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Onto Collab: Strategic Review Oriented Collaborative Knowledge Modeling using Ontologies

Pushpa CN, Gerard Deepak, Thriveni J, Venugopal K R
Department of Computer Science and Engineering
University Visvesvaraya College of Engineering
Bangalore University, Bangalore, India
pushpacn@gmail.com

Abstract—**Modeling efficient knowledge bases for improving the semantic property of the World Wide Web is mandatory for promoting innovations and developments in World Wide Web. There is a need for efficient and organized modeling of the knowledge bases. In this paper, a strategy Onto Collab is proposed for construction of knowledge bases using ontology modeling. Ontologies are visualized as the basic building blocks of the knowledge in the web. The cognitive bridge between the human conceptual understanding of real world data and the processable data by computing systems is represented by Ontologies. A domain is visualized as a collection of similar ontologies. A review based strategy is proposed over a secure messaging system to author ontologies and a platform for retracing the domain ontologies as individuals and as a team is proposed. Evaluations for ontologies constructed pertaining to a domain for non-wiki knowledge bases is carried out.**

Keywords—Cognitive Bridge, Collaborative Modeling, Ontologies, Review based Strategy.

I. INTRODUCTION

The need for collaborative ontology authoring has become a model to define ontologies and relate them with the existing concepts in the real world and make it fit for processing by computer systems. Ontology defining is considered to be a team-work activity in the recent times where the ontology defining is an integral phenomenon to craft for Knowledge Definition and Discovery. Studies have confirmed that, for collaborative aspects in ontology modeling Domain Experts (DEs) must work with Knowledge Engineers (KEs) for providing the best outcome in modeling ontologies. In this strategic way, a platform for providing communication and effective decision making can be strategized in geographically distributed teams of ontology contributors.

The proposed system provides a platform for the DEs to Collaborate with KEs in an organized manner. Also, the system allows DEs to directly author ontologies even in the absence of the KEs independently. In recent times, semantic wikis are among the most popular practical application of ontologies [1] that use ontologies as the primary model to incorporate formalized knowledge, links, structures, web contents, documents and other web based components through discrete and specialized mark-up language and intermediate ontology based technologies.

Traditional wikis enable their users to gather and share knowledge by storing and retrieving individual information whenever there is a requisite [1] and are minimally appropriate for obtaining aggregated information such that their content is often only weakly structured and not easily machine interpretable. Wikis typically offer some collaborative features [2] which can be exploited to favor the kind of collaboration needed for authoring of ontologies that needs to be overcome. It is semantics that actually capture the core [3] and the most vital ontologies. A collaborative model that is independent of semantic wikis yet which has an organization capability better than that of wikis is truly needed for ontology defining and knowledge modeling. Ontologies are the best created when they are constructed in a collaborative [4] manner. Evolution of Ontologies can take place in a specialized pragmatic approach or even a simple and yet robust engineering methodology [5]. Moreover, the quality of the ontologies must be a factor of consideration and not just the capability of organization of the ontologies.

Motivation: In Traditional Systems the supremacy of KEs failed to pave a way to DEs to author ontologies directly. Direct reviewing of ontologies by DEs was never permitted which made ontology modeling more agile. This created a vacuum and made ontology engineering more complex. DEs did not understand the language and tools of Ontology Engineering. Therefore a separate system was needed which gave preference to DEs to author and review ontologies.

Contribution: The system implemented not only provides a platform for authoring ontologies but enables the individual contributors to collaborate in editing the ontologies. It provides a way for mining the concepts from the structure of the document and formulates document structure when concepts are added to underlying Ontology Web Language (OWL) based domains. The Proposed method provides a means for strategic review of the defined ontologies and also traces the defined ontologies in an efficient manner. A review based strategy approach for Ontology Authoring Specific to a Domain. Performance Evaluation by considering Precision, Recall and F-Measure as metrics for ontology conception into a Specific Domain is proposed.

