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Full Length Research Paper

Optimizing the process of developing E-government website using decision support system

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The purpose of this paper was to address the issue of E-government website evaluation regarding the provision of a decision-making framework built around the concepts of website evaluation. The proposed framework deploys a Bayesian Belief Network (BBN) to conquer the subjectivity and inaccuracy that characterizes the conventional models for E-government website quality assessment. Since the developments of E-government system are becoming more and more complex, an entire quantitative evaluation process concerning all pertinent quality characteristics is also a complex issue. This is caused by a lot of intervening features, and by the compound logic relationships among attributes and characteristics. To achieve the preferred quality of E-government website, it is essential to produce an intelligent engine that enables evaluation of E-government system's quality. This intelligent engine would provide a consistent and practical approach for assessing the quality of the E-government website. The assessment can be carried out prior to the completion of the software development, therefore, providing insight into the trend and direction of correction and improvements. It can also be performed on accomplished and operational work, providing analysis of areas for enhancement. The performance of the intelligent engine should be pretty quick and practical in providing an overall comprehensive assessment with root-cause analysis that would lead to corrective measures to improve the quality of E-government website. Case studies were selected to demonstrate this and justify its validity.

Key words: E-government, E-government software developments, metrics, quality evaluation, decision support systems.

INTRODUCTION

The internet and mainly the World Wide Web has evolved into both private and public organizations all over the world from a primary tool for displaying information into a means of providing added value services to customers.

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However, while an active presence on the web appears like a competitive advantage for private organizations, for public bodies it constitutes, an obligation toward citizens (Markaki et al., 2015). According to Markaki et al. (2015) as public authorities at all government levels around the world attempt to embrace the digital revolution and place a broad range of materials on the web, from mere information to actual online services, expectations of the performance levels that E-government websites should provide have been considerably raised, bringing up the issue of their quality evaluation.

The necessity of ensuring quality through website evaluation originates not only from that E-government websites have been one of the most important channels for public services delivery and citizen-government interaction, but also from the need to justify government investment that makes web-based service delivery possible (Fath-Allah et al., 2014).

Past approaches concerning the quality of E-government systems emphasize usability standards using techniques like feature inspection and collecting data on end-users' opinion by questionnaires. These methods provide valuable feedback, and their outcome can be utilized as a useful background for future work. However, they do not contribute directly to a dynamic model that enables forecasting (Chan et al., 2001). Website style guides and design principles such as the IEEE Web Publishing Guide, 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 irresistible 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 direction 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 are 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 to consider automatic tools for supporting quality assessments.

According to Sonal et al. (2014), in expert systems, the word uncertainty is related to working with inexact data, inaccurate information, handling an identical situation, the reliability of the results, etc. An expert system allows the user to assign probabilities, certainty factors, or confidence levels and many more techniques to any or all input data. This feature closely represents how most problems are handled in the real world. An expert system can take all relevant factors into account and make a recommendation based on the best possible solution rather than the only exact solution to handle such problems.

This research paper provides a decision-making framework for evaluating E-government websites that is based on BBN. The proposed framework constitutes a holistic approach and is characterized by scalability.

RELATED WORK

Several models have been developed from the 1980s for investigating information system achievement and the broader term website success. However, few studies considered the combination of information system quality and online service quality variables as components of website success, Updated Delone and McLean IS Success Model (2003) are one of the highly cited models, which concerns both IS and Service quality as antecedents of website success. In this model, they identified six criteria to measure the success of a system, which is: system quality, information quality, information use, user satisfaction, individual impact and organizational impact.

Furthermore, different website evaluation approaches that deal with website usability and design, content, quality, user acceptance and user satisfaction are the most frequent outcomes measured to evaluate websites (Pearrow, 2000). Chiou et al. (2010) saw that these approaches from a strategic viewpoint were right by assessing user attitude towards the website and could be considered as an external user's view.

Fath-Allah et al. (2014) provided a comparative analysis of E-government quality models based on ISO based quality models and non-ISO based quality models. Table 1 shows a comparison between ISO quality models. Whereas, Table 2 displays a comparison between non-ISO quality models in terms of many criteria including year when the paper was published, ISO standard used related to software quality (such as ISO 9126, ISO 25000, etc.), whether the quality model introduces new quality characteristics or uses the existing ones from ISO standards, quality focus (for instance, supply side or demand side), quality domain (such as, service quality or Website quality, etc.), availability of the quality model's metrics, and finally whether the quality model is using a best practice model or not.

Fath-Allah et al. (2014) concluded that, in the ISO based quality models, only one model focuses on E-government portals' quality and it is using the ISO standard 9126. Whereas, from the non-ISO based quality models, two quality models are focusing on E-government

Table 1. Comparison of the ISO based quality models.

Model / Dimensions	Ulman et al. (2013)	Quirchmayr et al. (2007)	Chutimaskul et al. (2008)	Osama et al. (2013)
ISO Standard	ISO 25010	ISO 9126	ISO 9126	ISO 9126
Introduced new quality characteristics/sub-characteristics	New quality sub-characteristics	Added one quality dimension (privacy)	No	Added six quality characteristics
Provided definitions of quality characteristics	No definitions even for the newly added sub- characteristics	Provided definitions	No definitions	No definitions even for the newly added sub- characteristics
Quality focus	Citizen perspective quality (Quality in use)	Supply side and demand side	Importance of quality dimensions is taking citizen perspective into consideration	Supply side
Quality domain	Service quality	Service quality	Holistic (system quality, service quality and information quality)	E-government Websites
Provided metrics	Only short list of metrics (1 per quality sub- characteristics)	Only short list of metrics (1 per quality sub- characteristics)	No metrics	No metrics
Based on a best practice model	No	No	No	No

Source: Fath-Allah et al. (2014).

portals quality. However, each model has a different set of quality dimensions. According to Fath-Allah et al. (2014), bringing a convergence and international consensus on quality standards would facilitate both the measurement and the use of the quality models on the one hand and would guarantee the reliability and validity of the quality models on the contrary.

