Computer Life (CPL) ISSN: 1819-4818
DELIVERING QUALITY SCIENCE TO THE WORLD

Research on Ontology Technology

Yu Lei[a], Wang Cheng[b]

Department of Computer Engineering, Mechanical Engineering College, Shi JiaZhuang, China

[a]15511674637@163.com, [b]1047272896@qq.com

Abstract: This paper is concerned about the overview of Ontology technology research. Ontology is a formal explicit description of shared conceptual models, it is used to represent and share the domain knowledge. In this paper, the definition of Ontology is introduced and the Ontology description language is formally described and compared. Based on the introduction of Ontology construction methods and tools, the advantages and disadvantages is summarized. With the development of Ontology theory and technology, Ontology has been used in many fields and plays an important role. In this paper, some application of Ontology is introduced.
Keywords: Ontology, Ontology definition, Ontology description language, Ontology construction method, Ontology construction tool, Ontology application

---

1. INTRODUCTION

Ontology is originally a concept of philosophy, which is used to describe the objective existence of things. The concept of Ontology has been introduced into the fields of artificial intelligence, library information and knowledge engineering in 1990s, and it has become a hot research topic in these fields. In recent years, the research on Ontology theory and technology is gradually increasing, and the application field is expanding. In this paper, we review the research status of Ontology definition, Ontology description language, Ontology construction methods and tools, and summarize the application of Ontology research.

2. THE DEFINITION OF ONTOLOGY

The concept of Ontology has a new definition when it is introduced into the fields of artificial intelligence, knowledge engineering and so on. And because of the different understanding between experts and scholars, there are lots of ontology definitions.

In 1991, Neches who is a scholar in the field of artificial intelligence, gives a definition to Ontology. The definition means that Ontology is the basic terms and relations in the field of vocabulary, and using the terms and relations to stipulate the definition of lexical extension rules [1]. Neches is one of the first scholars to study Ontology definition. He gave the definition

to Ontology from the view of content and summarized the basic elements of Ontology which contain domain terms, relationships and rules. This provides a reference for the scholars in various fields to study the definition of Ontology.

In 1993, Stanford University scholar Gruber gives a definition to Ontology which means that Ontology is a conceptual specification [2]. The Ontology definition given by Gruber is the most classic, but it can not fully summarize the essence of Ontology. In 1997, Borst complements the definition given by Gruber, it said that Ontology is a formal specification of a shared conceptual model [3]. Borst puts forward the concept of Ontology sharing, clarifies the essence of Ontology sharing, but does not explain the relationship between concepts and concepts.

In 1998, German scholar Studer extended the definition of Ontology given by Borst and proposed the concept of "clear" definition. It explained that Ontology is a clear formal specification of the shared conceptual model [4]. The Ontology definition given by Studer is highly recognized by experts and scholars in various fields. It covers the basic characteristics of Ontology which are sharing, clarity, conceptualization and formalization. This definition is widely used in the academic circles, which has great significance to the later Ontology research.

Chinese scholars have done a lot of research on Ontology definition. In 2002, Professor Zhang Xiaolin holds that Ontology is a concept set, which is a conceptual representation of the objects and their relations in the field [5]. In 2005, Li Jing, a researcher at the China Institute of Standardization, argues that Ontology is an explicit specification of certain topics [6]. Tang Yanli and Lai Maosheng, professor of Peking University, believe that Ontology is an important component of the semantic web, is a clear and normative concept description of the world or domain knowledge, concept, entity and relationship [7]. And Professor Zhang Xiulan summarized the definition of Ontology based on the deep research of Ontology definition at home and abroad. It said that Ontology is a formal specification which is used in the field of communication and knowledge sharing between different forms, through describe and capture domain knowledge, and determine the relationship of common recognition concepts in the field [8].

Above all, there is no unified conclusion about the definition of Ontology, and it is a basic consensus that Ontology includes five features which are conceptualization, formalization, sharing, defining and describing domain knowledge. The essence of Ontology is basically summed up by these five characteristics, but with the development and extension of Ontology theory and technology, the application of Ontology will be more and more mature, and the Ontology definition will be clearer.

