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Ontology-Based Recommender System of Online Courses

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Abstract: Nowadays it is observed that everyone is learning new things to progress in their career through the internet and online courses. Online courses are the best source of learning, and it is helping students, graduate students, and employees to enhance their knowledge and skills. With the increased information on the internet about online courses, it has made it difficult for the learners to make decisions on courses that meet their requirements. A wide range of online courses are available on the internet from different organizers or providers and finding information regarding online courses from many websites is a challenging and time-consuming process. Therefore, we developed an ontology with a common knowledge base that provides a recommendation to help the learners to select the most appropriate course depending on their requirements. For this purpose, classes (subclass and superclass) and their properties (object properties and data properties) with constraints (facets) were defined depending on the scope and domain specified by the Competency Questions (CQs). Next, the ontology was populated with instances to test and check the consistency of the ontology with the reasoner. After testing and querying the ontology using SPARQL in protégé, it is concluded that the ontology developed is consistent and perfectly meets the requirements which were defined by domain to answer the CQs. With this kind of ontology, one can find interesting courses with different categories and get recommendations on courses based on requirements. For the future scope, ontology can include more categories of courses and real instances for a better recommendation.

Keywords: **Competency Questions, Online Course, Ontology, Reasoner and Recommendation**

I. INTRODUCTION

Online courses allow learners to access course contents through the network and study them in virtual classrooms [10]. It benefits learners since learning can be at any time or any place. However, there is vast information available about online courses on the internet and finding information regarding online courses from a large number of websites is a challenging and time-consuming process. Helping learners to make the correct choice from a myriad of available courses to meet their individual needs is a real challenge [3]. Such abundant information means that learners need to search, organize, and use the resources that can enable them to match their individual goals and interests. This can be a time-consuming process as it involves accessing each platform, searching for available courses, carefully reading every course syllabus, and then choosing the one that is most appropriate for the learners [6]. Therefore, to address this problem we build the ontology with a common knowledge base that recommends the courses for learners on a need basis.

There are many online courses available on the internet. The Internet is a vast source of information that has information related to all online courses that are available in different fields. However, each user has a specific need, and finding the course they really need is time-consuming. Each user has a specific need and there is a need for a system that can fulfill such users' needs. The main objective of this research is to develop an ontology that will recommend users who are interested in learning and finding interesting courses that suit them. The scope of the study is limited to only three areas as of now which are Data Science, Software Engineering, and Networking. Therefore, ontology will not be able to answer the queries out of these areas.

The main purpose of the ontology is to suggest learners with suitable online courses in areas as three categories mentioned above. The factors which are used to make suggestions are like the organizer of the course, the number of hours required for each course to complete, nature of assessment for the course, the fee of the course, author of the course, last updated date of course, course session (Recorded or Live), prerequisites of the courses, advancement courses, course rating and status of certificates (available or not). Further, users can make the queries based on a single factor or combination of factors. The ontology can give recommendations to the users based on either of the single factors or a combination of factors. For instance, users can query for the courses with a high rating, with certificates, and from a particular author. Ontology has 5 main classes (*Course, Learners, Author, CourseCategory, and CourseOrganizer*) which were created using protégé, and the queries were done using SPARQL.

The main users of our ontology are people who are interested in taking online courses. Ontology developed can help any students who are interested in online courses, and to find a suitable course for them. Even people who are working or employed, and who are interested in enhancing their skills and building their career in categories offered by ontology can use the system. They can choose an appropriate course through ontology. Nowadays, online courses have made it possible for people to change

their careers. Online courses have helped them to gain the skills which are required to enter the new fields of work, and they can do so easily by staying at home. Such ontology can be targeted to those users who have specific requirements and let them start with the basic level course and move to the advanced level.
First, this paper has explained the purpose of developing this ontology and its domain. Second, the paper will discuss some major-related work and methodology used to develop this ontology. Further results of the instances that are used in the ontology and the type of queries that the ontology can support will be described. Third, the paper covers the discussion with the weakness and strengths of ontology. Finally, the conclusions and future work will be deliberated.

II. RELATED WORK

There is an increase in dependence on online learning platforms and education resource repositories. Thus, the unified representation of digital learning resources has become important to support a dynamic and multisource learning experience [2]. In the specialized literature, several ontologies related to online courses can be found. Those ontologies were defined with distinct purposes and, therefore, describe different types of information related to that area. The EduCOR ontology, an educational, career-oriented ontology that provides a foundation for representing online learning resources for personalized learning systems. The ontology is designed to enable learning material repositories to offer learning path recommendations, which correspond to the user's learning goals, academic and psychological parameters, and labor-market skills [2].
With the quick increase of learning content on the web, it has become time-consuming to find the right courses for the learners [10]. There has been ample work done in the area of recommendation over the years. The interest in developing several recommender systems remains high because of the plenty of practical applications that help users to deal with information overload and provide personalized service [1]. The authors of "Ontology-Based Learning Content Recommendation" perform learning content recommendations based on ontology, which uses sequencing rules to connect learning objects. The rules are formed from the knowledge base and competency gap analysis [8].
The paper [3] presents a method that personalizes course recommendations that will fulfill the individual needs of users. The framework was developed with an ontology-based hybrid-filtering system called the ontology-based personalized course recommendation (OPCR). This approach integrates the information from various sources based on the hierarchical ontology which helps in enhancing efficiency and user satisfaction and to provide students with appropriate recommendations. Furthermore, OPCR uses an ontology mapping technique, recommending jobs that will be available after the completion of each course. This kind of method can enable students to gain a comprehensive knowledge of courses based on their relevance, using dynamic ontology mapping to link the course profiles and student profiles with job profiles.
In 'Ontology-Based Semantic Recommendation for Context-Aware E-Learning', [10] the recommender takes knowledge about the learner, content knowledge, and knowledge about the domain being learned into consideration. The challenge for recommender systems [4], is to better understand the student's interest and the purpose of the domain. This paper 'Ontology-Based Recommender System of Online Courses' differs from prior work in many dimensions. Thus, ontology provides online courses recommendation through the knowledge base created from competency questions with reasoners.

III. METHODOLOGY

Ontology development is all about defining terms in the domain and relationships between them. In short, the process can be as to define class/concept in the domain, arranging in the hierarchy (class-subclass hierarchy), and defining attributes and properties with constraints if required [9].
For Ontology Development we define the scope/domain and then classes for the ontology are defined with subclasses and superclasses hierarchy. After that, the attributes and properties of the classes along with their constraints are defined. Finally, instances are created to test different classes and properties.