The solution proposed by this research is the establishment of a BBN to overcome the subjectivity and inaccuracy that characterizes the conventional models for E-government website quality assessment. According to Uusitalo (2015), BBNs are often called decision support systems where the factors affecting a decision are modeled concerning their elements and inter-dependencies. Furthermore, BBNs have become a valuable tool for research and applications. They are useful for both inferential exploration of previously unknown relationships among variables and for descriptions of the relationships discovered. The aim of this paper was to create a decision support system to aid in the assessment and decision-making concerning the quality assessment of an E-government websites.

BUILDING A BAYESIAN BELIEF NETWORK MODEL

A BBN is a graph composed of variables connected by arrows indicating an influencing relationship between the connected nodes. Each node has a fixed number of states, and a table of probabilities showing its relationship with another node. Edges reflect cause-effect relationships within the domain. These effects are usually not completely deterministic. The strength of an effect is modeled as a probability (Skinner et al., 2014). Mathematically, a BBN is a probabilistic network that helps model and measure valuations and assessments (Skinner et al., 2014). According to Sonal et al. (2014), establishing a BBN is a two stage process. Qualitative analysis is the first phase, followed by quantitative analysis.

Qualitative analysis

Qualitative analysis involves representing the BBN in the form of an acyclic graph consisting of nodes and directed arcs. The resulting BBN is shown in Figure 1. The target model was built using Microsoft Research's Bayesian network Authoring and Evaluation Tool (MSBNX). As Figure 1 illustrates, there are three types of nodes:

Target node

The aim of the assessment, which is the quality node.

Intermediate nodes

Nodes with limited information or "beliefs". Functionality,

Table 2. Comparison between the non-ISO based quality models.

Dimensions / Models	Provided definitions	Quality focus	Quality dimensions	Theoretical	Quality Domain	Provided metrics	Based on a best practice method
Hien (2014)	Yes	Customer expectation	- Information quality - Service quality - Organization quality	Theoretical + To be verified in the future by a survey to CIO + factors will be verified by a questionnaire	E-government E-service quality	No	No
Elling et al. (2012) (WEQ)	No	Citizen's perspective	-Navigation -Content -Layout	Theoretical and then proved after an empirical study	E-government	Yes	No
Papadomichela ki (2012) and Mentzas (2009) (e-GovQual),	Yes	Citizen's perspective	-Reliability -Efficiency -Citizen support -Trust	Theoretical and then proved after an empirical study	E-government Service quality	Yes	No
Kaisara and Pather (2011) (e-GovSqal)	Explanations without clear definitions	User perspective (questionnaire for e-government users)	-Website design -Navigation -Website aesthetics -Information quality -Security Communication	Theoretical and then proved after an empirical study	E-government E-service	Yes	No
Henriksson et al. (2007) (EGWET)	Yes	Supply side (interviews with developers)	Security and privacy Usability Content Services Citizen participation Features	Conceptual model – A systematic review of contemporary research + Review of best practices in Website design + Interviews with Internet services managers	E-government Website	Not found in paper	No
Bhattacharya et al. (2012)	Explanations without clear definitions	Citizen's perspective	Security/privacy and transparency of transaction Completeness of Information about the service Citizen centric features and usability of portal	Theoretical and then proved after an empirical study	E-service of e-government portals	No	No

Source: Fath-Allah et al. (2014).

Reliability, Trustworthiness, Usability, User-Friendless, Efficiency are intermediate nodes.

Observable nodes

This can be directly observed. All the remaining nodes are observable and can be quantified, based on the findings from their sub-factor. Table 3 shows how the factors acting as BBN nodes influence the model from a business domain perspective.

Quantitative analysis

The second stage in building BBN model 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.

According to Uusitalo et al. (2015), the probabilistic, integrative decision support models can derive their data from three types of sources: from literature, elicited from experts, or learned directly from observations. 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 efficient 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 variables attributes having a negative influence in the website and (0) showing neutrality in the decision about the variable's influence within the website. A complete quantitative specification of our BBN model is not included as it would have too many relations for the

