

A Practical Framework for the Semantic Web Ontology Learning

*Razieh Asgarnezhad¹, Karrar Ali Mohsin Al-Hameedawi², Hind Abdulrazzaq Mohammed Ali³

¹Department of Computer Engineering, Aghigh Institute of Higher Education, Shahin Shahr, 8314678755, Isfahan, Iran

²Department of Computer Engineering, University of Baghdad, Baghdad, Iraq

³Civil engineering department, University of Technology-Iraq, Baghdad, Iraq

Abstract

The formal ontologies that organize underlying data are extensively utilized by the Semantic Web to achieve complete and portable machine comprehension. Because of this, the Semantic Web's success is heavily dependent on the spread of ontologies, which calls for quick and simple ontology architecture and the avoidance of a knowledge accumulation bottleneck. The ontology engineer's ability to build ontologies is significantly aided by ontology learning. The goal of the ontology learning approach is to enable a collaborative, semi-automatic ontology engineering process. We suggest here involves several complimentary fields that draw on various kinds of unorganized, semi-structured, and completely structured data. By importing, extracting, pruning, refining, and evaluating ontologies, our ontology learning system provides the ontology architect with a wide range of composed instruments for cosmology demonstration. Notwithstanding the general structure and engineering, we show in this paper a few illustrative methods in the metaphysics learning cycle that we have carried out in our philosophy learning climate, Text-To-Onto, for example, cosmology gaining from free text, from word references, or heritage ontologies, and we allude to others that should be utilized related with these to complete the full architecture, such as reverse engineering of ontologies from database schemata or learning from XML documents.

Keywords: Ontology learning, The Semantic web, XML, RDF

1. Introduction

The concept of machine-process able data on the Semantic Web is relevant to conceptual frameworks that specify an underlying taxonomy. Ontologies are (meta) data models that offer a controlled lexicon of ideas, each with a specified meaning that can be processed by computers. Ontologies support the interchange of semantics as well as syntax by outlining shared and common topic theories, which aid in the clear and concise communication of both humans and computers. Therefore, the quick and inexpensive creation of domain-specific ontologies is essential for the development and spread of the Semantic Web. Despite the fact that ontology building tools have advanced over the past ten years Ontology manual acquisition is still a time-consuming, difficult job that can quickly become a knowledge acquisition barrier. We had to deal with this problem after creating our ontology engineering workbench, OntoEdit, in particular when we were asked (Maedche & Staab, 2001). In reality, the time, difficulty, and trust issues that we ultimately faced were comparable to those that knowledge engineers had to deal with over the previous 20 years as they developed

*Corresponding author



methods for knowledge acquisition or workbenches for describing knowledge bases. For the knowledge acquisition task, combining knowledge acquisition with machine learning techniques was a plan that worked incredibly well (Webb et al., 1999).

In comparison, the structured knowledge or data source is more of an anomaly than the rule in the Web world that we work in when developing Web ontologies. Therefore, "intelligent means" for an ontology engineer has a distinct connotation than "integration architectures" for more traditional knowledge acquisition, which was very influential (Gaines & Shaw, 1992). In reality, new knowledge architectures and apps built on ontologies are being created for this new Web. Languages are required to communicate the meaningful data that the Web demands, which will end the heterogeneous data exchange in this heterogeneous world. It is a common assertion for all of these methods. In this case, we don't choose the Semantic Web's top language. Instead, we want to assist writers in selecting the best language for their modeling requirements (Gómez-Pérez & Corcho, 2002).

In order to make the creation of ontologies easier, our concept of "ontology learning" seeks to integrate a variety of fields, particularly machine learning. We view the process of ontology learning as semi-automatic with human involvement, employing the concept of balanced cooperative modeling for the creation of ontologies for the Semantic Web because completely automated knowledge acquisition by machines is still decades away. With this goal in mind, we created a framework that blends machine learning and knowledge acquisition, utilizing the resources that are currently available on the syntactic Free text, semi-structured text, design specifications (DTDs), etc. are all examples of web content. In our design, modules thus service various stages of the engineering cycle (Morik, 1993).

Steps in the ontology learning procedure

In order to make the creation of ontologies easier, our concept of "ontology learning" integrates many fields, particularly machine learning. Modules in the framework service various stages the subsequent five stages in the engineering cycle, which in this instance comprises of (Fig. 1).

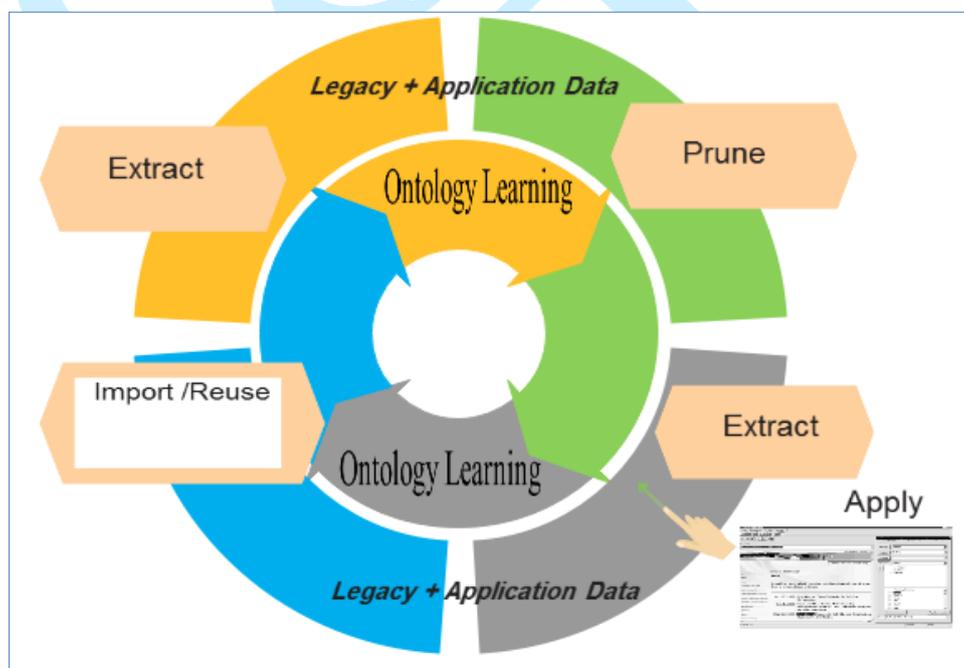


Fig. 1 Ontology Learning process steps

2. Related Work

We recommended some works related to the world of existence and the semantic web in recent years. We have summarized part of the huge business in this way. We compared previous works to each other and also to our own.

