Ontologies for Personalized E-Learning in the Semantic Web

Shabina Dhuria, Sonal Chawla

Abstract*—Semantic web, next generation intelligent web, is one of the emerging research areas in intelligent web technology and has high potential for research. It can be considered as a content-aware intelligent web. SW technologies will influence the next generation of e-learning systems and applications. To structure the learning material, ontology is a key constituent in the structural design of the Semantic Web. Ontology is a formal specification of a particular domain that describes set of objects, properties that objects can have and various ways how these objects are related to each other.This paper has threefold objective. Firstly, it would help to understand Semantic Web currently exists as a vision, is a promising technology for realizing eLearning requirements. Ontology is primary and most important part of semantic web, improves the learning process as it focuses on relationship rather than information. Secondly, it throws light on classification of ontologies in computer science and how ontoligies in higher education can enhance the search of the learning material. Thirdly, it focuses on analysis of various ontology tools helpful in knowledge retrieval, knowledge storage, and knowledge sharing.

Index Terms: E-Learning, Ontology, Ontology Tools, Semantic Web.

I. INTRODUCTION

Semantic web (SW), content-aware intelligent web, is one of the promising technology helps in intelligent decision making. SW technologies will influence the next generation of e-learning systems and applications. E-Learning is computer–assisted teaching and learning provides a learner-oriented environment for teachers and students. Many e-Learning applications are lacking in knowledge representation technology. Semantic Web properties common-shared-meaning and machine-processable metadata; satisfy the e-Learning requirements: fast, just-in-time and relevant learning. SW supports web content with associated formal semantics (i.e. meaning) results in more intelligent e-learning and provides intelligent answers to complex queries [1].To structure the learning material, ontology is a key constituent in the architecture of the semantic web. Ontology provides a link between the learning material and its conceptualization results in individualized learning paths.

A. Semantic Web

"*The Semantic Web is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation.*"[1] Semantic Web (SW) ahead of the capabilities of the current Web enables efficient and intelligent decision-making. It is an aggregation of intelligent websites and data stores accessible by an array of semantic technologies [2].

Manuscript received March, 2014.

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SW builds on traditional data modeling techniques, is much more expressive, comprehensive, and powerful form of data modeling. It is, a network of meaningful data, intended for information that can be processed by computers (i.e. make content understandable by computers) [3]. It provides a common framework that allows data to be shared and reused across application, enterprise, and community boundaries [4] .SW purpose is to find and access web sites and web resources both by keywords and definitions of their contents. Web of knowledge is availability of resources over the web having structured machine-understandable descriptions of their contents and relationships, formally defined by ontology [5] .Ontology is an important constituent of the promising Semantic Web technology as shown in Fig.1. It can be used as a tool for interchanging and querying metadata [6].

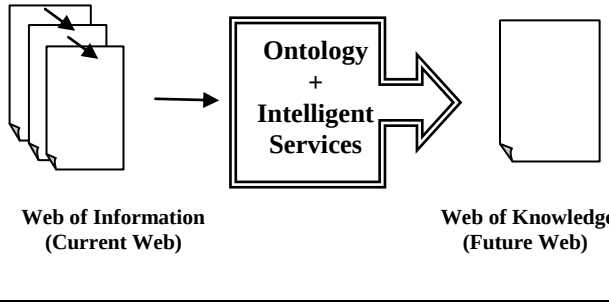

Fig.I : Realization of Current Web to Future Web [8]

Ontology provides a link between the learning material and its conceptualization results in individualized learning paths. It allows develop a dynamic learning environment with improved access to specific learning Ontologies [7].

B. Integrating E-Learning and Semantic web

E-Learning is computer–assisted teaching and learning provides a learner-oriented environment for teachers and students. E-learning makes a significant difference from traditional learning: how learners learn, how quickly they master a skill, how easy it is to study; and, equally important, how much they enjoy learning. Thus, it has different kinds of impact on the experience of learning. Many e-Learning applications are lacking in knowledge representation technology. Semantic Web properties common-shared-meaning and machine-processable metadata; satisfy the e-Learning requirements: fast, just-in-time and relevant learning. Semantic Web, new generation of the web, appears as a promising technology for implementing e-Learning [9].SW supports web content with associated formal semantics (i.e. meaning) results in more intelligent E-learning and provides intelligent answers to complex queries [1]. SW builds on the current World Wide Web constructs and topology; define machine-processable data with richer semantic associations [2].Ontology is primary and most important part of semantic web because it focuses on

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relationship rather than information. Semantics in educational knowledge domain is very emerging. Benefits of using Semantic web as a technology for e-learning:

- Replacing query-based search with query answering.
- Organising knowledge in conceptual spaces according to its meaning.
- Enabling automated tools to check for inconsistencies and extracting new knowledge.

