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Ontology Creation towards an Intelligent Web: Some Key Issues Revisited

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Abstract —**As we are aware that there is a need of extending the current web to an intelligent web which may result in meaningful or efficient retrieval of information on web. Sir Tim Berner's Lee, the father of web, has proposed a layered architecture of such a web known as semantic web where Ontology layer is of prime significance. One of the primary goal of Semantic Web is to store data in distributed locations and to use ontologies to aggregate or use it. There is a need of global information sharing and establishment of an appropriate standard known as Ontology to define the conceptual level of a metalanguage,which is described as sharable conceptualization of a specific domain of interest in a machine-understandable format which is also the goal of semantic web. Now, Ontology has several issues among which Ontology creation is the first and the most fundamental and significant aspect. Ontology creation is abstract and has various key issues concerned. It may be created in several ways where creating an ontology using some ontology building tool/editor is one of the methodology. Protégé is one of the most widely used tool or editor for ontology creation. Sometimes, large team-engineered ontologies are not sufficient to illustrate semantic web's full potential. There is a need of a specification for expressing personal and relationship information within the Semantic Web community. Using Semantic Web applications for social networks, automated aggregation of a user's distributed social connections will give a better picture of their profile and improve the functioning of the applications. FOAF(Friend-Of-A-Friend) Ontology/vocabulary may be a good solution for it. There are millions of FOAF profiles online, hosted at a number of websites. The way it is used satisfies the goal of using an ontology to represent considerable amounts of distributed data in a standard form.**

In this paper, first, we revisit, discuss and analyse about Ontology creation and it's various key aspects. Second , we illustrate an aspect of an Ontology creation using protégé 3.4 for the "University School of Information Technology(USIT)" of Indraprastha University, Delhi, India. Third, it also illustrates the query retrieval using query tab of protégé and TGviz tab for providing the route of the ontology with a graph to reach to any classes or subclasses. Finally,FOAF(Friend-of-A-Friend) Ontology has been revisited and highlighted illustrating a FOAF profile snippet generation using an online tool, Foaf-a-Matic.

Index Terms—**FOAF, Intelligent Web, Ontology, Protégé, Query Retrieval, Semantic Web**

I. INTRODUCTION

Searching information on the web has become most crucial these days. A lot of undesired or irrelevant results or hyperlinks of information appear as soon as we click our mouse for searching some information on web. There is need of an intelligent or meaningful web which cater to our needs of relevant and efficient information search on the web. Semantic web may be a solution to this problem. The aim of Semantic web is to tackle the growing problems of surfing the expanding web space, where presently most web resources may be found by syntactical matches ie; keyword search. The semantic web is an approach towards meaningful search and relies heavily on ontologies that structure underlying data for the purpose of comprehensive and transportable machine understanding. They properly define the meaning of data and metadata[13]. Ontology creation is the fundamental step towards an intelligent web and plays a significant role in the extraction of knowledge from different web sources efficiently.

In this paper, Section 1 highlights about semantic web, ontology, ontology creation activities and key issues for an intelligent web. Section 2 revisits and analyse about the basic questions which arise before starting with building an Ontology, key design issues, iterative steps of ontology construction, states of ontology life cycle, and reasons, approaches and problems of ontology development. Section 3, illustrates the starting of a new project and choosing the sub language using protégé tool. In Section 4, Ontology creation has been illustrated using Protégé 3.4 editor of an "University School of Information Technology(USIT)" of Indraprastha University, Delhi, India. Super class and Sub class hierarchy and instances of USIT Ontology have been presented with code snippets of OWL, RDF and XML generated. Section 5 illustrates the Query retrieval process. Section 6 presents the use of TGViz tab which illustrates the route of the above ontology with the graph focusing on "Dean" subclass. Section 7 revisits and highlights about FOAF Ontology/Vacabulary with an illustration of FOAF profile snippet generation using an online tool, Foaf-a-Matic, which may assist our search engines to look for a person who may or may not have his web page but has published his FOAF profile which is machine-understandable .

A. Semantic Web and Ontology

Semantic Web is the new and next generation web that tries to represent information in such a way that it can be used by machines not just for display purposes, but for automation, integration, and reuse across applications [2]. The popularity of Semantic Web has grown with the emergence of something known as Ontologies which are the most important tool in knowledge representation, as they allow to logically relate large amounts of data [2].