Alexander Maedche and others (2009) An ontology engineer's ability to build an ontology is greatly aided by their knowledge of ontologies. In order to enable a joint, semi-automated ontology learning process, we propose a number of complementary fields that pull from different types of unstructured and semi-structured data. process of existential engineering. By integrating, extracting, pruning, and refining ontologies, our ontology learning system continues to provide the ontology architect with an abundance of carefully selected tools for ontology modeling. Along with general design, the authors of this article present some standard Learning Ontology training methods that we used in our Environment for studying taxonomy using KAON Text-To-Onto. An official conception of a particular field of interest that a collection of people share is called an ontology. It is feasible to unify many software features that are primarily related to topic (like taxonomic structures) from those that are primarily related to processing (like querying) and data display when creating an ontology for information systems. (e.g. mapping). Programs for these information systems cannot be created with an implicit knowledge of the domain; instead, the domain perceptions must be made clear, which can be a challenging job, resulting to a well-designed program. - information barrier in knowledge engineering. While making your structures clear will enable easy scaling and adaptation is undoubtedly one response to this argument, which is also found in software engineering, it is still necessary to search for quicker and more affordable ontology design. Even though ontology building tools have improved over the past ten years, creating an ontology manually is still a time-consuming and difficult job (Maedche & Staab, 2004).

In 2000, Stefan Decker et al. The levels from the WWW that are presently accessible need to be topped off with a representation and inference layer. The writers suggest a general technique for encoding any ontology representation language into an RDF/RDF schema in order to build such a class. Applying the extension technique to a particular existential representation and reasoning language serves as an example of how it works (OIL). The "semantic Web," which is often referred to as the next iteration of the Web, will allow for the creation of personal websites, intelligent information services, and search engines that can understand natural language in addition to being meant for human users. Interoperability at the semantic level is necessary for the semantic web. Standards are needed for semantic compatibility in addition to the syntactic structure of texts. But also for computer processing, allowing language-enabled search engines, personal webpages, and sophisticated information services. Interoperability at the semantic level is necessary for the semantic web. Standards are needed for both the semantic substance and the syntactic structure of texts in order to achieve semantic interoperability. Recent W3C standardization initiatives, particularly the XML/XML Schema and the RDF/RDF Schema, have produced proposals targeted at semantic interoperability (Decker et al., 2000).

Hogan and others in 2020 More than 20 years ago, the first fundamental components of the semantic web were created. The past, present, and potential future impacts of the Semantic Web are still contentious issues. Given the results of more than two decades of research and development on the semantic web and associated technologies, the authors of this piece evaluate the semantic web's current state, its impact thus far, and potential future challenges. The writers begin by going over some outside critiques of this perspective made by various authors. They gathered specific critiques and presented arguments in favor of and against each one, depending on the acceptance level. We then, at that point, present the consequences of a review we put out on the Semantic Web mailing group to learn how much the original Semantic Web vision has been grasped and what impact it might have on the web from the respondents' point of view. (and different settings), its examples of overcoming adversity up to this point, as well as how much they concur with the above reactions of the semantic web concerning the two its present status and future reasonability. They closed by pondering future difficulties and open doors in the area (Hogan, 2020).

In their article, **Pouya Zangeneh and colleagues in 2020** suggest and assess the Unified Ontology to describe project knowledge that facilitates data gathering, processing, and use of big industrial projects throughout their life cycle. By allowing logical inferences and inferences, flexible growth, and data segmentation using linked data and the semantic web, the suggested Unified Presence project, or UPonto, offers a data framework for project analytics. Ontology facilitates cost normalizations, while defining global semantics for a variety of project risk factors and traits based on thorough study on pilot project risk and success literature, backed by practical considerations learned through expert input, we also used SPARQL to perform time queries and graph queries. creates the foundation for a knowledge network for an unstructured data endeavor; To enable smart IoT gadgets ingest project risk and identifier data, it also offers semantic meanings. The majority of sectors, including construction and those involved in the delivery process of large initiatives, have been impacted by the Fourth Industrial Revolution. These important paradigm changes did not, however, materially enhance the track record of project outcome prediction and resource estimation. One factor for this is the absence of common standards of data and knowledge representation that can be extended throughout the project lifetime to depict analytics megaprojects (Zangeneh & McCabe, 2020).

Dennis Diefenbach and others in 2020 The development of the semantic web has led to the availability of new organized data on the web in the form of knowledge libraries (KBs). Making this crucial data useful and accessible to end users should be one of the main goals of QA over KBs, claim the authors. The majority of contemporary QA tools execute 1 kilobyte, single language queries. (i.e. English). Existing methods are not designed to easily adjust to new language and data bases. First, the authors present an innovative method for translating verbal queries into SPARQL searches. It can question multiple KBs simultaneously in different languages and is readily adaptable to other KBs and languages. Wikidata, DBpedia, MusicBrainz, DBLP, and DBLP+ were the 5 different, well-known, big KBs that they used, and Spanish—to evaluate the effectiveness of our strategy. In order to make our strategy more approachable to the study community and end users, we then demonstrate how we have integrated it. To sum up, the writers offer a conceptual response to a multilingual query that the semantic web lacks the knowledge basis to address. The first estimate provided supports this idea (Diefenbach, Both, Singh, & Maret, 2020). Bin Hu and others in 2022 For more than ten years, educators have demanded change. The web-based semantic learning system has undergone numerous changes as a result of recent technological advancements. Development quickened after COVID-19 broke out last year. Providing students with online education, which differs greatly from conventional classroom instruction, is a current emphasis of many nations and educational systems. Students who attend classes online can set their own speed and learning methods. Education has thus become more active, as a consequence. Because of the system's constant change, it is challenging to describe customer demands. Many instructors advise using theory, machine learning, or artificial intelligence to enhance conventional teaching techniques. The authors chose to perform this poll because there aren't many studies that look at and contrast all web-based semantic education methodologies for researchers. They want to examine every potential web-based semantic learning system that could help new researchers advance their field of knowledge (Hu, Gaurav, Choi, & Almomani, 2022).