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Organization: In this paper Section I is the Introduction. Section II provides a brief overview of the related work. The Section III defines the problem and the Proposed Architecture is in the Section IV. Section V demonstrates the implementation and the empirical results of our system. Finally, the paper is concluded in Section VI.

II. RELATED WORK

Chiara et al., [6] proposed a novel strategy of using online semantic wikis with several modes of access for collaborative ontology authoring. This method needs the online availability of the semantic wiki which is used for adding and editing of the concepts. The strategy for collaboration and future retracing and review is unavailable in the system which becomes a major disadvantage in the system. Usage of semantic wikis makes this method totally dependent on third party vendor tools which definitely focus on a new environment for authoring ontologies.Dimitrova et al., [7] proposed a strategy in which Rabbit to OWL Ontology Authoring takes place where in conventional conceptual ontology is converted into logical ontology. This system uses a controlled language which creates havoc in its usability. Moreover, conversion of rabbit to OWL ontologies definitely isn't easy. It requires a high degree of expertise and the loss of ontological structuring can take place when Rabbit ontologies are converted to OWL ontologies.

Copeland et al., [8] proposed a novel approach where in agile authoring of ontology is the key strategy that is involved. Ontologies are dynamically collected as the collection of requirements and then the analysis takes place. The major underlying problem here in this paradigm is that depending on the requirements elicited for ontology authoring, the ontologies must be defined in a way such that it matches with the requirements gathered. The quality of ontologies is never a criterion in this approach for authoring of ontologies which is definitely a major drawback. Falconer et. al., [9] have followed a pathway of creating role based ontologies where role based workflows are created for ontology definitions. Role Based workflows are a set of prototypes which are followed for construction of situational ontologies where modeling of ontologies are checked several times and are assured for their best-fit with reference to domain.

Luna et. al., [10] have proposed a strategy of customized content generation based on personal choices. They have proposed a methodology that involves the modeling of ontologies for context-aware information systems and also the extraction of the information available in these types of expert systems is discussed. Also, Collaborative learning and Recommendation based strategy for extraction of relevant information is specified. Zaidan et. al [11] have visualized ontologies as artifacts which have a complex structure. The focus on implementing shared conceptualization and explicit definition of ontologies as Knowledge in Information Systems is described here. In this approach, the structure of Semantic Wiki for Ontology Authoring is based on Categorization for Classification, Properties, Data Types, Instances, URI.

Huang Y et. al., [12] has put forth yet another novel methodology for Knowledge Modeling and Reuse using Semantic Wiki Visualization technique. The concept of reusability of ontologies makes it more evitable and explicit. In this strategy, DEs are incorporated but based on semantic wikis using Knowledge Maps. The ontology conception is not considered here and the ontology quality is never in focus. Azevedo C L et. al., [13] have proposed the strategy of ontology based portfolio management and have related the correctness of ontology authoring with respect to a good quality management of portfolio. This methodology requires a foundation for unification of ontologies. A meta-model is initially developed for the Knowledge to be modeled using ontologies. Further the ArchiMate framework is designed for specified roles and functionalities as a modular approach. This is then followed by Capability Bundling which means the behavioral and the best fit functionality integration for the specified ontology roles.

Marques et. al., [14] have proposed a novel model of development of Semantic Wiki using a Collaborative Methodology and have specifically chosen the domain of Forest Management for further studying the ontologies. The baseline strategy for the same is incremental in nature with dynamically changing ontological requirements into the domain. The Collaboration level in this work is associated with construction of the Semantic Wiki itself and not the ontologies; this becomes a major drawback in this approach as the detailed structures are not given importance. Aveiro D et. al., [15] have proposed a strategy for management of enterprise models using Semantic Wiki as a Framework. Specifically, Semantic MediaWiki is employed in this approach with software engineering methodologies adaptive object model for construction of efficient knowledge bases with an essence of semantic Wiki. Type Square Pattern concept is also introduced for language oriented distributed enterprise management using ontologies. Strategies like rule induction and complicated ontology representations are incorporated in this model which a highly significant disadvantage is increasing the retrieval cost of the ontologies as inferences are difficult in such models.