An ontology describes basic concepts in a domain and defines relations among them and consists of a finite list of terms and the relationships between these terms. The terms denote important concepts (classes of objects) of the domain. An ontology is a model of a particular domain, built for a particular purpose and is the statement of a logical theory

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[4]. Researchers have created the vision of semantic web[15], where data has structure and Ontologies describe the semantic of the data. Ontologies allow users to organize information into taxonomies of concepts, each with their attributes, and describe relationships between concepts [15]. The ontology creation is the set of activities for building ontologies and may be classified into following categories [1] as shown in figure 1.1 below:

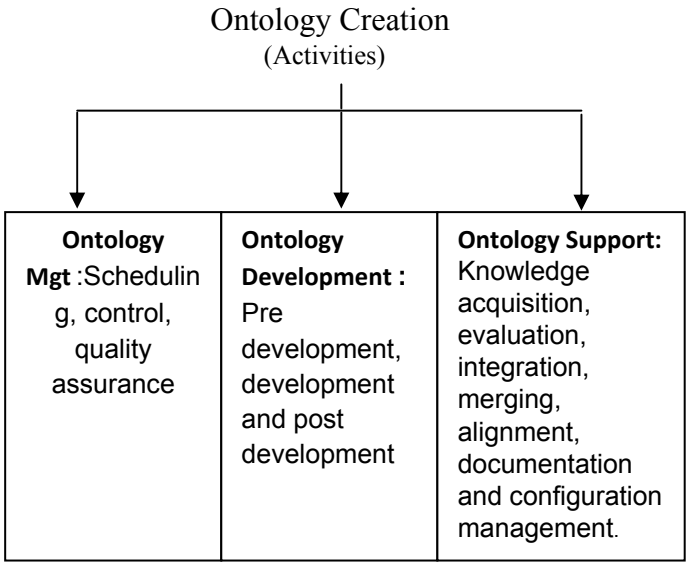

Figure 1.1 Ontology Creation Activities

There are several issues which may be responsible for an intelligent web as shown in figure 1.2 where ontology plays a significant role and ontology creation is the first and most fundamental aspect.

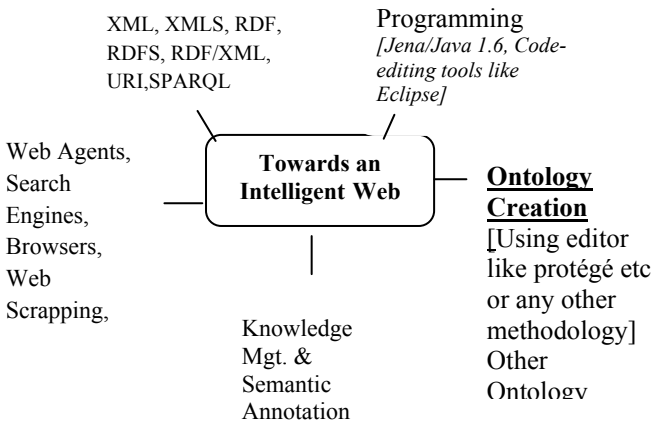

Figure 1.2. Towards an Intelligent Web

Ontology design and development, scope of this paper, includes classes or concepts , properties of each concept describing various features and attributes of the concept, and restrictions on slots[5].XML(Extensible Markup Language) and XMLS(XML Schema) are for meaningful data exchange. RDF(Resource Description Framework) and RDFS(RDF schema) are for representing the knowledge resources on the web and uses the web identifier URI (Uniform Resource Identifier) to identify the resources. SPARQL(Standard Protocol for RDF Query language) may be used for extracting meaningful information for machines. Semantic Search engines and browsers are being developed for semantic web surfing and agents(programs) carrying meaningful information from one machine to another for specific tasks. Knowledge Management is being used in various organizations to help users to create ,capture, store, share or retrieve information and Semantic Annotation for indexing or intelligent retrieval . Social networks are for common relationships and information exchange.

II. Ontology Design and Development

When an Ontology becomes large, it needs to be treated like a project. The design and development of an ontology is an iterative maturing process. This means the ontology will lead to full development, become mature, by evolving through intermediate states to reach a desired or final condition[12]. While making design and development decisions, we need to choose what and how to represent something in an ontology whose purpose is knowledge sharing and interoperation among programs based on a shared conceptualization[8]. A few basic questions which arise while starting with building an Ontology are given as given below [28]:

S.No	*Key Questions*
1	Does any such ontology exists already or before?
2	Whether I should start from scratch or reuse available ontologies?
3	Which methods/methodologies are available and to be used? Which activities to be performed in a particular methodology?
4	Whether to use some tool for support in ontology development and which tool will be appropriate to be used?Does tool have inference engine or required translator for different ontology formats?
5	How to store ontologies in files or databases?
6	Which will be the appropriate language for ontology implementation, information exchange and integration?
7	What is the probability of ontology growing too large to be used in it's entiriety and provision of a distributed approach of sub ontology extraction .
8	What are the various other related significant issues and how to start and complete?
9	What will be the design criteria for ontologies?

