

Ontology based Knowledge Management for Administrative Processes in Paperless Environment¹

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Abstract. The knowledge management is a challenging task especially in administrative processes with typical workflows of higher educational institutions such as university in paperless environment. The proposed system aSPOCMS (An Agent-based Semantic Web for Paperless Office Content Management System) can provide paperless environment, which requires ontology based knowledge management to manage the files and documents of various departments and sections of a higher educational institution. In Semantic Web, Ontology describes the concepts, relationships among the concepts and properties within their domain. It provides automatic inferring and interoperability between applications which is an appropriate vision for knowledge management. In this paper we discussed how Semantic Web technology can be utilized in higher educational institution for knowledge representation of various resources and handling the task of administrative processes. Therefore, we need to exploit the knowledge of various resources such as department, school, section, file and employee etc. of the university. The aSPOCMS is built on an agent-based system, thus ontology is used for communication between agent and user and for knowledge representation and management.

Keywords: Ontology, Knowledge Management, aSPOCMS, Workflow

1. Introduction

Knowledge Management is a big challenge for managing the knowledge and their representation especially in large organizations. Knowledge resides in mainly two extremes: (1) as explicit knowledge of documents and processes and (2) as inferred knowledge of people and procedures. When the organization needs to advance its knowledge manage-

ment then it is important to focus on strategically important knowledge of the organization. It is also important to simplify that how the organization appreciates and defines the knowledge.

Ontology based knowledge management of departments, sections, workflow of files and documents etc. in a precise and machine interpretable form for our system aSPOCMS (An Agent-based Semantic Web for Paperless office Content Management Sys-

¹ Footnote in title. Please ensure there is a 24 pt blank line before the title!

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tem) [1] is needed to process, share and reuse the knowledge of domain. In the universe, the knowledge of human is not based only on facts which may be true or false. It is also based on certain and uncertain knowledge which is partially true or false. There are several methods which can be used to represent such knowledge for machine, e.g. probability measures, fuzzy logic or computing with word [2]. There are only strongly true facts and workflows in knowledgebase of Universities. These facts and workflows are structured and defined by ontology. Ontology based knowledge is more simple and straight forward for agents to understand knowledge and also produce new knowledge from existing knowledge. The ontology based knowledge management of workflows and their resources improves administrative processes of the University in three ways [3]:

Improves the quality of work: Generally, the huge amount of files or documents has been processed to successfully accomplish the administrative work of the University. This kind of work requires well-defined knowledge of workflow. Agent can transmit the files and documents over well-defined workflow. The system based on ontology can encapsulate such knowledge to improve the quality of administrative work.

Saves the processing cost: System will provide the metadata of the resources (files or documents) and actions to be taken by previous user. This information can help to current user to take action at the resources. The electronic form of claim file will be transmitted through out the workflow of process. Therefore, this will be eliminated the printed papers and piles of files. The files or documents will be represented as URIs in the Semantic Web scenario. This will make the sharable of files or documents which will reduce the space to save the electronic files.

Time savings: The files or documents can be rapidly and without any difficulty reused and processed according to ontological description within the system aSPOCMS. However, there is no need to manually find related file or document within system. Moreover, the system aSPOCMS will inform the users about the progress of current workflow activity and about the pending processes of the system [4, 5].

Therefore, to built the effective technologies for knowledge management, we need to know that how the individuals or groups and organizations use the knowledge of the domain. In this sense, maximum knowledge of the domain should be represented in computer-readable forms which make the efficient use of knowledge to users as well as system. The

computer-readable form of the knowledge can help to derive the inference of knowledge from existing knowledge.

2. Related Work

Kuo-Cheng Ku et al. [6] described a model of ontology-based knowledge management for joint venture projects. They defined a framework for an ontology based model to analyze the knowledge management processing of joint ventures in the Integrated Circuit industry. They have used a methodology to implement the ontology based knowledge management for joint venture projects with seven steps. These steps are involved in ontology-based knowledge management process model when implementing joint venture projects, which include knowledge acquisition, knowledge identification, ontology analysis, ontology implementation, ontology verification, knowledge reposition and knowledge sharing/development.

