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Ontology Based Approach for Semantic Information Retrieval System

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Abstract—The Information retrieval system is taking an important role in current search engine which performs searching operation based on keywords which results in an enormous amount of data available to the user, from which user cannot figure out the essential and most important information. This limitation may be overcome by a new web architecture known as the semantic web which overcome the limitation of the keyword based search technique called the conceptual or the semantic search technique. Natural language processing technique is mostly implemented in a QA system for asking user's questions and several steps are also followed for conversion of questions to the query form for retrieving an exact answer. In conceptual search, search engine interprets the meaning of the user's query and the relation among the concepts that document contains with respect to a particular domain that produces specific answers instead of showing lists of answers. In this paper, we proposed the ontology based semantic information retrieval system and the Jena semantic web framework in which, the user enters an input query which is parsed by Standford Parser then the triplet extraction algorithm is used. For all input queries, the SPARQL query is formed and further, it is fired on the knowledge base (Ontology) which finds appropriate RDF triples in knowledge base and retrieve the relevant information using the Jena framework.

Index Terms— Semantic web, Ontology, Query processing, Information retrieval, RDF, SPARQL, WordNet, Jena API.

1 INTRODUCTION

The Information retrieval system is taking an important role in current search engine. Natural language processing technique is mostly implemented in a Question Answering (QA) system to ask user's questions and several steps are also followed in conversion of questions to the query form to retrieve an exact answers but processing of information on the web is mostly restricted to manual keyword searches which results in irrelevant information retrieval. However, this limitation may be overcome by a new web architecture known as the semantic web. In order to overcome the limitation of the keyword based search technique, the conceptual search technique is implemented [1]. In the conceptual search, the search engine interprets meaning of a user's query and a relation among the concepts that documents contain with respect to a particular domain. Ontology provides shared and reusable piece of knowledge about a specific domain, and has been applied in many fields, such as the semantic web, e-commerce and information retrieval systems, etc., many researchers begin to pay attention on ontology research. Consequently, many ontology editors have been developed to help domain experts to develop and manage the ontology for example Protégé, OntoEdit, TopBraid. One important benefit is that we can significantly save time and effort by reusing existing ontologies instead of building new ones every time. In addition to that, another advantage is the heterogeneous system and resources can be interoperate by sharing a common knowledge. In the proposed system, a meaningful concept is extracted from user's input query. Using this concept, query expansion is performed, the query is converted into a meaningful format [1]. In the proposed system, an input query is converted into the SPARQL query. SPARQL is RDF database language. The SPARQL query is fired in the RDF database and accessed the relevant information. Search engine performs searching operation based on keywords which results in an enormous amount of data available to the user, from which he or she cannot figure out the essential and most important information. The Basic objective of this project is to provide accurate information to a specific question instead of producing lists of expected information. QA system using Ontology technique, have higher result's precision than the system using the keyword based information retrieval techniques.

The objectives of the proposed system are as follows:

- To develop the ontological database for storage of domain-specific knowledge.
- Generating the SPARQL query from user's input query.
- Semantic search of NL query.
- To retrieve related answers from the domain specific ontology.

2 RELATED WORK

AquaLog is a portable question-answering system which takes queries expressed in natural language and an ontology as an input and returns answers drawn from one or more knowledge bases (KBs), which instantiate the input ontology with domain-specific information. AquaLog used the shallow parsing and WordNet for converting natural language queries in the SPARQL query. AquaLog adopts the triple-based data model.

Linked Open Data Question Answering (LODQA) System is developed to generate SPARQL queries from natural language, with the goal of providing an easy-to-use interface to search linked open RDF data. LODQA performs linguistic analysis and ontology lookup. For linguistic analysis, LODQA adopts the Enju parser which is trained on English-language questions (Hara et al., 2011). For ontology lookup, LODQA uses OntoFinder 3, which searches ontologies in BioPortal for ontology terms.

Semantic Information Retrieval Using Ontology in University Domain in which the developed system retrieves the web results more relevant to the user's query through keyword expansion. The results obtained here will be accurate enough to satisfy the request made by the user. The system will be of efficient use to the developers and researches who work on the web. For ranking, an algorithm has been applied which fetches more apt results for the user's query [2].

3 SYSTEM DESCRIPTION

In the proposed system, the user interface is created in which user enters an input query in natural language. Further, it processes by Standford parser, for all input queries, parse tree, tree bank structure is constructed by Standford parser. Ontotriples are constructed using ontology. Then the SPARQL query is formed and it is fired on the knowledge bases which finds appropriate RDF triples in knowledge base and retrieve the relevant information using Jena semantic web Framework.