Ontology Design issues

Some key issues in the design of an ontology are:[8]

S.No	*Key Design issues*
1	Objective should be clear
2	It should have clear definitions which should be objective and effectively communicating the meaning. Definitions to be clearly documented in natural language.
3	The inferences should be coherent with definitions.
4	There should be provision of extending the ontology ie; adding new terms or updating existing ones.
5	Provision of accommodating different representation systems with minimal hinderances.
6	Requirement of an ontology should be minimum commitment and claims sufficient for intended knowledge sharing conceptualization.

Some key issues are revisited and highlighted as below in sections:

A. Ontology Construction: Basic Steps

Ontology permits sharing common understanding of the structure of information among people and software agents and since there is no unique model for a particular domain, ontology development is best achieved through an iterative process.

An iterative approach for building Ontologies starts with a rough first pass through the main processes as follows: [14] [5].

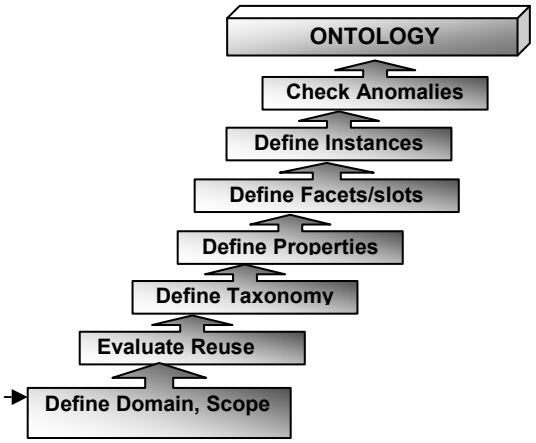

Figure 2.1: Ontology Construction Steps[14] [5]

Developing an ontology includes the various steps, some of which are as given below [14][5]:

Step	*Activity*
1	Define domain and scope of ontology; What ontology will cover? How it will be used? Who will use it?
2	Evaluate it.
	Whether it can be extended or reused?
3	Define Taxanomy to list all terms for overlapping concepts
4	Define properties for internal structure of concepts.
5	Define facets where properties add cardinality, values and characteristics.
6	Define Slots cardinality: the number of values a slot has.
7	Define instances of a class which requires choosing a class, creating an individual instance of that class and filling in the slot values
8	Check for anomalies such as incompatible domain and range definitions.

B. States of Ontology Life Cycle

Ontology life cycle moves through following states with support activities of knowledge acquisition, documentation and evaluation: [12]

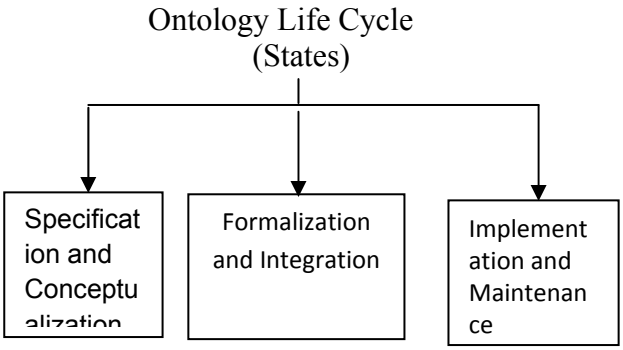

Figure 2.2: Ontology Life Cycle States

C. Ontology Development: Reasons

Few reasons of creating an ontology are as shown in figure 2.3 below [5]:

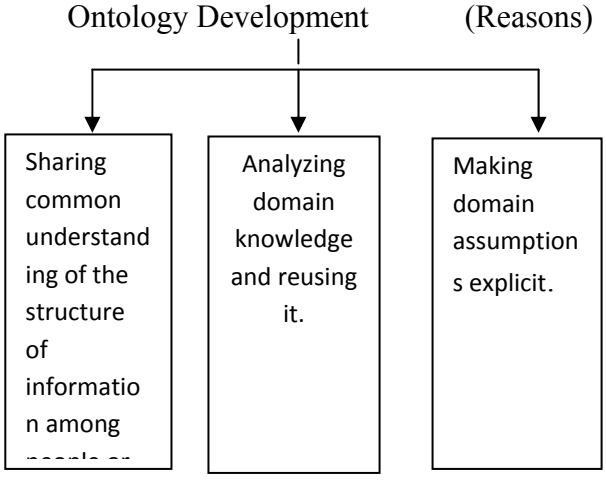

Figure 2.3. Ontology development reasons

D. *Ontology Building: Stages*

Different approaches/methodologies are used for building Ontologies like manual extraction of common sense knowledge from different sources. It includes various stages like: identifying the purpose of the ontology (why to build it, how will it be used, the range of the users), building the ontology, evaluation and documentation [10]. Building Ontologies is further divided into three stages: ontology capture, ontology coding and possible integration with existing Ontologies as highlighted in figure 2.4: [10]

