



State of Art in Ontology Development Tools

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ABSTRACT

Ontology plays an important role in semantic web, information extraction, artificial intelligence, natural language processing, knowledge management etc. Ontology building is a challenging task in today's world of semantic web. Manually construction of ontology is very time consuming and complex process. Wide variety of methods and tools are available for building ontology. These tools help users to construct the ontology and it is necessary to choose the appropriate tool for this purpose. This paper explores and analyzes various tools available for construction of ontology and also provides contrast among these tools.

Keywords: Ontology, Ontology Construction, Ontology Development Tools, Ontology Editors.

1. INTRODUCTION

Ontology is defined as formal, explicit specification of the shared conceptualization (Gruber, 1993). This small definition contains deep meaning as given below.

- **Explicit** refers to concepts, relation between various concepts and their constraints are explicitly defined.
- **Formal specification** term includes the machine readability of computational semantics.
- **Shared conceptualization** means the commonly accepted understanding for conceptual model of domain under construction.

Ontologies aim to capture the knowledge in a generic and formal way so that it may be reused and shared across applications and by groups of people [10]. There are number of tools developed for ontology building. These tools aim towards supporting ontology development process and its subsequent usage. Various reasons for developing ontology are as follows:

Need for Ontology Development

There are various reasons for developing ontology [1]. Some of these are:

- To share common understanding of the structure of information among people or software agents.
- To enable reuse of domain knowledge
- To make domain assumptions explicit
- To separate domain knowledge from the operational knowledge

- To analyze domain knowledge

Ontology Building Process

Ontology building process mainly comprises of three main steps [2] i.e. capturing the ontology, coding the ontology and to integrate with existing ontologies

This work mainly focuses on exploring ontology development tools available and to analyze them. Next section provides details of various such tools.

2. TOOLS FOR ONTOLOGY CONSTRUCTION

There are mainly two categories of ontology building tools [4].

- (i) **Ontology Development Tools:** It means ontology editors that allow users to define new concepts, relations, and instances. These tools usually have capabilities for importing and extending existing ontologies. Development tools generally include graphical browsers, search capabilities, and constraint checking. Protégé 2000, OntoEdit, OilEd, WebODE, and Ontolingua are some examples of development tools.
- (ii) **Tools for Mapping, Aligning and Merging Ontologies:** These are the ontology mapping tools that help users find similarities and differences between source ontologies. Mapping tools either identify potential correspondences automatically or provide the environment for the users to find and define these correspondences, or both. Mapping tools are often extensions of development tools. PROMPT, ONION, Chimaera [3, 6, 13] etc.

Next section explores some tools used for developing ontologies.

2.1 Ontolingua Server

Ontolingua server¹[7, 9] was the first ontology tool created and developed in early nineties at Knowledge Systems Laboratory (KSL) at Stanford University. It was built to ease the development of Ontolingua ontologies with form based applications. The creation of a new ontology becomes easier by flexibility of including parts of existing ontologies from a repository. This repository consists of a large number of ontologies from different fields. After completion of newly generated ontology, it can be added to repository for possible reuse. The following figure provides overview of this tool:

¹ <http://ontolingua.stanford.edu/>

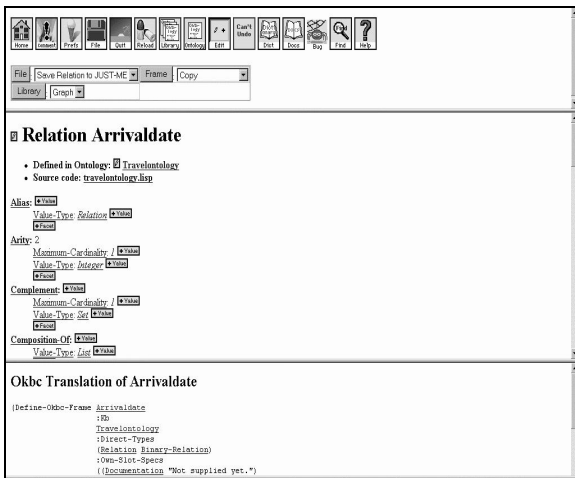


Figure 1: Ontolingua Snapshot [18]

The main module inside in this server is ontology editor, however it includes many other modules such as Webster, equation solver, Open Knowledge Based Connectivity (OKBC) server and Chimaera (an ontology merging tool) etc. The ontology editor also includes the translators to languages like Prolog, CORBA's, and Loom etc. Remote editors can browse and edit ontologies and remote or local applications can access any one of the ontologies in ontology library with OKBC protocol.