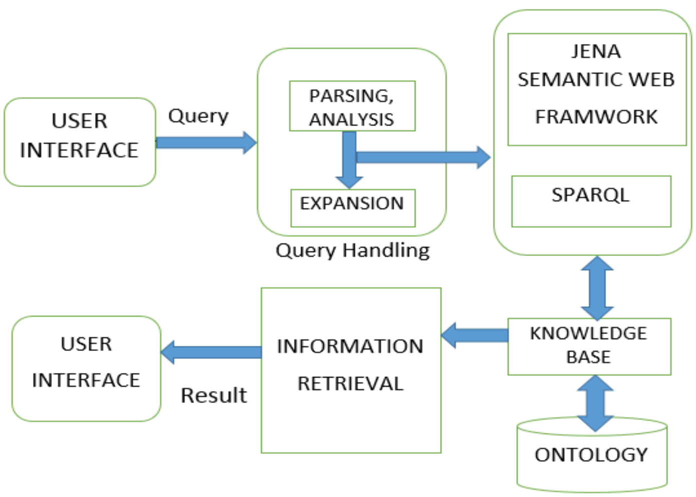


Fig.1. System Architecture

3.1 Query Parsing and Analysis: In this phase, the analytical operation of the question is found out. This Analysis is responsible for natural language processing (NLP). The query is processed by Standford Parser, for all input queries, parse tree, tree bank structure is constructed. It is a technique to identify the type of question, the type of answer, the subject, the verbs, the noun, the phrases and the adjectives from the question. Tokens are separated from the question and the meaning is analyzed and the reformulation of question/query is sent to the next stage [7].

3.2 Reformulation and Classification of Query: In this phase, the reformulation of query that is further expansion is generated with the help of WordNet or a domain specific local dictionary.

3.3 Knowledge Base: The Knowledge Base of this proposed system is domain specific. The storage of ontology is necessary one to retrieve the relevant and correct answer from the knowledge base. In our system the RDF database is used which can be easily linked in protégé or TopBraid.

3.4 Information Retrieval Search Engine: The user can search answers from the ontology. If the concept exists in the knowledge base, the system can answer the question quickly.

4 METHODOLOGY

4.1 Semantic Web:

The next generation intelligent web called the semantic web offers the users, the ability to work on shared meaningful knowledge representations on the web. The semantic web creates an artificial intelligence application which makes web content meaningful to the computers, thereby unleashing a revolution of new abilities and it intends to support machine-processing capabilities which will automate web applications and services. Agents (software programs) will perform various tasks by communication with other agents and seeking information from the web resources [2]. The Semantic web is a vision, the idea of having data on the web defined and linked in a way that it can be used by machines not just for displaying purposes, but for automation, integration and reuse of data across various applications [3].

4.2 Ontology:

An Ontology formally describes a list of terms which represent important concepts, such as classes of objects and the relationships between them. To compare conceptual information across two knowledge bases on the web, a program must have a way to discover common meanings and the solution for this is to collect information at a common place called Ontologies. Building an Ontology is divided into three steps: ontology capture, ontology coding and possible integration with existing ontologies [2]. An Ontology life cycle involves steps like specification, conceptualization, formalization, integration, implementation and maintenance [8].

4.3 WordNet:

WordNet is a lexical database for the English language. WordNet can help a question answering system to identify synonyms. For example, the verbs "start" and "begin" will be recognized as synonyms by WordNet. The synonym information can be used to help match a question with an appropriate rule [9].

4.4 Resource Description Framework (RDF):

The Resource Description Framework (RDF) is a family of World Wide Web Consortium (W3C) specifications originally designed as a metadata data model. It is a directed, labeled graph data format and its general-purpose is to represent the information in the web. In many applications which are relevant with Natural Language Processing (NLP) or the Semantic Web, RDF is broadly used to organize knowledge. It plays an important role in knowledge representation and ontology. An RDF Model consists of a set of triples. A triple includes three parts: subject, predicate and object. Its formulation is <subject, predicate, object>. For instance, we can represent "Albert Einstein's given name is Einstein" as a triple <Albert_Einstein, hasGivenName, Einstein>. We can read, write and operate RDF easily by the open source Java Project "Jena" [13].