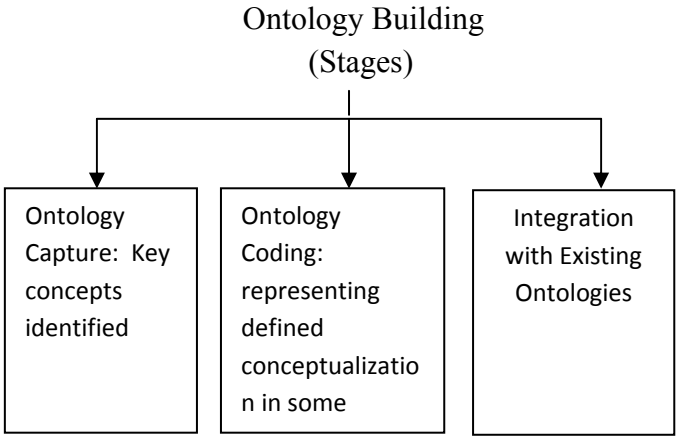

Figure 2.4. Ontology Building Stages

E. *Ontology Construction: Problems/tasks [10]*

Some problems or tasks involved in Ontology construction are: [10]

- **Extending the existing ontology**: using some text.
- **Learning Relations** between concepts for an existing ontology.
- **Ontology construction based on clustering**: Split each text document into sentences, parse the text and apply clustering.
- **Ontology construction based on semantic graphs**: Parse the text documents, perform coreference resolution, anaphora resolution, extraction of subject-predicate-object triples, and construct semantic graphs.
- **Ontology construction from a collection of news:** based on named entities.

III. STARTING WITH PROTÉGÉ FOR A NEW PROJECT

Design criteria for Ontologies may include clarity, coherence, Extendibility, minimal encoding bias and minimal ontological commitment [8]. The development of ontologies demands the use of various software tools which may be applied to several stages of the ontology life cycle including the creation, implementation, and maintenance of ontologies. These tools may be used for building a new ontology either from scratch or by reusing existing Ontologies.

Protégé is one of the most widely used ontology development tools which is a free, open-source platform that provides a growing user community with a suite of tools to construct domain models and knowledge-based applications with Ontologies [3]. It is an ontology editor which we can use to define classes and hierarchy, slots, and slot-value restrictions, relationships between classes and properties of these relationships [11].

Developing an ontology includes:[3] a) Defining classes b)Arranging the classes in a subclass, superclass hierarchy c)Defining slots and describing allowed values for these slots. d) Filling in the values for slots for instances.

Figure 3.1 depicts that how we may open the existing project or may create the new protégé project in pprj format.

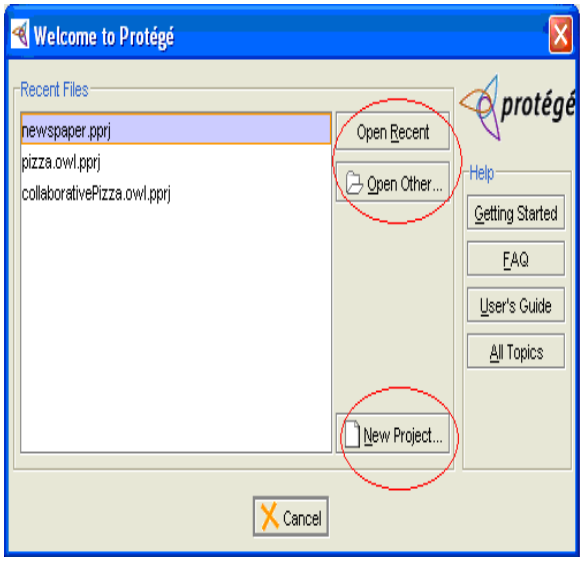

Figure 3.1. Open the existing project or create the new protégé project

The above figure illustrates about selecting the option of either opening the existing project or creating the new protégé project by clicking on ”Open Recent ” or ”New Project ” options respectively . In case, we select the option of “New Project”, then either of the options viz, OWL DL, OWL Lite, or OWL Full etc, any one is selected based on the application. Figure 3.2 refers about which OWL/RDF dialect to be used i.e.; which format of saving the new project.

