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OWL, RDF, RDFS Inference Derivation Using Jena Semantic Framework & Pellet reasoner

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***Abstract*— Semantic web is an extension of World Wide Web. In Semantic web each resources and services is annotated with the help of web ontology language (OWL). Resource description framework (RDF) represents the web information into its properties and values. Resource description framework schema (RDFS) represents information resources into classes and properties are defined with the help of these classes. In this paper we create university ontology with the help of protégé 4.3 alpha tool. We have proposed information retrieval framework that produce results with better precision, recall and information overkill. With the help of Jena semantic framework and pellet reasoner tools we analyze that OWL inference provide more relevant information compared to None, RDF and RDFS. We have developed five university domain ontologies but presented the result only for two ontologies. We have validated that our proposed framework provide more relevant information for these two ontologies.**

Keywords-Semantic Web; RDF; RDFS; OWL; Protégé 4.3 alpha tool; Jena semantic framework; Pellet reasoner

I. INTRODUCTION

Tim Berners-Lee, father of World-Wide-Web, defines semantic web as an "extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation" [1]. Tim Berners-Lee proposed 7 layer structures for semantic web as shown in figure 1 [1].

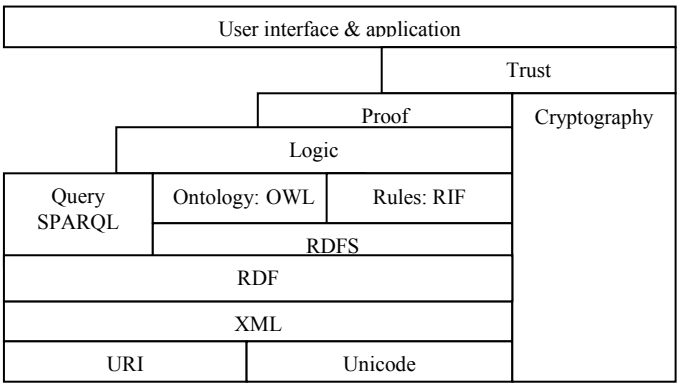

Fig.1. Hierarchical structure of semantic web

The first layer URI/IRI describes the resources of the web. The second layer RDF/XML, RDF schema identifies the resources on the web and its relations. XML schema describes the content and structure of the data. The third layer RDFS/OWL, RDFS schema gives specific dictionary for RDF that can be used to describe the taxonomies of classes, properties and its ranges also. OWL provides semantic of domain knowledge. The fourth layer Logic is used for calculating inference based on RDF, RDFS, and OWL. The fifth layer Proof evaluates and proves according to Logical descriptions. The sixth layer Trust provides the secret relationship between the users. Final layer User Interface & Application expresses the specific application ranges and distinct communication interfaces. The aim of the semantic web is to contribute a better plate form for the knowledge representation of related data to grant machine processing on an overall scale by adding logic, inference and rule systems across distinct applications and boundaries. In Semantic Web, information is described in meaningful form with the help of Resource Description Framework (RDF) [2], Resource Description Framework Scheme (RDFS) [3] and OWL [4] to permit computer to sense and find out relevant information from the web document.

This paper is organized in the following six sections: 1) introduction, 2) Related Work 3) University Ontology Structure 4) Proposed Framework for University system 5) Inference derivation 6) Conclusion

II. RELATED WORK

OWL is a World Wide Web Consortium (W3C) Recommendation for representing ontologies on the Semantic Web [5]. In semantic web, RDF/RDFS are the World Wide Web Consortium (W3C) standard models for representing metadata and ontology [2, 3]. RDF data model expressed by node and edge labeled directed graph. In RDF resources are described by ovals. Literal are described by rectangles and predicates are described by arrows. RDF shows the relationship with the help of RDF graph. RDF doesn't show the inverse property. RDF shows the poor inference, searching, indexing. DL query concept is not found in RDF. Prefix for RDF is rdf [6] [7]. RDFS is a standard language for

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creating ontology in RDF. RDF provides a specific dictionary for RDF that can be used to define taxonomies of classes, properties, domain and range for specification for properties. RDFS show the relationship with the help of RDFS graph. RDFS show the inverse property. RDFS show the better inference, searching, indexing compare RDF. DL query concepts are found in RDFS. Prefix for RDFS is rdfs. RDF classes consist of all the class details. The rdfs: type predicate is used to group resources together [6] [7]. OWL is an extension of RDF and RDFS. It converts all the things in descriptive logic. OWL shows the relationship with the help of Onto Graf. OWL shows the inverse property. OWL shows the better inference, searching, indexing compared to RDF/RDFS. DL query concepts are found in OWL. Prefix for OWL is owl. OWL defines three layers: OWL Lite, OWL DL, and OWL Full [6] [7] [8]. There are many tools (protégé, onto edit) available that are play important role for developing the ontology. In this paper we describe the inference for RDF, RDFS, and OWL.

