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Abstracts

With the increased information on the internet, 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. Consequently, we decided to develop a system which will help the learners to select the most appropriate course. For this purpose, classes and their properties were defined depending on our scope. Next, the ontology was populated with instances to check the consistency of the ontology. After the testing and querying the system, it can be concluded that the ontology developed is consistent and perfectly meets the requirements which were defined earlier. For the future scope, ontology can include more category of courses and real instance for better recommendation.

Introduction

There is vast information available about the 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. 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. Therefore, to address this problem we build the ontology which recommends the courses for learners on the need basis.

The main purpose of the ontology is to suggest learners' suitable online courses in areas such as Data Science, Software Engineering and Networking. The factors which are used to make suggestions are i) the organizer of the Course, ii) number of hours required for each course, iii) nature of assessment for the course, iv) fee v) author, vi) last update, vii) course session (Recorded or Live), viii) prerequisites, ix) advancement xi) rating and xii) status of Certificates (available or not). Further, users can make the queries based on the single factor or combination of factors. The system can give recommendations to the users based on either of the single factors or combination of factors. For instance, users can query for the courses with high rating, with certificates and Author XYZ. For this purpose, the 5 main classes (Course, Learners, Author, CourseCategory and CourseOrganizer) were made using protege, and the queries were run by SPARQL.

First, this report will explain the purpose of developing this ontology and its domain. Second, the report will discuss some major classes and key properties used to develop this ontology. Further the instances that are used in the ontology, and the type of queries which the ontology can support will be described. Third, the report will cover the weakness and strength of the ontology. Finally, the limitations, major conclusions and future work will be discussed.

Problem Statement

There are many online courses available on the internet. The Internet is a vast source of information which 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 specific needs. Therefore, there is a need for a system which can fulfill such users' needs.

Purpose and Scope of our ontology

The main objective of this project is to develop an ontology which will recommend users who are interested in learning and finding interesting courses that suit them. Our scope is limited to only three areas as of now which are Data Science, Software Engineering and Networking. Therefore, our ontology will not be able to answer the queries out of these areas.

Intended Users

The main users of our ontology are people who are interested in taking online courses in areas of Software Engineering, Data Science and Networking. Our system is developed to cover their specific requirements. We have defined these users in the following areas.

User1: Students

Any students who are interested in Software Engineering, Data Science and Networking can use our system to find a suitable course for them.

User2: Working People in Computer Science field

People who are working in Computer field, and who are interested in enhancing their career in these 3 areas can use our system. They can choose an appropriate course through our ontology.

User3: People interested in changing careers.

Nowadays, online courses have made it possible for people to change their careers. Online courses will help them to gain the skills which are required to enter the new fields, and they can do so easily by staying at home. Our ontology has targeted these users who have specific requirements. They can easily start with the basic level and move to the advancement level.

Related Work

In the specialized literature, several ontologies related to the Online courses can be found.

Those ontologies were defined with distinct purposes and, therefore, describe different types of information related to that area.

First, 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 the labor-market skills. (Eleni Ilkou, 2021)

Second, the “Ontology based Personalized Course Recommendation Framework” introduces a novel approach that personalizes course recommendations that will match the individual needs of users. A hybrid recommender method based on ontology has been proposed in this work. The proposed approach developed a framework of an ontology-based hybrid-filtering system called the ontology-based personalized course recommendation (OPCR). This approach aims to integrate the information from multiple sources based on the hierarchical ontology similarity with a view to enhancing the efficiency and the user satisfaction and to provide students with appropriate recommendations. Furthermore, OPCR uses an ontology mapping technique, recommending jobs that will be available following the completion of each course. This 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. (Ibrahim.M, 2018)

Competency Questions (CQs)

Competency questions help to determine the scope of the ontology. A knowledge base supported by the 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 Online Course ontology 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 assignment, quiz, and exam**.
3. Mrs. B is working in an organization and does not have time to attend **online live course**s 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 has to 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 of 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. E has some budget limitation; recommend some courses which are **below or equal to 100 Euro** to her.

Note:

For each CQs, we have uploaded our document file name “SPARQL_file_OnlineCourse” in google DRIVE which show the infer knowledge and related SPARQL query of 10CQs for our ontology.

Methodology

For Ontology Development we define the scope. First, the classes for the ontology were defined with subclasses and super classes hierarchy. Second, the attributes and properties of the classes along with their constraints were defined. Finally, few instances were made to test different classes and properties.

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. First, the most salient and obvious concepts in our domain were considered then these concepts were generalized and specialized appropriately.

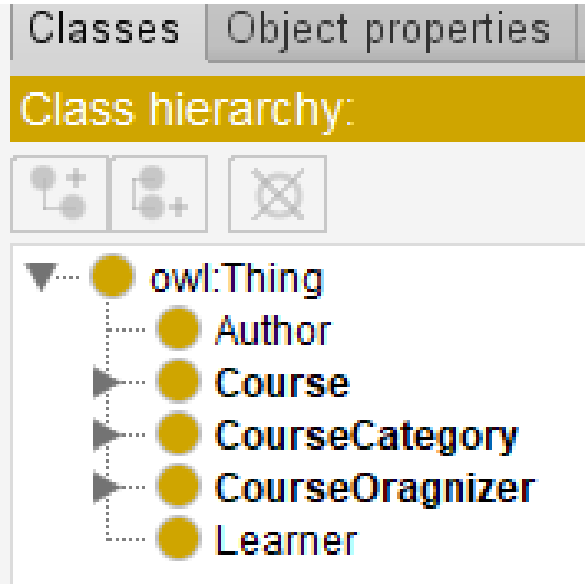


Figure 1. Class Hierarchy for Ontology based Recommender System of Online Courses

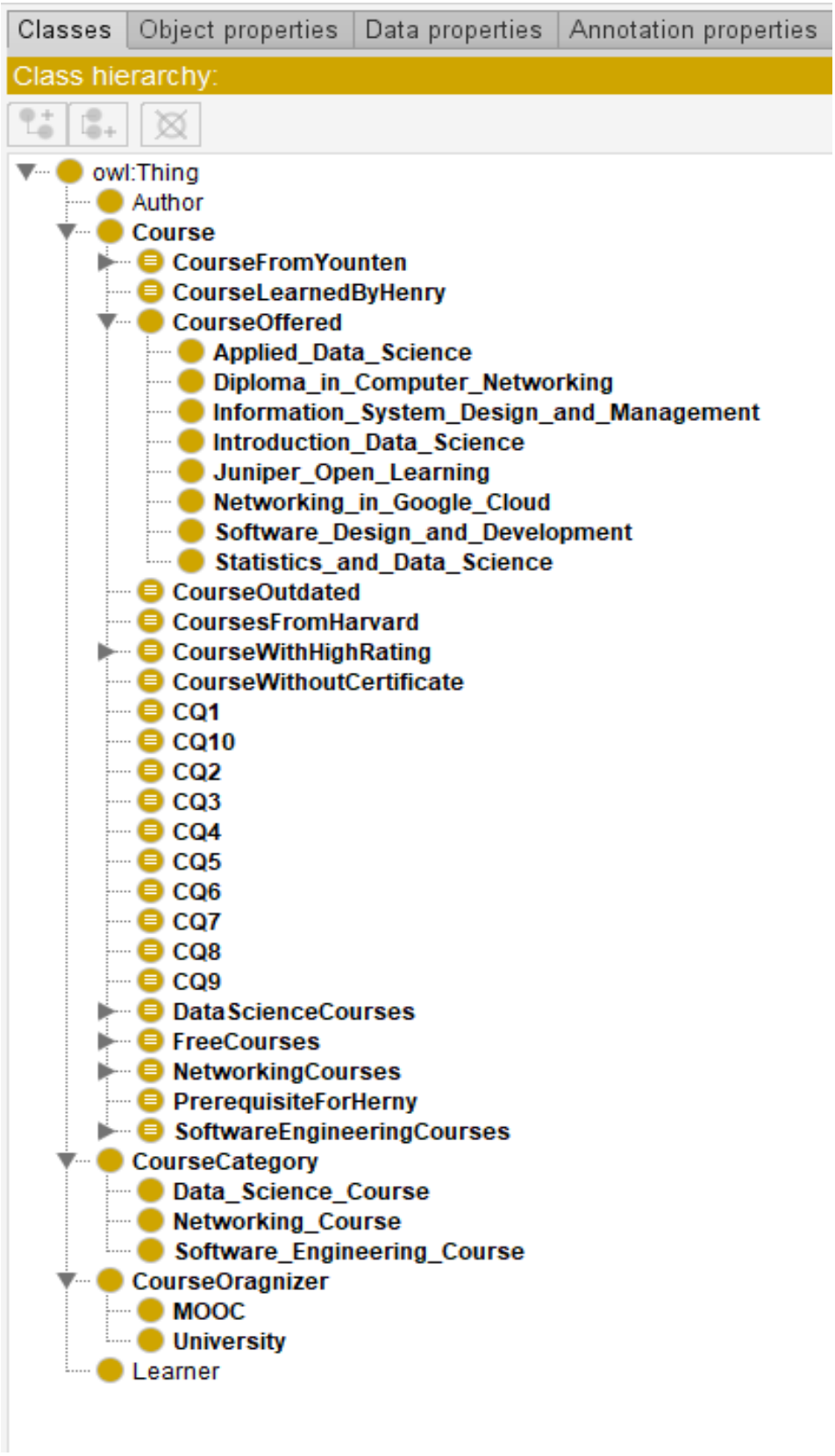


Figure 2. showing that details of subclasses in main class

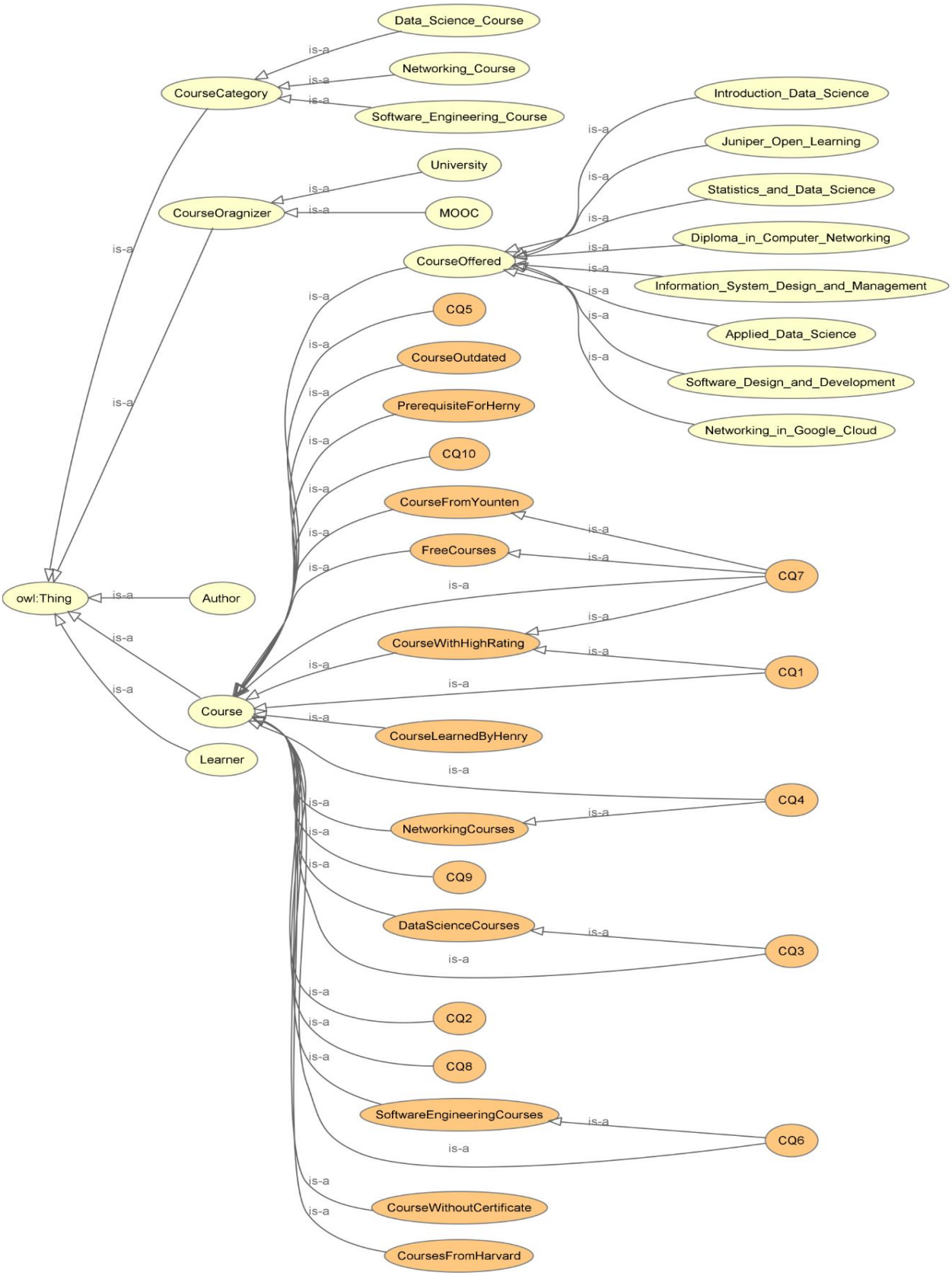


Figure 3. Asserted diagram generated by Protege.

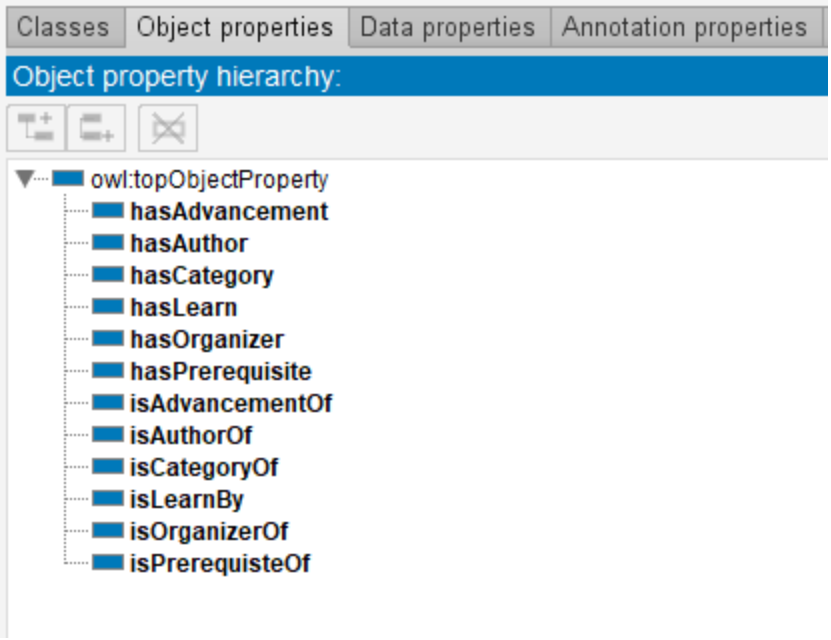


Figure 4. Object Properties used in ontology.

The above figure 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.

