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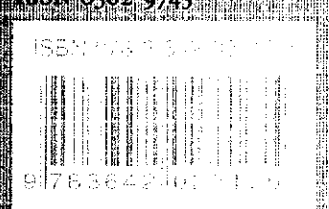

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Preface

As of 2009, the discipline of Web engineering is a well-established and mature field of research within the software engineering, database, information technology, and other related communities. By its very nature, Web engineering is, therefore, a multidisciplinary field that is beginning to establish ties even outside the domain of computer science. As a discipline, Web engineering systematically applies the knowledge of Web science to the development and evolution of Web-based applications and systems. This volume contains the proceedings of the 9th International Conference on Web Engineering (ICWE 2009), which was held in San Sebastián, Spain in June 2009. The ICWE conferences are among the most essential events of the Web engineering community. This fact is manifested both by the number of accomplished researchers that support the conference series with their work and contributions as well as by the continuing patronage of several international organizations dedicated to promoting research and scientific progress in the field of Web engineering.

ICWE 2009 followed conferences in Yorktown Heights, NY, USA; Como, Italy; Palo Alto, CA, USA; Sydney, Australia; Munich, Germany; Oviedo, Spain; Santa Fe, Argentina; and Cáceres, Spain. With San Sebastián as this year's venue, the conference series visits the country where it was originally launched in 2001 for the third time.

This year's call for papers attracted a total of 90 submissions from 33 countries spanning all continents of the world with a good coverage of all the different aspects of Web engineering. Topics addressed by the contributions include areas ranging from more traditional topics such as component-based Web engineering, model-driven Web engineering, navigation, search, Semantic Web, quality, and testing to novel domains such as the Web 2.0, rich internet applications, and mashups. All submitted papers were reviewed in detail by at least three members of the Program Committee which was composed of experts in the field of Web engineering from 23 countries. Based on their reviews, 22 submissions were accepted as full papers (24%) and 15 as short papers (22%). The program was completed by 8 posters and 10 demonstrations that were presented in dedicated sessions at the conference. Finally, the conference was also host to keynotes by James A. Hendler (Rensselaer Polytechnic Institute, USA), Jaideep Srivastava (University of Minnesota, USA), and Juan Jose Hierro (Telefonica, Spain) as well as an outstanding collection of four tutorials and four workshops.

We would like to express our gratitude to all the sponsors that supported ICWE 2009 financially, namely, the Regional Council of Gipuzkoa, the Association of Industries for Electronic and Information Technologies in the Basque Country (GAIA), LKS Co., and the University of the Basque Country (Summer Course Board). The conference would not have been possible without the endorsement of the International World Wide Web Conference Committee (IW^{3}C^2)

and the International Society for Web Engineering (ISWE). In this context, we would especially like to thank Bebo White and Geert-Jan Houben for their work as our liaisons to these two organizations. We are also indebted to the various Chairs (Josu Aramberri, Francisco Curbera, Florian Daniel, Peter Dolog, Jon Iturrioz, Oscar Pastor, Mario Piattini, Gustavo Rossi, Takehiro Tokuda, and Antonio Vallecillo) and to the local organizers who helped with their enthusiastic work to make ICWE 2009 a reality. Finally, a special thanks to all the researchers who contributed their work and participated in the conference. After all, as with any other conference, exchanging ideas and forging connections is what it is all about.

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Towards the Discovery of Data Quality Attributes for Web Portals*

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Abstract. The Internet has become in a place for the exchange and publication of data. Nowadays, Web portals serve as an important means to access information. In this context, the concepts of quality in general and of data quality in particular are highly relevant. The objective of this paper is to carry out a systematic literature review (SLR) in order to discover the state-of-the art in data quality for Web portals, and to evaluate the evolution of data quality since 2006, when another SLR was carried out, and in which a PDQM (Portal Data Quality Model) was defined. As a result, 39 attributes have been considered relevant for the assessment of data quality in Web portals.

Keywords: Data/Information quality, Web portals, data quality attributes.