III. UNIVERSITY ONTOLOGY STRUCTURE

The creation of ontology will be taken up in stages starting from the class definition and adding characteristics to facilitate reasoning and inference. The ontology is based on university structure.

A. Class Hierarchy

An OWL Class is an appropriate resource that shows a set of resource sharing common characteristics. OWL codes are shown below.

<?xml version="1.0"?><!DOCTYPE Ontology [<!ENTITY xs "http://www.w3.org/2001/XMLSchema#" >

<!ENTITY xml "http://www.w3.org/XML/1998/namespace" >

<!ENTITY rdfs "http://www.w3.org/2000/01/rdf-schema#" >

<!ENTITY rdf "http://www.w3.org/1999/02/22-rdf-syntax-ns#" >]>

<Ontology xmlns=http://www.w3.org/2002/07/owl# xml:base="http://swat.cse.lehigh.edu/onto/univ-bench.owl"

xmlns:rdfs=http://www.w3.org/2000/01/rdf-schema#

xmlns:xsd="http://www.w3.org/2001/XMLSchema#"

xmlns:rdf=http://www.w3.org/1999/02/22-rdf-syntax-ns#

xmlns:xml=http://www.w3.org/XML/1998/namespace

ontologyIRI="http://swat.cse.lehigh.edu/onto/univ-bench.owl">

<Prefix name="" IRI="http://swat.cse.lehigh.edu/onto/univ-bench.owl#"/>

<Prefixname="owl"IRI="http://www.w3.org/2002/07/owl#"/> <Prefix name="rdf" IRI="http://www.w3.org/1999/02/22-rdf-syntax-ns#"/>

<Prefixname="xsd"IRI="http://www.w3.org/2001/XMLSchema#"/>

<Prefix name="rdfs" IRI="http://www.w3.org/2000/01/rdf-schema#"/>

<Annotation> <AnnotationProperty abbreviatedIRI="owl:versionInfo"/> <Literal

datatypeIRI="&rdf;PlainLiteral">univ-bench-ontology-owl, ver April 1, 2004</Literal>

</Annotation> <Annotation> <AnnotationProperty abbreviatedIRI="rdfs:label"/> <Literal datatypeIRI="&rdf;PlainLiteral">Univ-bench Ontology</Literal>

</Annotation> <Annotation> <AnnotationProperty abbreviatedIRI="rdfs:comment"/> <Literal datatypeIRI="&rdf;PlainLiteral">An university ontology for benchmark tests</Literal>

</Annotation>

…….

<Declaration><Class IRI="#AdministrativeStaff"/>

</Declaration> <Declaration> <Class IRI="#Article"/>

</Declaration> <Declaration> <Class IRI="#AssistantProfessor"/>

</Declaration> <Declaration> <Class IRI="#AssociateProfessor"/>

……

<Class IRI="#Employee"/> <ObjectIntersectionOf>

<Class IRI="#Person"/> <ObjectSomeValuesFrom>

…….

RDFS codes for university ontology are shown below.

<?xml version="1.0"?> <!DOCTYPE rdf:RDF [<!ENTITY owl "http://www.w3.org/2002/07/owl#" >

<!ENTITY xsd "http://www.w3.org/2001/XMLSchema#" >

<!ENTITY rdfs "http://www.w3.org/2000/01/rdf-schema#" >

<!ENTITY rdf "http://www.w3.org/1999/02/22-rdf-syntax-ns#" >]>

<rdf:RDF xmlns=http://swat.cse.lehigh.edu/onto/univ-bench.owl#

xml:base=http://swat.cse.lehigh.edu/onto/univ-bench.owl

xmlns:rdfs=http://www.w3.org/2000/01/rdf-schema#

xmlns:owl="http://www.w3.org/2002/07/owl#"

xmlns:xsd=http://www.w3.org/2001/XMLSchema#

xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">

<owl:Ontology rdf:about="http://swat.cse.lehigh.edu/onto/univ-bench.owl">

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<rdfs:label>Univ-bench Ontology</rdfs:label>

<rdfs:comment>An university ontology for benchmark tests</rdfs:comment> <owl:versionInfo>univ-bench-ontology-owl, ver April 1, 2004</owl:versionInfo> </owl:Ontology>

<!-- ////////////////////////// Object Properties // ////////////////// -->

<!-- http://swat.cse.lehigh.edu/onto/univ-bench.owl#advisor --> <owl:ObjectProperty rdf:about="http://swat.cse.lehigh.edu/onto/univ-bench.owl#advisor"> <rdfs:label>is being advised by</rdfs:label> <rdfs:domain rdf:resource="http://swat.cse.lehigh.edu/onto/univ-bench.owl#Person"/> <rdfs:range rdf:resource="http://swat.cse.lehigh.edu/onto/univ bench.owl#Professor"/> </owl:ObjectProperty>