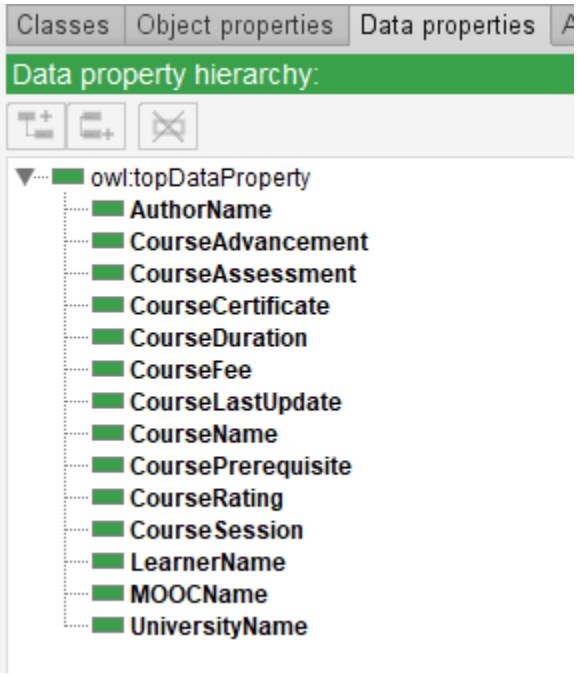


Figure 5. Data Properties used in our ontology.

The above figure shows the data properties that were used to develop the ontology.

The following sections detail each class and their respective subclasses and major properties.

Course

Subclass: CourseOffered

Example Instances: 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. The object property has inverse property *isPrerequisteOf* and *isAdvancementOf* which has domain CourseOffered and range Course.

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 the information related to the courses that are offered by the courseOrganizer. Our domain is specific to 3 main areas; therefore, this class is further 8 sub classes. Each of these classes is retrieved to get the related to the specific class.

Further each of the instances in these 8 sub classes has property assertion as below.

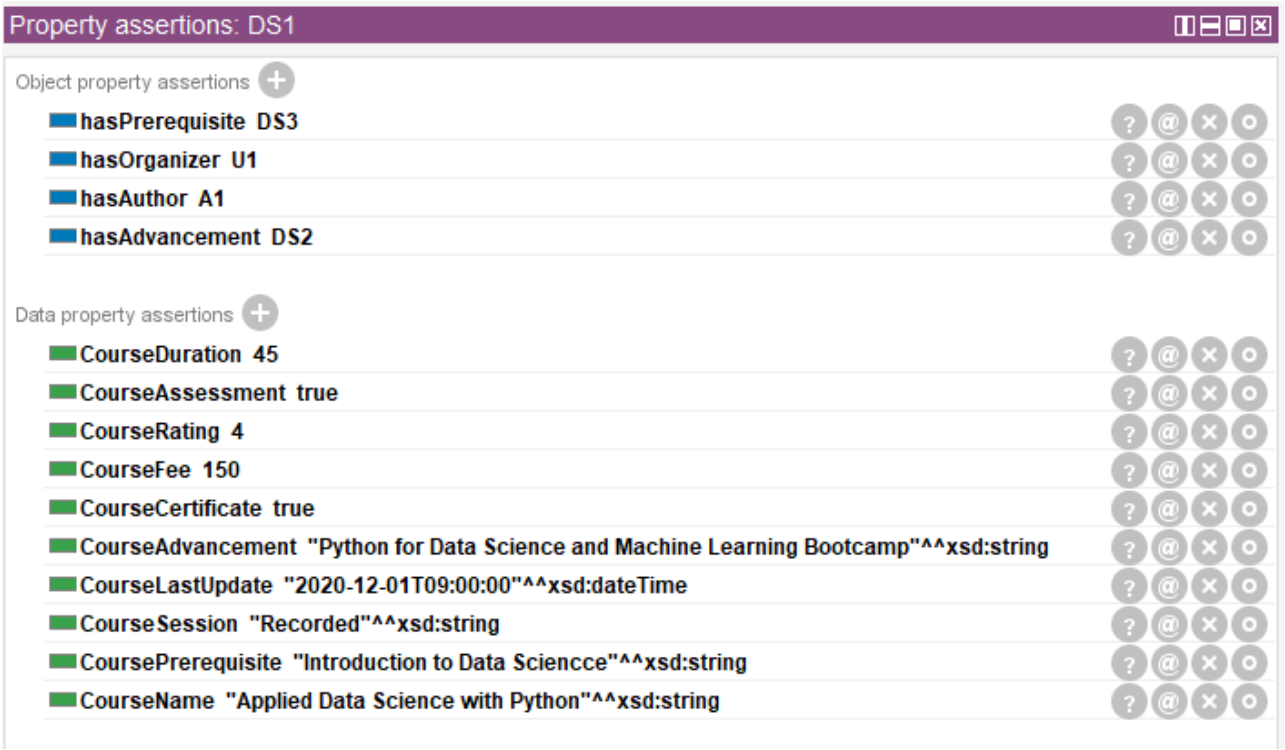


Figure 6. Details of data properties

The above diagram 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 linkage between the other classes.

CourseCategory

Sub Classes: Data_Science_Course, Networking_Course, Software_Engineering_Course

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 3 subclasses belongs to the class CourseCategory

This class has object property *hasCategory* with domain *Course* and Range *CourseCategory*. The object property *hasCategory* should be functional since one course can only be in one category.

CourseOrganizer

SubClasses: MOOC, University

The CourseOrganizer class which represents the organizer of the course can be either MOOC or University in our ontology. It has two key sub classes: *MOOC* and *University*. Further,there are no instances of class CourseOrganizer.All organizer instances are instantiated as either *MOOC* or *University* instances.

MOOC

Subclasses: None

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

The MOOC subclass represents online platforms such as Udemy, Coursera etc. Hence, it participates in a data property MOOCNamethat 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 aforementioned simple relationship.

University:

Subclasses: None

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

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

Author

Subclasses: None

Example 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. The object property *hasAuthor* has domain as *Course* and Range is *Author*.

Learner

Subclasses: None

Example Instances: L1(Ronney), L2(Henry)

The learners 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.

Result and Discussion

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.

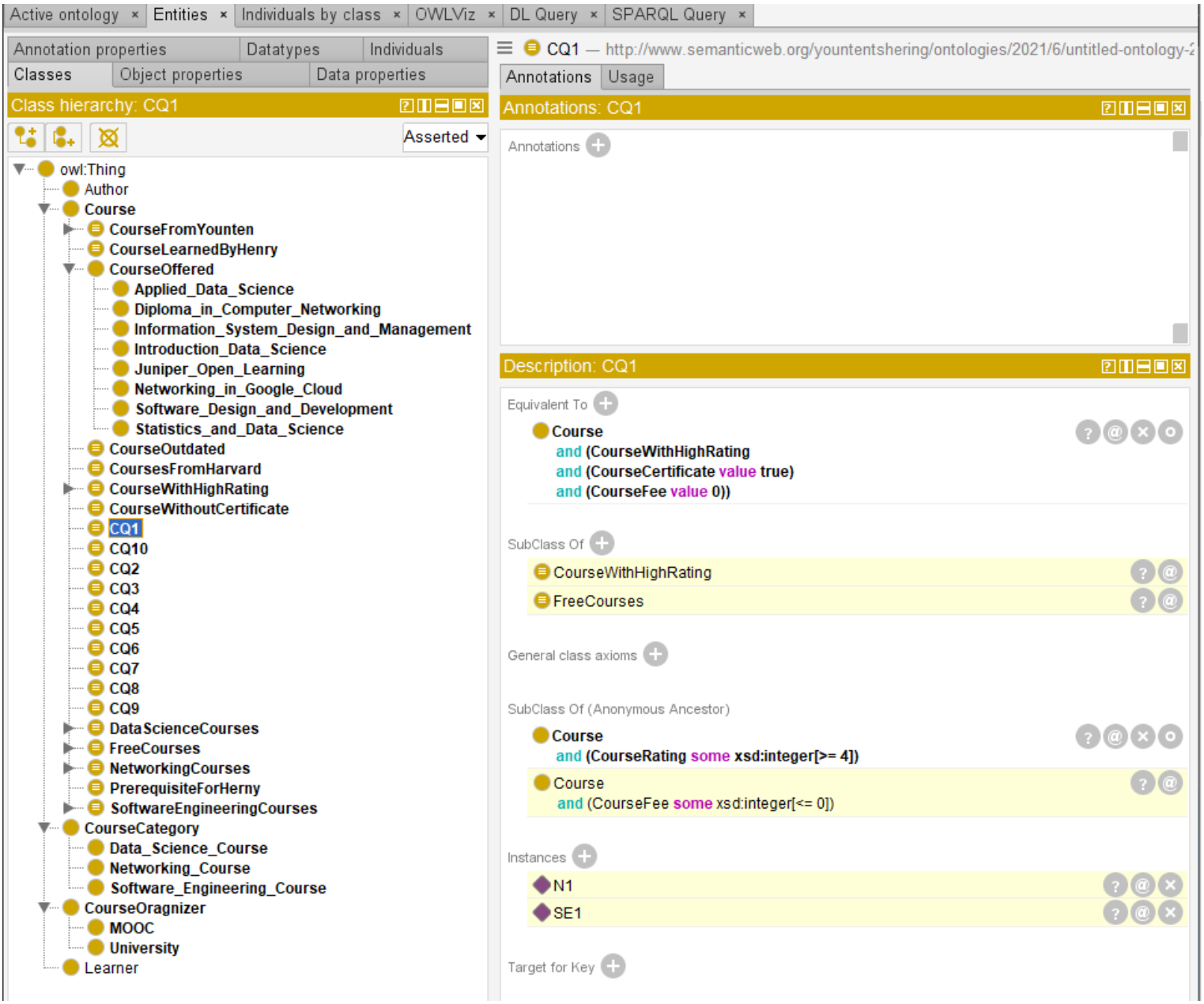


Figure 7. CQ1 Axiom

The above diagram shows that based on the axioms provided to the CQ (Competency Question)1 the reasoner in the protege gives output as N1 and SE1. Further, to check the consistency CQ1 was query in SPARQL.

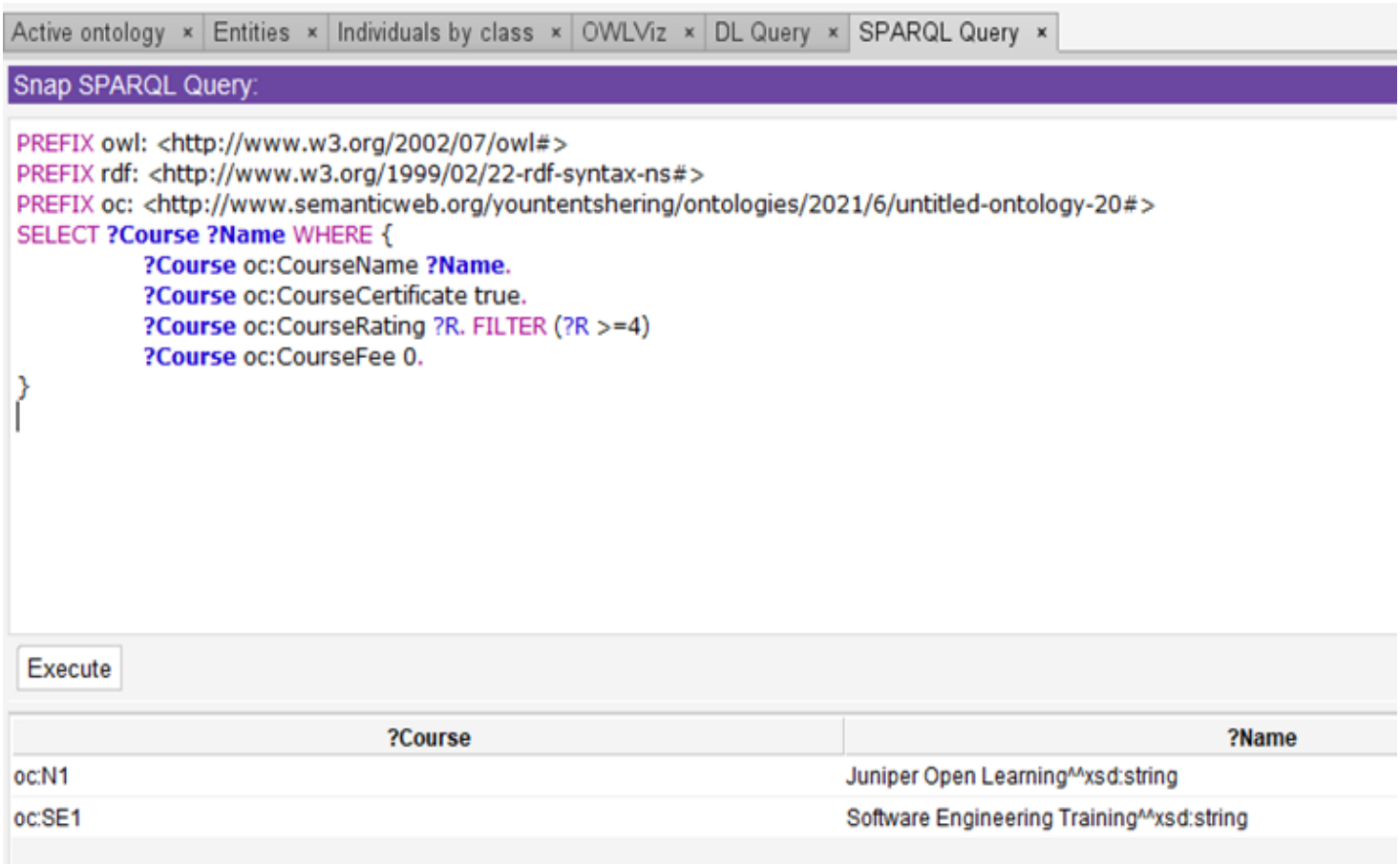


Figure 8. CQ1 SPARQL Query and Output

The above picture shows the output from the SPARQL query which are N1 And SE1. As the output from Protege reasoner matches with SPARQL query, we can conclude that our ontology is consistent. In addition, we have uploaded our document in canvas, related to the SPARQL query for 10CQs for our ontology with the file name “SPARQL_file_OnlineCourse”.

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.

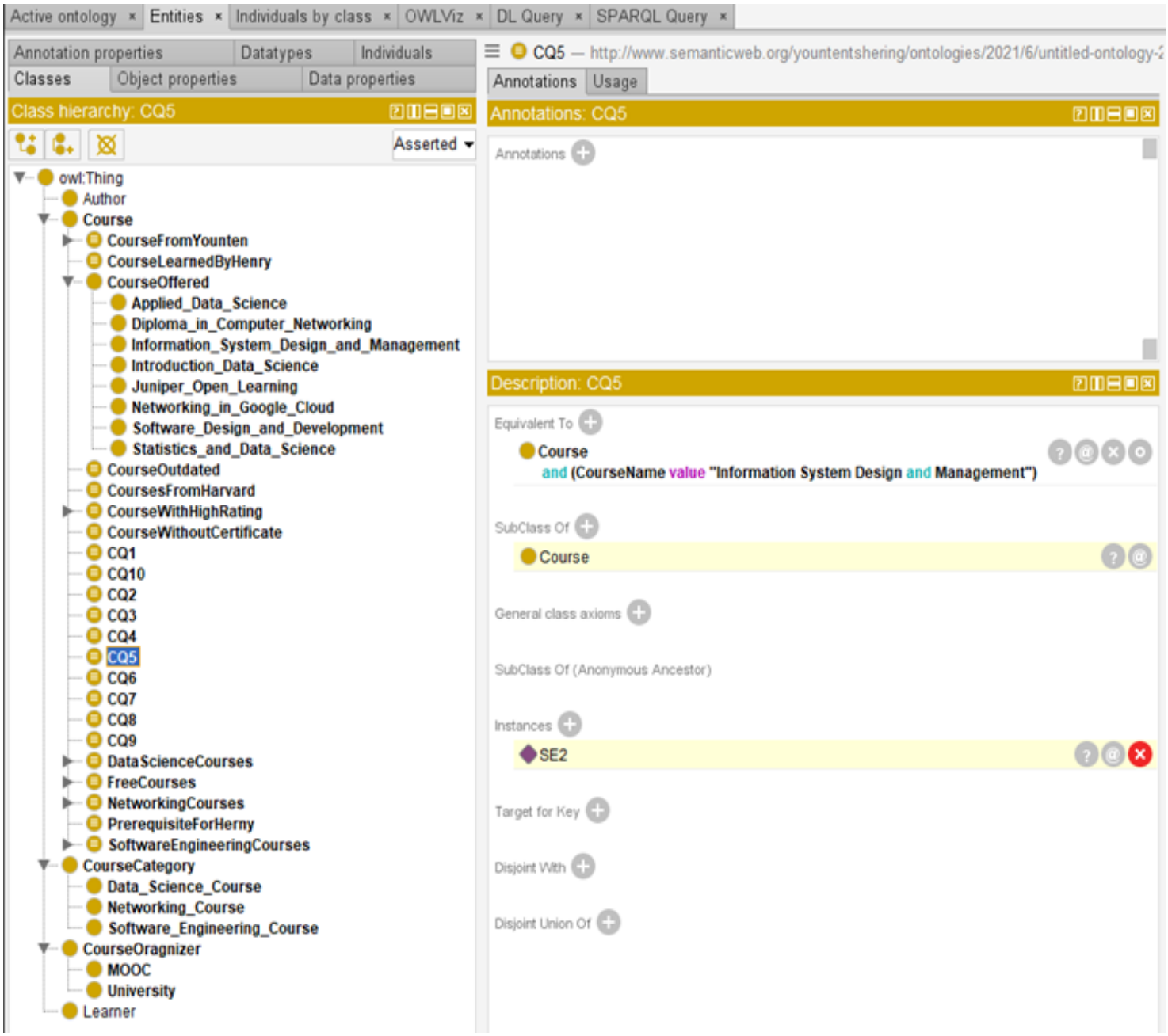


Figure 9. Axiom with Full value

The above diagram shows the Protege reasoner output for CQ5. The diagram 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" that means the keyword like management was not enough to get the output.

