An Ontology of Ontological Engineering

Amandeep Verma
Punjabi University Regional Centre, Mohali
vaman71@gmail.com

Abstract

Ontologies have proven its worth for knowledge representation and in the semantic web. Moreover, sharing and/or reuse a common understanding of information about explicit domains among people is among the utmost motive for the development of ontologies. In literature there are numbers of ontologies addressing various domains or disciplines. Ontological engineering is the discipline that deals with development and maintenance of ontologies. Representation of this discipline as an ontology offers the same benefits as the other existent ontologies. With this viewpoint, the present study developed ontology for ontological engineering as means for representing the concepts and their inter relationships in the said discipline. The developed ontology is an outcome of comprehensive review of the studies related to ontological engineering in the literature. The details of the phases in the process of development are presented in the paper. The ontology is evaluated for assessment purposes. It was developed in Protégé 5.0.

Keywords: *Ontology, Types of Ontology, Ontological engineering*

1. Introduction

Ontologies are good means for knowledge representation because of their ability to represent any type of contextual relationship among the terms defined in it, as compared to controlled vocabulary, taxonomy or even thesaurus. Moreover, sharing and/or reuse a common understanding of information about explicit domains among people is among the utmost motive for the development of ontologies [1]. For the web technology community, ontology is a representation that delivers a comprehensible foundation for the Semantic Web [2]–[4]. Ontologies are viewed as information artifacts; representations; formal structures; theories; hierarchies of types. All of these are the version of the diverse facet of ontology, but compatible to each other [5]. Ontologies may be considered either as lexicons, dictionaries, thesauri or even first order logical theories, however in all these variations, ontologies exhibit its worth because of the standardization of the terms used in it [6].

Ontologies have proven its worth for knowledge representation and as well for semantic web. A number of ontologies addressing various domains or disciplines are existent. Ontological engineering is a discipline that deals with the development and maintenance of ontologies. Representation of this discipline as an ontology offers the same benefits as the other existent ontologies. With this viewpoint, the present study developed ontology for ontological engineering as means for representing the concepts and their inter relationships in the said discipline. The intended readers of this work are the researchers seeking the details in the said area in the form of ontology.

The paper is organized as- section 2 is about the approach adopted for the development of ontology. It describes the details of the phases of the development from knowledge acquisition to evaluation. The concluding points are in section 3.

2. The Approach

In general, ontology development involves number of phases as described later in the ontology of methodology, but as far as the present study is concerned for simplicity, the methodology used for the development of ontology consists of the following phases

- Knowledge Acquisition
- Conceptualisation
- Implementation
- Evaluation

An ontology in Ontology Web Language (OWL), consists of named classes representing the concepts of the domain, object properties used to represent the inter relationship among concepts, data properties to show relationship of the concepts with type of values, individuals represents the members of the concepts.

2.1 Knowledge Acquisition

This phase is intended to acquire the knowledge of the domain. The literature in the ontological engineering is tremendous. In order to have comprehensive knowledge, a number of studies have been reviewed. The reviewed studies are cited in relevant subsections.

2.2 Conceptualisation

This phase involves the identification of the concepts and the relationships among them. The basic concepts are

- Ontological engineering with sub concepts ontology, methodology, tools and evaluation
  - Ontology with sub concepts like definition, processes, activities
  - Methodology with sub concepts scenarios and phases of development
  - Tools
  - Evaluation with sub concepts errors, anomalies and metrics

2.3 Implementation

The purpose is to implement the outcome of conceptualisation as ontology

2.3.1 Classes of Ontological Engineering

In literature Ontological engineering is defined as a methodology [7], discipline [8], [9], set of activities [10], [11] to develop a conceptualisation, implementation and deployment of ontology of the domain of interest. Its ontology is shown in Figure 1

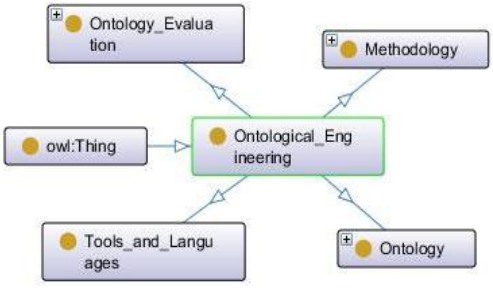

Figure 1: Ontological Engineering

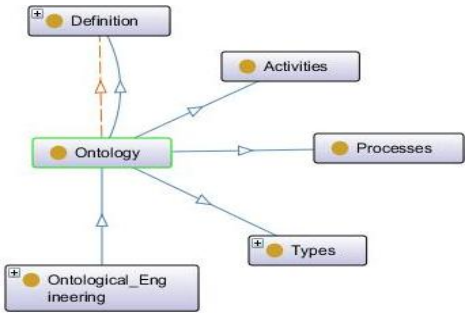

Figure 2: Ontology

2.3.1.1 Ontology

The ontology for ontology with concepts definition, activities, processes and its type is shown in Figure 2.

