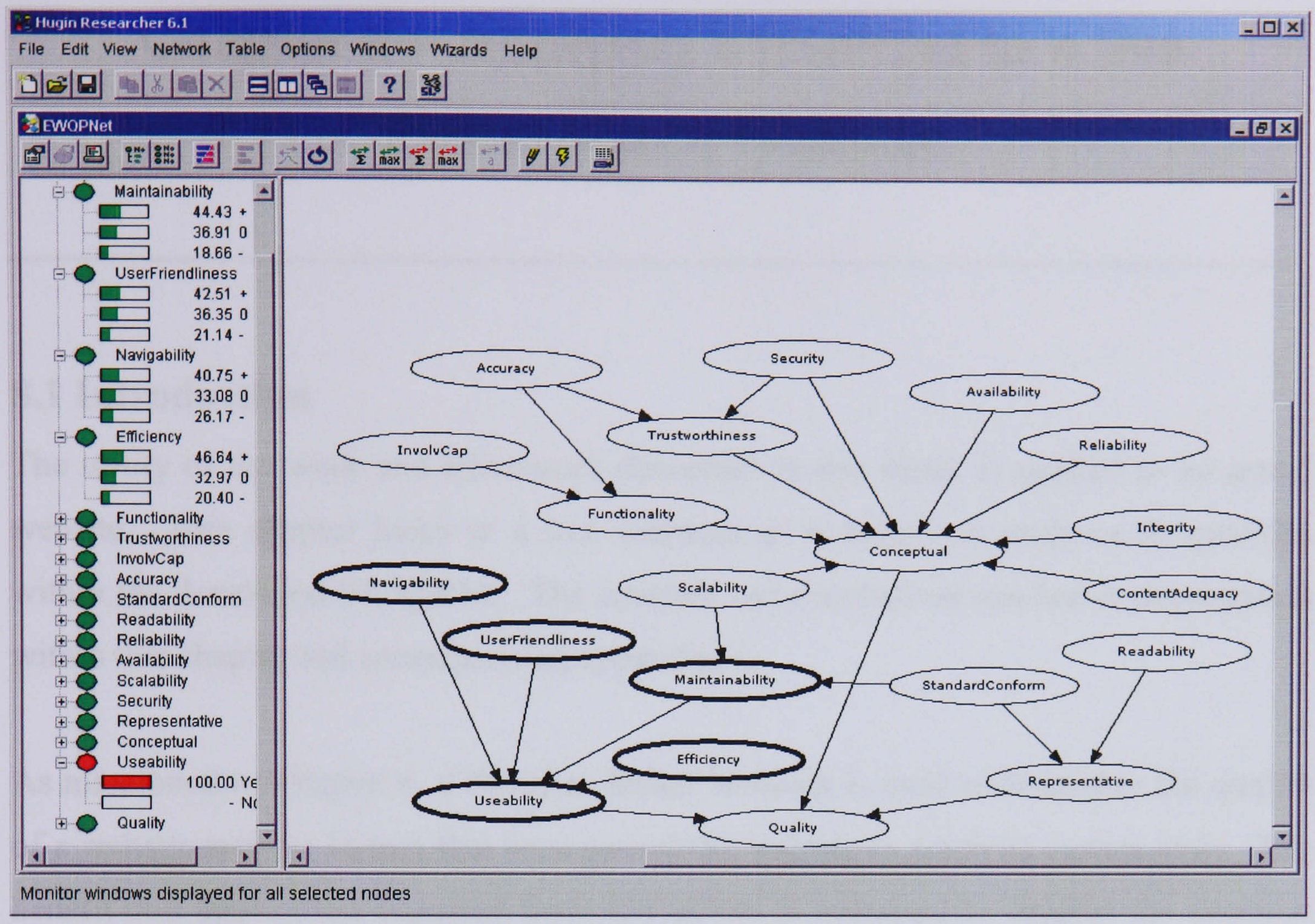
According to the EWQPNet, the results provide a prediction with 100% probability of high level of Conceptual Reliability, high level of Usability, and a satisfactory Quality level.




**- Figure 7-6: Using EWQPNet to conduct impact analysis -**

### 7.5.4 Quality Attribute Fulfillment.

EWQPNet can be used to give ratings and prioritized rankings of features that can be used to determine development priorities before coding begins. This can be done by entering beliefs about intermediate nodes into EWQPNet. The probabilities for all the observable nodes are then calculated. If, for instance, the design of the E-commerce website has to be highly usable, EWQPNet will probably give a high probability for Navigability, Maintainability, Efficiency, and User-Friendliness as shown in Figure 7-7. This information can help in cases where features that were under serious consideration are ranked near the bottom of the priority list; these can be removed from consideration, thereby saving valuable development resources. Based on this probability, the design team should give these quality factors more serious consideration during the development of an E-commerce website in order to produce a highly usable E-commerce site.




**- Figure 7-7: Using EWQPNet to ensure fulfillment of quality attributes -**

The four usage strategies can be used in combination with each other. A quality attribute prediction usage of the EWQPNet can, for instance, reveal problems (making it a diagnostic usage). This may be the starting point to do impact analysis for solutions for the detected problems. Alternatively, if there are a lot of problems, the quality attribute fulfillment strategy may be used to see how much the ideal quality level deviates from the actual level.

## 7.6 Conclusion

This chapter analyzes the EWQPNet model derived in the previous chapters from an intra-relational aspect using the Hugin Expert A/S tool and illustrates four usage strategies for the model. The results of the analysis in this chapter prepare the model for use in the case study applications that validate the model in subsequent chapters.

# Chapter 8 – Applying EWQPNet to a live E-commerce Website

## 8.1 Introduction

The utility of the work and framework described in this thesis is applied to an actual website. This chapter looks at a live commercial website and analyzes its qualities within the developed EWQPNet. The analysis and conclusions reached is documented within this chapter and accompanying appendices.

As mentioned in Chapter 6, a Bayesian Belief Network is used to determine the quality of a website and the factors that have caused the website to reach its current state. The benefit and application expected from EWQPNet is supposed to support the decision making regarding the next development steps appropriate for the website. A case study was selected to demonstrate this.

## 8.2 The Case Study

Softact.com is a live website providing E-commerce services in the area of business and technical artifacts. Items placed for sale are business artifacts targeting business consultants and professionals in the areas of business process automation. This constitutes a niche market which provides business value to the company. All purchased elements are furnished by email or, optionally, mailed on data media such as Compact Discs®. The website is the only sales channel available to Softact customers for the purchase of such listed artifacts. Thus, the quality of the website is crucial.

Average transactions per hour are 0.3 and giving a monthly total of 200. The peak, to date, was experienced in the week after the site was launched, reaching 6 transactions per minute.

The technology used to build the website is based on the Microsoft .NET framework of technologies. The technology used, from the operating system to the application

servers, is all Microsoft based. The site's hosting is outsourced to an organization in the United States, including all payment clearing and merchant based transaction processing.

The site was developed in two phases. The first phase was focused on establishing a marketing presence and presenting static informational content for which eleven static pages were built. The second phase has extended the site to an E-commerce platform which requires the addition of seventeen dynamic pages for processing the selling of business and technical artifacts. All efforts were built and coordinated by one team consisting of one senior person playing the dual role of an architect and a team leader with a team of three software engineers.

## 8.3 Basis for Selection

Softact was selected as a case study based on its attributes as a business model and its technical implementation, making it a typical representative of an E-commerce website. Softact's website:

- Targets users who conduct electronic commerce for the purpose of exchanging valued goods for money.
- Has been up for a time period exceeding one year and has attracted and retained customers.
- Has implemented and successfully demonstrated the business model it was intended for by its founders.

The site met the qualification criteria for case studies as set in Appendix F. Furthermore, the people behind Softact have expressed willingness to cooperate and support testing the website through the application of the developed EWQPNet model for the purpose of assessing its quality.

## 8.4 Exercise Methodology

The Goal-Question-Metric approach (Basili and Weiss, 1984) was followed to apply EWQPNet to Softact's website. Using this framework, the "beliefs", which are also known as the quality factors, were considered as the goals in this setting. The questions

being the qualifiers to the achievement of the goals were as described in Chapter 4 and Appendix B. The metrics were set to the three essential levels of positive (i.e. agreeing), negative (i.e. opposing) or neutral, indicating a lack of clear evidence.

This approach, according to Fenton and Pfleeger (1997), closely resembles a process improvement methodology, especially the one that is 'measurements-based'. This aligns with the ultimate goals of the thesis in seeking a quantifiable reusable methodology for the quality assessment of E-commerce websites.

## 8.5 EWQPNet Application

The website was analyzed by applying the EWQPNet model developed in this thesis. The target of identifying the "beliefs" on the intermediate nodes, as explained in Chapter 6, was achieved by conducting a score-based, Goal-Question-Metric study on the state of the site. The analysis was conducted using a combination of personnel investigation and "under the hood," source code and system inspections. On items warranting further elaboration, the Delphi method of investigation was applied in conjunction with a walk through of the source code. The results were then plugged into EWQPNet to derive the quality level.

## 8.6 Results

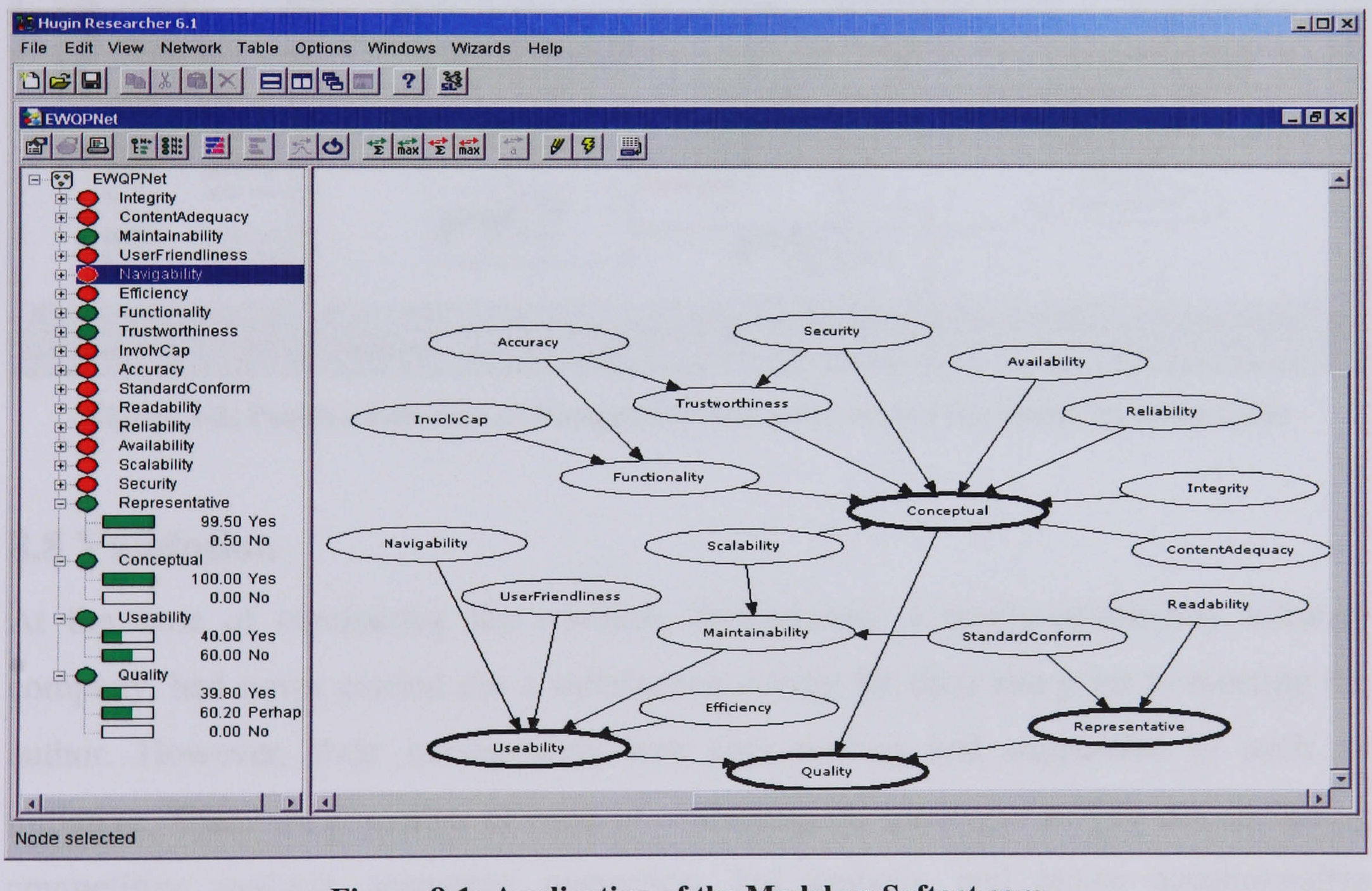
The assessment outcome is given in Table 8-1. As stated in Chapter 7, the EWQPNet model describes three types of key factors for achieving quality. Based on EWQPNet and the analysis framework applied the results were:

1. A low level of Usability attributes
2. A high level of Conceptual Reliability
3. A high level of Representative Reliability

Therefore, according to the EWQPNet, the results show an "unsatisfactory" quality for the website due to usability issues. Figure 8-1 shows the application of the EWQPNet on Softact.com.

**- Table 8-1: Assessment Results from the Model Exercise on Softact.com –**

| Nodes | Assessment |
|---|---|
| Security | Positive |
| Availability | Positive |
| Scalability | Positive |
| Integrity | Positive |
| Content Adequacy | Negative |
| Accuracy | Positive |
| Involved Capacity | Neutral |
| User-Friendliness | Positive |
| Navigability | Negative |
| Reliability | Positive |
| Efficiency | Negative |
| Readability | Positive |
| Standard Conformance | Positive |

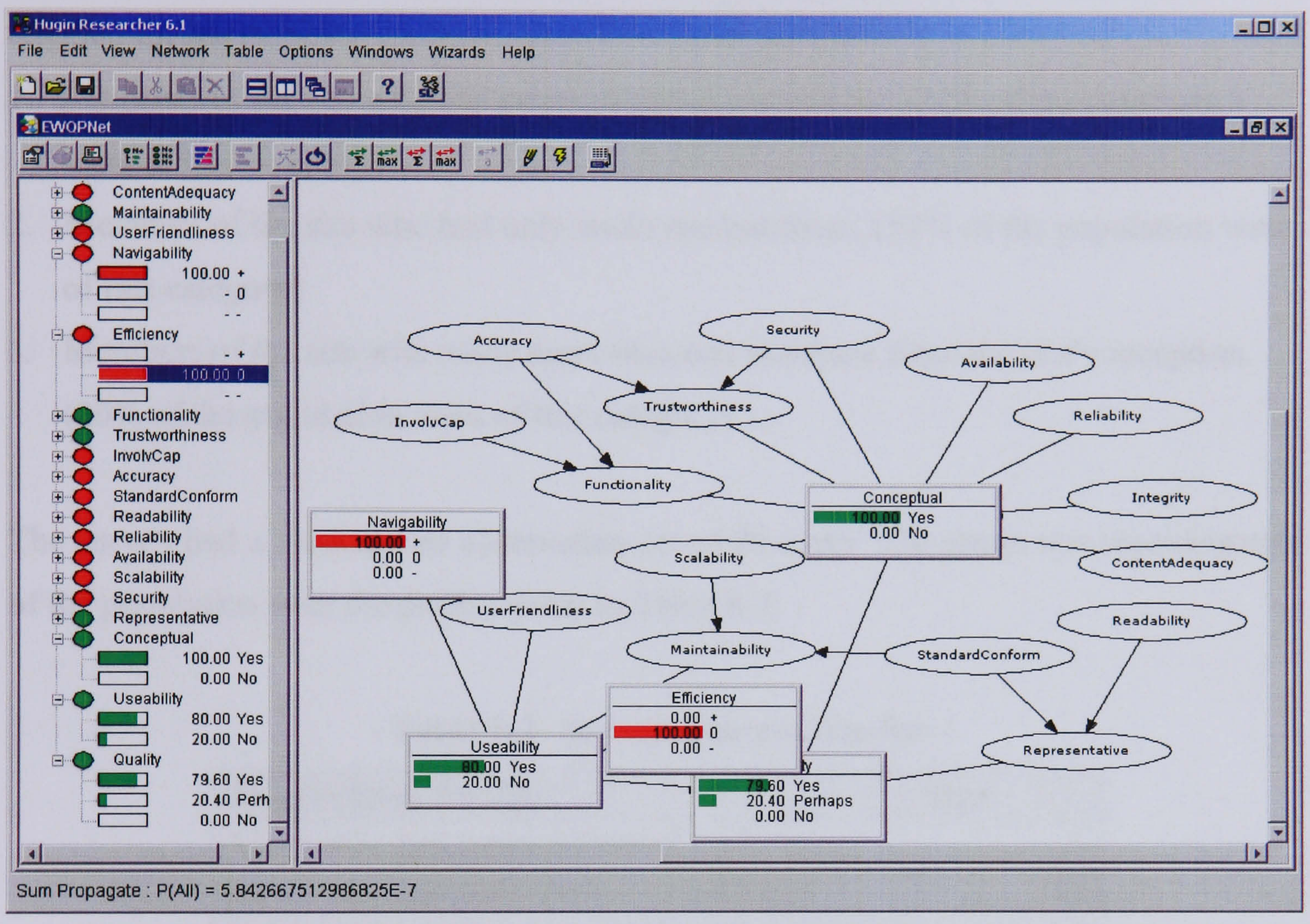



**- Figure 8-1: Application of the Model on Softact.com –**

## 8.7 What-if Analysis

Two factors were identified that influenced Softact.com's quality negatively, these are Navigability and Efficiency. Improving both factors to an acceptable status would bring the website to a high level of Usability and, therefore, to an acceptable state of quality. According to EWQPNet, even a neutral rating of Efficiency augmented with a positive

rating on Navigability would be sufficient to clear the low rating of the Usability of the website and upgrade Softact.com to quality status. This is shown in Figure 8.2.




**- Figure 8-2: Positive influence of Navigability and Efficiency of the Model on Softact.com -**

## 8.8 Validation

At the time of conducting the research, Softact.com, a newly-established software company, had never carried out a satisfaction survey for their site prior to meeting the author. However, their management was very willing and supportive of such an initiative. There are a number of ways of evaluating the quality of a Web site, including competitive analysis, scenarios, inspection, log analysis, and online questionnaires (Cunliffe, 2000).

The WebQual method was utilized to validate the "belief" established by EWQPNet for Softact.com website. The WebQual approach is to use an online questionnaire targeted at real users of an E-commerce offering. A survey was devised to validate the "belief"

derived by EWQPNet for Softact.com website. The survey was designed to particularly uncover issues, if any, regarding the navigability and efficiency of the website.

From the log-in statistics, three groups, totalling 2800 users, were identified and targeted for the survey:

1. Members of the site who had never executed a purchase. (22% of the population were of this category)
2. Members of the site who had only made one purchase. (58% of the population were of this category)
3. Members of the site who made more than one purchase since the site's inception. (20% of the population were of this category)

The survey had a randomized observation set of 20 users. The group was representative of the population with the profile given in Table 8-2.

**- Table 8-2: Survey Observation Set -**

| **Observation Profile** | **Size** |
|---|---|
| Users who had never executed a purchase | 5 |
| Users who had only made one purchase | 11 |
| Users who made more than one purchase | 4 |

## 8.9 Assessment of Survey Results

The survey conducted by Softact.com consisted of a rating-based questionnaire for a participant group of 20 Softact users. The questions were based on the different areas the WebQual method used in assessing the website quality. Each question was asked in the form of the user's satisfaction perspective on the website. Table 8-3 shows the provenance of WebQual 4.0.

The twenty users were randomly solicited using the user's database. The solicitation was dispatched by e-mailing it to the respective customers and it contained a link to an on-line page of the Softact.com site. Each question gave the respondents the option to answer with a score rating from 1 to 10, where an answer of "10" indicates ultimate satisfaction and "1" ultimate dissatisfaction. Each question had an additional space for

the respondent to supply comments. Appendix G shows the content of the survey. Questionnaires were checked online prior to submission to ensure that valid responses had been entered for all questions.

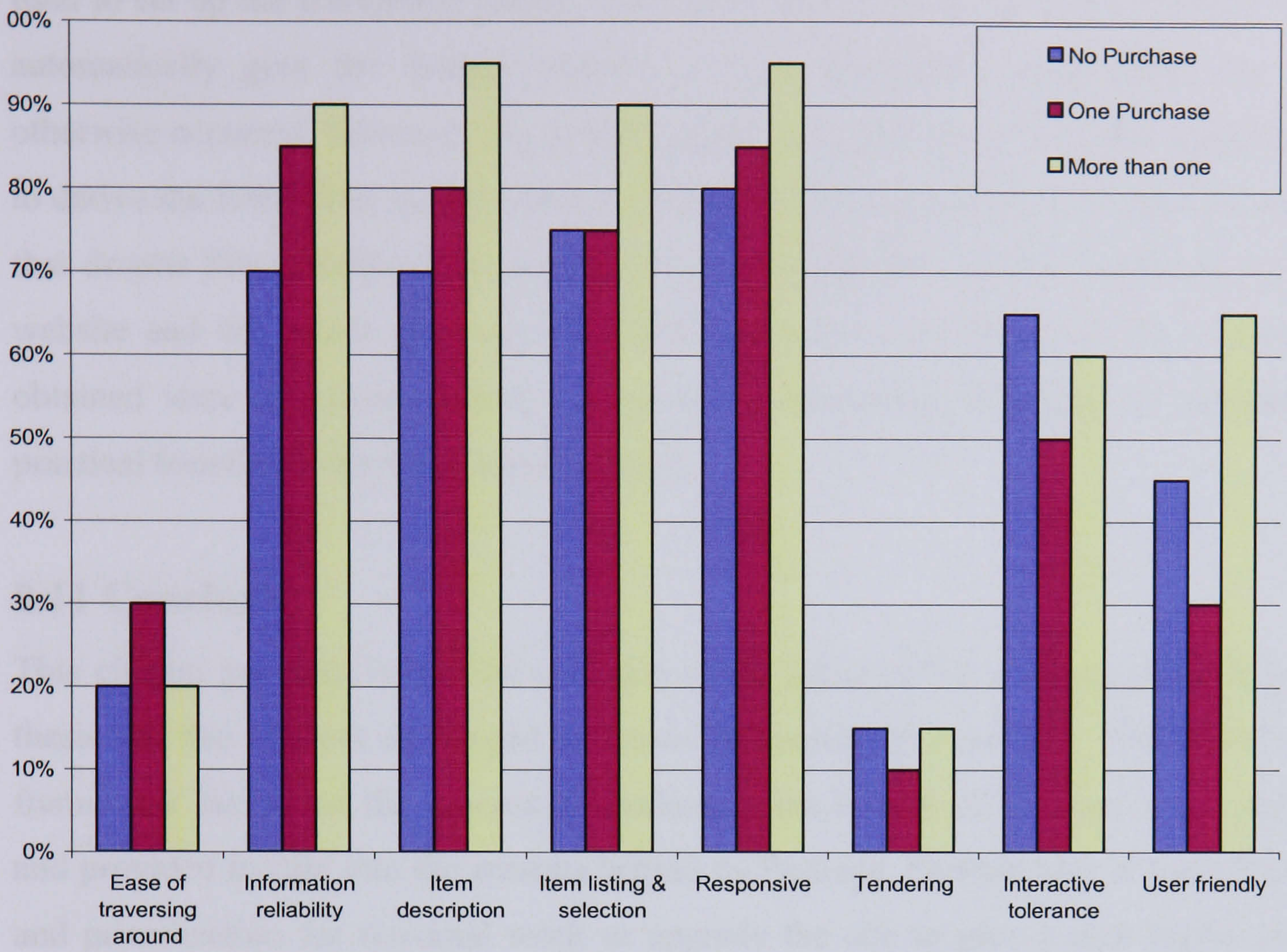
All 20 of the questionnaires were completed and returned, all responses were received between January 2nd and January 25th, 2005. The graph in Figure 8-3 provides the responses in aggregate by profile. The survey findings were statistically significant at a 95% confidence level with confidence interval of six.

The survey gave a clear indication of a problem area in the tendering process and related transaction. The users surveyed had the opportunity to provide their comments on the Softact website, in addition to providing their satisfaction assessment. In particular, there was clear dissatisfaction with the process to modify the selected items for purchase or to change the method of payment. It was "unacceptable" because it forced users to recreate and restart the entire tendering process. This directly indicates a deficiency in the area of Navigability and Efficiency of the website.

**Table 8-3: The provenance of WebQual 4.0. From Barnes and Vidgen (2002)**

| *Category* | *WebQual 4.0 Questions* | *Illustrative Support for Questions* |
|---|---|---|
| *Usability* | 1. I find the site easy to learn to operate | Bailey and Pearson 1983[2], Davis et al. 1989[2], Davis 1989[2], 1993[1], Ventakesh and Davis 2000[2] |
| | 2. My interaction with the site is clear and understandable | Davis et al. 1989[2], Davis 1989[2], 1993[1], Shneiderman 1998[2], Ventakesh and Davis 2000[2] |
| | 3. I find the site easy to navigate | Eighmey 1997[2], Levi and Conrad 1996[2], Nielsen 1999[2], 2000a[2], Spool 1999[2] |
| | 4. I find the site easy to use | Davis et al. 1989[2], Davis 1989[2], 1993[1], Ventakesh and Davis 2000[2], Nielsen 1993[2], 1999[2], 2000a[2] |
| | 5. The site has an attractive appearance | Nielsen 2000a[2], Parasuraman et al. 1988[1], 1991[2], Pitt et al. 1995[2], 1997[2] |
| | 6. The design is appropriate to the type of site | From WebQual workshops: no strong support, but tangential to research on customer expectations of appearance, e.g. Zeithaml et al. 1990 |
| | 7. The site conveys a sense of competency | Parasuraman et al. 1988[1], 1991[2], Pitt et al. 1995[2], 1997[2], Zeithaml et al. 1988[2], 1990[2], 1993[2] |
| | 8. The site creates a positive experience for me | Eighmey 1997[2], Moon and Kim 2001[2], Nielsen 2000a[2], White and Manning 1998[2] |
| *Information* | 9. Provides accurate information | Bailey and Pearson 1983[2], Strong et al. 1997[2], Wang 1998[2], Wang and Strong 1996[1], Wand and Wang 1996[2] |
| | 10. Provides believable information | Strong et al. 1997[2], Wang 1998[2], Wang and Strong 1996[1], Wand and Wang 1996[2] |
| | 11. Provides timely information | Bailey and Pearson 1983[2], Strong et al. 1997[2], Wang 1998[2], Wang and Strong 1996[1], Wand and Wang 1996[2] |
| | 12. Provides relevant information | Bailey and Pearson 1983[2], Strong et al. 1997[2], Wang 1998[2], Wang and Strong 1996[1], Wand and Wang 1996[2] |
| | 13. Provides easy to understand information | Bailey and Pearson 1983[2], Strong et al. 1997[2], Wang 1998[2], Wang and Strong 1996[1], Wand and Wang 1996[2] |
| | 14. Provides information at the right level of detail | Bailey and Pearson 1983[2], Strong et al. 1997[2], Wang 1998[2], Wang and Strong 1996[1], Wand and Wang 1996[2] |
| | 15. Presents the information in an appropriate format | Bailey and Pearson 1983[1], Chau et al. 2000[2], DeLone and McLean, 1992[2] |
| *Service Interaction* | 16. Has a good reputation | Aaker 1991[2], Aaker and Joachimsthaler 2000[2], Akshay and Monroe 1957[2], Cuningham 1966[2], Nielsen 1999[2] |
| | 17 It feels safe to complete transactions | Parasuraman et al. 1988[1], 1991[2], Pitt et al. 1995[2], 1997[2], Zeithaml et al. 1988[2], 1990[2], 1993[2] |
| | 18. My personal information feels secure | Clark 1999[2], Cranor 1999[2], Goodwin 1991[2], Hoffman et al. 1999[2], Wang et al. 1998[2] |
| | 19. Creates a sense of personalization | Gilmore and Pine 2000[2], McKenna 2000[2], Parasuraman et al. 1988[1], 1991[2], Pitt et al. 1995[2], 1997[2], Schubert and Selz 1997[2], Zeithaml et al. 1988[2], 1990[2], 1993[2] |
| | 20. Conveys a sense of community | Armstrong and Hagel 1996[2], Chang et al. 1998[2], Hagel and Armstrong 1997[2], Preece 2000[2], Rheingold 1993[2], Schubert and Selz 1997[2] |
| | 21. Makes it easy to communicate with the organization | Bitner et al. 2000[2], Jarvenpaa et al. 2000[2], Hoffman et al. 1999[2], Nielsen 2000a[2] |
| | 22. I feel confident that goods/services will be delivered as promised | Parasuraman et al. 1988[1], 1991[2], Pitt et al. 1995[2], 1997[2], Zeithaml et al. 1988[2], 1990[2], 1993[2] |

[1] denotes a primary source for a question - reworded for WebQual 4.0
[2] denotes a secondary influence for the inclusion of a question in WebQual 4.0




**- Figure 8-3: Softact's Users Satisfaction Survey Results -**

## 8.10 Benefit Analysis

The exercise indicated the focus of any improvement should prioritise the re-engineering of the payment process to produce a more friendly and efficient interface. This was evident from the assessment outcome of the developed model which gave a low rating on the Usability attributes of the site. This low rating was traced back to poor performance in the navigability aspects of the site, and this was confirmed by the user survey which pointed to the navigation of the tendering process as being particularly at fault.

Despite the negative scoring and evaluations in several areas, the model helped to prioritize and focus efforts on usability issues as these were identified as being the most critical.

It must be acknowledged that one possible criticism of the results of this case study is that one of the people who helped create the Softact website was also one of the experts

used to set up the EWQPNet model. This could mean that the EWQPNet model would automatically give the Softact website a more favourable result than may have otherwise occurred. However, the Softact expert was only one of the three experts used to derive the EWQPNet model which should reduce any bias. This is verified by the fact that despite this potential bias, the EWQPNet was still able to find weaknesses in the website and the results given by EWQPNet proved to be reliable as the conclusions obtained were measured against comparative assessment (WebQual) to validate the practical benefits of the work accomplished.

## 8.11 Conclusion

This chapter provided bona fide evidence of the value of the research reported in this thesis and the network developed to assess the quality of a website. The network and framework facilitated the process of evaluating the quality of the case study website, and provided insight into the reasons behind its findings. Furthermore, it gave direction and prioritization for remedial work to upgrade the site to give a new higher quality level of service.