<!-- http://swat.cse.lehigh.edu/onto/univ-bench.owl#affiliateOf --> <owl:ObjectProperty rdf:about="http://swat.cse.lehigh.edu/onto/univ bench.owl#affiliateOf"> <rdfs:label>is affiliated with</rdfs:label> <rdfs:domain rdf:resource="http://swat.cse.lehigh.edu/onto/univ bench.owl#Organization"/> <rdfs:range rdf:resource="http://swat.cse.lehigh.edu/onto/univ-bench.owl#Person"/> </owl:ObjectProperty> <!-- http://swat.cse.lehigh.edu/onto/univ-bench.owl#affiliatedOrganizationOf --> <owl:ObjectProperty rdf:about="http://swat.cse.lehigh.edu/onto/univ bench.owl#affiliatedOrganizationOf"> <rdfs:label>is affiliated with</rdfs:label> <rdfs:domain rdf:resource="http://swat.cse.lehigh.edu/onto/univ bench.owl#Organization"/>

……..

<!-- /////// Classes ///// !-->

<!-- http://swat.cse.lehigh.edu/onto/univ-bench.owl#AdministrativeStaff -->

<owl:Class rdf:about="http://swat.cse.lehigh.edu/onto/univ-bench.owl#AdministrativeStaff"> <rdfs:label>administrative staff worker</rdfs:label> <rdfs:subClassOf rdf:resource="http://swat.cse.lehigh.edu/onto/univ bench.owl#Employee"/> </owl:Class>

<!-- http://swat.cse.lehigh.edu/onto/univ-bench.owl#Article --> <owl:Class rdf:about="http://swat.cse.lehigh.edu/onto/univ-bench.owl#Article"> <rdfs:label>article</rdfs:label> <rdfs:subClassOf rdf:resource="http://swat.cse.lehigh.edu/onto/univ bench.owl#Publication"/> </owl:Class>

<!-- http://swat.cse.lehigh.edu/onto/univ-bench.owl#AssistantProfessor -->

<owl:Class rdf:about="http://swat.cse.lehigh.edu/onto/univ-bench.owl#AssistantProfessor"> <rdfs:label>assistant professor</rdfs:label> <rdfs:subClassOf rdf:resource="http://swat.cse.lehigh.edu/onto/univ-- bench.owl#Article --

……

Class hierarchy for university ontology is shown in figure 2.

B. Properties

A property in OWL is a resource that is used as a predicates in a statements that describe individuals. In OWL there are mainly two types of properties: Object property and Data property. Protégé is an ontology editor that provides another property called as annotation property.

1. Object Property

Object property is used for establishing the relationship between one individual to another individuals. Assistant Professor 'Ram' teaches 'Computer graphics'. Object properties are shown in figure 3.

2. Data Property

Data properties are used to establish the relationship between the individuals and literals values. Assistant Professor 'Ram' office number is '10'. Data properties are shown in figure 4.