2.3.1.1.1 Definition

Although the literature has a variety of definition of ontology, but the most accepted definition is *An ontology is a formal explicit specifications of shared conceptualizations* [12]. Conceptualisation symbolizes an abstract model of concepts of some observable fact in the world, so it entails recognition of appropriate concepts and their relations in a particular domain. Formal refers that ontology should be machine understandable. Explicit specifications present the exact description of any type(s), constraints on the usage of recognized concepts and on the relationships amongst them. Shared requires that there should be agreement on the ontology.

Conceptualisation is the core ingredient of any ontology and other terms may or may not be reflected in definitions of the ontology, depending on researcher interpretation or the type(s) of ontology. The ontology for definition and the individuals of its subclasses are shown in Figure 3.

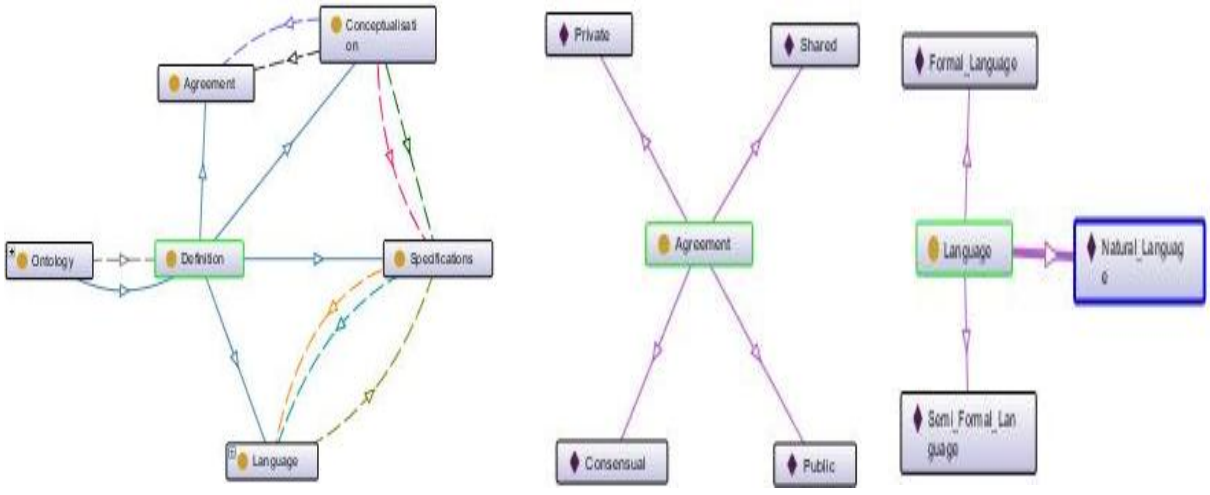

Figure 3: Ontology of definition and individuals of its subclasses

2.3.1.1.2 Types

Different ontologies differ not only in their content, but vary in structure, details of description, conceptual scope and specification of language as well [13]. Ontologies are also classified on the basis of level of formalism, expressiveness of language, purpose and many other criteria as shown in Figure 4.

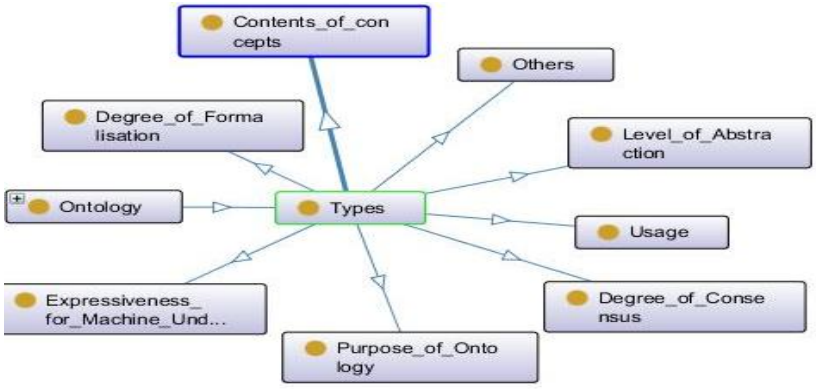

Figure 4: Classification of types of Ontologies

2.3.1.1.3 Processes

The processes [14] potentially involved in ontology constructions are shown as ontology in Figure 5.