A. Competency Questions (CQs)

The domain of ontology should cover based on what ontology will be used for and should answer the CQs using ontology after being developed [9]. Competency questions help to determine the scope of the ontology. A knowledge base supported by ontology should be able to answer these questions. In this way, CQs help to evaluate the ontology after its development. The list of CQs for the Ontology-Based Recommender System of Online Courses is given below:
1) Recommend top five rating courses which are free with certificates.
2) List some of the courses for learners who want a certificate after attending the course without having to do the assignment, quiz, and exam.
3) Mrs. B is working in an organization and does not have time to attend online live courses on Data Science; recommend some courses for her which are not live session courses.
4) Mr. A is from a management background, and he wants to learn some computer networking-related courses, ontology shall recommend some courses for him.

5) Mr. C is a new project manager in K-Bank, and he must develop an information system for ATM machines. What are the courses that will help him to manage the project well?
6) Mrs. D wants to apply for a job and for that job she needs a Software Training course certificate, and the deadline for the job application is in 1 month. List some of the Software Training courses with certificates that she can obtain within a month (20 hours).
7) Which is the highest rated course of Author XYZ which is free of cost?
8) If I take the ABC course, what are some of the prerequisite courses that I need to attend?
9) List some of the advanced/recommended courses after completing a particular course.
10) Mrs. B has some budget limitations; recommend some courses which are below or equal to 100 Euro.

For each CQs, we have uploaded our related document and text file name "SPARQL_File Modified after the Renaming of concepts" in GitHub:
(https://github.com/Younten-Tshering/Projects_and_related_works/tree/main/Ontology/Ontology-Based%20Recommender%20System%20of%20Online%20Courses)
which show the infer knowledge and related SPARQL query of 10CQs for our ontology.

B. Ontology Design

The top-level classes in the "Ontology-Based Recommender System of Online Courses" are *Author, Course, CourseCategory, CourseOrganizer, and Learner*. The ontology was developed using a combination approach where the most salient and obvious concepts in our domain were considered then these concepts were generalized and specialized appropriately.

Figure 1. Class Hierarchy for Ontology-based Recommender System of Online Courses

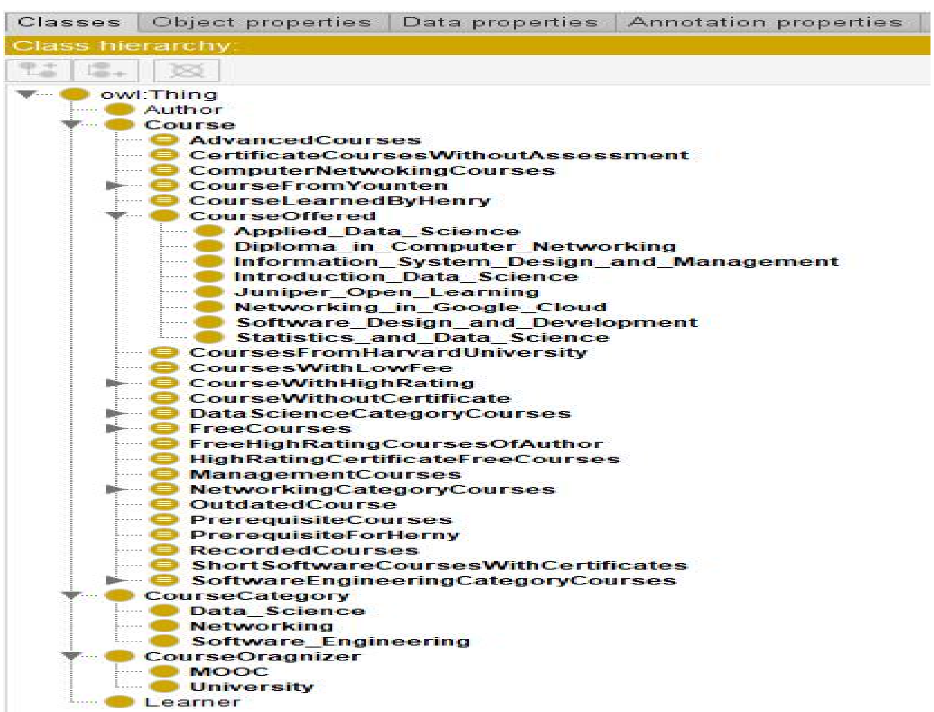

Figure 2. showing the details of subclasses in the main class

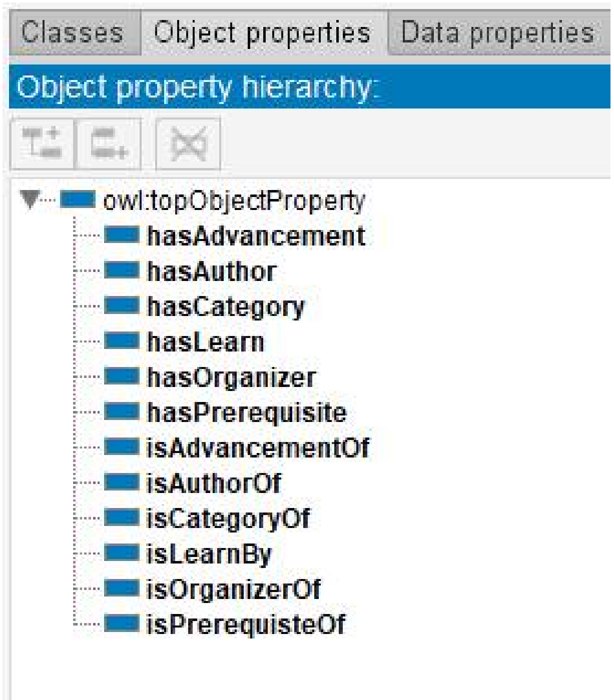

Figure 3. Object Properties used in ontology.

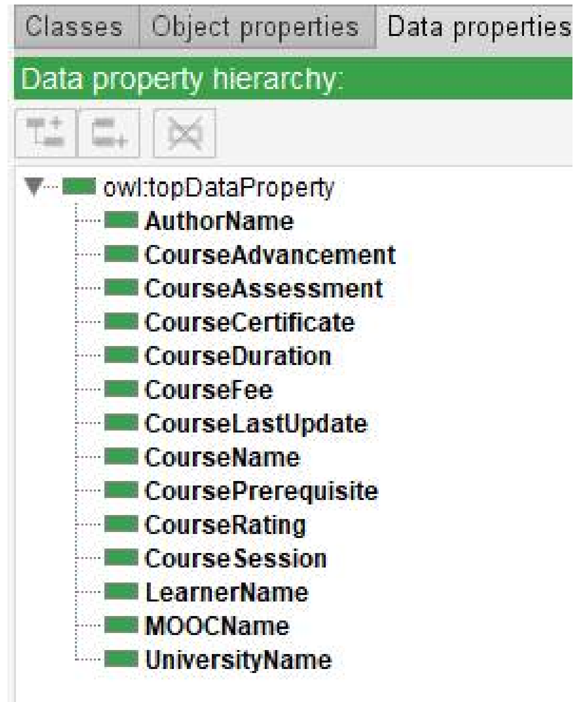

Figure 4. Data Properties used in our ontology.