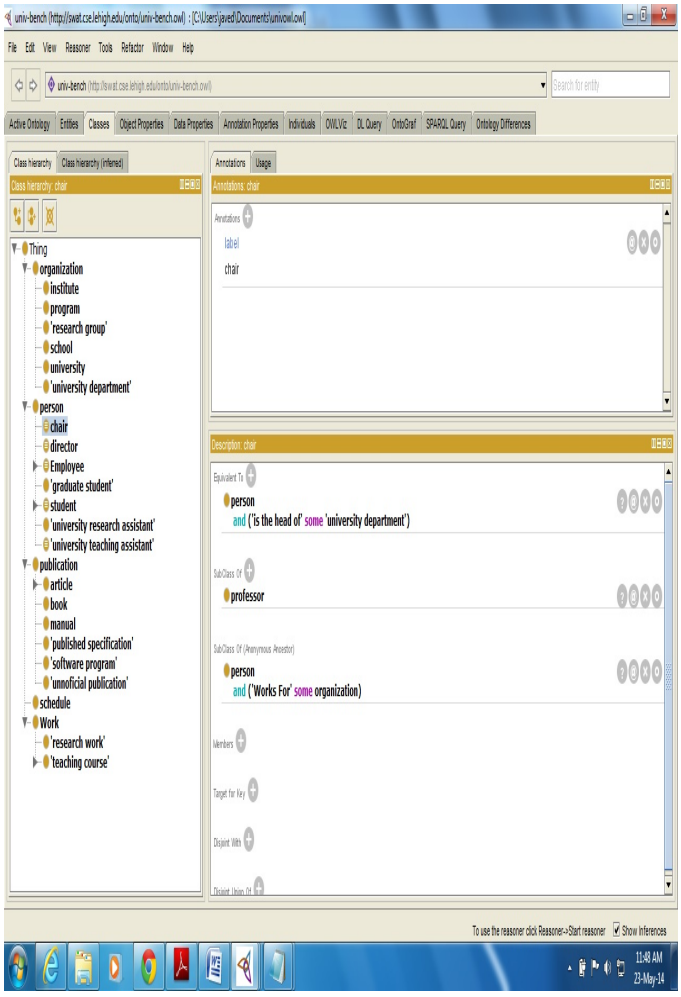

Fig.2. Class hierarchy for University Ontology

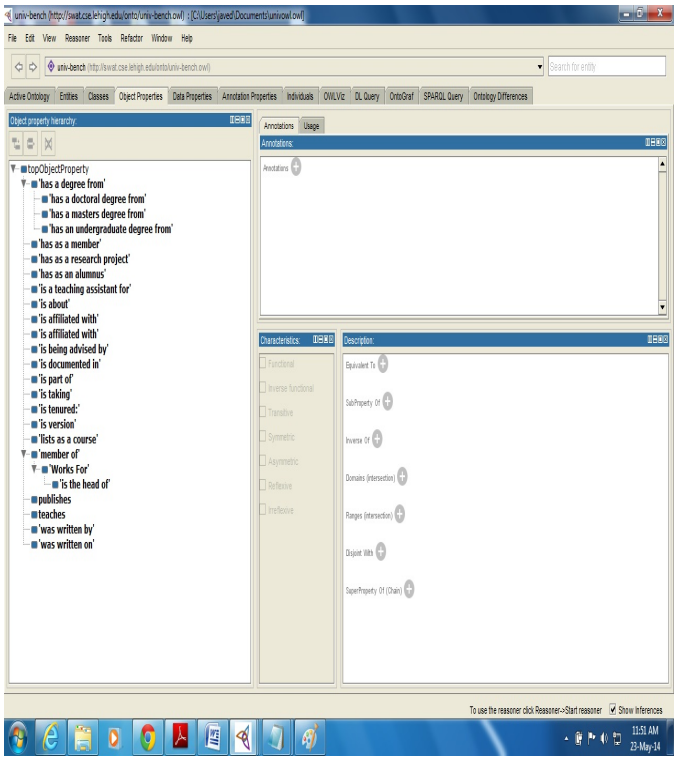

Fig.3. Object property

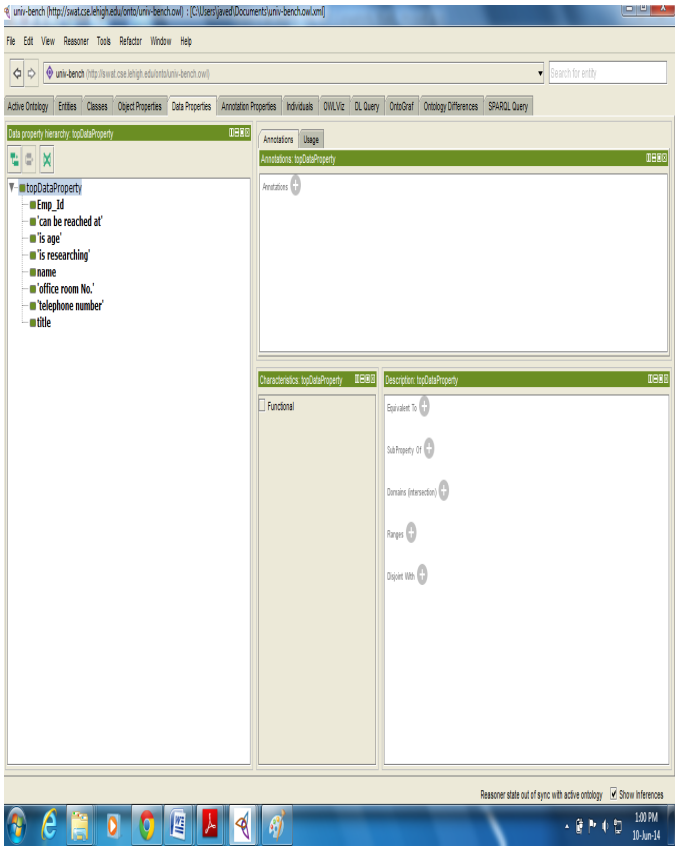

Fig.4. Data property

3. *Annotation Property*

Annotation property is similar to OWL property but they are not associated with semantics and are primarily used in human user interfaces. The two most common annotation properties: rdfs: label and rdfs: comment is shown in figure 5.