Laclavík M. et al. [7] presented the use of ontology for knowledge representation and handling for administrative processes. Using the CommonKADS methodology they have created the model of ontology based knowledge management for a public organization. It is further extended with the domain/application specific elements. They have taken the domain specific extension for the installation of Traffic Light in their representation and management of ontology based knowledge.

Budinska I., et al. [8] described a system architecture based on e-mail communication and a web portal which is suggested for ontology based knowledge management of workflow processes in administrative organizations. The ontology for the system has designed from a detail analysis of workflow process associated with military training preparation and organization.

P. Sureephong, et al. [9] proposed an ontology based knowledge management system to support knowledge management activities within the industry cluster. They have described the methodology to capture, create and represent ontology for organization development by using the knowledge engineering approach. Furthermore, the handicraft cluster in Thailand is used as a case study to illustrate the proposed methodology.

In order to manage the knowledge, ontology plays the significant role with enabling the content processing and sharing between experts and users. The ontological languages based on Web technology

standards such as XML, RDF, RDFS and OWL are used to implement the ontology. However, ontology is introduced in knowledge management for administrative processes in paperless environment. Thus, we have planned to use a methodology for ontology design to represent and manage the knowledge of university for administrative process in paperless environment.

3. Ontology and Knowledge Management for aSPOCMS

According to the Gruber [10] ontology is the “explicit specifications of a shared conceptualization”. The conceptualization is a conceptual model of facts in the world by identifying the relevant concepts of the phenomenon. The use of type of concepts and constraints are explicitly defined. Sharing of concepts means that ontology captures conceptual knowledge which is not private for individual, but accepted by the group. The role of ontology provides the facility to the construction of knowledge management processes of domain model. It provides a vocabulary of terms and relations in a specific domain. The ontology can be used to define the relationship among knowledge entities and return the knowledge to users [11] for utilization. In building of a knowledge management of aSPOCMS, we need two types of knowledge [12] such as:

3.1. Domain Knowledge

Domain Knowledge is the knowledge about a specific field of interest or subject. In ontology-based knowledge management for aSPOCMS, we need to represent domain knowledge about the objects of the university e.g. school, department, employee, workflow etc. Domain knowledge can be categorized in various level of ontology such as: top-level ontology, task ontology, domain ontology and application ontology. The ontology of domain knowledge can be used in several applications such that used as information systems for the domain. For example, ontology related to student can be used for student information system of university.

3.2. Problem-solving Knowledge of Domain

In the requirement of knowledge management of aSPOCMS, we must have the knowledge about how to use the domain knowledge to achieve the services of aSPOCMS in paperless environment. Problem

solving knowledge has the ability to utilize previously learned knowledge to solving a new problem [13]. To develop the ontology of problem solving knowledge, it must be identify major classes and instances of problem solving knowledge of Indian Universities that need to be communicated.

4. Methodology

We have divided the ontology of universities into four levels: top-level ontology, domain ontology, application ontology and task ontology [14]. The explicit knowledge of university will be represented in various level of ontology. In our approach, we will implement the ontology-based knowledge management for Universities. We will design an integrated ontology of the knowledge of various resources of universities. Ontology-based knowledge management involves various steps to represent the knowledge. The steps of ontology-based knowledge management are shown in figure 1.