4.5 SPARQL:

SPARQL [14] is the query language for the RDF data, it is similar to SQL and widely used in the query processing and inference engine like "ARQ", "Pellet", "Jena" and etc. We can query a triple by any component of the triple. SPARQL supports any constraining queries, optional pattern matching, optional graph pattern along with the operation of conjunctions and disjunctions. We can also create regular expression restriction by the keyword "FILTER". Either the results of SPARQL queries are results set or RDF graphs.

4.6 Jena API:

Jena API is used for mapping SPARQL query on RDF. Jena is as a number of major subsystems with clearly defined interfaces between them. RDF triples, graphs, and their various components, are accessed through Jena's RDF. Jena stores information as RDF triples in directed graphs, and allows your code to add, remove, manipulate, store and publish that information. RDF API has basic facilities for adding and removing triples to graph and finding triples that match particular patterns. Here you can also read in RDF from external sources, whether files or URS and serialized a graph in correctly-formatted text form. Both input and output support most of the commonly-used RDF syntax. The collection of the standards defines semantic web technologies includes SPARQL-the query languages for RDF, Jena conforms to all of the published standards and, tracks the revision and updates in the under-developed areas of the standard. Handling SPARQL, both for queries and updates, a SPARQL API is responsible [4].

6 Overview of Implementation

6.1 Database Used

Protege is the editor which creates data in RDF format. In the proposed system, Protege is used to create the ontology for Academic Library in RDF data format. The Academic Library Ontology contains several classes and subclasses. The root node, Academic Library contains classes Subject, Department, Administrative, Book_Title_Name, etc., similarly the class department has subclasses Computer Science, Mechanical, Civil, etc. Those subclasses are also further divided in classes. Individual instances of those classes and subclasses are created for instance, the class subject has instances operating system, compiler, Java, etc. The properties of those classes and subclasses are created which used as predicate in RDF for example, book_title_name, book_codes, rack_number, etc are properties of operating system subject book. In this way hierarchical view of Academic Library Ontology is developed then exported in RDF format which are written in XML which shows the RDF schema and Knowledge base KB for that schema. KB takes values of properties identified for classes and subclasses [11].

6.2 Conversion of Input Query to SPARQL Query

The User interface in which users enter an input query in natural language. Further, it processes by Standford parser, for all input queries parse tree, a tree bank structure is constructed. Then triplet that is Subject, Predicate, Object extraction algorithm is used to extract the triplets from tree bank structure. Then the SPARQL query is formed [4].

6.2.1 Triplets Extraction from Sentences

A sentence (S) is represented by the parser as a tree having three children: a noun phrase (NP), a verbal phrase (VP) and the full stop (.). The root of the tree will be S. Firstly, we intend to find the subject of the sentence. In order to find it, we search in the NP subtree. The subject will be found by performing a breadth first search and selecting the first descents of NP is a noun. Nouns are found in the following subtrees:

Subtree	The type of noun found
NN	noun, common, singular or mass
NNP	noun, proper, singular
NNPS	noun, proper, plural
NNS	noun, common, plural

Secondly, for determining the predicate of the sentence, a search will be performed in the VP subtree. The deepest verb descents of the verb phrase will produce the second element of the triplet. Verbs are found in the following subtrees:

Subtree	The type of verb found
VB	verb, base form
VBD	verb, past tense
VBG	verb, present participle or gerund
VBN	verb, past participle
VBP	verb, present tense, not 3rd person singular
VBZ	verb, present tense, 3rd person singular

Thirdly, we look for objects. These can be found in three different subtrees, all siblings of the VP subtree containing the predicate. The subtrees are: PP (prepositional phrase), NP and ADJP (adjective phrase). In NP and PP we search for the first noun, while in ADJP we find the first adjective. Adjectives are found in the following subtrees:

Subtree	The type of adjective found
JJ	adjective or numeral, ordinal
JJR	adjective, comparative

Stanford Parser generates a Treebank parse tree for the input sentence. Figure depicts the parse tree for the input sentence "*Who is author of operating system*".

```
(ROOT [42.197]
 (SBARQ [39.135]
  (WHNP [3.059] (WP Who))
  (SQ [31.209] (VBZ is)
   (NP [29.235]
    (NP [10.981] (NN author))
    (PP [18.116] (IN of)
     (NP [17.049] (NN operating) (NN system))))))

[root(ROOT-0, Who-1), cop(Who-1, is-2), nsubj(Who-1, author-3), nn(system-6, operating-5), prep_of(author-3, system-6)]
```

Fig.2 The parse tree generated by Stanford Parser

After applying the triplet extraction algorithm presented below, we obtain the result presented in following figure

```
(ROOT [42.197]
 (SBARQ [39.135]
  (WHNP [3.059] (WP Who))
  (SQ [31.209] (VBZ is)
   (NP [29.235]
    (NP [10.981] (NN author))
    (PP [18.116] (IN of)
     (NP [17.049] (NN operating) (NN system))))))

[root(ROOT-0, Who-1), cop(Who-1, is-2), nsubj(Who-1, author-3), nn(system-6, operating-5), prep_of(author-3, system-6)]
```

Fig.4 The triplet structure containing the triplet elements with their attributes

Once we acquire triplets, the SPARQL query can be generated, refer to results. Before generating SPARQL query, WordNet or local dictionary can be used to identify synonyms for predicates if matching predicate is not found in RDF database [15].