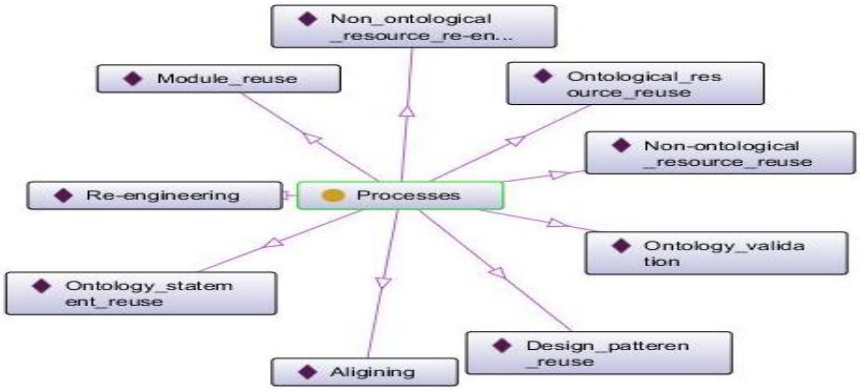

Figure 5: Processes in Ontological Engineering

2.3.1.1.4 Activities

The activities in ontological engineering are listed in the study [14]

2.3.1.2 Methodology

Ontology building is much in practice, so there is a need of well defined methodology for having high quality ontology. The popular methodologies are- TOVE based [15], based on Enterprise model [16], a unified approach [17], MethOntology [18], of ONIONS project [19], Ontology Development 101 [1], DILIGENT [20], HCOME [21], DOGMA approach [22], Melting Point [23], NeON [14], UPON [24]. The common phases of most of them have all, some

or additional of phases, more or less varies in detail of these phases. The ontology of methodology is shown in Figure 6 and the individuals are shown in Figure 7