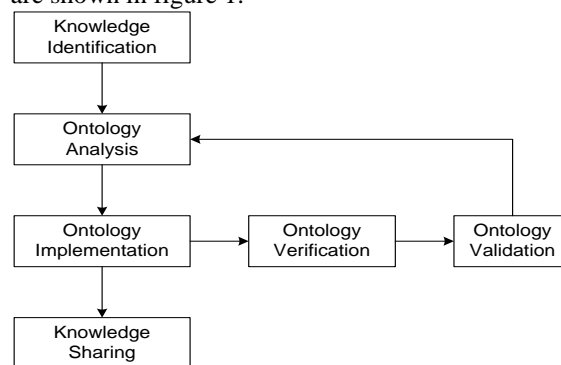


Figure 1: Ontology-based Knowledge Management for aSPOCMS

4.1. Knowledge Identification

Domain experts provide the explicit knowledge of the University domain which can involve the overall knowledge of various resources and workflow processes. This knowledge is utilized by aSPOCMS services. The domain experts also identify that what knowledge needs to be shared and what knowledge does not need to be shared. Poor knowledge given by domain experts can lead to incorrect design of ontology and incomplete result of the system aSPOCMS which is based on ontology. Therefore, it must be identify the explicit and correct knowledge of domain.

4.2. Ontology Analysis

Collected data and information of the universities are analyzed in this step. On the basis of analysis, the

ontology of knowledge can be divided into various levels: top-level ontology, domain ontology, task ontology and application ontology. The ontology of University domain is designed to achieve the expectation [15] of the Semantic Web technology in organization and the system aSPOCMS. The ontology analysis can also verify that how the ontology is useful to our system aSPOCMS. In this step, we will analyze the concept, individuals and conceptual roles of the University.

4.3. Ontology Implementation

The ontology implementation executes the process of ontology design and ensures that various levels of ontology of universities are designed in this step after the analysis of ontology. We will use the ontology development tools for ontology-based knowledge management [16]. Ontology is the hierarchical description of significant concepts in domain and the descriptions of the properties of each concept.

4.4. Ontology Verification

The verification of ontology includes the verification of various concepts such as:

- Definition and axiom of each individuals.
- Collections of definitions and axioms that are stated explicitly in the definitions of the ontology.
- Axioms that can be inferred using definitions [17].

The ontology verification also checks that the ontology satisfies particular constraints or not.

4.5. Ontology Validation

The consistency of ontology with respect to its applications checks in ontology validation. Validation of university ontology can be done by the defined concepts, axioms and assertions etc. in ontology and identified knowledge of university.

4.6. Knowledge Sharing

The resources of the university consists the definitions, metadata and axioms for aSPOCMS. The resources represented by URIs and metadata of the resources can be represented by using namespaces, which makes the resources and their metadata shared among the universe.

5. Ontology based approach for knowledge management

The knowledge of higher educational institutions can classify as terms and concepts. The representation of terms and concepts has done with the help of ontology within computer science. Ontologies are useful because they encourage standardization of terms used to represent knowledge of a domain. However, ontology plays the crucial role in our system aSPOCMS, which can be used to derive the new knowledge from existing knowledge of discourse. Ontologies [18] are designed for being used in applications that need to process the content of information and reasoning about it, instead of just presenting information to humans. Ontologies permit machine for better interpretability of content than that supported by RDF [19, 20], RDFS [21, 22] formatted with XML [23]. The Ontology Web Language (OWL) [24, 25] for ontology design is providing additional vocabulary along with a formal semantics.

The paperless office content management system of university domain is defining and using ontologies of knowledge representation and their management. The ontology in the system is focused the management of facts and workflow of university domain. The basic structure of knowledge of university can be represented by following figure 2:

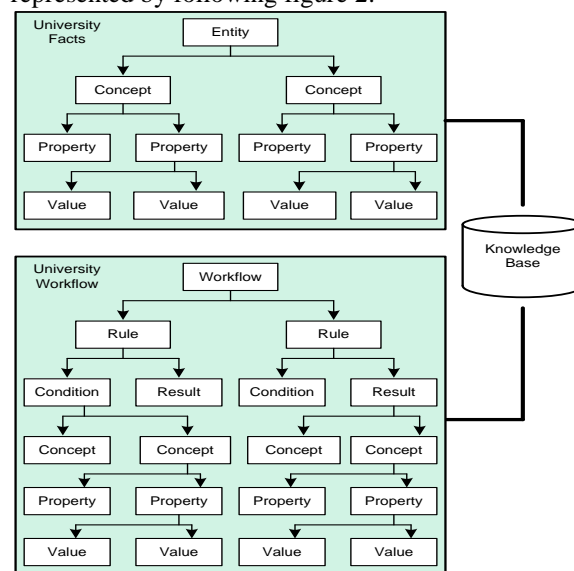


Figure 2: General structure of knowledge of the University

The knowledge of university has two major parts: (1) facts of the university, (2) workflow of the university. Facts of the university are various entities or objects, which participate in various workflow of the university. Entity of the university has concepts,