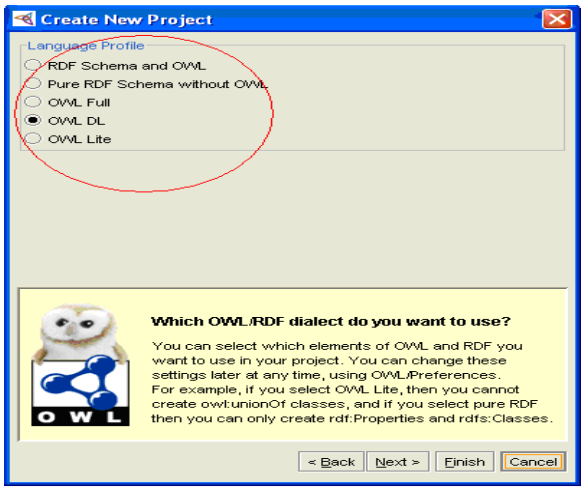

Figure 3.2: Selecting OWL/RDF dialect to be used

A. *OWL (WEB ONTOLOGY LANGUAGE) [7]*

OWL is the most recent development language which is divided into three sub-languages: OWL-Lite, OWL-DL and OWL-Full. OWL-Lite is the syntactically simplest sub-language and is intended to be used in situations where only a simple class hierarchy and simple constraints are needed. OWL-Full is the most expressive OWL sub-language and is intended to be used in situations where very high expressiveness is more important. OWL-DL is much more expressive than OWL-Lite and based on Description Logics

(hence the suffix DL) and are therefore amenable to automated reasoning. [7]

B. CHOOSING SUBLANGUAGE TO USE

A few simple rules for choosing the sub-language to be used are: [7]

- The choice between OWL-Lite and OWL-DL may be based upon whether the simple constructs of OWL-Lite are sufficient or not.
- The choice between OWL-DL and OWL-Full may be based upon whether it is important to be able to carry out automated reasoning on the ontology or whether it is important to be able to use highly expressive and powerful modeling facilities such as meta-classes (classes of classes) [7].

IV. EXAMPLE: UNIVERSITY SCHOOL OF INFORMATION TECHNOLOGY(USIT) ONTOLOGY

An example of "University School of Information Technology(USIT)" Ontology development has been illustrated using Protégé. The ontology is composed by a set of terms semantically related with its attributes, properties and relationships. The first step is to create the classes that describe the major concepts and then adding the properties (slots) and features (facets) to the classes to describe the internal structure of these concepts. Below is the snapshot showing a few classes and subclasses of the above mentioned ontology. Figure 4.1 shows the Sub Class and Super Class hierarchy of USIT ontology.The super class is ***USIT*** and the sub classes of ***USIT*** super class are ***Persons*** and ***Programs which also have further subclasses*** like Staff, Graduate etc respectively as shown in above figure 4.1.

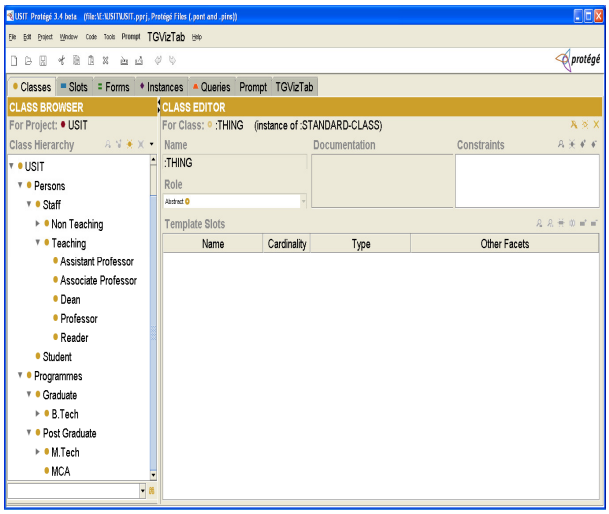

Figure 4.1: Super class and Sub class hierarchy of USIT Ontology

Now refer the snapshot of "Instances of USIT Ontology" which give details of the corresponding classes that may be useful in finding some information about the class like figure 4.2 shows the details of Prof. B.V.R. Reddy of "Dean" subclass with the slots value like: Add, Name, DOB, Qualification, DOJ, Ph.No., Sal, and ID.etc.

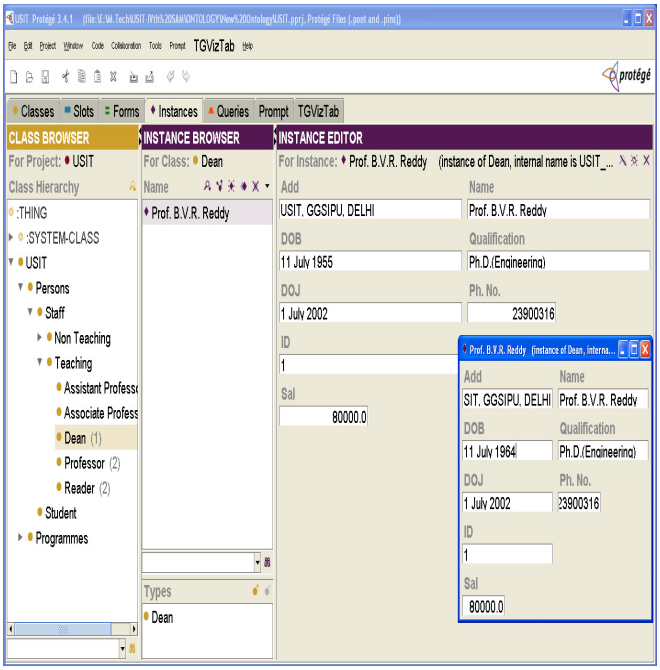

Figure 4.2: Instances of USIT Ontology

Following snippet codes of OWL , RDF and XML are generated.

