A Framework for Ontology Based Knowledge Management

Sunitha Abburu, G Suresh Babu

Abstract*— The three concepts of information science are data, information and knowledge. The structure of one is different from another. The structure of knowledge is more complex than data and information. Knowledge management is complex for traditional information management techniques due its complex structure and difficult to achieve common structure for knowledge captured from heterogeneous sources. Ontology is a upright technology to represent knowledge. Ontology provides homogeneous structure for knowledge acquired from heterogeneous sources. It enables knowledge sharing within and among organizations. Ontology based knowledge management provides a better support for integration of related knowledge sources and searching. The current work proposes a enhanced and clear framework for knowledge management using domain ontology. It addresses major issues of traditional and existing ontology based knowledge management systems.

Index Terms*— Knowledge, Knowledge Management, Knowledge Representation, Ontology.

I. INTRODUCTION

Data, information and knowledge are the crucial concepts that are basic building blocks of information science [1]. Often these three concepts are used interchangeably. But there are key differences between these key concepts, that play a vital role in representation, processing and reuse in the current scenario. Data is collection of facts and figures. But the collection is not organized in an order. Basically data does not provide information regarding patterns, context etc [2]. Information is a set of significant signs that has the ability to create knowledge. Data becomes information, by contextualization, categorization and calculations [3]. Fig. 1 shows relationship among data, information, and knowledge. Knowledge is the general understanding and awareness generated from accumulated information. Knowledge can be acquired through proper study and experience.

L. Zhiping et al., defined knowledge as a combination of real experiences, values, contextual information and experts approach [4]. Knowledge comes from various sources. The most popular knowledge sources are web, databases, contextual statistics, expert experiences and approaches. Fig. 2 shows various sources of knowledge.

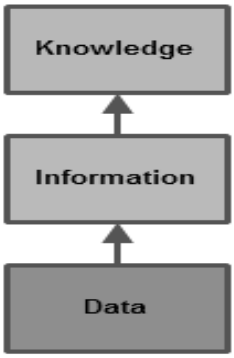

Fig. 1. Relationship between data, information and knowledge

Globalization and the era of internet leads to voluminous information on the World Wide Web (WWW). Semantic Web is the brain child of Tim Berners-Lee. Semantic web the extension of the WWW. It enables people to share knowledge beyond the boundaries of the applications. The current research is moving from web to semantic web.

Knowledge plays vital role in the semantic web. Knowledge management deals with intellectual resources. The cutting edge research is focused on transition from data to information and information to knowledge. Knowledge helps in major and crucial decisions. The most significant resource in the current era is the knowledge. Today knowledge is an imperative asset for individuals, researchers and organizations. It helps organizations to be in noble position in dynamic and competitive markets [5].

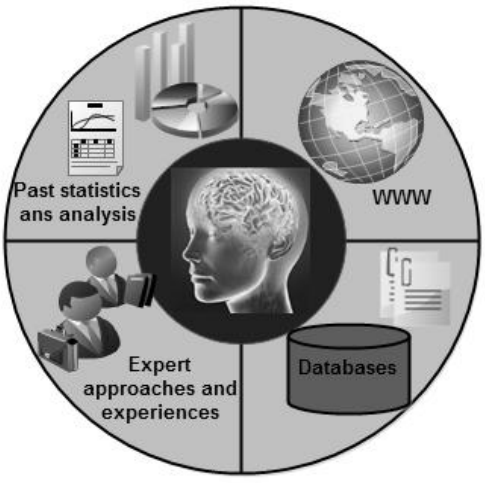

Fig. 2. Knowledge Resource

Knowledge management comprises of a series of activities such as capture, store, share, deploy knowledge using both information technology and business processes [6] [7] [8].

Manuscript Received on July, 2013.

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Knowledge management is important in all scientific fields like: enterprise, business, e-learning, government, Agriculture, airlines, railway, military etc. Knowledge management is essential for using knowledge effectually and efficiently at right time.

There are effective data and information management systems and techniques. Knowledge structure is more complex than data and it is difficult to represent and process by computer [9]. Knowledge management is difficult for the traditional information management techniques due to the following reasons.

- Data sources consisting knowledge are bind to specific applications [10].
- Knowledge stored in different sources tends to be redundant and inconsistent.
- Lack of central, logical and combined coordination of knowledge management tasks.

Many researchers strongly argue that ontology based knowledge management provides solutions for the issues of modern information systems [11] [12][13]. Ontology is an effective technology that enables integration of related resources, sharing the right knowledge and avoids irrelevant information.