which will be represented by URI. The concepts have property with URIs or literal values. Workflow of the university has numbers of rules to execute the administrative activities of the university. Rules of the workflow may have some condition or produces the result. Further, the conditions or results can have some concept with property and their literal values.

6. Knowledge Management Repository of University for aSPOCMS

The knowledge base of the system aSPOCMS is related to user's profile (Agent, Employees, Student and Visitor etc.), organizational structure and workflow of higher educational university, which encapsulates the users and their activities. For University domain, the representation of relevant knowledge can be based on primitive concepts from various level of ontology. Ontologies are designed for one or several domain, which may be organized into libraries. However, these libraries are enhancing the reusability.

When ontology of a specific domain is large then the tools for their management must be used. The tools can help with ontology verification and validation. The verification of ontology checks whether ontology satisfies particular constraints or not. For example, cardinality constraints for entity-relationship can be checked by the verification tools and the consistency of model with respect to its application. We have identified the knowledge of institute and university as following:

6.1. Identification of Knowledge of University

The ontology of the university must have explicit knowledge of various resources of University. The ontology for aSPOCMS involves the information of organizational structure, profile of employee, student profile and various workflows of processes of universities as knowledge. The integrated framework of this knowledge will be used for aSPOCMS services. Illustration of some information of typical organizational structure and workflow of university is given as below:

Information of organizational structure:

- University has various workflows.
- University has people of university.
- People of university are employee and student of university.
- University has schools.
- School of university is equivalent or same as faculty of university.

- School has various centre or department.
- University has various courses.
- University has administrative sections.

Information of workflow:

- File from a department related to finance is forwarded to head of department.
- Head of department forwarded the file to Assistant Registrar (Finance).
- Then, the file is forwarded to Finance Officer.

6.2. Ontology Analysis of information

After the knowledge identification, we have analyzed the ontology classes (owl:Class) and object properties of ontology (owl:ObjectProperty) of identified knowledge. The classes have individuals, which is represented by URIs. Object properties are used to represent the relationship between classes. We have conceptualized the information of university by using OWL concepts such as owl:Class, owl:unionOf and owl:ObjectProperty etc. These concepts are used to construct ontology of identified knowledge.

OWL Classes:

OWL Classes	Definition of Classes
University	Class of University of Country of India.
UniversityWorkflow	Contains the various workflow of university.
UniversityPeople	Have the people of university.
UniversityEmployee	Class of employees of university.
UniversityStudent	Has all student of university which enrolled in various courses in university.
UniversitySchool	Contains the schools of university.
UniversityFaculty	Has the faculty of university.
SchoolCentre	Contains the centre of schools.
UniversityCourses	Have the various courses of university.
AdministrativeBlock	Has all administrative section of administrative block.

Table 1: Classes of University Ontology and their definition

Object Properties:

Object Properties	Definition of Object Properties
unionOf	Super class has subclasses by using owl:unionOf property.
equivalentClass	Relationship among similar classes are represented by owl:equivalentClass.
has	Individual of a class has individual of other class.
sameClass	One class is same as other class.

