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Ontology Based Quality for Semantic Web Applications: A Survey

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ABSTRACT: Semantic Web Applications (SWAs) are very crucial these days because they are not only used in information reclamation in search engines but also being engaged in social networks, e-learning programs and healthcare industry. Semantic Web Applications enrich us with a wide array of benefits where reusability of machine understandable content in the form of ontology is the most important aspect. Ontology represents knowledge of a particular domain. Machine understandability makes a huge difference between Semantic Web Applications and traditional software. This difference leads to an essential adaptation of several features of software engineering paradigm to the SWAs so that the latter may be developed and utilized properly. This paper presents a rigorous review on the explorations made in this direction. Several aspects of quality evaluation in the field of Semantic Web Applications have been offered. Moreover, this paper throws light on research gaps and few observations notified after literature survey.

KEYWORDS: Semantic Web; Quality Model; Web Applications; Ontology; Semantic Web Applications

I. INTRODUCTION

The Semantic Web (SW) is a powerful means to bring structure to the meaningful content of Web Pages, create an environment for the Software Agents to accomplish the sophisticated tasks for users. SW has been considered as an extension to the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation. Like the Internet, Semantic Web will be decentralized as possible [1].

The SW aims to fabricate a common framework that permits data to be shared and reused across applications, enterprises and community boundaries. It proposes to use RDF as a flexible data model and employ ontology to represent data semantics. RDFS and OWL ontology can successfully capture data semantics and enable semantic query and matching, as well as data integration [2]. Semantic Web views the web as an association of data and meaning. It allows data sharing across applications which provides reusability. Machine understandable contents in SW harvest several benefits such as improving productivity, shortening the development life cycle, reducing cost and improving quality [3].

Semantic Web provides true interoperability, interaction between in-house and business partner systems without the requirement for custom code. The key technology involved is ontology which enables interaction between heterogeneous systems using common definitions. Data exchange structure makes it necessary to migrate web applications to Semantic Web Applications [4]. It is known that Web Applications are different from traditional software due to various functional and non functional requirements. These requirements may include continuous evolution, network intensiveness, unpredictability of load, concurrency, availability and context sensitivity etc [5]. Moreover SWAs differ from Web Applications in the provenance of the data-set, capability of inference, size or complexity of ontology, search engine capacity and query response time of the user interface [6]. Many future technology trends has been predicted in [7], besides these trends Semantic Web based applications will be the future of Web Engineering (WebE). Although WebE is leading the development of Web Applications yet few aspects of SWAs are not properly handled by WebE. Ontology development, inference capability and few others come under this category of aspects. Due to this improper handling of aspects, we need to adapt standard quality metrics and development methodologies for the SWAs. This paper reviews the work done in this direction. Research gaps and observations drawn from literature survey have also been specified.

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The remainder of this paper is structured as follows. Section II depicts the literature review of the state-of-art for the quality evaluation for the SWAs. Next, Section III describes the observations drawn from literature review. Section IV carries the discussion on various research gaps. Finally the paper has been concluded in Section V.

II. SOFTWARE QUALITY EVALUATION FOR SEMANTIC WEB APPLICATIONS

Various conventional features of WAs such as continuous evolution, aesthetics, network intensiveness, unpredictability of load, availability, data driven, context sensitivity have been discussed in [5]. In addition to these features, several other features including conciseness and completeness of semantic search engine results, reputation of data-set and usability of user interface play a very significant role in quality assessment of SWAs. But the quality evaluation of ontology is the most important addition to the existing quality evaluation models. This section presents a review on the quality evaluation of SWAs as a whole in general and on the quality assessment of ontology. Table I summarizes various pieces of work in this direction.

TABLE I. QUALITY EVALUATION OF SWAS

Study	Research Objective	Technique Used	Contribution	Limitation
[8]	To evaluate efficiency and accuracy of ontology comparison	Senses Refinement Algorithm and Set Theory	Provides an ontology comparison tool for SWAs	Focus is only on semantic ontology
[9]	To adapt coupling metrics for an ontology	The proposed research has been done via a case study	Defines coupling metrics for inter-class relationships in an ontology	"Class and Object" mapping can be made through new metrics
[10]	Evaluation and Ranking tool for ontologies	Mathematical formulation of instance and schema metrics	The proposed quality criteria is helpful in decision making	Only populated ontology can be ranked
[11]	To examine cohesion metrics for ontologies	A standard XML DOM parser has been used to parse XML-based OWL ontology syntactically	Modular relatedness of OWL ontologies has been contributed	Only the subclass relation of classes in ontologies has been used
[12]	To build an ontology modularization evaluation framework	Empirical experiments done using module coupling and cohesion metrics	Comparison and application of different modularize-ation techniques has been made easier	More metrics can be used