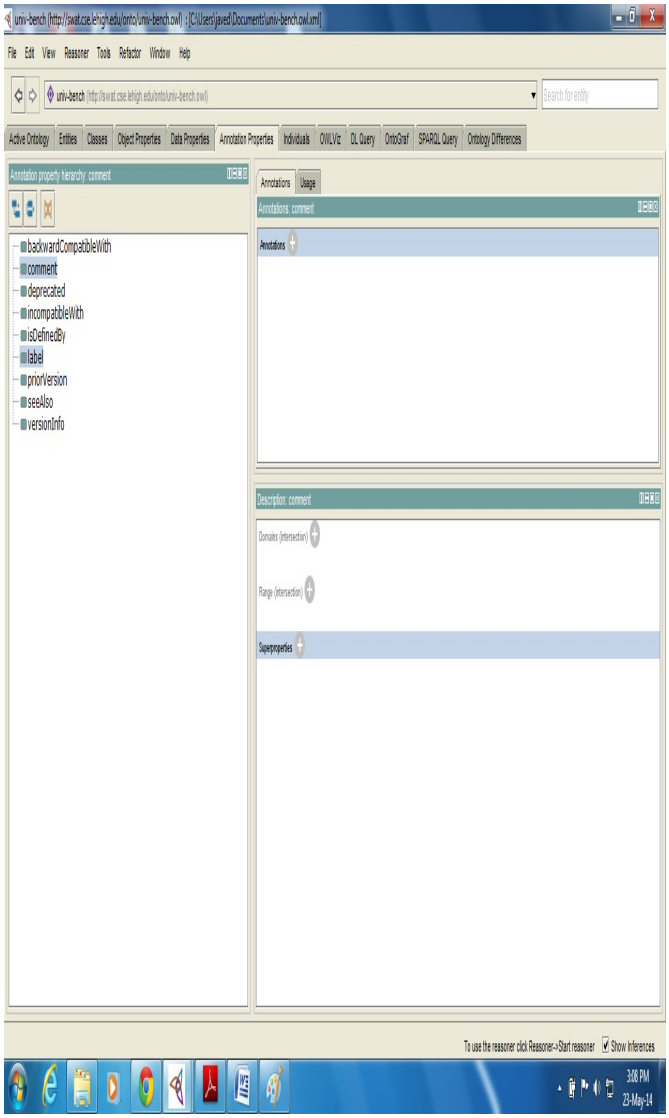

Fig.5. Annotation property

C. *DL Query*

Description logic query provides better for searching classified ontology. DL query collect all the information that match all the features of individuals class such as subclass, super class, equivalent class, ancestors class. DL query tests all the before creating classes. DL query provides 'Add' to ontology features. DL query output is shown in figure 6.

D. *Onto Graf*

Onto Graf describes relationship between the classes. It supports various relationships: subclass, individual, object

properties, data properties, object and data properties domain/range and equivalence. Onto Graf is shown in figure 7.

