Ranking of Academic Web-sites on the Basis of External Quality Measurement

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ABSTRACT

Web-sites are domain intensive and some important domains are social, cultural, entertainment, e-commerce, e-government, museum, tourism, academic, etc. It is obvious that domains of Web-sites differ significantly, and hence a common yardstick can not be applied to measure quality of all Web-sites. Signore, Loranca et al, Olsina et al, Tripathi & Kumar and others have tried to define quality characteristics that are domain specific. Shrivastava, Pandey & Kumar have specified and validated attributes, sub-attributes and metrics for measuring quality of Web-sites of academic domain. In the present work, the authors have measured quantifiable attributes (metrics) of quality for six Web-sites of academic domain. The usability, functionality, reliability and efficiency aggregation have been carried out using Logical Scoring of Preferences (LSP) method. Global aggregation of all four attributes is also carried out to rank six Web-sites.

Keywords: component; Web-site Quality, Academic domain, Attributes, Metrics, LSP

1. INTRODUCTION

New Web-sites are hosted every day, and often quality of Web-sites is unsatisfactory and basic Web principles like inter-portability and accessibility are ignored [1, 2]. The main reason for lack of quality is unavailability of trained staff in Web technologies/engineering and orientation of Web towards a more complex XML based architecture [1, 2, 3]. Thus, there is a need to define metrics that can be used to measure quality of Web-sites.

Web-sites can be categorized as social, cultural, e-commerce, e-government, museums, tourism, entertainment, and academic intensive. It is obvious that domains of Web-sites differ significantly, and hence a common yardstick can not be applied to measure quality of all Web-sites. Loranca et. al. [4] and Olsina et. al. [5] have identified attributes, sub-attributes, and metrics for measuring external quality of e-commerce based Web-sites. Olsina et. al. [6] have also specified attributes, sub-attributes and metrics for measuring quality, especially the usability of Web-sites of museums. Tripathi and Kumar [7] have specified quality characteristics for e-commerce based Web-sites of Indian origin from user point of view. Recently, Shrivastava, Rana and Kumar [8] have specified characteristics, sub-characteristics and metrics to measure external quality of academic Web-sites from user point of view.

In this research, we have measured external quality factors of six Web-sites of academic domain. The partial and global evaluation of external quality factors has been carried out using the technique of Logical Scoring of Preferences (LSP). The power of LSP lies in the fact that it permits input simultaneity and replaceability, etc. The sites are ranked on the basis of global scores obtained by these sites.

2. LITRATURE SURVEY

The software industry is more than three decades old but it still lacks a rigorous model of attributes and metrics that can be used to measure the quality of finished software product. It is due to the fact that the perception of quality differs from person to person. Some widely used software quality models were proposed by Boehm, Brown and Lipow [9] and McCall and Covano [10]. International bodies such as ISO/CEN (European) and IEEE have integrated different approaches to the definition of quality, starting from the awareness that the quality as an attribute which changes developer’s perspective and action context [11, 12]. The ISO/IEC 9126-1 model [11] defines three views of quality: user’s view, developer’s view, and manager’s view. Users are interested in the quality in use (external quality attributes), while developers are interested in internal quality attributes such as maintainability, portability etc. This model is hierarchical and contains six major quality attributes each very broad in nature. They are subdivided into 27 sub-attributes that contribute to external quality and 21 sub-attributes that contribute to internal quality. A detailed discussion of used metrics to measure quality of software can be found in [12, 13].

Offutt [3] was first to talk about Web-application software quality. He conducted a survey of Web software development personnel and practitioners to find out quality drivers of Web-applications. They agreed to have reliability, usability, security, scalability, maintainability, availability, and time to market as important quality attributes for Web-application success. However, Offutt did not mention the procedure to measure these quality attributes. Signore’s [2] work defined a quality model and a set of characteristics that can be measured in an automated fashion, relating internal and external quality factors and giving clues about potential problems. The five quality factors considered were correctness, presentation, content, navigation, and interaction. Liburne et. al. [14] suggested a framework for
measuring quality attributes of Web-applications, especially the maintainability (developer view). They defined criteria to measure analyzability, changeability, scalability, stability, and testability.