OWL Code Snippet

```
<?xml version='1.0' encoding='UTF-8'?>
<!DOCTYPE rdf:RDF [
<!ENTITY rdf 'http://www.w3.org/1999/02/22-rdf-syntax-ns#'>
<!ENTITY rdf 'http://protege.stanford.edu/rdf'>
<!ENTITY rdfs 'http://www.w3.org/2000/01/rdf-schema#'>]>
<rdf:RDF xmlns:rdf="&rdf;"xmlns:rdf_="&rdf_;"
xmlns:rdfs="&rdfs;">
<rdf:Property rdf:about="&rdf_;ASIP_ADD" rdfs:
label="ASIP_ADD">
<rdfs:domain rdf:resource="&rdf_;Assistant_ Professor"/>
<rdfs:range rdf:resource="&rdfs;Literal"/>
</rdf:Property>
```

RDF Code Snippet

```
<?xml version='1.0' encoding='UTF-8'?>
<!DOCTYPE rdf:RDF [
<!ENTITY rdf 'http://www.w3.org/1999/02/22-rdf-syntax-ns#'>
<!ENTITY rdf 'http://protege.stanford.edu/rdf'>
<!ENTITY rdfs 'http://www.w3.org/2000/01/rdf-schema#'>
<rdf:RDF xmlns:rdf="&rdf;" xmlns:rdf_="&rdf_;"
xmlns:rdfs="&rdfs;">
<rdf_:Assistant_Professorrdf:about="&rdf_;USIT_ Class0"
rdf_:ASIP_ADD="USIT, GGSIPU, DELHI"
rdf_:ASIP_DOB="5 June 1972" rdf_:ASIP_DOJ="July
1999" rdf_:ASIP_ID="1" rdf_:ASIP_Name="Mr. sanjay
Kumar Malik" rdf_:ASIP_Quali="PHD"
rdf_:ASIP_Sal="40000.0" rdf_:ASIT_PH="23900345"
rdfs:label="1Mr. sanjay Kumar Malik"/>
```

XML Code Snippet

```
<?xml version="1.0" ?>
<knowledge_base
xmlns="http://protege.stanford.edu/xml"xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
```

```
xsi:schemaLocation="http://protege.stanford.edu/xml
http://protege.stanford.edu/xml/schema/protege.xsd">
<class>
<name>:THING</name>
<type>:STANDARD-CLASS</type>
<own_slot_value>
<slot_reference>:ROLE</slot_reference>
<value value_type="string">Abstract</value>
</own_slot_value>
</class>
```

V. Query Retrieval Process

Figure 5.1 below shows that how we run the query using the query tab and find the particular information about any particular instances or classes. When the query is run giving the value of ID as "1", an instance of "Dean" subclass is created with its slot values like, Name, Add, DOB, DOJ, Ph.No., etc .

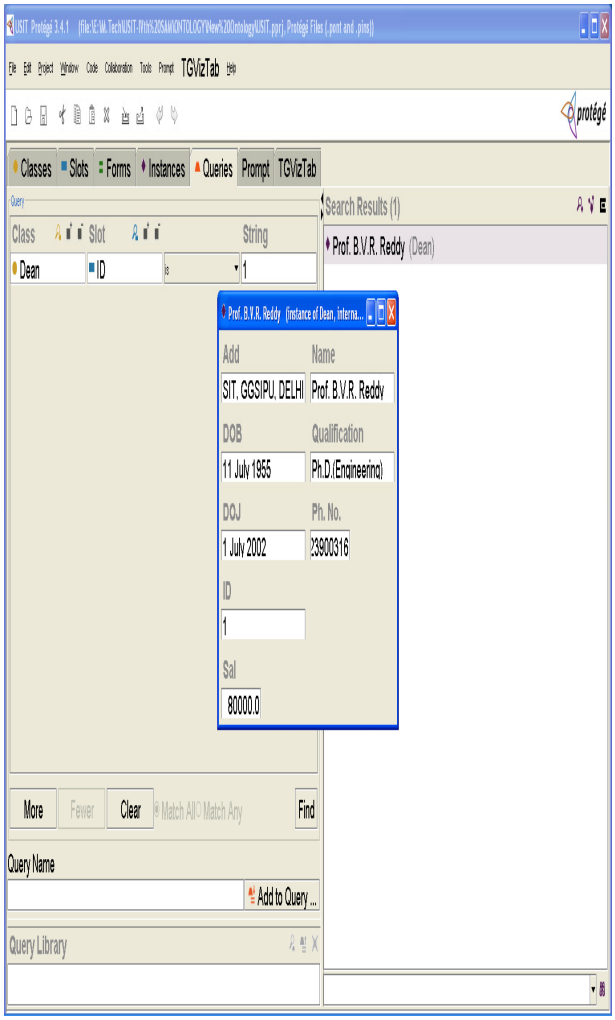

Figure 5.1: Running the query and getting the result.