1 Introduction

One of the aims of many web portals is to select, organize and distribute content (information or other services and products) in order to satisfy their users/customers [1]. However, unnecessary, out of date or erroneous data are also included. Data quality is an actual factor in competitiveness.

Bearing in mind the importance of data quality, the main goal of this paper is to discover the state-of-the-art in Web portal data quality through a systematic literature review (SLR). This SLR is based on a previous SLR [2], which covered the years 1996 to 2005, and in which 33 attributes considered to be relevant for Web portal data quality were chosen. These attributes were then used to define a quality model for the assessment of Web portal data quality, namely PDQM (Portal Data Quality Model), in [3]. The SLR which is presented here covers 2006 to the end of 2008. The objective of this SLR is to establish the evolution of Web portal data quality

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attributes. As a result, it will be possible to evaluate whether the PDQM attributes are still valid and to identify new relevant attributes.

This paper is organized as follows. In Section 2, the SLR process, including the planning and conduction phases, is presented. The main results obtained from the SLR are reported in Section 3. Finally, our conclusions and future works are outlined in Section 4.

2 Review Process

This section details the activities performed in each of the two main phases of the procedure for performing an SLR, as proposed by [4]: "Planning the review" and "Conducting the review".

a) Planning the review: The most important pre-review activities are identified by the research questions(s) that the systematic review will address, and by producing a review protocol (i.e. plan) which defines the basic review procedures. In this phase, the following steps have been carried out:

1. Identification of the need for a review: The SLR has been planned in an attempt to identify the most important attributes related to Web data quality. Therefore, the main goal of our SLR is to discover the state-of-the-art in data quality for the Web since 2006.

2. Specifying the research questions. The following research questions (see Table 1) guided the design of the review process.

Table 1. Research Questions

Research Questions	Main Motivation
RQ1: "Which Web data quality attributes are addressed by researchers?"	To identify the Web data quality attributes which have been researched in the Web context
RQ2: "From which point of view is the Web data quality analyzed?"	To discover whether the Web data quality is from the manager's, programmer's or consumer's/user's perspective
RQ3: "In what context is the Web data quality evaluated?"	To identify whether the work is focused on the Web in general, a Web site or a Web portal
RQ4: "Is a quality model defined?"	To evaluate whether a set of attributes and the relationships between them have been defined
RQ5:"Do any measures for Web data quality exist?"	To discover whether measures are defined
RQ6: "Does a tool which supports the proposed approach exist?"	To determine whether a tool that assesses Web data quality exists.

3. Developing a review protocol. The development of the review protocol is the most relevant activity of the review process, since it establishes the basis of the search.

Source selection. The planned list of sources with which to carry out the SLR review was: 1.- Digital libraries; 2.- Grey literature comprises some papers considered to be relevant by experts which were not included in the aforementioned digital sources, and 3.- The manual revision of the Conference Proceeding of WISE (Web Information Systems Engineering) and ICWE (International Conference on Web Engineering) of 2006 and 2007.

Search string. The following strings were defined: 1) "data quality" AND web; 2) "information quality" AND web; 3) ("data quality" and web) and ("information quality"); 4) web and ("information quality" or "data quality"); 5) ("data quality" and web) AND (aspect OR dimension OR characteristic OR factor OR criterion OR criteria OR attribute OR model); 6) ("information quality" and web) AND (aspect OR dimension OR characteristic OR factor OR criterion OR criteria OR attribute OR model). The results obtained by using search strings 3, 4, 5 and 6, are very similar in the majority of cases. This signifies that the terms "Data Quality" and "Information Quality" are used interchangeably in literature.