Figure 3 shows the object properties that were used to develop the ontology. Further, based on the properties the domain and range for each class were given. Figure 4 shows the data properties that were used to develop the ontology. The following are the details of each class and their respective subclasses and major properties.

1) Course: Subclass: *CourseOffered*

Course class doesn't have any instances; however, it will inherit all the instances from its subclasses. This class has object properties *hasPrerequiste* and *hasAdvancement* with domain Course and Range *CourseOffered*. These object properties have inverse property *isPrerequisteOf* and *isAdvancementOf* which has domain *CourseOffered* and range Course.

2) CourseOffered:

Subclasses: Applied_Data_Science, Diploma_in_Computer_Networking, Information_System_Design_and_Management, Introduction_Data_Science Juniper_Open_Learning, Networking_in_Google_Cloud, Software_Design_and_Development Statistics_and_Data_Science

This class contains information related to the courses that are offered by the *courseOrganizer*. Our domain is specific to 3 main areas; therefore, this class is having 8 subclasses. Each of these classes is retrieved to get the related information to the specific class. Further, each of the instances in these 8 subclasses has property assertion as shown in figure 5.

3) CourseCategory:

Subclass: Data_Science, Networking, Software_Engineering

The course category represents the categories of the course i.e., Data Science or Networking or Software Engineering. This means that all the instances of the 3 subclasses belong to the class *CourseCategory*. This class has object property *hasCategory* with domain Course and Range *CourseCategory*.

4) CourseOrganizer:

Subclass: MOOC, University

The *CourseOrganizer* class which represents the organizer of the course can be either Massive Open Online Course (MOOC) or University in our ontology. Further, there are no instances of class *CourseOrganizer*. All organizer instances are inserted as either MOOC or University instances.

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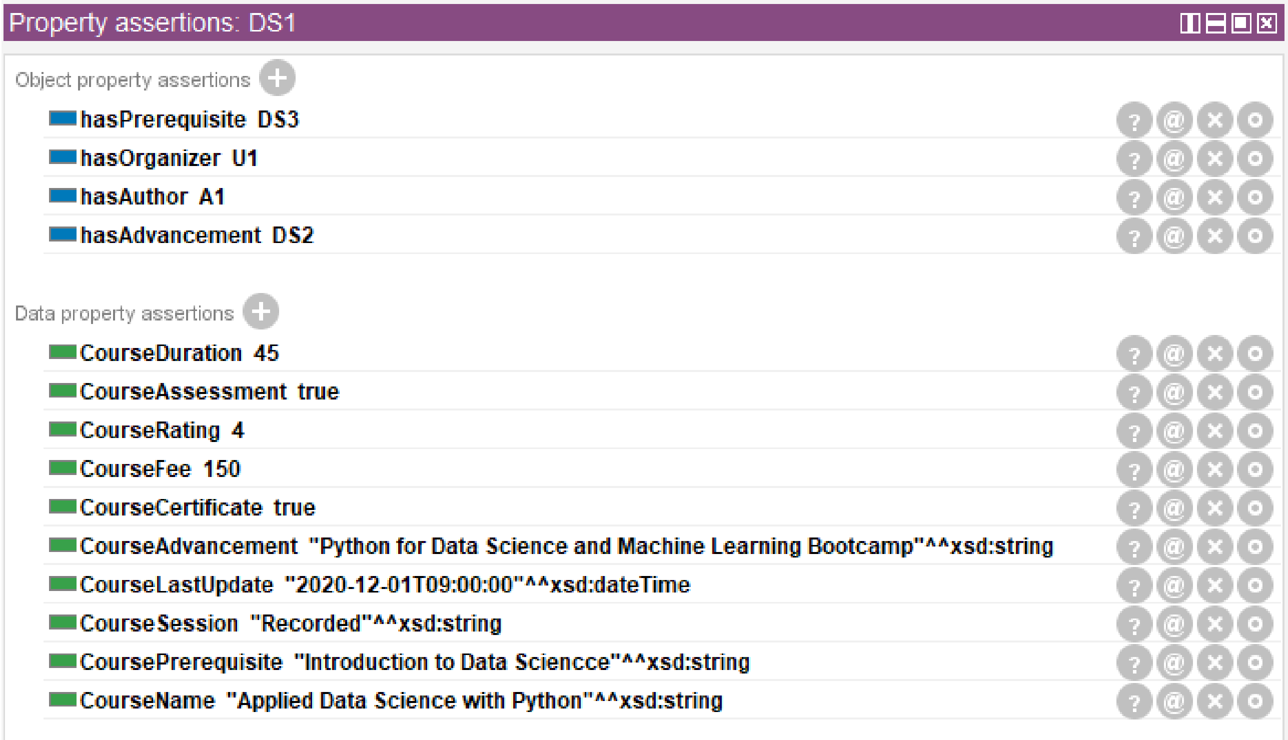

Figure 5. Details of properties with instances

Figure 5 shows one of the instances under the subclass Applied_Data_Science. The instance has the data properties such as *courseDuration*, *courseAssessment*, *CourseRating*, and so on. In addition, it has object property assertions such as *hasPrerequisite*, *hasOrganizer*, *hasAuthor*, and *hasAdvancement*. This object property helps to understand the linkage between the other classes.

5) MOOC:

Instances: M1(Coursera), M2(Udemy), M3(edX), M4(Cisco)

The MOOC subclass represents online platforms such as Udemy, Coursera, etc. Hence, it participates in a data property *MOOCName* that defines which MOOC instance is the organizer of a particular Course instance. It is noted that the importance of this class is minimal in this stage of our ontology development as it plays no further role other than the simple relationship.

6) University:

Instances: U1(Harvard), U2 (MIT), U3(AIT)

The University subclass represents universities such as MIT, AIT, etc. Hence, it participates in a data property *UniversityName* that defines which University instance is the organizer of a particular course instance.

7) Author:

Instances: A1(Tony), A2(William), A3(Shyam), A4(Younten), A5(Chaklam), A6(Chutiporn), A7(Thomas), A8(Kathy), A9(Radhika), A10(Kristina)

The Author represents the author of the course. One author can offer more than one course; therefore, the class has a property *hasAuthor* that represents the author of the particular course. The object property *hasAuthor* has domain as Course and Range as Author.

8) Learner:

Instances: L1(Ronney), L2(Henry)

The learner's subclass represents the users who are learning some online courses. The data property for this class is *LearnerName* where the instance name can be given for the particular learner.