Jung J J [16] has proposed a novel idea of Knowledge Management by means of employing Semantic Wiki. A Centralized Global Wiki Ontology (GWO) as a framework is incorporated into the appreciable methodology of Knowledge management. Concepts like Semantic Annotation and Collaborative Wiki content editing is proposed and justified with the usage of case studies which becomes the underlying driving force for Knowledge Representation and Retrieval Systems. Iorio Di A et. al., [17] have proposed a phenomenal method of content generation along with interfaces based on ontologies as an underlying motive. In this approach, qualities like genericity, customizability, proactivity and validation are used as metrics for evaluation. This work is motivating but still the ontologies must be focused and not the content as the quality of ontologies influence the Information Retrieval System. Ballatore A et. al. [18] have proposed a strategy for computing semantic similarity in Geo-Knowledge Graphs like Semantic Wikis, gazetteers, folksonomies, etc. In this approach, the Knowledge Authoring is done in a structured manner where the Ontological Concepts are modeled as vertices in the Geo-Knowledge Graphs and the Edges are linked to the relationships between the ontological entities. The concepts that need to be collated together is estimated by

means of computation of Network Lexical Similarity Measure. This approach is a paradigm of decisive computing and correlates to that of Human Thinking thus enhancing the cognitive ability of the information retrieval system.

Lange C [19] has proposed a language for Representing Mathematical Knowledge for Knowledge Organization, Sharing and Reuse. The incorporation of Wikis, Blogs and Web 2.0 for representing mathematical knowledge is difficult and highly tedious. A Resource Description Framework (RDF) based strategical methodology is proposed for Knowledge Representation. This work provides confidence to our methodology of OWL to RDF transformation as RDF provides a higher level of ease for Knowledge Representation in Information Modeling and Retrieval Systems. Stoilos G et. al., [20] have proposed a methodology of transforming OWL 2 RL by using Fuzzy sets to cater for approximate values. The major disadvantage of this approach is that when a fuzzy touch to OWL 2 RL transformations are done, it results in new set of semantic structure which in turn increases the complexity of ontologies defined.

Ma Y et. al., [21] have proposed a unique methodology for measuring of ontologies for normalizing them.. The disadvantage here is that the ontologies are they are being modeled are not properly governed rather they are normalized later which is again an unnecessary process of increasing the computational effort which can definitely be avoided when ontology monitoring is done as they are conceived or modeled. Noureddin A et. al., [22] have proposed a unique methodology for collaborative knowledge management specifically that of Judicial Nature using Semantic Wikis. The drawback of this approach is that it's very abstract when it comes to the actual structuring and organizations of Ontologies which need to be focused when modeling of ontologies are concerned. Palma R et. al., [23] has proposed a methodology of Collaborative Ontology Modeling under inter-organizational ontology environment by incorporating effective monitoring of Ontologies.

Tudorache T et. al., [24] have proposed conceptual formalization for representing ontologies. A successful OWL based ontology representation is achieved for Knowledge Modeling. The drawback of this approach is that it depends on a third party vendor WebProtege for ontology authoring which must be overcome. Krotzsch M et. al., [25] have proposed a unique methodology of achieving strong structuring between the entities in a Wiki. Semantic Wiki usages definitely increase the underlying complexity and are language specific and not interoperable. Moreover, the quality of ontologies is highly hindered in such approaches which must be a key strategy for focusing on ontology modeling rather than just using certain interfaces.

Bagni D et al., [26] have proposed a methodology in which Collaborative tool CONGAS was developed for ontology authoring in a collaborative model. The collaborative methodology here plainly refers to the involvement of Teams and there is no restriction for the teams organized. The underlying problem here is that there is no level of security and the quality of ontologies in never a factor of importance in this approach. Sure Y et al., [27] have proposed a strategy for Collaborative Ontology Authoring and development in a precise Knowledge Environment. The disadvantage of such systems is that change management is absent. Moreover, achieving consensus in a much easier manner for authoring ontologies is totally not present in the work implemented. Chen J et. al., [28] have proposed a methodology for solving the decision making problem based on a technique of Knowledge Modeling. The significance of this technique is to collate the available knowledge as Competence Set and Analysis of such competence set is the core strategy of this paper. Barton A et. al., [29] has proposed a strategy of incorporating probabilities to ontological relationships. Approaches of converting Unified Modeling Language (UML) to OWL were also considered [30] but they did not last.