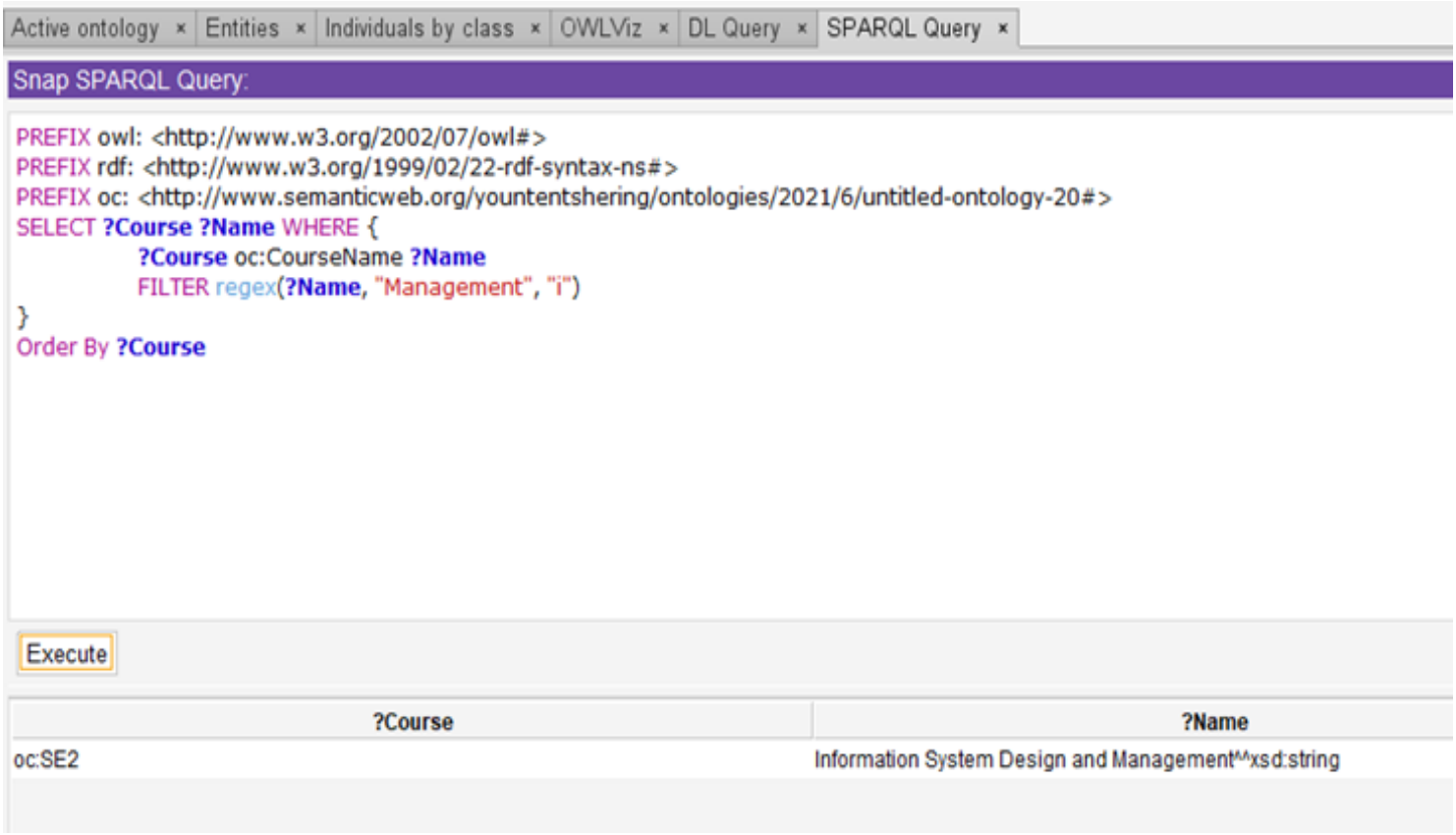


Figure 10. Query with keywords

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.

Strength

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.

Weakness

One of the most obvious weaknesses in our ontology is the design and proper namespacing of the IRIs. Currently, all resources in our ontology are located directly under the top-level domain. An improvement would be to move each respective into their own namespaces.

Conclusion

To conclude, the ontology "Ontology-Based Recommender System of Online Courses" was developed in order to address the problem of information overload by the learners who are interested in taking online courses. First, the CQs were set to give a guideline to develop the ontology. Additionally, the classes and subclasses were defined to address the CQs which were defined. Second, the properties were defined for each class, and the instances were created to check the classes and properties. Finally, the constraints 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.

Our system has some weaknesses and strengths. The major strength of our system is that the infer information in our ontology can be reused. The key weakness is the design and proper namespacing of the IRIs. Therefore, in future we plan to work on our weakness and add some additional features in our ontology. In addition, we are planning to add more classes and scope to our ontology. 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 users job position which are available based on the courses they have taken.

References

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

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.

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

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

Appendix

Inferred of knowledge using Axiom

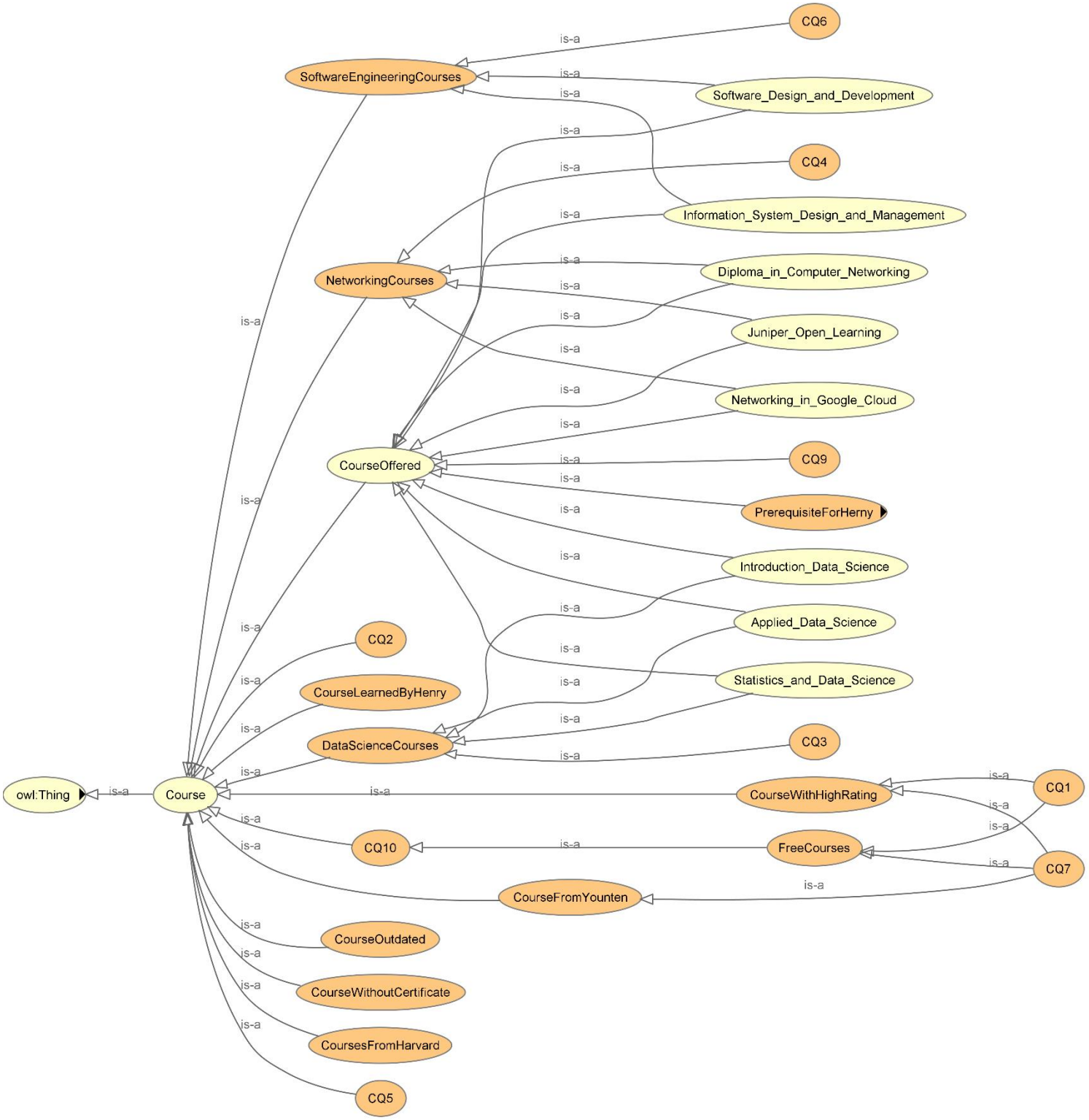
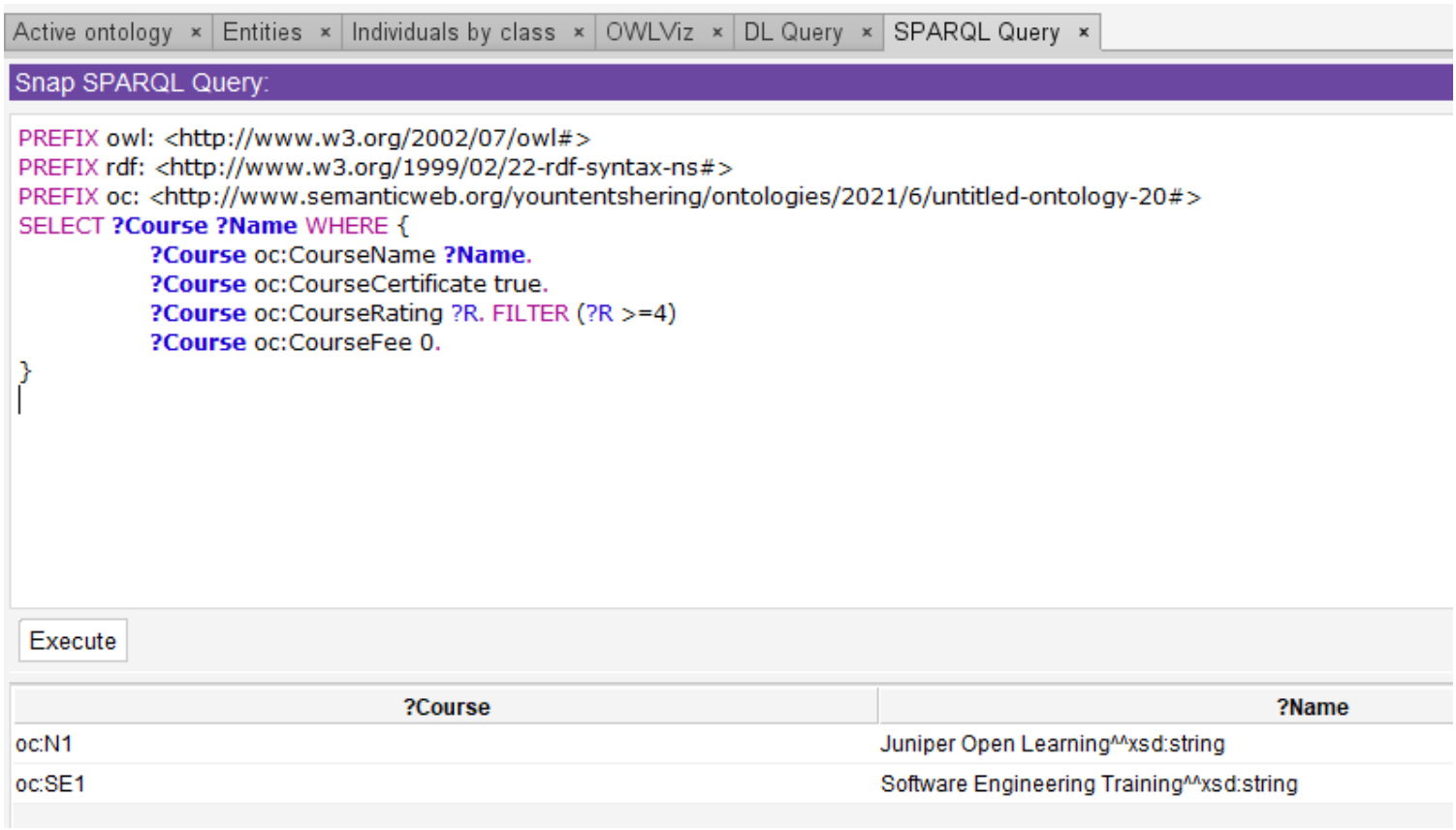


