Artificial Intelligence Techniques in Semantic Web Services

IJIMSR, Vol. 2, No. 2, (2024) 24.2.2.020

Dr. Vijay Kumar Burugari
Department of Computer Science and Engineering
Koneru Lakshmaiah Education Foundation
Vaddeswaram, Guntur, Andhra Pradesh, India
Email: vijaybru@kluniversity.in.

***Dr. Vijaya Chandra Jadala**
School of Computer Science and Artificial Intelligence
SR University, Warangal, 506371, Telangana, India
Email: vijayachandra.phd@gmail.com

***Corresponding author**

Received 4th June 2024; Accepted 29th July 2024

KEYWORDS: Semantic Web, Resource Description Framework, Ontology Tools, Artificial Intelligence, Web Ontology Language, Ontology.

Artificial Intelligence Techniques in Semantic Web Services

Dr. Vijay Kumar Burugari
Department of Computer Science and Engineering
Koneru Lakshmaiah Education Foundation
Vaddeswaram, Guntur, Andhra Pradesh, India
Email: vijaybru@kluniversity.in.

Dr. Vijaya Chandra Jadala
School of Computer Science and Artificial Intelligence
SR University, Warangal, 506371, Telangana, India
Email: vijayachandra.phd@gmail.com

ABSTRACT

It relates to the conventional machine interaction services, is the server end of a Client-Server system relates to the data on web that is understandable by the machines, its primary objective is to permit the humans and machines together. The World Wide Web is progressing quickly in the direction of the concept of semantic language for database. The ontology tool Protégé consists of the SPARQL Query Tab to execute the queries, whereas the alternative is the Apache Jena Fuseki. The semantic web framework is comprised of different Application interfaces that interacting collectively to execute RDF data. The Fuseki supports the SPARQL queries over Hyper Text Transfer Protocol. Apache Jena Fuseki is based framework for developing Artificial Intelligence Techniques in Semantic Web Services. The proposed methodology can handle queries of various convolutions and complexities. Semantic web services on the server end provide structured and standardized information about the services they offer, typically using technologies related to ontology ensure that the data is both readable and process by machines based on ontology. The Experimental Analysis is given along with the results based on different ontology based technologies. In the disciplines of design, Thinking and implementation, along with representation ontologies are used for semantic web services.

KEYWORDS: Semantic Web, Resource Description Framework, Ontology Tools, Artificial Intelligence, Web Ontology Language, Ontology.

1. INTRODUCTION

The Semantic Technology supports the artificial intelligence systems to understand the artificial intelligence web languages for process data to the information in the same way as humans do, based on the formal semantics. Semantic Technology principal objective is to allocate to handle to suggest meaning and knowledge from information to assist users in their activities. The Research objective at semantic web technology is to facilitate machines to understand data. Ontology based semantic web technologies are identified and understood of level in depth that provides and facilitates capabilities which provide intelligent factor, efficient, skilled relevant, and approachable based interaction between the humans and machines at improved information technologies [1].

Artificial Intelligence Technology which gives well-organized implication systems accelerate awareness illustrates estates subject matter and adjuncts knowledge databased systems. The Semantic Web organizes information in a structured and systematic manner, facilitating better understanding and interpretation by both humans and machines. Interconnection of Data enables the establishment of meaningful relationships and connections between different pieces of content and data on the web, fostering a more coherent and integrated web of knowledge. The Semantic Web ensures that the exchange of knowledge, data, and information is precise and unambiguous, reducing misunderstandings and enhancing interoperability. The Semantic Web aims to empower machines to understand and process specific information intelligently, assisting humans in obtaining high-quality results based on well-defined knowledge bases and contexts. Metadata plays a crucial role in the Semantic Web ecosystem. It serves as data about data, providing additional context and information to facilitate discovery, interpretation, and utilization of web resources. Multimedia metadata, utilized for describing multimedia content, enriching its representation, and enabling more effective search and retrieval. [2].