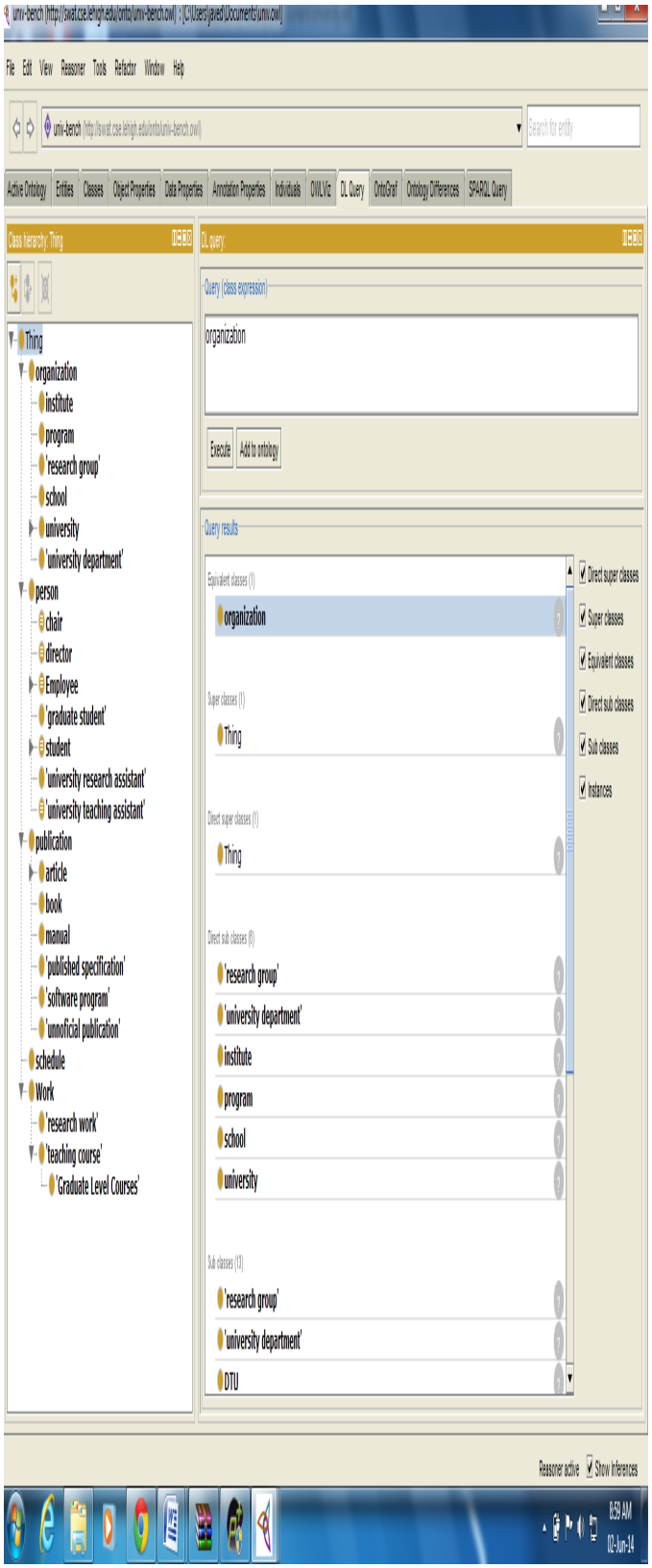

Fig.6. DL query output

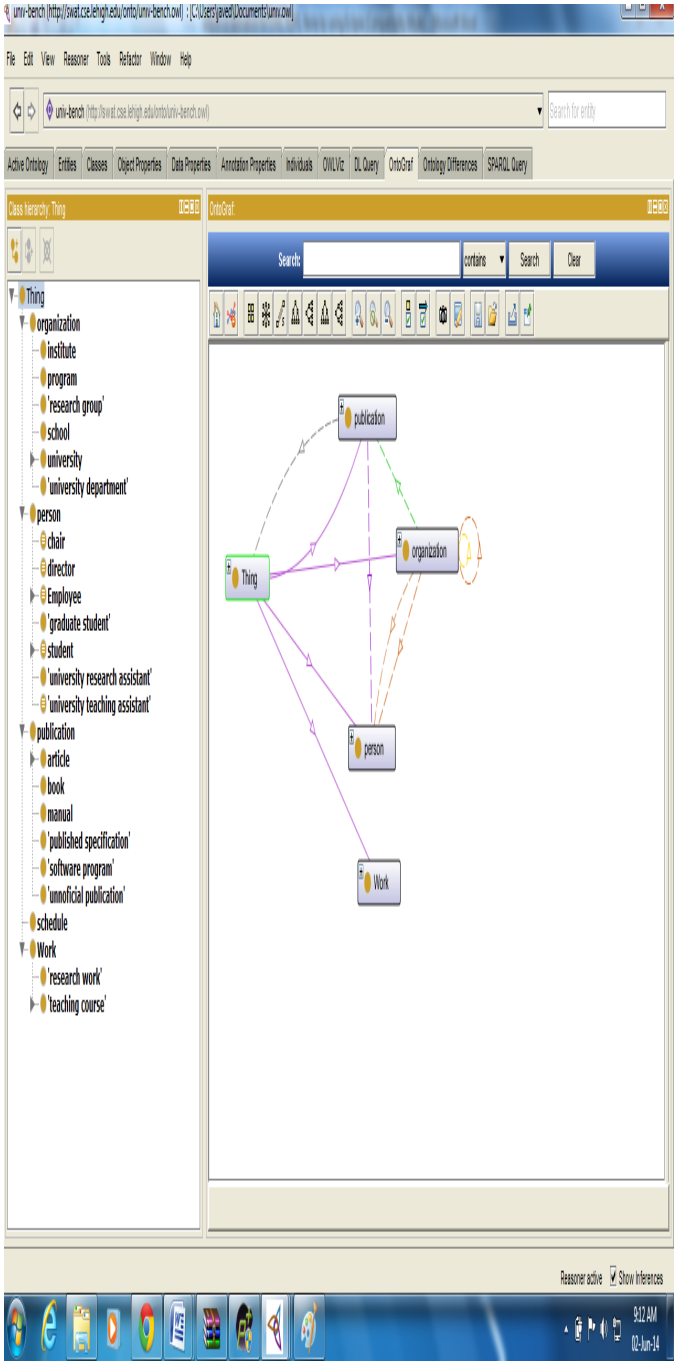

Fig.7. Ontograf for ontology

IV. Information Retrieval Framework for University System

We have proposed a framework that is shown in figure 8, which consist of eight steps and described in subsections.

A. Repository of OWL

We developed ontologies by using Protégé 4.3 alpha tool [8]. This repository is given as input to reasoner. Reasoner is next component of our framework. We have added source code

of two ontologies only. Similarly we can add n number of ontologies.

B. Semantic Reasoner

Reasoner performs semantic inference from the university ontology. To implement this, we used Jena Semantic framework [9], Pellet reasoner [10] tools to retrieve semantic information from the university ontology repository. It supports OWL features very well.

C. Thematic Repository

This repository is build by Pellet Reasoner. It consists of university ontology data property (office number) and corresponding inference result of the repository of university ontology. Thematic repository is given as input to next component of our proposed framework, i.e. Indexing.