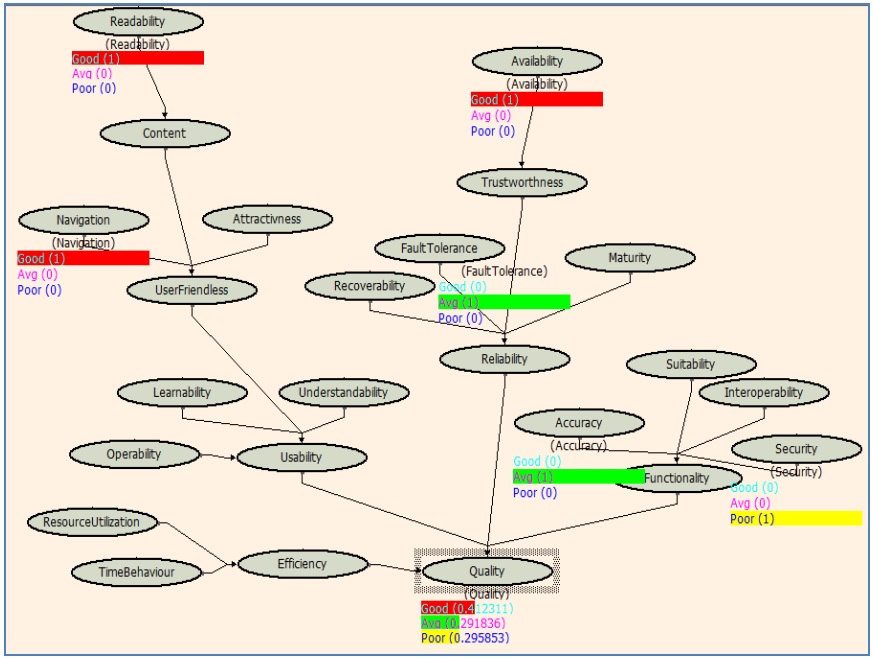

Figure 1. Qualitative specification of BBN model.

Table 3. How the factors acting as BBN nodes influence the model from a business domain perspective.

Observable node	Influenced described
Functionality	The extent of operational aspects of the website software and its fitness for use.
Reliability	The extent to which the website remains available and working.
Availability	The extent of website accessibility to users through different browsers in different times
Usability	Users' interface capabilities for which the website provides a supportive experience to the user.
Efficiency	The timelines in which the website responds to the user.
Readability	The appropriate application of the written language used in the website
Content	The extent to which the presented information is contextually applicable to the user and sufficient for the user's needs.
Navigability	The browsing extensibility which the website's software allows.
Security	The degree of safety assured against malicious or accidental intrusion.
Trustworthiness	The extent to which the user perceives the website to behave correctly, consistently
Maintainability	The reduced effort which the website's software requires for its maintenance
Portability	The ability of software to be transferred from one environment to another.

Table 4. The assessment results of SSC.gov.jo.

Nodes	Assessment
Security	Good
Interoperability	Poor
Suitability	Good
Accuracy	Good
Maturity	Good
Availability	Good
Fault Tolerance	Good
Recoverability	Good
Attractiveness	Good
Readability	Good
Navigation	Good
Understandability	Good
Learnability	Good
Operability	Poor
Time Behavior	Good
Resource Utilization	Good

space available.

EXPERIMENTAL EVALUATION

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.

Case 1: The Social Security Corporation (SSC)

SSC is a live website that provides general information about the corporation's insurances in addition to e-services in the field of social security. The technology exploited to build the site is based on Microsoft.NET framework of technologies. We were allowed to examine this company's internal documents in this study.
The primary goal of this evaluation is to facilitate the process of evaluating the quality of the website and provide insight into the reasons behind the findings. Furthermore, it gave direction and prioritizing for remedial work to upgrade the site to provide a new, higher quality level of service.

The Goal-Question-Metric approach (Fenton and Lawrence, 1997) was followed to apply BBN model to SSC website. In the first step of the process, the evaluation sheet of the E-government website was given to two evaluators to answer the proposed questions. Two reviewers were assigned to respond to the questions to avoid errors due to some carelessness or misunderstanding of the questions. The sheet was simply a questionnaire that gives the evaluator the option of a rating score from -100% to 100%, so that the third reviewer can then process them, scaling them down into three states: (+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.

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 (good, that is, agreeing), negative (poor, that is, opposing) or neutral (average), indicating a lack of clear evidence. This approach, according to Rababah (2007), closely resembles a process improvement methodology, especially one that is measurement-based. This aligns with the ultimate goals of the paper in seeking a reusable quantitative methodology for assessing the quality of E-governments websites in the spirit of their improvement.

Model application

The site was examined by applying the BBN model proven in this paper. The target of identifying the "beliefs" on the intermediate nodes was attained 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 4. This is illustrated in Figure 1. BBN model describes three types of critical factors for achieving quality. Based on the BBN model and the analysis framework that applied the results were: A low level of interoperability attributes, mainly because it does not work well on multiple browsers, a low level of operability attributes, because it does not provide search history, cannot be customized according to the user's preferences, and it is not accessible for users with disabilities.

The application of the BBN model on SSC shows an "average" level of quality with a value equals to 0.706 due to the low level of both interoperability and operability. This is illustrated in Figure 2.

What-if analysis

Two aspects were recognized that impacted on SSC.gov.jo quality negatively, these are interoperability and operability. Improving both factors to an acceptable status would bring the website to a high level of quality. According to the BBN model, a good rating of operability augmented with an average score on interoperability would be effective to raise the level of the website quality to good, with a value equals to 0.914. This is shown in Figure 3.

At the time of conducting the research, the current old SSC website was intended to be replaced by another website, though it has not been launched yet, for:

1. Improving and increasing the number of provided e-services. This is inferring that the current website is not flexible.
2. It is hard to update the website's design by the Corporation's staff. This reflects flexibility problem.
3. Not supporting audio and video.
4. The used content management system (CMS) tool is out of date.

The assessment that was conducted on the new SSC's website revealed an improvement in several factors over the old website as shown in Table 5. A forward forecasting was carried out to assess the probability that the underlying website will be of high quality. The results show a "satisfactory" quality of the site with value of 0.973. This is shown in Figure 4.

Case 2: E-Government portal

E-government portal is the official site of the Jordanian E-government, and is run by Ministry of Information and Communications Technology (MoICT). The portal gives access to users, who can find the information they are looking for in relation to the E-government program, national information system, connection to government agencies such as; Ministry of Public Works and Housing, Government Tenders Directorate, Jordan Tourism Board, etc.