VI. Using TGViz Tab For Route Graph

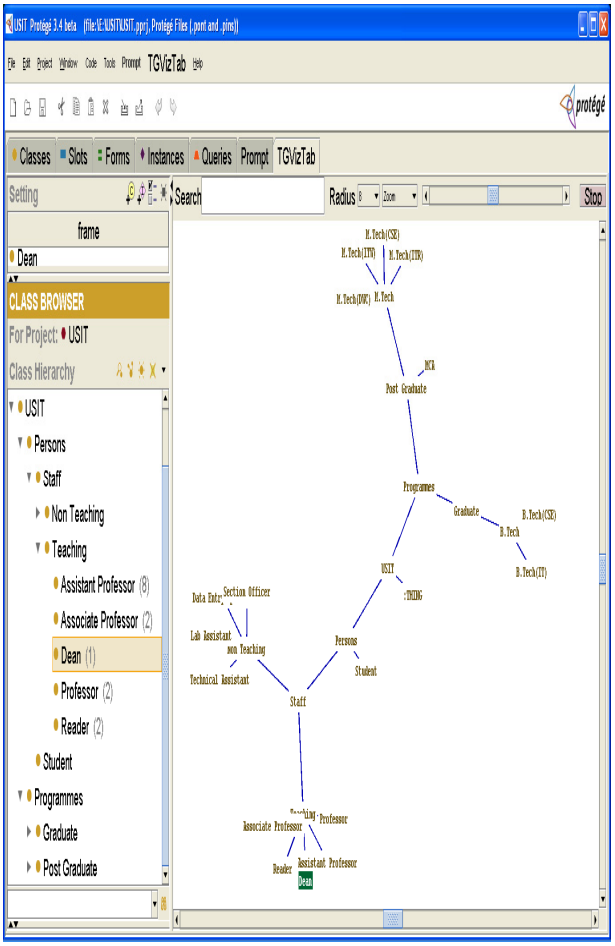

Figure 6.1: Graph corresponding to Dean sub- class using TGViz tab

Figure 6.1 above shows a graph corresponding to the class "***Dean***" using the TGViz tab which provides the route of the ontology and shows the possible options of how one can reach to any class from any other class or subclass. Using the radius option, one can vary the path distances between the nodes/classes.

VII. FOAF Ontology /Vocabulary for Generating User Profiles.

Although, the main thrust of research in intelligent web is on technologies like ontological modeling and inference engines but technologies such as FOAF, Dublin Core and RSS play a significant role in success of intelligent web[17]. The FOAF specification is produced as part of the FOAF project, to provide authoritative documentation of the contents, status and purpose of the RDF/XML vocabulary and document formats known informally as 'FOAF'[16]. The FOAF vocabulary was started to explore the applications of Semantic Web technologies like RDF/XML for describing personal details of people as: their professional or personal lives, their friends, interests, or other social commitments, with elements defined for describing an individual's social circle. It has been adopted by many blogging/weblog or social networking sites, such as Orkut, Facebook, Flickr, LiveJournal and others due to the property of FOAF to allow people to publish their content without the knowledge of HTML and automatically generate RDF/XML files having a significant impact on obtaining an intelligent web. Social networking sites

emerged but they allow users to post their profiles with basic information about them, to invite their friends and to link to their profiles in the system which allow to visualize and explore the resulting social network in order to discover friends in common, friends they think are lost or potential new friendships based on common interests. But users have soon discovered a number of drawbacks of such a system like the profiles stored in these systems are not being exported in a machine processable format, which means that the information is not portable among social networking sites. This became a problem when a number of alternatives to social networking centralised sites like Friendster appeared and the users had to recreate their profile and keep them updated separately on different sites. Secondly, these centralized sites did not allow users earlier to control the information they provide on their own terms and the information could be misused. Both of these problems may be addressed with the use of Semantic Web technology. The FOAF vocabulary/Ontology is a first attempt towards a formal, machine processable representation of user profiles and friendship networks[18]. Unlike with Friendster and similar sites, FOAF profiles are created by the individual users and stored in a distributed fashion (typically posted on the personal web page of the user). Much like web pages, these profiles also link to the profiles of friends, creating the so-called FOAF-web. In effect, the FOAF-web is a single social network described in a universal format that is directly accessible to machines[19]. FOAF is an ontology containing classes and properties designed to encapsulate existing identity knowledge available on the web at that time and is established to capture knowledge about a given person.