D. Indexing

In the proposed framework it is consider that University Ontology repository is indexed using semantic knowledge. Ontology based indexing add more authentic and precise results. We have certain number of resources and each resource have certain properties associated with their values. With the help of indexing we avoid redundancy.

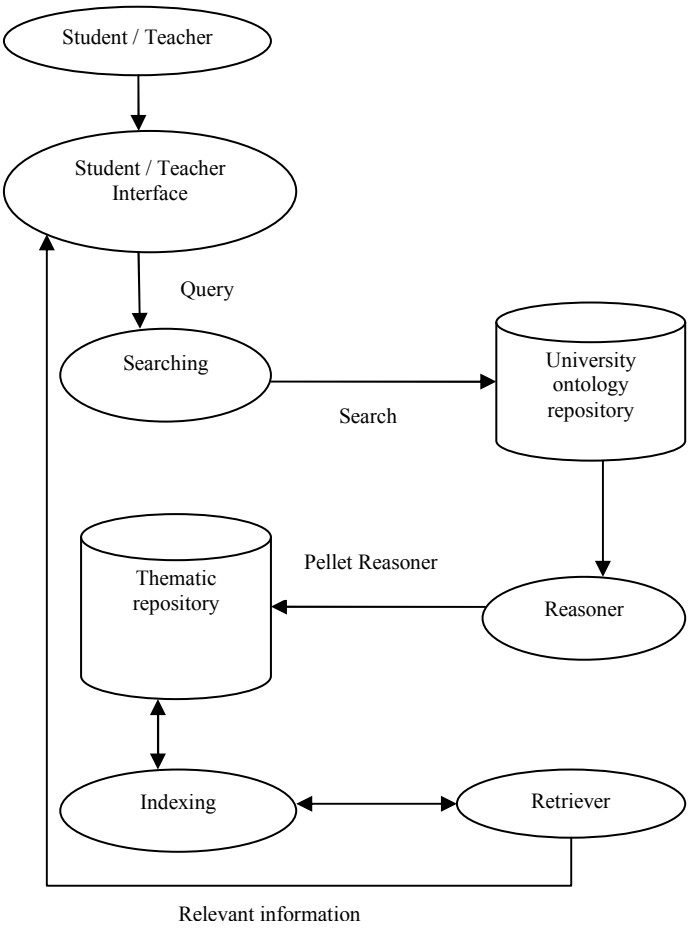

Fig.8. Information retrieval framework for University system

E. Semantic Retrieval

The aim of this component is to gives relevant information from the index to end users. There are three parameters that check the relevancy of information:

a. Precision:

Precision is the ratio of the number of relevant records retrieved to the total number of irrelevant and relevant records retrieved [11].

P = No. of relevant documents ÷ No. of retrieved documents

b. Recall:

Recall is the ratio of the number of relevant records retrieved to the total number of relevant records in the database [11].

R = No. of relevant documents ÷ No. of relevant retrieved documents.

c. Information Overkill:

A word could be used for several meanings in different context. Some contexts, which are not needed, increase the size of search results for nothing good and just become difficult in searching the exact information.

F. Searching

The objective of this component a set of potential information item is returned in response to user need.

G. User Interface

The aim of this component is to take input from users in term of keywords and returns the relevant information from the University ontology repository. User interface then connect with retrieval component to gives relevant result back to the users.

V. INFERENCE DERIVATION

A. Jena Framework & Pellet Reasoner

We use Jena framework & pellet reasoner for derivation of inference for RDF/RDFS, OWL. The RDF, RDFS, and OWL programming framework is found in Jena framework [9]. Pellet reasoner is a java based OWL DL reasoning engine that because pellet support multiple interfaces, Data type reasoning, Semantic Web Rule Language (SWRL) Rule support, ontology debugging and analysis. We use two development tools: Eclipse [12] for java, Protégé for ontologies. Depending upon the inference level the applications develop Jena onto model in one of four ways [6].

- None inference mode (none)
- RDF inference mode (RDF)
- RDFS inference mode
- OWL inference mode (OWL)

B. Parameter for derivation of Inference

To derive inference of an ontology following four parameters for deriving the inference level will be given [6]:

1. An input file
2. Input file format (N3, RDF/XML, N-Triples or TURTLE)
3. An output format
4. Inference level (None, RDF, RDFS, OWL).

VI. COMPARISIONS OF INFERENCE AMONG NONE, RDF, RDFS AND OWL

Here, in our example we have taken 5 ontologies of University domain to derive inference using Jena Semantic Framework and Pellet reasoner. Here we presented only a result of two ontologies due to space constraint. Inference wise output for subject ontology is shown in Table I and for teaching staff ontology is shown in Table II.