As in the previous case study at SSC.gov.jo, the Goal-Question-Metric approach (Fenton and Lawrence, 1997) was followed in

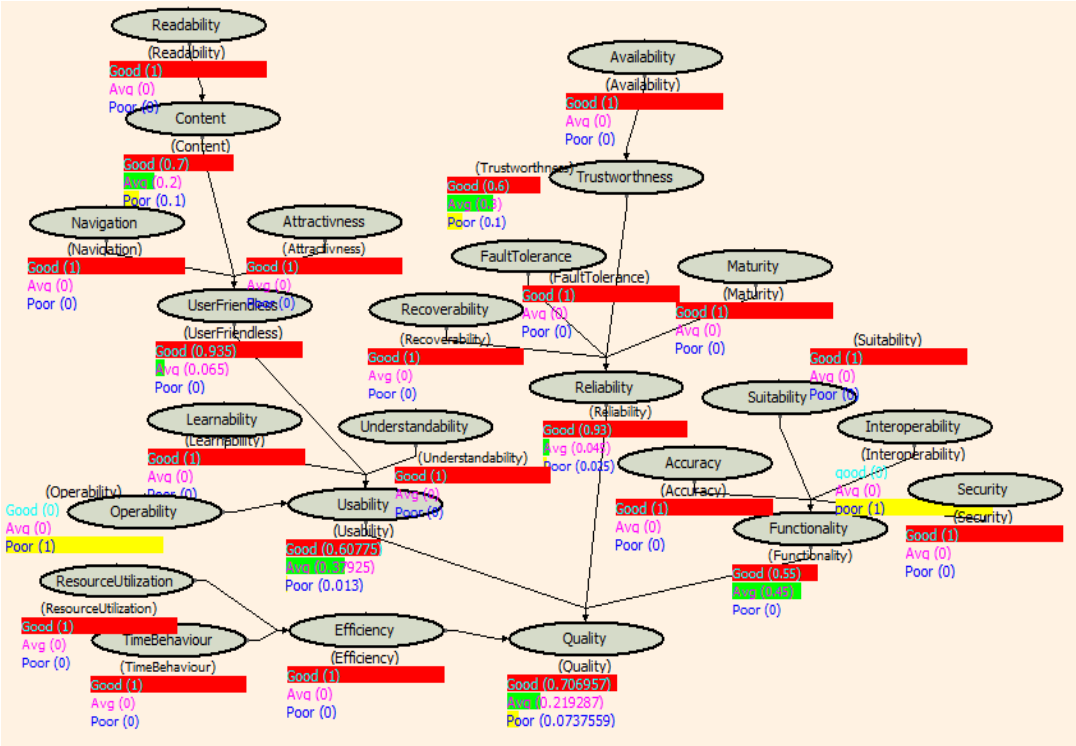

Figure 2. Application of the BBN Model on SSC.gov.jo.

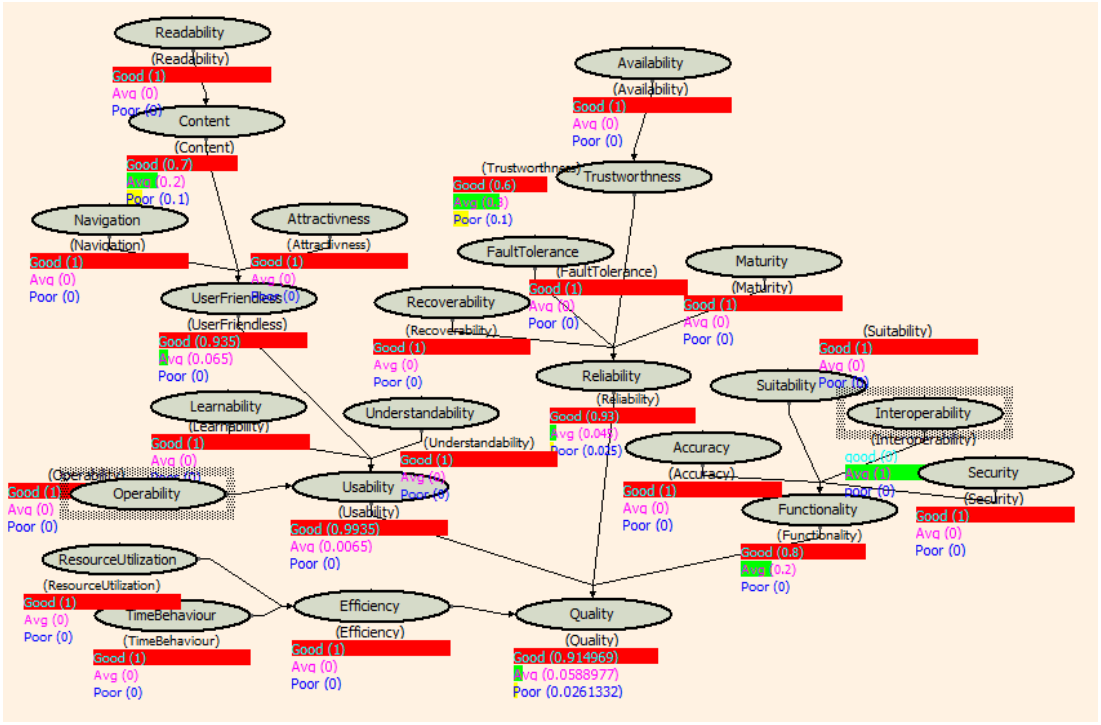

Figure 3. The influence of a good operability and an average interoperability on the website quality.

exercising the developed model. Using this framework, the “beliefs”, which were the quality factors, were the goals in this setting. The

Table 5. New SSC website assessment results.