Olsina et al. [5,6] have proposed hierarchical models of attributes, sub-attributes and metrics for assessing quality of Web-sites of e-commerce and museum domains. They have also developed a technique called WebQEM to measure quality of these sites [5]. Tripathi and Kumar [7] have identified attributes, sub-attributes and metrics for Indian origin e-commerce Web-sites. They have validated proposed quality characteristics model both theoretically and empirically [15]. Recently, Shrivastava, Rana and Kumar [8] have proposed and theoretically validated a hierarchical model of attributes, sub-attributes and metrics for evaluating quality of Web-sites of academic domain.

In this research, the authors have given an exact method of measuring attributes, sub-attributes and metrics. The partial and global aggregation of attributes has been carried out using the Logical Scoring of Preferences (LSP) method of Dujmovic [16]. The methodology is described below.

3. METHODOLOGY OF EVALUATING EXTERNAL QUALITY

Recently Shrivastava et al. [17] have suggested a framework to evaluate external quality of operational Web-sites. This framework suggests that evaluator should identify user needs (expectations) from Web-sites along with common practice of describing quality characteristics as defined in works of ISO/IEC 9126-1 [11] and IEEE 1061[12] standards. The identified characteristics, sub-characteristics should be expressed in terms of lower abstraction or attributes (metrics) that are directly measurable. The quality evaluation process consists of following three phases:

3.1 Quality Requirements Definition and Specification

Depending upon evaluation goal (internal or external) evaluators select appropriate quality characteristics model, say ISO 9126-1 or IEEE 1061 and also user expectation (viewpoint) translated in terms of characteristics, sub-characteristics and metrics. The selected characteristics, sub-characteristics and metrics are translated into quality requirement tree. The quality requirement tree is reproduced from [17] for ready reference (see Table 1).

3.2 Elementary Evaluation - Design and Implementation of Measurement Criterion

Here, for each measurable attribute $A_i$ of quality requirement tree, we can associate a variable $X_i$ which can take a real value of the attribute (metric). It should be noted that the measured metric value will not represent the elementary requirement satisfaction level, so it becomes necessary to define an elementary criterion function that will yield elementary indicator or satisfaction level. For example, consider invalid links then a possible indirect metric could be $X = \#\text{invalid links} / \#\text{total links on website}$. We can now define elementary criterion function (or elementary quality preference $EP_i$) as

$$
EP_i = \begin{cases} 
1 & \text{if } X = 0 \\
(X_{\text{max}} - X)/X_{\text{max}} & \text{if } X < X_{\text{max}} \\
0 & \text{if } X = X_{\text{max}} 
\end{cases}
$$

where $X_{\text{max}}$ is some agreed threshold value for invalid links.

3.3 Global Evaluation - Design and Implementation of Combining Measurements to Rank Websites

Here, we select an aggregation criterion and a scoring model to globally rank Websites. Further, this makes our evaluation model more structured, accurate, and easy to apply. For aggregation, we can use either linear additive model or non-linear multi-scoring model [16]. Both use weights to consider relative importance of metrics in the quality tree. The aggregation and partial/global preferences (P/GP), in case of additive model, can be calculated using formula

$$
\frac{P}{GP} = \sum_{i=1}^{m} W_i EP_i
$$

where $W_i$ are weights and $EP_i$ are elementary preferences in unit interval range [0,1]. The following is true for any $EP_i$:

$$
0 \leq EP_i \leq 1, \quad \text{or} \quad 0 \leq EP_i \leq 100
$$

Further

$$
\sum_{i=1}^{m} W_i = 1 \quad \text{and} \quad W_i > 0, \quad i = 1,2, \ldots , m.
$$

It should be noted that the basic arithmetic aggregation operator in equation (1) for inputs is the plus (+) connector. We can not use equation (1) to model input simultaneity.