The Education domain ontology is selected domain which gives a comprehensive idea tailored to specific aspects of education, developers can create more specialized and efficient systems for managing, sharing, and analysing educational data and resources within universities and educational institutions. These ontologies contribute to the broader goal of the Semantic Web by enabling more intelligent and interoperable educational systems and services [3].

For the Ontology development, I taken the scenario of the University in the Education Domain. The scenario consists of the faculty, students, and modules, where faculty teach modules and the students study the modules. The relationship between the students and faculty depends on the modules. Here, the concepts are two that is faculty teaches the modules and students studies the modules. The different concepts in relation between faculty, students, and modules that to be identified based on the classes, data properties, object properties and individuals [4]. Classes and object properties are fundamental components of ontologies, providing the structure and semantics necessary to represent knowledge in a formal and interoperable manner. Classes organize entities into meaningful categories, while object properties define relationships between these entities, enabling rich and expressive representations of domain knowledge. The properties are transitive or symmetric based characteristics [5]. we can claim supplementary information regarding properties such as domain and range, along with identifying inverse properties. In object properties are involved with illustrating how classes can correlate to each other based on their instances. The object properties are based on teaching and studying [6]

The layered architecture of the AI based Web provides a mechanism for understanding and implementing the technologies and standards that enable the creation, sharing, and consumption of machine-understandable data on the web. Each layer builds upon the one below it, contributing to the overall goal of making the web more intelligent and interconnected. The layered architecture proposed by Tim Berners-Lee helps to conceptualize the Semantic Web's infrastructure and the relationships between its various components, facilitating the development and adoption of semantic technologies and applications [7].

2. RELATED WORK

2.1 Resource Description Framework (RDF) is a specification prototype for data transaction on World Wide Web designed for the meta data model handles XML based Syntax. It provides data merging facility under different schemas. It facilitates time schedules for web events where machines can understand the code. RDF recognizes things utilizing web identifiers which means uniform resource identifiers that defines resources with property values and properties. [5] RDF declarations are association of resource, property value and properties to form a Statement. The ontology facilitates the machines to understand the sentence, where sentence consists of subject, predicate, and object. the declaration vocabularies are RDF Schemas that establishes based on different methodologies. RDF schemas play a critical role in specifying the semantics and property types used in RDF descriptions, allowing for the consistent representation and interpretation of data within a specific community or domain. The XML namespace mechanism facilitates the identification and referencing of RDF schemas within RDF documents, ensuring interoperability and consistency in RDF-based data modelling and exchange [8].

2.2 Protégé is an ontology and knowledge-based editor that has user-friendly interface that simplifies the creation, editing, and management of ontologies which is produced by Stanford University. Protégé is a versatile and powerful tool for ontology development and knowledge engineering, offering a range of features and capabilities to support users in creating and managing ontologies effectively. Its support for various user roles and its flexibility makes it a valuable resource for ontology developers across different domains [9].

2.3 Apache Jena Fuseki serves as a robust and versatile SPARQL server, providing support for querying and manipulating RDF data using the SPARQL query language. Its flexibility in deployment options and support for SPARQL protocol make it a popular choice for building RDF-based applications and services as a

Java web application (WAR file), and as a standalone server. It supports the SPARQL protocol and RDF Query Language that supports insert, update, delete and manipulate database based on instruction given through queries. It even supports the retrieval of information based on the SELECT Queries and Clauses [10].

2.4 SPARQL is a powerful and versatile query language for working with RDF data, providing a standardized way to retrieve and manipulate information in Semantic Web applications and systems. Its capabilities for querying diverse data sources and expressing complex graph patterns make it a valuable tool for extracting knowledge from RDF datasets [11].