# Chapter 9 – Applying EWQPNet to a Defunct E-commerce Website

## 9.1 Introduction

The application of this thesis is extended to defunct E-commerce websites. This chapter demonstrates a variation in the potential uses and values received from the network model developed. The intended purpose is to identify reasons that rendered websites in-operational and uncover potential reusability from their subparts.

According to Offutt (2002), customer loyalty is a key factor to sustain business in E-commerce. However, RingaDong (2005) failed to establish this. Their site was created in 2003 and launched later in December of that year. In May 2005, after 18 months of operational presence, the owners of the site decided to "turn it off" as it had failed to generate enough business and revenue to even sustain its daily operational costs. This chapter will aide in uncovering the causes of this failure from a technology and implementation-quality point of view.

## 9.2 Case at Hand

Despite RingaDong's effective marketing campaign, attractive site name, and competitive price offerings, the site was not producing enough business from registered members.

RingaDong offered for purchase and download ring tones, phone images and screens savers, games and phone management software for the mass population of mobile phone users, particularly, youth enthusiasts.

Consumer user behavior statistics, which was auto-collected by the website software, was somewhat alarming. For example, during the month of April, 2004 the site's

servers received approximately 320,000 external access hits, and in all of these, the requested pages were successfully served. However, the site membership only went up by approximately 1500, of which only 38 made actual purchases. This means that the success ratio for capturing further attention from website users was 1:213, of which 1:39 were motivated to complete a purchase. This achievement was significantly below the marketing target and business plan of the company.

## 9.3 Basis for Selection

RingaDong was selected as a case study based on its attributes from both a business model and its technical implementation. It is a typical representative of an E-commerce website as RingaDong had:

- An active web site targeting users in order to conduct electronic commerce for the purpose of exchanging valued goods for money.
- The site had implemented and successfully demonstrated the business model that was intended by its founders.

The site met the qualification criteria for case studies as set out in Appendix F. Further, the people behind RingaDong expressed a willingness to cooperate and support the quality assessment of the website using the developed EWQPNet model.

## 9.4 Exercise Methodology

As in the previous case study at Softact, the Goal-Question-Metric approach (Basili and Weiss, 1984) was followed in exercising EWQPNet. Using this framework, the "beliefs", which were the quality factors, were the goals in this setting.

The website was never set up to survey customer satisfaction, and it was not feasible to perform such an exercise at the time of this research because the website had been unused for over six months. As an alternative, with the support of the site owners, the website was loaded on a personal computer stand-alone environment and studied for technical suspected causes that had contributed to its unsuccessful fate.

With the support of the company's resident Architect, using the observable nodes associated with the developed EWQPNet as qualifiers, the site was inspected.

The panel of three experts who had earlier participated in deriving inter-dependencies between quality factors, were invited to a group discussion to assess the potential reasons for failure and to identify sub-components of the site that were of sufficient quality to enable these aspects be reused.

In order to alleviate the problem of expert bias, the Delphi technique (Dunham, 1998) was used as an effective way of getting group consensus. The Wideband Delphi Approach (Boehm and Sullivan, 2000) was used to improve the estimate consensus obtained by the Delphi technique. The following steps described the assessment process adopted:

1. The author of this thesis acted as a coordinator for the panel of three independent experts and one expert from the company who was the site's original architect.
2. The coordinator provided an assessment form to each of the participants to review the RingaDong website. Appendix H shows the content of the assessment form.
3. The coordinator conducted a group meeting to discuss potential reasons for failure of RingaDong website.
4. Participants completed the assessment forms anonymously and returned it to the coordinator.
5. The coordinator fed back the results of the participants' responses.
6. The coordinator then conducted another group meeting to discuss variances in the participants' responses to achieve a possible consensus.
7. The coordinator asked participants for re-estimates, again anonymously.
8. Steps 4-7 were repeated to the point were consensus was reached. This was achieved after 3 cycles of steps 4 to 7.

While conducting the assessment process, the author as a coordinator was able to reach the consensus between experts easily because there was a lot of agreement from the beginning.

The assessment outcome is given in Table 9-1.

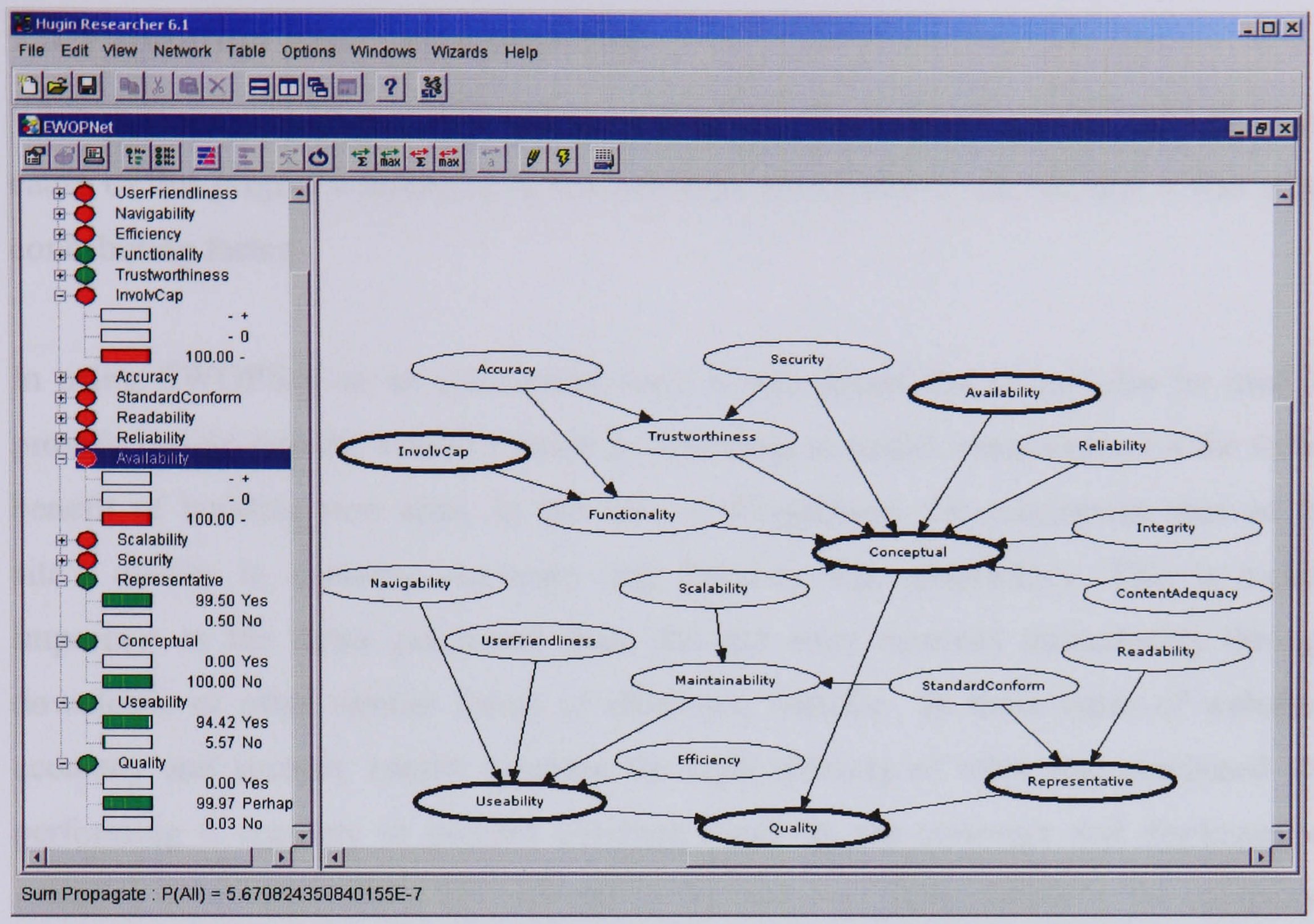
**Table 9-1 Assessment Results**

| Nodes | Assessment |
|---|---|
| Security | Positive |
| Availability | Negative |
| Scalability | Neutral |
| Integrity | Positive |
| Content Adequacy | Positive |
| Accuracy | Positive |
| Involved Capacity | Negative |
| User-Friendliness | Positive |
| Navigability | Positive |
| Reliability | Positive |
| Efficiency | Positive |
| Readability | Positive |
| Standard Conformance | Positive |

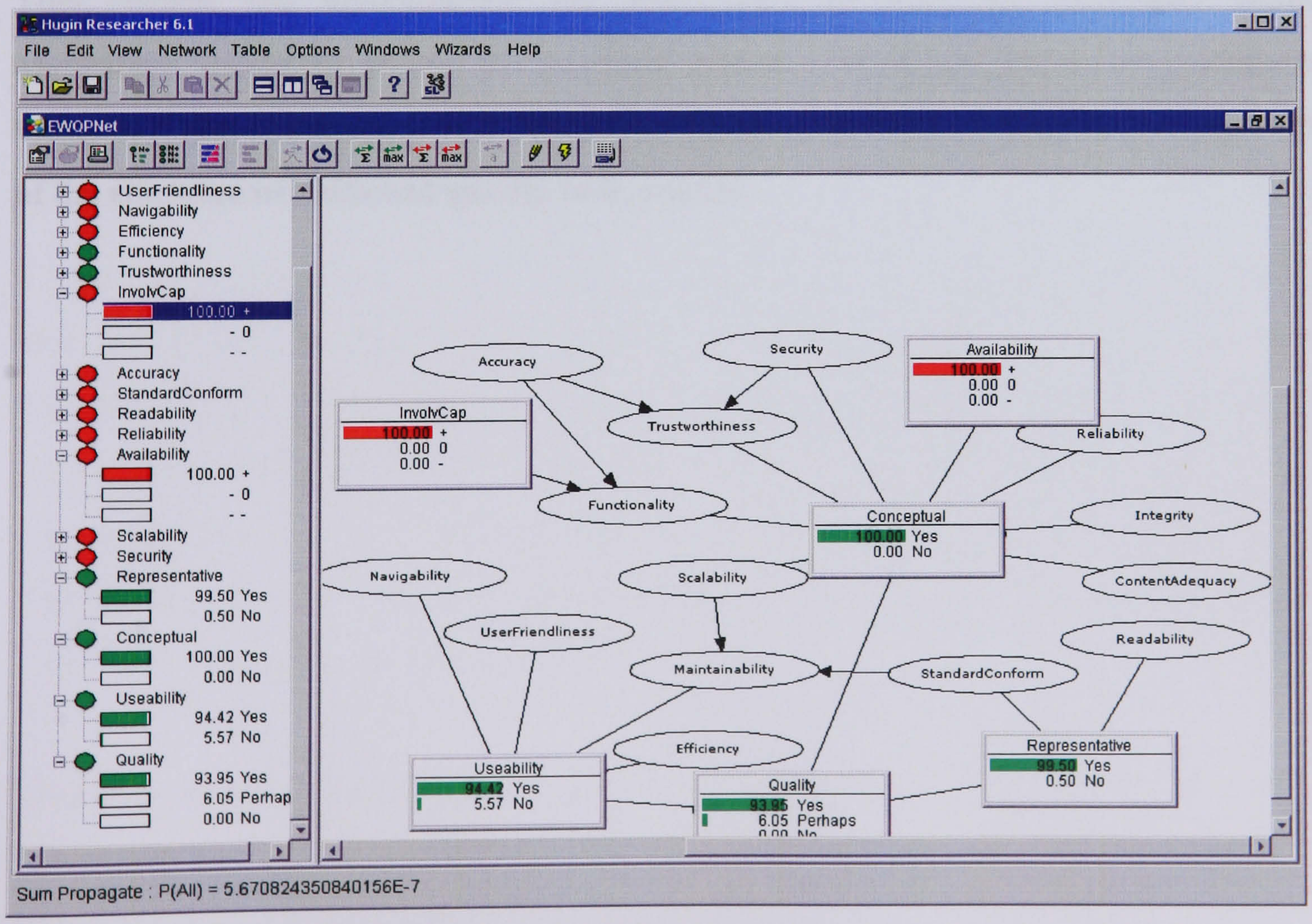
## 9.5 Application of EWQPNet

Investigating the site's software quality identified Involved Capacity and Availability as major shortcomings. This caused a deficiency in the site Conceptual Reliability as shown in Figure 9-1.

Improving both factors to an acceptable status would bring the website to a high level of Conceptual Reliability and, therefore, to an acceptable state of quality. This is shown in Figure 9-2.




**- Figure 9-1: Execution of the Model on RingaDong.com –**




**- Figure 9-2: Positive influence of Availability and Involved Capacity of the Model on RingaDong.com–**

## 9.6 Validation and Value Benefits

While it is not possible to comfortably confirm that Conceptual Reliability was the main cause of this project's failure, it is, nevertheless, reasonable to deduce that it was a key contributing factor.

In using EWQPNet as an assessment tool, it was found that it can also be used to provide insight into the viability levels in extracting re-usable components for the future benefit of building new sites. In the case of RingaDong, the assessment showed the site's quality in ensuring Accuracy and Security was satisfactory. This is clearly important as the items purchased from the site were received immediately through downloads or other similar forms of electronic transfer. In these types of websites, accuracy and security entails ensuring the right delivery of what was purchased and performing it securely to prevent purchase fraud by the customer and disclosure of sensitive information about the customer or the customer phone details by the company.

## 9.9 Conclusions

This chapter has demonstrated the practicality of using the developed quality assessment model to assess the potential reasons for failure for a non-operational website. It also showed that EWQPNet could be used to identify which sub-components of the site were of sufficient quality to be reused.

# Chapter 10 – Using EWQPNet in Constructing a New E-commerce Website

## 10.1 Introduction

This chapter exercises the EWQPNet model in a case study of a new E-commerce initiative to provide insight on how EWQPNet can be applied to set priorities and directions for the development and implementation strategies when realizing and materializing an E-commerce website.

The development of quality software is better assured when the development effort is driven by a systematic software development lifecycle and methodology. According to Bennatan (2000), having a software development lifecycle improves the reliability of completing the efforts of developing the software by fifty percent. Further, having a project management approach to software development helps to achieve the timely completion of work within half the given budget of human and material resources that would otherwise have been used (Ludaise, 2002).

The people behind Iconopportunities are eager to have a successful implementation of their newly developed E-commerce website, www.Iconopportunities.com. To ensure this, work under construction is following a software development methodology based on software best practices and governed by a project management framework and approach. The work effort is managed by a dedicated and experienced project manger. The project manager has produced an elaborate project plan, as illustrated in Figure 10.1, and is making sure the team follows this plan.

This case study stemmed from a motivation by the company's founders to have, in addition to a completed website on time and within budget, successful acceptance of the site in the marketplace measured by a high rate of usage and loyalty evident by the rate of regular re-use.

While the practices of software development methodologies and project management are fundamental to assuring successful production of software, this chapter focuses on the application of EWQPNet in assuring a quality outcome at the site's launch. By producing evidence of the factors that influence the quality of its E-commerce website, EWQPNet contributes to the market acceptance and success of the company. This chapter illustrates how the developed quality assessment model can be applied to E-commerce websites under construction.

## 10.2 The Case Study Environment

Iconopportunities.com is a new, up-and-coming site aimed to provide consumers with newly branded services over the Internet for recharging their mobile phone with air-time using their credit card. The site works in combination with a banking payment gateway to credit card validation and settlements, and with a mobile phone messaging gateway to dispense the PIN numbers that would activate the additional purchased air-time access on the mobile.

The site is being built on Java™ technologies. A software development lifecycle is being followed consisting of four prominent stages as follows:

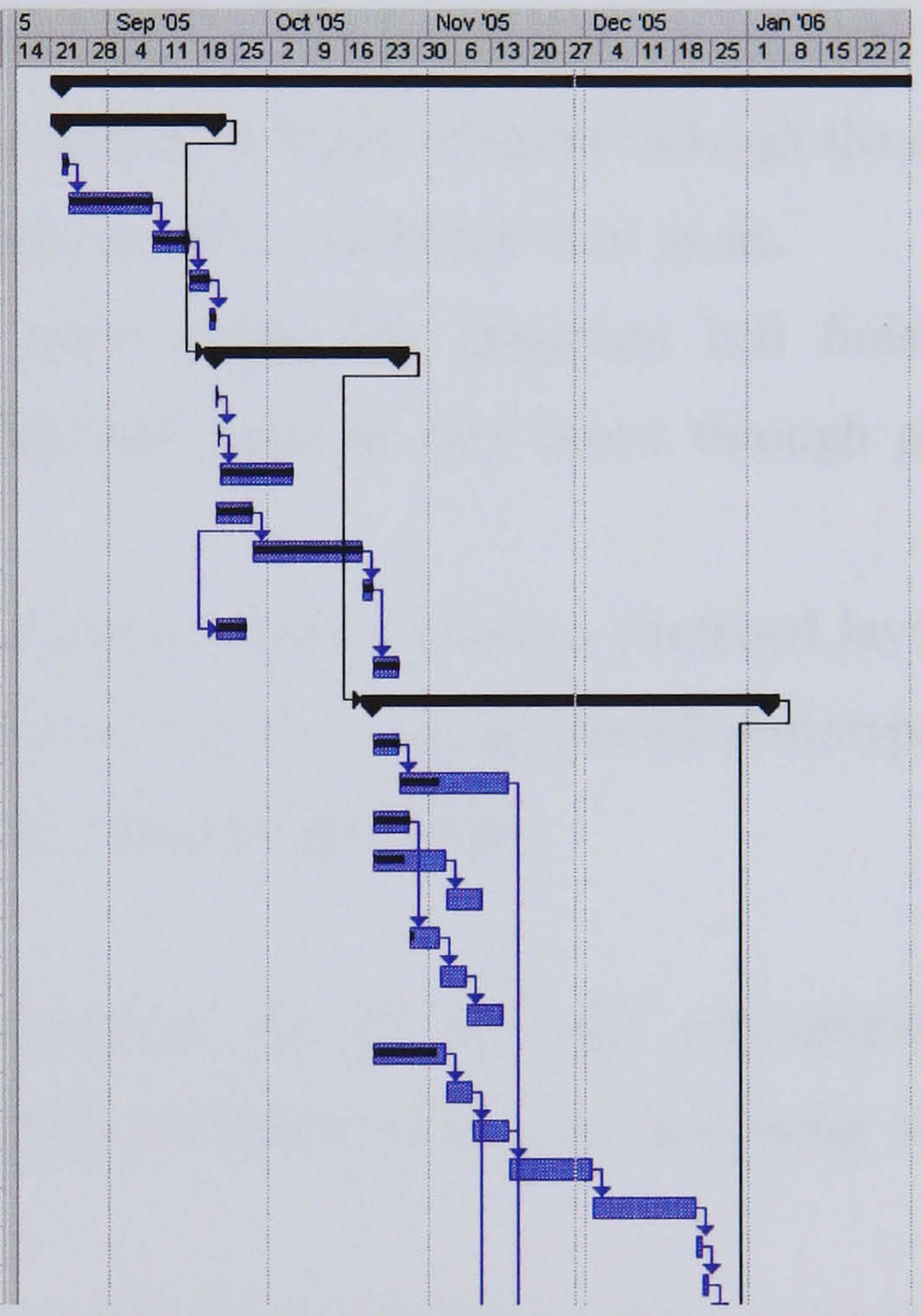
- The Definition Stage that has an outcome goal of establishing a clear definition of the sites proposed consumer capabilities and the underlying non-functional criteria and specifications. This stage aims to have all the usage scenarios of the website clarified and documented.
- The Design Stage that produces the overall architectural framework of the software behind the E-commerce website and the technology criteria and constraints for realizing this software. This stage aims to have all the software subsystems and module components that make up the total solution identified and defined in term of their objectives and interface specifications.
- The Development Stage that realizes the system by developing and implementing the software according to the design and architectural criteria and addressing the system functional requirements defined in the previous stages. In this stage, quality control operations in terms of software testing and validation

are performed to ensure the completion of the development of the software and its readiness for deployment and use.

- The Deployment Stage that takes the completed software to its final destination, hosting it on the Internet, and integrating it with the third party vendors in communications and banking.

As illustrated in Figure 10-1, the status of the project at the time of the study had reached the start of the development stage.

| | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | **Website Launch** | **137 days** | **Tue 8/23/05** | **Wed 3/1/06** |
| 2 | **Define** | **21 days** | **Tue 8/23/05** | **Tue 9/20/05** |
| 3 | Vision and Scope | 1 day | Tue 8/23/05 | Tue 8/23/05 |
| 4 | Use Case Scenarios | 12 days | Wed 8/24/05 | Thu 9/8/05 |
| 5 | Non-functional Requirements | 5 days | Fri 9/9/05 | Thu 9/15/05 |
| 6 | Analysis and Pattern Indentifications | 2 days | Fri 9/16/05 | Mon 9/19/05 |
| 7 | Finalized Documentation | 1 day | Tue 9/20/05 | Tue 9/20/05 |
| 8 | **Design** | **25 days** | **Wed 9/21/05** | **Tue 10/25/05** |
| 9 | Technology Selection criteria | 0.5 days | Wed 9/21/05 | Wed 9/21/05 |
| 10 | Technology Selection | 0.5 days | Wed 9/21/05 | Wed 9/21/05 |
| 11 | Conceptual System Views | 10 days | Thu 9/22/05 | Wed 10/5/05 |
| 12 | Logical System Views | 5 days | Wed 9/21/05 | Tue 9/27/05 |
| 13 | Dynamic Views Scenarios | 15 days | Wed 9/28/05 | Tue 10/18/05 |
| 14 | Physical Deployment Views | 2 days | Wed 10/19/05 | Thu 10/20/05 |
| 15 | Implementation Guidelines | 4 days | Wed 9/21/05 | Mon 9/26/05 |
| 16 | Finalized Documentation | 3 days | Fri 10/21/05 | Tue 10/25/05 |
| 17 | **Develop** | **54 days** | **Fri 10/21/05** | **Wed 1/4/06** |
| 18 | Database setup and schemas | 3 days | Fri 10/21/05 | Tue 10/25/05 |
| 19 | Database stored procedures | 15 days | Wed 10/26/05 | Tue 11/15/05 |
| 20 | Payment Gateway Interface | 5 days | Fri 10/21/05 | Thu 10/27/05 |
| 21 | Presentation Layer | 10 days | Fri 10/21/05 | Thu 11/3/05 |
| 22 | Data fields validations | 5 days | Fri 11/4/05 | Thu 11/10/05 |
| 23 | Middle tier Logic engine | 4 days | Fri 10/28/05 | Wed 11/2/05 |
| 24 | Business rules for pricing | 3 days | Thu 11/3/05 | Mon 11/7/05 |
| 25 | Tendering Process | 5 days | Tue 11/8/05 | Mon 11/14/05 |
| 26 | SMS Gateway Implementation | 10 days | Fri 10/21/05 | Thu 11/3/05 |
| 27 | SMS Communication Protocols | 3 days | Fri 11/4/05 | Tue 11/8/05 |
| 28 | Generating a PIN number | 5 days | Wed 11/9/05 | Tue 11/15/05 |
| 29 | Dispensing a PIN number | 12 days | Wed 11/16/05 | Thu 12/1/05 |
| 30 | Transactioning Framework | 14 days | Fri 12/2/05 | Wed 12/21/05 |
| 31 | Recording purchase transaction | 1 day | Thu 12/22/05 | Thu 12/22/05 |
| 32 | Registering users | 1 day | Fri 12/23/05 | Fri 12/23/05 |




- Figure 10-1: Iconopportunities .com Project Development Plan -

# 10.3 The Role of the EWQPNet Model

As in the previous case studies at Softact and RingaDong, the Goal-Question-Metric approach (Basili and Weiss, 1984) was used in exercising EWQPNet. The quality factors of EWQPNet were used as a checklist to find evidence of quality factors within the website software under construction.

A panel of three independent experts was invited to a group discussion to assess the quality factors within the website software under construction. As in the previous case

study at RingaDong, the Delphi technique (Dunham, 1998) was used as an effective way of getting group consensus and the Wideband Delphi Approach (Boehm and Sullivan, 2000) was used to improve the estimate consensus obtained by the Delphi technique.

At the time of conducting this assessment the following information sources were available:

1. The Web design team had finished identifying the needs and expectations of the site's target audience.
2. Site designers had finished creating profiles of representative target audience members and had identified how they would be likely to move through the site, from section to section and page to page, in order to achieve their goals.
3. The site map and user workflows were ready; the designers had finished planning how users will interact with each page as they move through page sequences to accomplish key tasks.
4. The designers had finished creating a site-navigation scheme, sketched layouts for each page, and had created models of the site - a paper-based prototype, a computer-based linear prototype, and a functional prototype.

A thorough walkthrough of the site architecture, design and the corresponding implementation tasks was performed to identify the future state. The following steps described the assessment process adopted:

1. The author of this thesis planned the walkthrough, identifying how it would be conducted and what the participants would expect to see and experience along the way.
2. The author then acted as the coordinator for the panel consisting of himself, the three independent experts and three developers of the website.
3. The coordinator provided a checklist form for each of the participants to assess the future state of Iconopportunities website. Appendix I shows the content of the checklist form.
4. The coordinator conducted a group meeting to discuss the assessment process of the Iconopportunities website.

5. The analysis of the checklist was conducted; all factors were considered in parallel. A mind mapping technique was used for documentation and to present thoughts that may be needed to justify decisions at some stage.
6. The participants completed the checklist forms anonymously and returned them to the coordinator.
7. The coordinator compiled and then fed back the results of participants' responses to the whole group.
8. The coordinator conducted a group meeting to discuss variances in the participants' responses to achieve a possible consensus.
9. The coordinator asked participants to re-assess the website, again anonymously.
10. Steps 5 to 9 were repeated until consensus was reached, which in this case took 3 cycles of steps 5 to 9.

While conducting the assessment process the author as a coordinator was able to reach the consensus between experts easily because there was a lot of agreement from the beginning.

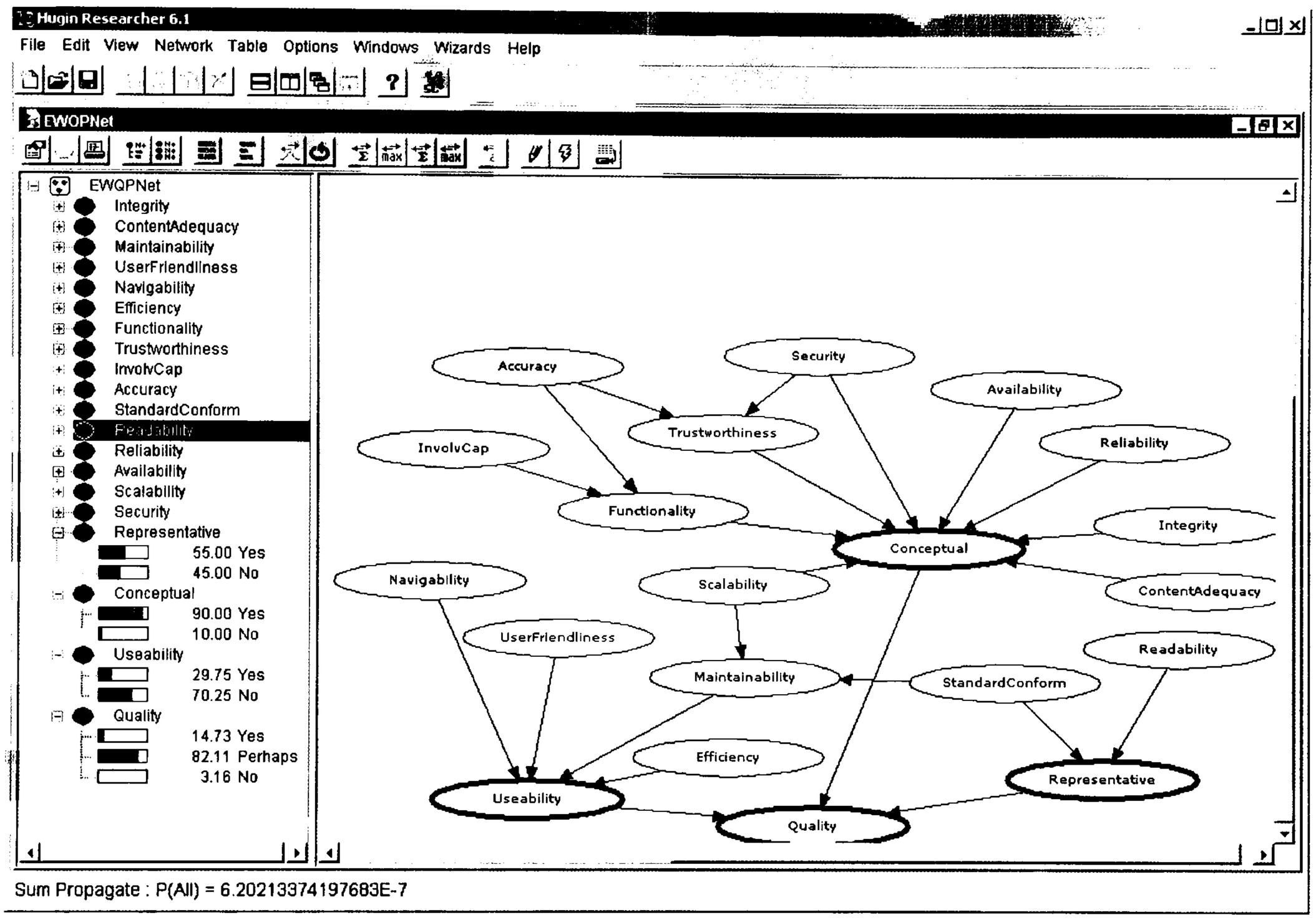
The assessment outcome is given in Table 10-1.

**Table 10-1 Assessment Results**

| **Nodes** | **Assessment** |
|---|---|
| Security | Positive |
| Availability | Neutral |
| Scalability | Neutral |
| Integrity | Positive |
| Content Adequacy | Positive |
| Accuracy | Neutral |
| Involved Capacity | Neutral |
| User-Friendliness | Negative |
| Navigability | Negative |
| Reliability | Positive |
| Efficiency | Positive |
| Readability | Negative |
| Standard Conformance | Positive |

Once that review was completed, a forward forecasting was carried out using EWQPNet to assess the probability that the underlying website software will be of high quality.