Inclusion and Exclusion criteria. The inclusion criteria defined for this review were papers that present approaches or proposals that: a)were written in English, b)were published after 2005, c)identified a set of data quality characteristics, attributes or measures. And the following were defined as exclusion criteria: a) the work is previous to 2006, b) the paper is not within the scope of data quality in the Web, c) the paper does not propose a data quality attribute, or is not relevant, d) it does not contain the terms 'data quality' or 'information quality' either in the title or in the abstract e) studies are only available in the form of abstracts or Powerpoint presentations, f) duplicate studies, g) quality is not a part of the contributions of the paper.

b) Conducting the review: Once the protocol has been agreed, the review can begin. In this phase, the following steps have been made:

1. Selection of primary studies. The search process was completed on 31/12/2008 in the digital libraries previously mentioned, and 4105 papers were found. Many of the papers were eliminated owing to the fact that the use of different search strings in the digital libraries had caused them to be duplicated. Once these papers had been discarded, 1332 papers remained. These papers were then analyzed. This was done by first analysing the title and the abstract, and a total of 173 papers were selected. The full texts were then read, and once the inclusion and exclusion criteria had been applied, 69 papers were obtained.

2. Data extraction and monitoring. Once the primary studies had been chosen, the extraction of the relevant information for this SLR was stored in a data extraction form which was structured as follows: a) Data of the paper, including the search engine, title, year, type of publication and authors; b) Data of the classification, considering the following dimensions: quality attributes, point of view, context, application domain, quality model, measure and tool.

3 Results

This section provides an in depth presentation of the "Reporting the review" phase. For the purpose of our analysis, the papers were classified in order to answer the research questions listed in Table 1.

Our classification will hereafter be used in this section to present the answers to each research question.

RQ1: "Which Web data quality attributes are addressed by researchers?"
A total of 130 attributes were initially obtained. Bearing in mind that our objective is to select the set of most relevant attributes, the attributes which did not contain descriptions were first discarded. 20 attributes were thus eliminated. Next, we

analyzed the attributes specific to Web Site or Web that could be applicable for Web portals. 63 attributes were defined for data quality in the Web or in a Web site. However, after studying their applicability to the Web portal context only 22 attributes were selected. We then analyzed the definition of the attributes and detected that there were different names which were related to the same concept.

A total of 39 attributes related to data quality attributes were eventually selected (see Table 2).

Table 2. Attributes by origin

Attributes not obtained in our SLR (for authors other than those of [2])	Attributes obtained in our SLR also included in [2]			New attributes obtained in our SLR and not in [2]
Customer Support	Accessibility	Consistent Representation	Reliability	Effectiveness
Documentation	Accuracy	Currency	Reputation	Efficiency
Duplicates	Amount of data	Ease of operation	Security	Readability
Expiration	Applicability	Interactivity	Specialization	Usability
Flexibility	Attractiveness	Interpretability	Timeliness	Usefulness
Response Time	Availability	Novelty	Understandability	Verifiability
Traceability	Believability	Objectivity	Validity	
	Completeness	Organization	Value-added	
	Concise Representation	Relevancy		

As was previously stated, in [2] the best attributes for Web portals were selected, but this selection was made in 2005. Therefore, we wish to make a comparison between the PDQM attributes and the attributes detected in our SLR. The main findings of this comparison are shown in Table 2. Note that there is a set of attributes which was only selected in [2]. These attributes are presented in the first column. The second column shows the attributes which were chosen both in this paper and in PDQM. Finally, the last column presents 6 attributes which have been added in this paper as a result of the SLR.