In Artificial Intelligence, is the substance that blends techniques based on Ontologies that correspond to a feasible approach to produce by combining dissimilar information domains can support ontology? The crucial characteristics for validating different types of knowledge are logic, ontology, and computation based on the cross-domain and system analyses. By providing machine-readable descriptions, semantic web services enable more efficient discovery, integration, and utilization of web resources and functionalities. This facilitates automated interactions and integration of various services, ultimately enhancing the interoperability and functionality of distributed systems on the web. The semantic technologies are concentrated on a specified language, simulations, prototypes, mechanisms, methodologies.

3. EXISITNG MODEL DESCRIPTION

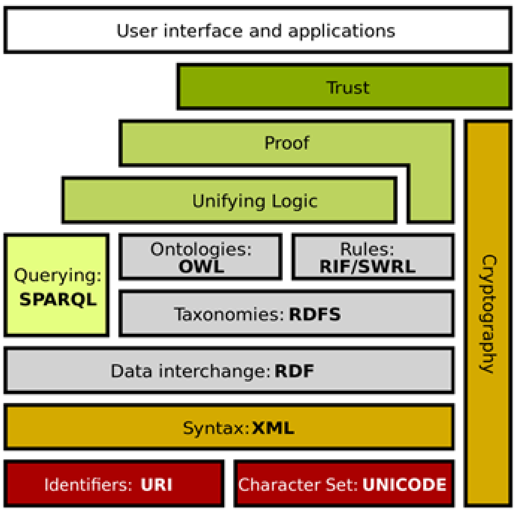

Figure 1: Semantic web Layers

3.1 Uniform Resource Identifiers (uris): A uri is a string of characters that provide a means for referencing and accessing resources, such as web pages, documents, or data entities, in a globally unique manner, which provides mean to uniquely identify a Semantic Web resource.

3.2 Unicode: These are the serves which represents influence text, allows for the encoding of a wide range of characters and symbols used in human communication.

3.2.1 XML: It is an Ontology based One of the Semantic Web objectives, that is to provide significance to organized documents.

3.2.2 Rdf: It generally utilized to identify and differentiates between the class and the set of instances. Were each class is associated with a set.

3.2.3 Rdf Schema (rdfs): RDFS is a vocabulary jointly associated with RDF which provides a set of terms. RDFS provides a foundational vocabulary and framework for creating ontologies in the Semantic Web. It enables developers to define the structure, semantics, and relationships of RDF data, facilitating more effective data integration, sharing, and interpretation on the web.

3.2.4 RIF/SWRL: RIF and SWRL are both rule languages used in the Semantic Web context, with RIF focusing on rule interchangeability and SWRL specifically tailored for reasoning over RDF data within OWL ontologies. They play complementary roles in enabling the specification and execution of rules for semantic web applications and systems.

3.2.5 OWL: It extends the capabilities of RDF and RDFS by providing more advanced constructs for describing ontologies and representing knowledge on the Artificial Intelligence based Web. It permits the construction of more expressive and sophisticated ontologies that can be used for reasoning, data integration, and knowledge representation in various domains.

3.2.6 The Rule Interchange Format (rif): RIF enables the exchange and Inter-change of rules between different rule-based systems and languages within the Semantic Web ecosystem. The widespread technologies that support networks, sensors, ontologies, and semantic web has created Artificial Intelligence based systems, which supports the soft computing. It promotes interoperability, collaboration, and knowledge sharing in rule-based reasoning tasks, facilitating more effective and efficient utilization of rules in Semantic Web applications and systems.

3.3 Components that Support Semantics

3.3.1 RDF is the Semantic web ontology format that practices storing information on AI based semantic graph database Web.

3.3.2 SPARQL is query-based language uses queries such as create, select, insert for semantic web ontology. Purposely, intended to query data through numerous systems and databases, and to retrieve and process data stored in RDF format.

3.3.3 OWL provides a powerful language and framework for defining ontologies and representing knowledge on the Semantic Web. It supports the formalization of domain-specific concepts, relationships, and constraints, enabling more effective data integration, sharing, and reasoning in various application domains.