Table 2: Some Object Properties and their definition

Individuals of OWL Classes:

Individuals	OWL Classes	Definition of Individuals
InternationalStudies	UniversitySchool	School of International Studies
LLCStudies	UniversitySchool	School of Language, Literature and Culture Studies

SocialSciences	UniversitySchool	School of Social Sciences
Arts	UniversityFaculty	Faculty of Arts
CommerceBusinessStudies	UniversityFaculty	Faculty of Commerce & Business Studies
Education	UniversityFaculty	Faculty of Education
EuropeanStudies	SchoolCentre	Centre for European Studies
EastAsianStudies	SchoolCentre	Centre for East Asian Studies
Linguistics	SchoolCentre	Centre for Linguistics
PoliticalStudies	SchoolCentre	Centre for Political Studies
EnvironmentalScience	UniversityDepartment	Department of Environmental Science
HumanRights	UniversityDepartment	Department of Human Rights
HMLanguage	UniversityDepartment	Department of Hindi and Modern Language

Table 3: List of Individuals their respective OWL Classes and Definition

Here, table 1 shows the OWL classes of the information. Table 2 shows the object-property to represent the relationship between OWL classes. Finally, the individuals of the OWL classes are represented in table 3. These concepts are used to implement the ontology of identifies knowledge of university.

6.3. Implementation of Ontology of Knowledge of Indian Universities

University Ontology consists of hierarchical description of concepts such as super class, sub class and descriptions of the properties of each class. According to analyzed concepts of knowledge in table 1, 2 and 3 in previous subsection, we have constructed the ontology of identified knowledge by using ontology editor tool. There are many ontology editor tools. Some of them are Portege, Neon, Altova Semantic