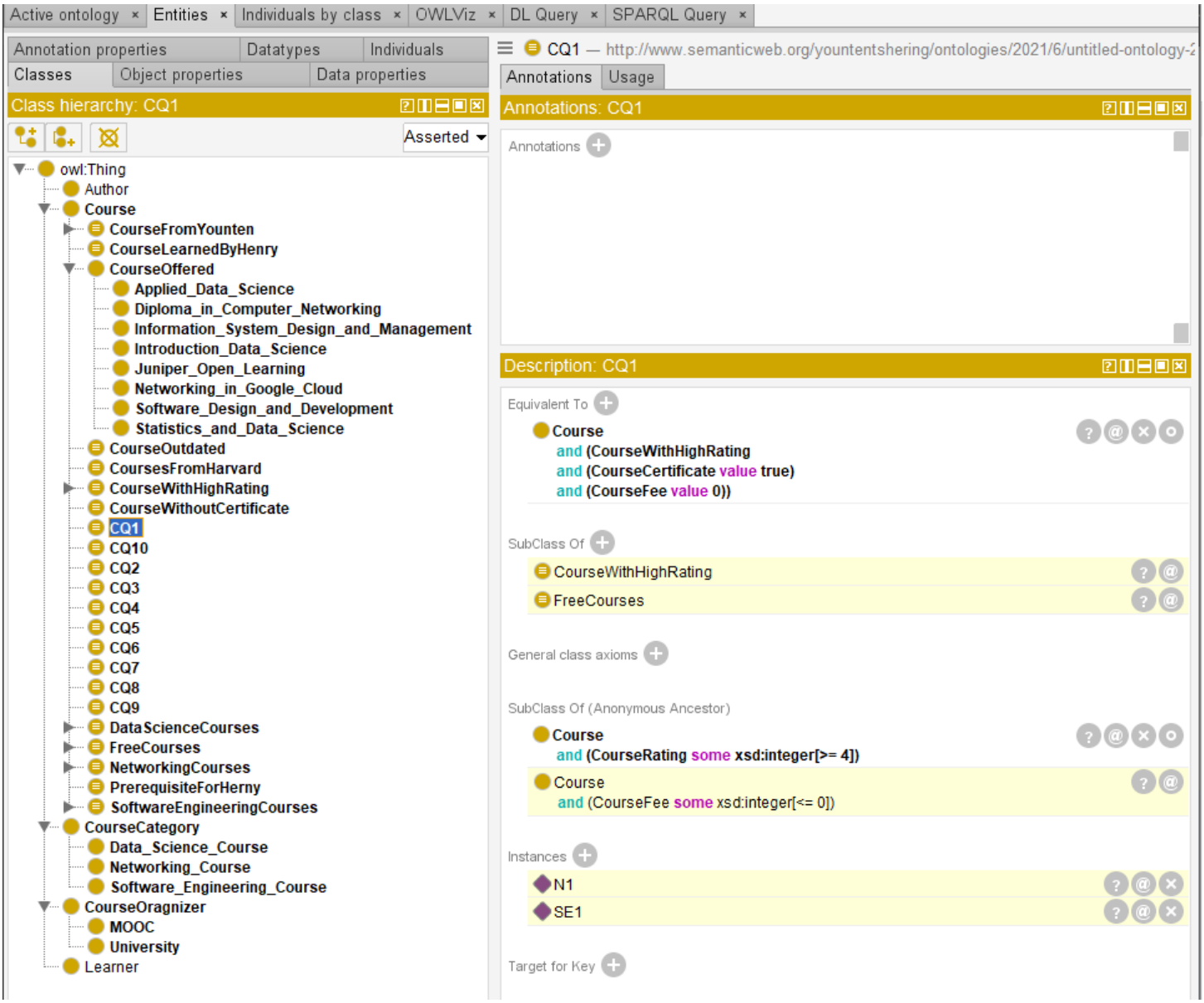
Figure 11. Inferred Diagram

Competency Questions

1. Recommend top five rating courses which are free with certificates.

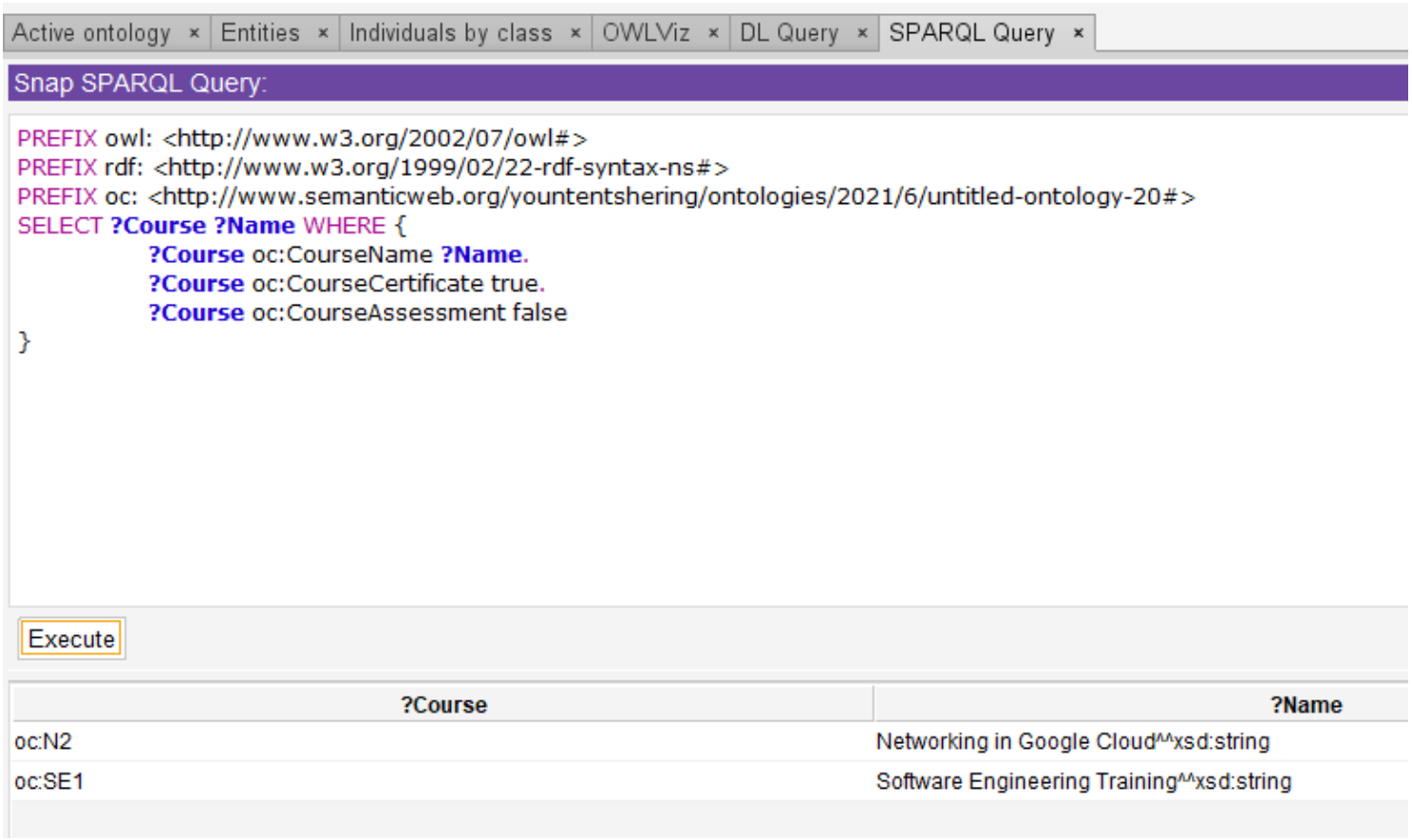
```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course ?Name WHERE {
        ?Course oc:CourseName ?Name.
        ?Course oc:CourseCertificate true.
        ?Course oc:CourseRating ?R. FILTER (?R >=4)
        ?Course oc:CourseFee 0.
}
```

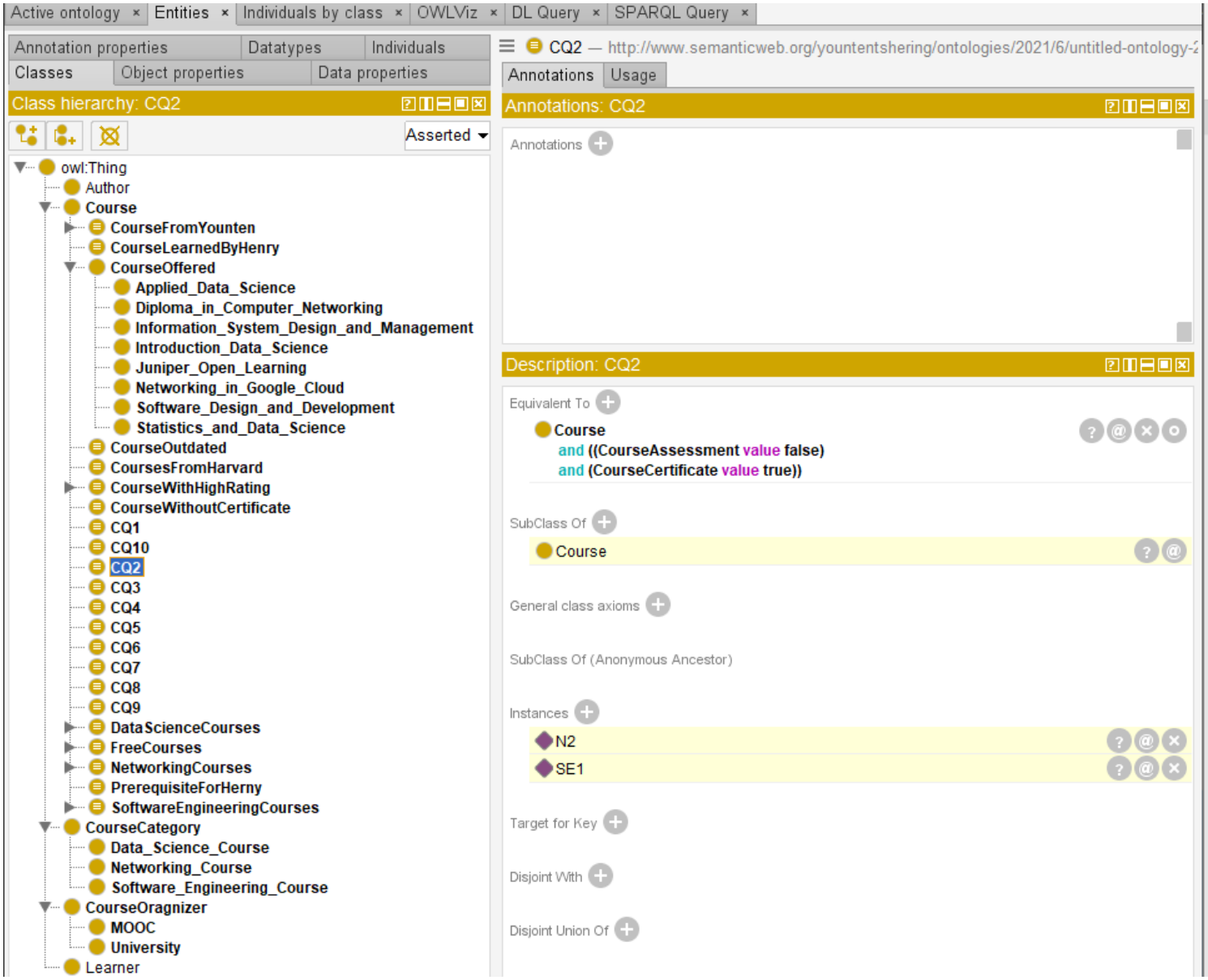



Active ontology
Entities
Individuals by class
OWLViz
DL Query
SPARQL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: CQ1
Asserted
owl:Thing
Author
Course
CourseFromYounten
CourseLearnedByHenry
CourseOffered
Applied_Data_Science
Diploma_in_Computer_Networking
Information_System_Design_and_Management
Introduction_Data_Science
Juniper_Open_Learning
Networking_in_Google_Cloud
Software_Design_and_Development
Statistics_and_Data_Science
CourseOutdated
CoursesFromHarvard
CourseWithHighRating
CourseWithoutCertificate
CQ1
CQ10
CQ2
CQ3
CQ4
CQ5
CQ6
CQ7
CQ8
CQ9
DataScienceCourses
FreeCourses
NetworkingCourses
PrerequisiteForHerny
SoftwareEngineeringCourses
CourseCategory
Data_Science_Course
Networking_Course
Software_Engineering_Course
CourseOragnizer
MOOC
University
Learner
CQ1 — http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-2
Annotations
Usage
Annotations: CQ1
Annotations
Description: CQ1
Equivalent To
Course
and (CourseWithHighRating
and (CourseCertificate value true)
and (CourseFee value 0))
SubClass Of
CourseWithHighRating
FreeCourses
General class axioms
SubClass Of (Anonymous Ancestor)
Course
and (CourseRating some xsd:integer[>= 4])
Course
and (CourseFee some xsd:integer[<= 0])
Instances
N1
SE1
Target for Key

2. List some of the courses for learners who want a certificate after attending the course without having to do assignment, quiz, and exam.