C. Ontology

Ontology is explicit specification of conceptualization [10]. It is a formal object based on a formal language .This formal language defines a vocabulary of shared common concepts, a set of relationships among this concepts and a set of constraints on this concepts [6]. In Computer Science, ontology defines knowledge of a particular domain as a set of concepts [11].It is a data model that represents a domain and is used to inference about the objects in that particular domain and the relations between those objects.

"Ontologies are formal, explicit specifications of how to represent the objects, concepts, and other entities in a particular system, as well as the relationships between them." [9]

Below mentioned Table1 describes ontology.

Table I : Ontology Definition

Properties	Description
Formal	Abstract model of portion of world
Explicit Specification	Machine-readable and understandable
Shared	Based on a consensus
Conceptualization	Concepts, properties …

II. ONTOLOGY APPLICATIONS

Ontology comprises a set of definitions of concepts, properties, relations and constraints that describe a specific domain. It defines a common vocabulary and shared understanding results in intelligent applications. [12]. It acts as medium for mutual understanding that helps in information access. Ontological framework organizes information that is used in artificial intelligence, semantic web, biomedical informatics, and system engineering and information architecture as a form of knowledge representation [13]. On the basis of a survey, most of the ontologies are created in the field of Education (31%), Computer software (28.50%), Government (17%), Business (17%), Life sciences (15.5%) and Communications (13%) as shown in Fig. 2 [14]:

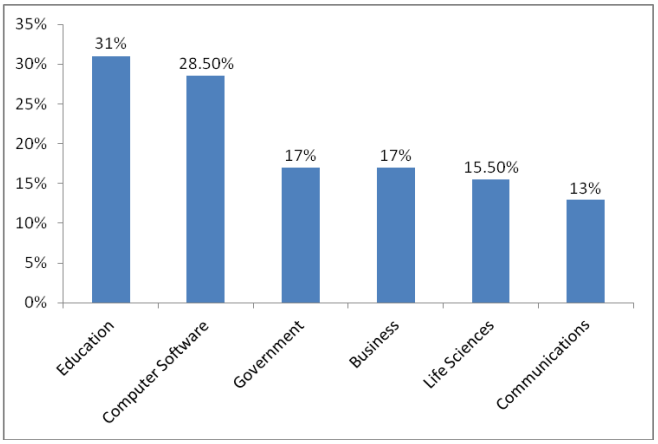

Fig. II : Ontologies in different domains

A. Ontologies in Computer Science

Ontologies in computer science classified according to the level of detail they provide, below mentioned in Table2. These ontologies used in cooperative information systems, intelligent information integration, information retrieval and extraction, knowledge representation, and database management systems. Ontologies main intent is to assist reasoning [15], [16].

Table II :Classification of Ontologies in Computer Science

Types	Parameters	Example
Top level Ontologies or Upper Ontology	define concepts that support development of an ontology.	Cyc[17], wordNET, Euro wordNET
Domain related Ontologies	define concepts related to a particular domain or area of interest, viz. education, medicine and information technology	O4E (ontology for education) [18], GO (gene ontology)
Application related Ontologies	describe concepts depending on a particular domain/ ontologies designed for specific tasks	EFO(Experimental Factor Ontology), NIF (Neuro Informatics Framework)

B. Ontologies in Education

Ontologies in educational system give information about relationships between various classes [14]. Ontologies offers a wide range of potential benefits and applications in higher education, viz. information sharing across educational systems, provide frameworks for learning object reuse, and enable intelligent and personalized student support [19]. Education related ontology is formed on the basis of different requirements of each corresponding university [14]. Below mentioned projects describe usage of ontologies to support e-learning.