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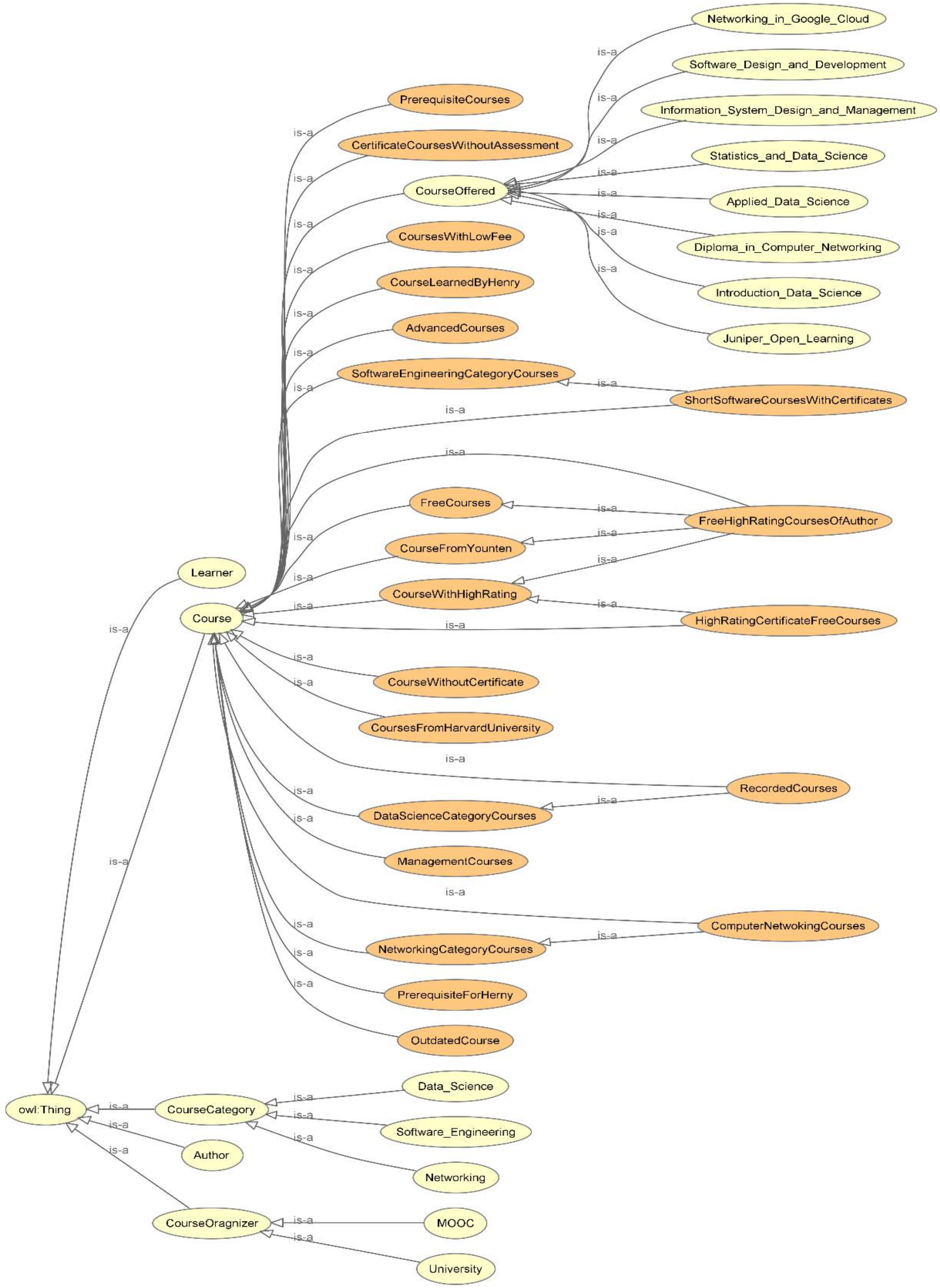

Figure 6. Asserted diagram generated by Protege.

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IV. RESULTS

The ontology consistency was checked through the ontology reasoner. With the help of the reasoner, we can discover implicit information and infer the relationship defined in axioms.