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course ?Name WHERE {
        ?Course oc:CourseName ?Name.
        ?Course oc:CourseCertificate true.
        ?Course oc:CourseAssessment false
}
```

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CourseLearnedByHenry
CourseOffered
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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
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CourseWithoutCertificate
CQ1
CQ10
CQ2
CQ3
CQ4
CQ5
CQ6
CQ7
CQ8
CQ9
DataScienceCourses
FreeCourses
NetworkingCourses
PrerequisiteForHerny
SoftwareEngineeringCourses
CourseCategory
Data_Science_Course
Networking_Course
Software_Engineering_Course
CourseOragnizer
MOOC
University
Learner
CQ2 — http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-2
Annotations
Usage
Annotations: CQ2
Annotations
Description: CQ2
Equivalent To
Course
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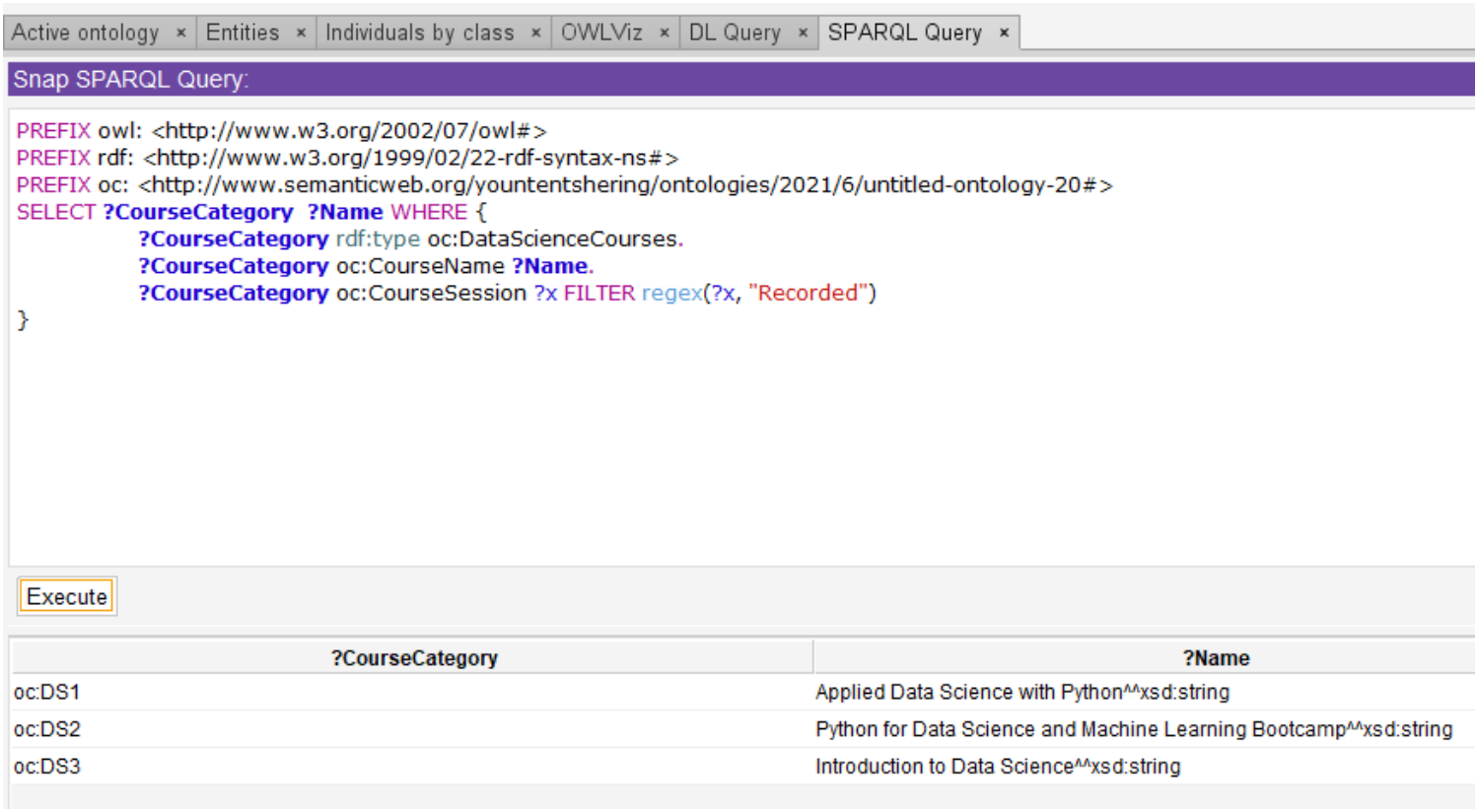
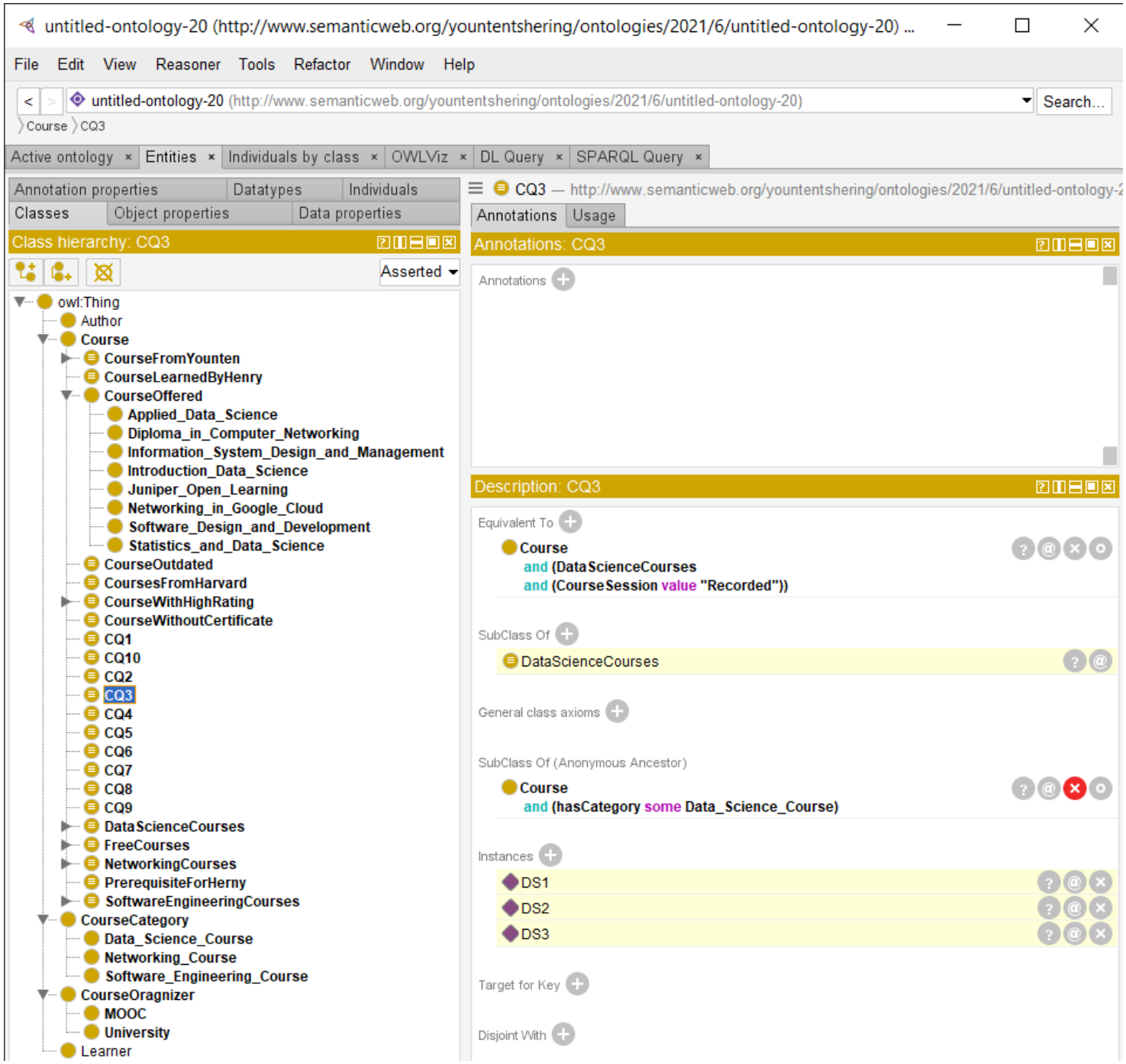
and (CourseCertificate value true))
SubClass Of
Course
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
N2
SE1
Target for Key
Disjoint With
Disjoint Union Of

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.

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?CourseCategory  ?Name WHERE {
        ?CourseCategory rdf:type oc:DataScienceCourses.
        ?CourseCategory oc:CourseName ?Name.
        ?CourseCategory oc:CourseSession ?x FILTER regex(?x, "Recorded")
}
```

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untitled-ontology-20 (http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20)
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Active ontology Entities Individuals by class OWLViz DL Query SPARQL Query
Annotation properties Datatypes Individuals
Classes Object properties Data properties
Class hierarchy: CQ3
Asserted
owl:Thing
Author
Course
CourseFromYounten
CourseLearnedByHenry
CourseOffered
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Information_System_Design_and_Management
Introduction_Data_Science
Juniper_Open_Learning
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Software_Design_and_Development
Statistics_and_Data_Science
CourseOutdated
CoursesFromHarvard
CourseWithHighRating
CourseWithoutCertificate
CQ1
CQ10
CQ2
CQ3
CQ4
CQ5
CQ6
CQ7
CQ8
CQ9
DataScienceCourses
FreeCourses
NetworkingCourses
PrerequisiteForHerny
SoftwareEngineeringCourses
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CourseOragnizer
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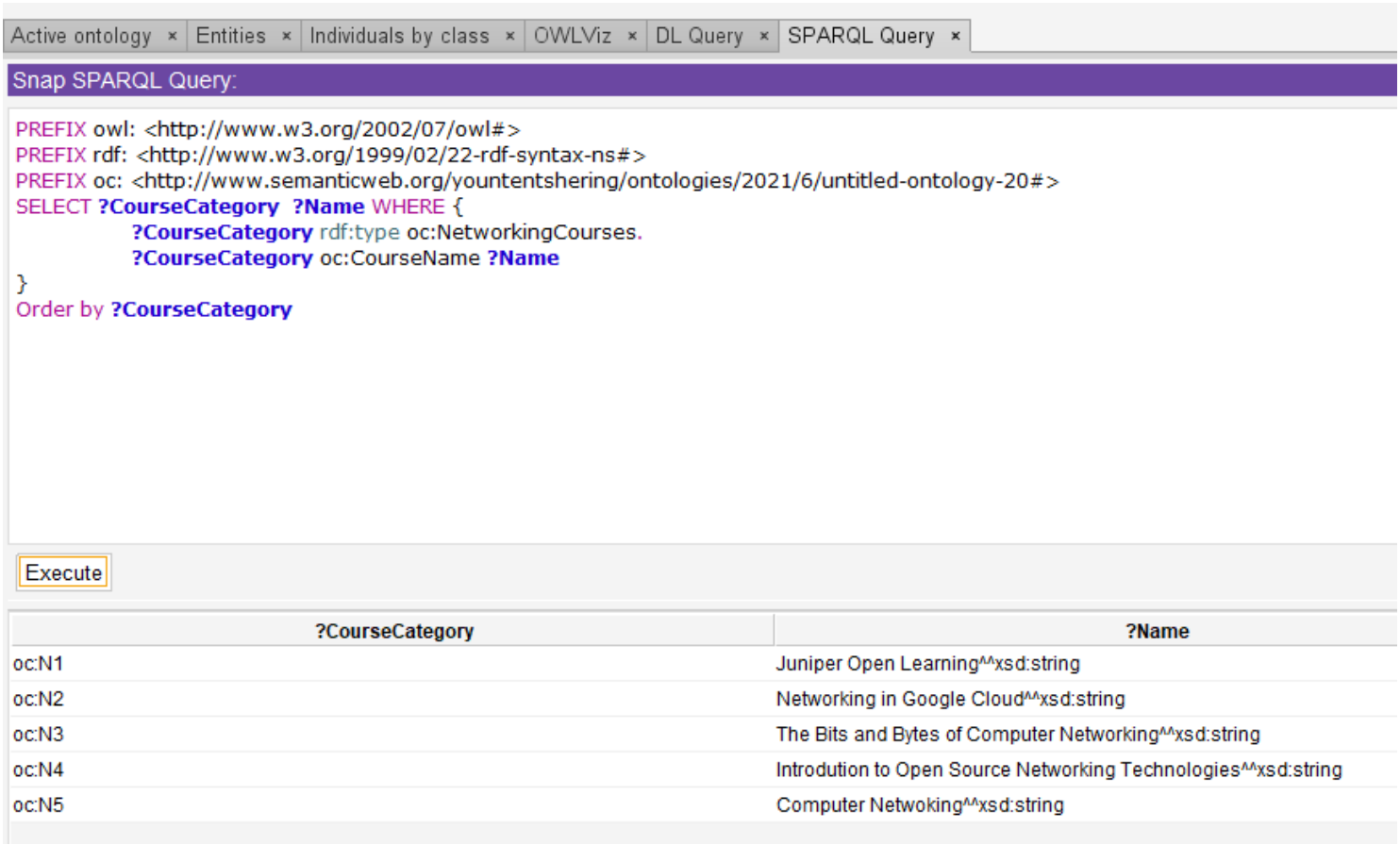
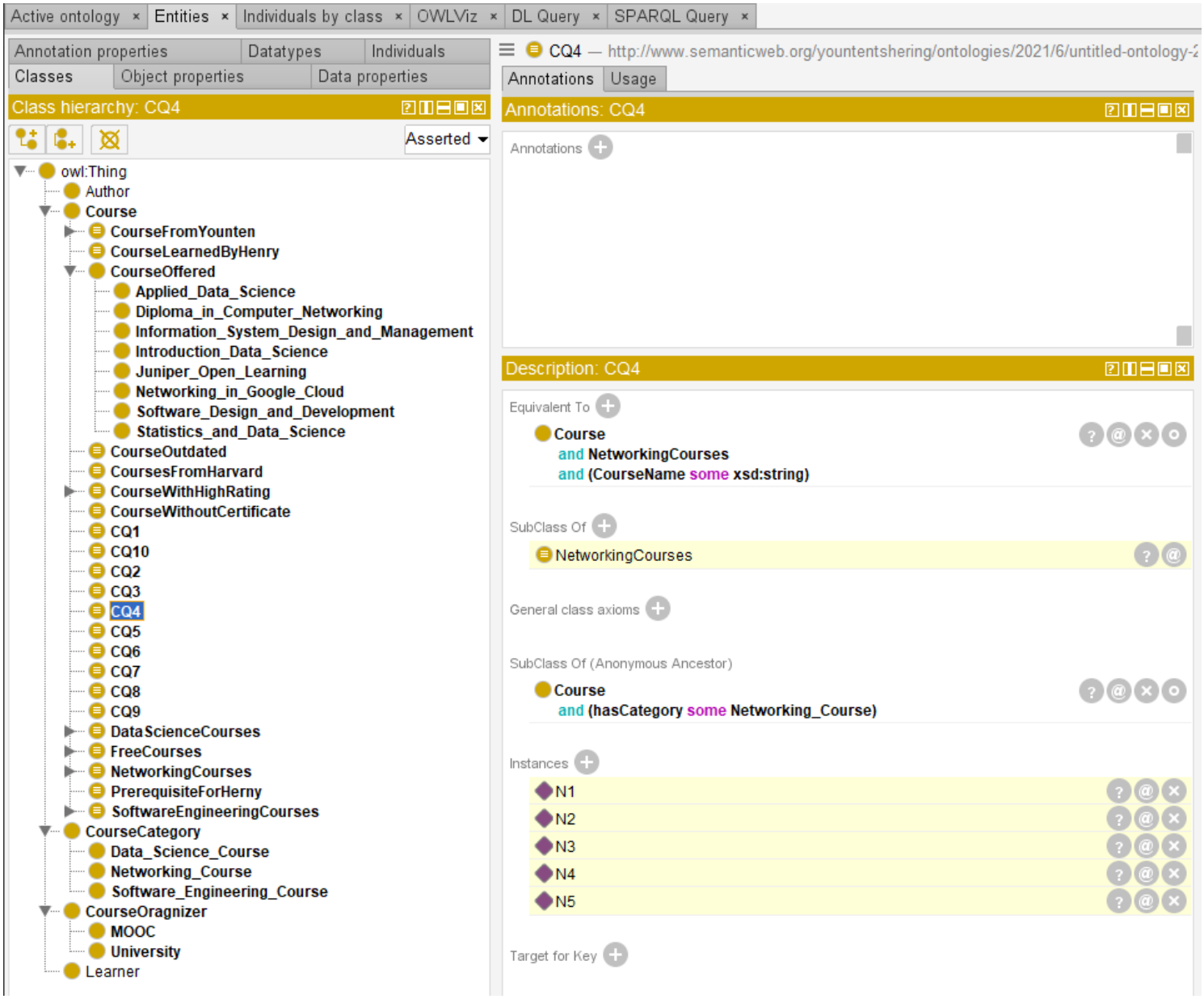
University
Learner
CQ3 — http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-2
Annotations Usage
Annotations: CQ3
Annotations
Description: CQ3
Equivalent To
Course
and (DataScienceCourses
and (CourseSession value "Recorded"))
SubClass Of
DataScienceCourses
General class axioms
SubClass Of (Anonymous Ancestor)
Course
and (hasCategory some Data_Science_Course)
Instances
DS1
DS2
DS3
Target for Key
Disjoint With

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.