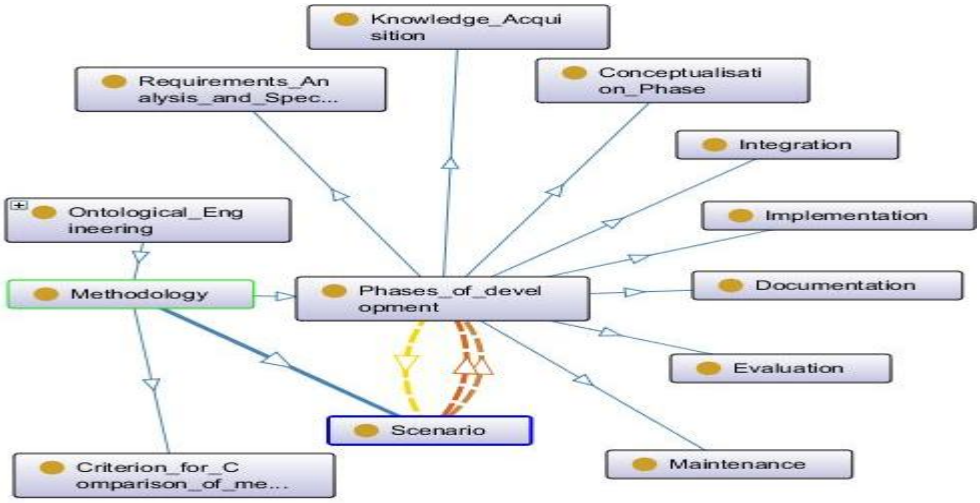

Figure 6: Ontology of Methodology

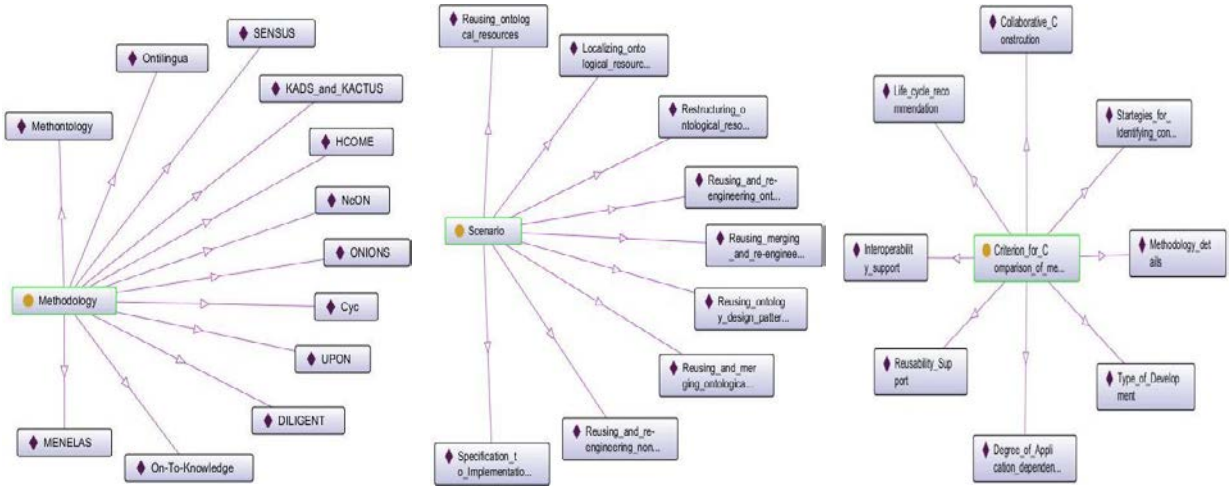

Figure 7: Individuals of methodology

2.3.1.3 Tools and Languages

There are number of tools and editors. An exhaustive review and comparison of these are in literature. A comparison of OntoLingua, WebOnto, ProtégéWin, OntoSaurus, ODE, KADS 22 were reviewed in the study [25]. Protégé 2000, OilED, Apollo, RDEedt, OntoLingua, OntoEdit, WebODE, KAON, ICOM, DOE, WebONTO, K-infinity were compared [26]. OntoEdit [27], Hozo, WebODE and ODEClean were discussed in the study [28]. Another comparison was in study [29]. Swoop, TopBraid were also compared with already stated tools [30]. The W3C standard for defining ontologies is OWL. The individuals of tools are shown in Figure 7.

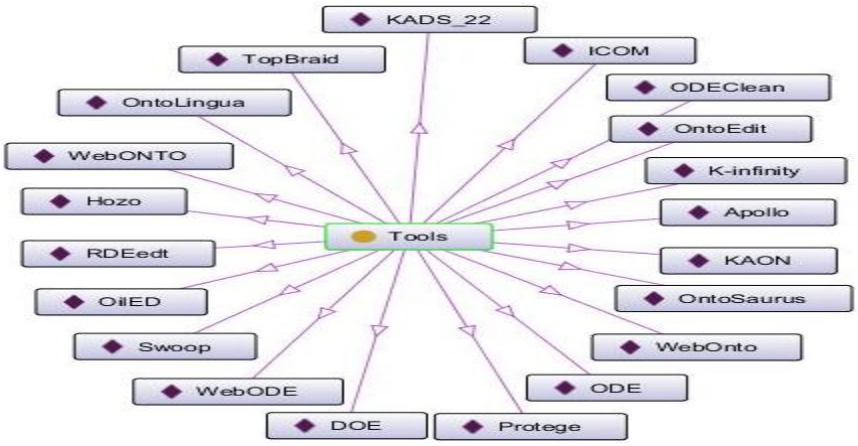

Figure 7: Individuals of Tools

2.3.1.4 Evaluation

This phase refers to the assessment of the developed ontology. In ontology engineering, evaluation of ontology is considerable phase and it is either for the estimation of ontology for assessment reasons or it is to make decision to choose the best alternatives for reuse purposes among the available ontologies by ranking the alternatives.

The ontology gets evaluated for the correctness as well the quality and it is shown as ontology in Figure 8.