A nonlinear multi-criteria scoring model is used to represent input simultaneity or replace ability, etc. This is a generalized additive model, called Logic Scoring of Preferences (LSP) model, and is expressed as

$$
P / GP = \sum_{i=1}^{m} \left(W_i EP_i^r \right)\frac{1}{r} ; i = 1,2, \ldots , m
$$
where \( -\infty \leq r \leq \infty \) and

\[
\frac{P}{GP} = \begin{cases} 
\min(EP_i); & r = -\infty \\
\max(EP_i); & r = \infty 
\end{cases}
\]

The parameter \( r \) is a real number that is selected to achieve the desired logical relationship and polarization intensity. The equation (2) is additive when \( r = 1 \), which models neutrality relationships. The equation (2) models input replace ability or disjunction when \( r \geq 1 \) and models input conjunction or simultaneity when \( r < 1 \). The values of \( r \) for 2, 3, 4 and 5 inputs were calculated by Dujmovic [16] and will be used in this paper.

### Table 1: Quality Characteristics Hierarchical Tree for Academic Institute Web-sites

<table>
<thead>
<tr>
<th>1 Usability</th>
<th>2.3. Student-Oriented Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1. Global Site understandability</td>
<td>2.3.1 Academic Infrastructure Information</td>
</tr>
<tr>
<td>1.1.1 Site Map (location map)</td>
<td>2.3.1.1 Library Information</td>
</tr>
<tr>
<td>1.1.2 Table of Content</td>
<td>2.3.1.2 Laboratory Information</td>
</tr>
<tr>
<td>1.1.3 Alphabetical Index</td>
<td>2.3.1.3 Research Facility Information</td>
</tr>
<tr>
<td>1.1.4 Campus Image Map</td>
<td>2.3.1.4 Central Computing Facility Information</td>
</tr>
<tr>
<td>1.1.5 Guided Tour</td>
<td>2.3.2 Student Service Information</td>
</tr>
<tr>
<td>1.2. On-line Feedback and Help Features</td>
<td>2.3.2.1 Hostel Facility Information</td>
</tr>
<tr>
<td>1.2.1 Student Oriented Help</td>
<td>2.3.2.2 Sport Facilities</td>
</tr>
<tr>
<td>1.2.2 Search Help</td>
<td>2.3.2.3 Canteen Facility Information</td>
</tr>
<tr>
<td>1.2.3 Web-site last Update Indicator</td>
<td>2.3.2.4 Scholarship Information</td>
</tr>
<tr>
<td>1.2.4 E-mail Directory</td>
<td>2.3.2.5 Doctor/Medical Facility Information</td>
</tr>
<tr>
<td>1.2.5 Phone Directory</td>
<td>2.3.3 Academic Information</td>
</tr>
<tr>
<td>1.2.6 FAQ</td>
<td>2.3.3.1 Courses Offered Information</td>
</tr>
<tr>
<td>1.2.7 On-line Feedback in form of Questionnaire</td>
<td>2.3.3.2 Academic Unit (Department) Information</td>
</tr>
<tr>
<td>1.3. Interface and Aesthetic Features</td>
<td>2.3.3.3 Academic Unit Site Map</td>
</tr>
<tr>
<td>1.3.1 Link Color Style Uniformity</td>
<td>2.3.3.4 Syllabus Information</td>
</tr>
<tr>
<td>1.3.2 Global Style Uniformity</td>
<td>2.3.3.5 Syllabus Search</td>
</tr>
<tr>
<td>1.3.3 What is New Feature</td>
<td>2.3.4 Enrollment Information</td>
</tr>
<tr>
<td>1.3.4 Grouping of Main Control Objects</td>
<td>2.3.4.1 Notification uploaded</td>
</tr>
</tbody>
</table>

### Table 2: A Sample Template for Measuring Functionality

<table>
<thead>
<tr>
<th>Template</th>
<th>Illustrative Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title(code)</td>
<td>Functionality (2)</td>
</tr>
<tr>
<td>Type</td>
<td>Characteristics</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Sub-characteristic (Code)</td>
<td>Search Mechanism (2.1)</td>
</tr>
<tr>
<td>Definition &amp; Comments</td>
<td>The capability of Web-site to maintain specific level of search mechanism</td>
</tr>
<tr>
<td>Subtitle (code)</td>
<td>Academic Department Search (2.1.3)</td>
</tr>
<tr>
<td>Type</td>
<td>Attribute</td>
</tr>
<tr>
<td>Definition and Comments</td>
<td>It represents the facility to search for any department in the institute</td>
</tr>
<tr>
<td>Metric criterion</td>
<td>To find out whether such a search mechanism exists on the Website</td>
</tr>
<tr>
<td>Data collection</td>
<td>Whether data is gathered manually or automatically through some tools (manually)</td>
</tr>
<tr>
<td>Elementary Preference Function</td>
<td>EP=1, if search mechanism exists</td>
</tr>
<tr>
<td></td>
<td>= 0, if it does not exist.</td>
</tr>
</tbody>
</table>