These literature surveys prove a fact that a collaborative model for authoring ontologies is a mandatory requisite for proper construction of domain ontologies and hence forth improve the semantic property of the World Wide Web. However, an organized review based model for the ontologies defined must be the centralized concept on which the system should be based.

III. PROBLEM DEFINITION

Ontology authoring is a tedious and a coherent process which involves adequate domain knowledge and high expertise in defining the structure of concepts for conceptual modeling of a specific Domain in Ontology Engineering. The task of defining and appropriately accommodating ontology to its highest degree of fit must be governed well to its appropriateness [31]. The existing problems in ontology authoring includes the legacy problem of ontology definition by KEs, lack of technical expertise of the document structure by DEs, geographical separation of the DEs and KEs and the absence of conflict resolution on a specific topic in ontology definition.

IV. PROPOSED ARCHITECTURE

The proposed Onto Collab system is to enables several participators in the definition of ontology to collaborate based on a review model rather than live collaboration keeping in mind the constraint of geographical location of the participators. The Empirical Model for collaborative authoring on ontologies is studied based on the prototype that is designed for collaboration. The architecture of Onto Collab is shown in Fig. 1.Onto Collab begins with a Team select module which enables the individual teams to register. The teams once registered can collaborate by individually selecting the DEs and KEs. Each DE or KE is associated with individual ids like DE1, DE2, DE3, etc. or KE1, KE2, KE3, etc. for DEs and KEs respectively. This has facilitated DEs and KEs to distinguish among themselves and also provision for collaboration has become quite simple and easy. Moreover, the uniqueness to the identities of the DEs and KEs is maintained which also easily focuses on further identity based review of DEs or KEs which is definitely an added advantage.

Once the collaboration is initiated by individual KEs and DEs choosing each other, a secure access mechanism is introduced for providing security feature. A non-wiki

collaborative paradigm for ontology modeling is developed in which an intermediate OWL to RDF conversion as an underlying methodology is followed for Collaborative Ontology Definition and Modeling between a pair of KE and DE.

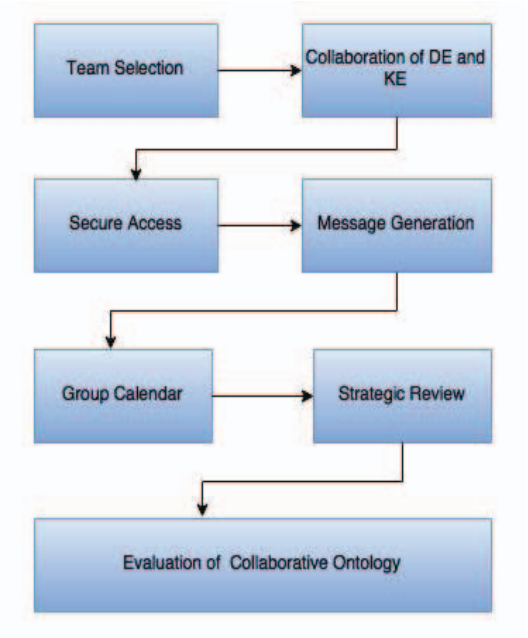

Fig. 1: Architecture of the Collaborative Ontology Authoring System incorporating Strategic Review

An intermediate text message generation is imbibed in the system, for securely recording the date, time and the person modifying the ontology which is integrated with a group calendar for future date based review. This in turn constitutes and lays the basis for a Review Oriented Strategy for Ontology Authoring. As a result of this paradigm, the quality of ontologies is improved. This in turn enhances the overall structure as well as the Knowledge that is stored is enriched and can never be a redundant ontology. The ontology which is finally modeled has an enriched structure and can never render a meaning that is contradictive or deviating.