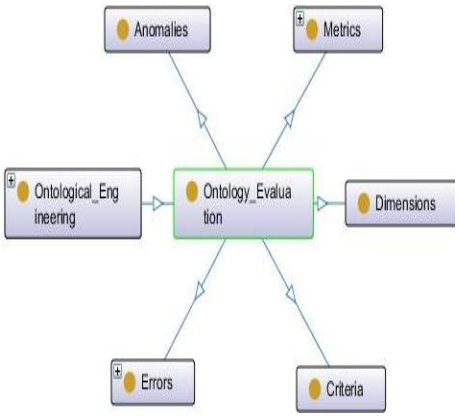

Figure 8: Ontology of Ontology Evaluation

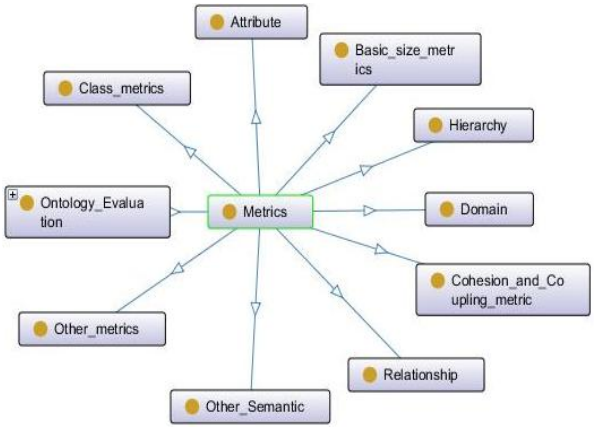

Figure 9: Ontology of metrics

2.3.1.4.1 Metrics

The metrics are developed for exclusively for ranking [31]–[34]of ontologies as well for individual assessment of the ontologies [35]–[40]. These metrics can be used interchangeably i.e. metric for ranking can also be used for the assessment of individual and metrics for individual assessment can be for ranking the group of ontologies. A classification is shown as ontology in Figure 9

2.3.1.4.4 Dimensions

Ontology Verification is to ensure that their definition satisfies the ontology requirements and competency questions, or function correctly in the real world. *Ontology Validation* refers to check whether the definitions of ontology model the intended real world. To evaluate a given ontology, the criteria is: consistency, completeness, conciseness, expandability and sensitiveness [41].

Broadly, the evaluation approach can be classified as – that compares it with the golden standards [42]; on the basis of outcome for particular application [43]; on the basis of user/ expert opinion [44]; or approximate coverage against data standards [45].

2.3.1.4.3 Anomalies

The anomalies are quoted in the study [46] are shown as individuals of anomalies shown in Figure 10.

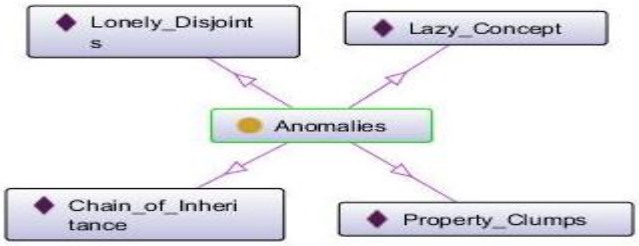

Figure 10: Individuals of Anomalies

2.3.1.4.4 Errors

The literature identified the possible errors [41] [47] in ontologies that can cause inconsistency, incompleteness and redundancy in the ontology shown as ontology in Figure 11a and further individuals are shown in Figure 11b, 11c, 11d.