2.2 Ontosaurus

This tool is developed by Information Sciences Institute (ISI) at the University of South California. It consists of two modules: an ontology server which uses Loom as its knowledge representation system and a web browser for Loom ontologies. It includes the translators from Loom to Ontolingua, Knowledge Interchange Format (KIF) and C++. Ontosaurus² [7] ontologies can also be accessed with OKBC protocol. The screenshot of Ontosaurus is shown as:

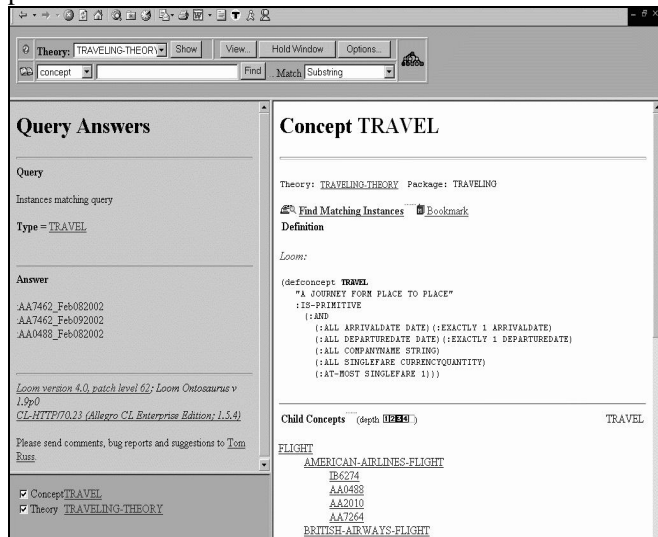


Figure 2: Ontosaurus Tool [18]

2.3 WebOnto

WebOnto³ is web based tool. It has been developed by Knowledge Media Institute (KMI) of Open University. This tool is designed to support the collaborative creation, editing, browsing of ontologies and to complement the ontology discussion tool 'Tadzebao' [14]. WebOnto is ontology editor for Operational Conceptual Modeling Language (OCML). WebOnto is mainly graphical tool for constructing ontologies which make easy to use and work cooperatively on ontologies. It also facilitates for scaling to larger ontologies.

2.4 Protégé

This tool has been developed by Stanford Medical Informatics (SMI). It is an open source, standalone application with an extensible architecture [12]. The main module of this environment is ontology editor and it holds library of plugins that add more functionalities to the environment. Protégé 4.2 is the latest version in protégé line of tools released in 2013. This version has several new plugins, including an ontology difference tool, enhanced explanation support, and support for code generation. In [11], an online survey was conducted, which shows Protégé is most dominant and domain independent tool used by 75% respondents from different domains. Protégé 4.2 is shown as:

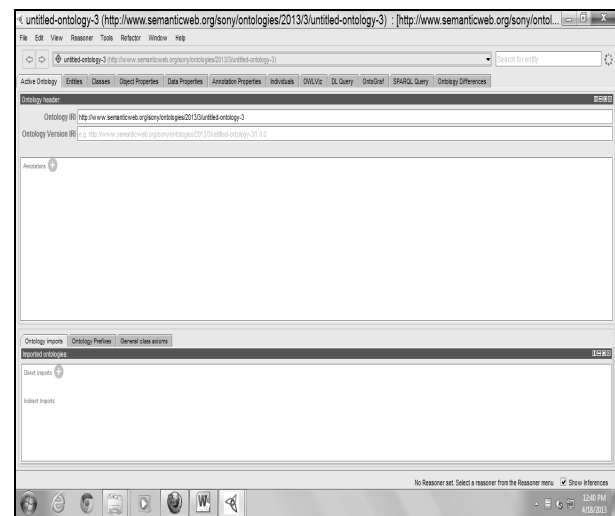


Figure 3: Protégé version 4.2

WebProtégé 2.0 beta: It is new released by SMI Stanford University in January 2013. It is an open source web-based light weight ontology editor and knowledge acquisition tool. This editor is used for browsing ontologies on the web. WebProtégé [8] provides a friendly and highly configurable user interface that can be adapted by domain experts. It has support for form-based editing and full-fledged collaboration in ontology construction process. The WebProtégé user interface is built as a portal, inspired by similar infrastructures, such as, iGoogle⁷ and myYahoo. This portal is composed of tabs that are either predefined or defined by the users. Its predefined tabs contain the most popular

² <http://www.isi.edu/isd/ontosaurus.html>

³ <http://kmi.open.ac.uk/projects/webonto>

functionality in the Protégé desktop editor. WebProtege 2.0 has a content management system. Users can log in and upload their ontologies on server, edit them, invite collaborators to contribute, and may set permissions for collaborators. The screenshot is shown as:

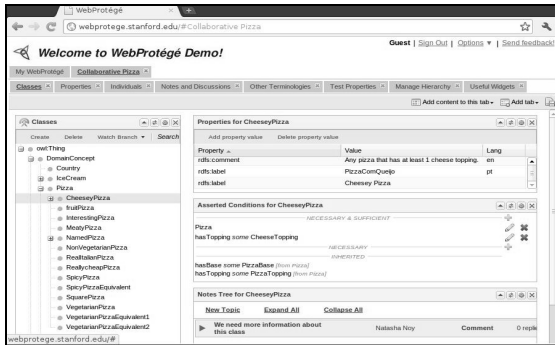


Figure 4: WebProtégé version 2.0 beta⁴

2.5 WebODE

WebODE⁵ is the successor of Ontology Design Environment (ODE). It has been developed in Artificial Intelligence Lab from Technical University of Madrid. It is not used as standalone application but as web server with web interface. The core of this environment is ontology access service being used by all the services and applications plugged into the server. There are several services for ontology language importation/exportation, ontology documentation, ontology evaluation and ontology merge. WebODE [7, 15] ontologies are stored in relational database.

2.6 OntoEdit

It has been developed by AIFB in Karlsruhe University. It is extensible and flexible environment based on plugins architecture which provides functionalities to browse and edit ontologies [7]. This tool is available in two versions i.e. Free and Professional. It includes plugins for exporting and importing ontologies in different formats. The tool is based on a flexible plugin framework. Firstly it allows extending functionality in modularized way. The plugin interface is open to third parties which enable users to extend OntoEdit easily with additionally required functionalities. Secondly, having a set of plugins available such as a domain lexicon, an inference plugin and several export and import plugins, allows for user friendly customization of the tool for different usage scenario. It also provides the collaborative development of ontologies for semantic web [5]. The screenshot of OntoEdit is shown as:

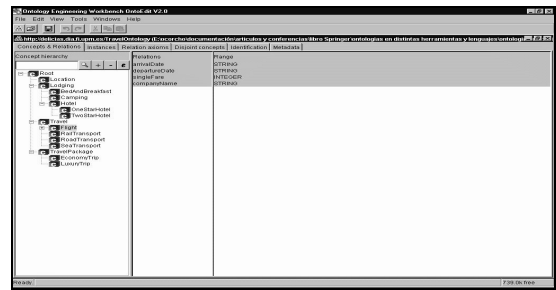


Figure 5: OntoEdit Tool [18]

2.7 OILED

OILED was initially developed as an ontology editor for Ontology Inference Layer (OIL) ontologies [7, 16]. OILED has evolved and now it is editor of DAML+OIL ontologies. OILED users can connect to the FACT inference engine, which provides consistency checking and automatic concept classification features. It also supports several documentation options with HTML and graphical visualization of ontologies. OILED screenshot is shown as:

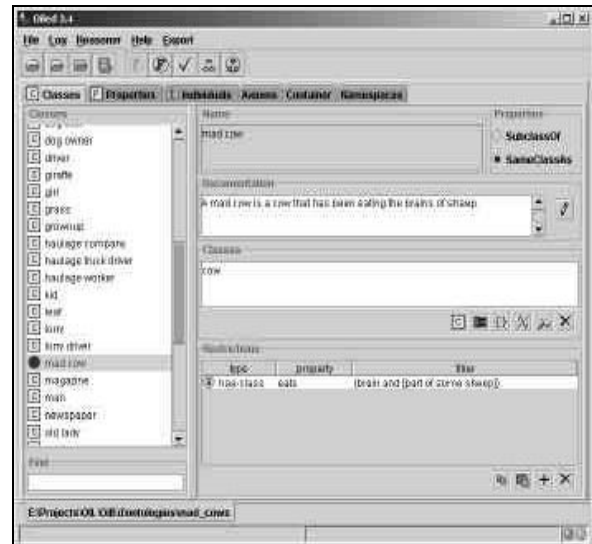


Figure 6: OILED Screenshot [18]

2.8 Apollo

Apollo [17] is a user friendly ontology development application. A snapshot of Apollo is shown in figure 7. A hierarchical representation of existing ontologies is shown in the top left pane. The hierarchy of classes and instances is shown in the bottom left pane. Once selected, a class or instance is shown in detail in the panes on the right hand side of the screen. The slots and values of a class or instance can then be added using a spreadsheet style interface. Apollo supports all the basic primitives of knowledge modeling like ontology creation by defining classes, instances, functions and relations. Full consistency checking is done while editing. Apollo has its own internal language for storing the ontologies, but can also export the ontology from different representation languages. Apollo is implemented using Java language.