3. ONTOLOGY DESCRIPTION LANGUAGE

Ontology, as a kind of shared, formal description of the concept, needs to be described or expressed in the language specified in advance. In the research process of Ontology theory and

technology, a variety of Ontology description languages have emerged. Among them, the representative Ontology description language can be divided into two categories. One is based on predicate logic and the other is based on Web.

3.1 Ontology description language based on predicate logic

Ontology description language based on predicate logic mainly includes Ontolingua, OCML, LOOM, Cycl and Flogic. Among them, Ontolingua, OCML and Flogic are Ontology description language based on first-order predicate logic and frame model, LOOM is based on description logic, and Cycl is the two order logic language based on extension of first order predicate logic. Those Ontology description language can be used to realize the automatic processing of the computer, but the deficiency is that some of the concepts and the relationships is difficult to accurately express.

3.2 Ontology description language based on Web

Ontology description language based on Web mainly includes XOL, RDFS, SHOE, OIL, DAML+OIL and OWL. XOL is a XML based Ontology exchange language, and SHOE is an extension of the HTML Ontology. RDFS, OIL, DAML+OIL and OWL are based on the further expansion of RDF, inherited the RDF syntax and expression ability.

3.3 The comparison of Ontology description languages

Table 1 The result of the Ontology description languages comparison

Language	Concept	Multiple relations	Function	Procedure	Instances	Axiom	Rules	Formal semantics
Ontolingua	Y	Y	Y	Y	Y	Y	N	Y
CycL	Y	Y	Y	N	Y	Y	Y	Y
Loom	Y	Y	Y	Y	Y	Y	Y	Y
OCML	Y	Y	Y	Y	Y	Y	Y	Y
Flogic	Y	Y/N	Y/N	N	Y	Y	N	Y
XOL	Y	N	N	N	Y	N	N	Y
RDFS	Y	Y	N	N	Y	N	N	N
SHOE	Y	Y	N	N	Y	N	N	N
OIL	Y	Y	Y	N	Y/N	Y/N	Y/N	N
DAML+OIL	Y	Y	Y	N	Y	Y	Y	Y
OWL	Y	Y	Y	N	Y	Y	Y	Y

In this paper, we compare the main elements of the Ontology description languages in tabular

form by using the evaluation criteria developed by the Polytechnic University of Madrid. The Table 1 shows the result of the comparison. “Y’’ indicates that the description language has this property, “N” indicates that the description language hasn’t this property, “Y/N” means that it can be implemented without coercion.

The table 1 shows almost all languages support definitions of concepts, relationships, and instances. And the Ontology description language based on predicate logic has formal semantics which Web based hasn’t. Loom and OCML has “Y” in each index so that it is the most complete language to definite domain knowledge.

4. ONTOLOGY CONSTRUCTION METHODS

Ontology construction methods can be divided into abstract methods and specific methods. Abstract methods are used to illustrate the steps for Ontology construction, and specific methods are used to illustrate the specific needs of the Ontology construction process. In this paper, we discuss the abstract methods.

There are lots of representative Ontology construction methods just like skeleton method [9], IDEF5 method [10], Seven step method [11], five step circulation method [12], METHONTOLOGY method [13], TOVE method [14], KACTUS method [14], SENSUS method [15] and cyclic acquisition method [16].

Skeleton method, TOVE method and IDEF5 method are used in the construction of enterprise domain Ontology. But skeleton method is a process oriented construction method, which provides a framework for building methodology. The TOVE method is essentially to construct the knowledge logic model described by Ontology. The IDEF5 method can be used to construct the Ontology of enterprise domain by providing graph language and detailed description.