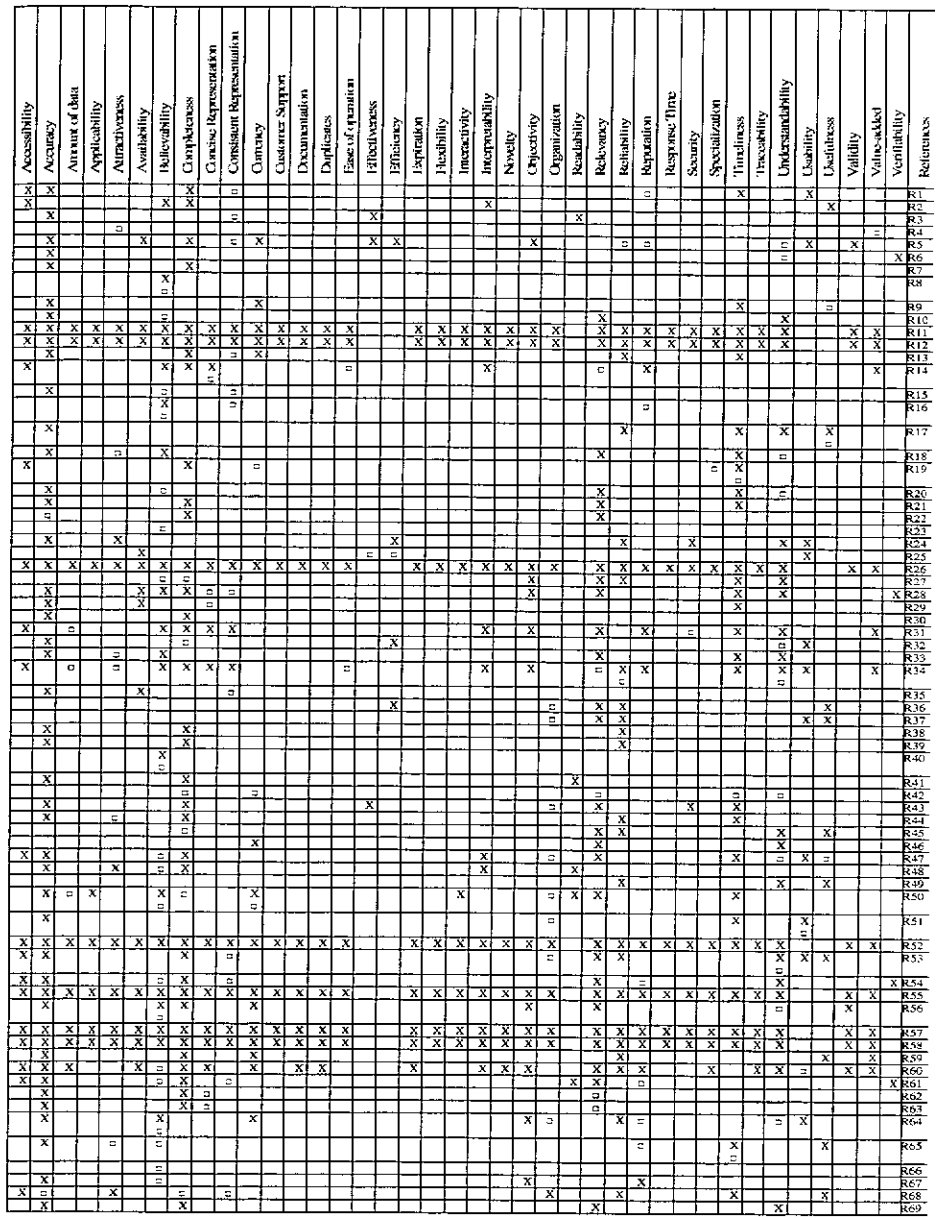
Table 3 presents the data quality attributes. The table shows the selected papers. The attributes which appear in the papers under the same name have been marked with an "X", and those which have a different name but explain the same concept have been marked with a "□". References are detailed in Appendix Table I.

RQ2: "From what point of view is the Web data quality analyzed?"
In this paper, we consider that data quality can be analyzed from three points of view: manager, programmer and consumer. Fig 1 summarizes the number of papers for each point of view.

We can deduce that the majority of the papers are related to the consumer or user. This signifies that researchers are more concerned about the quality of the data with which the consumer is provided. We can therefore affirm that it is necessary to make an effort to study the data quality from the other perspectives, since all the perspectives are obviously related.

RQ3: "In which context the Web data quality is evaluated?"
As was previously stated, in order to attain a wide knowledge of data quality attributes the following contexts were included: Web portal, Web site and the Web in general. However, each attribute has been reviewed, and only those which are of interest in the context of Web portal data quality have been selected. Fig 2 illustrates the classification of papers according to their context. It must be stressed that Web sites are studied more frequently than Web portals.