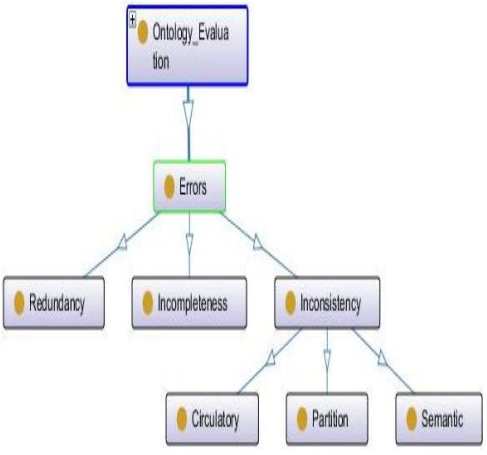

Figure 11a: Classification of Errors

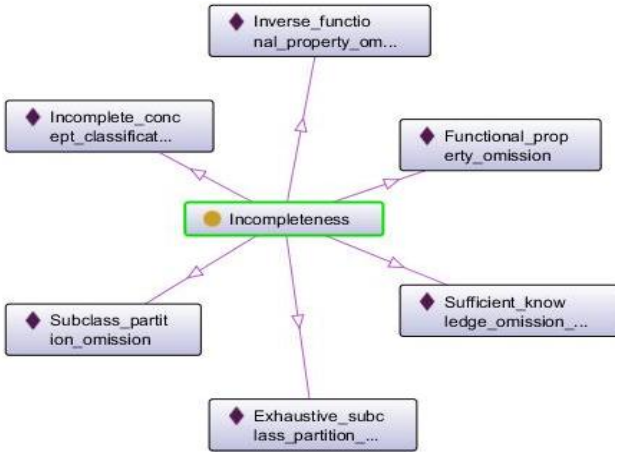

Figure 11b: Individuals of Incompleteness Error

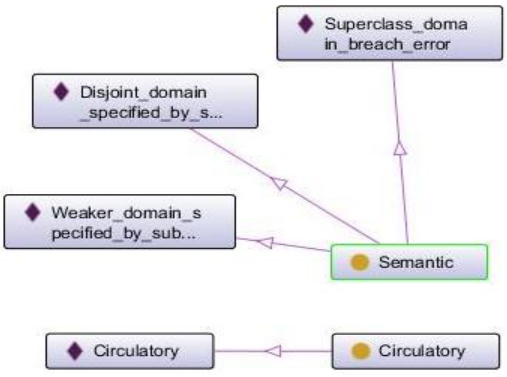

Figure 11c: Individuals of Semantic Error

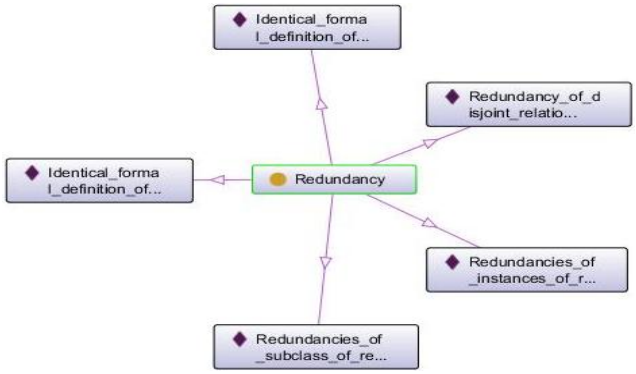

Figure 11d: Individuals of Redundancy Error

2.3.2 Object Properties

The object properties identified to represent inter relationships among concepts are shown in Table 1 with the listing of property and its domain and range.

Table 1: Object Properties in Ontological engineering

Property	Domain	Range
hasAgreement	Conceptualisation	Agreement
hasdetermine	Scenario	Phases_of_development
hasExplicit	Conceptualisation	Specifications
hasType	Ontology	Types
isdefinedBy	Ontology	Definition
isdependentOn	Expressiveness_for_Machine_Understanding	Language
isdeterminedBy	Phases_of_development	Scenario
isRepresenting	Language	Specifications
istypeOf	Types	Ontology
Represented_by	Specifications	Language

2.3.3 Restrictions

The restrictions are special kind of class description for some classes where some indicates existential quantification and any indicates universal quantification. The restrictions on concepts are shown in Table 2

Table 2: Restrictions on Concepts

Class	Restriction
Scenario	hasdetermine some Phases_of_development
Conceptualisation	hasAgreement **some** Agreement
Conceptualisation	hasExplicit **only** Specifications
Specifications	represented_by **some** Language

2.4 Evaluation

In order to get an idea about the expressiveness of the ontology various metrics and their corresponding values for the developed ontology is shown in Table 3

Table 3: Assessment of Ontology

Metric	Value
Axiom	758
Logical Axiom	363
Class Count	57
Object property	10
Individual count	316

3. Conclusion

The definition of ontology varies as per the requirement and aim of the ontology to be built. The ontologies can be classified on the basis of abstractness, level of formalism and other criterion. Building, evaluation and maintenance are all the phases of ontological engineering discipline. The current study covers all aspects of the ontological engineering and represents them as ontologies.

References

[1] N. F. Noy and D. L. McGuinness, "Ontology Development 101: A Guide to Creating Your First Ontology," *Stanford Knowl. Syst. Lab.*, p. 25, 2001.

[2] M. M. Taye, "Understanding Semantic Web and Ontologies: Theory and Applications," *J. Comput.*, vol. 2, no. 6, pp. 182–192, 2010.

[3] I. Horrocks, "Ontologies and the semantic web," *Commun. ACM*, vol. 51, no. 12, p. 58, 2008.

[4] T. Berners-Lee, J. Hendler, and O. Lassila, "The Semantic Web," *Sci. Am.*, vol. 284, no. 5, pp. 34–43, 2001.

[5] L. Jansen and S. Schulz, "The Ten Commandments of Ontological Engineering," in *OBML Workshop*, 2011, pp. 41–46.