3.3.4 Protégé is open-source ontology editor where it can be download able freely, it is the best knowledge-based framework that support web ontology. Protégé is widely regarded as one of the best ontology editors available, offering a powerful yet user-friendly environment for ontology development and Semantic Web application development. Its open-source nature and extensive feature set make it a valuable tool for anyone working with ontologies and knowledge representation.

3.4 Reasons For Developing Ontology

3.4.1 To enable reuse of domain knowledge is one of the best reasons for leading services following recent methodologies in ontology research.

3.4.2 To make domain assumptions explicit creates the situation feasible to modify these assumptions based on the knowledge related to artificial intelligence about domain modifications.

3.4.3 To distinct domain based on knowledge from different operations, where large ontologies are constructed with the integration of the several existing ontologies based on the domain interest.

3.4.4 To analyse domain knowledge based on the client interest and needs different tools related to Ontologies are provided along with the comprehensive description of the domain.

4. DESIGNED MODEL

The System structure encompasses the essential components required for processing user queries, mapping them to relevant concepts in the system's ontology, and retrieving accurate answers from the underlying data sources. By integrating these components seamlessly, the system aims to provide effective and efficient question answering capabilities to users. The structure is composed of steps starting from Processing of data to Information retrieval. A semantic web service is indeed a type of web service that operates within the framework of the semantic web. Artificial Intelligence based web technologies enables Information to be distributed and understood by computers and humans alike. Semantic web services aim to provide machine-readable descriptions of their capabilities, interfaces, and behaviours, allowing automated invocation. Currently, a massive volume of data on the internet is based on the ontology and semantic web.

Data Processing: The Data Processing component serves as the foundation for the QA system, providing the necessary infrastructure and mechanisms for managing and representing domain knowledge effectively. It enables the system to answer questions within a specific domain while demonstrating its potential for broader applicability across diverse knowledge domains [10].

4.1 Question Processing: The Question Processing component of your QA system is responsible for handling natural language queries and converting them into a format suitable for further processing. Here are the Seven steps involved in this process: -

4.1.1 Normalization: In the Context of Text Processing, refers to the process of transforming text data into a standard or canonical form. It converts all letters to lowercase or uppercase to ensure consistency in letter case.

4.1.2 Tokenizing: It involves breaking down the query into individual words or tokens. This step helps to segment the query into manageable units for further analysis.

4.1.3 Elimination: It involves removing punctuation that is stripping out punctuation marks from the text to focus on the words themselves, eliminating common words that occur frequently in text but do-not carry significant semantic meaning, such as “the”, “is”, “and” etc., 4.1.4 Stemming: Reducing words to their base or root form by removing suffixes or prefixes. For example, stemming transforms words like "running" and "ran" to their root form "run".

4.1.5 Tagging: Tagging plays a crucial role in various Natural Language Processing and semantic web tasks, including information extraction, sentiment analysis, machine translation, and more. It helps in understanding the structure and meaning of text data, enabling computers to process and analyse natural language text more effectively.

4.1.6 Word Mapper: The words are mapped with Ontological Dictionary, where a large quantity of specific words are identified and mapped with concepts, classes and Instances.

4.1.7 Retrieval of Information: A set of rules are introduced and a snippet is generated to identify the SPARQL query from the Natural Language query based on the addictions and complication between the query relationships for the information retrieval [11].

4.2 Steps involved in Model Execution and Evaluation

4.2.1 Implementation of the model

- The Ontology development with the example of University, where University Ontology in Education Domain is selected.
- The First Step is to create a new project.
- Step 2 is to select the options like OWL DL or OWL lite or OWL Full etc for the new project.
- PROTÉGÉ Editor is used to create the University Ontology.

4.2.2 Testing the model

- Query Retrieval Process: “Queries” tab is used to show how we can run the query and find the Particular Information about any Certain Instances or Classes.