V. IMPLEMENTATION AND RESULT

The collaboration platform is provided for DEs (DEs) and The KEs (KEs) for authoring of the ontologies and to construct effective domain level ontologies. A pattern lock technique is used for enhancing security aspects which is a feature of Natural Language Processing (NLP) technique. The data sets used for implementation is of the format .owl, i.e., OWL files. For carrying out the experiment, the OWL files of several domains like ice-cream, products, transports, shopping, firm are used. Each OWL file is interpreted in the Non-Collaborative Model using the RDF interpretation technique. There is a need for language independent model for ontology development to enhance the reusability and interoperability between the ontological contents [8]. The contents of the OWL file, ie, several defined ontologies is structured into its resource description format file. The RDF file holds the schematic representation of the domain level ontologies, which make it UI (User Interface) interactive especially for the DEs who are technically incapable of writing the ontologies as OWL for reading and working with the defined ontologies.

The experimentation involved 25 individuals, who were incapable of defining the OWL contents of Ontologies, i.e., they were technically not knowledged about defining OWL based ontologies for a specific domain. But they were highly knowledged about their respective domains namely shopping, products, ice-cream and transport. Thus these individuals equivalently resembled the DEs (DEs). The individuals were able to interact with the OWL contents without knowing how to interpret the OWL file with the help of *term extraction* feature and henceforth were able to add, edit or extract concepts or individuals. The *add concept* feature enabled the individuals to author or define the ontological data pertaining to the domain. The experiment also constituted a single individual who was technically literate about ontology definition in the OWL and had reviewed the evaluated ontologies. The *send message* feature enabled to generate the date and time automatically and record the data for historical purposes and recording the sensitive information. The collaboration is spatially feasible as the system does not require the DEs and KEs to be in a single location at the same geographical time.

A review based strategy helps the DEs and KEs to be independent to each other but still collaborate for ontology authoring and inclusion into a specific domain. This in turn enhances the overall quality of the ontologies from the instance their conception had begun as there is a review at every stage when the respective ontologies are authored. The group calendar feature enables the other Collaborating DEs and KEs to retrace and reiterate the time-line on which the ontologies modified and also the clear visibility of the individuals who worked on the ontology modification makes the system more efficient. The collaboration of several DEs and KEs is indicated in the Fig. 2 that enables the collaborators to choose between team and DEs using Team Id and Domain Expert Id such that the teams can be retraced.

Fig. 2: Collaboration and Group Calendar Visibility of Defined Ontologies

The Group Calendar feature enables the DEs and KEs to know the exact time and date of modification along with the ArticleId and ArticleName which was modified. The

conversion of OWL files into the intermediate RDF for adding concepts facilitates the DEs to use the User Interface features of the system rather than technically analysing the OWL files. The results of collaboration of the DEs and KEs for non-wiki collaborative are depicted in Fig 3. In Fig. 3, Percentage of Modifications refers to the percentage of number of modifications that the ontology file has undergone in order to evolve as the proper domain level ontology. The evolved ontologies can satisfactorily constitute to the semantic content of the web and henceforth improvise the look and feel of the World Wide Web such that these defined ontologies will be directly in correlation with the domain in which they are defined.