In 2022, Senthil Kumar Narayanasamy and others They provided a thorough analysis of the use of the semantic web in healthcare, as well as some virtual communities and other information retrieval initiatives, in this article. The demand for the semantic web in the fields of healthcare, online networks, and information search has grown significantly in recent years as its use has become increasingly widespread. Applying the appropriate ontology is essential to resolve doubts and prevent any ongoing conceptual errors in order to understand the words or terms used in the written content in the correct sense. This article has emphasized

all the material necessary for a comprehensive comprehension of the semantic web and its existential frameworks. With the help of the semantic web, which links users so they can create their own content, it is now simpler than ever to convey information in a way that computers can understand. As we advance closer to the Fourth Industrial Revolution, many real-time application development processes are being made possible by the implied use of AI-enabled semantic web technologies. In order to give data gathered from various sources a common label and pave the way for an example that can be replicated very easily, ontologies, which allow the uniform sharing and re-use of ideas, are the basis for the ubiquitous use of semantic web technologies (Narayanasamy, Srinivasan, Hu, Masilamani, & Huang, 2022).

3. Ontology Languages

During the most recent couple of years, and they will without a doubt become cosmology dialects with regards to Web of semantics. Some of them, like Metaphysics Markup Language (OML), Philosophy Trade Language (XOL),³ SHOE⁴ (which was newly based on HTML), and Asset Portrayal System, rely on XML punctuation. (RDF)⁶ and RDF Schema ⁷ are languages developed by World Wide Web Consortium (W3C) working groups. Finally, two additional languages, Cosmology Surmising Layer (OIL)⁸ and DAML+OIL⁹, are being built on top of RDF(S), the combination of RDF and RDF Pattern, to work on its components (Fig. 1). Additionally, various languages have typically been used when creating taxonomies (Gómez-Pérez & Corcho, 2002), however, that investigation is out of the extent of this article.

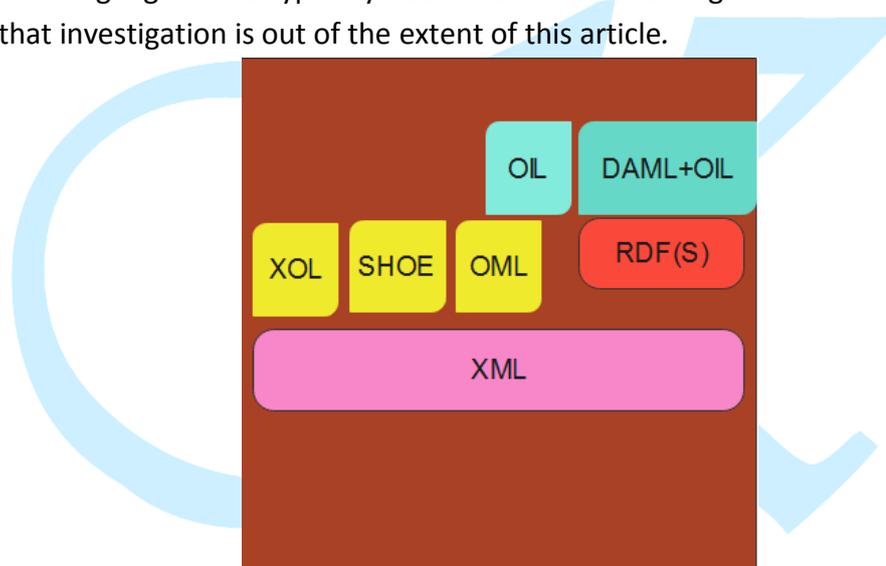


Fig.2 Shows how the Semantic Web's languages are stacked

4. Ontology Exchange Language based on XML

The US bioinformatics group developed XOL to facilitate ontology meaning exchange among a wide variety of software systems in their discipline. Researchers studied the pictorial needs of bioinformatics experts before developing it. In order to merge the OML grammar, built on XML, with the great versatility of OKBC-Lite, a subset of the Open Knowledge built Connectivity protocol, they chose Ontolingua and OML as the foundation for XOL. Ontologies cannot be created using XOL because there are no instruments for doing so. However, because XOL files use XML notation, we can create XOL files using an XML tool (Gómez-Pérez & Corcho, 2002).