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?CourseCategory  ?Name WHERE {
        ?CourseCategory rdf:type oc:NetworkingCourses.
        ?CourseCategory oc:CourseName ?Name
}
Order by ?CourseCategory
```

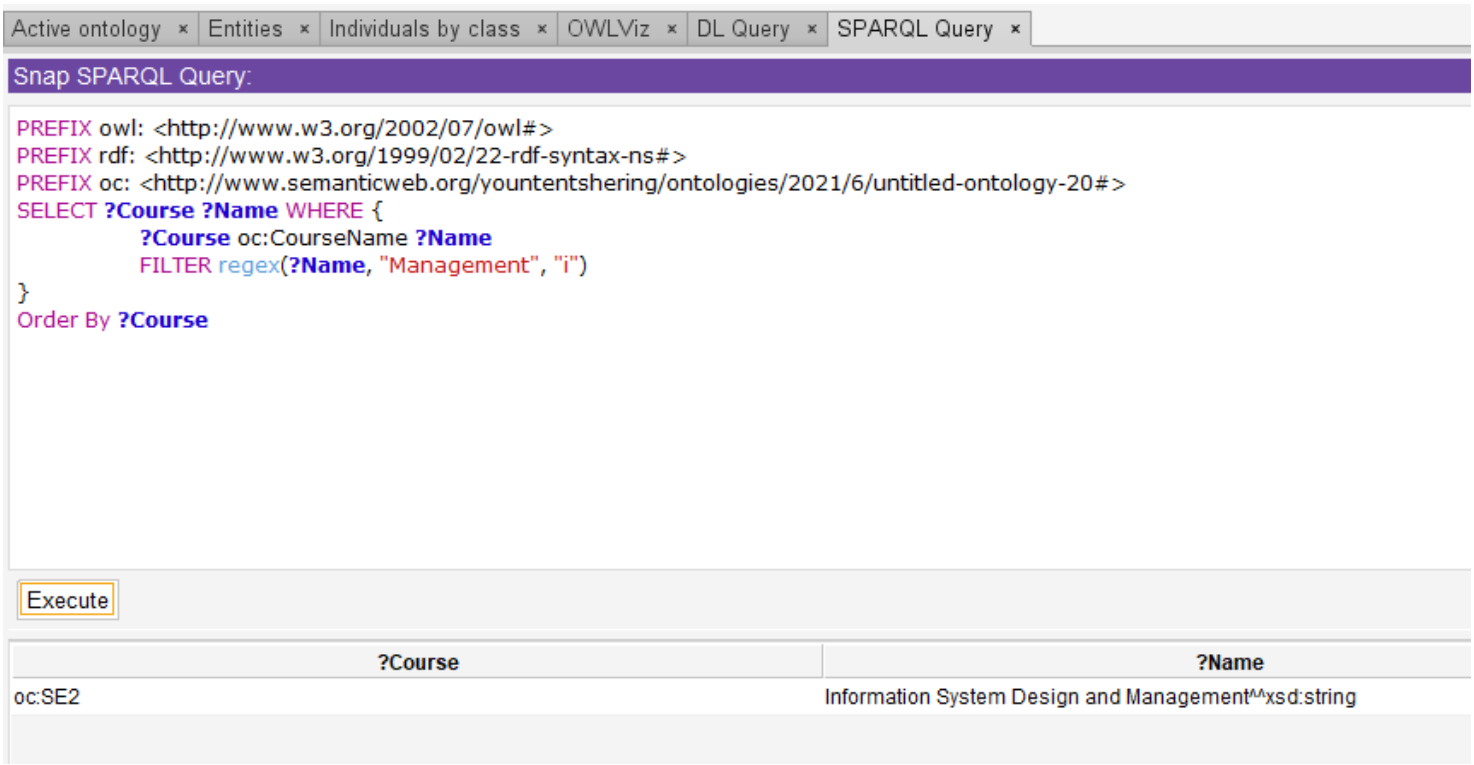


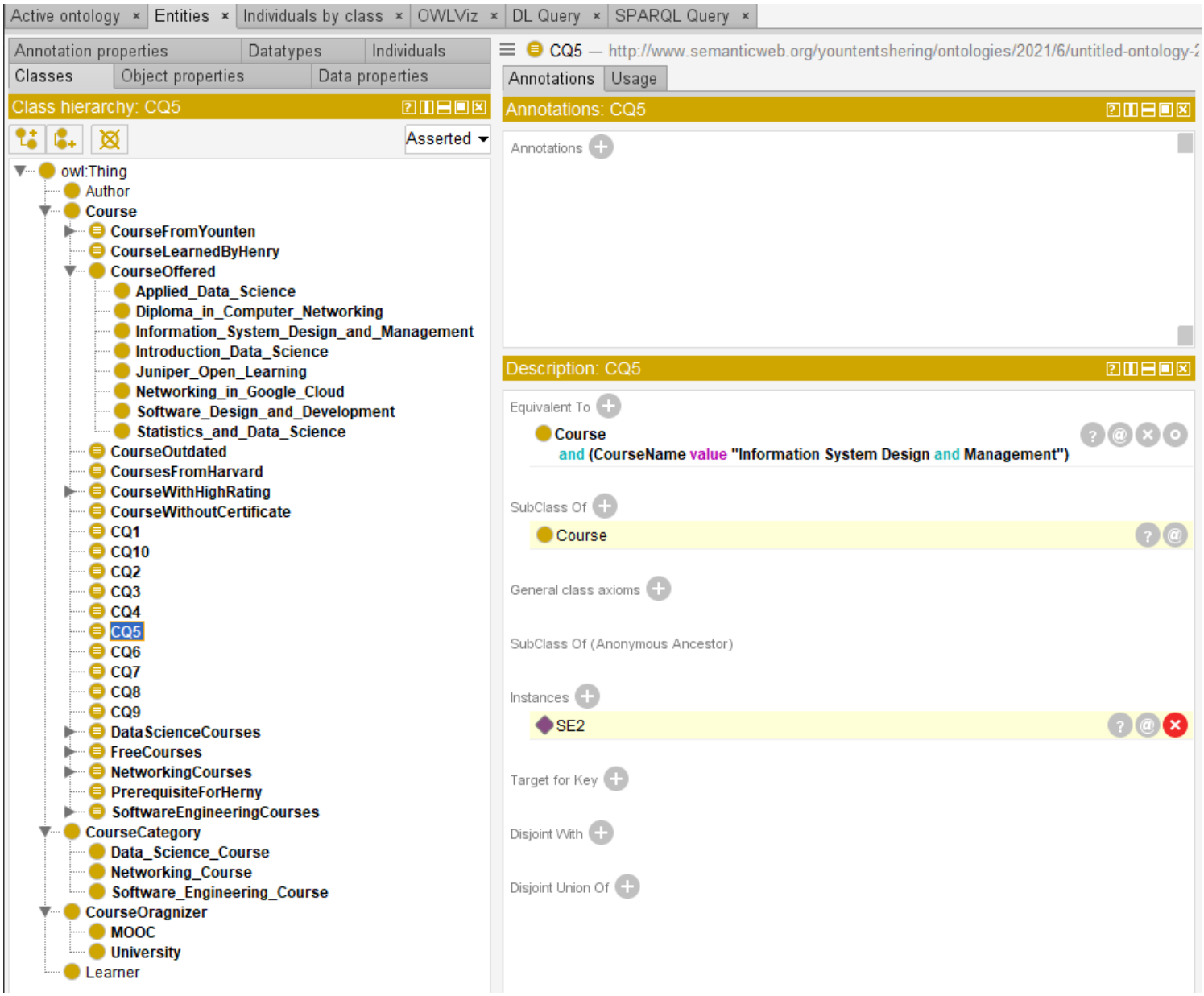
?CourseCategory	?Name
oc:N1	Juniper Open Learning^^xsd:string
oc:N2	Networking in Google Cloud^^xsd:string
oc:N3	The Bits and Bytes of Computer Networking^^xsd:string
oc:N4	Introdution to Open Source Networking Technologies^^xsd:string
oc:N5	Computer Netwoking^^xsd:string


Active ontology
Entities
Individuals by class
OWLViz
DL Query
SPARQL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: CQ4
Asserted
owl:Thing
Author
Course
CourseFromYounten
CourseLearnedByHenry
CourseOffered
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
CourseOutdated
CoursesFromHarvard
CourseWithHighRating
CourseWithoutCertificate
CQ1
CQ10
CQ2
CQ3
CQ4
CQ5
CQ6
CQ7
CQ8
CQ9
DataScienceCourses
FreeCourses
NetworkingCourses
PrerequisiteForHerny
SoftwareEngineeringCourses
CourseCategory
Data_Science_Course
Networking_Course
Software_Engineering_Course
CourseOragnizer
MOOC
University
Learner
CQ4 — http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-2
Annotations
Usage
Annotations: CQ4
Annotations
Description: CQ4
Equivalent To
Course
and NetworkingCourses
and (CourseName some xsd:string)
SubClass Of
NetworkingCourses
General class axioms
SubClass Of (Anonymous Ancestor)
Course
and (hasCategory some Networking_Course)
Instances
N1
N2
N3
N4
N5
Target for Key

5. Mr. C is a new project manager in K-Bank, and he has to develop an information system for ATM machines. What are the courses that will help him to manage the project well?

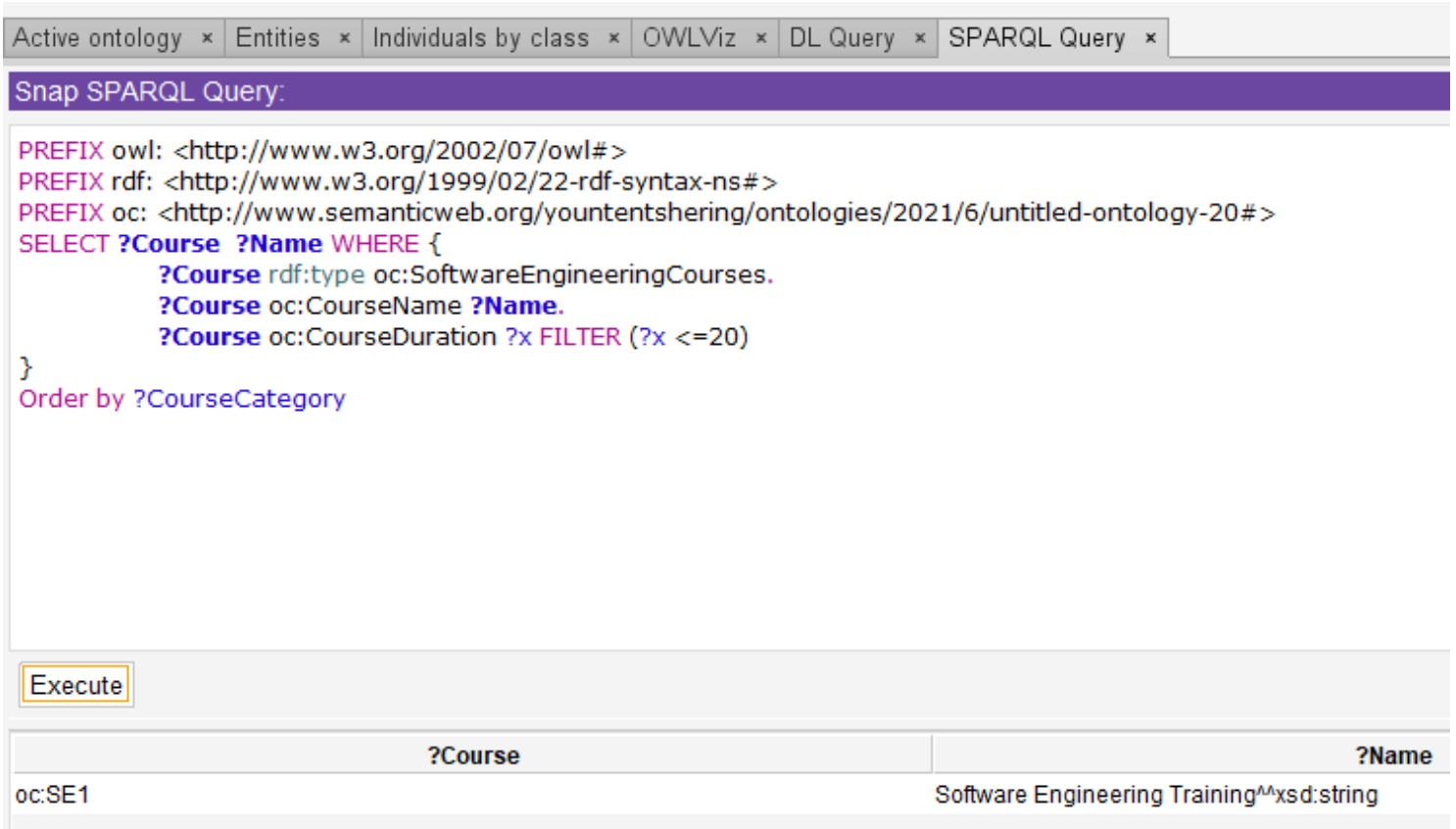
```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course ?Name WHERE {
        ?Course oc:CourseName ?Name
        FILTER regex(?Name, "Management", "i")
}
Order By ?Course
```

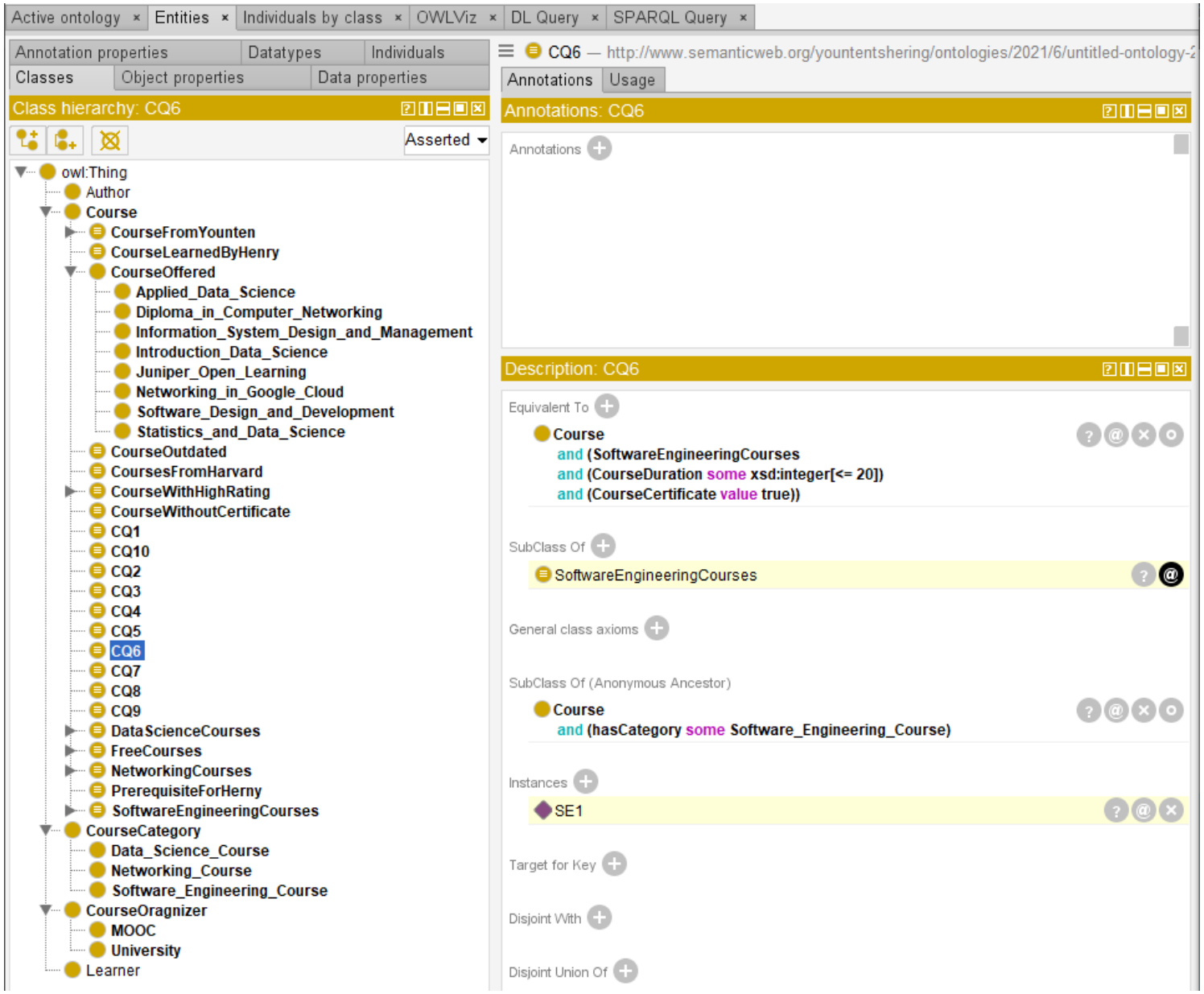



Active ontology
Entities
Individuals by class
OWLViz
DL Query
SPARQL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: CQ5
Asserted
owl:Thing
Author
Course
CourseFromYounten
CourseLearnedByHenry
CourseOffered
Applied_Data_Science
Diploma_in_Computer_Networking
Information_System_Design_and_Management
Introduction_Data_Science
Juniper_Open_Learning
Networking_in_Google_Cloud
Software_Design_and_Development
Statistics_and_Data_Science
CourseOutdated
CoursesFromHarvard
CourseWithHighRating
CourseWithoutCertificate
CQ1
CQ10
CQ2
CQ3
CQ4
CQ5
CQ6
CQ7
CQ8
CQ9
DataScienceCourses
FreeCourses
NetworkingCourses
PrerequisiteForHerny
SoftwareEngineeringCourses
CourseCategory
Data_Science_Course
Networking_Course
Software_Engineering_Course
CourseOragnizer
MOOC
University
Learner
CQ5 — http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-2
Annotations
Usage
Annotations: CQ5
Annotations
Description: CQ5
Equivalent To
Course
and (CourseName value "Information System Design and Management")
SubClass Of
Course
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
SE2
Target for Key
Disjoint With
Disjoint Union Of

6. Mrs. D wants to apply for a job and for that job she needs a Software Training course certificate, and the deadline of the job application is in 1 month. List some of the Software Training courses with certificates that she can obtain within a month (45 hours).

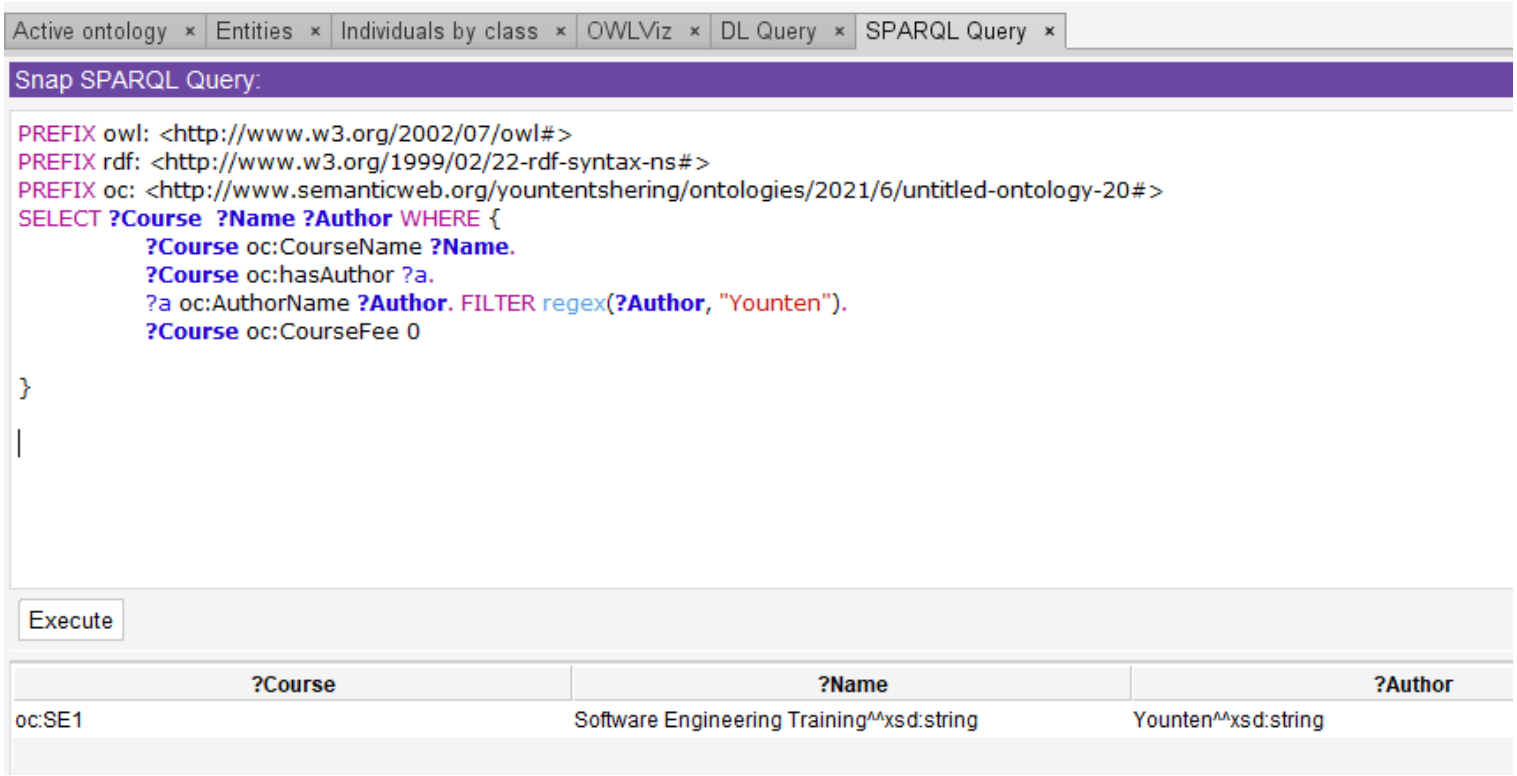
```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course  ?Name WHERE {
        ?Course rdf:type oc:SoftwareEngineeringCourses.
        ?Course oc:CourseName ?Name.
        ?Course oc:CourseDuration ?x FILTER (?x <=20)
}
Order by ?CourseCategory
```

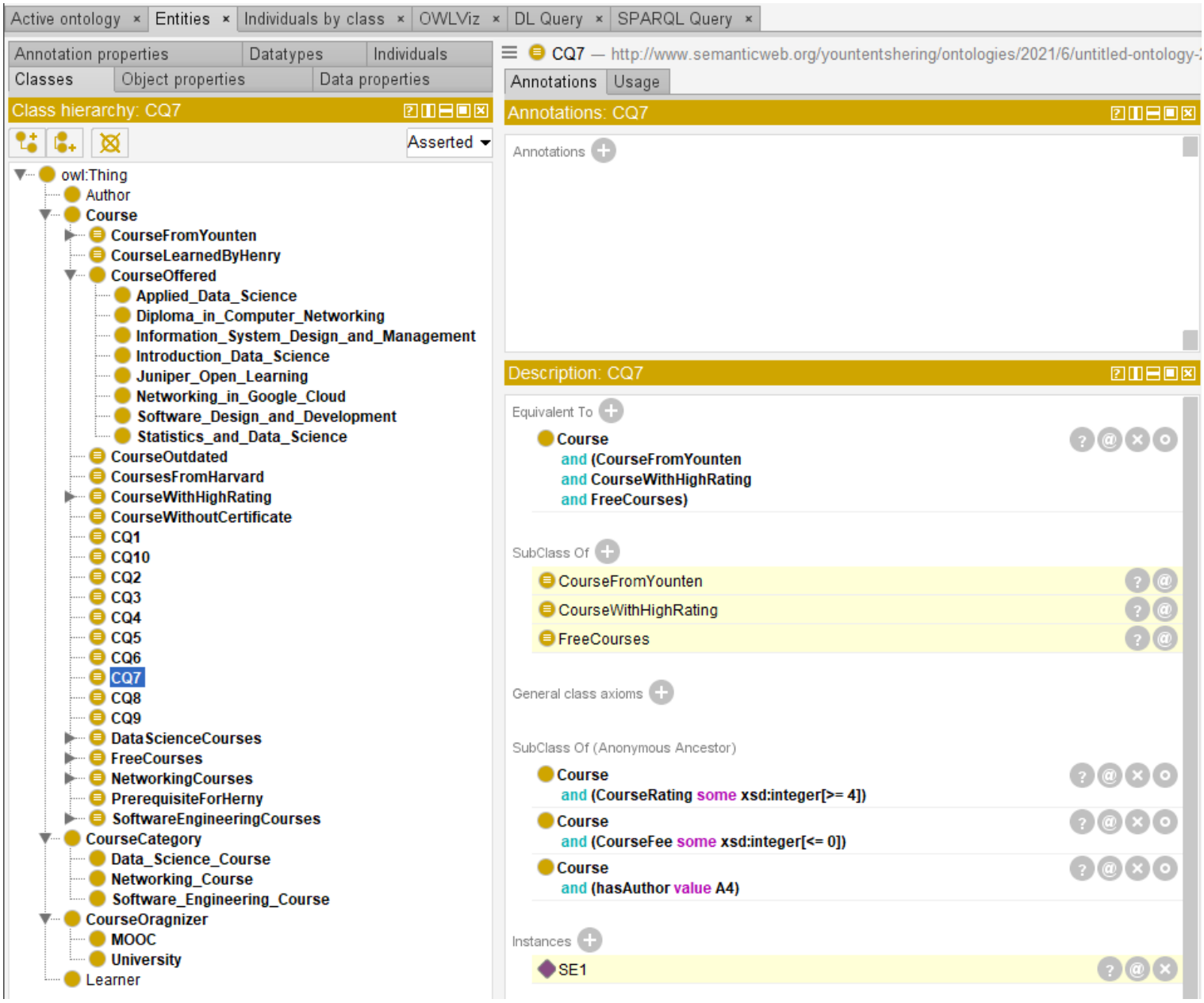



Active ontology
Entities
Individuals by class
OWLViz
DL Query
SPARQL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: CQ6
Asserted
owl:Thing
Author
Course
CourseFromYounten
CourseLearnedByHenry
CourseOffered
Applied_Data_Science
Diploma_in_Computer_Networking
Information_System_Design_and_Management
Introduction_Data_Science
Juniper_Open_Learning
Networking_in_Google_Cloud
Software_Design_and_Development
Statistics_and_Data_Science
CourseOutdated
CoursesFromHarvard
CourseWithHighRating
CourseWithoutCertificate
CQ1
CQ10
CQ2
CQ3
CQ4
CQ5
CQ6
CQ7
CQ8
CQ9
DataScienceCourses
FreeCourses
NetworkingCourses
PrerequisiteForHerny
SoftwareEngineeringCourses
CourseCategory
Data_Science_Course
Networking_Course
Software_Engineering_Course
CourseOragnizer
MOOC
University
Learner
CQ6 — http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-2
Annotations
Usage
Annotations: CQ6
Annotations
Description: CQ6
Equivalent To
Course
and (SoftwareEngineeringCourses
and (CourseDuration some xsd:integer[<= 20])
and (CourseCertificate value true))
SubClass Of
SoftwareEngineeringCourses
General class axioms
SubClass Of (Anonymous Ancestor)
Course
and (hasCategory some Software_Engineering_Course)
Instances
SE1
Target for Key
Disjoint With
Disjoint Union Of

7. Which is the highest rated course of Author XYZ which is free of cost?

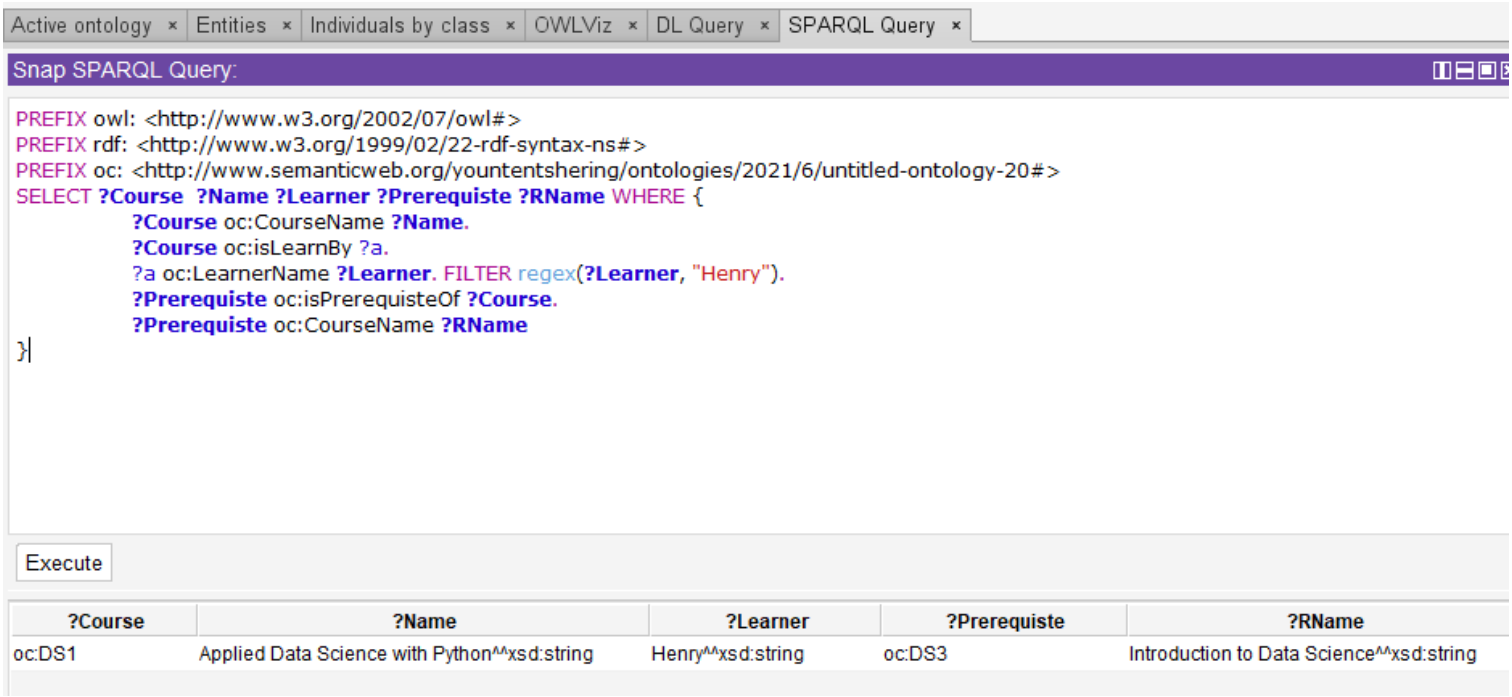
```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course  ?Name ?Author WHERE {
        ?Course oc:CourseName ?Name.
        ?Course oc:hasAuthor ?a.
        ?a oc:AuthorName ?Author. FILTER regex(?Author, "Younten").
        ?Course oc:CourseFee 0