METHONTOLOGY method, KACTUS method, SENSUS method and seven step method are mainly used to construct domain Ontology. But the METHONTOLOCY method is based on the Ontology construction method in the field of chemistry, which has been improved and developed. The KACTUS method is mainly used to refine and extend the existing Ontology, so it is difficult to construct a new Ontology. The SENSUS method follows the top-down hierarchical structure, which has strong operability. And The seven step method is based on Ontology construction tool Protege, which is more practical and widely used.

It is similar to five step circulation method and cyclic acquisition method that they both emphasize Ontology iteration loop and support Ontology evolution. But the five step method is the Ontology construction method for Ontology learning in Semantic Web Environment and the cyclic acquisition method is based on the text of the domain Ontology construction methods which lack of specific technology.

Each method has its own application field. Because of the different characteristics of different domain knowledge, the applicability and universality of the method are greatly reduced. And most of the methods do not support the iteration of Ontology, ignoring the need

of Ontology evolution. Therefore, in the use of the construction method, the majority of scholars will be to improve the adaptability of the method, or one of the two or more methods of integration, and then in accordance with the improved method for Ontology construction. So, we should try to choose the appropriate construction method in the construction of Ontology, and combine with the characteristics of domain knowledge.

5. ONTOLOGY CONSTRUCTION TOOLS

Ontology development is a huge project, which needs the development tools to complete the task of Ontology construction. Ontology construction tools are mainly used in the development of Ontology, most of them have the functions of editing, drawing, converting the system content into database automatically, and transforming the markup language automatically. At present, there are two main types of Ontology building tools, which are visual hand build tool and semi build tool.

5.1 Visual hand build tool

Visual hand build tools are mainly contain Protege, Apollo, Web Onto, Web ODE and Onto Edit, etc. These tools usually provide a visual interface for the user, and the user can complete the construction of a simple operation.

5.1.1 Protege

Protege has a graphical user interface which operated simple and convenient. It provide detailed help documentation and support modular design. The protege support DAML + OIL and OWL language, and modify the Ontology using RDF, RDFS and OWL Ontology description language outside the system. Because of its open source and support of Chinese editing, Protege is well received by domestic scholars. However, the biggest drawback of Protege is that it can not import data in batches, it is time-consuming and laborious to build a large scale Ontology, and the error rate is high and the efficiency is low.

5.1.2 Apollo

Apollo uses Java language to support all primitives in the knowledge model, and it performs consistency checking in the editing process. But there are still some problems in the support ability, logical reasoning ability and expansibility of Ontology language.

5.1.3 Web Onto

Web Onto is a knowledge model based on OCML inference engine. Multiple inheritance and

locking mechanisms are provided in Web Onto, and it supports users to browse, build and edit ontologies. In order to retrieval information easily, Web Onto provides custom data representation type options and client API. But Web Onto does not provide the source code and has poor.

5.1.4 Web ODE

Web ODE is an upgraded version of the Ontology design environment (ODE) which can be achieved through Java, RMI, COBRA, XML Technology. The METHONTOLOGY Ontology construction method can be used to improve the reusability of the conceptual model, which has great flexibility and expansibility. It supports METHONTOLOGY Ontology construction method and improves the reusability of conceptual models by defining instance sets.

5.1.5 Onto Edit

Onto Edit is an engineering environment that supports the development and management of ontologies using graphical methods. It supports RDFS, DAML +OIL language and provides concurrent operations on the Ontology. It has good expansion function with the support of a variety of plug-ins.

However, these tools do not automatically or semi automatically acquire knowledge and maintenance capabilities, so that the constructed Ontology has poor compatibility and is difficult to reuse in heterogeneous systems.

5.2 Semi automated build tool

Jena based on the Java language is a semi-automatic Ontology building tool. It provides the method of Ontology formalization and invokes program to realize the automatic construction of Ontology. Jena uses a variety of protocols to publish data and efficient storage large scale RDF three tuples to hard disk. It provides API to handle OWL and RDFS Ontology, while customers can use Java API access Jena and share data to internet. Thus the Ontology can be shared. Jena has greatly improved the efficiency of Ontology construction, but it has not yet realized the full meaning of the automated Ontology construction, which needs further study.