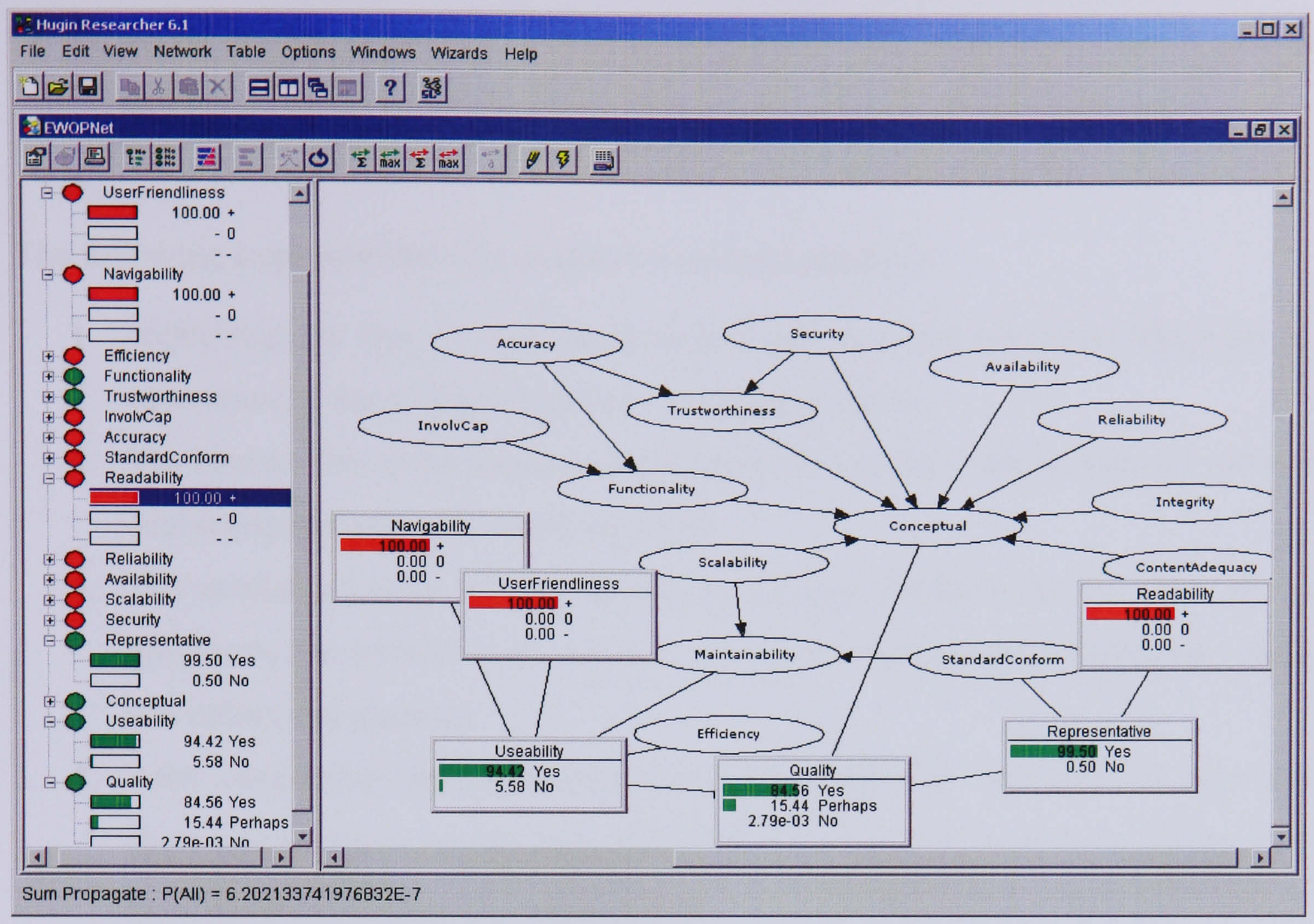
According to EWQPNet, the results show an "unsatisfactory" quality for the website due to Usability and Representative Reliability issues. This is high-lighted in Figure 10.2.




**- Figure 10-2: Model Forecasting on Iconopportunities .com -**

# 10.4 Impact Analysis

Three factors were identified that influenced Iconopportunities.com's quality negatively, these are User-Friendliness, Navigability and Readability. Improving the three factors to an acceptable status would bring the website to a high level of Usability and Representative Reliability, and therefore, to an acceptable state of quality. This is shown in Figure 10-3.




**- Figure 10-3: Model Forecasting with positive remedies -**

## 10.5 Validation

A cognitive walkthrough was conducted to validate the "belief" established by EWQPNet for the website. According to Rubin (1994) a cognitive walkthrough is an inspection method that focuses on evaluating a design for ease of learning, particularly by exploration. The walkthrough was conducted particularly to uncover issues, if any, regarding Navigability, User-Friendliness and Readability of the website.

The researcher selected six experts who did not use EWQPNet for the cognitive walkthrough to ensure the independency of the validation of the EWQPNet. Three of them were from the development team at Iconopportunities and the other three were the independent experts who had earlier participated in deriving inter-dependencies between quality factors. The evaluation was conducted from two different perspectives:

1. In the first perspective the evaluators judged the website as users.

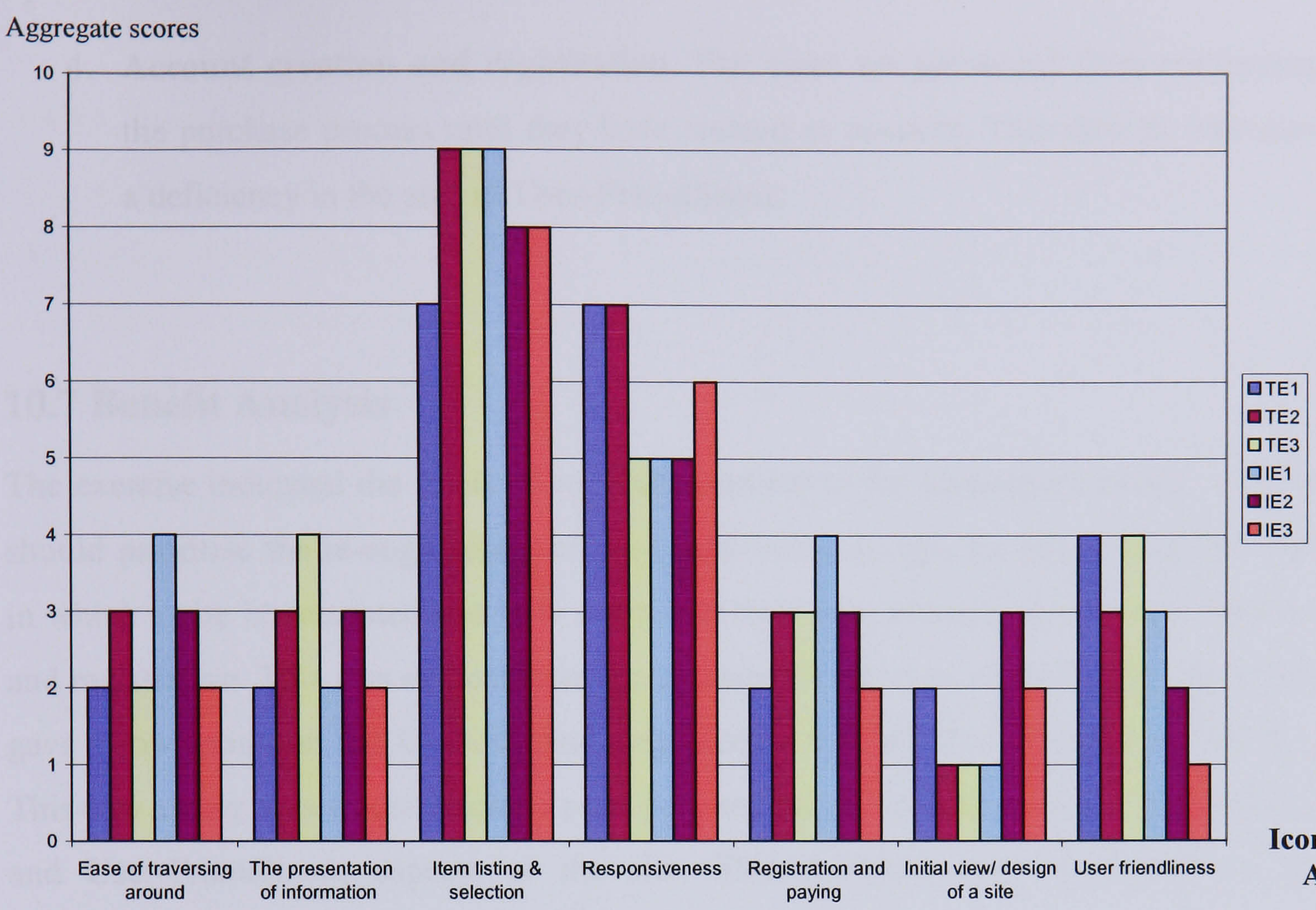
2. In the second perspective the evaluators judged the website as experts, not as users.

The following steps described the evaluation process adopted:

1. Identifying the type of user the evaluator will view the system as (the level of experience or knowledge the user is expected to have).
2. The second step of the evaluation process is to actually walkthrough the website evaluating the fully functional prototype.
3. The evaluators were asked individually to give feedback on the flow of the processes, the overall look and feel, layout and navigation, terminology used, and colors and graphics.
4. After completing the evaluation process, the evaluators were asked to answer a short questionnaire to rate how satisfactory they found the website and to give their recommendations for future action.

## 10.6 Assessment of Evaluation Results

All of the six evaluators completed their evaluation and returned the questionnaire along with their recommendation for future action. The survey conducted on Iconopportunities.com consisted of a rating-based questionnaire. The questions where selected based on the different areas EWQPNet focuses on when assessing the website quality. Each question was asked in a form that would gather the evaluator satisfaction perspective on the website. Each question gave the respondents the option to answer with a score rating from 1 to 10, where an answer of "10" indicates ultimate satisfaction and "1" indicates ultimate dissatisfaction. Each question had space for supplying comments. Appendix I shows the content of the questionnaire. The graph below provides the responses in aggregate by profile.




**- Figure 10-4: Iconopportunities Evaluators Satisfaction Survey Results -**

The evaluation gave a clear indication of problems in the following:

1. **Initial view/design of the Iconopportunities' website**. The Iconopportunities developers had missed the importance of using colours, particularly when it comes to locating information. This directly indicates a deficiency in the area of Navigability and User-Friendliness of the website.
2. **The readability of the Iconopportunities' website**. The Iconopportunities developers missed language correctness. This directly indicates a deficiency in the area of the readability of the website.

3. **The way in which a site is presented and how users find their way around**. The Iconopportunities developers often place content in a less than optimal position in terms of its importance to the user. This directly indicates a deficiency in the area of navigability which is detrimental to the success of a site and its trustworthiness as it leads to user frustration.

4. **Account creation and registration.** The users are prevented from continuing the purchase process until they have created an account. This directly indicates a deficiency in the area of User-Friendliness.

## 10.7 Benefit Analysis

The exercise indicated the focus of any improvement to the Iconopportunities' website should prioritise the re-engineering of the initial view/ design, the readability, the way in which a site is presented and how users find their way around, and account creation and registration. This was evident from the assessment outcome of the EWQPNet which gave a low rating on the Usability and Representative Reliability attributes of the site. This low rating was traced back to poor performance in the Readability, Navigability and User-Friendliness aspects of the site. This therefore was confirmed by the identification of fault areas by the evaluator survey.

Though the negative scoring and evaluations in several areas, EWQPNet helped to prioritize and focus efforts on usability and representative reliability issues as these were identified as being the most critical.

## 10.8 Remedies and Impact

The EWQPNet provides an aid in identifying what needed to be done to accomplish Iconopportunities' E-commerce website. If the development of the site can yield a positive assessment on the Navigability, User-Friendliness and Readability, then EWQPNet will yield much better results with a "YES" probability of high quality (84.56%). Also, EWQPNet provides an aid to the developers as:

1. It gives ratings and prioritized rankings of features that can be used to determine development priorities before coding begins.
2. After running the model, the features which were under serious consideration and were given high priority by developers are ranked near the bottom of the priority list, that is why these (features) should not be taken into consideration to save time and effort.

## 10.9 Conclusions

This chapter has demonstrated the practical effectiveness of using the EWQPNet and the framework developed in this thesis to provide guiding insight that can influence the work decisions and priorities when building an E-commerce website to help ensure that a high quality website is achieved. The Iconopportunities company has now accepted the findings of this analysis and, at the time of writing this thesis, are making the suggested changes to improve the website so that it may achieve the high quality the company needs for its success. The ultimate test for the usefulness of EWQPNet would be to show how the company achieves business success through the use of the improved website. However, time does not permit such a long term study in the constraints of this PhD research project. Nevertheless, the fact that a company has been able to use the EWQPNet model, and believe they are strengthening their chances of success by doing so, can only be considered a positive endorsement of this research.

# Chapter 11 – Conclusion and Recommendations for Further Work

## 11.1 Introduction

This chapter reviews the aim and objectives of the thesis in the context of what was achieved. It also explores the next steps and further work and modifications that could be carried out in subsequent research projects.

## 11.2 Reflection on the Foundation

E-commerce websites are becoming increasingly complex systems and the availability of tools to aid and secure the production of a quality website that secures customer satisfaction and retention will, therefore, provide solace and efficiency to the website owner and sponsor.

The complexity of E-commerce websites is caused by the large amount of intervening attributes and by the complex logic relationships among the quality attributes. The research effort commenced in identifying and refining the top quality and key relevant attributes to be evaluated and objectively measured in order to produce a comprehensive assessment and judgment of existing websites, and foresight and insight into ones under construction. Once the work was compiled and refined it was modeled into a Bayesian Belief Network so that it could be re-used consistently for assessment and evaluation.

## 11.3 Restatement of Aims and Objectives

The aim of this research was to provide a framework for assessing the quality attributes of an E-commerce website and their interrelations, and also to provide an engine that automates quantification of E-commerce website quality levels.

In order to achieve this, the following activities were performed:

A. A study on the published literature and case studies on the subject was conducted. The gaps were identified to assess how this research would relate and contribute to existing knowledge and have the highest possible impact.

B. The different available methodologies to conduct the reach effort were analyzed to determine the best approach to apply with the right mix of the methodologies. The chosen approaches were as follow:

- The Interpretivist approach was followed to conduct the research. Interpretive research is more effective for this type of research since it produces an understanding of the context of the information system and the process whereby the information system influences and is influenced by its context.
- Kuutti's (1991) principles of Activity Theory were used to study the quality factors that contribute to assessing the overall quality of an underlying website. Interpretation can be aided by choosing one or several social theories in order to understand the relationships between work, people and technology. In addition, the use of technology as an aspect in such theory is important for the subject of study.
- The research was conducted using the five-step approach of Wohlin et al. (2000) as it was considered to be suitable for the study of software.
- The Delphi technique effectively elicited information and judgments from participants to facilitate problem-solving, planning, and decision-making. It does so without physically bringing together the contributors so it avoids the problems of personality conflict that can lead to poor group decision making.
- The Goal-Question-Metric approach (Basili and Weiss, 1984) was followed to apply the developed EWQPNet. This approach, according to Fenton and Pfleeger (1997) closely resembles a process improvement methodology, especially one that is measurements-based. This aligns with the ultimate goals of the thesis in seeking a quantifiable reusable methodology for the quality assessment of E-commerce websites in the spirit of their betterment.

C. The selection, refinement and categorization of top rating quality attributes were carried out and the relationships among these attributes were determined. In conducting the study to establish the domain final model, the research involved the solicitation and compilation of eighty-four quality factors from previously published research. This set was analyzed and qualified by conducting a comprehensive questionnaire administered to a representative sample set of twelve qualified E-commerce users. A statistical rating scheme based on frequency of rate was used to rate the most important relations among factors. Statistical correlation was used in analyzing the data obtained from the responses to the questionnaire to establish initial inter-factors relations. The validation of this possibility was exercised by using a panel of experts to analyze the results of the correlation analysis to draw conclusions about which viable inter-dependencies to include in the assessment model.

D. A probabilistic model based on Bayesian theory was applied to create the model. Bayesian probability uses probability theory to manage uncertainty by explicitly representing the conditional dependencies between the different knowledge components. It offers a language and calculus for reasoning about the beliefs in the presence of uncertainty.

E. The Hugin Expert A/S (Hugin, 2006) was employed to program the Bayesian Belief Network model. The Hugin Expert A/S provides a comprehensive and flexible interface to model Bayesian Belief Networks.

F. Case studies were employed to show how the model can be conveniently and effectively used. The utility of the work and framework described in this thesis is applied to three cases. Case studies are a fairly intensive examination of what has happened in a single bounded context. This helps to explore, unravel and validate problems, issues and relationships in a particular situation.

G. The Goal-Question-Metric approach (Basili and Weiss, 1984) was followed to apply EWQPNet to three case studies. The analysis was conducted using a combination of personnel investigation and "under the hood," source code and

system inspections. The results were then plugged into EWQPNet to derive the quality level. The conclusions were measured against comparative assessments to validate the practical benefits of the work accomplished.

## 11.4 Realization

The overall conclusion is that the research has been successful in satisfying its aims and objectives and that the working framework produced should be useful for any company to use in evaluating the qualities of an E-commerce website.

It was shown in this thesis that a Bayesian Belief Network (BBN), which is a network-based technique for representing and analyzing models involving uncertainty, is an appropriate and applicable tool for the modelling and representation of E-commerce quality relationships. This technique enables the software engineering/web development community to produce solutions with more confidence, overcoming one of their biggest problems, the challenge of making good decisions using data that is usually scarce and incomplete. By modeling uncertainties, certain structural and behavioral aspects of the target system become more visible and understandable, thereby enabling future development steps to be carried out more efficiently and effectively.

This thesis has shown that it is a reliable utility to apply as an assessment tool for the E-commerce qualities of a website and the root-causes of any quality problems.

## 11.5 Moving Forward

The effort undertaken on this specific topic of E-commerce website quality assessment and in software quality in general, is minute in comparison with the sea of research opportunity and exploration this subject warrants.

In general, the output of EWQPNet is quite accurate, given the limited input provided in the case studies. This suggests that extending EWQPNet may allow for even more accurate output. The sometimes rather obvious nature of the conclusions of EWQPNet is a result of the fact that the current version of EWQPNet is relatively simple. It has,

nevertheless, been proved that the underlying principles behind EWQPNet are successful in providing a new and useful tool for website development. EWQPNet can be extended in the future to allow for more detailed analysis and guidance for website development.

Although case studies show that this is a promising technique, a larger, preferably industrial, case study is needed to validate EWQPNet. Case studies could be carried out over long periods of time so that a quality prediction could be made during a website development and an assessment subsequently made after it has been in active service for a while so that predicted success can be compared with actual success. Another extension to the case studies would be to apply the EWQPNet model to case studies outside the Middle East area. This would help identify if there are any cultural effects that would affect the applicability of the model.

The goal should be to provide a model with even lower level of subjectivity. This can be achieved by finding ways of analyzing E-commerce websites' characteristics in such a way that the user does not need to provide estimates but precise answers of a predefined nature. Furthermore, the nodes that correspond to the E-commerce websites characteristics can be further analysed into one or two levels. This is a way to improve the model's accuracy even further.

## 11.6 Related Work

Important work in the field of BBNs is that of Judea Perl (Judea, 1988). In this book the concept of belief networks is introduced and algorithms to perform calculations on BBNs are presented. Other important work in this area includes that of Drudzel and Van der Gaag (1995) where methodology for quantification of a BBN is discussed.

This research is not the first to apply belief networks to software engineering. For example: Neil and Fenton (1996) used BBNs to assess system dependability and other quality attributes. Unlike this research, their work focuses on dependability and safety aspects of software systems. Stefani et al. (2003) used BBNs to assess the quality of E-commerce systems based on the ISO 9126 quality standard (ISO, 2001). Unlike this research, their work focuses on functionality, usability, reliability and efficiency aspects

of E-commerce systems. Specifically, it relies on the set of those quality characteristics and sub-characteristics that are directly related to quality as perceived by the end-users while the model created in this research includes additional quality characteristics that are directly related to quality as perceived by the end-users and developers.

The qualitative network created in this research could be perceived as a complex quality requirement framework similar to the one presented by Stefani et al. (2003). In addition to the fact that EWQPNet is more complex, there are some structural differences compared to Stefani et al.'s (2003) model. Similar to EWQPNet, abstract attributes are decomposed into less abstract attributes, but Stefani et al.'s model is far simpler: it is only a hierarchical model that has connection between levels. In addition, there are no connections within the same level. Although Stefani et al.'s model is not as advanced as the model created in this research, the fact that their general approach, which was published well after this research had started, takes a similar direction is a verification of the research concept developed in this thesis.

## 11.7 Conclusion

This thesis has presented a technique for assessing the quality of an E-commerce website called EWQPNet. The assessment can be carried out before the completion of the website development, thus, providing insight on the likely outcome and a direction for corrections and improvements. It can also be carried out on completion and during the website operation, providing analysis of areas for improvement and support for the decision making regarding the next development steps appropriate for the website. Case studies were selected to demonstrate this and to justify its validity.

It is recommended to view the developed EWQPNet model as a base, a "Version 1.0" to be enhanced and expanded with added granularity that yields better accuracy in detailing the quality state of any assessed E-commerce website. Despite the small size of EWQPNet, the author was able to get meaningful output for the tested cases from EWQPNet. There was a little deviation from alternative, independent assessment during the case studies, but this could be explained by either examining the network more closely or by pointing out that there was a subtle difference in reviewer opinion when evaluating a certain E-commerce website.

The overall conclusion is that the research has been successful in satisfying its aims and objectives and that the working framework produced should be useful for any company to use in evaluating the qualities of E-commerce website. The results obtained gave a good indication of the usability of EWQPNet for assessing the quality of the E-commerce website.

The final objective of this thesis was to disseminate the findings through published papers and the publication of this thesis. Two papers have been published at the time of writing this thesis titled, "E-Commerce Websites Quality Factors and Their Interrelations" (Rababah et al., 2006a) and "Quality Assessment of E-Commerce Websites Using Bayesian Belief Networks" (Rababah et al., 2006b). Both papers were presented at the International Conference on Multidisciplinary Information Sciences and Technologies, InSciT 2006. After the publishing of the two research papers in the proceedings of InSciT 2006, the author received various positive responses from professionals from universities around the world. The following are two responses received:

*"I find your two papers published in the proceeding of InSciT 2006 very interesting, and I would like to introduce them to our students here in Singapore"*

Chang Yun-Ke of Nanyang Technological University, Singapore.

*"I have come across InSciT 2006 in the proceedings, and I found that your work. It's so impressive and I would prefer to share your information's within my university and in my Incubation center for the consultancy in Istanbul www.kosgeb.gov.tr with your permission"*

Dr.Mathew of Fatih University- Istanbul.

These comments represent the final endorsement of the usefulness and applicability of this research.

# Appendix A – Qualifying for the Quality Factors Questionnaire

## A.1 Introduction

To qualify for the Quality Factors Questionnaire, each person was required to obtain a score based on answering the questions stated below. The process was continued until a set of seven was obtained from Representative Consumer's group and six from the Expert Specialist group.

A score of 20 or above was used as the qualification to be considered as an expert (A score of 20 was chosen for convenience to get a range of experience of building websites with several different companies). Each question gave the respondents the option to select one answer from multiple answers. Each answer was assigned a score from 0 to 7 depending on the question. The basis for weightings each score was based on consulting experts. Its worth saying that this selection is subjective and may differ from one expert to another.

## A.2 Representative Consumers Criteria

1- How often do you visit an E-commerce website?

A. At least once daily (score 7)
B. At least once weekly (score 6)
C. At least once monthly (score 3)
D. Never did (score 0)

2- When was the last time you purchased an item only?

A. Today (score 7)
B. This week (score 6)
C. This month (score 4)
D. This year (score 3)
E. Last year (score 1)
F. Never did (score 0)

3- If you buy online, how many E-commerce websites do you use?

A. More than 5 (score 7)
B. Between 2 to 5 (score 5)
C. Only 1 (score 3)
D. N/A (score 0)

4- How many times have you purchased items online last year?

A. More than 20 (score 7)
B. 10 to 20 (score 6)
C. 5 to 10 (score 5)
D. Less than 5 (score 3)
E. N/A (score 0)

## A.3 Expert Specialist Criteria

1- How many E-commerce websites have you been part of establishing?

A. Over 5 (score 7)
B. 3 to 5 (score 5)
C. 1 to 2 (score 3)
D. Never did (score 0)

2- What role did you play as part of your last E-commerce website?

A. Customer (score 1)
B. Project Manager (score 3)
C. Technical Architect (score 7)
D. Business Analyst (score 5)
E. Software Engineer (score 3)
F. Quality Engineer (score 3)
G. Not part (score 0)

3- When was the last E-commerce website you were part of establishing?

A. Over a year (score 3)
B. Last month (score 5)

C. Currently involved (score 7)

D. Not part (score 0)

4- What is the highest hit rate your best E-commerce website has achieved?

A. Over 10,000 per week (score 7)

B. 5,000 to 10,000 per week (score 5)

C. 1,000 to 5,000 per week (score 3)

D. Less than 1,000 per week (score 2)

E. Less than 100 per week (score 0)

5- What is the highest number of different types of pages your most website generates?

A. Over 30 per week (score 7)

B. 20 - 30 (score 5)

C. 10 -20 (score 3)

D. 5 - 10 (score 2)

E. Less than 5 (score 1)

F. None (score 0)

# Appendix B - Quality Factors Questionnaire

Dear Respondent,

Thank you for your time and effort in filling out this questionnaire. By providing us with your input and insight to the questions below, you are taking part of a research study at Loughborough University - UK that examines and identifies Quality Attributes of an E-commerce website and analyzes the inter-dependencies among them. You have been selected to take part of this questionnaire based on your knowledge and experience with E-commerce websites. The questions seek to rate factors impacting quality attributes for E-commerce website.

All questions are meant to be answered on the basis of "Comparative Ratings" approach. Each question provides a list of options (also known as factors) for a quality element to a website. Our goal is to find out how these rated factors influence the probability of related quality factor under study. What is required is rating the options in terms of perceived importance to element under study. A rating of "1" applied on a factor indicates that this factor is the most influence within the set. "2" is applied to the second most important, and so on.

## B.1 Questioning E-commerce website's Usability

Usability entails the quality objective that refers to the characteristics that allow use of the E-commerce site in the most diverse situations.

Please rate the following factors in their influence in affecting the usability of an E-commerce solution

1. **Efficiency** (The timeliness of which the website responds to the user)

| **Factors** | **Ratings** |
|---|---|
| **Time behavior**<br>How far does "timing" factor in terms of processing and response to the | |

| Factors | Ratings |
|---|---|
| user influences Efficiency? | |
| **Purchase process performance**<br>How the timeliness in processing a purchase affects Efficiency? | |
| **Page generation speed**<br>How the length in time to dynamically generated page to the user affects Efficiency? | |

2. **User-Friendliness** (The user interface capabilities to which the website provide a supportive experience to the user)

| Factors | Ratings |
|---|---|
| **Understandability**<br>How important is ease-of-understanding content and direction impacts User-Friendliness of the website? | |
| **Products information availability**<br>How important is having detailed information about the products under sale on the User-Friendliness of the website? | |
| **Interactivity**<br>How important is having a highly responsiveness user interface to the user action influences the User-Friendliness of the website? | |
| **Learn-ability**<br>How important is having the abilities to remember user actions and data entered for re-use by the user influences the User-Friendliness of the website? | |
| **Localizability**<br>How important is having the abilities to adapt to language locales and localizations influence the User-Friendliness of the website? | |
| **Response time uniformity**<br>How important is the consistency of system performance between different pages and actions impacting the user expectations and influencing the User-Friendliness of the website? | |
| **Forms of payment availability** | |

| Factors | Ratings |
|---|---|
| How important is having forms of payments available online to complete the tender process impacts the User-Friendliness of the website? | |
| **Storage of purchase list**<br>How important is having the ability to store purchase lists for users affects the User-Friendliness of the website? | |
| **Help availability**<br>How important is having online help facilities in impacting the User-Friendliness of the website? | |
| **Products Comparison**<br>How important is having the ability to compare the attributes of similar products for purchase side-by-side in the User-Friendliness of the website? | |
| **"Shopping cart" metaphor**<br>How important is having the popular "shopping cart" metaphor and "checkout" facilities on the User-Friendliness of the website? | |
| **Print Facilities**<br>How important is having the ability to display pages in printable format for printing impact the User-Friendliness of the website? | |
| **Download Facilities**<br>How important is having the ability to download catalogs and product information brochures impact the User-Friendliness of the website? | |

**3. Navigability** (The browsing extensibility which the website's software allows)

| Factors | Rating |
|---|---|
| **Absence of navigation errors**<br>How important is the elimination of any navigational errors to Navigability of the website? | |
| **Minimal path & Shortcut facility**<br>How important is driving for implementing the minimum path possible to reach a functionally and providing shortcuts when needed impact the | |

| Factors | Rating |
|---|---|
| Navigability of the website? | |
| **Drawback**<br>How important is having the ability to back out from a navigational decision and interrupt a process selection on the level of Navigability of the website? | |
| **Navigation structure taxonomy**<br>How important is the navigation facilities layout, organization and structure has on the level of Navigability of the website | |
| **Links visibility**<br>How important is the visual presentation and layout of links on the level of Navigability of the website? | |
| **Links visualization consistence**<br>How the consistency of these links impacts the level of Navigability of the website? | |
| **Alternative paths**<br>How important is to provide multiple navigational options to the same destination impacts the level of Navigability of the website? | |
| **Navigational prediction**<br>How important is the predictability of each action while navigating the E-commerce website? | |
| **User level adaptability**<br>How important is having navigational options change to the change in the user type and class impact the level of Navigability of the website | |
| **Interaction storage capacity**<br>How important is having the ability to remember and retrace the user's sequence of navigational actions on the Navigability of the website? | |
| **Mobile devices accessibility**<br>How important is having the accessibility from mobile devices such as cellular phones to the website influences the level of Navigability of the website? | |

**4. Maintainability** (The reduced efforts to which the website's software requires for its upkeep, enhancing its ability to be kept up to date and usable)

| Factors | Ratings |
|---|---|
| **Stability**<br>How important is the stability in the functionalities of the website influences the level of Maintainability? | |
| **Testability**<br>How important is the capability of the website system to put itself into various test oracles? | |
| **Analyzability**<br>How important is the ease of analyzability of the website in terms of functionality and implementation impacts the level of Maintainability of the website? | |
| **Changeability**<br>How important is the ease of making structural and component-based changes impacts to the level of Maintainability of the website? | |

**5. Involvement Capacities** (The measure of which the website can adapt to and attract each user's individuality)

| Factors | Ratings |
|---|---|
| **Attractiveness**<br>How important is the attractiveness of the website in capturing the involvement levels of users? | |
| **Aesthetic attributes**<br>How important is conforming to accepted notions of good taste and style impacts the involvement levels of users? | |
| **Client profile identification**<br>How important is identifying with the user's profile and adapting the layout and structure of the website to the user preferences impacts the involvement levels of users? | |
| **Simulation** | |

| Factors | Ratings |
|---|---|
| How important is providing simulation of functionalities in maximize the user's involvement? | |
| **Additional services availability**<br>How important is providing "extras" in terms of services draws on higher level of users involvement? | |

## B.2 Questioning E-commerce website's Conceptual Reliability

Conceptual reliability is concerned with the E-commerce site's capacity to implement, satisfactorily, what was specified and designed.