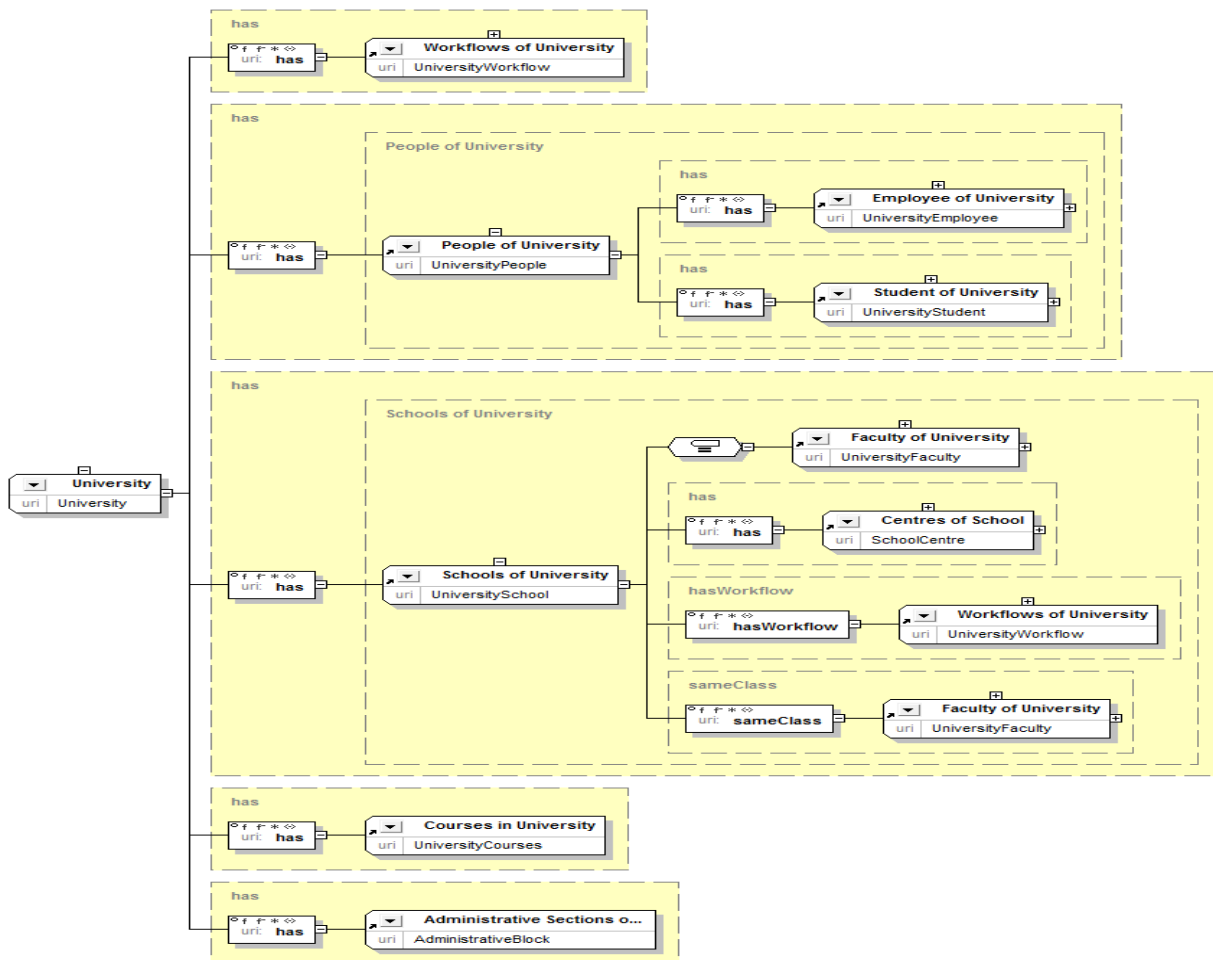


Figure 3: Graphical representation of University Ontology by using SemanticWorks, Jism etc. We have used

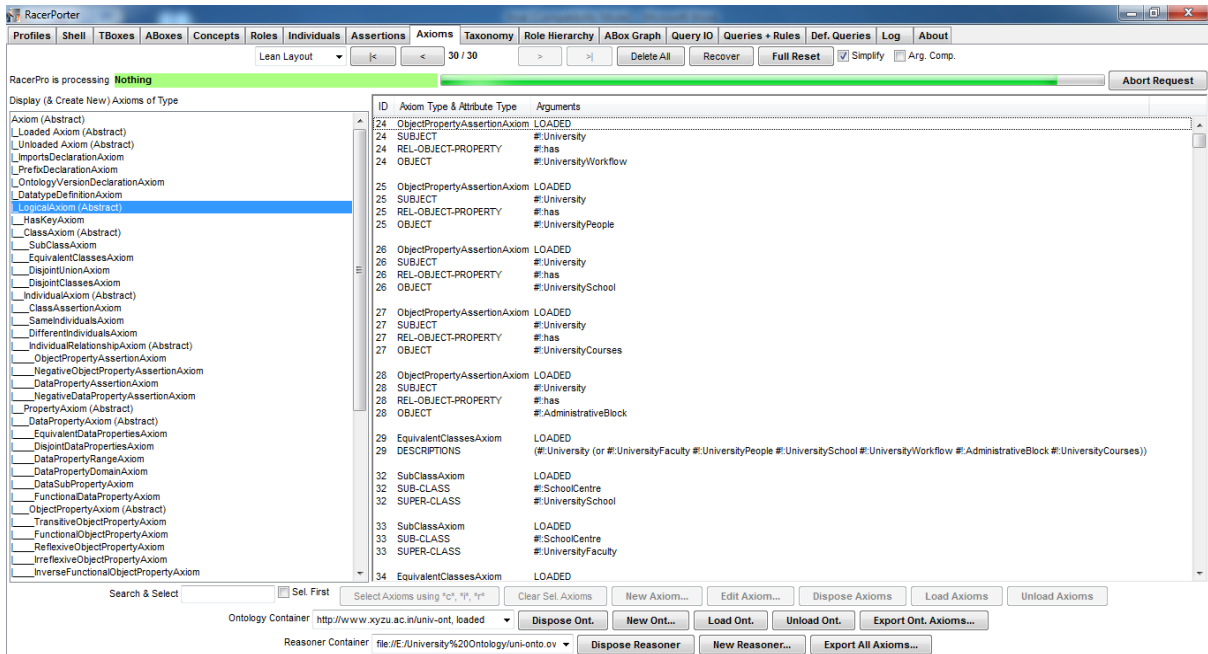


Figure 4: Axioms in University Ontology by using RacerPro 2.0.

the SemanticWorks 2009 [26] to implement the ontological concepts of the information. The graphical view of ontology based information and analyzed concepts of identified knowledge of university are represented in figure 3.