Nodes	Assessment
Security	Good
Interoperability	Good
Suitability	Good
Accuracy	Good
Maturity	Good
Availability	Good
Fault Tolerance	Good
Recoverability	Good
Attractiveness	Good
Readability	Good
Navigation	Good
Understandability	Good
Learnability	Good
Operability	Good
Time Behavior	Good
Resource Utilization	Good

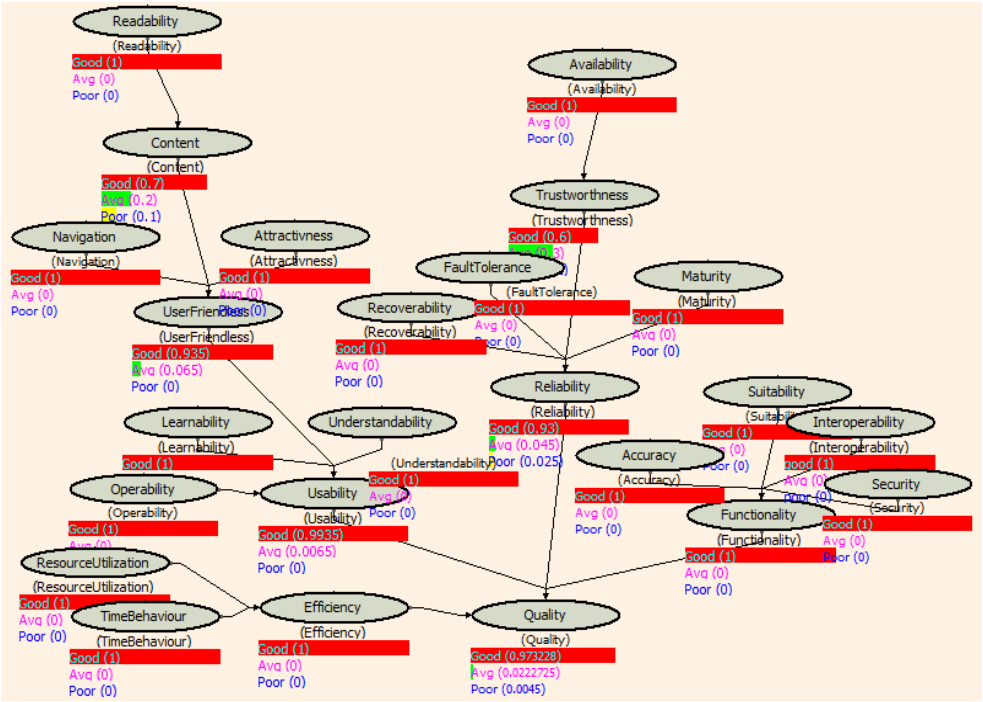

Figure 4. Model forecasting with good quality.

assessment outcome is given in Table 6.

Validation and value benefits

Investigating the site's software quality identified involved interoperability, accuracy, attractiveness, learnability, and operability as major shortcomings. When applying BBN Model, the results show an "unsatisfactory" quality for the website where the quality value equals 0.462, this is due to the five identified poor factors. This is shown in Figure 5 where the poor status is illustrated in yellow color. Improving these five factors: Interoperability, accuracy, attractiveness, learnability and operability, to an acceptable average status, would bring the site from 0.462 to a high level of quality equals 0.928, as shown in Figure 6.

The site was never set up to survey customers' satisfaction.

Table 6. E-government portal assessment results.

Nodes	Assessment
Security	Good
Interoperability	Poor
Suitability	Good
Accuracy	Poor
Maturity	Good
Availability	Good
Fault Tolerance	Good
Recoverability	Good
Attractiveness	Poor
Readability	Good
Navigation	Good
Understandability	Good
Learnability	Poor
Operability	Poor
Time Behavior	Good
Resource Utilization	Average