6.3 Interfacing Using Jena API

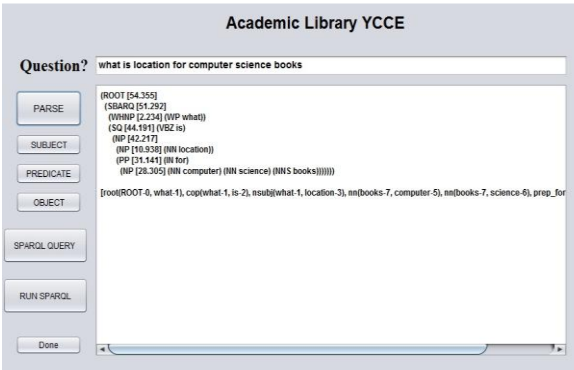
Jena API is used for mapping generated SPARQL query as above mentioned on RDF. Jena provides SPARQL API to handle both SPARQL query and their update. Jena stores information as RDF triples in directed graphs, and allows your code to add, remove, manipulate, store and publish that information. A key feature of the semantic web application is the semantic rules of RDF, RDFS and OWL can be used to infer the information which is not explicitly stated in the graph. For instance, if class C is a sub-class B, and B is a sub-class of A, then by implication C is a sub-class Of A. Jena's interference API provides the means to make these entailed triples appear in the store just as if they had been added explicitly. The Jena API provides a number of rule engines to perform this job, either using the built-in-rules sets for OWL and RDFS, or using application customs rules. In this way Jena API enables the SPARQL query for mapping with RDF database, further, it is fired on RDF database and retrieves the relevant information performing a semantic search into the database

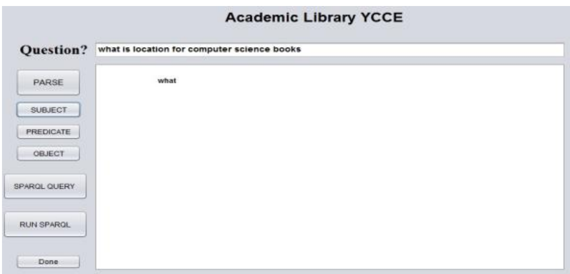
Triplets Extraction Algorithm

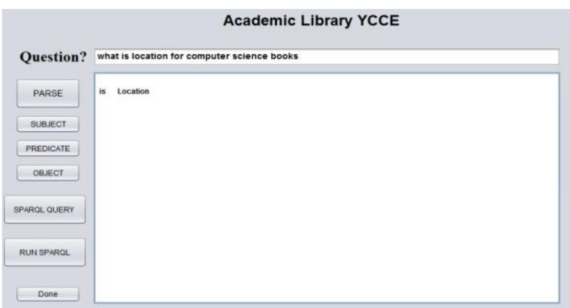
```
function TRIPLET-EXTRACTION(sentence) returns a solution, or failure
        result ← EXTRACT-SUBJECT(NP_subtree)
                ∪ EXTRACT-PREDICATE(VP_subtree)
                ∪ EXTRACT-OBJECT(VP_siblings)
        if result ≠ failure then return result
        else return failure

function EXTRACT-ATTRIBUTES(word) returns a solution, or failure
        // search among the word's siblings
        if adjective(word)
                result ← all RB siblings
        else
                if noun(word)
                        result ← all DT, PRP$, POS, JJ, CD, ADJP, QP, NP siblings
                else
                        if verb(word)
                                result ← all ADVP siblings
        // search among the word's uncles
        if noun(word) or adjective(word)
                if uncle = PP
                        result ← uncle subtree
        else
                if verb(word) and (uncle = verb)
                        result ← uncle subtree
        if result ≠ failure then return result
        else return failure

function EXTRACT-SUBJECT(NP_subtree) returns a solution, or failure
        subject ← first noun found in NP_subtree
        subjectAttributes ←
                EXTRACT-ATTRIBUTES(subject)
        result ← subject ∪ subjectAttributes
        if result ≠ failure then return result
        else return failure

function EXTRACT-PREDICATE(VP_subtree) returns a solution, or failure
        predicate ← deepest verb found in VP_subtree
        predicateAttributes ←
                EXTRACT-ATTRIBUTES(predicate)
        result ← predicate ∪ predicateAttributes
        if result ≠ failure then return result
        else return failure

function EXTRACT-OBJECT(VP_sbtree) returns a solution, or failure
        siblings ← find NP, PP and ADJP siblings of
                VP_subtree
        for each value in siblings do
                if value = NP or PP
                        object ← first noun in value
                else
                        object ← first adjective in value
                objectAttributes ←
                        EXTRACT-ATTRIBUTES(object)
        result ← object ∪ objectAttributes
        if result ≠ failure then return result
        else return failure
```