5. The Resource Description Framework (RFD)

It is a language used to describe data about sites found on the World Wide Web. It is especially designed to depict metadata about Web resources, such as a Web page's title, creator, and modification date, a document's copyright and licensing information, or the expected release date of a shared resource. However, even if they can't be found right away on the Web, RDF can be used to describe information about things that can be identified there, by broadening the definition of a "Web resource". Examples include details about

products offered by online retailers (such as information about features, costs, and availability) or a summary of a Web user's preferred methods of receiving information. RDF is designed for scenarios in which this data must be processed by apps as opposed to simply being presented to users. RDF offers a standard structure for describing this data so that it can be transferred between apps without losing any of its original meaning. Designers of applications can take advantage of the availability of standard RDF parsers and processing tools because it is a common structure. Information that can be exchanged between apps can be made accessible to applications other than the ones for which it was initially designed (Manola, Miller, & McBride, 2004). <http://www.w3.org/TR/2004/REC-rdf-primer-20040210/> (3 of 107)04/05/2004 17:53:17 RDF is founded on the concept of naming objects using Web IDs, also known as Uniform Resource IDs (URIs). Resources can be described in terms of straightforward properties and property values and RDF Primer Identifiers (or URIs). As a result, RDF can express straightforward claims that resources can be represented as a network of nodes and lines that both depict the resources themselves and their characteristics and values. The collection of assertions "there is a Person identified by <http://www.w3.org/People/EM/contact#me>, whose name is Eric Miller, and whose email address is em@w3.org" has been included to help make this conversation clearer as soon as feasible (Manola et al., 2004), and whose title is Dr." could be represented as the RDF graph in Fig. 3.

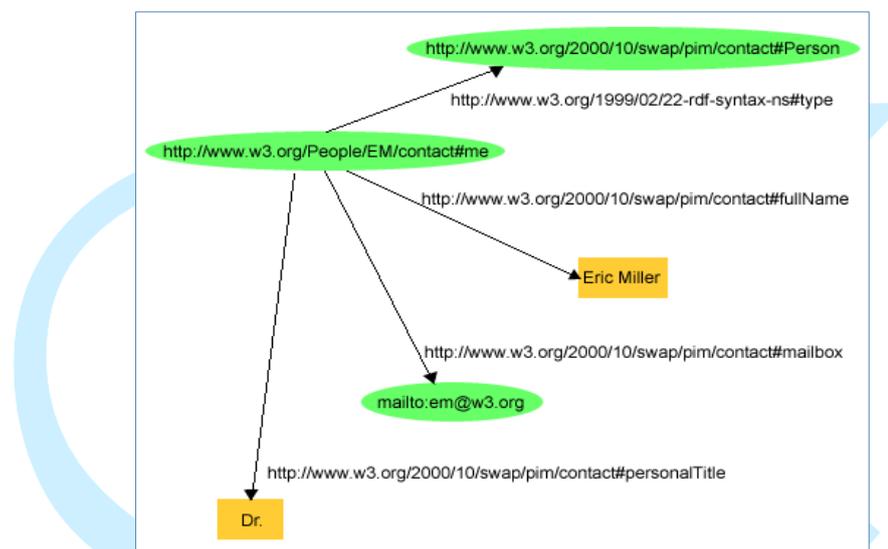


Fig. 3 Eric Miller as Described by an RDF Graph

Fig. 3 shows how RDF employs URIs to identify people, such as Eric Miller, who is recognized by the URI <http://www.w3.org/People/EM/contact#me> types of objects, such as Person, recognized by contact information from

<http://www.w3.org/2000/10/swap/pim/Person>; <http://www.w3.org/2000/10/swap/pim/contact#mailbox> lists the characteristics of those items, such as mailbox. numbers for those attributes, for instance <mailto:em@w3.org> as the value of the mailbox property (other values for properties in RDF include character sequences like "Eric Miller" and values from other datatypes like dates and numbers) (Manola et al., 2004).

6. XML

In the WWW world, XML [Bray et al, 1998] is now well-known and serves as the foundation for a large number of software development tasks that are expanding quickly. XML will only be briefly discussed in order to make this essay concise. Unlike HTML, which is a markup language for a particular type of hypertext document, XML is designed to be a markup language for random document format. A correctly nested collection of open and close tags with multiple attribute-value combinations for each tag makes up an XML document. The fact that the vocabulary of the tags and the permitted combos of them can be specified for each XML application is essential (Decker et al., 2000). A portion of the taxonomy presented above is serialized in the case shown in Fig. 4.

```

<class-def>
  <class name=" plant"/>
  <subclass-of>
    <NOT><class name=" animal" /></NOT>
  </subclass-of>
</class-def>
<class-def>
  <class name=" tree"/>
  <subclass-of>
    <class name=" plant"/>
  </subclass-of>
</class-def>
<class-def>
  <class name=" branch"/>
  <slot-constraint>
    <slot name=" is-p art-o P"/>
    <has-value>
      <class name=" tree"/>
    </has-value>
  </slot-constraint>

```

Fig. 4 Partial Ontology XML-Serialization

The fundamental data-model of XML is a labeled tree, and it is clear from the indentation of the sample above that each tag correlates to a labeled node in the data-model and that each nested sub-tag is an offspring in the tree². It is crucial to note that the XML syntax described above is just one option available for the taxonomy described above; in fact, it is the one specified in [Horrocks et al, 2000]. The same meaning information could have been specified in numerous other XML versions quite simply. For instance, although Fig. 6 is correct XML and includes basically the same information as the end class description in Fig. 3, it has a completely different syntactic structure (Decker et al., 2000). An individual ID-attribute can be assigned to an XML entity. Any node in the tree can link to any other node using this ID. As a consequence, this method can be used to encode any network. We stress that this is merely a tree-based representation of a general graph, and that a tree still serves as the fundamental data model. A well-formed XML text is one whose nested elements create a balanced structure. It is also possible to impose restrictions on the tags that must be used and the level of tag layering that is permitted. In XML 1.0

```

<class-def>
  <name>branch</name>
  <slot-constraint>
    <name>is-part-of</name>
    <has-value>tree</has-
value>
  </slot-constraint>

```

Fig. 5 XML-Serialization

7. Ontology Learning Architecture and Process Model

This section aims to introduce a generic ontology learning architecture and its four major components before going into detail about the conceptual model we have developed for our KAON Text-To-Onto system. Therefore, our process model builds on the basic idea of data mining as a process by incorporating the phases of business and data understanding, data preparation, modeling, evaluation, and deployment. (e.g., (Chapman et al., 1999)). This implies that, unlike some targeted ontology learning applications, for which one may choose to construct a particular processing workflow, our conception of ontology learning renders all process stages visible. The latter would need to be set up using the KAON Text-To-Ont general components (Maedche & Staab, 2004).

tools. A range of perspectives are offered to the spectator, focusing on the epistemological level as opposed to a particular representation language. However, the generated ontological structures can be exported to widely used Semantic Web representation languages, such as OIL and DAML-ONT, as well as our own F-Logic-based RDF extensions (Maedche & Staab, 2001).