Please rate the following factors in their influence in affecting the Conceptual reliability of an E-commerce solution.

**1. Functionality** (The extend of the operational aspects of the website software and its fitness of use)

| Factors | Rating |
|---|---|
| **Accuracy**<br>How important is the accuracy of data content and computations in assessing the level of Functionality of the E-commerce website? | |
| **Client support**<br>How important is having client support provided with the system impacts the level of Functionality of the E-commerce website? | |
| **Information on product delivery**<br>How important is providing additional information on the products status of delivery impacts the level of Functionality of the E-commerce website? | |
| **Suitability**<br>How important is the suitability of the site to the users conditions in terms of the user's background, culture and aspiration in impacting the level of Functionality of the E-commerce website? | |

| Factors | Rating |
|---|---|
| **Flexibility**<br>How important is having flexibility when undergoing user operations impacts the level of Functionality of the E-commerce website? | |
| **Interoperability**<br>How important is the level of interoperability the website software has in interfacing with other business-level systems impacts the level of Functionality of the E-commerce website? | |

**2. Security** (The extend of safety assured when using the website)

| Factors | Rating |
|---|---|
| **Payment systems security**<br>How important is the security of the payment system has in assessing the overall security of the E-commerce website? | |
| **Vulnerability**<br>How important is the vulnerability of the website is to attacks from intruders' impacts the overall security assessment of the E-commerce website? | |
| **Site authentication**<br>How important having to authenticate users to access the website on the overall security assessment of the E-commerce website? | |
| **Access control (authorization)**<br>How important having different levels of access controls to the websites services in assessing the overall security of the website? | |
| **Confidentiality**<br>How important is securing confidential information through tools such as encryptions impacts the overall security assessment of the E-commerce website? | |
| **Privacy**<br>How important is securing and protecting access to users' private information impacts the overall security assessment of the E-commerce website? | |

**3. Reliability** (The extend of which the website's software can sustain against irregularities)

| Factors | Ratings |
|---|---|
| **Recoverability**<br>How important having the ability to recover for data entry or operational error and the continuity of the system impacts the reliability of the E-commerce website? | |
| **Maturity**<br>How important the level of maturity and development cycle the underlying website software underwent on the level of reliability of the E-commerce website? | |
| **Fault tolerance**<br>How important is resilience to faults the underlying website software has on the level of reliability of the E-commerce website? | |

**4. Integrity** (The reliability, consistency and correctness of stored data)

| Factors | Ratings |
|---|---|
| **Data Integrity**<br>How important the level of integrity of the data on the overall integrity of the E-commerce website? | |
| **Data entry signalizing**<br>How important the validation and consistency control applied on data entered impact the overall integrity of the E-commerce website? | |
| **Robustness**<br>How important having the output and operation inventiveness to mal-practices in inputs and user directions impact the overall integrity of the E-commerce website? | |
| **Audit trail**<br>How important having an audit trail tracing the operations and transactions of the system in impacting the overall integrity of the E-commerce website? | |

**5. Trustworthiness** (The extend to which the website behaves consistently and reliability to build trusting relation with the user)

| Factors | Ratings |
|---|---|
| **Correctness**<br>How important is the correctness in responses to user actions impact the level trustworthiness in E-commerce websites? | |
| **Completeness**<br>How important is it to have complete information in the E-commerce solution impact the level trustworthiness in E-commerce websites? | |
| **Necessity**<br>How important assessing the necessity of content impact the level trustworthiness in E-commerce websites? | |

**6. Content Adequacy** (The extend to which the information presented is contextually applicable to the user)

| Factors | Ratings |
|---|---|
| **Updated content**<br>How important the frequency in updating content impacts the levels of Content Adequacy in the E-commerce website? | |
| **Correctness**<br>How important is correctness of information and content impacts the levels of Content Adequacy in the E-commerce website? | |
| **Intelligibility**<br>How important is incorporating intelligence in the website application impacts the levels of Content Adequacy in the E-commerce website? | |
| **User oriented**<br>How important is making the website application sensitively oriented to the users and their attributes impacts the levels of Content Adequacy in the E-commerce website? | |
| **Respectability**<br>How important framing the content in respectable languages and dialects | |

| | |
|---|---|
| impacts the levels of Content Adequacy in the E-commerce website? | |
| **Concise content**<br>How important having the content concise on the subject matter impacts the levels of Content Adequacy in the E-commerce website? | |
| **Completeness**<br>How important having the content complete with the necessary requirements about the products and purchases impacts the levels of Content Adequacy in the E-commerce website? | |
| **Compatibility with real store**<br>How important having the content resembles "real store" experience impacts the levels of Content Adequacy in the E-commerce website? | |

**7. Scalability** (The website readiness to meet rising demands in users and usage)

| Factors | Ratings |
|---|---|
| **Multiprocessor handling**<br>How important is having the system scale with processing additions to the hosting server impacts the level of scalability in the E-commerce website? | |
| **Farming capabilities**<br>How important is having the extend with multiple machines impacts the level of scalability in the E-commerce website? | |

**8. Availability** (The website extend of accessibility to users through different browsers in differing times)

| Factors | Ratings |
|---|---|
| **24/7/365**<br>How important having the system available round the clock in a 24 by 7 mode impacts the level of availability the E-commerce website has? | |
| **Partial Availability**<br>How important having partial availability an option impacts the level of availability the E-commerce website has? | |

| Factors | Ratings |
|---|---|
| **Browser version compatibility**<br>How important is ensuring the website software compatibility with different version of the same web browser software impacts he level of availability the E-commerce website has? | |
| **Cross-browser Support**<br>How important is ensuring the website software compatibility with different brands and types of web browser software impacts the level of availability the E-commerce website has? | |

## B.3 Questioning E-commerce website's Representation Reliability

Representative reliability refers to the E-commerce site's representation characteristics that affect its understanding and manipulation along its lifecycle.

Please rate the following factors in their influence in affecting the Conceptual reliability of an E-commerce solution.

**1. Readability** (The appropriate application of the written language within the website)

| Factors | Ratings |
|---|---|
| **Language correctness**<br>How important is the correctness in language influences the readability levels of the E-commerce website? | |
| **Style uniformity**<br>How important is the uniformity in language and writing styles influences the readability levels of the E-commerce website. | |
| **Clarity**<br>How important is the clarity in the messages conveyed influences the readability levels of the E-commerce website? | |
| **Conciseness**<br>How important how concise the writings in the website's content influences the readability levels of the E-commerce website? | |

| Factors | Ratings |
|---|---|
| **Terminology uniformity**<br>How important is the uniformity and consistency in use of terminology influences the readability levels of the E-commerce website? | |
| **Abstraction uniformity**<br>How important is the uniformity in abstraction of concepts influences the readability levels of the E-commerce website? | |

**2. Standards Conformance** (The extend of consistency applied within the user interface of the website)

| Factors | Ratings |
|---|---|
| **Interface standards**<br>How important is standardizing the interface influences the conformance to standards assessment of the E-commerce website? | |
| **Programming standards**<br>How important is standardizing the programming and code style influences the conformance to standards assessment of the E-commerce website? | |
| **Navigation standards**<br>How important is standardizing the navigational menu and mechanism influences the conformance to standards assessment of the E-commerce website? | |

**3. Ease of Manipulate** (The extend of help provided to operate the website and the software underneath it)

| Factors | Ratings |
|---|---|
| **Up-to-date**<br>How important is having the underlying website software up to date with tools and technologies influences how easy is to manipulate and update the E-commerce website? | |
| **Ability to trace**<br>How important is having abilities in the underlying website software to trace operations influences how easy is to manipulate and update the E- | |

| Factors | Ratings |
|---|---|
| commerce website? | |
| **Documentation availability**<br>How important is having documentation on the underlying website software implementation influences how easy is to manipulate and update the E-commerce website? | |
| **Structure**<br>How important is having the underlying website software implementation adhering to a well defined structure influences how easy is to manipulate and update the E-commerce website? | |

Thank you for your participation and responses

# Appendix C - Quality Response Results

## C.1 Introduction

The questions in the questionnaire were meant to be answered on the basis of "Comparative Ratings" methodology. Each Quality Factor was treated as a "fact" having a list of factors that attributes to its probability of being true. The survey sought to rate these factors in order of importance, where 1 meant the most important contributor to the validity of the fact, 2 is the second most important and so on.

For example, a question in the questionnaire sought to analyze the contributing factors that impact the Efficiency of an E-commerce web site. The list is given in Table C-1

**- Table C-1: Factors that impact the Efficiency of an E-commerce web site -**

| Factors | Ratings |
|---|---|
| **Time behavior**<br>How far does "timing" factor in terms of processing and response to the user influences Efficiency | |
| **Purchase process performance**<br>How the timeliness in processing a purchase affects Efficiency | |
| **Page generation speed**<br>How the length in time to dynamically generated page to the user affects Efficiency | |

According to their importance in the opinion of the qualified interviewee, a rating was given, as in the example in Table C-2, rating "Time behavior" as the most important contributor and "Page generation speed" the least.

**- Table C-2: Example ratings -**

| Factors | Ratings |
|---|---|
| **Time behavior**<br>How far does "timing" factor in terms of processing and response to | **1** |

| Factors | Ratings |
|---|---|
| the user influences Efficiency | |
| **Purchase process performance**<br>How the timeliness in processing a purchase affects Efficiency | **2** |
| **Page generation speed**<br>How the length in time to dynamically generated page to the user affects Efficiency | **3** |

The responses were compiled and rated in the Table C-3.

**- Table C-3: Full list of ratings of all respondents -**

| S | QF | SF | Title | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | M | N | Rnk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | **Usability** | | | | | | | | | | | | | | | |
| 1 | 1 | 0 | **Efficiency** | | | | | | | | | | | | | | | |
| 1 | 1 | 1 | Time Behavior | 1 | 1 | 2 | 1 | 2 | 3 | 2 | 1 | 2 | | 2 | | 1.42 | 3 | **53** |
| 1 | 1 | 2 | Purchase Process Performance | 3 | 3 | 3 | 1 | 3 | 1 | 3 | 3 | 3 | | 1 | | 2.00 | 3 | 33 |
| 1 | 1 | 3 | Page Generation Speed | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | | 3 | | 1.42 | 3 | **53** |
| 1 | 2 | 0 | **User-Friendliness** | | | | | | | | | | | | | | | |
| 1 | 2 | 1 | Understandability | 4 | 3 | 3 | 5 | 4 | 5 | 3 | 3 | 1 | 5 | 1 | 3 | 3.33 | 14 | **76** |
| 1 | 2 | 2 | Products Information Availability | 14 | 12 | 13 | 14 | 14 | 6 | 1 | 13 | 13 | 12 | 13 | 5 | 10.83 | 14 | 23 |
| 1 | 2 | 3 | Interactivity | 5 | 7 | 5 | 1 | 6 | 1 | 4 | 1 | 4 | 3 | 5 | 4 | 3.83 | 14 | **73** |
| 1 | 2 | 4 | Learn-ability | 6 | 6 | 2 | 4 | 5 | 2 | 5 | 2 | 3 | 1 | 6 | 12 | 4.50 | 14 | **68** |
| 1 | 2 | 5 | Localizability | 13 | 13 | 14 | 13 | 13 | 7 | 13 | 5 | 2 | 11 | 14 | 6 | 10.33 | 14 | 26 |
| 1 | 2 | 6 | Response Time Uniformity | 3 | 4 | 4 | 3 | 8 | 3 | 2 | 4 | 6 | 4 | 2 | 1 | 3.67 | 14 | **74** |
| 1 | 2 | 7 | Forms Of Payment Availability | 12 | 14 | 12 | 12 | 12 | 4 | 8 | 12 | 9 | 8 | 3 | 7 | 9.42 | 14 | 33 |
| 1 | 2 | 8 | Storage Of Purchase List | 11 | 11 | 11 | 11 | 11 | 11 | 14 | 11 | 10 | 9 | 4 | 8 | 10.17 | 14 | 27 |
| 1 | 2 | 9 | Help Availability | 7 | 8 | 10 | 6 | 1 | 9 | 7 | 6 | 8 | 2 | 7 | 9 | 6.67 | 14 | **52** |
| 1 | 2 | 10 | Products Comparison | 1 | 2 | 6 | 8 | 3 | 14 | 10 | 7 | 7 | 10 | 8 | 11 | 7.25 | 14 | 48 |
| 1 | 2 | 11 | "Shopping Cart" Metaphor | 2 | 1 | 1 | 2 | 2 | 10 | 9 | 14 | 14 | 7 | 9 | 10 | 6.75 | 14 | **52** |
| 1 | 2 | 12 | Printing Facilities | 9 | 10 | 8 | 9 | 9 | 12 | 11 | 8 | 11 | 13 | 11 | 13 | 10.33 | 14 | 26 |
| 1 | 2 | 13 | Download Facilities | 8 | 9 | 7 | 7 | 10 | 13 | 12 | 10 | 12 | 14 | 12 | 14 | 10.67 | 14 | 24 |
| 1 | 3 | 0 | **Navigability** | | | | | | | | | | | | | | | |
| 1 | 3 | 1 | Absence Of Navigation Errors | 4 | 4 | 5 | 1 | 2 | 1 | 7 | 3 | 2 | 4 | 6 | 4 | 3.58 | 11 | **67** |
| 1 | 3 | 2 | Minimal Path & Shortcut Facility | 1 | 3 | 2 | 2 | 3 | 4 | 3 | 2 | 1 | 3 | 1 | 2 | 2.25 | 11 | **80** |
| 1 | 3 | 3 | Drawback | 11 | 9 | 11 | 8 | 9 | 7 | 9 | 10 | 11 | 7 | 11 | 8 | 9.25 | 11 | 16 |
| 1 | 3 | 4 | Navigation Structure Taxonomy | 3 | 2 | 1 | 5 | 4 | 2 | 1 | 5 | 3 | 1 | 3 | 1 | 2.58 | 11 | **66** |
| 1 | 3 | 5 | Links Visibility | 2 | 1 | 3 | 3 | 1 | 3 | 4 | 1 | 4 | 2 | 4 | 3 | 2.58 | 11 | **72** |
| 1 | 3 | 6 | Links Visualization Consistence | 6 | 5 | 6 | 7 | 6 | 8 | 5 | 7 | 5 | 6 | 2 | 5 | 5.67 | 11 | 48 |
| 1 | 3 | 7 | Alternative Paths | 5 | 7 | 10 | 9 | 10 | 9 | 11 | 6 | 6 | 5 | 10 | 7 | 7.92 | 11 | 28 |
| 1 | 3 | 8 | Navigational Prediction | 10 | 11 | 9 | 4 | 11 | 10 | 10 | 8 | 9 | 9 | 8 | 11 | 9.17 | 11 | 17 |
| 1 | 3 | 9 | User Level Adaptability | 7 | 6 | 4 | 6 | 5 | 5 | 2 | 11 | 7 | 8 | 5 | 6 | 6.00 | 11 | 45 |

| S | QF | SF | Title | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | M | N | Rnk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 10 | Interaction Storage Capacity | 9 | 8 | 7 | 11 | 8 | 6 | 6 | 4 | 8 | 10 | 7 | 10 | 7.83 | 11 | 29 |
| 1 | 3 | 11 | Mobile Devices Accessibility | 8 | 10 | 8 | 10 | 7 | 11 | 8 | 9 | 10 | 11 | 9 | 9 | 9.17 | 11 | 17 |
| **1** | **4** | **0** | **Maintainability** | | | | | | | | | | | | | | | |
| 1 | 4 | 1 | Stability | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 3 | 1.58 | 4 | **60** |
| 1 | 4 | 2 | Testability | 3 | 4 | 3 | 2 | 2 | 3 | 4 | 4 | 3 | 2 | 3 | 2 | 2.92 | 4 | 27 |
| 1 | 4 | 3 | Analyzability | 4 | 3 | 4 | 4 | 3 | 4 | 3 | 3 | 4 | 3 | 4 | 4 | 3.58 | 4 | 10 |
| 1 | 4 | 4 | Changeability | 2 | 1 | 1 | 3 | 4 | 2 | 2 | 1 | 1 | 4 | 1 | 1 | 1.92 | 4 | **52** |
| **1** | **5** | **0** | **Involvement Capacity** | | | | | | | | | | | | | | | |
| 1 | 5 | 1 | Attractiveness | 1 | 1 | 1 | 2 | 3 | 1 | 3 | 1 | 1 | 3 | 3 | 2 | 1.83 | 5 | **63** |
| 1 | 5 | 2 | Aesthetic Attributes | 2 | 4 | 3 | 3 | 2 | 2 | 1 | 2 | 3 | 2 | 1 | 3 | 2.33 | 5 | **53** |
| 1 | 5 | 3 | Client Profile Identification | 3 | 2 | 2 | 5 | 1 | 3 | 2 | 3 | 2 | 1 | 2 | 1 | 2.25 | 5 | **55** |
| 1 | 5 | 4 | Simulation | 4 | 3 | 4 | 4 | 5 | 5 | 4 | 3 | 4 | 4 | 4 | 4 | 4.00 | 5 | 20 |
| 1 | 5 | 5 | Additional Services Availability | 5 | 5 | 5 | 1 | 4 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 4.50 | 5 | 10 |
| **2** | **0** | **0** | **Conceptual Reliability** | | | | | | | | | | | | | | | |
| **2** | **1** | **0** | **Functionality** | | | | | | | | | | | | | | | |
| 2 | 1 | 1 | Accuracy | 1 | 3 | 2 | 1 | 4 | 1 | 2 | 1 | 3 | 2 | 1 | 3 | 2.00 | 6 | **67** |
| 2 | 1 | 2 | Client Support | 2 | 2 | 1 | 2 | 3 | 5 | 3 | 2 | 4 | 3 | 2 | 5 | 2.83 | 6 | **53** |
| 2 | 1 | 3 | Information On Product Delivery | 3 | 4 | 3 | 3 | 1 | 4 | 6 | 6 | 1 | 4 | 3 | 2 | 3.33 | 6 | 44 |
| 2 | 1 | 4 | Suitability | 4 | 1 | 4 | 4 | 2 | 3 | 1 | 3 | 2 | 1 | 4 | 1 | 2.50 | 6 | **58** |
| 2 | 1 | 5 | Flexibility | 5 | 5 | 5 | 5 | 6 | 2 | 5 | 4 | 5 | 5 | 6 | 6 | 4.92 | 6 | 18 |
| 2 | 1 | 6 | Interoperability | 6 | 6 | 6 | 6 | 5 | 6 | 4 | 5 | 6 | 6 | 5 | 4 | 5.42 | 6 | 10 |
| **2** | **2** | **0** | **Security** | | | | | | | | | | | | | | | |
| 2 | 2 | 1 | Payment Systems Security | 1 | 2 | 1 | 5 | 1 | 1 | 1 | 2 | 1 | 6 | 5 | 4 | 2.50 | 6 | **58** |
| 2 | 2 | 2 | Vulnerability | 6 | 5 | 4 | 6 | 6 | 5 | 5 | 4 | 6 | 4 | 6 | 5 | 5.17 | 6 | 14 |
| 2 | 2 | 3 | Site Authentication | 3 | 1 | 3 | 3 | 2 | 3 | 3 | 6 | 2 | 1 | 3 | 1 | 2.58 | 6 | **57** |
| 2 | 2 | 4 | Access Control | 4 | 3 | 2 | 2 | 3 | 2 | 4 | 3 | 5 | 2 | 2 | 3 | 2.92 | 6 | **51** |
| 2 | 2 | 5 | Confidentiality | 5 | 6 | 5 | 4 | 5 | 6 | 6 | 5 | 4 | 3 | 4 | 6 | 4.92 | 6 | 18 |
| 2 | 2 | 6 | Privacy | 2 | 4 | 6 | 1 | 4 | 4 | 2 | 1 | 3 | 5 | 1 | 2 | 2.92 | 6 | **51** |
| **2** | **3** | **0** | **Reliability** | | | | | | | | | | | | | | | |
| 2 | 3 | 1 | Recoverability | 1 | 1 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 1.42 | 3 | **53** |
| 2 | 3 | 2 | Maturity | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3.00 | 3 | 0 |
| 2 | 3 | 3 | Fault Tolerance | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1.58 | 3 | 47 |
| **2** | **4** | **0** | **Integrity** | | | | | | | | | | | | | | | |
| 2 | 4 | 1 | Data Integrity | 1 | 1 | 1 | 1 | 3 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1.25 | 3 | **58** |
| 2 | 4 | 2 | Robustness | 2 | 3 | 3 | 3 | 1 | 3 | 1 | 3 | 3 | 1 | 3 | 2 | 2.33 | 3 | 22 |
| 2 | 4 | 3 | Audit Trail | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 2.25 | 3 | 25 |
| **2** | **5** | **0** | **Trustworthiness** | | | | | | | | | | | | | | | |
| 2 | 5 | 1 | Correctness | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.00 | 2 | 50 |
| 2 | 5 | 2 | Completeness | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.00 | 2 | 0 |
| **2** | **6** | **0** | **Content Adequacy** | | | | | | | | | | | | | | | |
| 2 | 6 | 1 | Updated Content | 1 | 1 | 2 | 3 | 2 | 1 | 6 | 3 | 2 | 6 | 3 | 1 | 2.58 | 8 | **68** |
| 2 | 6 | 2 | Correctness | 2 | 2 | 1 | 2 | 5 | 2 | 7 | 1 | 1 | 5 | 2 | 7 | 3.08 | 8 | **61** |
| 2 | 6 | 3 | Intelligibility | 8 | 6 | 3 | 6 | 6 | 7 | 8 | 5 | 4 | 4 | 8 | 6 | 5.92 | 8 | 26 |
| 2 | 6 | 4 | User Oriented | 5 | 5 | 4 | 1 | 3 | 6 | 4 | 2 | 3 | 3 | 4 | 3 | 3.58 | 8 | **55** |
| 2 | 6 | 5 | Respectability | 6 | 7 | 6 | 5 | 8 | 3 | 5 | 8 | 5 | 8 | 6 | 5 | 6.00 | 8 | 25 |

| S | QF | SF | Title | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | A12 | M | N | Rnk |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 6 | 6 | Concise Content | 4 | 4 | 7 | 8 | 4 | 8 | 3 | 4 | 6 | 2 | 5 | 4 | 4.92 | 8 | 39 |
| 2 | 6 | 7 | Completeness | 3 | 3 | 5 | 4 | 1 | 4 | 2 | 7 | 7 | 7 | 1 | 2 | 3.83 | 8 | **52** |
| 2 | 6 | 8 | Compatibility With Real Store | 7 | 8 | 8 | 7 | 7 | 5 | 1 | 6 | 8 | 1 | 7 | 8 | 6.08 | 8 | 24 |
| **2** | **7** | **0** | **Scalability** | | | | | | | | | | | | | | | |
| 2 | 7 | 1 | Multiprocessor handling | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | | | 2 | 1.58 | 2 | 21 |
| 2 | 7 | 2 | Farming capabilities | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | | | 1 | 0.92 | 2 | **54** |
| **2** | **8** | **0** | **Availability** | | | | | | | | | | | | | | | |
| 2 | 8 | 1 | 24/7/365 Readiness | 1 | 3 | 3 | 1 | 2 | 4 | 2 | 1 | 2 | 3 | 2 | 4 | 2.33 | 5 | **53** |
| 2 | 8 | 2 | Partial Availability | 5 | 4 | 2 | | 1 | 5 | 4 | 4 | 1 | 4 | 4 | 3 | 3.08 | 5 | 38 |
| 2 | 8 | 3 | Notification Integrity | 4 | 5 | 5 | 3 | 4 | 3 | 3 | 5 | 5 | 5 | 5 | 5 | 4.33 | 5 | 13 |
| 2 | 8 | 4 | Browser version compatibility | 2 | 1 | 1 | | 3 | 2 | 5 | 2 | 3 | 2 | 3 | 2 | 2.17 | 5 | **57** |
| 2 | 8 | 5 | Cross Browser Support | 3 | 2 | 4 | 2 | 5 | 1 | 1 | 3 | 4 | 1 | 1 | 1 | 2.33 | 5 | **53** |
| **3** | **0** | **0** | **Representation Reliability** | | | | | | | | | | | | | | | |
| **3** | **1** | **0** | **Readability** | | | | | | | | | | | | | | | |
| 3 | 1 | 1 | Language Correctness | 1 | 2 | 1 | 1 | 2 | 3 | 1 | 1 | 1 | 1 | 3 | 1 | 1.50 | 6 | **75** |
| 3 | 1 | 2 | Style Uniformity | 3 | 3 | 3 | 4 | 6 | 2 | 3 | 6 | 2 | 6 | 2 | 5 | 3.75 | 6 | 38 |
| 3 | 1 | 3 | Clarity | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 3 | 1 | 4 | 3 | 2.00 | 6 | **67** |
| 3 | 1 | 4 | Conciseness | 4 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 5 | 2 | 1 | 2 | 4.00 | 6 | 33 |
| 3 | 1 | 5 | Terminology Uniformity | 5 | 4 | 6 | 3 | 3 | 4 | 6 | 3 | 4 | 5 | 6 | 6 | 4.58 | 6 | 24 |
| 3 | 1 | 6 | Abstraction Uniformity | 6 | 6 | 5 | 6 | 4 | 6 | 4 | 4 | 6 | 6 | 5 | 4 | 5.17 | 6 | 14 |
| **3** | **2** | **0** | **Standards Conformance** | | | | | | | | | | | | | | | |
| 3 | 2 | 1 | Interface Standards | 1 | 3 | 1 | 2 | 1 | 1 | | 1 | | 2 | 1 | 1 | 1.17 | 3 | **61** |
| 3 | 2 | 2 | Programming Standards | 2 | 2 | 3 | 3 | 2 | 2 | | 2 | | 1 | 2 | 2 | 1.75 | 3 | 42 |
| 3 | 2 | 3 | Navigation Standards | 3 | 1 | 2 | 1 | 3 | 3 | | 3 | | 3 | 3 | 3 | 2.08 | 3 | 31 |
| **3** | **3** | **0** | **Ease Of Manipulation** | | | | | | | | | | | | | | | |
| 3 | 3 | 1 | Up-To-Date | 1 | 1 | 2 | 1 | 4 | 4 | 4 | 3 | 3 | 1 | 2 | 1 | 2.25 | 4 | 44 |
| 3 | 3 | 2 | Ability To Trace | 2 | 3 | 4 | 2 | 3 | 2 | 1 | 4 | 1 | 2 | 3 | 3 | 2.50 | 4 | 38 |
| 3 | 3 | 3 | Documentation Availability | 3 | 2 | 3 | 4 | 2 | 1 | 2 | 2 | 4 | 3 | 4 | 2 | 2.67 | 4 | 33 |
| 3 | 3 | 4 | Structure | 4 | 4 | 1 | 3 | 1 | 3 | 3 | 1 | 2 | 4 | 1 | 4 | 2.58 | 4 | 35 |

# Appendix D – Panel of Experts Profile

## D.1 Introduction

Identifying the interdependencies between E-commerce quality factors and sub-factors was based on a two-stage approach. The initial stage provided statistical analysis on the correlations among factors. For the second stage, a panel of subject experts was invited to perform their analysis and draw conclusions on the relevant and important cause-effect relations among the factors. Below is the profile of the panel members.

## D.2 Panel Profiles.

### D.2.1 Basil Qubain, Estarta Solutions

Qubain is the Senior Director of the Innovation Centre at Estarta. With over 17 years of experience in IT, Qubain's focus is on providing leading edge technologies in the "e" web space, in particularly, the business-to-business and government-to-government domains. Qubain has managed and directed over 65 software projects in his career, half of which were on Internet-based technologies and over a third serving E-commerce objectives.

Estarta Solutions is a regional software innovation provider. The company is co-owned by Microsoft Corporation and Cisco Systems, and focuses on the enablement of its client through leading software solutions. Their motto is "Turning Visions to Reality."

### D.2.2 Osamah Telfah, ePageCafe

Telfah is the principle owner and Chief Architect of ePageCafe. With over 8 years of experience, Telfah has focused on the development E-commerce applications with a specialization in the facilitation and securing of financial transactions. In his career, Telfah has been exposed and involved in a variety of tools and platforms for implementing E-commerce solutions ranging from propriety GCI scripting to high-end turnkey commerce services such as Microsoft Site Builder.

ePageCafe, formally known as IT Matrix, has been in business for over five years focusing on providing E-Commerce website development and services to business-to-

consumer and consumer-to-consumer clientele. Clients can rely on ePageCafe to realize their E-commerce goals by utilizing off-the-shelf tools and applications developed by ePageCafe or tailoring their implementation utilizing their software development human resources.

### D.2.3 Dawsar Zghoul, Softact Inc

Zghoul is the Chief Technology Architect of Softact. He has over 10 years of experience in software and web-based application development, particularly in the business-to-consumer and government-to-citizens domains. Zghoul has played several roles in E-commerce projects from Architect to Software Engineer. Zghoul exploited several tools and technologies from Microsoft, Java Soft and the Open Source Foundation. His current role is advising on the architectural direction in client E-commerce website engagements and providing training and coaching on E-commerce website implementation.

Softact is a leader in workplace learning and performance. The company advises clients on how to reduce the technology adoption lifecycle and improve the delivery framework of IT, through coaching, training and consultancy support. Softact's Internet portal itself is an E-commerce website.

# Appendix E - Conditional Probability Table Listings

The tables below are the conditional probability tables for the created Bayesian Belief Network. The tables are screen shots from the application developed using the Hugin Expert A/S software for Bayesian Belief Networks (Hugin, 2006).

If the node is parentless, the node will contain a marginal probability table of the probability distribution over the states of the variable that it represents. If the node has parents represented by arcs or edges, the node contains a conditional probability table (CPT) where each cell in the table contains a conditional probability for the node being in a specific state, given a specific configuration of the states of its parents. The number of cells in a CPT for a discrete node is the product of the number of possible states for the node and the number of possible states for the parent nodes.