In short, there are still a lot of problems in the current Ontology building tools, and have not yet achieved efficient Ontology automatic construction. While most tools provide a good graphical interface and error checking mechanism, and the majority of human errors are avoided. However, these tools still need to manually input and edit a large amount of data information, so it is difficult to achieve large-scale Ontology construction. There is a valuable research direction that how to realize the automatic construction of Ontology using the automatic acquisition of knowledge.

6. THE APPLICATION OF ONTOLOGY

With the development of Ontology theory and technology, Ontology has been used in many fields and plays an important role in these fields. This paper briefly describes the application of Ontology from the following aspects.

6.1 Application in information retrieval

The application of Ontology in information retrieval is mainly focused on two aspects, one is to use Ontology for document preprocessing, and the other is to improve the accuracy of information retrieval. The Research Institute of IBM [17], University of Maryland [18] did depth research in intelligent information retrieval system theory and methods based on the Ontology and put forward efficient information retrieval methods. Mohamethfrancois Sy [19] has developed Ontology based life science information retrieval system, which provides users with a visual query. Moonseo Park [20] applies Ontology to building knowledge retrieval, and develops a prototype of Ontology based knowledge system. Using Ontology technology and information retrieval technology, Ma Bin [21] achieve a domain oriented intelligent retrieval system and greatly improving the accuracy of information retrieval.

6.2 Application in semantic web

Ontology as a conceptual system with common standards, it supports logical reasoning and promotes computer understanding and interoperability. The application of Ontology in semantic Web is mainly focused on improving the ability of language description of fuzzy information, and promoting the semi-automatic and automatic Ontology generation. JiangXing [22] learn and express the individual needs of users by constructing user Ontology. Pulido J [23] makes use of SOM method and Ontology technology to make the knowledge map and serve the dynamic intelligent operation of semantic Web. With the deep research of Ontology and semantic Web, the application of Ontology in semantic Web will be more and more extensive, and the semantic Web service will be more intelligent.

6.3 Application in heterogeneous data integration and fusion

In the distributed network environment, massive data information is stored in different systems and databases, which results in the problem of data redundancy and heterogeneity. Ontology is a formal specification of shared conceptual model, which can effectively solve the problem of heterogeneous data integration and fusion. Lihua Zhao and RyutaroIchise [24] constructed a semi automated system for Ontology integration framework. The system provides Ontology integration based on graph, Ontology based on machine learning and attribute query method, and effectively reduce the heterogeneity of Ontology. Cinzia Daraio et al. [25] put forward an

Ontology based data management method, which can solve the problem of heterogeneous data integration by Constructing Ontology Conceptual Mode.

6.4 Applications in other disciplines

In addition to the above areas, Ontology is also widely used in medicine, education, e-commerce, agriculture, military, tourism, geographic information, law, biology and other fields. In these fields, most of them build domain Ontology to achieve the integration of domain knowledge and knowledge sharing.

7. CONCLUSION

With the development of intelligent Internet, artificial intelligence and other fields, Ontology research will continue to heat up. As an important knowledge organization system, Ontology will play an important role in Intelligent Knowledge Service. Therefore, Ontology based personalized knowledge retrieval and intelligent Web services will be one of the important research directions in the future. The number and scale of Ontology library are increasing continuously, and it is is very important to develop and maintain Ontology. So, it is necessary to make a deeper research on Ontology automatic evolution and self-learning.

REFERENCES

[1] Neches R, Fikes R E, Gruber T, et al, “Enabling Technology for Knowledge Sharing”, AI Magazine, 1991, Vol.12(3) : p36-56.

[2] Gruber T, “A Translation Approach to Portable Ontology Specifications”, Knowledge Acquisition, 1993, Vol.5 : p199-220.

[3] Borst W N, “Construction of Engineering Ontologies for Knowledge Sharing and Reuse”, Ph. D thesis, 1997.

[4] Studer B, Benjamins V R, Fensel D, “Knowledge Engineering: Principles and Methods”, Data and Know ledge Engineering, 1998, Vol.25(1 /2) : p161-197.