[6] I. Jurisica, J. Mylopoulos, and E. Yu, "Ontologies for Knowledge Management: An Information Systems Perspective," *Knowl. Inf. Syst.*, vol. 6, no. 4, pp. 380–401, 2004.

[7] R. Mizoguchi and M. Ikeda, "Towards ontology engineering," *Journal-Japanese Soc. Artif. Intell.*, pp. 1–10, 1998.

[8] N. Guarino, D. Oberle, and S. Steffen, "What Is an Ontology?," in *Handbook on Ontologies*, S. Staab and R. Studer, Eds. Berlin Heidelberg: Springer-Verlag, 2007, p. 654.

[9] G. Schreiber, "Knowledge Engineering. In: Handbook of Knowledge Representation," *Knowl. Eng. Handb. Knowl. Represent.*, 2008.

[10] V. Devedzić, "Understanding ontological engineering," *Commun. ACM*, vol. 45, no. 4, p. 136, 2002.

[11] E. Simperl and M. Mochol, "Achieving Maturity: the State of Practice in Ontology Engineering in 2009," *Int. J. Comput. Sci. Appl.*, vol. 7, no. 1, pp. 45–65, 2010.

[12] R. Studer, R. Benjamins, and D. Fensel, "Knowledge Engineering: Principles and

Methods," *Data Knowl. Eng.*, vol. 25, no. 1–2, pp. 161–197, 1998.
[13] A. Gali and C. Chen, "From ontology to relational databases," *Concept. Model. …*, pp. 1–12, 2004.
[14] M. C. Suarez-Figueroa, A. Gómez-Pérez, and M. Fernández-López, "The NeOn Methodology for Ontology Engineering," in *Ontology Engineering in a Networked World*, M. C. Suárez-Figueroa, A. Gómez-Pérez, E. Motta, and A. Gangemi, Eds. Berlin Heidelberg: Springer, 2012, p. 444.
[15] M. Gruninger and M. S. Fox, "Methodology for the Design and Evaluation of Ontologies," *Ind. Eng.*, vol. 95, pp. 1–10, 1995.
[16] M. Uschold and M. King, "Towards a Methodology for Building Ontologies," in *Workshop on Basic Ontological Issues in Knowledge Sharing*, 1995, no. July, pp. 1–13.
[17] M. Uschold, "Building Ontologies : Towards a Unified Methodology," in *16th Annual Conference of the British Computer Society Specialist Group on Expert Systems*, 1996, no. September, pp. 1–18.
[18] M. Fernández-López, A. Gómez-Pérez, and N. Juristo, "METHONTOLOGY: From Ontological Art Towards Ontological Engineering," *AAAI-97 Spring Symp. Ser.*, vol. SS-97–06, pp. 33–40, 1997.
[19] A. Gangemi, D. M. Pisanelli, and G. Steve, "Overview of the ONIONS project: applying ontologies to the integration of medical terminologies," *Data Knowl. Eng.*, vol. 31, no. 2, pp. 183–220, 1999.
[20] H. S. Pinto, S. Staab, and C. Tempich, "DILIGENT : Towards a fine-grained methodology for DIstributed , Loosely-controlled and evolvInG Engineering of oNTologies," in *European Conference on Artificial Intelligence*, 2004, pp. 393–397.
[21] K. Kotis and G. A. Vouros, "Human-centered ontology engineering: The HCOME methodology," *Knowl. Inf. Syst.*, vol. 10, no. 1, pp. 109–131, 2006.
[22] M. Jarrar and R. Meersman, "Ontology Engineering -The DOGMA Approach," in *Advances in Web Semantics*, Springer, 2008.
[23] A. Garcia, K. O'Neill, L. J. Garcia, P. Lord, R. Stevens, O. Corcho, and F. Gibson, "Developing Ontologies within Decentralised Settings," *Semant. E-Science*, pp. 99–139, 2010.
[24] A. De Nicola, M. Missikoff, and R. Navigli, "A software engineering approach to ontology building," *Inf. Syst.*, vol. 34, no. 2, pp. 258–275, 2009.
[25] A. J. Duineveld, R. Stoter, M. R. Weiden, B. Kenepa, and V. R. Benjamins, "WonderTools? A comparative study of ontological engineering tools," *Int. J. Hum. Comput. Stud.*, vol. 52, no. 6, pp. 1111–1133, 2000.
[26] D. Mcleod, "Ontology Development Tools for Ontology-Based Knowledge Management," pp. 1–7, 2006.
[27] Y. Sure, J. Angele, and S. Staab, "OntoEdit: Guiding ontology development by methodology and inferencing," *Proc. Confed. Int. Conf. CoopIS, DOA ODBASE*, pp. 1205–1222, 2002.
[28] R. Mizoguchi and K. Kozaki, "Ontology Engineering Environments," *Handb. Ontol.*, pp. 315–336, 2009.
[29] S. C. Buraga, L. Cojocaru, and O. C. Nichifor, "Survey on Web Ontology Editing Tools," *Trans. Autom. Control Comput. Sci.*, vol. NN, no. ZZ, pp. 1–6, 2006.