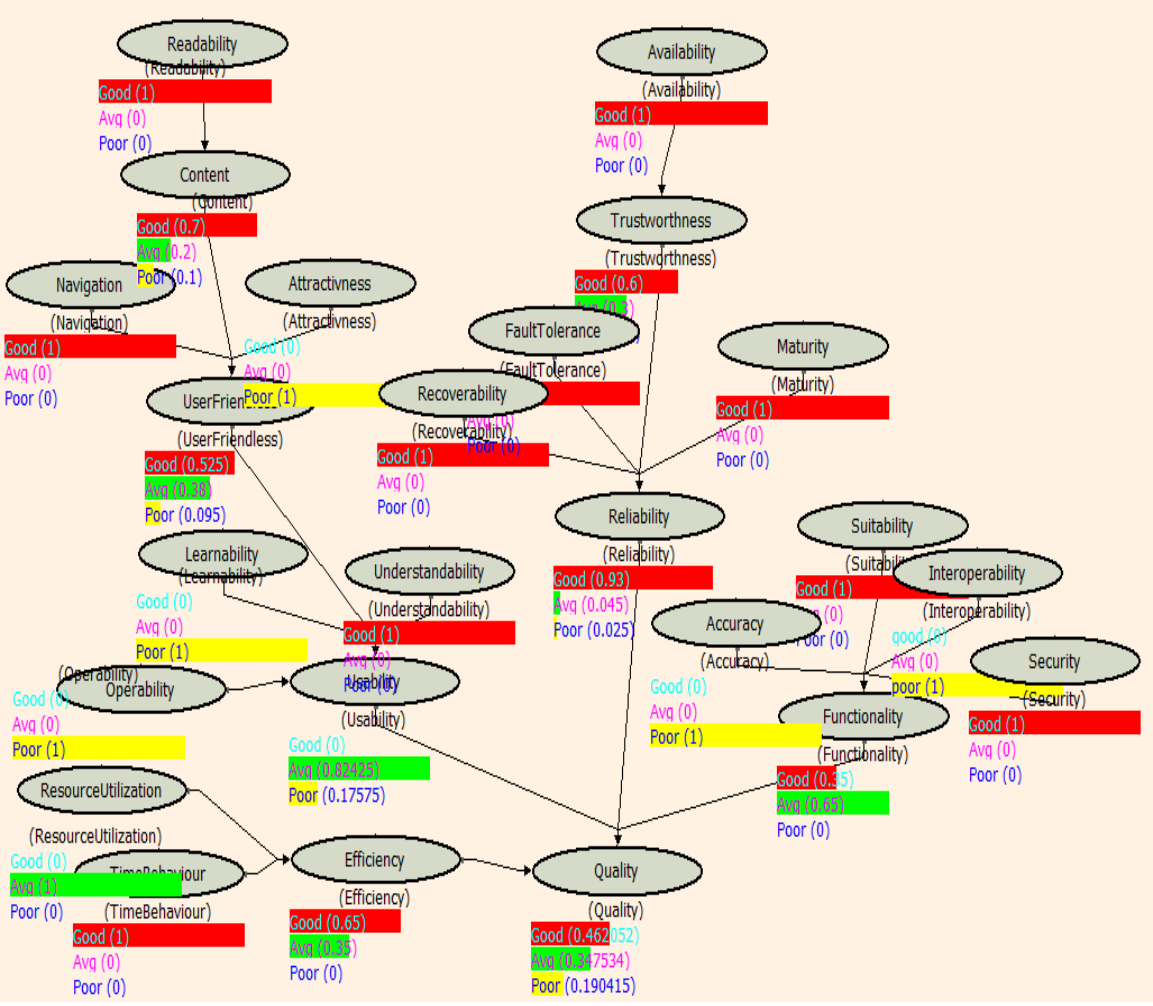

Figure 5. Execution of the model on E-government portal website.

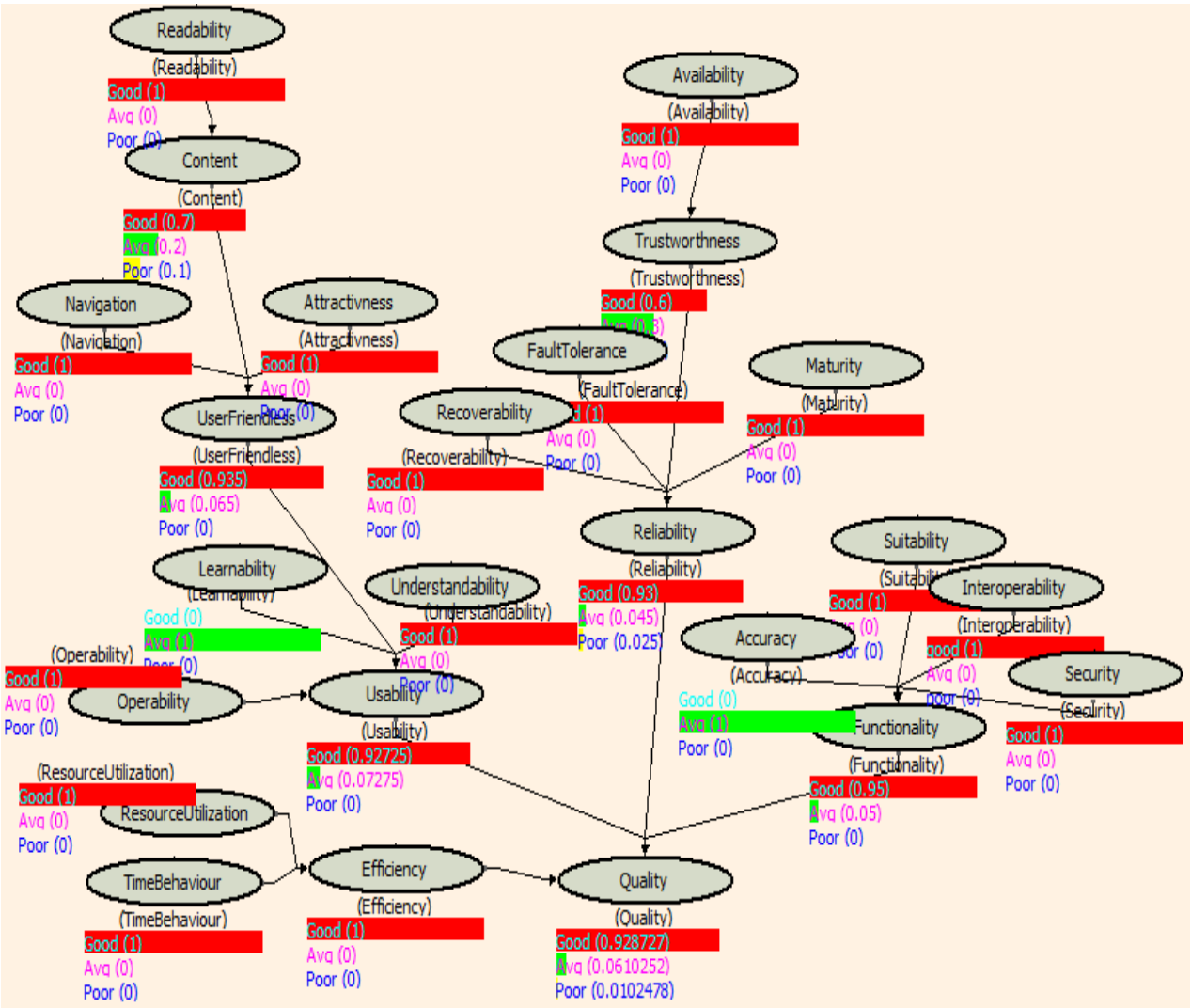

Figure 6. Positive influence of improving factors on the website's quality.