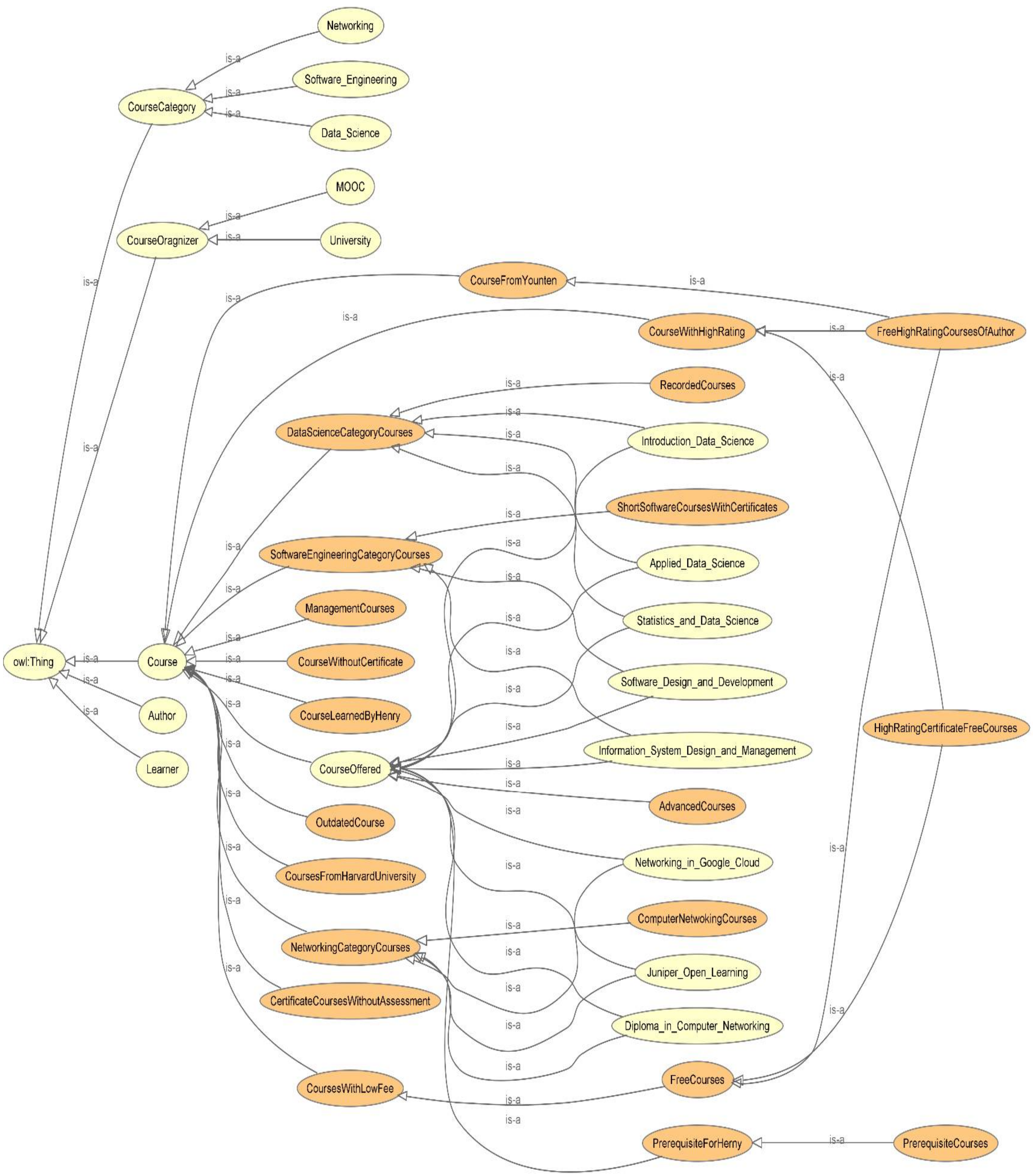

Figure 7. Inferred diagram generated by Protege

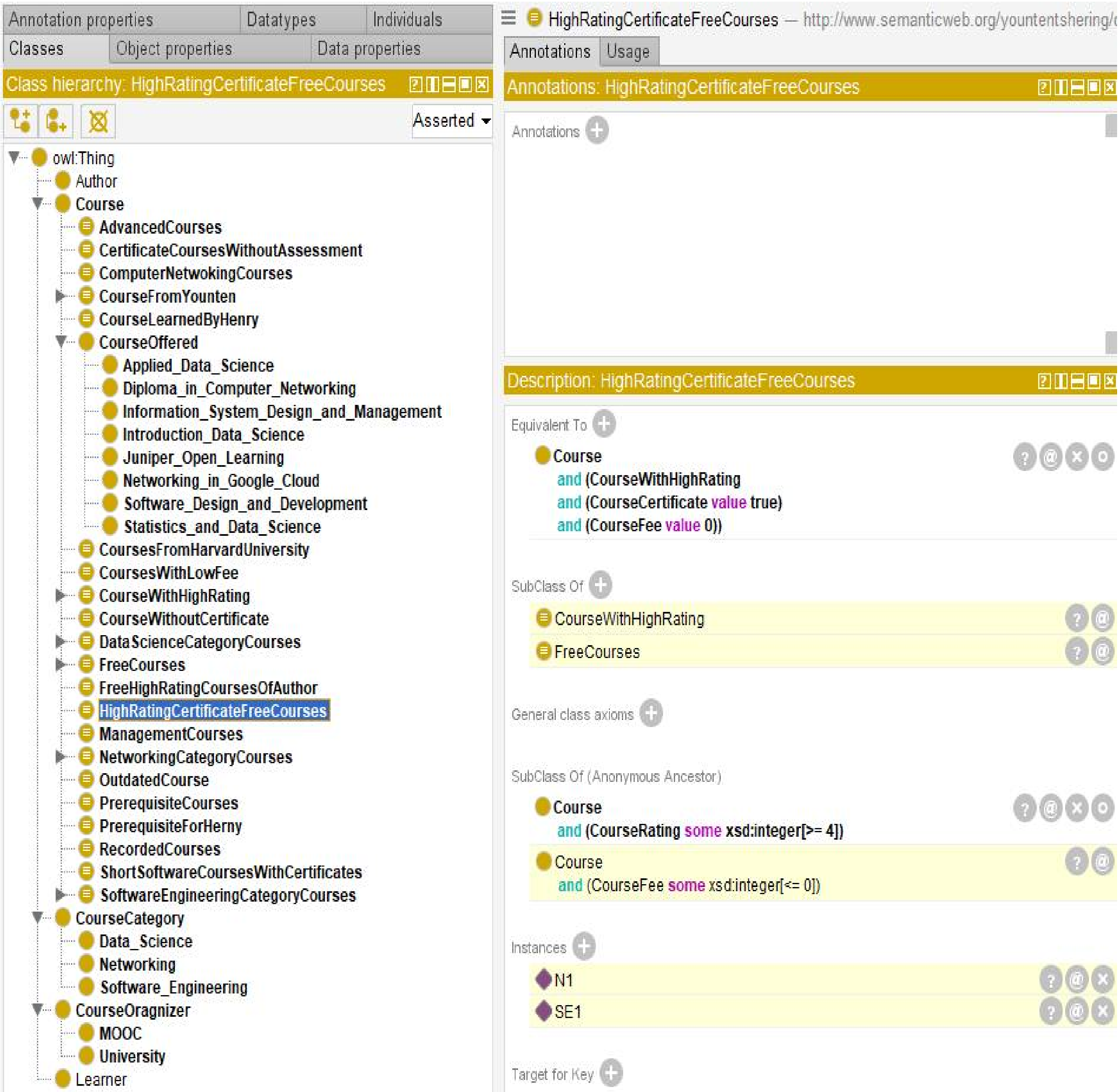

Figure 8. CQ1 Axiom

Figure 8 shows that based on the axioms provided to the CQ1 the reasoner in the protege gives instance output as N1 and SE1. Further, to check the consistency CQ1 was queried in SPARQL.

Figure 9 shows the output from the SPARQL query which are N1 And SE1. As the output from the Protege reasoner matches with the SPARQL query, we can conclude that our ontology is consistent. In addition, we have uploaded our documents in GitHub, related to the SPARQL query for 10CQs of our ontology with OWL file and other documentation related to this paper.

Link to files:

https://github.com/Younten-Tshering/Projects_and_related_works/tree/main/Ontology/Ontology-Based%20Recommender%20System%20of%20Online%20Courses/Documentation

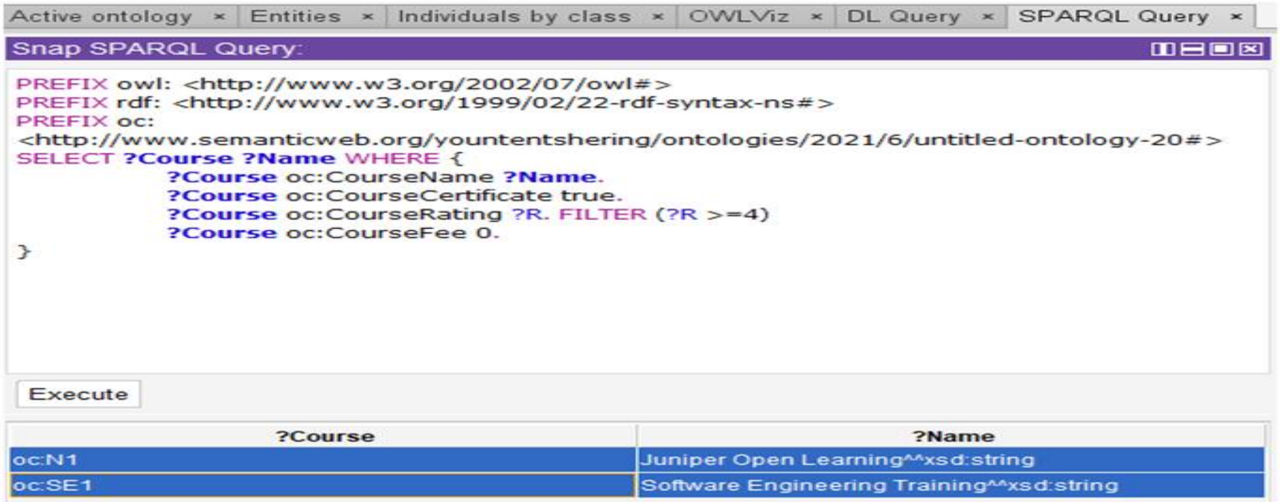

Figure 9. CQ1 SPARQL Query and Output

V. DISCUSSION

A. Querying CQs

All CQs were possible based on the knowledge base that we have created. For the axiom in CQ5, we had to give the full name of the course to get the course related to management.