**Table E-1 - Availability Probabilities**

| Availability | Labelled |
|---|---|
| + | 0.33 |
| 0 | 0.34 |
| - | 0.33 |

**Table E-2 - Accuracy Probabilities**

| Accuracy | Labelled |
|---|---|
| + | 0.33 |
| 0 | 0.34 |
| - | 0.33 |

**Table E-3 - Content Adequacy Probabilities**

| entAdequacy | Labelled |
|---|---|
| + | 0.33 |
| 0 | 0.34 |
| - | 0.33 |

**Table E-4 - Efficiency Probabilities**

| Efficiency | Labelled |
|---|---|
| + | 0.33 |
| 0 | 0.34 |
| - | 0.33 |

**Table E-5 - Integrity Probabilities**

| Integrity | Labelled |
|---|---|
| + | 0.33 |
| 0 | 0.34 |
| - | 0.33 |

**Table E-6 - Involved Capacity Probabilities**

| InvolvCap | Labelled |
|---|---|
| + | 0.33 |
| 0 | 0.34 |
| - | 0.33 |

**Table E-7 - Navigability Probabilities**

| Navigability | Labelled |
|---|---|
| + | 0.33 |
| 0 | 0.34 |
| - | 0.33 |

**Table E-8 - Reliability Probabilities**

| Reliability | Labelled |
|---|---|
| + | 0.33 |
| 0 | 0.34 |
| - | 0.33 |

**Table E-9 - Scalability Probabilities**

| Scalability | Labelled |
|---|---|
| + | 0.33 |
| 0 | 0.34 |
| - | 0.33 |

**Table E-10 - Security Probabilities**

| Security | Labelled |
|---|---|
| + | 0.33 |
| 0 | 0.34 |
| - | 0.33 |

**Table E-11 - Standard Conformance Probabilities -**

| ardConform | Labelled |
|---|---|
| + | 0.33 |
| 0 | 0.34 |
| - | 0.33 |

**Table E-12 - User-Friendliness Probabilities**

| Friendliness | Labelled |
|---|---|
| + | 0.33 |
| 0 | 0.34 |
| - | 0.33 |

**Table E-13 - Readability Probabilities**

| Readability | Labelled |
|---|---|
| + | 0.33 |
| 0 | 0.34 |
| - | 0.33 |

**Table E-14 - Functionality Probabilities**

| Functionality | Labelled | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| InvolvCap | + | | | 0 | | | - | | |
| Accuracy | + | 0 | - | + | 0 | - | + | 0 | - |
| + | 1 | 0.9 | 0.5 | 0.3 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0.1 | 0.5 | 0.7 | 1 | 0.5 | 0.4 | 0.05 | 0 |
| - | 0 | 0 | 0 | 0 | 0 | 0.5 | 0.6 | 0.95 | 1 |

**Table E-15 - Maintainability Probabilities**

| Maintainability | Labelled | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Scalability | + | | | 0 | | | - | | |
| StandardConfor... | + | 0 | - | + | 0 | - | + | 0 | - |
| + | 1 | 0.85 | 0.2 | 0.65 | 0 | 0 | 0.45 | 0 | 0 |
| 0 | 0 | 0.15 | 0.75 | 0.35 | 0.9 | 0.5 | 0.55 | 0.15 | 0 |
| - | 0 | 0 | 0.05 | 0 | 0.1 | 0.5 | 0 | 0.85 | 1 |

**Table E-16 - Trustworthiness Probabilities**

| Trustworthiness | Labelled | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Security | + | | | 0 | | | - | | |
| Accuracy | + | 0 | - | + | 0 | - | + | 0 | - |
| + | 1 | 0.9 | 0.5 | 0.3 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0.1 | 0.5 | 0.7 | 1 | 0.5 | 0.4 | 0.05 | 0 |
| - | 0 | 0 | 0 | 0 | 0 | 0.5 | 0.6 | 0.95 | 1 |

**Table E-17 - Representative Reliability Probabilities**

| Representative | Labelled | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| StandardConfor... | + | | | 0 | | | - | | |
| Readability | + | 0 | - | + | 0 | - | + | 0 | - |
| Yes | 0.995 | 0.8 | 0.55 | 0.85 | 0.6 | 0.4 | 0.55 | 0.4 | 0.2 |
| No | 0.005 | 0.2 | 0.45 | 0.15 | 0.4 | 0.6 | 0.45 | 0.6 | 0.8 |

**Table E-18 -Conceptual Reliability Probabilities -**

| Conceptual | Labelled | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Security | + | | | | | | | | | | | | | | | | | |
| Integrity | + | | | | | | | | | | | | | | | | | |
| ContentAdequacy | + | | | | | | | | | | | | | | | | | |
| Functionality | + | | | | | | | | | | | | | | | | | |
| Trustworthiness | + | | | | | | | | | | | | | | | | | |
| Reliability | + | | | | | | | | | 0 | | | | | | | | |
| Availability | + | | | 0 | | | - | | | + | | | 0 | | | - | | |
| Scalability | + | 0 | - | + | 0 | - | + | 0 | - | + | 0 | - | + | 0 | - | + | | |
| Yes | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | | |
| No | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | | |

*Only a portion of the table is shown. Actual table contains 100 different probability conditions*

**Table E-19 -Usability Probabilities**

| Useability | Labelled | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UserFriendliness | + | | | | | | | | | | | | | | | | | |
| Navigability | + | | | | | | | | | 0 | | | | | | | | |
| Maintainability | + | | | 0 | | | - | | | + | | | 0 | | | - | | |
| Efficiency | + | 0 | - | + | 0 | - | + | 0 | - | + | 0 | - | + | 0 | - | + | | |
| Yes | 0.995 | 0.8 | 0.55 | 0.85 | 0.6 | 0.4 | 0.55 | 0.4 | 0.2 | 0.8 | 0.65 | 0.45 | 0.7 | 0.45 | 0.2 | 0.5 | | |
| No | 0.005 | 0.2 | 0.45 | 0.15 | 0.4 | 0.6 | 0.45 | 0.6 | 0.8 | 0.2 | 0.35 | 0.55 | 0.3 | 0.55 | 0.8 | 0.5 | | |

*Only a portion of the table is shown. Actual table contains 36 different probability conditions*

**Table E-20 -Quality Probabilities**

| Quality | Labelled | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Representative | Yes | | | | No | | | |
| Conceptual | Yes | | No | | Yes | | No | |
| Useability | Yes | No | Yes | No | Yes | No | Yes | No |
| Yes | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Perhaps | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| No | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |

# Appendix F – E-commerce Website Case Study Qualification

In selecting qualifying E-commerce websites, a two stage approach was adopted. The first stage involved selecting web sites that could be unambiguously classed as E-commerce sites. The second stage considered the access to the owning organization's personnel and data that the author would need for the site to be used as a case study in this research. Tables F-1 and F-2 give the criteria required for qualification at each stage. This process was continued until a set of three E-commerce websites were selected.

- Table F-1: Criteria for a website to qualify as an E-commerce site -

| **The site must have:** |
|---|
| the ability to purchase items online |
| more than one item in more than one category available for purchase |
| the ability to allow for purchase of more than one copy/piece/instance of an item |
| the facility to pay on-line using a credit card |
| more than 50 transactions per month with total sale exceeding $25,000 |

- Table F-2: Criteria for a website to qualify for use as a case study –

| **The author must be able to:** |
|---|
| communicate with the architects, technical leaders and developers of the website |
| review some sort of customer feedback and service satisfaction assessments |
| get transparency and disclosure (while maintaining confidentiality) to source code, development and feature techniques |

# Appendix G – A Score-based Analysis of Softact.com

## G.1 Introduction

A score-based study was conducted on the quality attributes of the Softact.com website to assess the overall quality of the website. In essence the Goal-Question-Metric approach (Basili and Weiss, 1984) was adopted, as described in Chapter 8. The scoring sheet used could be standardized and applied to other websites to compare the assessment against the model developed in this thesis.

Table G-1 gives the overall results and table G-2 gives the detailed scoring for this assessment.

**- Table G-1: Results of the Softact Assessment -**

| Nodes | Assessment |
|---|---|
| Security | Positive |
| Availability | Positive |
| Scalability | Positive |
| Integrity | Positive |
| Content Adequacy | Negative |
| Accuracy | Positive |
| Involved Capacity | Neutral |
| User-Friendliness | Positive |
| Navigability | Negative |
| Reliability | Positive |
| Efficiency | Negative |
| Readability | Positive |
| Standard Conformance | Positive |

- Table G-2: Survey Scored Results –

| Node | Qualifiers | Base Score | Normalized Score | Evidence |
|---|---|---|---|---|
| **Security** | | | **1.0** | |
| | Does access to the website require authentication? | 100% | 0.3 | Log in required |
| | Is there an authorization framework on who can access what? | 100% | 0.3 | Based on user profile and access mode |
| | Are the processing of sensitive transactions such as payments encrypted? | 100% | 0.3 | Leverage SSL |
| | Is saved personal information protected from public access? | 75% | 0.2 | Database is secured in location and access. No financial sensitive information is stored |
| **Availability** | | | **1.0** | |
| | Can the hosting infrastructure and technology sustain 24/7/365 without the need to restart/reboot systems? | 75% | 0.3 | Using Windows Enterprise Servers. All configuration settings are based on re-loadable .INI files |
| | Does the system respond constructively to non supported access types? | 75% | 0.3 | Browser and Protocol compatibility checking is performed on initial access |
| | In the event of error, does the system continue communications with the user? | 75% | 0.3 | All application and system errors are captured and surfaced as application server messages |
| **Scalability** | | | **1.0** | |
| | Can the hosting infrastructure and software allow for scalability? | 100% | 0.5 | Website is compatible with Windows Data Center server and operating requirements. All address and references are "relative" and not "hard wired" |
| | Are scalability needs proactively measured? | 50% | 0.3 | Measurements and monitoring are conducted ad hoc with no routine scheduled |

- Table G-2: Survey Scored Results (continued) –

| | | | | |
|---|---|---|---|---|
| **Integrity** | | | **1.0** | |
| | Is there user-interface bound data validation? | 50% | 0.2 | On static pages only, not dynamic pages |
| | Is there server-bound data validation? | 100% | 0.3 | On both dynamic and static fields |
| | Are calculation errors properly notified and explained? | 50% | 0.2 | Errors are notified without detailed explanation |
| **Content Adequacy** | | | **-1.0** | |
| | Have there been customer requests for information beyond the content provided? | -75% | 0.4 | Yes. Customers often require samples of the work which are not provided on-line |
| | Is the breadth and depth of information among items balanced? | -50% | 0.3 | Technical artifacts are less detailed than business ones. Issues of ambiguity detected. |
| **Accuracy** | | | **1.0** | |
| | Have there been errors in calculations detected in the regular processing of the systems? | 100% | 0.5 | Never. All calculations had been peer reviewed to ensure correctness |
| | Are calculation errors properly notified and explained? | 50% | 0.3 | Errors are notified without detailed explanation |
| **Involved Capacity** | | | **0.0** | |
| | Are there personalization features based on user requests or profile? | 0% | 0.0 | No such features exists |
| | Does the system maintain and preserve user settings for future log-ins? | 0% | 0.0 | No such features exists |

- Table G-2: Survey Scored Results (continued) –

| | | | |
|---|---|---|---|
| **User-Friendliness** | | **1.0** | |
| Is the content organized and structured to put the user at ease? | 100% | 0.3 | Consistency is evident across the website |
| Does the system keep the user notified of progress on background operations? | 0% | 0.0 | On payment transactions there is no information of progress |
| Is there customer support or are there on-line help extensions? | 75% | 0.3 | Online contextual help is provided |
| **Navigability** | | **-1.0** | |
| Does the system enable the user to back track and change course of action easily? | -75% | -0.4 | The system does not maintain session content because of security issues. |
| Does the system enable the user to access the site map contents freely from any point within the website? | 0% | 0.0 | Active menu is available most of time |
| **Reliability** | | **1.0** | |
| Does the system capture internal errors gracefully? | 100% | 0.5 | All error is globally captured and re-communicated. All errors are centrally captured by the system's core processing and re-channeled to log files and saved with all possible detailed information. The user receives user friendly, easy to read and assess messages. |
| Does the system handle bad behavior and data entry? | 100% | 0.5 | Data validation exists on both client and server sides |

- Table G-2: Survey Scored Results (continued) –

| | | | | |
|---|---|---|---|---|
| **Efficiency** | | | **-1.0** | |
| | Does the system have areas of response time exceeding 5 seconds? | -75% | -0.4 | All payment processing transaction have tendencies to exceed time limits without any indication of progress |
| | Does the system leverage client side processing for extensive activities? | -50% | -0.3 | All operations, except some data validation, is server bound |
| **Readability** | | | **1.0** | |
| | Have there been grammar or language errors identified? | 0% | 0.0 | Minor |
| | Are the size of the font acceptable, and the consistency of the print style uniform? | 75% | 0.4 | The site has been professionally reviewed |
| **Standard Conformance** | | | **1.0** | |
| | Does the implementation of the website follow any industry standards? | 100% | 0.5 | Site is MS Graphical User Interface standard compliant |
| | Does the design of the website follow any industry standards? | 75% | 0.4 | The Unified Modeling Language and Object Oriented Paradigm was consistently followed |

## G.2 User's Satisfaction Survey

The survey conducted on Softact.com consisted of a rating-based questionnaire for a participant group of 20 Softact users. The questions where selected based on the different areas EWQPNet focused on in assessing the website quality. Each question was asked in the form of the user's satisfaction perspective on the website. The content of the survey is as follows:

- **Table G-3: Customer Survey Form –**

Thank you for your time and effort in filling out this survey. Our aim is to ensure quality of survey and your satisfaction with our website experience.
Please answer each question by rating your agreement on the aspect where an answer of "10" indicates ultimate satisfaction and "1" ultimate dissatisfaction.
Should you have comments to share with us, feel free to provide in "comments" section

| | *1 low satisfaction, 5 neutral and 10 highest satisfaction* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| 1. The ease of navigating and traversing through the different sections of the website using the menu and buttons available in the website. | | | | | | | | | | |
| Rating | | | | | | | | | | |
| Comments: | | | | | | | | | | |
| 2. The completeness of the information provided in the website, its consistency and reliability | | | | | | | | | | |
| Rating | | | | | | | | | | |
| Comments: | | | | | | | | | | |
| 3. The completeness of the description and information on items for purchase | | | | | | | | | | |
| Rating | | | | | | | | | | |
| Comments: | | | | | | | | | | |

| | *1 low satisfaction, 5 neutral and 10 highest satisfaction* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| | | | | | | | | | | |

4. The ease of accessing listed items and in the process of selecting / deselecting them for purchase

| Rating | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|

Comments:

5. The responsiveness of the website to your commands and directions

| Rating | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|

Comments:

6. The processing of tendering (paying) for items and checking out

| Rating | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|

Comments:

7. The tolerance of the site to errors in entry or selection

| Rating | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|

Comments:

8. The overall friendliness and user experience of the web site

| Rating | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|

Comments:

## G.3 User Survey Results

Results were captured into a Microsoft Excel application file. The full set of results is given in Table G-3.

**- Table G-3: Customer Survey Results –**

| Respondent / Question | NP1 | NP2 | NP3 | NP4 | NP5 | 1P1 | 1P2 | 1P3 | 1P4 | 1P5 | 1P6 | 1P7 | 1P8 | 1P9 | 1P10 | 1P11 | P1 | P2 | P3 | P4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.Ease of traversing around | 4 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 3 | 2 | 4 | 5 | 3 | 5 | 3 | 4 | 3 | 2 | 5 | 2 |
| 2.Information reliability | 8 | 7 | 6 | 7 | 7 | 9 | 7 | 8 | 9 | 7 | 9 | 8 | 8 | 5 | 9 | 9 | 10 | 9 | 8 | 9 |
| 3.Item description | 5 | 6 | 7 | 8 | 9 | 6 | 6 | 8 | 9 | 8 | 9 | 10 | 8 | 6 | 9 | 9 | 9 | 9 | 9 | 9 |
| 4.Item listing & selection | 7 | 10 | 6 | 6 | 9 | 8 | 8 | 5 | 8 | 5 | 9 | 10 | 7 | 8 | 9 | 5 | 4 | 4 | 4 | 4 |
| 5.Responsiveness | 9 | 9 | 6 | 7 | 9 | 9 | 9 | 6 | 9 | 7 | 10 | 7 | 8 | 9 | 9 | 9 | 9 | 7 | 10 | 8 |
| 6.Tendering | 2 | 1 | 2 | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 3 | 1 | 1 | 2 | 1 | 1 | 3 | 2 |
| 7.Interactive tolerance | 5 | 7 | 8 | 5 | 8 | 4 | 3 | 5 | 8 | 5 | 4 | 7 | 5 | 3 | 4 | 6 | 6 | 7 | 6 | 5 |
| 8.User friendliness | 5 | 3 | 5 | 5 | 4 | 3 | 4 | 3 | 4 | 2 | 3 | 3 | 3 | 4 | 5 | 4 | 6 | 6 | 7 | 7 |

Legend:
NPx: Users who had never executed a purchase (1 – 5)
1Px: User who had only made one purchase (1 – 11)
Px: Users who made more than one purchase since the site's inception (1 – 4)