a) *Language Technology for e-learning (LT4eL)*

LT4eL project is supported by Information Society technologies.LT4eL ontology, is a hierarchical storage area of concepts, extracts knowledge from learning materials.LT4eL aim is to enhance the management, distribution and retrieval of the learning material. This ontology supports extensibility feature by adding new concepts from WordNet and Wikipedia sources. To comprehend the hierarchy of concepts domain ontology is connected with an upper ontology (i.e. DOLCE Ultralite) with the help of OntoWordNet. Ontology main purpose is concept browsing and semantic search, results in invaluable source for cross-lingual searches [20].Web Ontology Language (OWL) is a language proposed for Web applications and documents to explain the classes and relations among them.

Table III : Overview of LT4eL

Ontology / Parameters	Domain Ontology	OntoWordNet	DOLCE Ultralite
Concepts	1002	169	105
Language	OWL (XML based representation)		
Graphical View	Protégé System		
Purpose	Concept Browsing (i.e. provides relation-based map view of concepts)		
	Semantic Search (i.e. documents annotated with concepts)		

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i. *Framework of LT4eL*

LT4eL, European project, has formed new or personalized previously existing language resources to support ontology-based semantic search within domain specific documents as shown in Fig.3. LT4eL offers various open source tools easily available from the project website and are integrated into the ILIAS learning management system. These tools ensure that the offered definitions fit in the context of the course material. The project has devised a 'keyword extractor' for keyword extraction and suggests a keywords list that can be accepted, rejected or modified. The archetype focuses on learning material in e-learning that works with documents in 9 different languages (i.e. Bulgarian, Czech, Dutch, English, German, Maltese, Polish, Portuguese and Romanian). The 'semantic search' tool organizes keywords and definitions in a hierarchical manner along with their meaning and ontology defines the relation among them. Basic services provided by LT4eL are keyword generation, definition detection and enhanced semantic and multilingual search capabilities results in better search functionalities in learning management systems .LT4eL improves retrieval of learning material by creation of personalized content and facilitates construction of user specific courses that supports decentralization of content management [20].

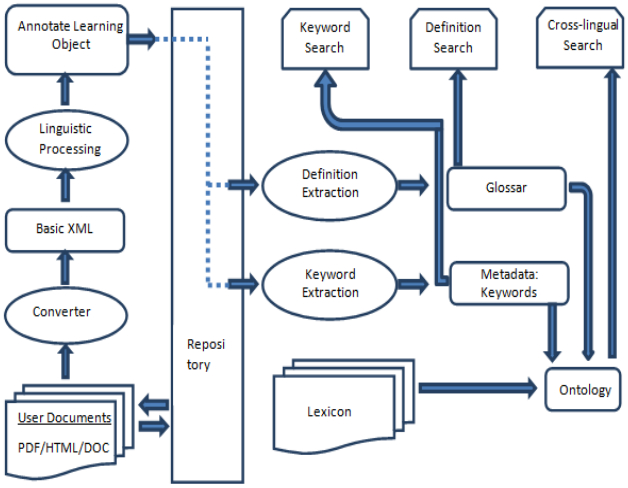

Fig. III :Architecture of LT4eL

ii. *Browsing the ontology*

LT4el ontology, repository of concepts, extracts knowledge from learning materials.LT4eL purpose is to enhance the management, distribution and retrieval of the learning material. Browsing an ontology helps to find concepts. The following Fig. 4 depicts select topics to go to the ontology.

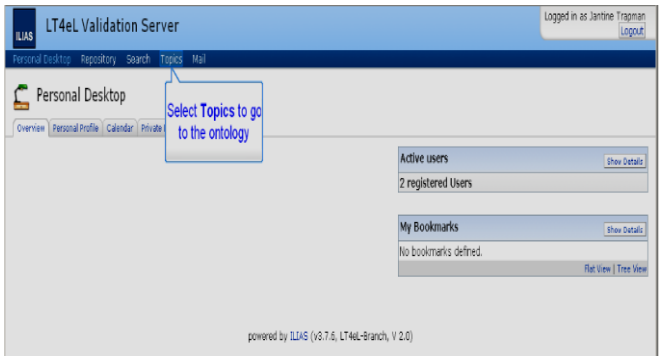

Fig. IV : Browsing the Ontology

As we select topics, it offers three different tabs each having different purpose as shown in Fig.5. Hierarchy tab used to select language for ontology concept. There are 9 languages (Bulgarian, Czech, Dutch, English, German, Maltese, Polish, Portuguese and Romanian) in which ontology concept can be displayed.