Figure 10 shows the Protege reasoner output for CQ5. The figure shows that to get the instance value for CQ5 in the axioms the course name should be full form i.e., "Information System Design and Management" which means the keyword like management was not enough to get the output.

In contrast, in the SPARQL query using the keyword like *management* from the *courseName* "Information System Design and Management" was enough. This shows the advantage of SPARQL over Protege.

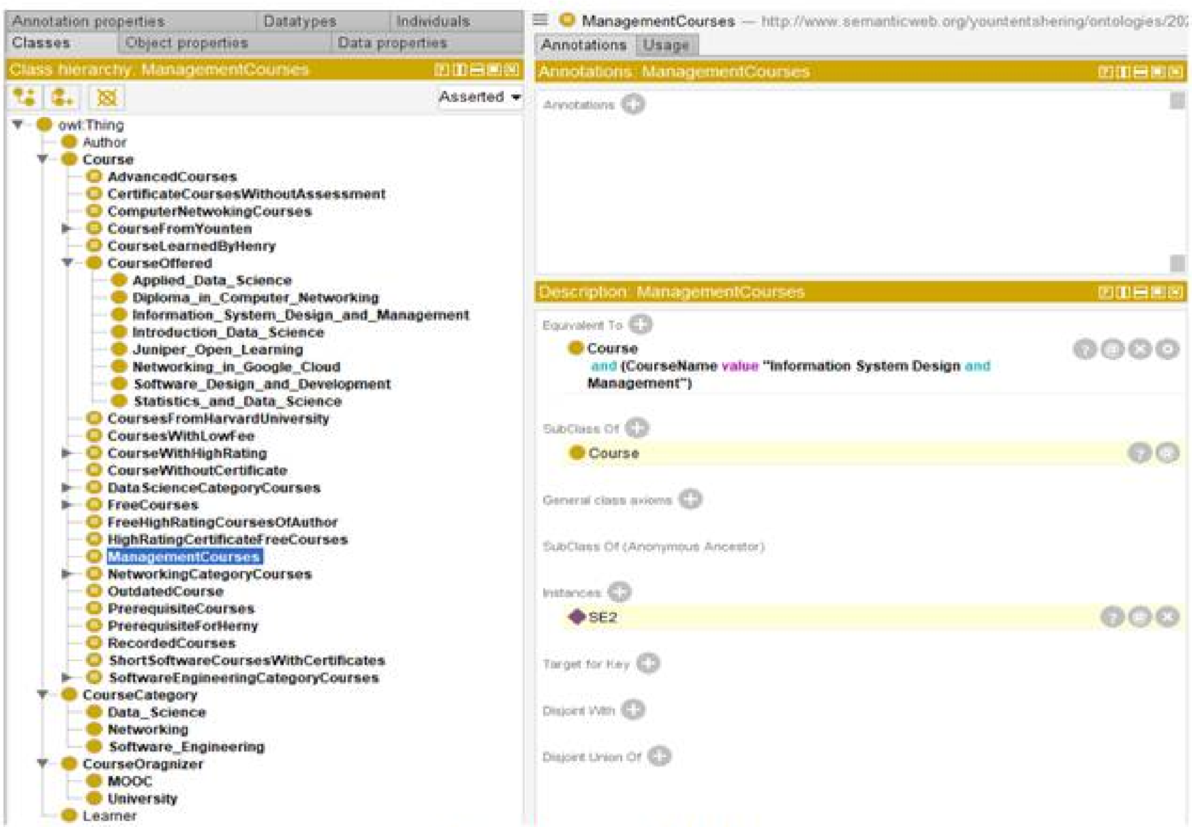

Figure 10. Axiom with Full value

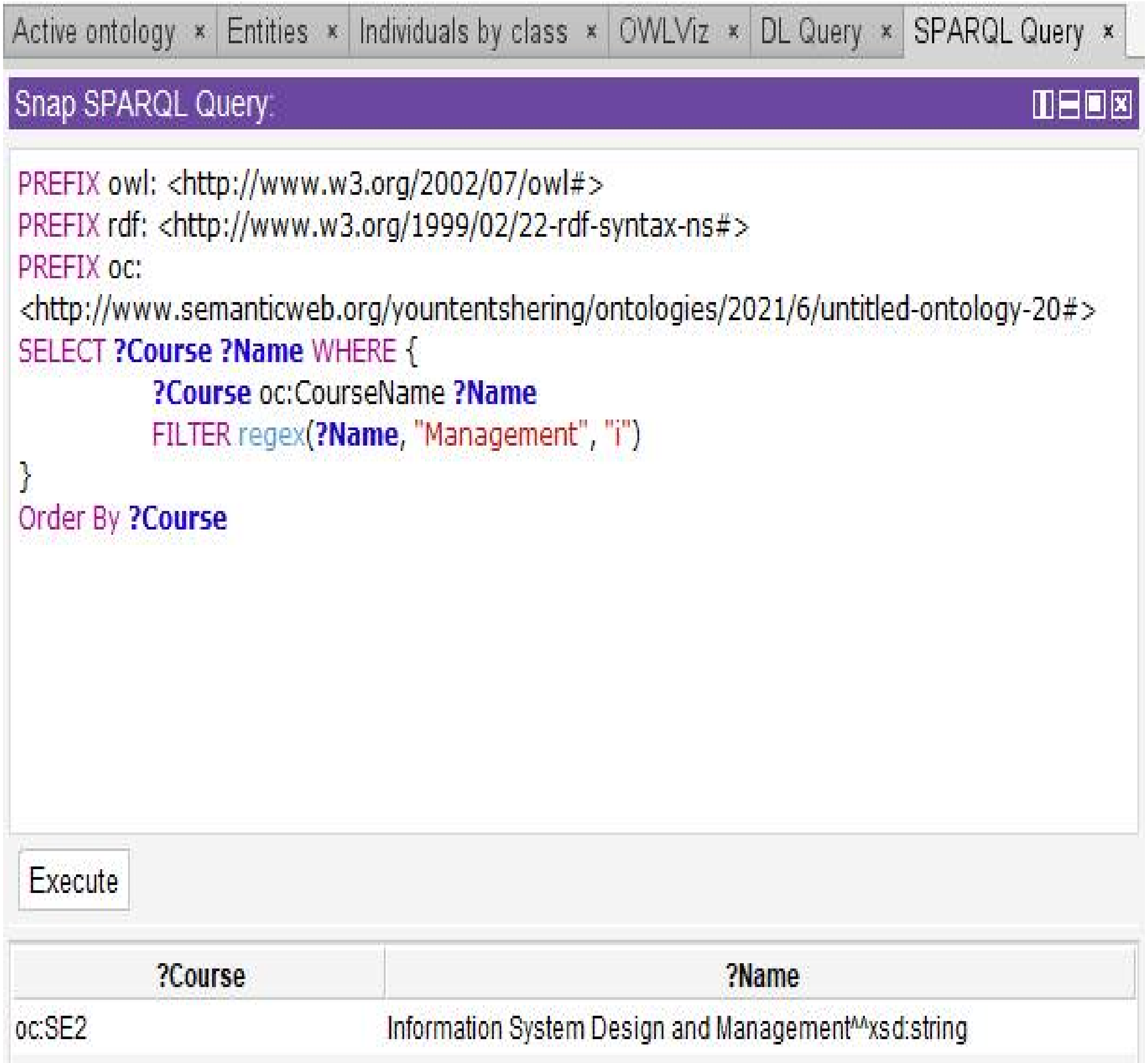

Figure 11. Query with keywords (management)

B. Disjoint used for course categories

One course can be in two categories because the courses that are offered are not disjoint. As shown in figure 12 the course Applied Data Science can fall under two categories which are Data Science and Software Engineering. In addition, as shown in figure 13, we have run the SPARQL query to check if Applied Data Science can fall under Data Science and Software or not. The result shows Applied Data Science can fall under both of the course categories (where two instances of Applied Data Science are in two categories). Therefore, one course can fall under several course categories.

C. Strength and Weakness

One of the core strengths of our ontology would be the effective use of OWL to classify Courses and CoursesOffered into useful inferred subclasses. This allows users to quickly query for the other interesting reasoner or reuse the infer information. One of the most obvious weaknesses in our ontology is there is no proper namespacing of the Internationalized Resource Identifier (IRI). Currently, all resources in our ontology are located directly under the top-level domain. An improvement would be to move each respective into their namespaces.