Figures G-1 to G-8 show the results of each question in graphical form

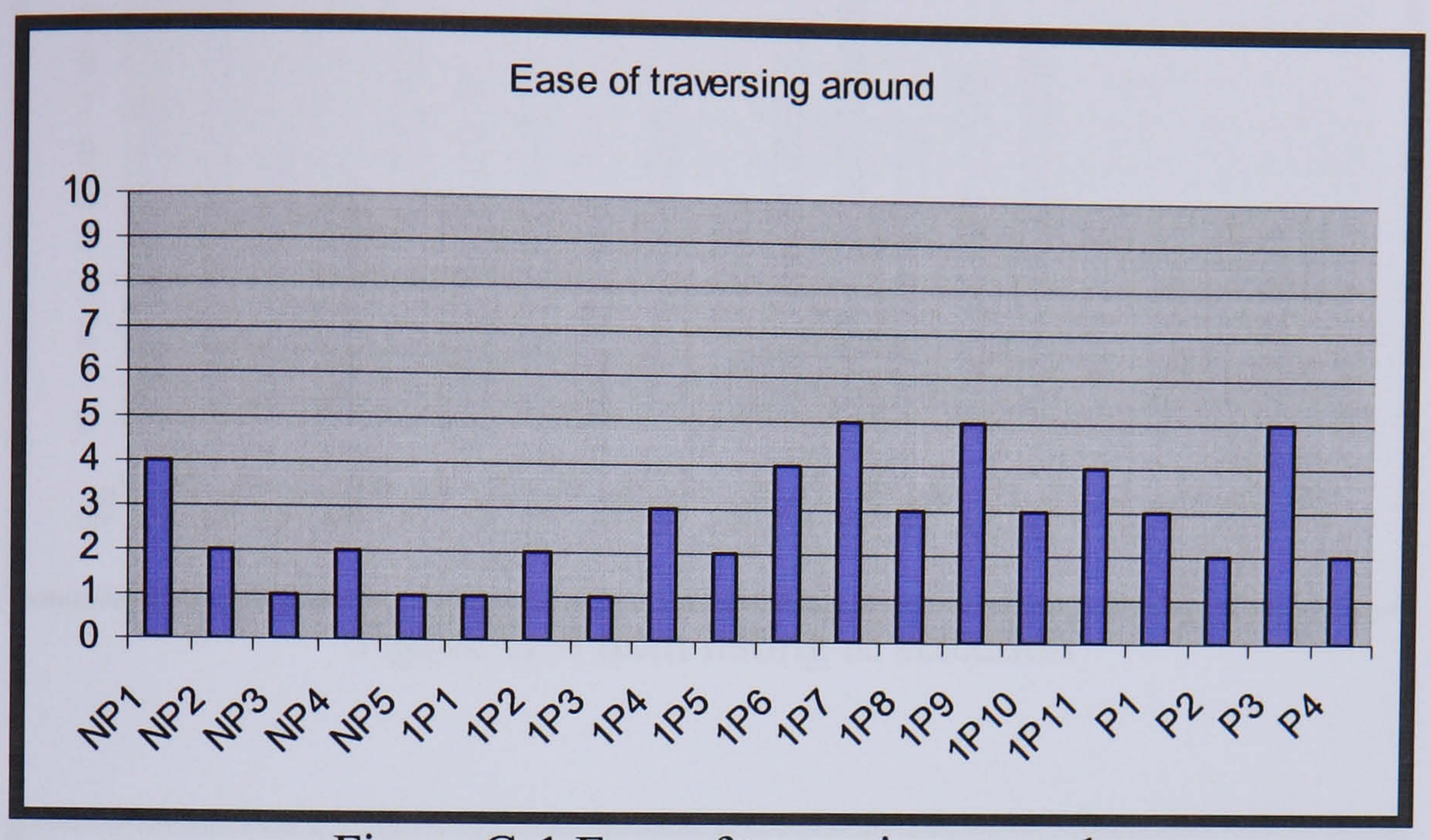



Figure G-1 Ease of traversing around

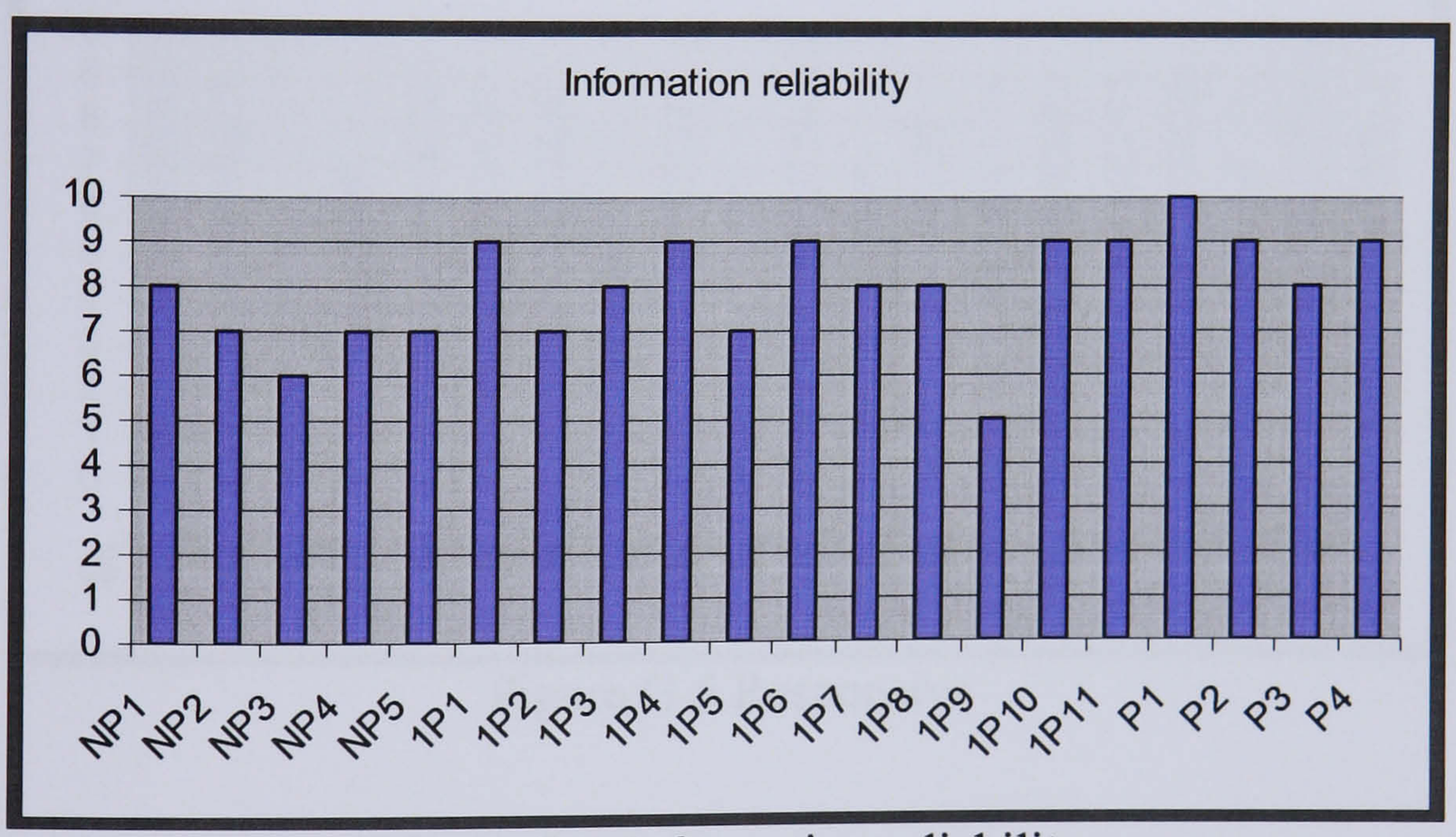



Figure G-2 Information reliability

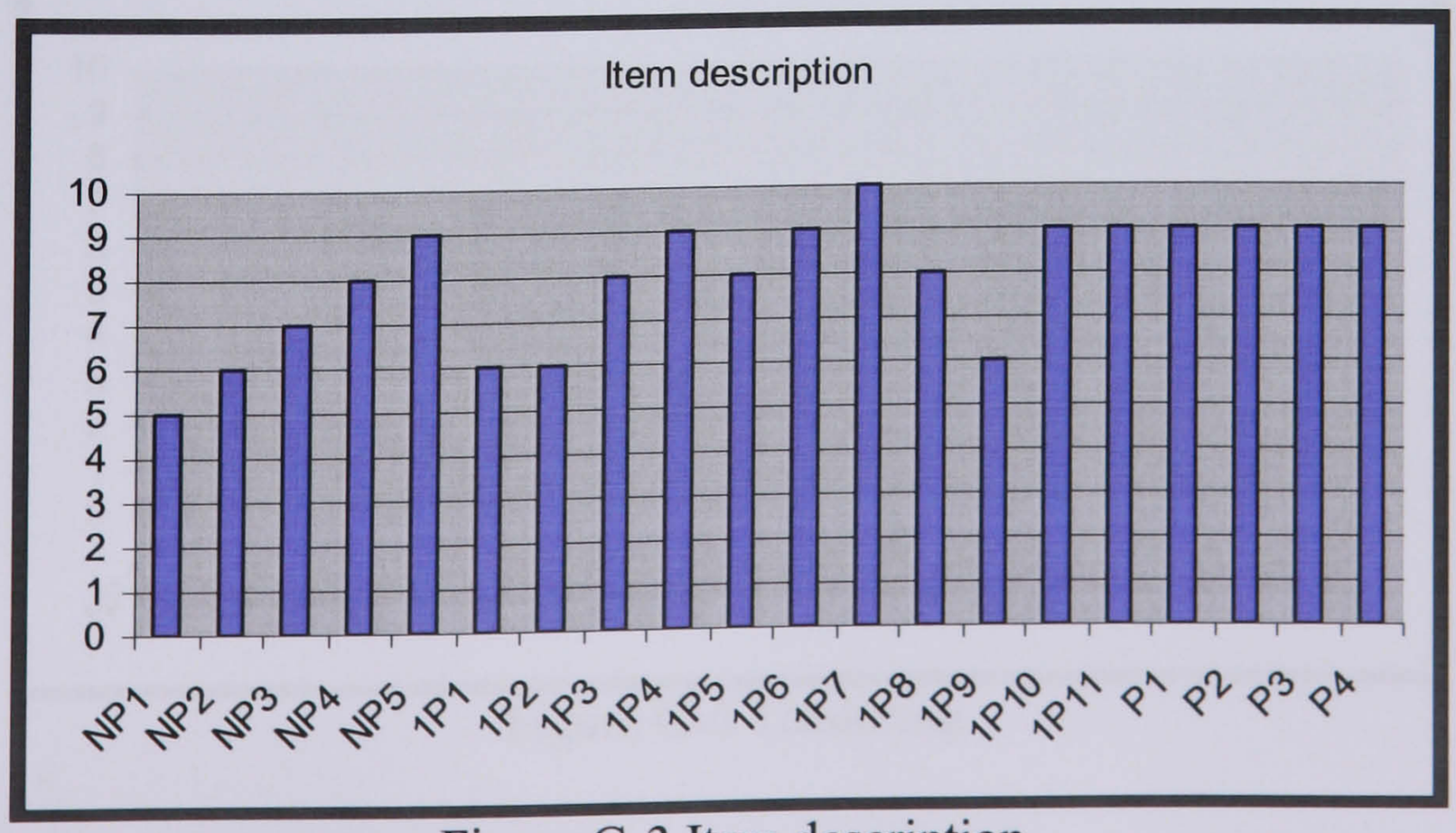



Figure G-3 Item description

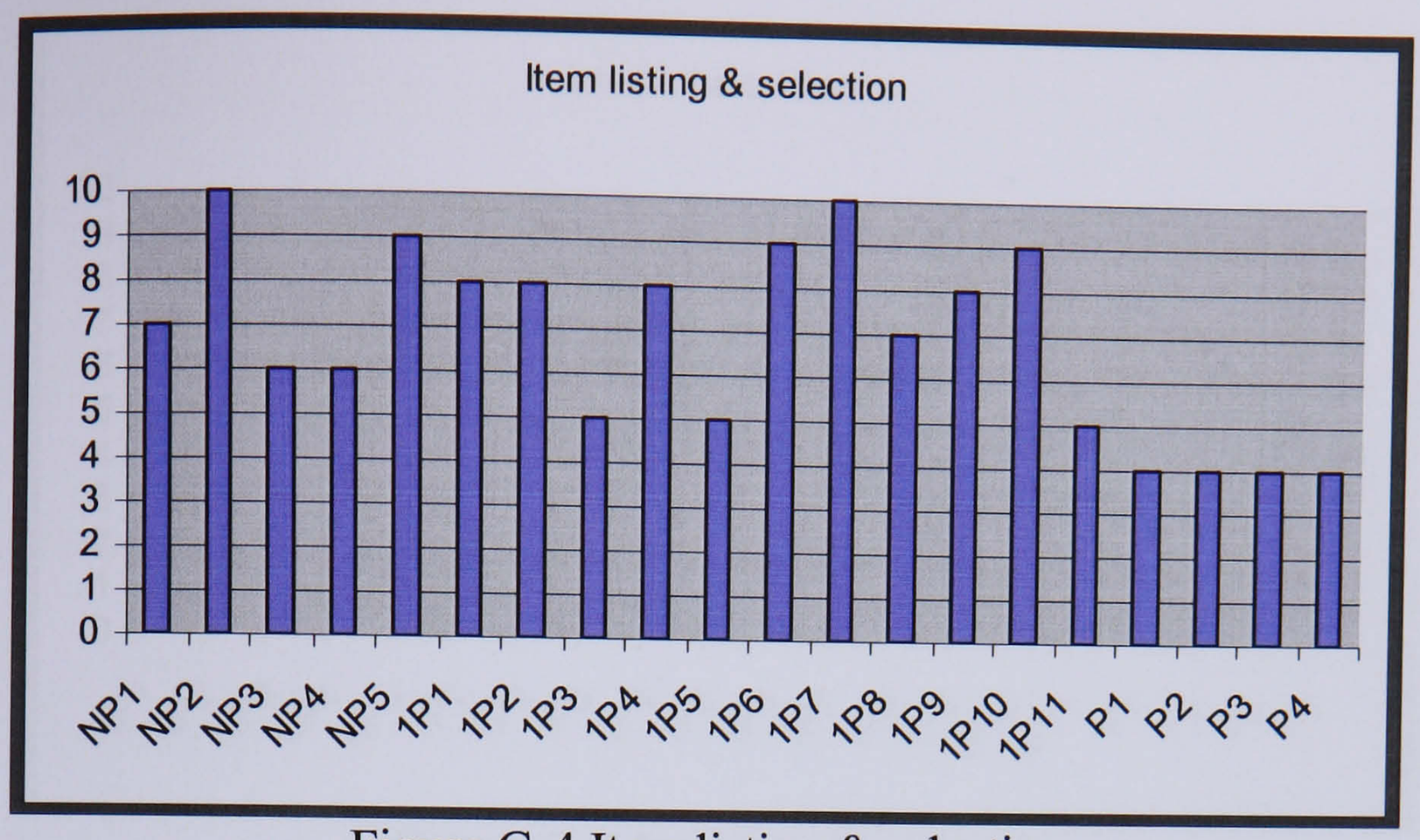



Figure G-4 Item listing & selection

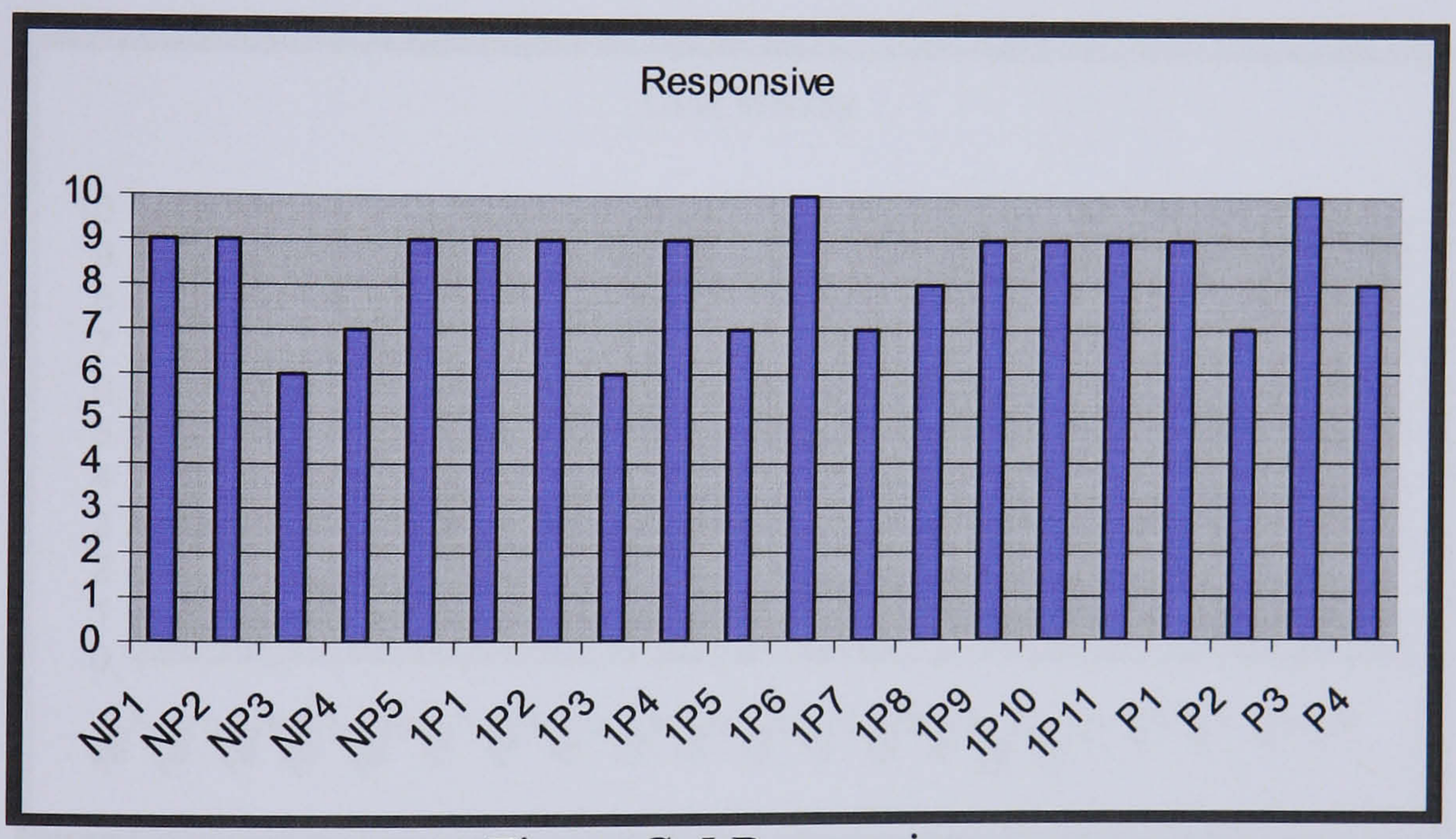



Figure G-5 Responsive

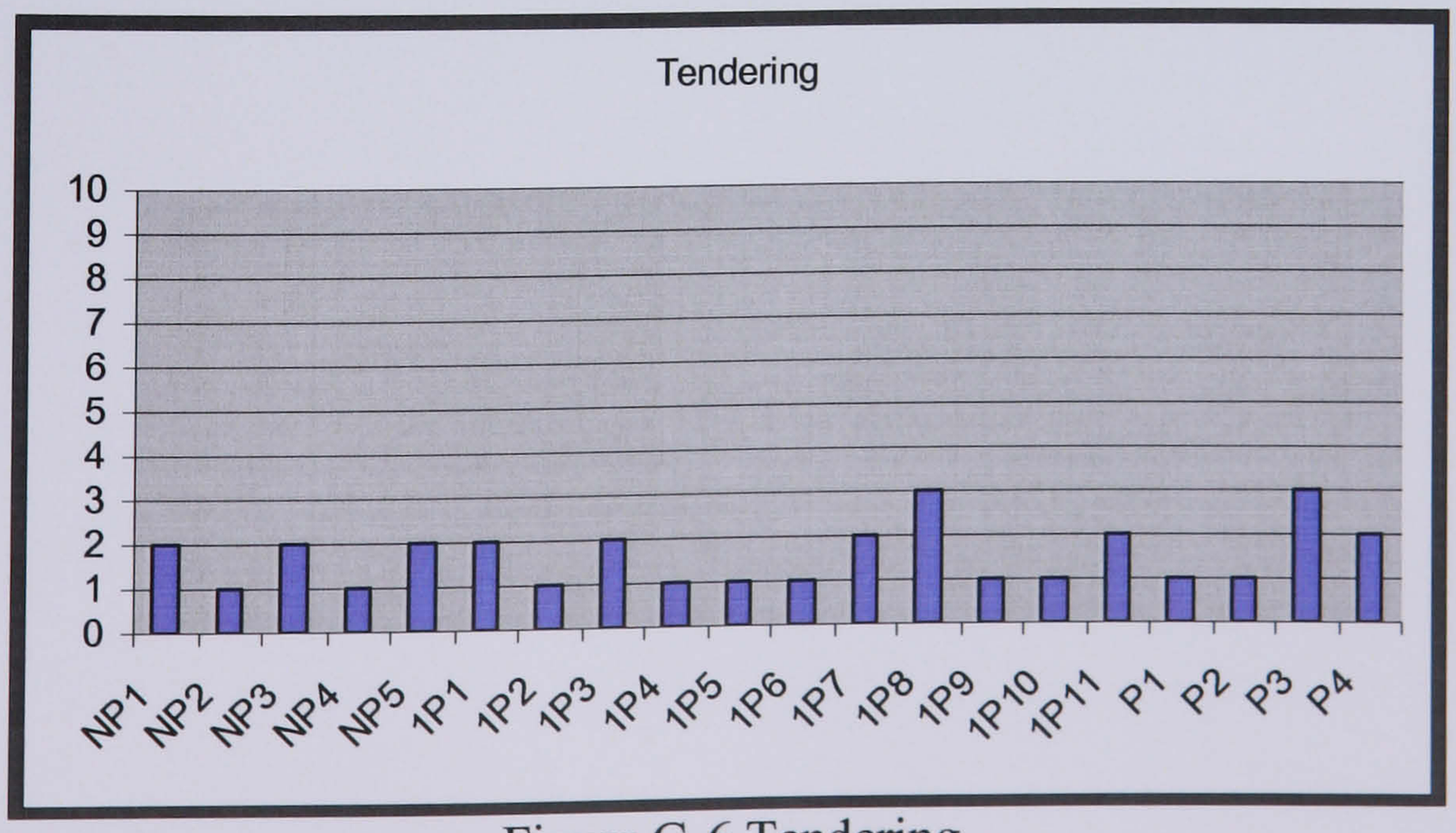



Figure G-6 Tendering

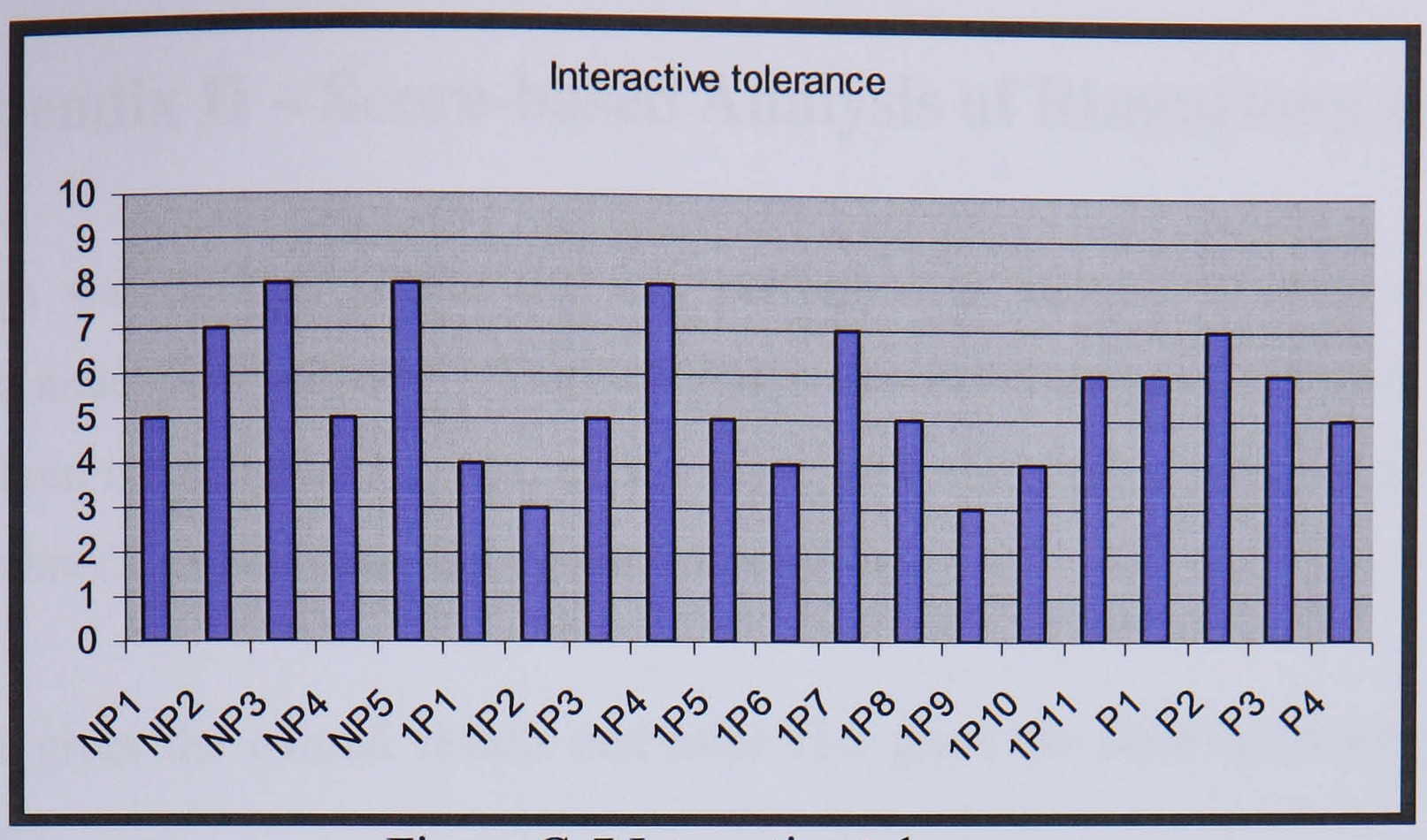



Figure G-7 Interactive tolerance

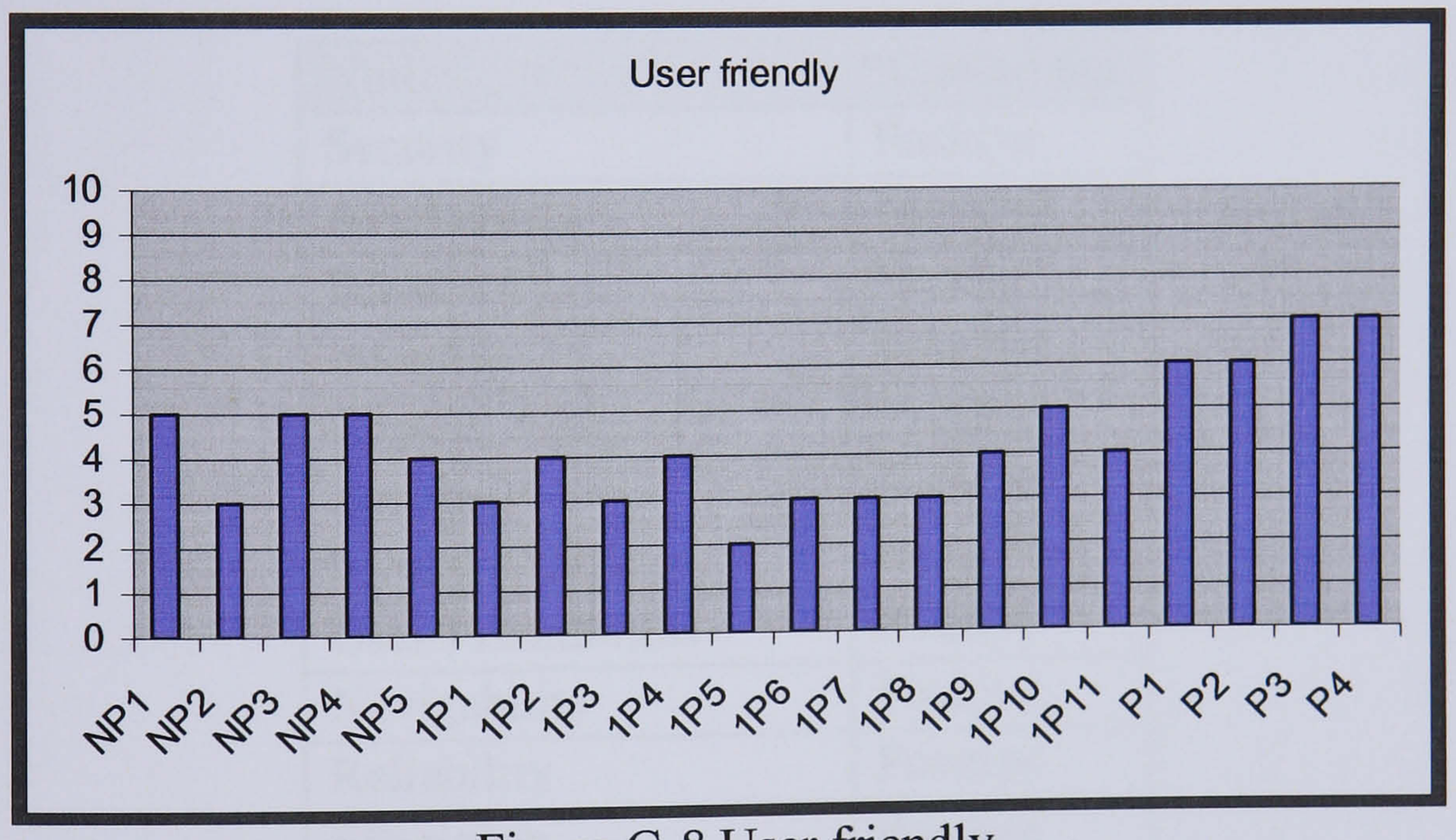



Figure G-8 User friendly

# Appendix H – Score-based Analysis of RingaDong.com

A thorough walkthrough of the site was performed to identify its state from each observable node point-of-view. The analysis was conducted using a combination of panel of three independent experts, expert input from the site's original architect, and "under the hood" source code and system inspections.

Table H-1 gives the overall results and table H-2 gives the detailed scoring for this assessment.

**Table H-1: Results of the RingaDong Assessment**

| Nodes | Assessment |
|---|---|
| Security | Positive |
| Availability | Negative |
| Scalability | Neutral |
| Integrity | Positive |
| Content Adequacy | Positive |
| Accuracy | Positive |
| Involved Capacity | Negative |
| User-Friendliness | Positive |
| Navigability | Positive |
| Reliability | Positive |
| Efficiency | Positive |
| Readability | Positive |
| Standard Conformance | Positive |

- Table H-2: The Detailed Scores of the RingaDong Assessment –

| Node | Qualifiers | Base Score | Normalized Score | Evidence |
|---|---|---|---|---|
| **Security** | | | **1.0** | |
| | Does access to the website require authentications? | 100% | 0.3 | Log in required |
| | Is there an authorization framework on who can access what? | 100% | 0.3 | Based on user profile and access mode |
| | Are the processing of sensitive transactions such as payments encrypted? | 100% | 0.3 | Uses SSL |
| | Is saved personal information protected from public access? | 75% | 0.2 | Database is secured in location and access. No financial sensitive information is stored |
| **Availability** | | | **-1.0** | |
| | Can the hosting infrastructure and technology sustain 24/7/365 without requirements to restart/reboot systems? | -100% | -0.3 | It was an assumption that the same rebooting would be required for other servers. |
| | Does the system respond constructively to non supported access types? | 50% | 0.2 | Browser and Protocol compatibility checking is performed on initial access |
| | In the event of error, does the system continue communications with the user? | -100% | -0.3 | No. |
| **Scalability** | | | **0.0** | |
| | Does the hosting infrastructure and software allow for scalability? | 0% | 0.0 | Needs to be tested. |
| | Are scalability needs proactively measured? | 0% | 0.0 | No. |

- Table H-2: The Detailed Scores of the RingaDong Assessment (continued) -

| | | | | |
|---|---|---|---|---|
| **Integrity** | | | **1.0** | |
| | Is there user-interface bound data validation? | 100% | 0.3 | On all data fields and pages |
| | Is there server-bound data validation? | 100% | 0.3 | On both dynamic and static fields |
| | Are calculation errors properly notified and explained? | 100% | 0.3 | Errors are notified without detail explanation. |
| **Content Adequacy** | | | **1.0** | |
| | Have there been customer requests for information beyond the content provided? | 100% | 0.5 | No customer request incidents occurred |
| | Is the breadth and depth of information among items balanced? | 50% | 0.3 | The site assumes the consumer is familiar with the purchase items' capabilities. A facility to sample tones and sounds before buying is available. |
| **Accuracy** | | | **1.0** | |
| | Have calculation errors been detected in the regular processing of the systems? | 100% | 0.5 | Never. All calculations were peer reviewed to ensure correctness |
| | Are calculation errors properly notified and explained? | 100% | 0.5 | Any potential error is notified and the system allows for retries |
| **Involved Capacity** | | | **-1.0** | |
| | Are there personalization features based on user request or profile? | -100% | -0.5 | No such feature exists and no facilities are available to capture audience loyalty |
| | Does the system maintain and preserve user settings for future log-ins? | 0% | 0.0 | No such feature exists |

- Table H-2: The Detailed Scores of the RingaDong Assessment (continued) -

| | | | | |
|---|---|---|---|---|
| **User-Friendliness** | | | **1.0** | |
| | Is the content organized and structured to put the user at ease? | 100% | 0.3 | Consistency is evident across the website |
| | Does the system keep the user notified of progress on background operations? | 100% | 0.3 | A special location on the page is dedicated for keeping the user in constant update on operations performed in response to requested commands |
| | Is there customer support or on-line help extensions? | 0% | 0.0 | No help is provided. Assumes the site is intuitive and that users understand the site's capabilities |
| **Navigability** | | | **1.0** | |
| | Does the system enable the user to back track and change a course of action easily? | 100% | 0.5 | System maintains session content.<br>Content is easy to find. |
| | Does the system enable the user to access the site map contents freely from any point within the website? | 100% | 0.5 | Active menu is always available |
| **Reliability** | | | **1.0** | |
| | Does the system capture internal errors gracefully? | 100% | 0.5 | All errors are globally captured and re-communicated |
| | Does the system handle bad behavior and data entry? | 100% | 0.5 | Data validation exists on both client and server sides |

- Table H-2: The Detailed Scores of the RingaDong Assessment (continued) -

| | | | | |
|---|---|---|---|---|
| **Efficiency** | | | **1.0** | |
| | Does the system have areas where response time exceeds 5 seconds? | 100% | 0.5 | The redundancy in the hardware hosting the site ensures consistency in prompt performance. |
| | Does the system use client side processing for extensive activities? | 75% | 0.4 | All operations, except some data validation, are server bound |
| **Readability** | | | **1.0** | |
| | Have grammar and language errors been identified in the statement of contents? | 0% | 0.0 | Minor |
| | Is the size of the font acceptable, and the consistency of the print style uniform? | 75% | 0.4 | The site has been professional reviewed |
| **Standard Conformance** | | | **1.0** | |
| | Have grammar and language errors been identified in the statement of contents? | 100% | 0.5 | The site is MS Graphical User Interface standard complaint. |
| | Does the design of the website follow any industry standards? | 75% | 0.4 | The Unified Modeling Language and Object Oriented Paradigm were consistently used in the design. |

# Appendix I – Score-based Analysis to Iconopportunities.com

## I.1 Introduction

A thorough walkthrough of the site architecture, design and the corresponding implementation tasks was performed to identify future state of the site in assuring the positive evidence of the quality factors that constitutes the model established in this thesis. The analysis was conducted in a checklist investigation style factor by factor. The results of information gathered and analyzed are established within.

## I.2 Results

**Table I.1 Assessment Results**

| Nodes | Assessment |
|---|---|
| Security | Positive |
| Availability | Neutral |
| Scalability | Neutral |
| Integrity | Positive |
| Content Adequacy | Positive |
| Accuracy | Neutral |
| Involved Capacity | Neutral |
| User-Friendliness | Negative |
| Navigability | Negative |
| Reliability | Positive |
| Efficiency | Positive |
| Readability | Negative |
| Standard Conformance | Positive |

## I.3 Checklist Investigation Results

- Table I-2: Survey Scored Results –

| Node | Qualifiers | Base Score | Normalized Score | Evidence |
|---|---|---|---|---|
| **Security** | | | **1.0** | |
| | Does access to the website require authentication? | 100% | 0.3 | Log in required |
| | Is there an authorization framework on who can access what? | 100% | 0.3 | Based on user profile and access mode |
| | Are the processing of sensitive transactions such as payments encrypted? | 100% | 0.3 | Leverage SSL |
| | Is saved personal information protected from public access? | 75% | 0.2 | Database is secured in location and access. No financial sensitive information is stored |
| **Availability** | | | **0.0** | |
| | Can the hosting infrastructure and technology sustain 24/7/365 without the need to restart/reboot systems? | 0% | 0.0 | Needs to be tested. |
| | Does the system respond constructively to non supported access types? | 0% | 0.0 | Needs to be tested. |
| | In the event of error, does the system continue communications with the user? | 0% | 0.0 | Needs to be tested. |
| **Scalability** | | | **0.0** | |
| | Can the hosting infrastructure and software allow for scalability? | 0% | 0.0 | Needs to be tested |
| | Are scalability needs proactively measured? | 0% | 0.0 | Needs to be tested. |

- Table I-2: Survey Scored Results (continued) –

| | | | | |
|---|---|---|---|---|
| **Integrity** | | | **1.0** | |
| | Is there user-interface bound data validation? | 50% | 0.2 | On static pages only, not dynamic pages |
| | Is there server-bound data validation? | 100% | 0.3 | On both dynamic and static fields |
| | Are calculation error properly notified and explained? | -50% | -0.2 | Errors are notified without detailed explanation |
| **Content Adequacy** | | | **1.0** | |
| | Have there been customer requests for information beyond the content provided? | 100% | 0.5 | No |
| | Is the breadth and depth of information among items balanced? | 100% | 0.5 | Yes. No ambiguity detected |
| **Accuracy** | | | **0.0** | |
| | Have there been errors in calculations detected in the regular processing of the systems? | 50% | 0.0 | No. All calculations had a peer reviewed to ensure correctness |
| | Are calculation errors properly notified and explained? | -50% | 0.0 | Errors are notified without detail explanation |
| **Involved Capacity** | | | **0.0** | |
| | Are there personalization features based on user requests or profile? | 0% | 0.0 | No such features exists |
| | Does the system maintain and preserve user settings for future log-ins? | 0% | 0.0 | No such features exists |

- Table I-2: Survey Scored Results (continued) –

| | | | | |
|---|---|---|---|---|
| **User-Friendliness** | | | **-1.0** | |
| | Is the content organized and structured to put the user at ease? | -100% | -0.3 | Inconsistency in the contents is evident across the website |
| | Does the system keep the user notified of progress on background operations? | -100% | -0.3 | On payment transactions there is no information of progress |
| | Is there customer support or are there on-line help extensions? | 75% | 0.3 | Online contextual help is provided |
| **Navigability** | | | **-1.0** | |
| | Does the system enable the user to back track and change course of action easily? | -75% | -0.4 | The system does not maintain session content because of security issues |
| | Does the system enable the user to access the site map contents freely from any point within the website? | 0% | 0.0 | Active menu is available most of time.<br>Long web pages require a link to the top of the page |
| **Reliability** | | | **1.0** | |
| | Does the system capture internal errors gracefully? | 100% | 0.5 | All errors are centrally captured by the system's core processing and re-channeled to log files and saved with all possible detailed information. The user receives user friendly, easy to read and assess messages. |
| | Does the system handle bad behavior and data entry? | 50% | 0.3 | Data validation exists on the server side only. |

- Table I-2: Survey Scored Results (continued) –

| | | | | |
|---|---|---|---|---|
| **Efficiency** | | | **1.0** | |
| | Does the system have areas of response time exceeding 5 seconds? | 100% | 0.5 | No |
| | Does the system leverage client side processing for extensive activities? | 75% | 0.4 | All operations are server bound |
| **Readability** | | | **-1.0** | |
| | Have there been grammar or language errors identified? | -100% | -0.5 | Yes.<br>Some pages contain jargon |
| | Are the size of the font acceptable, and the consistency of the print style uniform? | 0% | 0.0 | The site needs to be reviewed<br>Line length more than 450pixels / 9 to 15 words per line / 40 to 60 characters |
| **Standard Conformance** | | | **1.0** | |
| | Does the implementation of the website follow any industry standards? | 50% | 0.3 | Site is MS Graphical User Interface standard compliant |
| | Does the design of the website follow any industry standards? | 50% | 0.3 | The Unified Modeling Language and Object Oriented Paradigm was followed |

## I.4 Evaluators Satisfaction Survey

The survey conducted on Iconopportunities.com consisted of a rating-based questionnaire for a participant group of 6 experts evaluators. The questions where selected based on the different areas the EWQPNet focus on in assessing the website quality. Each question was asked in the form of the evaluator's satisfaction perspective on the website. The content of the survey was as follows:

- Table I-3: Evaluators Survey Form -

Thank you for your time and effort in filling out this survey. Our aim is to ensure quality of survey and your satisfaction with our website based on your evaluation.

Please answer each question by rating your agreement on the aspect where an answer of "10" indicates ultimate satisfaction and "1" ultimate dissatisfaction.

Should you have comments to share with us, feel free to provide in "comments" section.

| | *1 low satisfaction, 5 neutral and 10 highest satisfaction* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| 1. The ease of navigating and traversing through the different sections of the website using the menu and buttons available in the website. | | | | | | | | | | |
| Rating | | | | | | | | | | |
| comments: | | | | | | | | | | |
| 2. The completeness of the information provided in the website, placing content in terms of its importance to the user, its consistency and reliability | | | | | | | | | | |
| Rating | | | | | | | | | | |
| comments: | | | | | | | | | | |
| 3. The ease of accessing listed items and in the process of selecting / deselecting them for purchase | | | | | | | | | | |
| Rating | | | | | | | | | | |

| | *1 low satisfaction, 5 neutral and 10 highest satisfaction* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| comments: | | | | | | | | | | |
| 4. The responsiveness of the website to your commands and directions | | | | | | | | | | |
| Rating | | | | | | | | | | |
| comments: | | | | | | | | | | |
| 5. Registration and paying for goods | | | | | | | | | | |
| Rating | | | | | | | | | | |
| comments: | | | | | | | | | | |
| 6. The first impression and Initial view/ design of a site | | | | | | | | | | |
| Rating | | | | | | | | | | |
| comments: | | | | | | | | | | |
| 7. The overall friendliness and user experience of the web site | | | | | | | | | | |
| Rating | | | | | | | | | | |
| comments: | | | | | | | | | | |

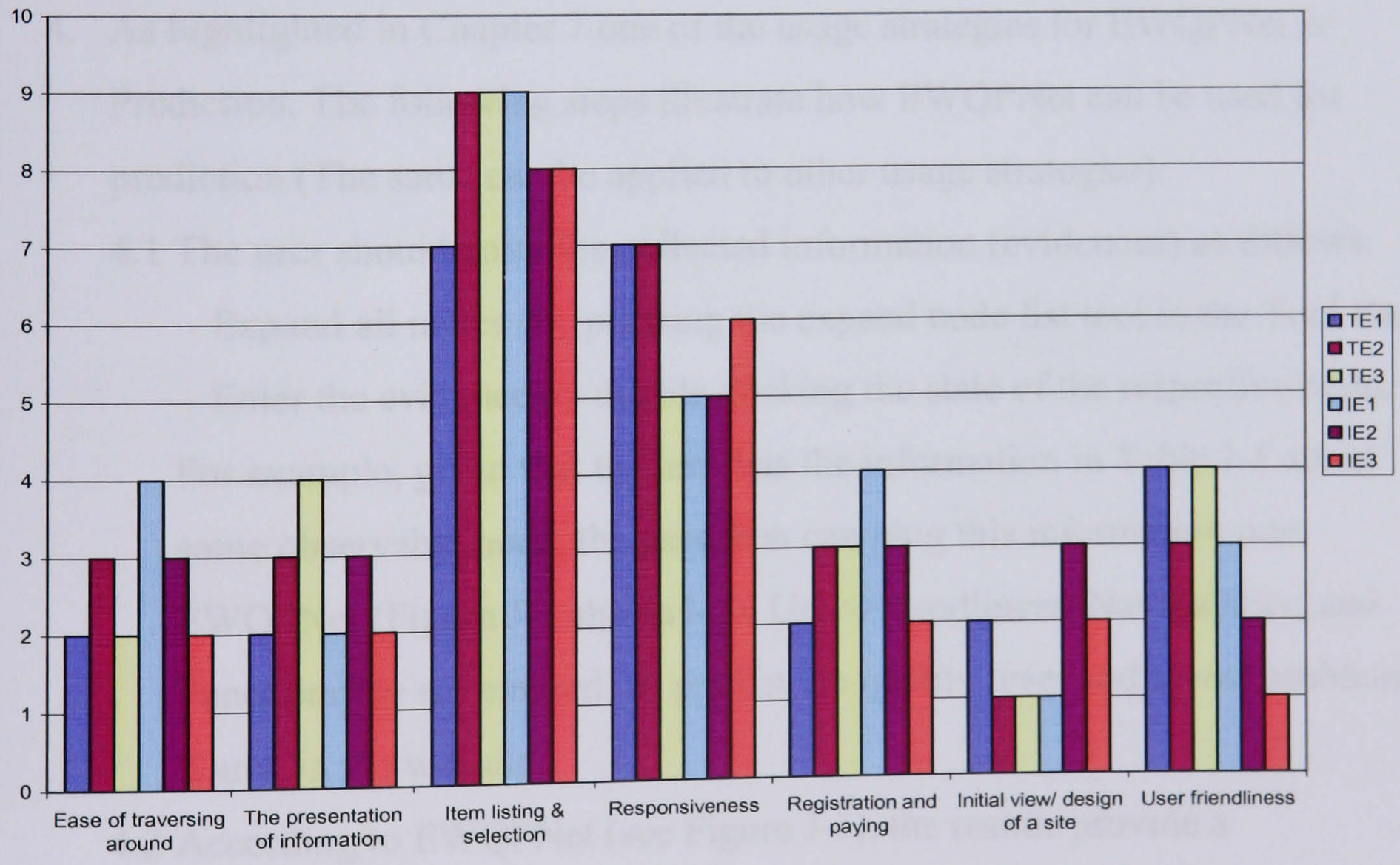
## I.5 Evaluators Survey Results

Results were captured into a Microsoft Excel application file. The full set of results is given in Table I-4.