### 4. APPLYING THE METHODOLOGY

Following the guidelines given in the section III, and the hierarchical tree of quality characteristics (Table1), we have evaluated external quality of Web-sites of six academic institutions, viz., Georgia Institute of Technology, Stanford University – School of Engineering, BHU – Institute of Technology, Varanasi, I. I. T., Delhi, M. A. N. I. T., Bhopal, and BITS, Pilani. During the evaluation process, we have defined for each quantifiable attribute (metric), the basis for the elementary evaluation criterion so that measurement becomes unambiguous. For this, we have created templates as shown in Table 2 for each characteristic of hierarchical tree of Table 1 and measured each attribute. The measurements were done both manually and automatically, using open source software, and during 1st – 15th May’11.

#### 4.1 Partial And Global Aggregation Mechanism

We have applied step wise aggregation mechanism on the elementary preferences calculated for each measurable attribute. We have used logical scoring model called Logical Scoring of Preferences (LSP). The detailed discussion of LSP relationships and Continuous Logic Preference (CLP) operators can be found in [16]. The strength of LSP lies in the power to model different logical relationships to reflect evaluator’s needs. It represents

- Simultaneity (C) – which is perceived when two or more input preferences are present simultaneously (for example site map and table of contents).
- Replaceability (D) – which is perceived when two or more attributes can be replaced or there exists alternative. In other words, low quality input can be compensated with high quality input preference.
- Neutrality (A) – which is understood when two or more input preferences can be grouped independently (i.e. neither conjunctive or disjunctive relationship).

We further classify CLP operators as

- Neutrality (A) represents arithmetic mean operator relationship.
- Simultaneity (C) represents pure conjunction. We categorize C as C+, CA and C- to represent strong, medium and weak conjunction. Further, C- is between A and C-.
- Replaceability (D) represents pure disjunction. We categorize D as D+, DA, D- and D+ - as strong, medium, weak and lying between D+ and DA.

Using above terminology, we have carried out partial and global aggregations of all four attributes and a sample of usability aggregation is given in Fig. 1. The global aggregation...
Fig. 1: Usability Aggregation

Fig. 2: Global Quality Aggregation

Fig. 3: Usability Comparison

Fig. 4: Functionality Comparison

Fig. 5: Reliability Comparison

Fig. 6: Efficiency Comparison

Fig. 7: Global Ranking
of quality using all four attributes is given in Fig. 2. The values obtained from usability, functionality, reliability and efficiency aggregations are plotted respectively in Fig. 3, 4, 5 and 6. The global quality ranking of six Web-sites is shown in the Fig. 7. It is to be noted that rank value of Georgia Institute of Technology is almost equal to rank value of Indian Institute of Technology, Delhi. The lowest rank is obtained by BITS, Pilani. This means that it has low usability from user point of view.

5. CONCLUSION

The paper describes a methodology for measuring external quality of Web-sites. It emphasizes that Web user needs, evaluation goals, and international guidelines for quality measurement should be guiding force for deciding the characteristics, sub-characteristics, and metrics to be used for measuring the quality. For measuring quantifiable attributes (metrics), we have created templates similar to sample template of Table 2. Metric values are measured for six Web-sites of academic domains. The aggregations of four attributes, viz., usability, functionality, reliability and efficiency were performed using LSP, and they are plotted in Fig. 3, 4, 5, 6. It should be noted that the IIT, Delhi’s usability and functionality are comparable to Georgia Institute and Stanford University, which are used as benchmark sites. The Global ranks of sites are compared in Fig. 7. It should be noted that the IIT, Delhi has highest rank followed by Georgia Institute of Technology, especially with the selected weight factors. The weight factors can easily be changed in the general developed program for aggregation.

REFERENCES


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