}
```

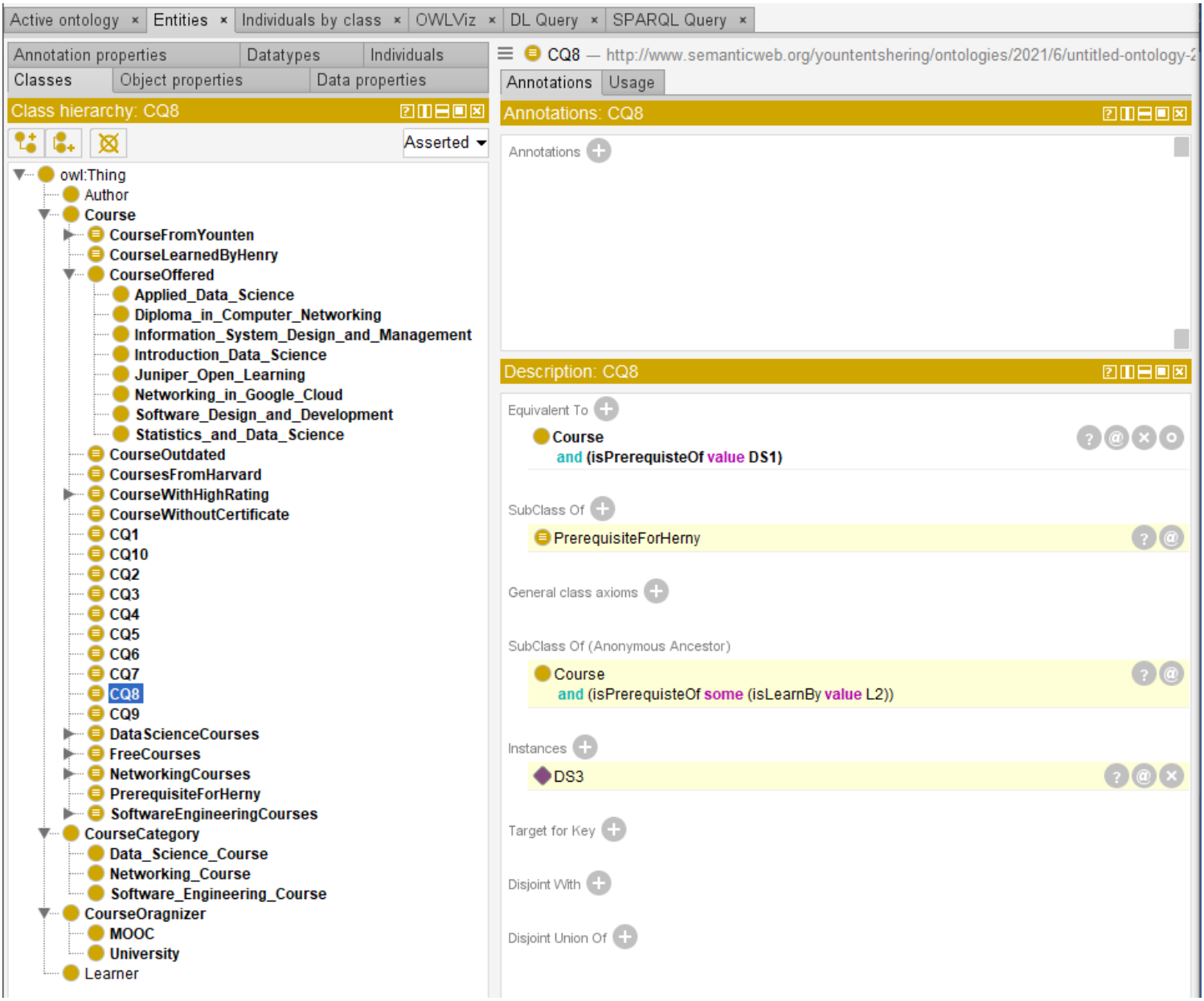



Active ontology
Entities
Individuals by class
OWLViz
DL Query
SPARQL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: CQ7
Asserted
owl:Thing
Author
Course
CourseFromYounten
CourseLearnedByHenry
CourseOffered
Applied_Data_Science
Diploma_in_Computer_Networking
Information_System_Design_and_Management
Introduction_Data_Science
Juniper_Open_Learning
Networking_in_Google_Cloud
Software_Design_and_Development
Statistics_and_Data_Science
CourseOutdated
CoursesFromHarvard
CourseWithHighRating
CourseWithoutCertificate
CQ1
CQ10
CQ2
CQ3
CQ4
CQ5
CQ6
CQ7
CQ8
CQ9
DataScienceCourses
FreeCourses
NetworkingCourses
PrerequisiteForHerny
SoftwareEngineeringCourses
CourseCategory
Data_Science_Course
Networking_Course
Software_Engineering_Course
CourseOragnizer
MOOC
University
Learner
CQ7 — http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-
Annotations
Usage
Annotations: CQ7
Annotations
Description: CQ7
Equivalent To
Course
and (CourseFromYounten
and CourseWithHighRating
and FreeCourses)
SubClass Of
CourseFromYounten
CourseWithHighRating
FreeCourses
General class axioms
SubClass Of (Anonymous Ancestor)
Course
and (CourseRating some xsd:integer[>= 4])
Course
and (CourseFee some xsd:integer[<= 0])
Course
and (hasAuthor value A4)
Instances
SE1

8. If I take the ABC course, what are some of the prerequisite courses that I need to attend?

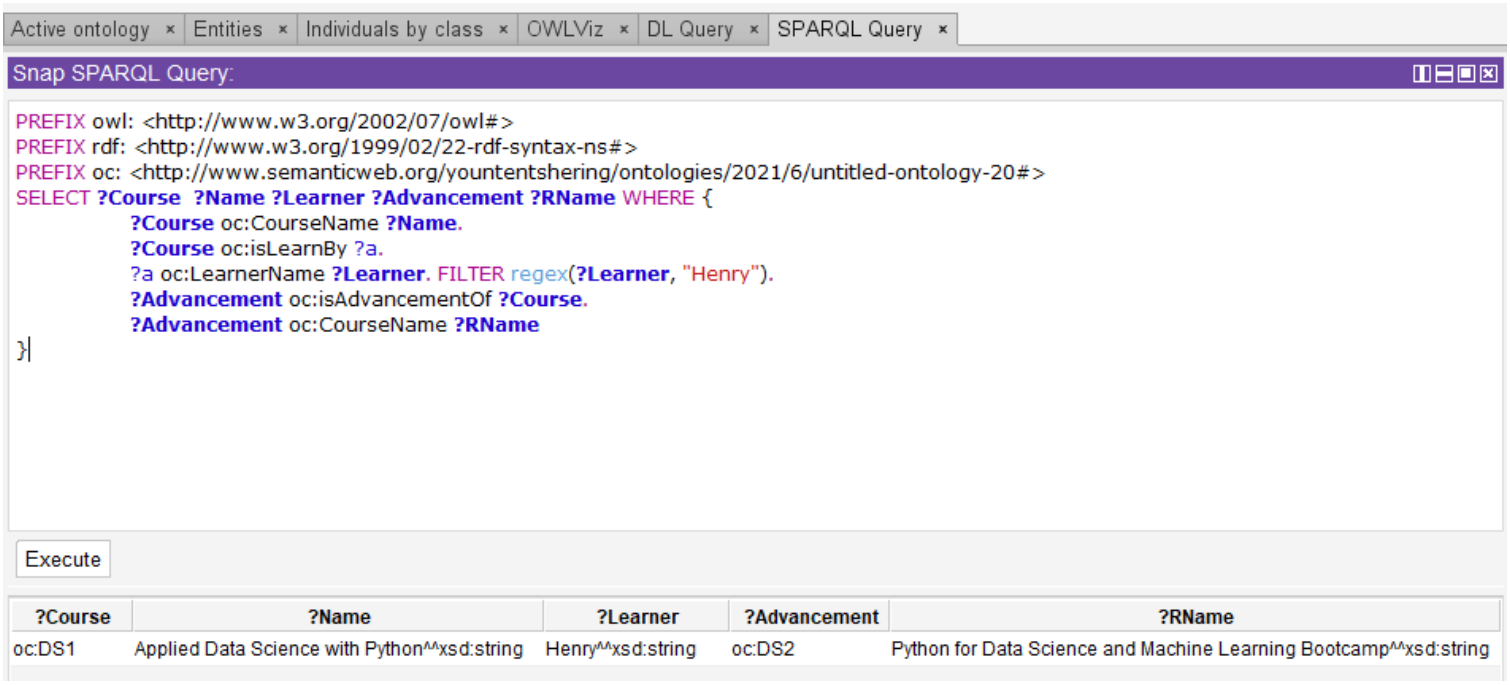
```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course  ?Name ?Learner ?Prerequiste ?RName WHERE {
        ?Course oc:CourseName ?Name.
        ?Course oc:isLearnBy ?a.
        ?a oc:LearnerName ?Learner. FILTER regex(?Learner, "Henry").
        ?Prerequiste oc:isPrerequisteOf ?Course.
        ?Prerequiste oc:CourseName ?RName
}
```




Active ontology
Entities
Individuals by class
OWLViz
DL Query
SPARQL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: CQ8
Asserted
owl:Thing
Author
Course
CourseFromYounten
CourseLearnedByHenry
CourseOffered
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
CourseOutdated
CoursesFromHarvard
CourseWithHighRating
CourseWithoutCertificate
CQ1
CQ10
CQ2
CQ3
CQ4
CQ5
CQ6
CQ7
CQ8
CQ9
DataScienceCourses
FreeCourses
NetworkingCourses
PrerequisiteForHerny
SoftwareEngineeringCourses
CourseCategory
Data_Science_Course
Networking_Course
Software_Engineering_Course
CourseOragnizer
MOOC
University
Learner
CQ8 — http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-2
Annotations
Usage
Annotations: CQ8
Annotations
Description: CQ8
Equivalent To
Course
and (isPrerequisteOf value DS1)
SubClass Of
PrerequisiteForHerny
General class axioms
SubClass Of (Anonymous Ancestor)
Course
and (isPrerequisteOf some (isLearnBy value L2))
Instances
DS3
Target for Key
Disjoint With
Disjoint Union Of

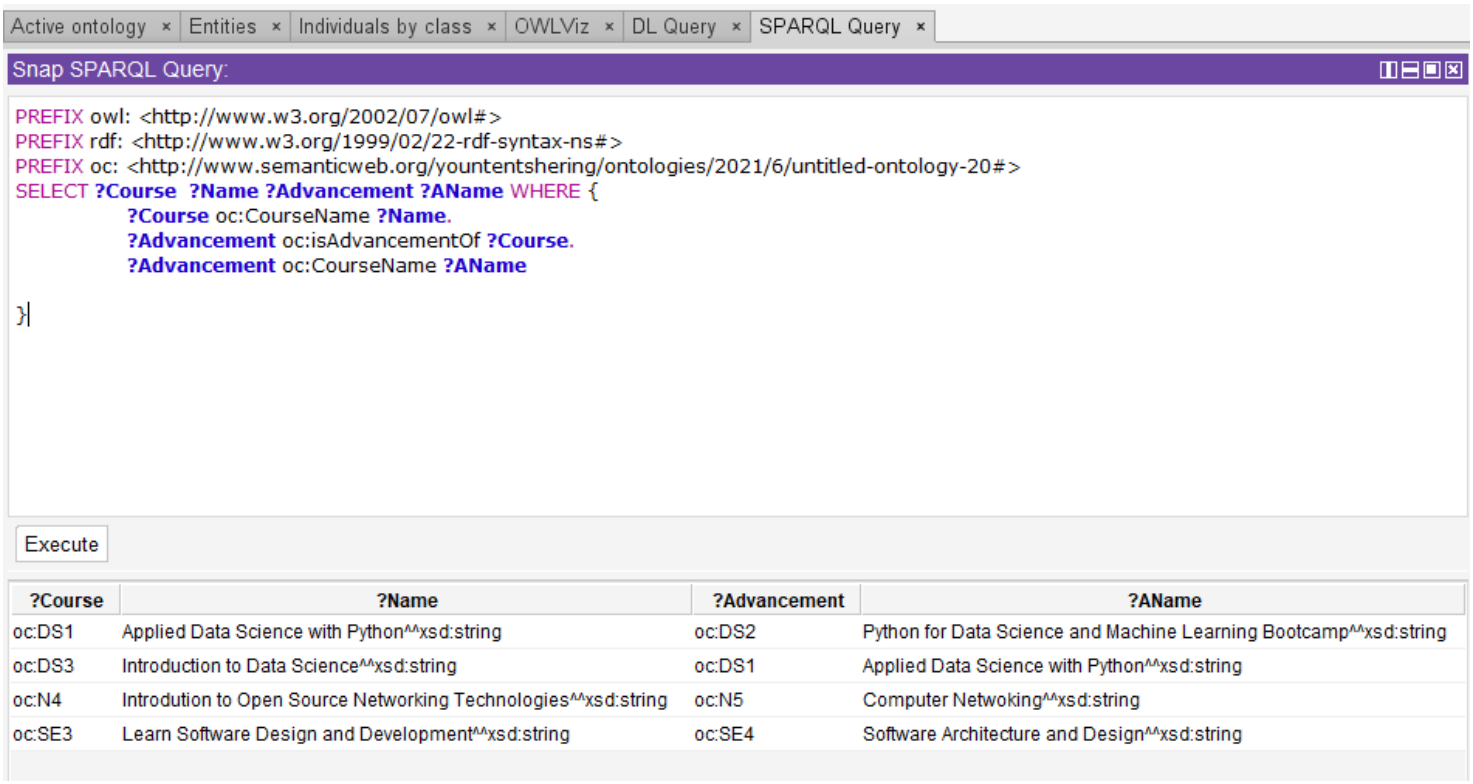
9. List some of the advanced/recommended courses after completing a particular course.

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course  ?Name ?Learner ?Advancement ?RName WHERE {
        ?Course oc:CourseName ?Name.
        ?Course oc:isLearnBy ?a.
        ?a oc:LearnerName ?Learner. FILTER regex(?Learner, "Henry").
        ?Advancement oc:isAdvancementOf ?Course.
        ?Advancement oc:CourseName ?RName
}
```