4.3 Model Evaluation

The Fundamental steps which are key in the development of an ontology using a tool are

- Obtain Domain knowledge: An in-depth understanding into knowledge representation regarding domain and a comprehensive knowledge of the corresponding domain is essential for model design and construction of any domain ontology.
- Identify the key concepts: The major identifiable Concepts that signify the domain are identified and hence executed by methods of classes.
- Build the taxonomy: The class hierarchy is created by creating the class and their respective subclasses, and instances of classes.
- Identify relationships between classes: To recognize relations between the classes the Properties are identified and applied.
- Consistency checking: The domain ontology design model and implementation must be checked for regularity using reasoners.
- Implementation of ontology: It involves deployment of ontology to enable machine-to-machine communication.

4.4 Results and discussions·

Graphical Representation: “TGViz” tab in Protégé provides a graphical visualization of the ontology's class hierarchy, allowing users to explore the relationships between classes and subclasses. Majorly focusing on class hierarchy, to represent as a node in the graph, and the relationships between them are represented as edges. Users can navigate through the graph to explore the connections between different classes and subclasses. This allows them to understand the hierarchical structure of the ontology and how different concepts are related to each other. The visualization provides options for exploring the paths between classes and subclasses. Users can identify the possible routes to reach a specific class or subclass from any other class or subclass in the ontology. The "radius" option allows users to adjust the distance between nodes or classes in the graph. This can help in better visualizing the relationships between classes and understanding the hierarchy more clearly. Overall, the "TGViz" tab in Protégé enhances the understanding of the ontology's structure by providing a visual representation of the class hierarchy. It facilitates navigation, exploration, and analysis of the ontology, enabling users to effectively work with and evaluate the ontology model.

5. EXPERIMENTAL ANALYSIS

Protégé is a free, open-source platform that provides a growing user community with a suite of tools to construct domain models and knowledge-based applications with ontologies.

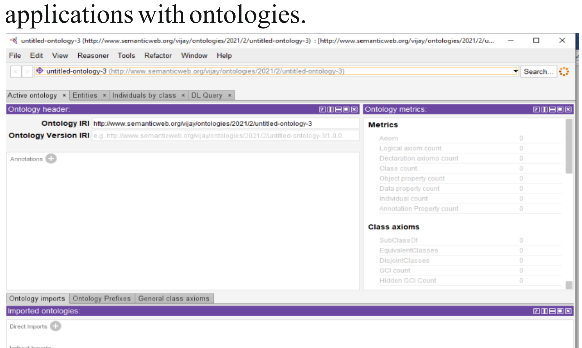

Figure 2: The ontology software Protégé 5.5 First Screen

Now I am going to build the ontology for the University, the main objective is to identify the students, faculty, and courses. The version I taken is 5.5, which is the latest version of the Protégé. The next step is saving the file as university and extension as owl. For the annotation we can add the description, so I am adding the description as This ontology that is about University. Next select the language as en(English), then press ok. Now RDFS comment will be appeared on the Annotations.

Now it's time to create the classes, where the classes are the sets, collections, concepts, types of objects or kinds of things. Now click on the option classes on the Tab menu, Classes which are also called as instances defines names of the relevant domain and their logical characteristics. The class hierarchy will be displayed on the menu or main screen, Class hierarchy: OWL Thing. Classes may be organized into a superclass-subclass hierarchy, which is also known as a taxonomy. Subclasses specialize that 'are subsumed by' their super-classes. Create a Class called University and two subclasses that is Faculty and students. Now we must give courses so that the courses will be handled by the Faculty and courses will be taken by the students. So, the relation between the students, faculty and courses can be handled using ontology. “OWLViz” tab is used which shows a graph corresponding to the subclass which provides the possible route and options of how one can reach to any class or subclass from any other class or subclass. The path distances between the nodes/classes distances between the nodes/classes can be varied using radius option.