Management component: The ontology specialist uses the administration component to select relevant resources, such as pre-existing ontologies, databases, HTML and XML documents, document type descriptions, and HTML and XML documents, for use in the following finding process. Additionally, using the management component, the ontology expert chooses an algorithm from the algorithm collection and from a selection of resource processing methods made available by the resource processing component (Maedche & Staab, 2001).

Association Rules: Finding associations between things, such as supermarket goods, in a collection of interactions, such as customers' orders, is one of the prototypical data mining uses for association rule learning algorithms. By focusing on descriptors at the proper taxonomy level, such as "snacks are purchased together with drinks" rather than The generalized association rule learning algorithm moves beyond its default to learn that "chips are bought with beer" and "peanuts are bought with soda". The user can add the derived connections by dragging and sliding them into the ontology. Before adding a relation to the ontology, the user can explore and select the suitable aggregation level by looking through the hierarchy view on derived properties as shown in the left-hand section of Figure. This view can also be used by the ontology developer to describe appropriate SUBPROPERTYOF connections between properties, like SUBPROPERTYOF.(HASDOUBLEROOM, HASROOM) (Maedche & Staab, 2001).

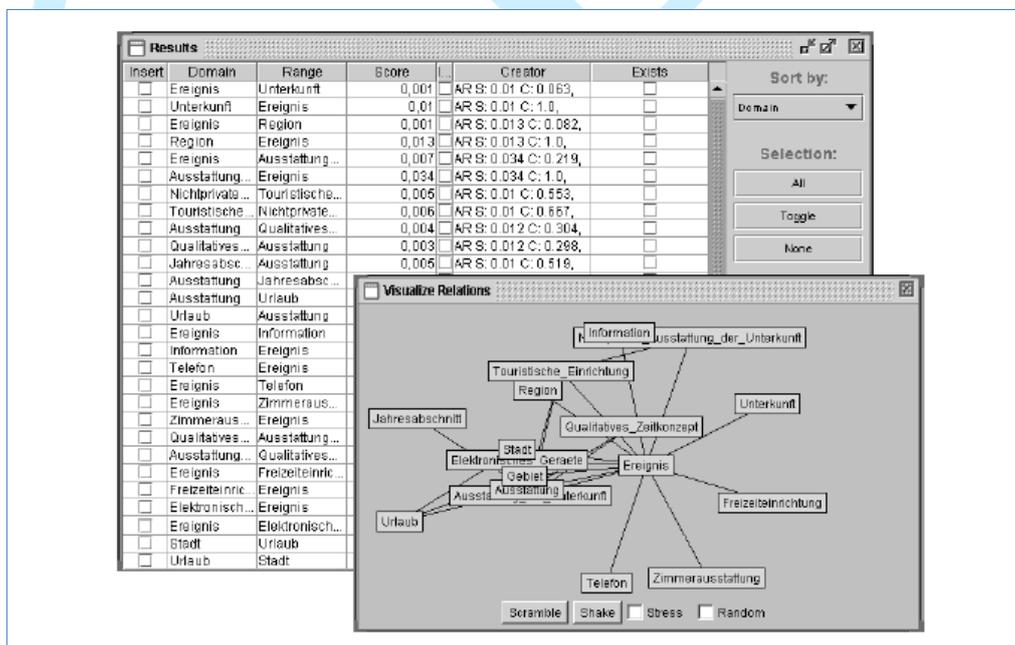


Fig. 7 Text-To-Onto Results Presentation

8. Ontology Management

Our ontology administration and application infrastructure, known as the Karlsruhe Ontology and Semantic Web Infrastructure (KAON), serves as the cornerstone of our approach, which enables simple ontology administration and application. A paradigm of ontology as described in serves as the foundation for KAON. Momentarily, the philosophy language depends on RDF(S), yet with clean division of demonstrating natives from the actual cosmology (accordingly staying away from the traps of self-depicting RDFS natives like subClassOf), giving means to displaying meta-classes and consolidating a few normally utilized demonstrating

natives, like transitive, symmetric and backwards properties, or cardinalities. All data is arranged into what are known as OI-models (ontology-instance models), which hold both the examples of ontology entities (concepts and properties) and their associated ontology entities. Each definition from the included OI-model is immediately made accessible when an OI-model includes another OI-model.