6.4. Verification of University Ontology

As discussed in previous subsection, we can now verify the university ontology at local host. We used RacerPro Version 2.0 [27] inference engine to verify the various concept, assertions and axioms etc. of university ontology. The RacerPro 2.0 is verifying the concepts, roles, individuals, assertions, axioms, taxonomy and role hierarchy etc. which is defined in ontology on the basis of knowledge. University ontology verification shows that definition and axioms of each individuals of University are accurate. Figure 4 represents the axioms in university ontology using inference engine RacerPro Version 2.0. The axioms show that the concepts of identified information of university and are well defined in ontology.

6.5. Validation of University Ontology

The validation of university ontology has been done manually on the basis of ontology verification and knowledge identification. We verified the ontology of University by using the inference engine

RacerPro Version 2.0 in previous subsection. In this subsection, we validated the concepts, individuals and role of the concepts, assertions, axioms, taxonomy and hierarchy of the role defined in University Ontology. The assertions of ontology validate the information, which is represented in university ontology. Some of the assertions of university ontology are shown as below:

```
(#:TeachingEmployee #:UniversityStudent) #:teaches)
(:(#:UniversityDepartment #:UniversityStudent) #:has)
(:(#:UniversityDepartment #:UniversityWorkflow) #:hasWorkflow)
(:(#:UniversityEmployee #:Non-TeachingEmployee) #:has)
(:(#:UniversityEmployee #:TeachingEmployee) #:has)
(:(#:UniversityEmployee #:UniversityWorkflow) #:isPlayedWith)
(:(#:UniversityFaculty #:UniversityDepartment) #:has)
(:(#:UniversityFaculty #:UniversityWorkflow) #:hasWorkflow)
(:(#:UniversityPeople #:UniversityEmployee) #:has)
(:(#:UniversityPeople #:UniversityStudent) #:has)
(:(#:UniversitySchool #:SchoolCentre) #:has)
(:(#:UniversitySchool #:UniversityFaculty) #:sameClass)
(:(#:UniversitySchool #:UniversityWorkflow) #:hasWorkflow)
(:(#:UniversityStudent #:PartTimeStudent) #:has)
(:(#:UniversityStudent #:RegularStudent) #:has)
(:(#:University #:AdministrativeBlock) #:has)
(:(#:University #:UniversityCourses) #:has)
(:(#:University #:UniversityPeople) #:has)
(:(#:University #:UniversitySchool) #:has)
(:(#:University #:UniversityWorkflow) #:has)
```

Figure 5: Snapshot of Assertions of Ontology identified by RacerPro 2.0.

In figure 5, statement ((#:TeachingEmployee #:University Student) #:teaches) is representing that property 'teaches' is established relationship between TeachingEmployee and UniversityStudent. Wherein, TeachingEmployee and UniversityStudent are the OWL classes. Simi-

larly, some information from the statements of figure 5 is shown below, which identified in subsection 6.1:

- Teaching employee teaches the University student.
- Department has the University student.
- Department has University workflow.
- University employee has non-teaching employee.
- University employee is played with University workflow.

Some information is conceptualized as axioms (subject, relational object-property and object) in ontology representation and ontology based knowledge management. Some axioms are identified by inference engine RacerPro 2.0 as in figure 6, which conceptualized in ontology representation of information. These axioms are represented in ontology on the basis of table 1, 2 and 3, which is discussed in ontology analysis sub section.