6. CONCLUSION

This research has examined to develop and implement an ontology using Protégé, the process begins with launching the Protégé software, which serves as the foundation for constructing the ontology model. The next step is selecting the appropriate ontology language based on the complexity of the domain; if the domain requires complex relationships, OWL (Web Ontology Language) is chosen, otherwise, RDF (Resource Description Framework) is selected for simpler applications. Development of the ontology within Protégé involves opening a new project and creating ontology classes. Each class is meticulously defined with a hierarchy, properties, and specific data types and constraints to accurately represent the domain. Once the ontology is constructed, the query retrieval process is completed by defining and executing SPARQL queries to extract and store relevant data. To ensure the ontology's accuracy, domain knowledge is obtained through expert consultations and the gathering of domain-specific literature. Building the taxonomy involves creating a hierarchical structure of concepts, defining parent-child relationships, and linking these concepts with properties and attributes. The ontology is then validated using a reasoned or validator to ensure consistency and logical correctness in all relationships. After validation, the ontology is exported in the required format (such as OWL or RDF) and integrated with the target system or application. Result analysis involves comparing ontology-based results with expected outcomes to identify areas for improvement and refinement. Finally, graphical analysis using the TGViz tool helps visualize the ontology's structure, providing insights into the relationships and dependencies among different concepts.

REFERENCES

[1] Amara, F.Z., Hemam, M., Djezzar, M., Maimor, M.: Semantic web and internet of things: challenges, applications and perspectives. J. ICT Stand. 10, 261–292 (2022).

[2] Chatzimichail, Angelos & Stathopoulos, Evangelos & Ntioudis, Dimos & Tsanousa, Athina & Rousi, Maria & Mavropoulos, Athanasios & Meditskos, Georgios & Vrochidis, Stefanos & Kompatsiaris, Ioannis. (2020).

[3] Gascueña, José & Fernández-Caballero, Antonio & González, Pascual. (2006). Domain Ontology for Personalized E-Learning in Educational Systems. 456 - 458. 10.1109/ICALT.2006.1652470.

[4] V. Rana and G. Singh, "Analysis of web mining technology and their impact on semantic web," 2014 Innovative Applications of Computational Intelligence on Power, Energy and Controls with their impact on Humanity (CIPECH), Ghaziabad, India, 2014.

[5] Ghadeer Ashour, Ahmad Al-Dubai, Imed Romdhani, "Ontology-based Course Teacher Assignment within Universities", IJACSA) International Journal of Advanced Computer Science and Applications, Vol. 11, No. 7, 2020.

[6] Sanjay Kumar Malik et. al. "Developing an University Ontology in Education Domain using Protégé for Semantic Web", International Journal of Engineering Science and Technology, Vol. 2(9), 2010, 4673-4681.

[7] Patel, A., & Jain, S. (2019). Present and future of semantic web technologies: a research statement. International Journal of Computers and Applications, 43(5), 413–422. https://doi.org/10.1080/1206212X.2019.1570666.

[8] Alaoui, K., Bahaj, M. (2020). Semantic Oriented Data Modeling Based on RDF, RDFS and OWL. In: Ezziyyani, M. (eds) Advanced Intelligent Systems for Sustainable Development (AI2SD'2019). AI2SD 2019. Advances in Intelligent Systems and Computing, vol 1105. Springer, Cham. https://doi.org/10.1007/978-3-030-36674-2_42

[9] L. Bi, X. -q. Di and Y. Zhang, "Ontology modularization method based on the K-PSO algorithm," 2016 9th International Congress on Image and Signal Processing, BioMedical Engineering and Informatics (CISP-BMEI), Datong, China, 2016, pp. 2009-2013, doi: 10.1109/CISP-BMEI.2016.7853049.

[10] Han Li, Tianzhen Hong (2022), "A semantic ontology for representing and quantifying energy flexibility of buildings", Advances in Applied Energy, Volume 8, December-2022, 100113, ISSN 2666-7924, https://doi.org/10.1016/j.adapen.2022.100113.

[11] Liang, S., Stockinger, K., de Farias, T.M. et al. Querying knowledge graphs in natural language. J Big Data 8, 3 (2021). https://doi.org/10.1186/s40537-020-00383-w.