TABLE I. Comparisons of None, RDF, RDFS and OWL Inference for Subjects ontology

Ontology	Inference level	Output
University Ontology (Subjects)	**None**	Individual: C++ breed:http://www.semanticweb.org/javed/ontologies/2014/4/University.owl#C type:http://www.w3.org/2002/07/owl#NamedIndividual type:http://www.semanticweb.org/javed/ontologies/2014/4/University.owl#Btech
	RDF	Individual: C++ type:http://www.w3.org/2002/07/owl#NamedIndividual type:http://www.semanticweb.org/javed/ontologies/2014/4/University.owl#BTech name : MMM type:http://www.semanticweb.org/javed/ontologies/2014/4/University.owl#Courses
	RDFS	Individual: C++ breed:http://www.semanticweb.org/javed/ontologies/2014/4/University.owl#C registeredname : MMM type:http://www.w3.org/2002/07/owl#NamedIndividual type:http://www.semanticweb.org/javed/ontologies/2014/4/University.owl#BTech name : MMM type:http://www.semanticweb.org/javed/ontologies/2014/4/University.owl#Courses
	OWL	Individual: C++ name : MMM registeredname : MMM breed:http://www.semanticweb.org/javed/ontologies/2014/4/University.owl#C type:http://www.semanticweb.org/javed/ontologies/2014/4/University.owl#Courses type:http://www.semanticweb.org/javed/ontologies/2014/4/University.owl#BTech type: http://www.w3.org/2002/07/owl#Thing sameAs:http://www.semanticweb.org/javed/ontologies/2014/4/University.owl#C type:http://www.w3.org/2002/07/owl#NamedIndividual

TABLE II. Comparisons of None, RDF, RDFS and OWL Inference for Teaching Staffs ontology

Ontology	Inference level	Output
University Ontology (Teaching Staff)	**None**	Individual: AssociateProfessor Teaches:http://www.semanticweb.org/javed/ontologies/2014/5/Unversity.owl#AssistantProfessor type : http://www.w3.org/2002/07/owl#NamedIndividual type:http://www.semanticweb.org/javed/ontologies/2014/5/Unversity.owl#Teaching_Staff
	RDF	Individual: AssociateProfessor Teaches:http://www.semanticweb.org/javed/ontologies/2014/5/Unversity.owl#AssistantProfessor Registered_name : R V type : http://www.w3.org/2002/07/owl#NamedIndividual type:http://www.semanticweb.org/javed/ontologies/2014/5/Unversity.owl#Teaching_Staff Name : R V
	RDFS	Individual: AssociateProfessor Teaches:http://www.semanticweb.org/javed/ontologies/2014/5/Unversity.owl#AssistantProfessor Registered_name : R V type : http://www.w3.org/2002/07/owl#NamedIndividual type:http://www.semanticweb.org/javed/ontologies/2014/5/Unversity.owl#Teaching_Staff type:http://www.semanticweb.org/javed/ontologies/2014/5/Unversity.owl#BTech Name : R V type:http://www.semanticweb.org/javed/ontologies/2014/5/Unversity.owl#Courses

	OWL	Individual: AssociateProfessor Teaches:http://www.semanticweb.org/javed/ontologies/2014/5/Unversity.owl#AssistantProfessor Registered_name : R V Name : R V type:http://www.semanticweb.org/javed/ontologies/2014/5/Unversity.owl#BTech type:http://www.semanticweb.org/javed/ontologies/2014/5/Unversity.owl#Teaching_Staff type:http://www.semanticweb.org/javed/ontologies/2014/5/Unversity.owl#Courses type : http://www.w3.org/2002/07/owl#Thing sameAs:http://www.semanticweb.org/javed/ontologies/2014/5/Unversity.owl#AssociateProfessor type : http://www.w3.org/2002/07/owl#NamedIndividual

Here, we find that in None Inference level gives very little relevant information as shown in Table I and Table II. In RDF the classes and subclass represents the relationship. RDF output combines inference that appears as results between the classes and properties. RDF provides more relevant information for a particular class compare to None as shown in Table I and Table II. In RDFS subclass and sub property relationship will take effect. RDFS output includes inferences that occur as a result of taxonomic relationships between the classes and properties. RDFS show more relevant information compared to None and RDF as shown in Table I and Table II. OWL Show all the relationship between the classes and subclasses. OWL is very effective due to use restrictions, advance classes and property descriptions. OWL provides sameAs property while other inference level like (None, RDF and RDFS) don't show this property. SameAs property links an individual to other individual and its show that two individual have the same 'identity'. OWL show more relevant information compared to None, RDF and RDFS as shown in Table I and Table II. Here in each case we find that OWL inference gives more relevant information about ontology.

VII. CONCLUSION

In this paper we have presented a framework for deriving better inference for developed university domain ontology. We proposed an owl-based retrieval model for university system. We have developed 5 universities domain ontologies. Here we derived the inference for two ontologies and present retrieval result for two ontologies. We show result for two ontologies are shown in Table I and Table II. Our proposed framework provides 100% precision, recall and information overkill corresponding to each user query. OWL offers new features compared to None, RDF and RDFS including better semantic joins, searching and retrieving properties.

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