ID	Axiom Type & Attribute Type	Arguments
24	ObjectPropertyAssertionAxiom	LOADED
24	SUBJECT	#:University
24	REL-OBJECT-PROPERTY	#:has
24	OBJECT	#:UniversityWorkflow
25	ObjectPropertyAssertionAxiom	LOADED
25	SUBJECT	#:University
25	REL-OBJECT-PROPERTY	#:has
25	OBJECT	#:UniversityPeople
26	ObjectPropertyAssertionAxiom	LOADED
26	SUBJECT	#:University
26	REL-OBJECT-PROPERTY	#:has
26	OBJECT	#:UniversitySchool
27	ObjectPropertyAssertionAxiom	LOADED
27	SUBJECT	#:University
27	REL-OBJECT-PROPERTY	#:has
27	OBJECT	#:UniversityCourses
28	ObjectPropertyAssertionAxiom	LOADED
28	SUBJECT	#:University
28	REL-OBJECT-PROPERTY	#:has
28	OBJECT	#:AdministrativeBlock
32	SubClassAxiom	LOADED
32	SUB-CLASS	#:SchoolCentre
32	SUPER-CLASS	#:UniversitySchool
33	SubClassAxiom	LOADED
33	SUB-CLASS	#:SchoolCentre
33	SUPER-CLASS	#:UniversityFaculty
34	EquivalentClassesAxiom	LOADED
34	DESCRIPTIONS	(#:SchoolCentre #:UniversityDepartment)
37	SubClassAxiom	LOADED
37	SUB-CLASS	#:UniversityDepartment
37	SUPER-CLASS	#:UniversityFaculty
38	SubClassAxiom	LOADED
38	SUB-CLASS	#:UniversityDepartment
38	SUPER-CLASS	#:UniversitySchool
39	EquivalentClassesAxiom	LOADED
39	DESCRIPTIONS	(#:UniversityDepartment #:SchoolCentre)
40	ObjectPropertyAssertionAxiom	LOADED
40	SUBJECT	#:UniversityDepartment
40	REL-OBJECT-PROPERTY	#:has
40	OBJECT	#:UniversityStudent
41	ObjectPropertyAssertionAxiom	LOADED
41	SUBJECT	#:UniversityDepartment
41	REL-OBJECT-PROPERTY	#:hasWorkflow
41	OBJECT	#:UniversityWorkflow
44	EquivalentClassesAxiom	LOADED
44	DESCRIPTIONS	(#:UniversitySchool #:UniversityFaculty)

Figure 6: Axiom Type & Attribute Type and their Arguments of defined information in ontology.

In figure 6, illustration of axiom id: 24 has the subject, object-property and object as 'University',

'has' and 'UniversityWorkflow' respectively. Therefore, the information of axiom id: 24 are 'University has University Workflow'. Similarly, the information of some other axioms id of figure 6 is as following:

Axioms id	Information from axioms id
25	University has people of university.
26	University has schools of university.
27	University has university courses.
28	University has administrative block.
32	Centre of school is the subclass of university school

Table 3: Information from axioms of university ontology

6.6. Sharing of Knowledge of University

The sharing and reuse of knowledge of ontology does not appear only at the data level, but also at the application level in Semantic Web. Nowadays, there are many existing ontology from a wide range of sources that can be reused when building Semantic Web Applications. Ontologies provide the shared and reused knowledge and ontology across the applications. After the verification and validation, the concepts and individuals etc. of the university defined in ontology is ensured to correct. As a final point, university ontology is ready to use for the system aSPOCMS and other applications.

The resources of the information of university are represented as URIs. The URI makes the global sharing of knowledge among the universe. The content defined by URIs is easily understandable and processible by computer. Any user can access the content of ontology by using their URIs. In figure 7, URI <http://www.xyzu.ac.in/univ-onto#InternationalStudies> is represented a school "School of International Studies", which is access by any user with their URI. Therefore, this ontology is used as library of university ontology, which can be shared by using their URI.

7. Conclusion

The development of ontology for knowledge management depicts the conceptualization to be modeled and the vocabulary with its axioms to give the meaning of application domain of higher educational institutions such as university. We have represented an approach for ontology based knowledge management of University for our system aSPOCMS. This approach is used to develop the ontology of University,

which is integrated as top-level ontology, domain ontology, task ontology and application ontology. We have also verified the concepts, individuals, their roles, assertions, axioms and taxonomy and role hierarchy of the ontology by using inference engine RacerPro Version 2.0. The verification of ontology have done on account of defined concepts in ontology and identified knowledge. Most of the higher educational institution deal with well defined administration process (workflow), so the architecture uses the workflow as a basic work context of the users.

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