[30] E. Alatrish, "Comparison Some of Ontology Editors," *Manag. Inf. Syst.*, vol. 8, no. 2, pp. 18–24, 2013.
[31] S. Tartir and I. B. Arpinar, "Ontology evaluation and ranking using OntoQA," *ICSC 2007 Int. Conf. Semant. Comput.*, pp. 185–192, 2007.
[32] H. Alani, C. Brewster, and N. Shadbolt, "Ranking Ontologies with AKTiveRank," *Semant. Web-ISWC 2006*, pp. 1–15, 2006.
[33] H. Alani and C. Brewster, "Metrics for ranking ontologies," in *CEUR Workshop Proceedings*, 2006, vol. 179.
[34] J. Brank, J. Brank, M. Grobelnik, M. Grobelnik, D. Mladeni, and D. Mladeni, "Automatic Evaluation of Ontologies," London: Springer, 2007, pp. 193–219.
[35] M. A. Sicilia, D. Rodríguez, E. García-Barriocanal, and S. Sánchez-Alonso, "Empirical findings on ontology metrics," *Expert Syst. Appl.*, vol. 39, no. 8, pp. 6706–6711, 2012.
[36] A. Duque-ramos, J. T. Fernández-breis, M. Iniesta, M. Dumontier, M. Egaña, S. Schulz, N. Aussenac-gilles, and R. Stevens, "Evaluation of the OQuaRE framework for ontology quality," *Expert Syst. Appl.*, vol. 40, no. 7, pp. 2696–2703, 2013.
[37] A. Farooq, S. Ahsan, and A. Shah, "Web-Ontology Design Quality Metrics," *J. Am. Sci.*, vol. 6, no. 11, pp. 52–58, 2010.
[38] H. Hlomani and D. Stacey, "Approaches, methods, metrics, measures, and subjectivity in ontology evaluation: A survey," *Semant. Web J.*, vol. 1, pp. 1–11, 2014.
[39] F. Ensan and W. Du, "A semantic metrics suite for evaluating modular ontologies," *Inf. Syst.*, vol. 38, no. 5, pp. 745–770, 2013.
[40] R. Žontar and M. Heričko, "Adoption of object-oriented software metrics for ontology evaluation," *Proc. Fifth Balk. Conf. Informatics - BCI '12*, p. 298, 2012.
[41] A. Gomez-Prerez, "Ontology Evaluation," in *Handbook on Ontologies*, S. Staab, Ed. Berlin Heidelberg: Springer, 2004, pp. 293–313.
[42] J. Brank and D. Mladenic, "Gold standard based ontology evaluation using instance assignment," *Proc. EON 2006 Work.*, 2006.
[43] R. Porzel and R. Malaka, "A task-based approach for Ontology evaluation.," in *ECAI Workshop on Ontology Learning and population*, 2004, vol. 4 Suppl 1, p. S4.
[44] L. Ouyang, B. Zou, M. Qu, and C. Zhang, "A method of ontology evaluation based on coverage, cohesion and coupling," in *Proc. of 8th International Conference on Fuzzy Systems and Knowledge Discovery*, 2011, vol. 4, pp. 2451–2455.
[45] C. Brewster, H. Alani, S. Dasmahapatra, and Y. Wilks, "Data driven ontology evaluation," *Fourth Int. Conf. Lang. Resour. Eval.*, pp. 641–644, 2004.
[46] J. Baumeister and D. Seipel, "Smelly owls - Design anomalies in ontologies," *Proc. Eighteenth Int. Florida Artif. Intell. Res. Soc. Conf. FLAIRS 2005 - Recent Adv. Artifical Intell.*, pp. 215–220, 2005.
[47] M. Fahad and M. A. Qadir, "A framework for ontology evaluation," in *CEUR Workshop Proceedings*, 2008, pp. 149–158.