- Table I-4: Evaluator Survey Results –

| Respondent / Question | TE1 | TE2 | TE3 | IE1 | IE2 | IE3 |
|---|---|---|---|---|---|---|
| 1.Ease of traversing around | 2 | 3 | 2 | 4 | 3 | 2 |
| 2.The presentation of information | 2 | 3 | 4 | 2 | 3 | 2 |
| 3.Item listing & selection | 7 | 9 | 9 | 9 | 8 | 8 |
| 4. Responsiveness | 7 | 7 | 5 | 5 | 5 | 6 |
| 5. Registration and paying for goods | 2 | 3 | 3 | 4 | 3 | 2 |
| 6. Initial view/ design of a site | 2 | 1 | 1 | 1 | 3 | 2 |
| 7. User-friendliness | 4 | 3 | 4 | 3 | 2 | 1 |

Legend:
TEx: Team Evaluator (1 – 3)
1Ex: Independent Evaluator (1 – 3)




- Figure I-1: Iconopportunities Evaluators Satisfaction Survey Results -

# Appendix J – How to use EWQPNet

The following steps explain how to use EWQPNet:

1. Load EWQPNet into the system.

2. Compile EWQPNet by Pressing the Run Mode tool button  in the Tool Bar.
   The compiler checks for the following errors:
   - Cycles. There must be no directed cycles in a network.
   - For each parent configuration of a node, the probabilities of the different states must have the sum of 1. In other words, each column of the table must sum to 1. If there is a column that does not sum to 1, the compilers will normalized the values. This fact can be utilized when filling in the probabilities.
3. After the compilation, the Run Mode is entered. Running in Run Mode, the network window is split into two by a vertical bar (see Figure J-1). To the left is the Node List Pane and the right is the Network Pane.
4. As highlighted in Chapter 7 one of the usage strategies for EWQPNet is Prediction. The following steps illustrate how EWQPNet can be used for prediction (The same can be applied to other usage strategies):

   4.1 The user should enter the collected information (evidences) as follows:
   - Expand all nodes (by pressing the expand node list tool in the Tool Bar.
   - Enter the evidence by double clicking the state of the respective node.

   For example, given that the user has the information in Table J-1 about some observable node, the user then can plug this information into EWQPNet (Figure J-1 shows how User-Friendliness, Navigability, and Functionality are entered) to predict the quality level and reveal problems, if any, in the website.

   4.2 According to EWQPNet (see Figure J-1), the results provide a forecast, with a 100% probability that the site would be lacking in Conceptual Reliability, giving a 99.50% high level of Usability and an "unsatisfactory" Quality for the website.
5. Other examples for using EWQPNet are available in Chapter 7

Table J-1: An example of observable node assessment –

| Nodes | Assessment |
|---|---|
| User-Friendliness | Positive |
| Navigability | Positive |
| Efficiency | Positive |
| Involved Capacity | Neutral |
| Scalability | Positive |
| Reliability | Positive |
| Security | Negative |
| Accuracy | Negative |
| Readability | Positive |
| Standard Conformance | Positive |

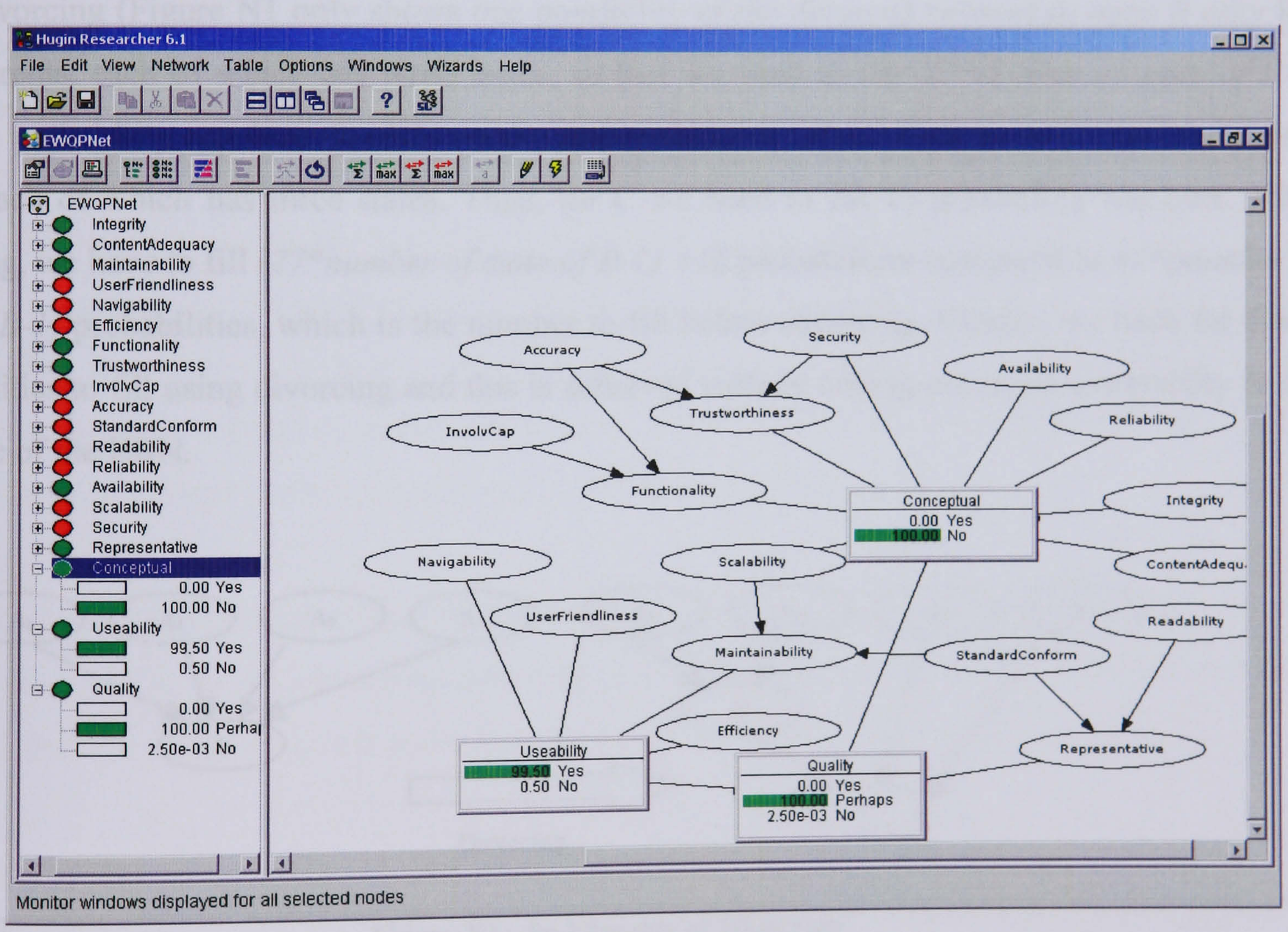



Figure J-1: Using EWQPNet as a prediction tool -

# General BBNs Modeling Concepts

## K1. Divorcing

Let $A$ ,..., $A_n$ be a list of variables all of which are causes of $B$. If you wish to specify P (B | $A$,..., $A_n$), you might have a very large knowledge acquisition task ahead of you.

**Divorcing** is the technique to simplify this kind of task. Let us consider an example first. Suppose we are interested in P (B | $A$,..., $A_n$), where $A$ ,..., $A_n$ each have 3 states, we will have to produce *81*(number of state of B-1)* separate probability numbers for B's conditional probability table.

After divorcing (Figure N1 only shows one possibility of the divorced networks), node $B$ only has three parents, each of which has three states, so that we need to fill (*27*number of state of B-1)* separate probability numbers for B's conditional probability table. Also, node $C$ has two parent nodes each of which has three states. Thus, for C we need to fill 18 probability numbers. After divorcing, we have to fill (*27*number of state of B-1) +18* probabilities compared to *81*(number of state of B-1)* probabilities, which is the number to fill before divorcing. Clearly, we have far fewer probabilities to fill using divorcing and this is achieved without adding too much complexity in the structure of the BBN.

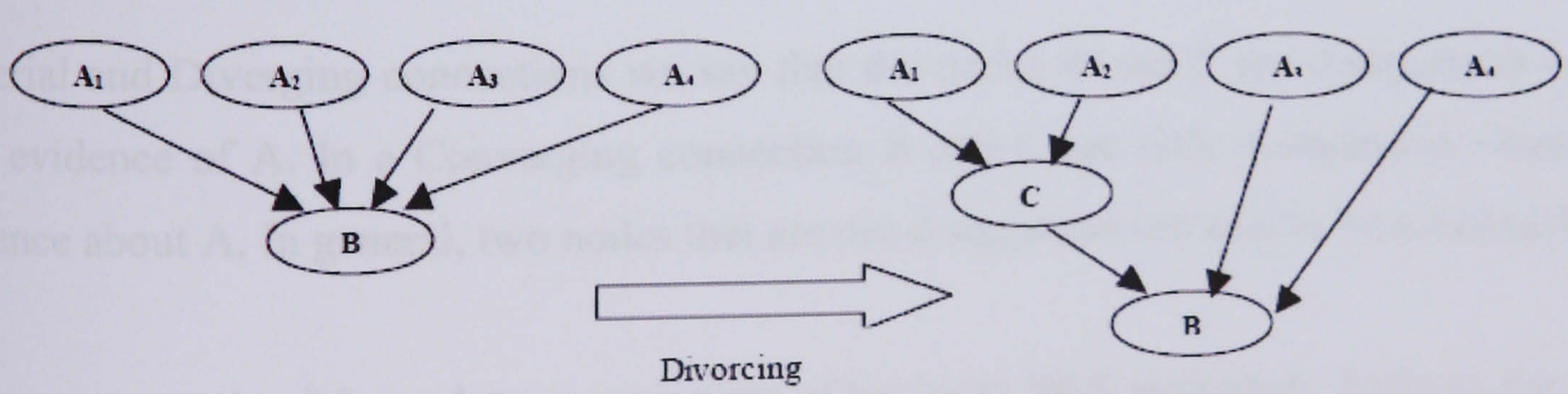



**Figure K1: An Example of Divorcing**

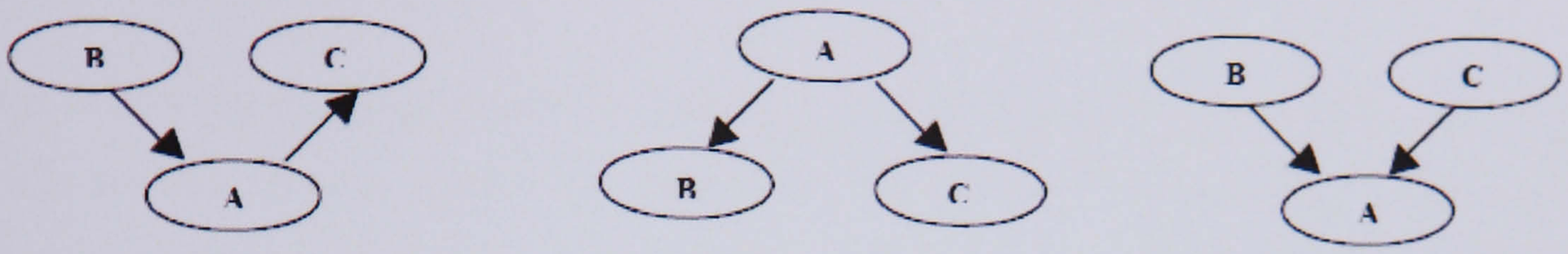
## K2. D-separation and arc representation

Before we define d-separation, we first look at the way that evidence is transmitted in BBNs. We consider two types of evidence:

**Definition 1**: **Hard Evidence** (instantiation) for a node A is evidence that the state of A is definitely a particular value.

**Definition 2**: **Soft Evidence** for a node A is any evidence that enables us to update the prior probability values for the states of A.

The following are the three cases of connections in BBNs:



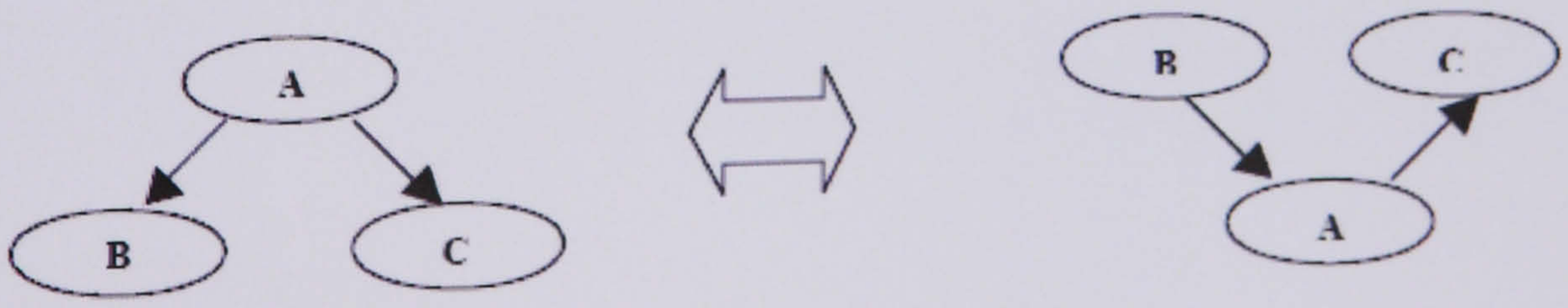

Serial Connection Diverging Connection Converging Connection

**Figure K2: D-connections**

- In a **serial connection** from Node B to Node C via Node A, evidence from B to C is blocked only when we have hard evidence about A. Evidence on B will influence A which influences C.
- In a **diverging connection** where Node B and Node C have the common parent Node A, evidence from B to C is blocked only when we have hard evidence about A.
- In a **converging connection,** where Node A has parents Node B and Node C, any evidence about A results in evidence transmitted between B and C. Here nodes B and C are conditionally dependent given evidence at Node A. This means that if we have entered evidence at Node A then entering evidence at Node B will update Node C.

In Serial and Diverging connections we say that the nodes B and C are d-separated when there is hard evidence of A. In a Converging connection B and C are only d-separated when there is no evidence about A. In general, two nodes that are not d-separated are said to be d-connected.

Let us prove a pair of dependences equivalent of the basic BBN structures. Refer to the equations in Figure N3 for the proof. It is obvious that these two structures are essentially equal in topology.




$$P(A,B,C) = P(B \mid A)P(C \mid A)P(A)$$
$$= P(C \mid A)P(A,B)$$

$$P(A,B,C) = P(C \mid A)P(B)P(A \mid B)$$
$$= P(C \mid A)P(A,B)$$

**Figure K3: Structure Equivalent**

# Appendix L - Paper: Quality Assessment of E-Commerce Websites Using Bayesian Belief Networks

The following six pages give a copy of a paper written by the author and presented with another paper, given in Appendix M, at the International Conference on Multidisciplinary Information Sciences and Technologies, InSciT 2006, in Madrid in October 2006.

# Quality Assessment of E-Commerce Websites Using Bayesian Belief Networks

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The most experienced and successful E-commerce companies are beginning to realize that key determinants of success or failure are not merely a web presence or low price but delivering on a high quality website. To attain the desired quality of website software, it is necessary to produce a framework and model that enables evaluation of a website's quality. In this paper we introduce a model, EWQPNet (E-commerce Website Quality Prediction Network). This model would provide a consistent and practical approach to assessing the quality of the website. The assessment can be carried out before the completion of the website development, thus, providing insight on the trend and direction for correction and improvements. It can also be carried out on completed and operational work, providing analysis of areas for improvement. The performance of the EWQPNet should be relatively quick and practical in providing an overall comprehensive assessment with root-cause analysis that would lead to corrective measures to improve the quality of the E-commerce website.

Keywords: E-commerce, metrics, quality evaluation.

## 1 INTRODUCTION

Quality has been established as a key factor to ensuring success of E-commerce in attracting and retaining customer (Stefani, 2003). In order to assess the success of a website, a quality model highlighting relevant properties of the website and specifying how to measure them is needed.

Past approaches concerning the quality of E-commerce systems emphasize usability standards using techniques like feature inspection and collecting data about end-users' opinion by questionnaires. These methods provide important feedback and their results can be utilized as a useful background for future work, however, they do not contribute directly to a dynamic model that enables forecasting (Chan, 2001).

Website style guides and design principles such as the IEEE Web Publishing Guide, http://www.ieee.org/web/developers/style, IEEE Std 1061-1992, "IEEE Standard for a Software Quality Metrics Methodology" and ISO/IEC 9126-1991 have emerged to assist developers in the development process. According to de Chazal (2005), there seems to be an almost overwhelming abundance of quality standards that lead to a high level of cynicism and skepticism surrounding them and the eventual lack of use.

In fact, some guidelines suggest specific testing techniques able to detect whether or not the guideline is satisfied. Automatic tools are also available to carry out some of these tests. At least for usability-related questions, quality models should blend these techniques with other ones, like user testing or heuristic evaluation.

The time and effort needed to carry out heuristic evaluation or user testing is in conflict with two fundamental pragmatic aspects of current websites. Web technologies evolve extremely fast, enabling sophisticated tools to be deployed and complex interactions to take place. Secondly, the life cycle of a website is also extremely fast: maintenance of a website is performed at a rate that is higher than that of other software products because of market pressure and lack of distribution barriers (Brajnik, 2001). Such conflict is one more reason why it is necessary to consider automatic tools for supporting quality assessments.

The solution proposed by this research is the establishing of a Bayesian Belief Network (BBN) model called EWQPNet. According to Jensen (2002), BBNs are often called decision support systems where the factors affecting a decision are modeled in terms of their elements and inter-dependencies. The aim of this paper is just that – to create a decision support system to aid in the assessment and decision making with regard to the quality assessment of an E-commerce websites.

According to Niedermayer (1998), BBNs have become an important tool for research and applications. They are useful for both inferential exploration of previously undetermined relationships among variables

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and for descriptions of the relationships discovered.

# 2 EWQPNET CONSTRUCTION

A BBN is a graph composed of nodes connected by edges indicating an influencing relationship between the connected nodes. Mathematically, and according to Jensen (2002), a BBN is a probabilistic network that helps model and measure valuations and assessments. Establishing a BBN is a two stage approach (Jensen, 2002).Qualitative analysis is the first stage, followed by quantitative analysis.

## 2.1 Qualitative Analysis

Qualitative analysis entails representing the BBN in the form of an acyclic graph consisting of nodes and directed arcs. The resultant BBN is shown in Figure 1. The target EWQPNet was built using the tool, Hugin Expert A/S (Hugin, 2006). As Figure 1 illustrates, there are three types of nodes in EWQPNet:

**Target nodes**, the nodes about which the objective of the EWQPNet is to make an assessment. In EWQPNet, Quality is the target node. This assessment is expressed with a quantifiable target variable for quality.

**Intermediate nodes**, which are nodes for which one has limited information, or only "beliefs". The associated variables are the hidden variables. In EWQPNet, Usability, Conceptual Reliability and Representative Reliability are intermediate nodes.

**Observable nodes**, which can be directly observed with associated observable variables that are measurable or quantifiable, even though this measurement may not be exact and objective. All remaining nodes in EWQPNet are observable nodes that can be quantified based on the findings gathered from their sub-factors. Table 1 lists how the factors acting as BBN nodes influence the model from a business domain perspective.

| Observable Nodes | Influence Described |
|---|---|
| Security | The extent of security when accessing and using the E-commerce website ultimately influences the quality from the perspective of the E-commerce website's basic reliability, trustworthiness and conceptual reliability. |
| Availability | The extent of availability of the E-commerce website influences the quality from the perspective of conceptual reliability. |
| Scalability | The extent of scalability of the E-commerce website to consistently match growing demand on its services influences the quality from the perspective of the conceptual reliability. |
| Integrity | The extent that stored and processed data can be relied on influences the website quality from the perspective of the conceptual reliability. |
| Content Adequacy | Ensuring the right amount and appropriate type of information is presented within context influences the quality from the perspective of the conceptual reliability. |
| Trustworthiness | The extent that the user can trust the consistency in performance, data and processing of data influences the quality from the perspective of the overall conceptual reliability |
| Accuracy | The correctness in performing calculations and measurements influences the quality from the perspective of the functionality of operations and the overall conceptual reliability. |
| Involved Capacity | The measure of which the E-commerce website can adapt to each user's individuality influences the quality from the perspective of the functionality of operations and the overall conceptual reliability, |
| Maintainability | The ease of adapting and changing the underlying software of the E-commerce website to meet user changing and growing requirements influences the quality from the perspective of usability. |
| User Friendliness | The ease of matching users' expectations and the minimization of users' effort to achieve objectives when using the E-commerce website influences the quality from the perspective of usability. |

| | |
|---|---|
| Navigability | The ease of traversing the E-commerce website pages influences the quality from the perspective of usability. |
| Reliability | The fundamental reliability of basic operations and execution of functions influences the quality from the perspective of the overall conceptual reliability. |
| Efficiency | The reduction in time consumed to achieve goals and objectives by the user when using the E-commerce website influences the quality from the perspective of the overall conceptual reliability. |
| Readability | The ease of reading and comprehending the content of the E-commerce website influences the quality from the perspective of the overall representative reliability. |
| Standard Conformance | The consistency of implementation of the E-commerce website and its adherence to standards influences the quality from the perspective of the overall representative reliability. |
| Functionality | The level of richness and practicality of the functional features the E-commerce website offers influences the quality from the perspective of the overall conceptual reliability. |

- Table 1: How the factors acting as BBN nodes influence the EWQPNet from a business domain perspective. -

## 2.2 Quantitative Analysis

The second stage in building EWQPNet is to quantify it with weights and figures, providing a representation of the joint probabilities. This necessitates assessing the probabilities of each factor on the developed network from the probability distributions for each of the factors, and conditionally, on their direct predecessors.

This needed data may be gleaned from literature, elicited from experts, or learned directly from observations (Grois, 1995). In this paper, the second option, elicitation from experts, was used for building the model. A panel of three experts was asked to help derive an effective mechanism for quantifying the relations. Unanimously, the three experts agreed to limit quantifiable assessment of each variable to 3 values: (+1) meaning the variable has positive influence within the website, (-1) indicating an absence of the variable's attribute having a negative influence in the website and (0) indicating neutrality in the decision about the variable's influence within the website. A complete quantitative specification of our network (EWQPNet) is not included as it would have too many relations for the space available. EWQPNet contains 20 variables that are linked together in all sorts of ways.

# 3 Application of the Model

The utility of the work and framework described in this paper is applied to three cases. The conclusions are measured against comparative assessment to validate the practical benefits of the work accomplished.

## 3.1 Case 1: A live commercial website

Softact.com is a live website providing E-commerce services in the area of business and technical artefacts. The technology exploited to build the website is based on Microsoft .NET framework of technologies. We were allowed to examine this company's internal documents in this study.

The main goal of this evaluation is to facilitate the process of evaluating the quality of the website, and provided insight into the reasons behind its findings. Furthermore, it gave direction and prioritizion for remedial work to upgrade the site to give a new, higher quality level of service.

The Goal-Question-Metric approach (Fenton, 1997) was followed to apply EWQPNet to Softact's website. Using this framework, the "beliefs", which are the quality factors, were considered as the goals in this setting. The metrics were set to the three essential levels of positive (i.e. agreeing), negative (i.e. opposing) or neutral, indicating a lack of clear evidence. This approach, according to Fenton (1997) closely resembles a process improvement methodology, especially one that is measurement-based. This aligns with the ultimate goals of the paper in seeking a quantifiable reusable methodology for the assessment the quality of E-commerce websites in the spirit of their betterment.

**3.1.1 Model Application:** The website was analyzed by applying the EWQPNet established in this paper. The target of identifying the "beliefs" on the intermediate nodes was achieved by conducting a score-

based, Goal-Question-Metric study on the state of the site, and the results were plugged into the model to derive the quality level. The assessment outcome is shown in Table 2.

| Nodes | Assessme | Nodes | Assessme |
|---|---|---|---|
| Security | Positive | Maintainability | Positive |
| Availability | Positive | User | Positive |
| Scalability | Positive | Navigability | Negative |
| Integrity | Positive | Reliability | Positive |
| Content | Negative | Efficiency | Negative |
| Trustworthin | Positive | Readability | Positive |
| Accuracy | Positive | Standard | Positive |
| Involved Capacity | Neutral | Functionality | Negative |

Table 2 Assessment Results

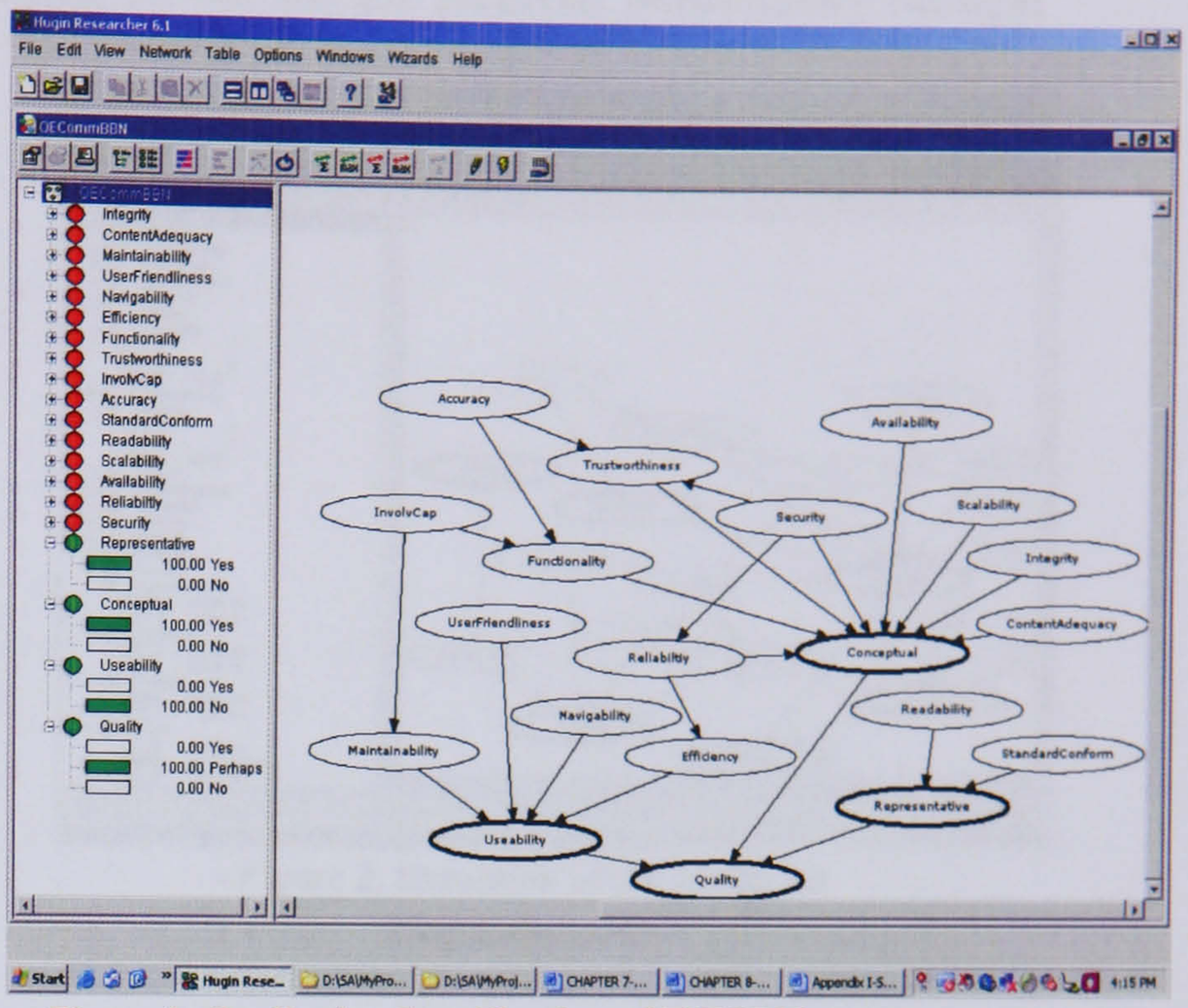



Figure 1: Qualitative Specification of EWQPNet Application of the Model on Softact.com)

EWQPNet describes three types of key factors for achieving quality. Based on the EWQPNet and the analysis framework applied the results were: A low level of Usability attributes, a high level of Conceptual Reliability, and a high level of Representative Reliability. Therefore, according to the EWQPNet, the results show an "unsatisfactory" quality for the website due to usability issues.