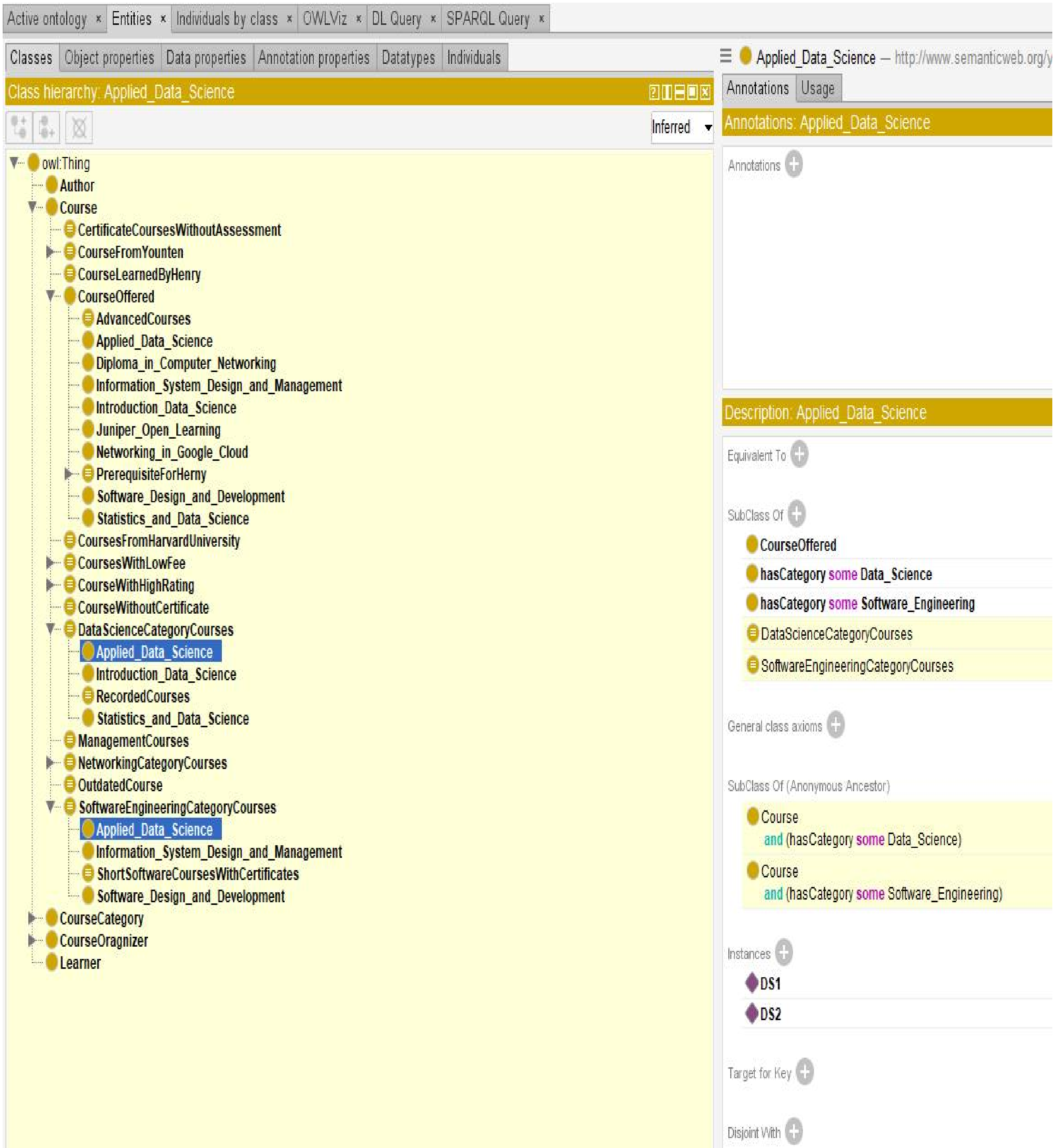

Figure 12. The rule applied to have same courses under different categories

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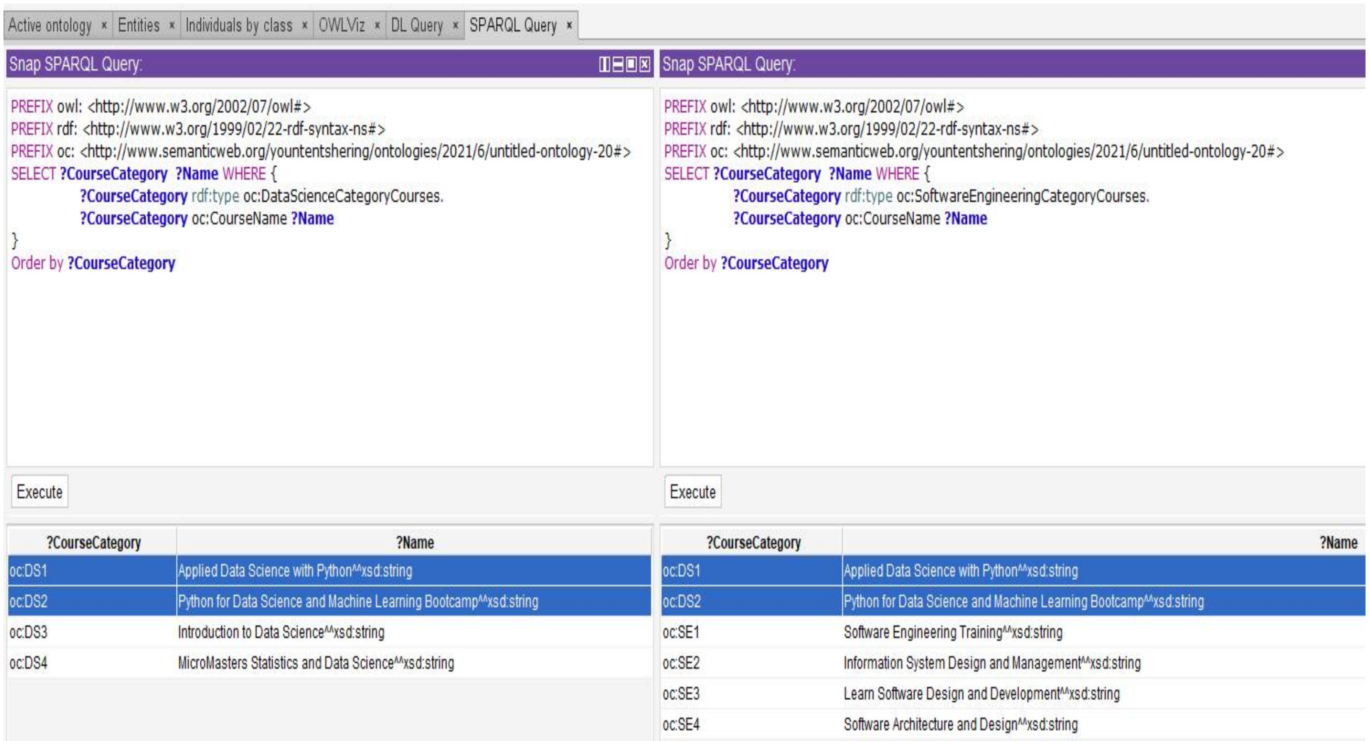

Figure 13. SPARQL query showing DS1 and DS2 in two categories

VI. CONCLUSIONS

To conclude, the ontology "Ontology-Based Recommender System of Online Courses" was developed in order to address the problem of information overload which made searching and finding relevant courses by the learners difficult. First, the CQs were set to give a guideline to develop the ontology. Additionally, the classes and subclasses were defined to address the CQs. Second, the properties were defined for each class, and the instances were created to check the classes and properties. Finally, the constraints and axioms were defined for the ontology to be able to answer our CQs. Our ontology was able to answer all the CQs which we had defined earlier in methodology.

The major strength of ontology is that the infer information in the ontology can be reused. The drawback of the design is there is no proper namespacing for IRIs. Therefore, in the future, we plan to work on drawbacks and add some additional courses and axioms in our ontology to increase the recommendation. Currently, our domain is specific to only 3 key categories of courses. However, in the future, we can broaden our areas by covering additional fields of online courses. For instance, we can recommend user's job positions that are available based on the courses they have taken. The ontology developed can be a beneficial tool for system developers as it is based on a recommender system and a knowledge base is created for better knowledge management.

ACKNOWLEDGMENT

The success and outcome of this work required immense guidance and assistance from many people, and it is always a pleasure to remind the fine people of the sincere guidance we received to uphold our work.

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REFERENCES