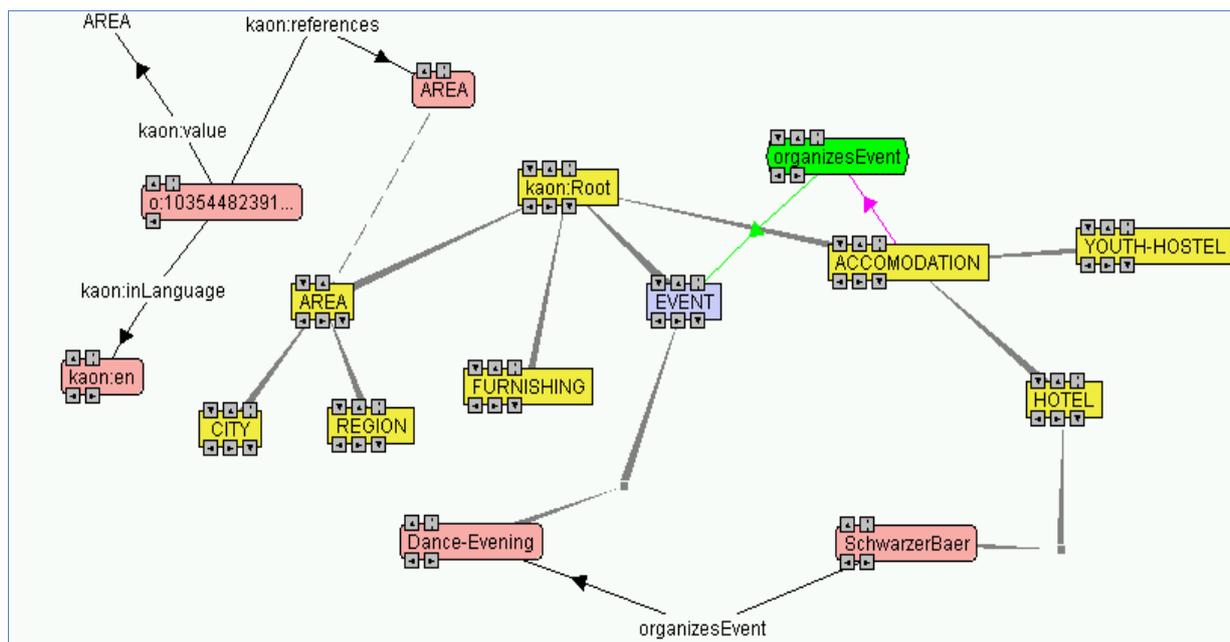


Fig. 8 OI-model illustration

An OI-model is expanded by a few particular elements that represent different lexical characteristics of ontology entities. For example, ideas like PLANET-VENUS (but also relations) have a name, such as "Venus" alternatives, such as "evening star" and "morning star," a lexical stem, and written evidence.

9. Algorithm for Learning Ontologies

Here are some examples of learning methods. They discuss various components of the ontology definition, which can also be examined independently of one another.

Lexical Entry & Concept Extraction

Counting the frequency of terms in a given collection of (linguistically preprocessed) documents, the corpus D , is a straightforward method for extracting pertinent lexical entries that may suggest ideas. In general, this method is predicated on the idea that a common word in a collection of texts that are unique to a given area denotes the presence of a pertinent concept. There are word weighting techniques that are more efficient than just tallying numbers, according to research on information retrieval. Based on the following metrics, a conventional information retrieval strategy is followed for word weighting.

Definition 1: Assume that $lef_{l,d}$ is the lexical entry l 's word frequency in the text d . Let df_l represent the lexical element l 's total document frequency. The lexical element l for the text d is then given by the form

$$tfidf_{l;d} = lef_{l,d} * \log\left(\frac{D}{df_l}\right) \quad (1)$$

$$tfidf_l := \sum_{d \in D} tfidf_{l;d}; \quad tfidf_l \in \mathbb{IR} \quad (2)$$

The criterion $K \in \mathbb{R}$ that $tfidf_l$ must surpass may be set and modified by the user. Following this threshold, words from the corpus are investigated for possible incorporation in the idea hierarchy and the collection of lexical entries.

10. Protégé -5.5.0 program

It is a program that builds an ontology, and here in this paper we relied on it to build the ontology of engineer Karrar Ali Mohsen, and this made our work easy. The foundation of his work and one of the most significant elements of the Semantic Web is ontology. It is well recognized as a means of illustrating ideas in our environment. By relating them to significant connections, which aids in a deeper comprehension of various ideas. By doing this, we can train the machine to comprehend meanings at a level that is comparable to that of a person. This research focuses on the fundamental ideas and principles of semantic web ontology and how it can help e-learning systems' semantic websites solve search and retrieval issues by performing in-depth analyses of digital material. The study focuses on reviewing the structural structure of ontology in the context of its relations with other basic components of the semantic web, in order to identify its role and demonstrate its effects in enhancing interactive services such as personalization, personalization, semantic navigation, collaborative work mechanisms, and interoperability between applications, in addition to exploring its impact on supporting and developing available services. See Fig. 9, Fig. 10, and Fig. 11 below, which are the stages of starting to build the ontology in this paper using this program.