The current research describes an ontology based knowledge management framework. The proposed framework consist effective components of knowledge management such as capture, store and deploy to address the issues of current knowledge management.

Rest of the paper is organized as follows. Section 2 briefly describes ontology background, section 3 gives related research work recent ontology based knowledge management approaches, section 4 briefly describes proposed approach, section 5 illustrates knowledge representation, section 6 presents proposed framework for knowledge management and section 7 concludes.

II. ONTOLOGY BACKGROUND

Several ontology definitions are available in the literature. Among them most popular and primary ontology definition is "Ontology is an explicit formal specification of a shared conceptualization" [14]. An ontology is "Special kind of graph describes entities of a domain, properties and relation between them" [5]. Ontologies enable knowledge representation in machine process able format. The role of ontologies is to support knowledge sharing and reuse within and among the organizations [15].

The major components of ontology are concepts, properties, instances, restrictions, axioms and facts [16].

Concept: describes an entity of a domain.
Instance: represents an individual of a concept.
Properties: establish relationship between two individuals or an individual and literal value.
Restrictions: define restrictions on property values.
Axioms: provide information about classes and properties.
Facts: represents statements that are always true in the domain knowledge base.

With wide usage of ontology in knowledge management, ontology has become a popular research area. Several languages and tools have been developed by researchers to construct ontologies.

Ontology languages encode the knowledge of a domain and provide support for processing of the knowledge [17]. In the last decade several ontology languages were developed to express the knowledge of domain in the form of ontology. OWL is most popular and W3C recommended language for ontology implement.

Tool support is really important to construct ontology [18]. Without any kind of tool support, ontology construction is time consuming and complex. To easy ontology development several ontology development tools have been developed by researchers and software enterprises. The popular ontology construction environments are protégé [19], NeOn toolkit [20], TopBraid Composer [21], SWOOP [22] and WebODE [23] etc.

III. RELATED RESEARCH WORK

Ontologies are introduced to cope with many challenges of Knowledge Management Systems (KMS). Ontologies enable KMS to integrate related resources and sharing. Many researchers have proposed and developed ontology based KMSs to handle the knowledge management issues in different fields.

A. Uszok et al., [12] proposed an approach to manage knowledge from documents of different formats. G. Rong et al., [24] developed Domain ontology based information retrieval system to manage and retrieve non-metallic pipe knowledge of oilfield. [25] Presents an ontology based Knowledge management approach for E-Learning systems and integrated data quality component. [26] describes an ontology based method for forest knowledge management. A. maalel et al., [27] proposed domain ontology and case based reasoning combined approach for Knowledge management of critical areas, such as rail road accidents.

[28] illustrates a general framework for knowledge management from different sources using domain ontology. J. Zhang et al., [11] proposed three multiple ontology based knowledge management system.

The detailed survey on the recent ontology based knowledge management approaches, methods and systems concludes that following are the common limitations in the knowledge management.

- There is no proper method and clear approach for knowledge management
- Many of the knowledge management systems are static
- Closed knowledge management

There is no proper approach for uniform representation of heterogeneous data

IV. PROPOSED APPROACH

The proposed ontology based knowledge management approach has two phases. 1) Knowledge Representation 2) knowledge management by means of ontology.

V. KNOWLEDGE REPRESENTATION

Knowledge representation is important for effective and efficient knowledge management of a domain. Ontology is a good technology for knowledge representation of a domain. A Well constructed ontology can help to build an effective knowledge management system [29].

Ontology engineering methodology is a set of procedures, guidelines and best practices derived from real world ontology development experiences [30]. It helps ontology designer and domain experts to obtain a well constructed ontology. Many researchers have proposed ontology development methodologies for last decade. Some of the most popular methodologies are On-To-Knowledge [31], Methontology [32], DILIGENT [33], and NeOn methodology [34]. Many ontology engineering methodologies have the following steps in common. Fig. 3 shows ontology development process

- *Define scope and competency questions*
- *Conceptualization*: Abstract semantic vocabulary (concepts) and statements about the target domain.
- *Formalization:* define concept hierarchy and relationship between the concepts
- *Implementation*: Construct ontology using an IDE like protégé, Neon
- *Evaluation*: Check consistency using an ontology reasoner and valid with competency questions.

VI. ONTOLOGY BASED KNOWLEDGE MANAGEMENT

KMS is divided into three parts [11].

- *Knowledge Acquisition*: Conversion process of semi-structured and unstructured information into structured information using concepts of ontology.
- *Knowledge Store*: A process of storing acquired knowledge in a database.