FOAF provides an environment which enable us to tell the web about the connections between the things concerned to us. Using FOAF, one can help machines understand his home page, and learn about the relationships that connect people, places and things described on the Web. FOAF uses RDF(Resource Description Framework) technology to integrate information from one's home page and with that of his friends and so on. It's objective is to create a web of machine-readable pages which describe people and the links between them. A person begins by describing himself or herself using the *foaf:Person* class, listing key identity attributes such as name, gender, and resources related to them. They can also mention their interests, and each person is uniquely identified by using the *foaf:mbox* property containing their email address. The person in question then moves on to describing their friends, each friend is an instance of the *foaf:Person* class. FOAF is both machine-readable, and human-readable, and was adopted by LiveJournal, the blogging site, to offer the facility for each user to export their personal information and expressing personal and relationship information within the Web community. There are millions of FOAF profiles online, hosted at a number of websites. The way it is used satisfies the goal of using an ontology to represent considerable amounts of distributed data in a standard form.

The FOAF-based profile merging may be performed which is helpful to social network users and it is common for people to have accounts on several networks which may give a better picture of their profile and improve the functioning of the applications. In a merged social network, friends who have multiple accounts would be represented as a single person. Information about the user distributed across several sites would also be merged.

FOAF : Key factors

- a potential solution to sharing social networking data among sites[20].
- aims to create a web of machine-readable web-pages describing people, the links between individuals and the things they create and do.
- publishes "Web homepages for people, groups, companies and other kinds of things", and it is "written in XML syntax, and adopts the conventions of the Resource Description Framework (RDF)" [21][24].
- The FOAF ontology is described using the Ontology Web Language (OWL) [22]. To join the FOAF world, all one has to do is generate a FOAF profile describing oneself and publish it on the Web[23].
- Creates systems supporting online communities and enriches the expression of personal information and relationships.
- FOAF profiles are created by the individual user and stored in a distributed fashion usually as personal web page of the user. Much like web pages,these profiles also link to the profiles of friends, creating the so-called FOAF-web[25].

FOAF vocabulary is managed in an open source manner, i.e., it is not stable and is open for extension [26]. Therefore, inconsistent FOAF vocabulary usage is expected across different FOAF documents. Currently, a large amount of FOAF documents are contributed by the fast-growing 'blog' websites[27]. FOAF-a-matic is an application that allows one to create a FOAF ("Friend-of-A-Friend") description of himself.

A. FOAF Profile Snippet of Dr. Nupur Prakash generated using FOAF-a-matic

```
<rdf:RDF
 xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xmlns:foaf="http://xmlns.com/foaf/0.1/"
  xmlns:admin="http://webns.net/mvcb/">
<foaf:PersonalProfileDocument rdf:about="">
  <foaf:maker rdf:resource="#me"/>
  <foaf:primaryTopic rdf:resource="#me"/>
  <admin:generatorAgent
rdf:resource="http://www.ldodds.com/foaf/foaf-a-matic"/>
<admin:errorReportsTo
rdf:resource="mailto:leigh@ldodds.com"/>
</foaf:PersonalProfileDocument>
<foaf:Person rdf:ID="me">
<foaf:name>Nupur Prakash</foaf:name>
<foaf:title>Dr.</foaf:title>
<foaf:givenname>Nupur</foaf:givenname>
<foaf:family_name>Prakash</foaf:family_name>
<foaf:nick>Nupur</foaf:nick>
<foaf:mbox_sha1sum>8c4514240870d98566632492c7b7128
342d408d6</foaf:mbox_sha1sum>
<foaf:homepage rdf:resource="www.ipu.ac.in"/>
<foaf:workplaceHomepage
rdf:resource="www.ipu.ac.in/igit"/>
```

<foaf:workInfoHomepage
rdf:resource="http://ipu.ac.in/igit/fac_profile.html"/>
<foaf:knows>
</foaf:Person>
</rdf:RDF>

The above may assist our search engines to look for a person who may or may not have his web page but has published his Foaf profile which is machine-understandable .

VIII. Conclusions and Future Work

The paper revisits, discusses and highlights about some key issues in ontology creation and illustrates the usage of protégé for starting a new project with an example. Super class and Sub class hierarchy and instances of Ontology have been presented with code snippets of OWL, RDF and XML generated. Query retrieval process and use of TGViz tab has been illustrated with graphical route of ontology with some classes and subclasses. FOAF Ontology/Vacabulary has been revisited and highlighted with an illustration of a FOAF profile snippet generation . It may be a useful resource work for researchers who would like to initiate with ontology creation and it's key issues. The researcher also gets an idea of FOAF and FOAF profile snippet generation by using tools like foaf-a-matic. The work may be extended to other critical research issues of ontology.

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