⁴ <http://protegewiki.stanford.edu/wiki/WebProtege>

⁵ <http://webode.dia.fi.upm.es/>

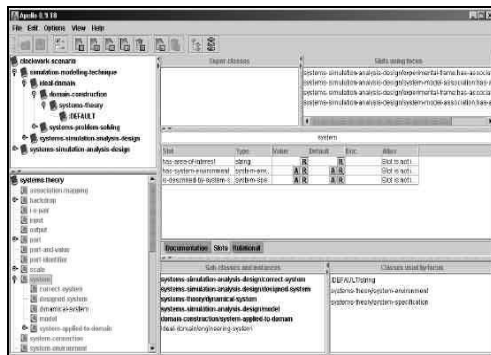


Figure 7: Apollo Snapshot [18]

Many other ontology related tools with specific purposes exist nowadays [7]:

- Ontomorph: Ontology transition between languages
- COHSE, OntoMat, SHOE Knowledge Annotator
Ontology based Web page Annotation
- OntoAnalyser, ONE-T, ODEClean: Ontology Evaluation
- RDFSuite, Sesame, Jena: RDF Query Engines

3. COMPARATIVE STUDY OF ONTOLOGY DEVELOPMENT TOOLS

The results for comparison of tools are shown in form of Table 1 which are categorized on the basis of following features:

- (i) General Issues in which Developers, Release and Pricing Policy are examined.
- (ii) Software Architecture in which architecture, extensibility, Ontology Storage and backup facilities are discussed.
- (iii) Interoperability in which import and export formats are discussed.
- (iv) Knowledge Representation and Methodological support
- (v) Inference services in which inference engine and automatic classifications are discussed.
- (vi) Usability in which GUI views, working and Ontology library are listed.

TABLE 1: COMPARISON AMONG VARIOUS ONTOLOGY DEVELOPMENT TOOLS

Features ↓	Apollo KMI(Open University)	Ontolingua KSL(Stanford University)	Ontosaurus ISI	WebOnto KMI	WebODE UPM	Protégé SMI(Stanford University)	OntoEdit Ontoprise	OILED University of Manchester
Pricing Policy	Open Source	Free Web Access	Open Source Evaluation	Free Web Access	Free Web Access Licenses	Open Source	Freeware and licenses	Freeware
S/w Architecture	Standalone	Client/Server	Client/Server	Client/Server	3-tier	Standalone	Client/server and standalone	Standalone
Extensibility	Plugins	None	None	No	via Plugins	via Plugins	via Plugins	No
Storage	Files	Files	Files	File	DBMS (JDBC)	File/ DBMS (JDBC)	File/ DBMS	File
Back up	×	×	×	√	√	×	×	×
Import Format	Apollo Meta-Language	Ontolingua IDL KIF	LOOM IDL ONTO KIF C++	OCML	XML, RDF(S), CARIN	XML,RDF(S),XML Schema	XML, RDF(S), FLogic, DAML+OIL	RDF(S), OIL, DAML+OIL
Export Format	OCML	KIF-3.0,CLIPS CML,LOOM, OKBC Syntax	LOOM IDL ONTO KIF C++	OCML, Ontolingua,GXL,RDF(S),OIL	XML,RDF(S),OIL, DAML+OIL,CARIN,FLogic,Prolog,Java,Java	XML,RDF(S),XML Schema, FLogic,CLIPS,Java,HTML	XML,RDF(S),FLogic, DAML+OIL,SQL-3	OIL,RDF(S),DAML+OIL, SHIQ, Dotty HTML
KR Paradigm	Frames	Frames+ FOL	DL (LOOM)	Frames+ FOL	Frames+ FOL	Frames+ FOL+ Meta Classes	Frames+ FOL	DL (DAML+OIL)
Axiom Language	Unrestricted	√	√	√	√	√	√	√
Methodology	×	×	×	×	√	×	√	×
Built in inference Engine	×	×	√	√	√	√	√	√
Attached inference Engine	×	ATP	√	×	Jess	JessFaCT FLogic	×	×
Automatic Classifications	×	×	√	×	×	×	×	√
GUI	√	√	×	√	√	√	×	×
Collaborative Working	×	√	√	√	√	×	√	×
Ontology Libraries	√	√	×	√	×	√	√	√

- √ ----denotes Yes
- × ----denotes No

4. CONCLUSION

In this Paper, various ontology development tools have been explored. From the above results we conclude that there are similar set of tools available for ontology development. These tools only include the design and implementation of ontology and don't cover all the steps of ontology life cycle. The problem of integrating the ontology into ontology library of different tool or if two ontologies are built using different tools occur due to lack of interoperability between all these tools. None of the tools includes project management facilities, ontology maintenance and Exception Handling mechanism.

Future work will include the creation of common workbench for construction of ontology which facilities all the activities of ontology life cycle.

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