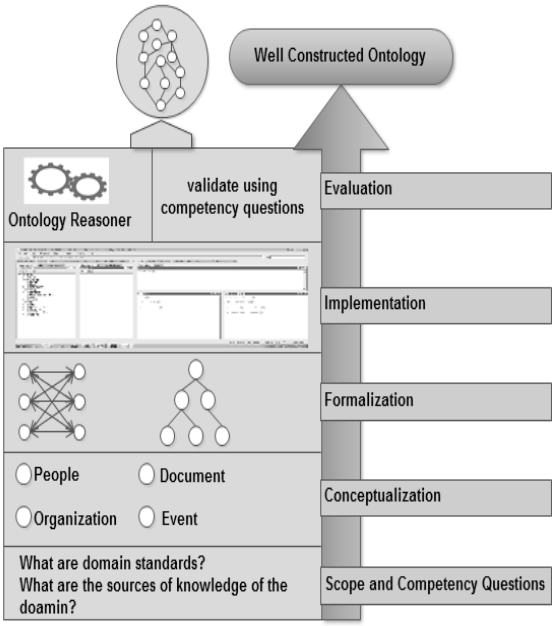

Fig. 3. Ontology development

- *Knowledge Reuse*: Use of knowledge in applications to retrieve relevant contents of user needs.

We adapted the same components of knowledge management in the proposed approach. The three components of ontology based knowledge management are interrelated. Each component is described in detail in the following section. Fig. 4 shows framework of the proposed approach.

A. Knowledge Acquisition

Proposed approach divides knowledge source into two categories. 1) Learning objects (documents of different formats and reports) 2) Non-Learning objects (human experiences, ideas, expert approaches etc.). The following section describes knowledge acquisition of both learning and non learning objects.

Knowledge acquisition from learning objects: semi-automated annotation process is used to capture knowledge from learning objects. Extensible architecture of oracle database supports information extractors [35]. This is one of the complementary to the current work. The extractors take text document as input and produce an RDF/XML document as output automatically. This can be done for every new learning object which comes into the knowledge source. Extracted RDF triples of an object are stored as a named RDF graph. Named RDF graph is a set of RDF triples that describes about a resource. Each named graph is uniquely identified by Uniform Resource Identifier (URI). Meta information of the learning objects is generated manually by entering information in form based interface. The generated Meta information is also converted into RDF triples and added to the corresponding named graphs.

Knowledge acquisition from non-learning objects: form based interface is used for annotation of non learning objects. Form is generated dynamically with the features of the class to which instance is to be added. The form generated information of a non-learning object instance is converted into a named graph internally.

To improve the retrieval performance, inferences are applied over the named RDF graphs of both learning and non-learning objects using domain ontology. The inferred triples are also added to the corresponding named graph.

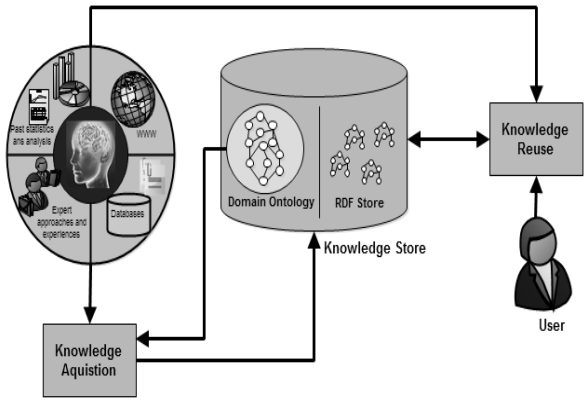

Fig. 4. Proposed ontology based knowledge management frame work

The knowledge acquisition phase extracts knowledge from various sources. The knowledge acquisition from both learning and non learning objects is uniformly represented in RDF format. Fig. 5 presents knowledge acquisition in the proposed framework.

B. Knowledge Store

Since knowledge is represented in RDF triple format, an efficient RDF data management is essential. Researchers proposed several storage models for RDF. Among them the most straight forward relational approach is vertical three column table [36]. Popular data base developers (Oracle) adapted this approach for efficient RDF triple management [37].

Oracle DB enables users to add extra column to the triple store. In the current work a binary column is added to differentiate knowledge of learned objects from non-learned objects. Bit 1 indicates learned object (physically availability of resource in the knowledge store) and 0 indicates non-learned object (non availability of resource in the knowledge store). Table I shows an example RDF triples contained in two named graphs (ng1 & ng2) and associated bit value.

Every learning object in the knowledge source is associated with its corresponding named RDF graph URI. See Table II. It enables to retrieve learning object from knowledge source using RDF graph itself as index. Fig. 6 shows architecture of proposed knowledge store.