Authors in [8] propose an ontology comparison tool based on a senses refinement algorithm which constructs a senses set to precisely represent the semantics of the input ontology. The algorithm is based on the automatic extraction of senses from the electronic lexical database WordNet. The refinement algorithm ensures efficiency and accuracy of ontology comparison. In [9], relationship among classes in OWL is specified by the object properties that are defined as a binary relation between classes. The proposal is based on the coupling metric that has been adopted in software engineering as a need for ontology. Work done in [10] specifies the need for tools that compare and rank ontologies in accordance with a certain set of metrics involving different aspects of ontologies. The proposed approach OntoQA permits user to rank towards certain features of ontology according to the suitability of the application if the the global criteria for ranking is absent. In [11], researchers examine the cohesion metrics for ontologies using standard XML DOM parsing technique. The cohesion metrics in this study are Number of Root Classes, Number of Leaf Classes and Average Depth of Inheritance Tree of all Leaf Nodes. Authors in [12] propose a novel evaluation framework for ontology modularization. This framework intends to measure the quality of ontology modules and the logical consistency for the modularization process. Quality measurement of ontology modules has been performed using few parameters such as module size, module cohesion and module coupling metrics derived from software engineering. Research work in [13] also revolves around the proposal of novel metrics for measurement of ontology modularity. To evaluate the ontology modules, researchers introduce cohesion and coupling on the basis of software metrics. A cohesion metric and two

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coupling metrics have been used to measure the cohesion and coupling of ontology modules. A consistency check has been put between ontology modules and the original ontology.

Researchers in [14] depict a comprehensive comparative evaluation of some mapping tools. The tools under consideration are WSDL2OWL-S, Mindswap OWL-S API and OWL-S Editor. Inspired by the software metrics for design complexity, researchers in [15] propose a metric suit for design complexity of ontology. Authors in [16] present the evaluation of complexity metrics theoretically against Weyuker's properties and practically by use of ontologies available from Swoogle [17]. The work in [18] describes quality criteria and evaluation technique for assessing quality of ontology. Focus of ontology quality evaluation is on the mapping between ontology and implicit conceptual modeling of domain. According to results, none of the ontology was of good quality in regard of cognitive quality. In [19], the researchers propose an extension of WebE method to the ontology model in order to state data and functionality which thereafter becomes accessible to the external applications. Research in [20] revolves around the examination of merging of traditional SE methods and Semantic Web technologies to delineate software development process for Semantic Web.

III. OBSERVATIONS

The crucial feature of adaptations of SE to SW- based development is specified as treatment of machine understandable web content and sharing across applications. It is observed that some researchers have adapted model driven development for Semantic web based applications which appears to be a good choice. It may be due the reason that ontology is considered to be the natural selection for modeling [20]. Observations reveal the extent of usage of evaluation techniques for quality of ontology. Cohesion and coupling metrics usage for modularity of ontology find a larger space in this direction. Tools have been used in few researches for quality assessment. Also the evaluation process continues with public ontology and expert users according to few researchers. Moreover, Observations depict that already available research work is focused on few of the quality metrics instead of using them all. These quality metrics include Semantics, Ranking, Coupling, Cohesion, Instance Metrics and Class-Level Metrics.

IV. RESEARCH GAPS

In the face of rising changes in the manner software is developed and delivered, the adaptation of SE to SW-based system development appears gratifying. Various aspects of SE that need an adaptation for WebE in the face of Semantic web may be further explored. It is obligatory to provide standardization and easiness in the way information is retrieved, reused and pooled in Semantic Web. This calls for changes in each life cycle phase as well as umbrella activities which are crucial for quality such as configuration management, change management and risk management etc [21].

The viability of tracking relevant metrics during SW development can be considered. Moreover, novel metrics for quantifying cost, quality and other attributes of SWSs could be devised. Also, a quality model capturing various attributes to determine quality of ontology in practical useful manner can be proposed. Ontology is a crucial quality aspect for SW-based applications. Therefore some mathematical verification could also be devised for such ontology.

V. CONCLUSION

The future shall confront with the mainstreaming of Semantic Web technology, hence it is imperative to develop an efficient framework for the development of software on such platforms. Our prime concern is to analyze and classify the quality metrics for the SW based applications. We have observed a lot of researchers' interest in the field of SE for SW based applications. However, this area of work is unsaturated and needs practical solutions. Adaptation of SE process models, reengineering for SWAs and measurement and metrics for quality of SWAs might be the interesting research problems. Also subcategories of quality metrics for SW based applications could be devised and the research can be extended to include few more attributes for evaluation.

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BIOGRAPHY

Naveen Malik and Vinisha Malik (Husband-Wife) are Research Scholars in the Computer Science Department, MM University Mullana, Ambala, India. They received Master of Technology (M.TECH) degree in 2013. Now both are pursuing PhD from Maharishi Markandeshwar University Mullana, Ambala, India. Being a married couple they supported and helped each other in the research.