[5] Zhang Xiaolin, Li Yu, “The Metadata for Describing Knowledge Organization Systems”, Library and Information Service, 2002, Vol.2: p64-69.

[6] Li Jing, “Research on the application of ontology theory in document retrieval system”, Beijing Library Publishing Company, 2005: p5-6.

[7] Tang Yanli, Lai Maosheng, “Study of the Application of Ontology in Natural Language Information Retrieval”, New Technology of Library and Information Service, 2005: p5-6.

[8] Zhang Xiulan, Jiang Ling, “Overview of Ontology Concept Research”, Information Journal, 2007, Vol.4: p527-532.

[9] Yu Fan, “Domain Ontology Construction Method and Empirical Research”, Wuhan University Publishing Company, 2015: p39-40.

[10] Yan Ye, Dong Yang, Zhibin Jiang, et al. “Ontology-based Semantic Models for Supply Chain Management”, The International Journal of Advanced Manufacturing Technology, 2008, Vol.37 (11) : p1250-1260.

[11] A Guide to Creating Your First Ontology[EB /OL], [2016-01-20], http: //www. Protégé. Stanford. edu / publications / ontology_development / ontology101. Pdf.

[12] Maedche A, Staab S, “Ontology Learning for the Semantic Web”, Kluwer Academic Publishers, 2001: p37-44.

[13] Li Hengjie, Li Junquan, Li Ming, “Research on Modeling Method of Domain Ontology”, Computer Engineering and Design, 2008, Vol.29(2): p381-383.

[14] Hu Zhaoqin, “Ontology and Knowledge Organization”, Beijing Literature and History Publishing Company, 2013: p65-66.

[15] Ontology Creation and Use: SENSUS[EB /OL][2016 - 04 -01], http: //www. isi. edu / natural - language / resources / sensus. Html.

[16] Extracting a Domain-Specific Ontology from a Corporate Intranet [EB /OL], [2016 - 04 - 03]. http://acl-web. org /anthology //signll. Html.

[17] Luo G, “Design and Evaluation of the iMed Intelligent Medical Search Engine”, In Proceedings of the Int’l Conf. on Data Engineering (ICDE2009), 2009.

[18] Han LS, Finin T, Joshi A, “Schema Free Structured Querying of DBpedia Data ”, In Proceedings of the 21st ACM Int’l Conf. on Information and Knowledge Management(CIKM 2012), 2012: p2090-2093.

[19] Mohameth-Francois Sy, Sylvie R, Jacky M, et al, “User Centered and Ontology Based Information Retrieval System for Life Sciences”, BMC Bioinformatics 2012, Vol.13(S1): S4.

[20] Moonseo P, Kyung-won L. Hyunsoo L, “Ontology-based Construction Knowledge Retrieval System”, KSCE Journal of Civil Engineering, 2013, Vol.17(7): p1654-1663.

[21] Ma Bin, Wang Jinhong, Yan Juanjuan, “Study and Design of Intelligent Retrieval System Based on Ontology”, Information Science, 2015, Vol.2: p46-49.

[22] Jiang X, Tan P. “Learning and Inferencing in User Ontology for Personalized Semantic Web Services, Automatic Fuzzy Ontology Generation for Semantic Web”, In Proceedings of the 15th international conference on World Wide Web,2006: p1067-1068.

[23] Pulido J, Herrera R, Arechiga M, et al, “Identifying Ontology Components from Digital Archives for the Semantic Web”, In Proceedings of the 2nd IASTED International Conference on Advances in Computer Science and Technology,2006: p7-12.

[24] Zhao L H, Ryutaro I, “Ontology Integration for Linked Data”, Journal on Data Semantics, 2014, Vol.3(4) : p237-254.

[25] Cinzia D, Maurizio L, Claudio L, et al, “Data Integration for Research and Innovation Policy: an Ontology-Based Data Management approach”, Scientometrics, 2016, Vol.106(2) : p857-871.