Neither was it feasible to perform such an exercise at the time of this research.

Case 3: Public Security Directorate

The third case is the website of the PSD www.psd.gov.jo. This website provides general information on PSD, its services, e.g. Issuing Certificate of Non-Criminal Record, and links to other similar agencies, e.g. Driver and Vehicle License, the Residence and the Border, and the Traffic department, etc.

When conducting the assessment process, it was found that the website does not determine the access rights for each user and is not accessible to users with disabilities. These findings affect the status of both the Security and Operability negatively. This assessment is given in Table 7. After applying the model to the website, a low level of quality was revealed, which is .64. This is explained by the low level of Security and Operability as shown in Figure 7.The upgrading of the status of these two factors, Security to good and Operability to average increased the quality of the website to 895 as illustrated in Figure 8.

REALIZATION

It was shown in this paper that a BBN, which is a network, based technique for representing and analyzing models involving uncertainty, is an appropriate and applicable tool for the modeling and representation of E-government quality relationships. This method 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 paper has shown that it is a reliable utility to apply as an assessment tool for the E-government qualities of a website and the root-causes of any quality

Table 7. PSD website assessment results.

Nodes	Assessment
Security	Poor
Interoperability	Good
Suitability	Good
Accuracy	Good
Maturity	Good
Availability	Good
Fault tolerance	Good
Recoverability	Good
Attractiveness	Good
Readability	Good
Navigation	Good
Understandability	Good
Learnability	Good
Operability	Poor
Time behavior	Good
Resource utilization	Good

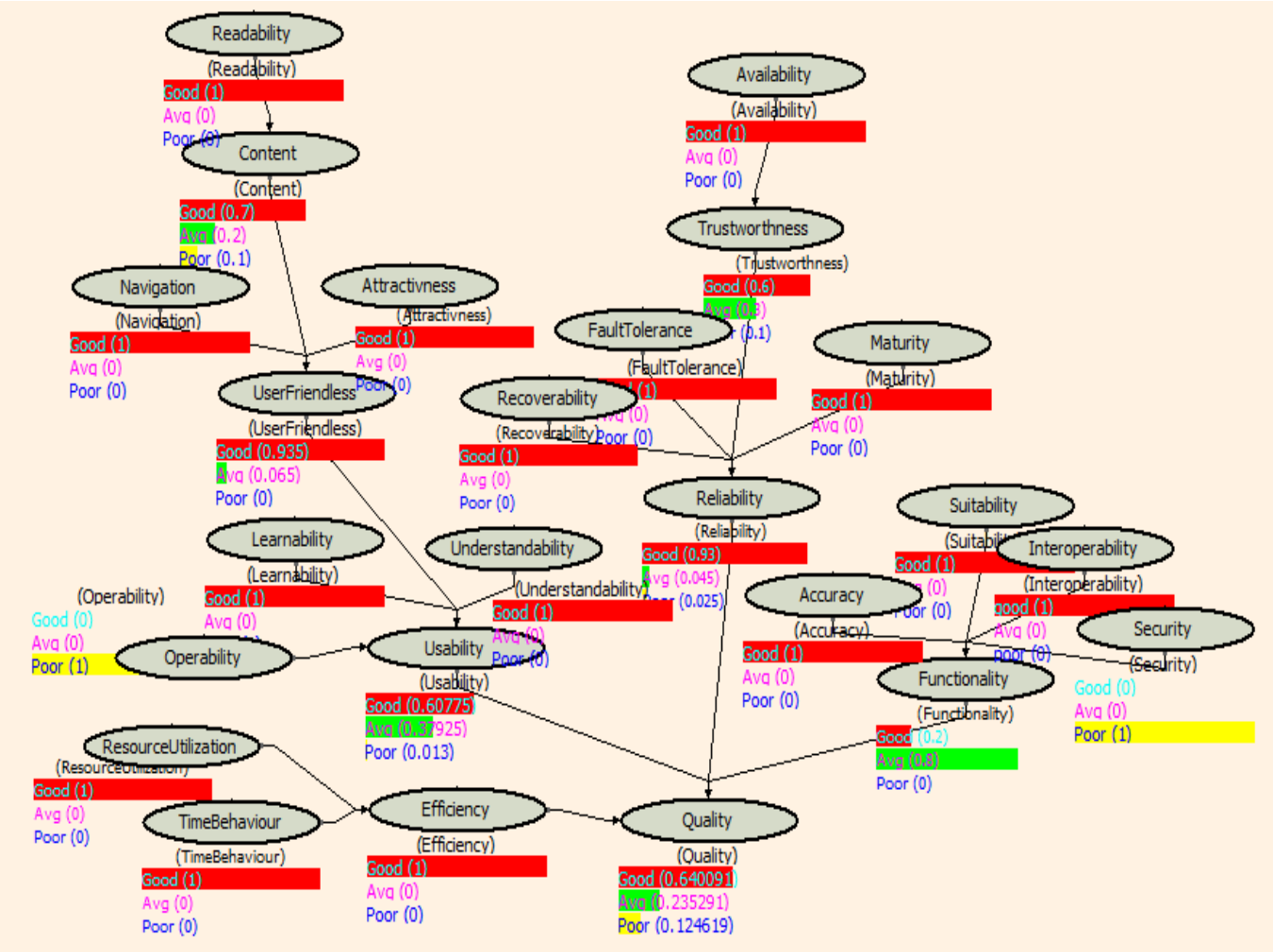

Figure 7. Application of the model on public security directorate.