Fig. V Ontology concept in different languages

Alphabetically tab used to get a list of all concepts of the ontology ordered alphabetically. Search results tab having ontology concepts based on different search criteria.

iii. *Searching using the ontology*

Ontology, is hierarchal storage area of concepts, can be displayed in 9 different languages. Click the search topic button as shown in Fig.6, to find the related concept in the ontology.

Fig. VI :Ontology based search

Besides searching with concepts from the ontology, it is also possible to perform a semantic search with search terms, retrieval languages and search method as input as mentioned in Fig.7.

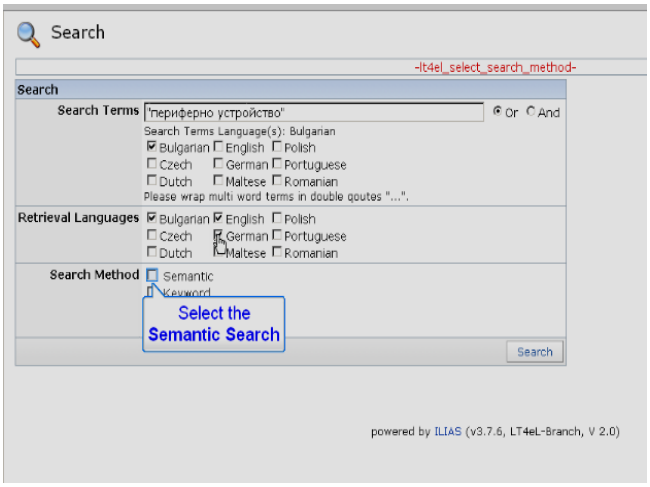

Fig. VII :Ontology and Semantic Search

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b) *Ontology for Education (O4E)*

O4E collects and formalizes the available information related to the use of ontologies in the field of education. Creation of an ontology helps in representation of collected information. O4E project works on two types of knowledge subject: domain and structure results in following ontologies [21]:

- Domain ontology: defines the basic concepts of the specific domain.
- Structure ontology: defines the logical structure of the content.

Ontological technologies for education based on two different perspectives technological and application. Technological perspective defines role of ontology and in what manner technology is implemented in a project. It describes knowledge representation technology, information retrieval technology and semantic web technology. Application perspective defines type of knowledge and ontology as a cognitive tool in education domain. It describes knowledge construction, knowledge communication and knowledge assessment for learning purposes. The following Fig.8 depicts the state-of-the-art ontology of ontological technologies for education.

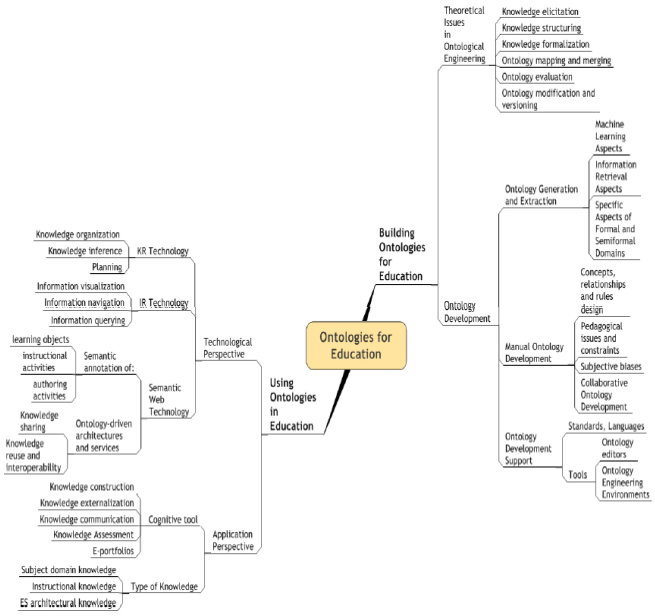

Fig.VIII :State-of-the-Art Ontology of Ontological Technologies for Education [21]

O4E Web Portal is a collaborative project between Winston-Salem State University, University of Pittsburgh and Saint-Petersburg State Polytechnic University. The main objective of the project is to bring together and disseminate web resources in the field of application of ontologies and relevant technologies for the modern educational perspectives. It provides a web place to publish the created ontology and access to the relevant online information. The initial step is to develop a website with a graphical representation of the developed taxonomy and an index page to link all resource web pages .Fig.9 shows a screenshot of the website [21].