**3.1.2 What-if Analysis:** Two factors were identified that impacted on Softact.com's quality negatively, these are Navigability and Efficiency. Improving both factors to an acceptable status would bring the website to a high level of Usability and, therefore, to an acceptable state of quality. According to the model, even a neutral rating of Efficiency augmented with a positive rating on Navigability would be sufficient to clear the low rating of the Usability of the website and upgrade Softact.com to quality status.

**3.1.3 Benefit Analysis:** The exercise indicated the focus of any improvement should be to prioritise the re-engineering of the payment process to produce a more friendly and efficient interface. This was evident from the assessment outcome of the developed model which gave a low rating on the Usability attributes of the site. This low rating was traced back to poor performance in the Navigability aspects of the site. In spite the negative scoring and evaluations in several areas, the model helped to prioritize and focus efforts on usability issues as these were identified as being the most critical.

### 3.2 Case 2: Defunct E-commerce websites

RingaDong.com is an E-commerce website offering for purchase and download ring tones, phone images, screens savers, games and phone management software for the mass population of mobile phone users and, particularly, youth enthusiasts.

According to Offutt (2002), customer loyalty is a key factor to sustain business in E-commerce. However, RingaDong failed to establish this. Their site was created in 2003 and launched later in December of that year. In May 2005, after 18 months of operational presence, the owners of the site decided to "turn it off" as it had failed to generate enough business and revenue to even sustain its daily operational costs. The main goal of this evaluation is to identify reasons that rendered the website inoperable and uncover potential reusability from its subparts.

As in the previous case study at Softact, the Goal-Question-Metric approach (Fenton, 1997) was followed in exercising the developed model. Using this framework, the "beliefs", which were the quality factors, were the goals in this setting. The assessment outcome is given in Table 3 below:

**3.2.1 Knowledge Framework:** Investigating the site's software quality identified Involved Capacity and Functionality as major shortcomings. This caused a deficiency in the site Conceptual Reliability as highlighted in the diagram below.

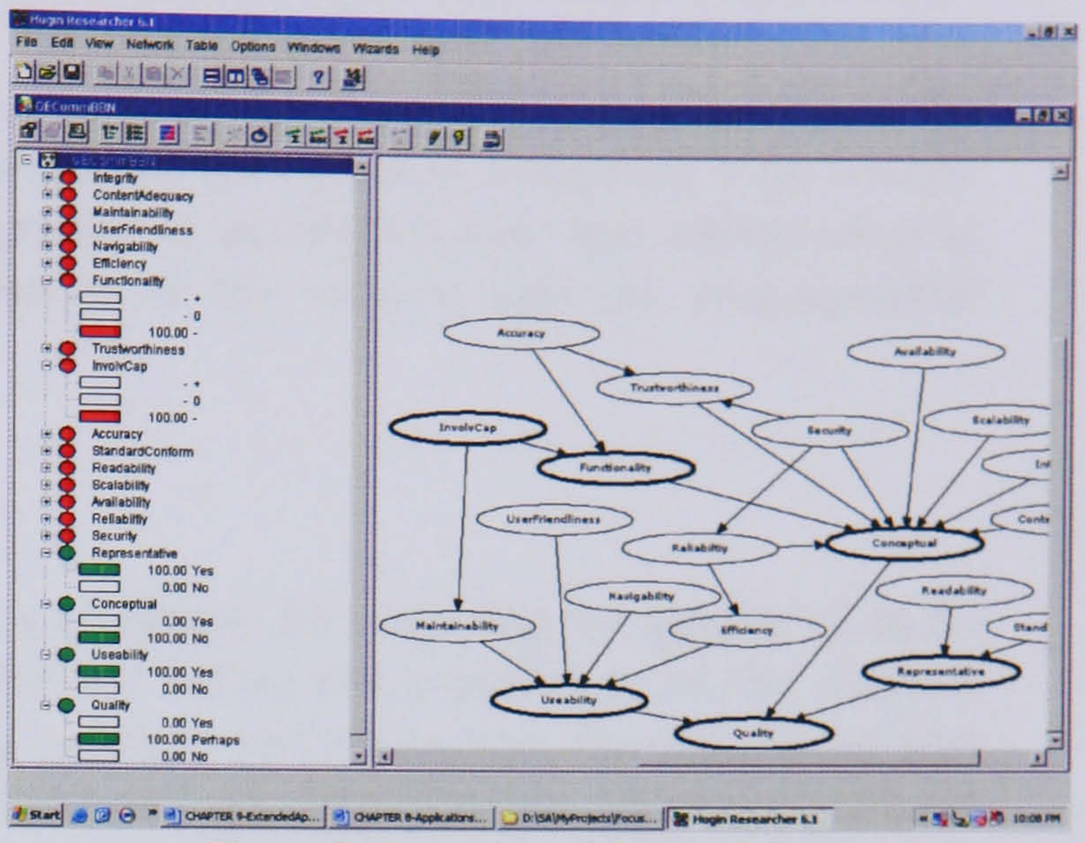
**3.2.2 Validation and Value Benefits:** While one cannot comfortably confirm that this is the main cause of this project failure, it can be reasonably deduced that it was a key contributing factor.

In using the EWQPNet as an assessment tool, it was found that it can also be used to provide insight

on to the viability levels in extracting re-usable components for the future benefit of building new sites. In the case of RingaDong, the assessment showed the site's quality in ensuring Accuracy and Security was satisfactory. This is clearly important as the items purchased off the site are received immediately through downloads or other similar forms of electronic transfer.

| Nodes | Assessme | Nodes | Assessm |
|---|---|---|---|
| Security | Positive | Maintainability | Positive |
| Availability | Neutral | User | Positive |
| Scalability | Negative | Navigability | Negative |
| Integrity | Positive | Reliability | Positive |
| Content Adequacy | Positive | Efficiency | Positive |
| Trustworthiness | Positive | Readability | Positive |
| Accuracy | Positive | Standard | Neutral |
| Involved Capacity | Negative | Functionality | Negative |

Table 3 Assessment Results




- Figure 2: Execution of the Model on RingaDong.com-

### 3.3 Case 3: A new E-commerce Website

This case exercises EWQPNet in a case study of a new E-commerce website to provide insight on how the framework and quality assessment model described in this paper can be applied to set priorities and directions to the development and implementation strategies when producing an E-commerce website.

IconOpportunities.com is a new, up and coming site aimed to provide consumers with newly branded services over the Internet that enable consumers to recharge their mobile phone with air-time usage their credit card. The site works in combination with a banking payment gateway to credit card validation and settlements, and with a mobile phone messaging gateway to dispense the vended PIN numbers that would activate additional air-time access on the mobile. The site is being built on Java ™ technologies.

The quality factors of the model were used as a checklist to find evidence of quality factors within the website software under construction. A forward forecasting was then carried out using the model to assess the probability that the underlying website software will be of high quality.

The results provided a forecast, with a 65% probability, that the site would be lacking comprehensive quality. In analyzing the root causes, it was apparent that there were issues in the lack of positive factors for Navigability, User Friendliness and Scalability.

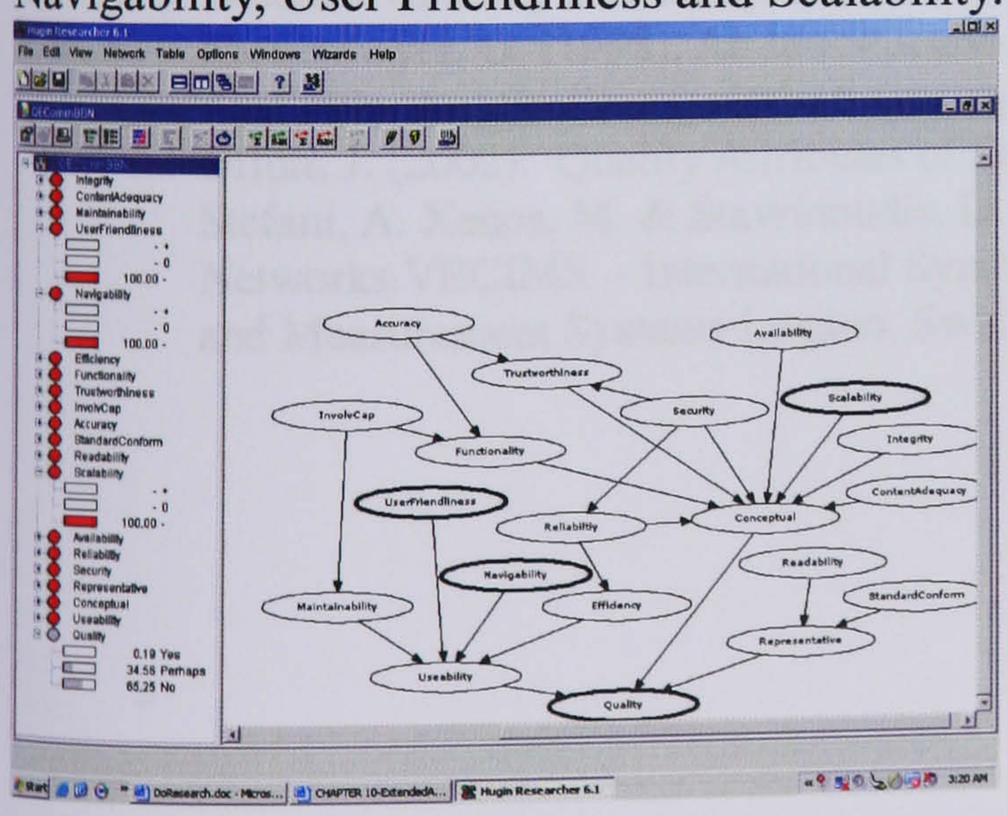



Figure 3: Model Forecasting on IconOpportunities.com

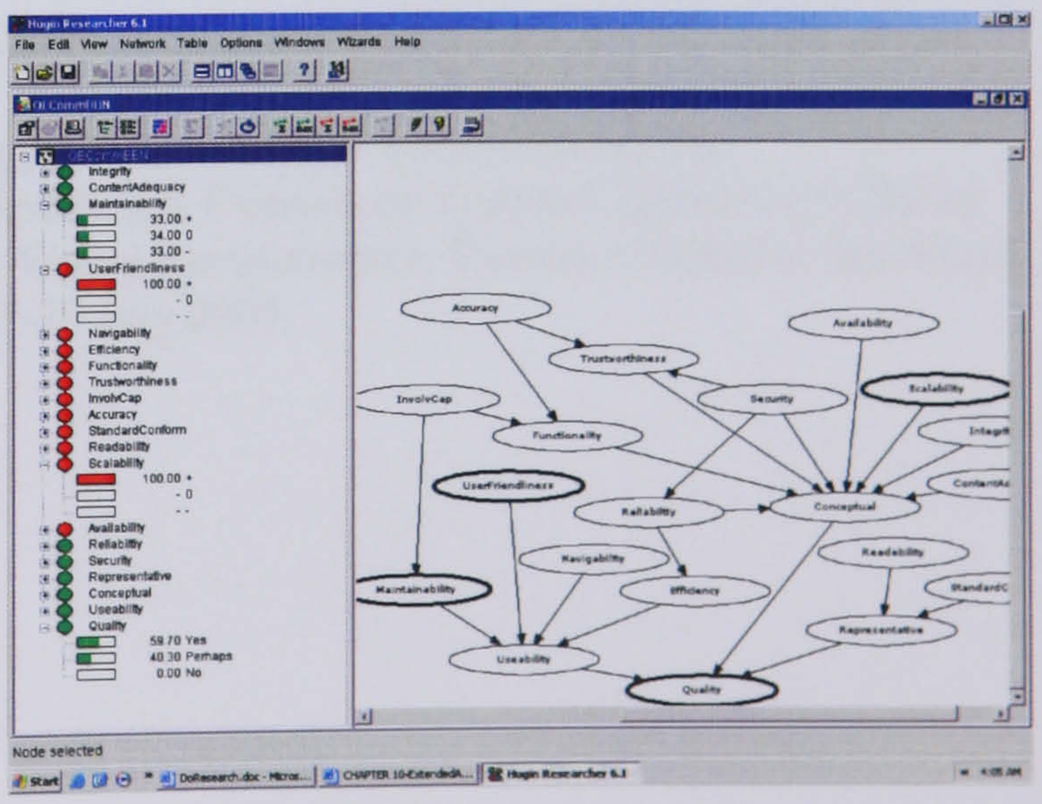



Figure 4: Model Forecasting with positive remedies

**3.3.1 Remedies and Impact** The model provides a useful aid in identifying what needed to be done to complete IconOpportunities' E-commerce website. Forecasting the positive assurance on Navigability, User Friendliness and Scalability yielded better results with a "YES" probability of 57%.

The inclusion of the extra work to improve the low rated quality factors increased the effort requirement of the project by a 11%. This impacted the schedule, extending it by 5 days. The onus was then on IconOpportunities' management to decide whether this additional cost was worth the improvement in the probable quality of the website and the consequential reduction of the potential risk of market failure.

# 4 CONCLUSION

In this paper we have presented EWQPNet, a technique for assessing the quality of an E-commerce website. The assessment can be carried out before the completion of the website development, thus, providing insight on the likely outcome and a direction for corrections and improvements. It can also be carried out on completed and operational work, providing analysis of areas for improvement and support for the decision making regarding the next development steps appropriate for the website. Case studies were selected to demonstrate this and to justify its validity.

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# Appendix M - Paper: E-Commerce Websites Quality Factors and Their Interrelations

The following six pages give a copy of a paper written by the author and presented with another paper, given in Appendix L, at the International Conference on Multidisciplinary Information Sciences and Technologies, InSciT 2006, in Madrid in October 2006.

# E-Commerce Websites Quality Factors and Their Interrelations

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Quality is a key factor to ensuring success of E-commerce in attracting and retaining customers. To this end, it is necessary to define what constitutes a high-quality E-commerce website as well as a methodology for evaluating the quality of E-commerce systems. This paper establishes the factors needed to assesses the quality of an E-commerce website. This work identifies and ranks the main quality attributes for this application domain. Having these quality factors enables the measurement of the specified attributes and variables. Such quality factors should be given serious consideration during the development of E-commerce systems (Stefani, 2003). The primary goals are identifying, qualifying, categorizing and ranking these factors and defining the interrelations among these quality factors. The list of attributes was derived from the specialized literature and by analysis of significant websites. The relationships are identified from the results of a questionnaire described in this paper and by using statistical analysis and expert opinion.

Keywords: E-commerce, metrics, quality evaluation.

## 1 INTRODUCTION

Most E-commerce systems seek to provide high quality services to the end-users, and to this end they include specific applications so as to meet specific end-user requirements. The software behind any E-commerce website is, in essence, the virtual organization and business operation of that site. It is thus reasonable to conclude that the quality and evaluation methods of E-commerce systems will always be dependant on the quality of applications they contain and their ability to meet end-user requirements. According to Larsson (2005), quality factors are primarily attributes of the software that are often labeled as "non-functional requirements". The goal of the paper is to identify these quality factors and the relationships amongst themselves.

## 2 CATEGORIZING

The quality of a website is a property difficult to define and capture in an operational way, yet everybody feels it when it is missing. In fact, for a website there can be as many views of its quality as there are usages. Quality may depend on task-related factors affecting end users such as presentation quality and appeal, content and function adequacy, and navigability. It may also depend on performance-related factors that affect the efficiency of end users and the economics of the website within the company running it. These factors include response time, transaction throughput, reliability and robustness. It may depend on development-related factors that affect developers and maintainers of a website. These include code complexity, code readability, code flexibility, portability, page coupling and modifiability.

The foundation model used to identifying quality factors and attributes is based on research by Albuquerque et al (2002). The model is extended with further research investigation and expert reviews and interviews. Albuquerque organizes a comprehensive set of software quality attributes into objectives where each objective is composed of a set of quality factors. Each quality factor is further decomposed into sub-factors. According to Albuquerque et al (2002), three broad objectives formulate the model, as illustrated in Figure 1, that enable evaluation of an E-commerce website's quality.

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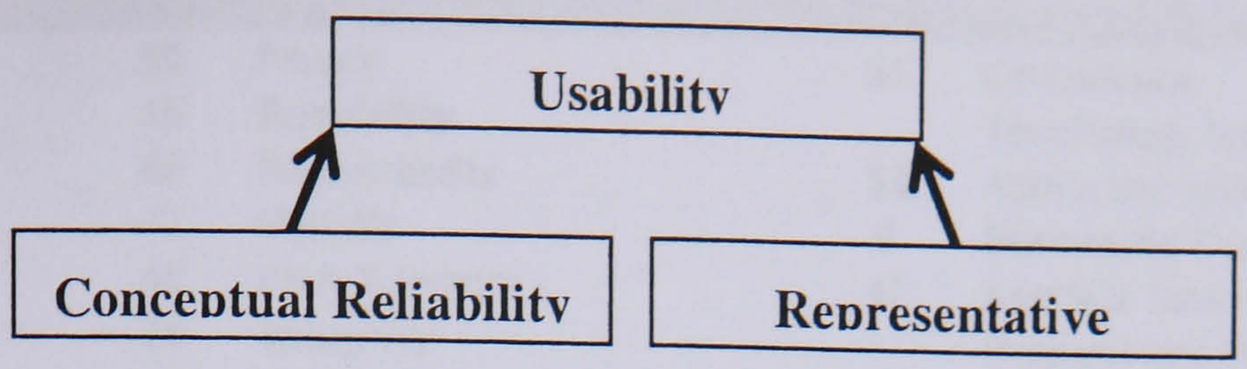
[8] Dr. Fawaz Masoud - Department of Computer and Information systems, The University of Jordan, Amman, Jordan




- Figure 1: E-commerce quality objectives -

Usability is a quality objective that refers to the characteristics that allow use of the E-commerce site in the most diverse situations, not only during its development process, but also during its operation and maintenance. This objective builds on the reliability of the web site. Reliability is composed of two aspects. Conceptual reliability is concerned with the E-commerce site's capacity to implement, satisfactorily, what was specified and designed. Representative reliability refers to the E-commerce site's representation characteristics that affect its understanding and manipulation through its lifecycle.

## 3 IDENTIFYING

Further quality factors and attributes were researched to ensure having a comprehensive list of quality factors. Of most prominent, scalability and availability were added. According to Firesmith (2003), E-commerce website software is large and complex but quality requirements demand the key performance of factors such as availability, performance, scalability, and security. This, in essence, provides the biggest influence on the effective implementation of a website.

Further, the scope of Albuquerque's quality factors extends beyond the technical and operational aspects of a website to its economics and business viabilities. However, in aligning with the goals of this paper, factors relating to such attributes were removed from the list.

At this stage, and based on the academic research exercised, it was felt that a list of seventeen factors within three objectives would satisfy an assessment of the quality to the operational software of an E-commerce website. The next step was to extend the factors with sub-factors that allow measurement to qualify the assessment. Table 1 displays the complete set of those quality attributes. They are a total of eighty eight sub-factors organized within the quality factors.

| Quality Sub-Factors | Rank |
|---|---|
| **Usability** | |
| **Efficiency** | |
| Time Behavior | 53 |
| Purchase Process | 33 |
| Page Generation Speed | 53 |
| **User Friendliness** | |
| Understandability | 76 |
| Products Information | 23 |
| Interactivity | 73 |
| Learn-ability | 68 |
| Localizability | 26 |
| Response Time Uniformity | 74 |
| Communication Facilities | 48 |
| Forms Of Payment | 33 |
| Storage Of Purchase List | 27 |
| Help Availability | 52 |
| Products Comparison | 48 |
| "Shopping Cart" Metaphor | 52 |
| Printing Facilities | 26 |
| Download Facilities | 24 |
| **Navigability** | |
| Absence Of Navigation | 67 |
| Analyzability | 10 |
| Changeability | 52 |
| **Involvement Capacity** | |
| Attractiveness | 63 |
| Aesthetic Attributes | 53 |
| Client Profile Identification | 55 |
| Simulation | 20 |
| Additional Services Availability | 10 |
| **Conceptual Reliability** | |
| **Functionality** | |
| Accuracy | 67 |
| Client Support | 53 |
| Information On Product | 44 |
| Suitability | 58 |
| Flexibility | 18 |
| Interoperability | 10 |
| **Security** | |
| Payment Systems Security | 58 |
| Vulnerability | 14 |
| Site Authentication | 57 |
| Access Control | 51 |
| Confidentiality | 18 |
| Updated Content | 68 |
| Correctness | 61 |
| Intelligibility | 26 |
| User Oriented | 55 |
| Respectability | 25 |
| Concise Content | 39 |
| Completeness | 52 |
| Compatibility With Real Store | 24 |
| **Scalability** | |
| Multiprocessor handling | 21 |
| Farming capabilities | 54 |
| **Availability** | |
| 24/7/365 Readiness | 53 |
| Partial Availability | 38 |
| Notification Integrity | 13 |
| Browser version compatibility | 57 |
| Cross Browser Support | 53 |
| **Representation Reliability** | |
| **Readability** | |
| Language Correctness | 75 |
| Style Uniformity | 38 |
| Clarity | 67 |

| Quality Sub-Factors | Rank | Quality Sub-Factors | Rank | Quality Sub-Factors | Rank |
|---|---|---|---|---|---|
| Minimal Path & Shortcut | 80 | Privacy | 51 | Conciseness | 33 |
| Drawback | 16 | **Reliability** | | Terminology Uniformity | 24 |
| Navigation Structure | 66 | Recoverability | 53 | Abstraction Uniformity | 14 |
| Links Visibility | 72 | Maturity | 0 | **Standards Conformance** | |
| Links Visualization | 48 | Fault Tolerance | 47 | Interface Standards | 61 |
| Alternative Paths | 28 | **Integrity** | | Programming Standards | 42 |
| Navigational Prediction | 17 | Data Integrity | 58 | Navigation Standards | 31 |
| User Level Adaptability | 45 | Robustness | 22 | **Easy Of Manipulation** | |
| Interaction Storage | 29 | Audit Trail | 25 | Up-To-Date | 44 |
| Mobile Devices Accessibility | 17 | **Trustworthiness** | | Ability To Trace | 38 |
| **Maintainability** | | Correctness | 50 | Documentation Availability | 33 |
| Stability | 60 | Completeness | 0 | Structure | 35 |
| Testability | 27 | **Content Adequacy** | | | |

- Table 1: Identified Quality Sub-Factors and their ranks -

## 4 QUALIFYING

To determine a ranking system for the factors, a standard statistical ranking scheme based on frequency of expert rating was used to reflect the relative importance of the different sub-factors within a factor. The weighting system was based on questionnaire results from expert specialists in E-commerce development and representative consumers of E-commence. Participants in the questionnaires were selected based on meeting qualifying criteria. Once qualified, the participants were asked to respond to the questionnaire that asked them to rank each sub-factor in order of importance of the attribute to the factor it belongs to. The questionnaire also provided an explanation of how each sub-factor influences the attributes of the factor.

A total of thirteen responses to the questionnaire were collected. Six qualified as expert specialists and seven as representative consumers. For the both groups, the expert specialist and the E-commerce consumer representatives, filling the questionnaire was facilitated by the author. For each interview engagement, an introduction orientation was given on the questionnaire followed by a one-on-one question and answer session to gain the answers. The answers were recorded by the author to assure accuracy and consistency, which follows the guidelines of the Delphi method. In general, the process of soliciting answers followed the standard Delphi method (Dunham, 1998) in soliciting expert opinions.

## 5 RANKING

The ranking of sub-factors within each factor was sequentially based on the order of importance of the sub-factor in its influence on its factor. So for factor S having six sub-factors of SS1 to SS6, each participant ranked the importance of each SSn in influencing S where 1 was the most important and 6 was the least.

Once all results were collected, a weighting scheme was applied to reflect the relative importance (ranking) of the different sub-factors based on the formula:

*Sub-factor Percent Importance = 100 – (M / N)*100*

Where M represents the average rating received on a sub-factor and N represents the total number of sub-factors attributes for a given factor. The subtraction from 100 is to reverse the ranking scale of the questionnaire as the questionnaire ranking of "1" has the highest percentage importance. The final ranking achieved has the highest percentage given to the most important sub-factor, proceeding to the least important in a descending fashion. Table 1 shows the rank received by each sub factor.

## 6 FACTORS RELATIONS

An understanding of the inferences and causal relations the quality factors have amongst themselves is essential for a reliable model (Eleanor, 1999). Statistical correlation was used in

analyzing the data obtained from the responses to the questionnaire to establish initial inter-factor relations. Correlation is not an indication of cause-and-effect relationships (StatSoft, 2006) where changes in one variable impacts, and is the direct cause of changes in the correlated variable. Correlations merely indicate whether two variables are in unison in terms of movement. However, a harmony in movement in either the same direction or opposite (inverse) direction provides insight into possible cause-and-effect relationships. In this paper, correlations are used with rating scales, but with care. After the completion of identifying the factors' significant inter-relations, the results were reviewed by a panel of experts to ensure they were comfortable with the results.

The validation of each possible relationship was carried out using a panel of experts to analyze the results of the correlation analysis to draw conclusions about which viable inter-dependencies exist amongst sub-factors. The panel members were invited to a group discussion on what would be the relevant and important relationships among the sub-factors. Using Martin's (2003) approach, a stepwise model selection technique combining forward selection and backwards elimination was used. Every panel member was asked to select the best causal relationship, in their view. The selection was iterated one relationship at a time in a round-robin approach. Not knowing when a cessation would be reached in this process, the members continued till their own point of satisfaction was reached and no further selection was added to their derived list. At that point a reversal elimination process started where each member was asked to return the least desired relation from their possession. The process continued in a round-robin fashion until the panel collectively retained 50% of the initially selected relations. The exercise was concluded at that point. Table 2 shows the results of the selection process.

| **Sub Factor** | | **Sub Factor** |
|---|---|---|
| "Shopping Cart" Metaphor | Influences | Client Support |
| 24/7/365 Readiness | Influences | Client Support |
| Access Control | Influences | Payment Systems Security |
| Clarity | Influences | Understandability |
| Completeness | Influences | Learn-ability |
| Data Integrity | Influences | Attractiveness |
| Help Availability | Influences | Attractiveness |
| Links Visibility | Influences | Clarity |
| Minimal Path & Shortcut Facility | Influences | Clarity |
| Minimal Path & Shortcut Facility | Influences | Understandability |
| Navigation Structure Taxonomy | Influences | Privacy |
| Page Generation Speed | Influences | Response Time Uniformity |
| Page Generation Speed | Influences | Recoverability |
| Recoverability | Influences | Time Behavior |
| Site Authentication | Influences | Suitability |

# Appendix M

| | | |
|---|---|---|
| Stability | Influences | Clarity |
| Stability | Influences | Understandability |
| Updated Content | Influences | Attractiveness |

- Table 2 Finalized Selections of Sub-Factors Interdependencies –

| | **Usability** | Efficiency | User Friendliness | Navigability | Maintainability | Involvement Capacity | **Conceptual Reliability** | Functionality | Security | Reliability | Integrity | Trustworthiness | Content Adequacy | Scalability | Availability | **Representation Reliability** | Readability | Standards Conformance | Easy Of Manipulation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Usability** | | | | | | | | | | | | | | | | | | | |
| Efficiency | | | | | | | | | | | | | | | | | | | |
| User Friendliness | | 1 | | | | | | | | | | | | | | | | | |
| Navigability | | 3 | 3 | | | | | | | | | | | | | | | | |
| Maintainability | | 1 | 0 | 0 | | | | | | | | | | | | | | | |
| Involvement Capacity | | 0 | 5 | 2 | 0 | | | | | | | | | | | | | | |
| **Conceptual Reliability** | | | | | | | | | | | | | | | | | | | |
| Functionality | | 3 | 3 | 3 | 2 | 0 | | | | | | | | | | | | | |
| Security | | 0 | 0 | 0 | 4 | 0 | | 3 | | | | | | | | | | | |
| Reliability | | 0 | 0 | 0 | 4 | 0 | | 3 | 5 | | | | | | | | | | |
| Integrity | | 0 | 0 | 0 | 4 | 0 | | 4 | 6 | 6 | | | | | | | | | |
| Trustworthiness | | 0 | 0 | 0 | 0 | 0 | | 5 | 6 | 6 | 6 | | | | | | | | |
| Content Adequacy | | 5 | 4 | 1 | 2 | 0 | | 4 | 0 | 0 | 0 | 5 | | | | | | | |
| Scalability | | 3 | 0 | 0 | 5 | 3 | | 0 | 0 | 3 | 0 | 0 | 0 | | | | | | |
| Availability | | 0 | 0 | 0 | 0 | 0 | | 3 | 0 | 0 | 0 | 0 | 0 | 1 | | | | | |
| **Representation Reliability** | | | | | | | | | | | | | | | | | | | |
| Readability | | 4 | 5 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| Standards Conformance | | 0 | 0 | 0 | 5 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | | |
| Easy Of Manipulation | | 0 | 0 | 0 | 0 | 0 | | 4 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | | 0 | 0 | |

- Table 3 Factors Polled Relations -

The same panel of three experts was invited to another exercise to perform interrelation analysis at the quality factors level. All the possible factor relationships, as shown in Table 3, were projected at a display wall. The panel members were asked to assess the relation "cells" and provide a score of 0 to 2 where "2" indicates the presence of strong causal relations and a "0" the lack of such a relationship. Table 3 lists possible relations among factors and the rating

results received. The results are given in Table 4. Table 5 shows the resultant relations inferred.

| | |
|---|---|
| Highest and Highest Possible Score | 6.0 |
| Lowest and Lowest Possible Score | 0.0 |
| Total Score | 150 |
| Total Count | 120 |
| Average (Mean) | 1.25 |
| Median | 0.0 |
| Threshold | 4.0 |

- Table 4: Factor Relations Polling Results –

| **Factor** | | **Factor** |
|---|---|---|
| Involvement Capacity | Influences | User Friendliness |
| Security | Influences | Maintainability |
| Reliability | Influences | Security and Maintainability |
| Integrity | Influences | Security, Reliability, functionality and Maintainability |
| Trustworthiness | Influences | Functionality, Security, Reliability and Integrity |
| Content Adequacy | Influences | Efficiency, User Friendliness, Functionality and Integrity |
| Scalability | Influences | Maintainability |
| Readability | Influences | User Friendliness |
| Standards Conformance | Influences | Maintainability |
| Easy Of Manipulation | Influences | Maintainability and Scalability |

- Table 5 Finalized Selection of Factor Interdependencies -

# 7 CONCLUSION

This paper has identified and ranked the factors and sub-factors that contribute towards the quality of an E-commerce website. Furthermore, the relationships between these factors showing which factors influence others have been derived. The results provide an important foundation for the understanding of quality in E-commerce websites that will allow developers to assess the strengths and weaknesses of their sites in order to know where to focus further development to achieve the high quality needed for E-commerce success.

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