Table 3. Quality attributes investigated in the context of SPL



RQ4: "Is a quality model defined?"
With regard to whether a quality model is proposed, as Fig 3 shows, 60% of the works defined a quality model. This means that there is a tendency towards covering

all the aspects related to quality, and that the works are not limited to the simple definition of attributes.

RQ5: "Do measures for Web data quality exist?"
Only 22% of the papers do not include measures, as is shown in Fig 4. Therefore, unlike the situation of some years ago, researchers have now realized the importance of measurement and almost all the proposals define measures with which to assess the data quality level. We believe that this is a very positive aspect, since without measures it is obviously not possible to evaluate quality.

RQ6: "Does a tool with which to support the proposed approach exist?"
The proposal was considered to contain a tool when the authors affirmed that a new tool had been created or when one or several existing tools could support their proposal. Only 8 of the 69 selected papers provided a support tool, which represents 12% of the total.

In conclusion, we can state that although the majority of the proposals define measures (as was mentioned in the previous section), their assessment it not automated. This reveals the difficulty of automating the proposed measures. Hence, as a future work it will be necessary to work on the automation of measure assessment.

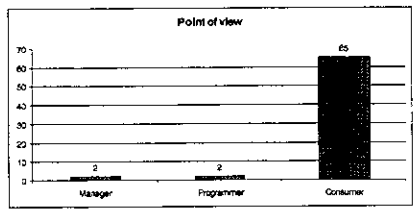


Fig. 1. Papers according to whose point of view they are directed towards

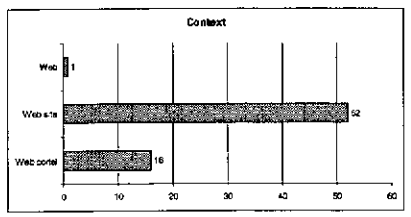


Fig. 2. Papers according to their context

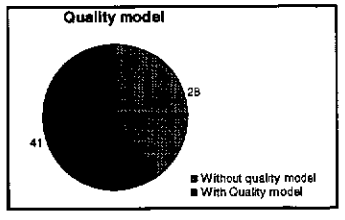


Fig. 3. Proposals with a quality model

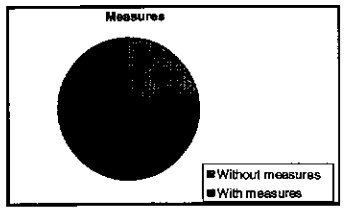


Fig. 4. Proposals which define measures

4 Conclusions and Future Works

In this paper, a systematic literature review has been carried out in order to obtain the portal data quality attributes that have been proposed in literature.

Moreover, the realization of this SLR has led us to certain conclusions. Firstly, the majority of the papers study Web data quality from the consumer's perspective, and more effort should therefore be made to study this from the other perspectives. Secondly, it should be noted that Web sites are studied more frequently than Web portals. Thirdly, more than half the proposals define a quality model. This means that there is a tendency towards covering all the aspects related to quality and that the works are not limited to the simple definition of attributes. Fourthly, it is also of interest to stress that researchers have realized the importance of measurement, and that almost all the proposals define measures with which to assess the data quality level.

Without measures it is obviously not possible to evaluate quality. However, these measures are not easy to calculate automatically since only 12% of the proposals have developed a tool for their assessment.

Finally, in comparison with the previous work [2], we conclude that a greater number of papers related to data quality attributes were selected, and a greater number of attributes were identified. We have therefore included all the attributes of [2] and have added other attributes detected in this SLR which we consider to be relevant to our study.

In the future we shall compare both the data quality attributes obtained and SQUARE [5]. Since some PDQM attributes are now obsolete and are included in this work, it is necessary to review and analyze the possibility of discarding them. In order to do this, we shall first study the data quality attributes of SQUARE [5], and shall then analyze both the attributes obtained in this SLR and the PDQM attributes, which will eventually be compared in order to select the most relevant attributes.

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Appendix

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