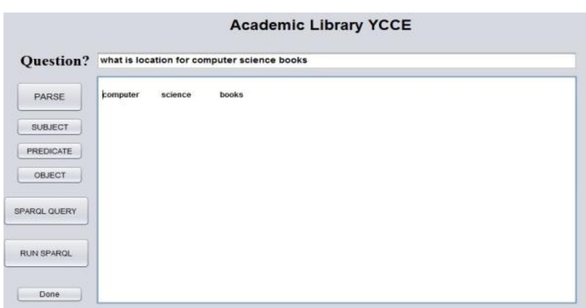
7 RESULTS

Sample output for the query after parsing by Standford parser and then retrieve subject, predicate, object by using the triplet extraction algorithm.

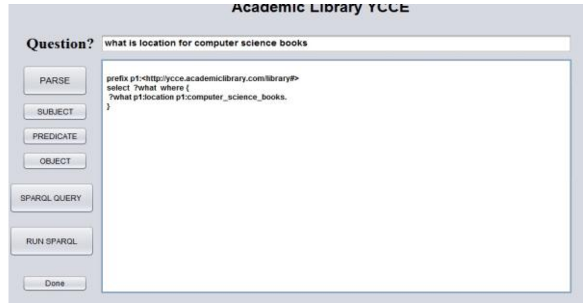


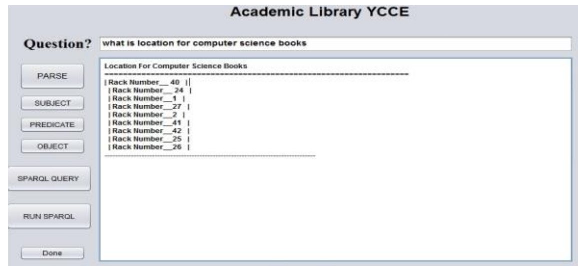


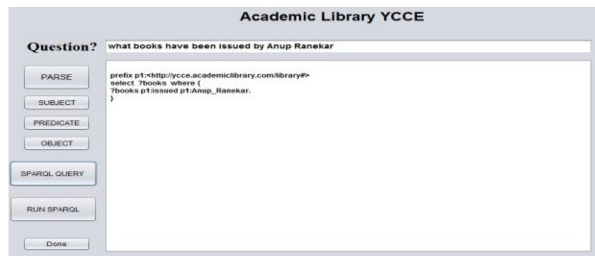


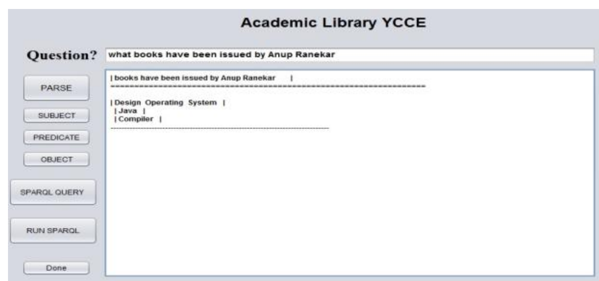


Further, SPARQL query is generated for above triplets and final relevant answer is retrieved using Jena API









8 CONCLUSION

The proposed system overcomes the limitation of keyword based query handling systems and capable extracting relevant information instead of showing lists of answers. The triplet extraction algorithm is working efficiently to extract triples from sentences. Jena API is used for mapping of SPARQL with the RDF database and retrieving the relevant information. Protege editor is used for creating an ontology in RDF data format for Academic Library. This system is domain specific, but in future the method can also be applied in different domains. This system is currently capable of handling simple queries. The further development would be required to answer to all possible types of queries.

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