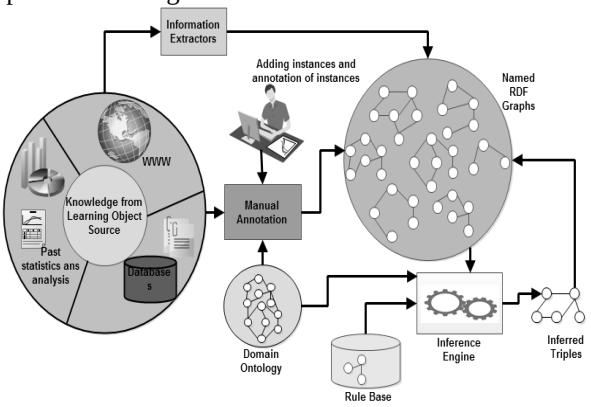

Fig. 5. Knowledge acquisition

Table I: Triples contained in two named graphs

URI	Subject	Predicate	Object	Bit
:ng1	:ram	rdf:type	:persion	0
:ng1	:ram	persion:ssno	"GN04"	0
:ng1	:ram	persion:ocupation	:employee	0
:ng2	:xyz	rdf:type	:document	1
:ng2	:xyz	document:title	"First deliverable"	1
:ng2	:xyz	document:size	"14mb"	1

Table II: Association of learning object instances and corresponding RDF URI

Document ID	URL (physical location of document)	RDF URI
-	-	-
-	-	-

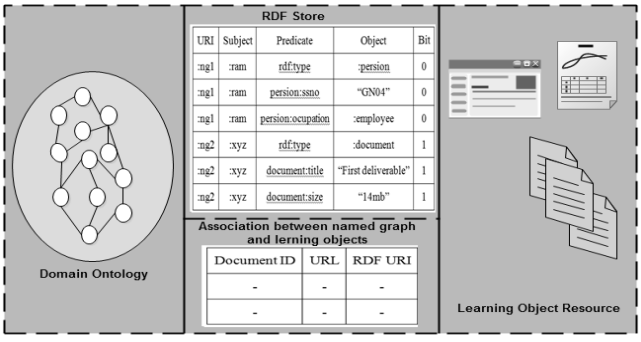

Fig. 6. Knowledge store

C. Knowledge Reuse

SPARQL is the primary query language for RDF data [38]. Though systems provide keyword interfaces (or) NL based to simplify user interaction, the input query should be translated in SPARQL.

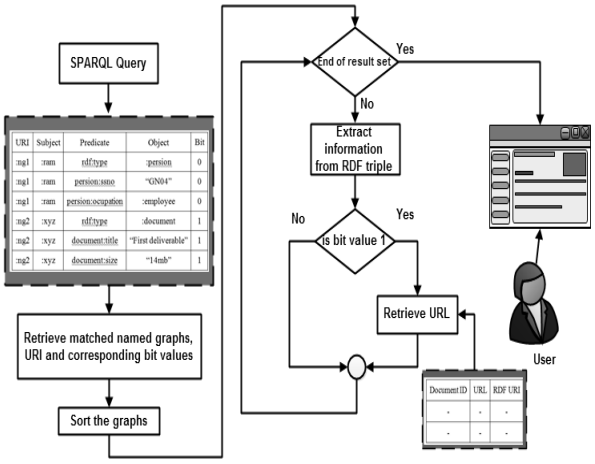

Fig. 7. Knowledge Retrieval

SPARQL query on RDF store identifies named graphs matched to its query pattern. Retrieve named graphs, associated URI and bit values into memory. Sort the named graphs using sem_contains operator of oracle database so that most relevant first. For each named Graph a) extract information and represent in user understandable format. b) If named graph associated bit value is 1 then provide learning object URL to the users for reference. Fig. 7 shows querying knowledge.

VII. CONCLUSION

This paper presents a frame work for ontology based knowledge management. The proposed approach has two phases 1) knowledge representation and 2) knowledge management. Farmer describes knowledge representation through ontology development and later describes a framework of ontology based knowledge management. Ontology based knowledge management has three components: knowledge acquisition, store and retrieval. Each component is described in detail. The proposed approach provides better solution for some of the open issues of ontology based knowledge management.

ACKNOWLEDGMENT

The work presented in this paper is done as part of a sponsored project founded by government of India, Ministry of Defence, DRDO (ER&IPR), and done in the labs of Adhiyamaan College of Engineering where the author is working as a Professor& Director in the department of Master of Computer Applications. The author would like to express her sincere thanks to DRDO for providing the support.

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