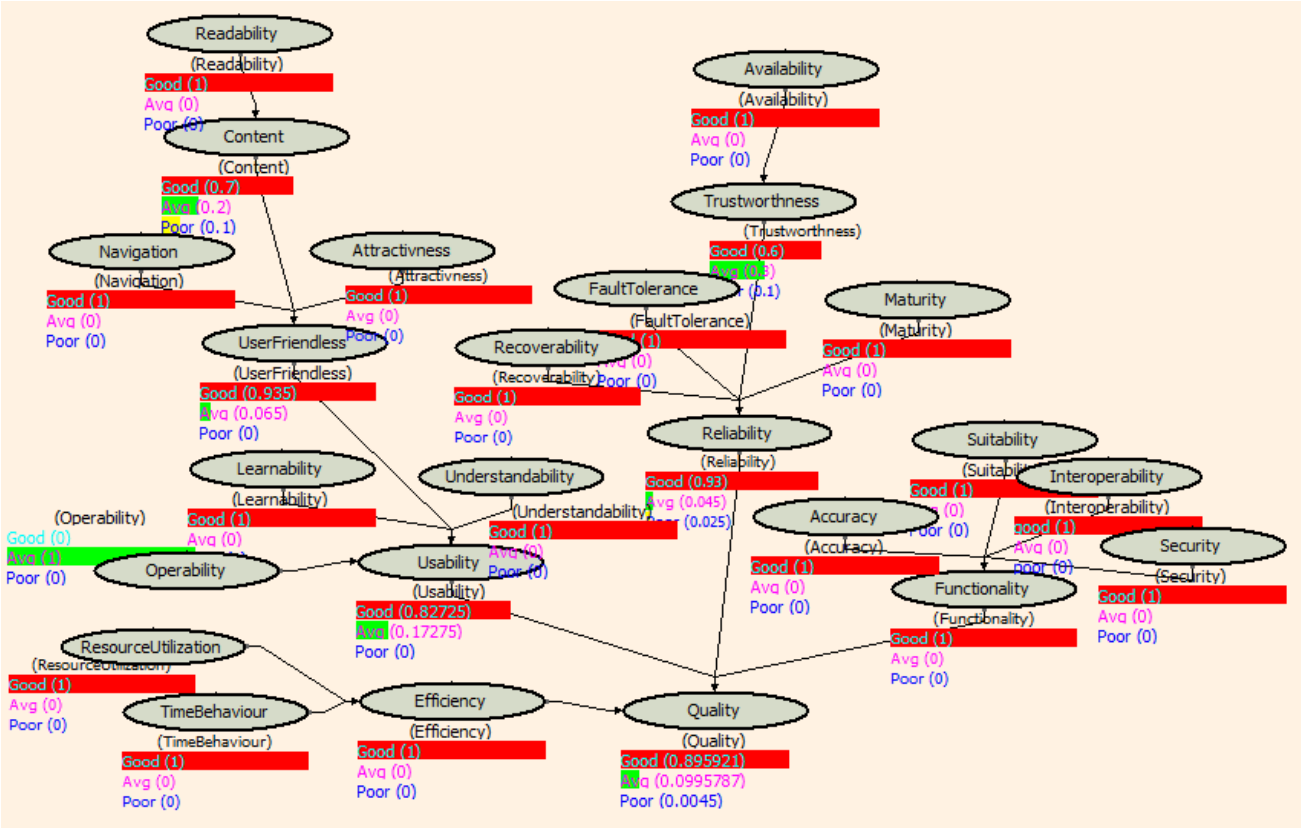

Figure 8. The result of upgrading security and operability.

problems.

This research is not the first to apply belief networks to software engineering. For example, Stefani et al. (2003) used BBNs to assess the quality of E-commerce systems based on the ISO 9126 quality standard. Unlike this research, their work focused on functionality, usability, reliability and efficiency aspects.

CONCLUSIONS

In this paper, a decision support system for assessing the quality of an E-government website was presented based on a BBN model for factors influencing the quality of sites. 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 evaluating the qualities of an E-government websites. It was shown in this paper that a BBN, which is a network based technique for representing and analyzing models involving uncertainty, is an appropriate and applicable tool for the modeling and representation of E-government 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 paper has shown that it is a reliable utility to apply as an assessment tool for the E-government qualities of a website and the root-causes of any quality problems.

After using the model, the output was quite accurate, given the limited provided input. This suggests that extending the model may allow even more precise output. The model can be extended in the future to allow more detailed analysis and guidance for website development.

Although, case studies show that this is a promising technique, a larger case study is needed to validate the model. Case studies could be carried out over extended 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 model to case studies of different cultures. This would help identify if there are any cultural effects that would affect the applicability of the model.

Conflict of Interests

The authors have not declared any conflict of interest.

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