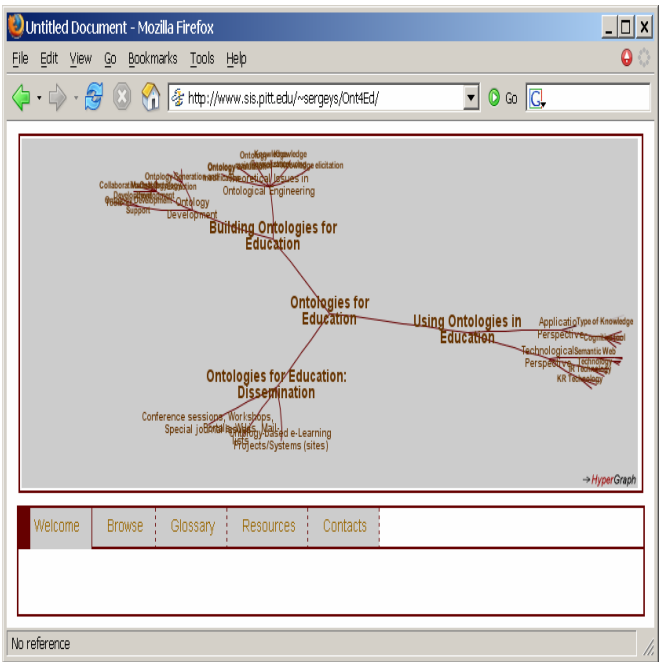

Fig.IX :Graphical representation of the developed ontology

III. ONTOLOGY TOOLS

Ontology is, "the specification of shared knowledge", helpful in knowledge management (i.e. knowledge retrieval, storage, and sharing) [22]. Above mentioned projects conclude with how different ontology tools used in higher education at different level to realize the learning benefits. Protégé system is used for graphical view in LT4eL project. Various ontology tools exist to apprehend the learning benefits. Below mentioned Table 4 comprehend various ontology tools along with their developers, availability and each tool respective purpose [23].

Table IV : Overview of Ontology Tools

S.No	Tools	Developers	Availability	Purpose
1	**Protégé 2000**	SMI, Stanford University	http://protege.stanford.edu	Create and Edit domain ontology
2	**OilEd**	Information Management Group, University of Manchester, United Kingdom	http://img.cs.man.ac.uk/oil/	Create and Edit OIL ontology
3	**Apollo**	Knowledge Media Institute (KMI), Open University, United Kingdom	http://apollo.open.ac.uk/	Knowledge Modeling based application

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4	**RDFedt**	Jan Winkler of Germany	http://www.jan-winkler.de/dev/e_rdfe.htm	Structured RDF Documents
5	**OntoLingua**	Knowledge Systems lab of Stanford University	http://www.ksl.stanford.edu/software/ontolingua/	Includes library of reusable ontologies
6	**OntoEdit**	Karlsruhe University, Ontoprise of Germany	http://www.ontoknowledge.org/tools/ontoedit.shtml	Flexible Plug-in Framework
7	**WebODE**	Technical school of Computer Science, Spain	http://webode.dia.fi.upm.es/WebODEWeb/index.html	Ontological Engineering
8	**KAON (KArlsruhe ONtology)**	FZI Research center & AIFB Institute, Germany	http://kaon.semanticweb.org/	Manage Business Applications
9	**WebOnto**	KMI,Open University, England	http://kmi.open.ac.uk/projects/webonto/	Ontology Management: Graphical Interface
10	**ICOM**	Free University, Italy	https://www.inf.unibz.it/~franconi/icom/	Intelligent Conceptual Modeling Tool
11	**Medius Visual Ontology Modeler (VOM)**	Sandpiper Software	http://www.sanssoft.com/products.html	UML-based Ontology Modeling Tool
12	**DOE (Differential Ontology Editor)**	National Audio-Visual Institute, France	http://homepages.cwi.nl/~troncy/DOE/	Add Lexicon definition to Concepts
13	**LinKFactory**	Language & Computing Inc.	http://www.landcglobal.com/pages/linkfactory.php	Language- Independent Ontology
14	**K-Infinity**	Intelligent Views ,German Company	http://www.i-views.de/en/	Object Oriented Knowledge Modeling