[1] Adomavicius, G., Tuzhilin, A.: Toward the Next Generation of Recommender Systems: A Survey of the State-of-the-Art and Possible Extensions. IEEE Transactions on Knowledge and Data Engineering 17(6), 734–749 (2005)

[2] I, Eleni., Abu-Rasheed, H., Tavakoli, M., Hakimov, S., Kismihók, G., Auer, S., Nejdl, W. (2021). EduCOR: An Educational and Career-Oriented Recommendation Ontology. Retrieved from https://arxiv.org/pdf/2107.05522.pdf

[3] M. E. Ibrahim, Y. Yang, D. L. Ndzi, G. Yang and M. Al-Maliki, "Ontology-Based Personalized Course Recommendation Framework," in IEEE Access, vol. 7, pp. 5180-5199, 2019, doi: 10.1109/ACCESS.2018.2889635.

[4] M. E. Ibrahim, Y. Yang, and D. Ndzi, "Using ontology for personalised course recommendation applications," Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 10404, pp. 426–438, 2017.

[5] Pukkhem N. (2014) LORecommendNet: An Ontology-Based Representation of Learning Object Recommendation. In: Boonkrong S., Unger H., Meesad P. (eds) Recent Advances in Information and Communication Technology. Advances in Intelligent Systems and Computing, vol 265. Springer, Cham. https://doi.org/10.1007/978-3-319-06538-0_29

[6] R. G. Apaza, E. V. Cervantes, L. C. Quispe, and J. O. Luna, "Online courses recommendation based on LDA," CEUR Workshop Proc., vol. 1318, pp. 42–48, 2014.

[7] Rabahallah, Kahina & Mahdaoui, Latifa & Azouaou, Faical. (2018). MOOCs Recommender System using Ontology and Memory-based Collaborative Filtering. 635-641. 10.5220/0006786006350641.

[8] Shen, L., Shen, R.: Ontology-Based Learning Content Recommendation. International Journal of Continuing Engineering Education and Life-Long Learning 15(3/4/5/6), 308–317 (2005)

[9] Tshering, Younten. (2021). Ontology-Based Approach of E-government for Interoperability, Volume 9, Issue VII, International Journal for Research in Applied Science and Engineering Technology (IJRASET), Page No: 3197-3202, ISSN: 2321-9653, www.ijraset.com

[10] Yu, Z., Nakamura, Y., Jang, S., Kajita, S., & Mase, K. "Ontology-Based Semantic Recommendation for Context-Aware E-Learning". Ubiquitous Intelligence and Computing: 4th International Conference, UIC 2007, LNCS 4611, pp. 898–907