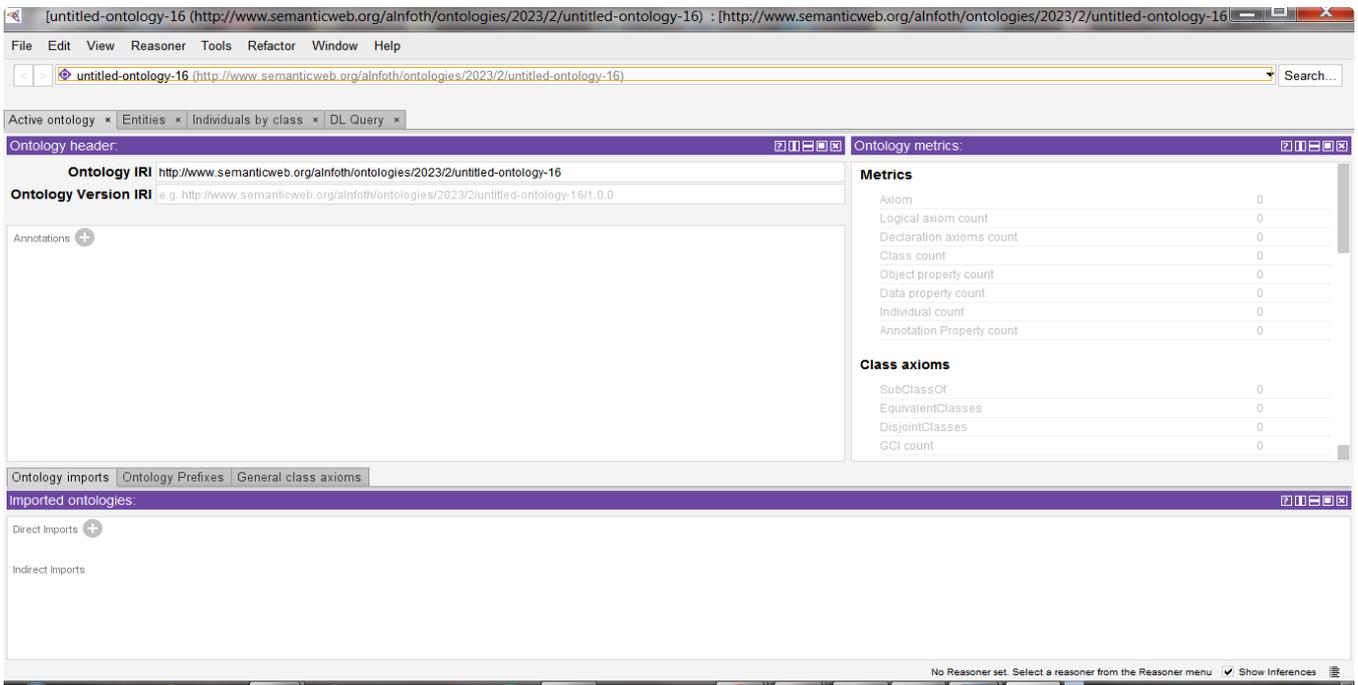


Fig. 9 Portage interface

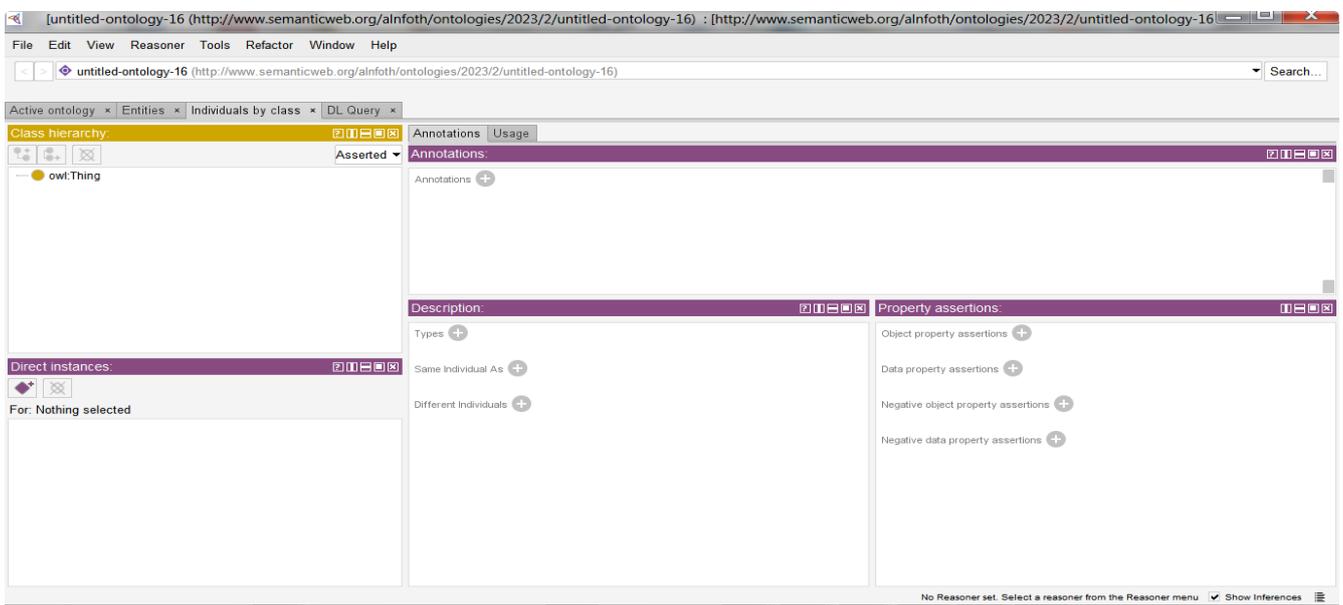


Fig. 10 Portage interface with ontology

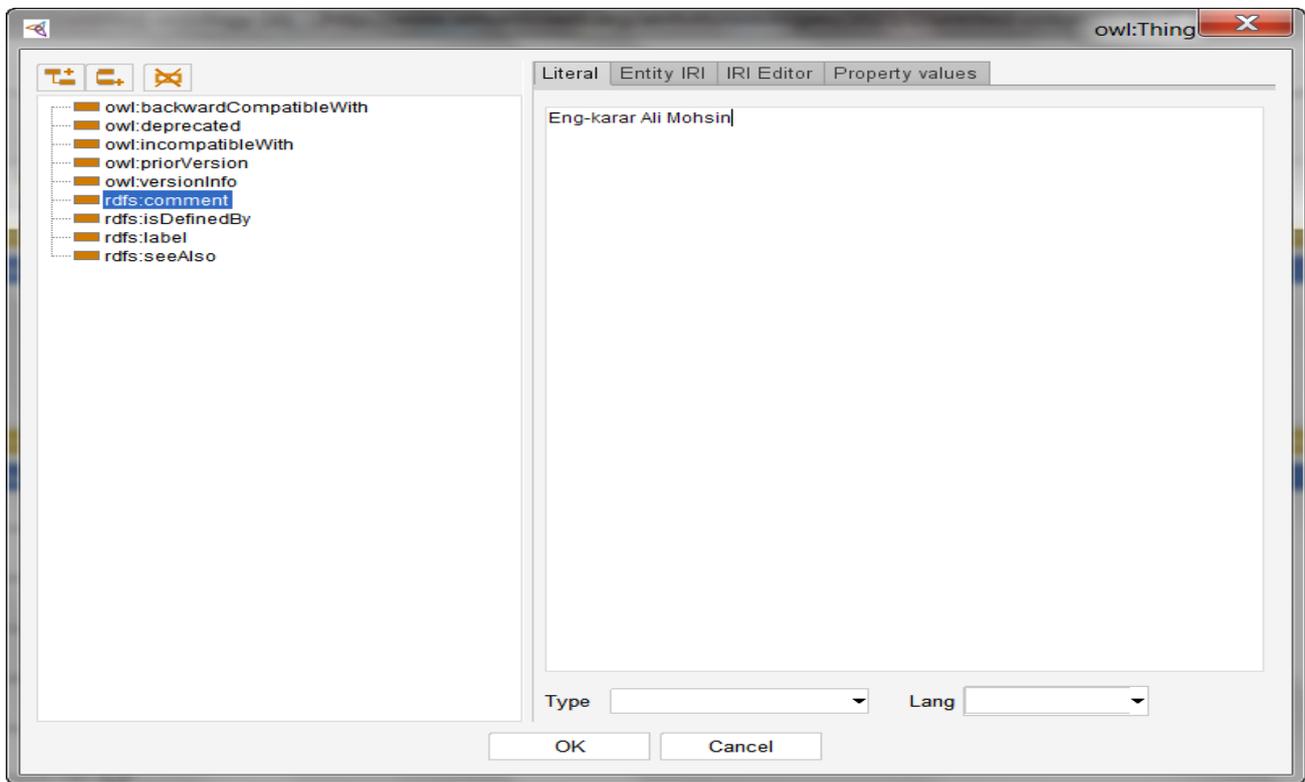


Fig. 11 Start building the ontology by the engineer

11. Results and discussion

Because it encourages the creation of domain ontologies, which we require rapidly and affordably for the Semantic Web to flourish, learning ontology can significantly increase the leverage of the Semantic Web. We provided a thorough structure for learning theory that transcends the limitations of particular fields. The Protege program, created by computer engineer Karrar Ali Mohsen, was used in this article to represent the offspring of the universe of existence. We got positive outcomes from this effort. See Fig. 1 to Fig. 11, which depict the most significant actions we took, from learning philosophy to creating the universe in the beginning to constructing it at the conclusion. In this manner, in this manner, we set an example for others. While there are still many issues in each field, new difficulties have emerged. Regarding the unique challenge of mastering the semantic web's taxonomy. First off, the idea of an ontology with clearly specified boundaries—i.e., only definitions enclosed in a single file—would vanish with XML-based namespace mechanisms. As an alternative, since ontologies incorporate and reference one another, the semantic web may become "amoebalike" in terms of ontology borders (see for example primitive DAML-ONT import). However, it is still unclear how these forms will be semantically. These findings highlight the significance of techniques like theory, Ontology will increasingly undergo trimming and spreading. Second, we have limited our focus on learning ontology to the (almost) complete mental structures found in RDF(S) up to this point. A novel method of ontology design optimization with axioms would also be needed for additional semantic layers on top of RDF, such as OIL or DAML-ONT with axioms.

12. Conclusion

We have described ontology learning as a strategy that could make building the ontology builder much simpler to use ontologies. This article introduces the concept of "ontology learning," which aims to bring together a number of fields to make the creation of ontologies simpler. The complete process is believed to be semi-automatic with human participation. The "balanced cooperative modeling" method, which outlines a planned interaction between a human modeler and learning software, is the foundation for creating ontologies for the Semantic Web.