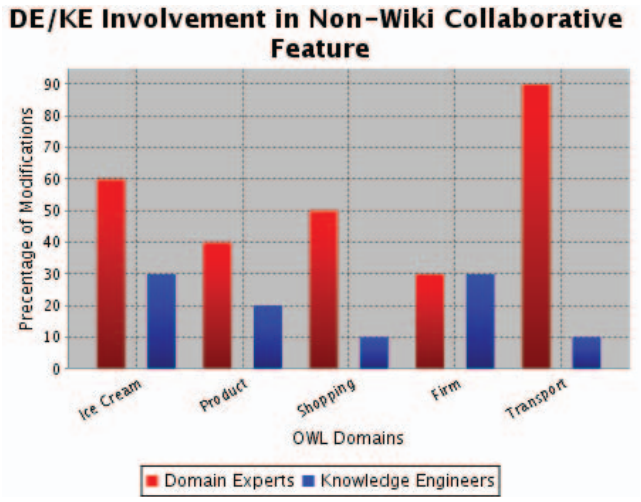

Fig. 3: DE/KE involvement in Non-Wiki Collaborative feature

The Fig. 3 depicts the contribution analysis of the DEs and KEs in ontology authoring and editing. From the figure, the inference that can be made is the DEs contribute at a much higher percentage than the KEs. In order to drive the ontology authoring mechanism, there is a mandate for the DEs to contribute; the contributions of the DEs cannot be neglected. For the domains "Ice-cream" and "Product", there is a 50% higher contribution for ontology authoring by the DEs when compared to the KEs. The difference between the contributions of DEs and KEs for the domains "Shopping" and "Transport" is 40% and 80% respectively. However for the domain "Firm", there is an equal contribution between the DEs and KEs. The inference of the evaluation is that DEs cannot be ignored or neglected for authoring ontologies. Onto Collab is based on this paradigm where in a separate platform for collaboration of the DEs and KEs is created. Time Line based review feature is implemented for facilitating the DEs to strategically review the authored ontologies.

Also, the team level evaluations were conducted for Onto Collab where in teams comprising of DEs and KEs were formulated. Each team must have at least one DE was the only condition imposed on Team Level Evaluations in Onto Collab. Collaborations between DEs and KEs, and their contributions as a team for a specific domain was studied which makes the collaboration more effective and meaningful. Performance Evaluation Parameters like the Precision, Recall and F-Measure of Onto Collab were calculated using the standard formulae but with reference to ontologies conceived into a domain and the ontologies authored. The Performance Evaluation parameters are computed separately for Ontology authoring using KEs and also following the Collaborative Model of KEs and DEs. The Performance Evaluations are specified as follows:

Table 1: Performance Measure considering KEs alone

Domain	Precision %	Recall %	F-Measure %
Ice-Cream	77.7	73.6	74.91
Product	80	76.9	78.42
Shopping	79.1	76	77.51
Firm	76.2	76.2	76.2
Transport	75	70.5	72.68
Average	**77.6**	**74.64**	**75.94**

The performance for authoring of ontologies by considering metrics as Precision, Recall and F-Measure is computed for different domains. Table 1 depicts the performance for the five basic domains considered when KEs alone are involved in Authoring of Ontologies. The Average percentage of Precision, Recall and F-Measure is 77.6, 74.64, and 75.94 respectively when KEs alone are involved in Ontology Authoring. Table 2 specifies the ontology authoring for the five basic domains considered but with a collaborative effort which involves both KEs and DEs incorporating Review Based Strategy.

Table 2: Performance Measure considering KEs and DEs

Domain	Precision %	Recall %	F-Measure %
Ice-Cream	87.5	82.3	84.8
Product	86.9	83.3	85
Shopping	86.3	82.6	84.4
Firm	86.9	86.9	86.9
Transport	85.7	81.6	83.6
Average	**86.7**	**83.3**	**84.9**

It is clearly evident from the Table 2 that the overall percentage of Precision, Recall and F-Measure is much higher when a collaborative model involving KEs and DEs for ontology authoring is considered. The Average Percentage of Precision, Recall and F-Measure are 86.7, 83.3 and 84.9 respectively when collaborative effort of KEs and DEs are considered on applying review based strategy.

VI. CONCLUSIONS

A mechanism for providing Collaborative Ontology Modeling is developed. Both the DEs and KEs are actively involved in Ontology Definition and Authoring in this developed model following a Review Based Strategy. The Strategic Review Oriented Method Focuses on an easy level of consensus between the ontology authors resulting in a higher precision, recall and F-measure. The interaction between the

participants is recorded by means of an auto-generated message time stamp for proper authentication of KEs and DEs. The Spatial and remote location problem of the participators in ontology modeling is overcome in our paper by providing a review-oriented strategic approach for collaborative ontology authoring.

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