A comparative study of ontology tools is in Table 5 on basis of several important aspects extensibility, ontology storage, inference engine, exception handling, consistency check, ontology library, and graphical user interface.

Table V :A Comparison of Ontology Development tools

S.no	Tools	Software Architecture		Inference Services			Usability	
		Extensibility	Ontology Storage	Inference Engine	Exception Handling	Consistency Check	Ontology Library	GUI
1	**Protege 2000**	Via Plug-ins	File & DBMS (JDBC)	With PAL	No	Via plug-ins like PAL and FaCT	Yes	Via plugins like GraphViz and Jambalaya
2	**OilEd**	No	File	With FaCT	No	Via FaCT	Yes	No
3	**Apollo**	Via Plug-ins	Files	No	Yes	Yes	Yes	No
4	**RDFedt**	No	Files	No	No	Only checks writing mistake	No	No
5	**OntoLingua**	No	Files	No	No	Yes	Yes	No
6	**OntoEdit**	Via Plug-ins	File	No	No	Yes	No	Yes
7	**WebODE**	Via Plug-ins	DBMS (JDBC)	Prolog	No	Yes	No	Form based graphical user interface
8	**KAON**	No	?	Yes	No	Yes	Yes	No
9	**WebOnto**	No	File	Yes	No	Yes	Yes	Yes
10	**ICOM**	Yes	DBMS	Yes	No	Via Fact	?	Yes
11	**Medius VOM**	Yes	?	Yes	?	With a set of ontology authoring wizards	Yes	UML diagrams via Rose
12	**DOE**	No	File	Yes	No	Via type inheritance and	Yes	No

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						detection of cycles in hierarchies		
13	**LinKFactory**	Yes	DBMS	Yes	No	Yes	Yes	No
14	**K-Infinity**	No	DBMS	Yes	?	Yes	Yes	With Graph Editor

As discussed above, Ontology tools find analysis on the basis of various important aspects i.e. Software Architecture, Inference Services and Usability. Protégé 2000, OilEd, and OntoEdit used to test the interoperability of ontology tools [22]. Based on a survey, frequently used tool among other tools is Protégé (68.20%) [14]. Interoperability and ontology storage are still weak points of these tools. To integrate ontology in applications, interoperability with other ontology development tools and databases, is an important factor. Following drawn pie chart, Fig.10 depicts the ontology in different domains using different ontology tools.

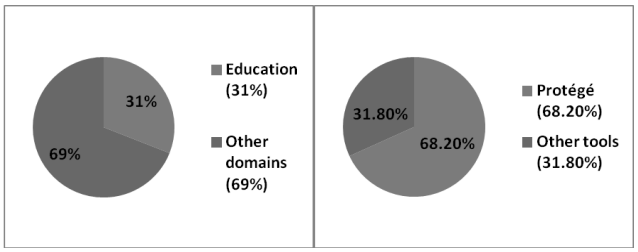

Fig.X :Ontology tools and Ontology in different domains

IV. CONCLUSION

Ontology is the specification of shared knowledge whose most percolation in education domain (31%).It offers a wide range of potential benefits and applications in higher education, viz. information sharing across educational systems, provide frameworks for learning object reuse, and enable intelligent and personalized student support. As part of case studies discussed above in the research paper it has been observed that LT4eL is multilingual project uses semantic web technology to improve the retrieval of learning material. It also facilitates personalized access to the learning content and defines domain ontology for semantic search. O4E project works on two types of knowledge subject i.e. domain and structure. It offers a web portal to define the e-learning relevant research publications. From the above analysis it can be concluded that there exists number of ontology tools and a tool named Protégé system is being used (68.20%). This conclusion finds basis in the above drawn pie chart.

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