Funding Information

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Conflict

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Chapman, P., Clinton, J., Kerber, R., Khabaza, T., Reinartz, T., Shearer, C., & Wirth, R. (1999). The CRISP-DM user guide. Paper presented at the 4th CRISP-DM SIG Workshop in Brussels in March.
2. Decker, S., Melnik, S., Van Harmelen, F., Fensel, D., Klein, M., Broekstra, J., . . . Horrocks, I. (2000). The semantic web: The roles of XML and RDF. *IEEE Internet computing*, 4(5), 63-73.
3. Diefenbach, D., Both, A., Singh, K., & Maret, P. (2020). Towards a question answering system over the semantic web. *Semantic Web*, 11(3), 421-439.
4. Gaines, B. R., & Shaw, M. L. (1992). Integrated knowledge acquisition architectures. *Journal of Intelligent Information Systems*, 1, 9-34.
5. Gómez-Pérez, A., & Corcho, O. (2002). Ontology languages for the semantic web. *IEEE Intelligent systems*, 17(1), 54-60.
6. Hogan, A. (2020). The semantic web: Two decades on. *Semantic Web*, 11(1), 169-185.
7. Hu, B., Gaurav, A., Choi, C., & Almomani, A. (2022). Evaluation and comparative analysis of semantic web-based strategies for enhancing educational system development. *International Journal on Semantic Web and Information Systems (IJSWIS)*, 18(1), 1-14.
8. Maedche, A., Motik, B., Stojanovic, L., Studer, R., & Volz, R. (2003). Ontologies for enterprise knowledge management. *IEEE Intelligent systems*, 18(2), 26-33.
9. Maedche, A., & Staab, S. (2001). Ontology learning for the semantic web. *IEEE Intelligent systems*, 16(2), 72-79.
10. Maedche, A., & Staab, S. (2004). Ontology learning Handbook on ontologies (pp. 173-190): Springer.
11. Manola, F., Miller, E., & McBride, B. (2004). RDF primer. *W3C recommendation*, 10(1-107), 6.
12. Morik, K. (1993). Balanced cooperative modeling. *Multistrategy Learning: A Special Issue of Machine Learning*, 109-127.
13. Narayanasamy, S. K., Srinivasan, K., Hu, Y.-C., Masilamani, S. K., & Huang, K.-Y. (2022). A contemporary review on utilizing semantic web technologies in healthcare, virtual communities, and ontology-based information processing systems. *Electronics*, 11(3), 453.
14. Webb, G. I., Wells, J., & Zheng, Z. (1999). An experimental evaluation of integrating machine learning with knowledge acquisition. *Machine Learning*, 35, 5-23.
15. Zangeneh, P., & McCabe, B. (2020). Ontology-based knowledge representation for industrial megaprojects analytics using linked data and the semantic web. *Advanced Engineering Informatics*, 46, 101164.