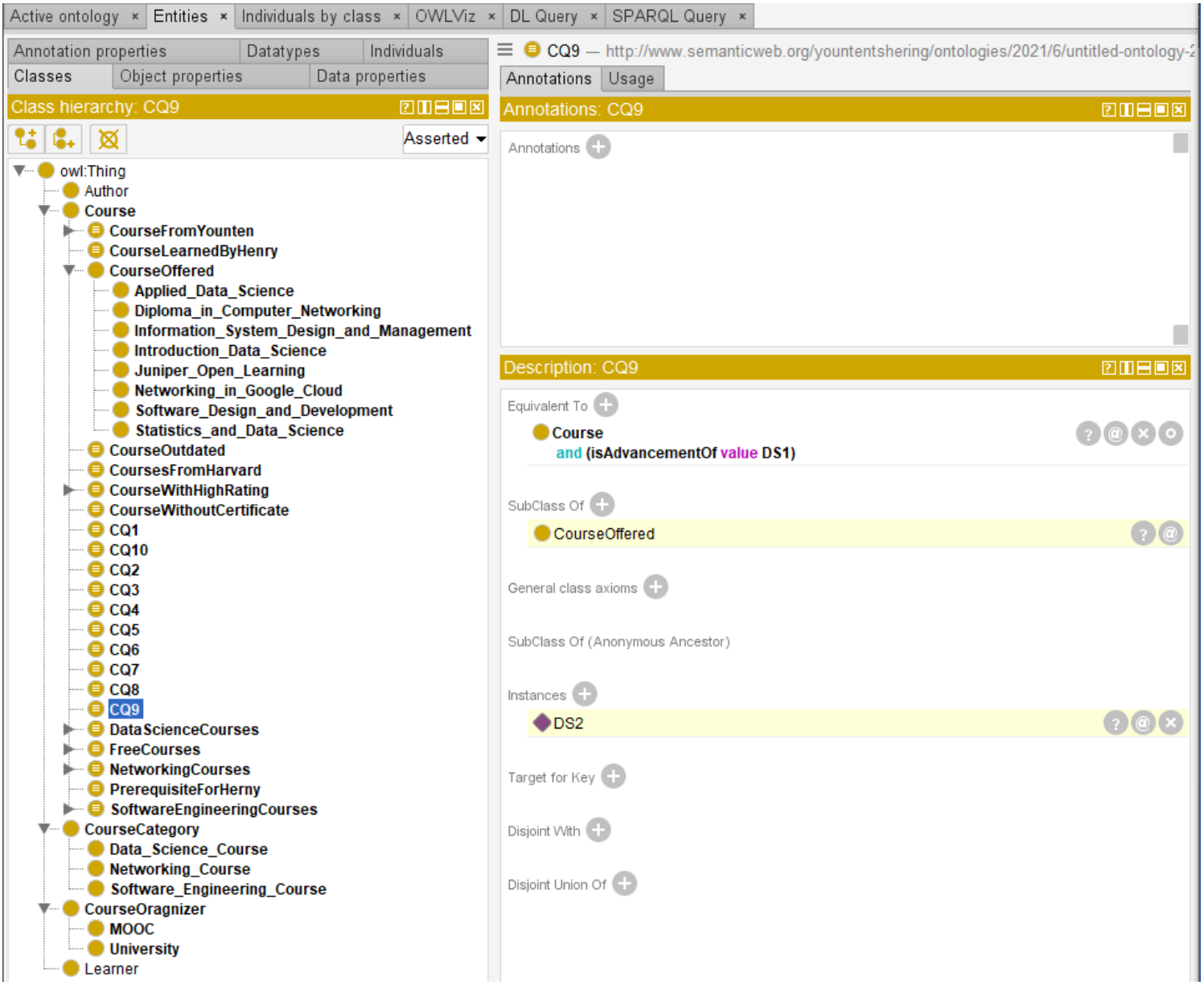


Another Way to get the list:

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course  ?Name ?Advancement ?AName WHERE {
        ?Course oc:CourseName ?Name.
        ?Advancement oc:isAdvancementOf ?Course.
        ?Advancement oc:CourseName ?AName

}
```

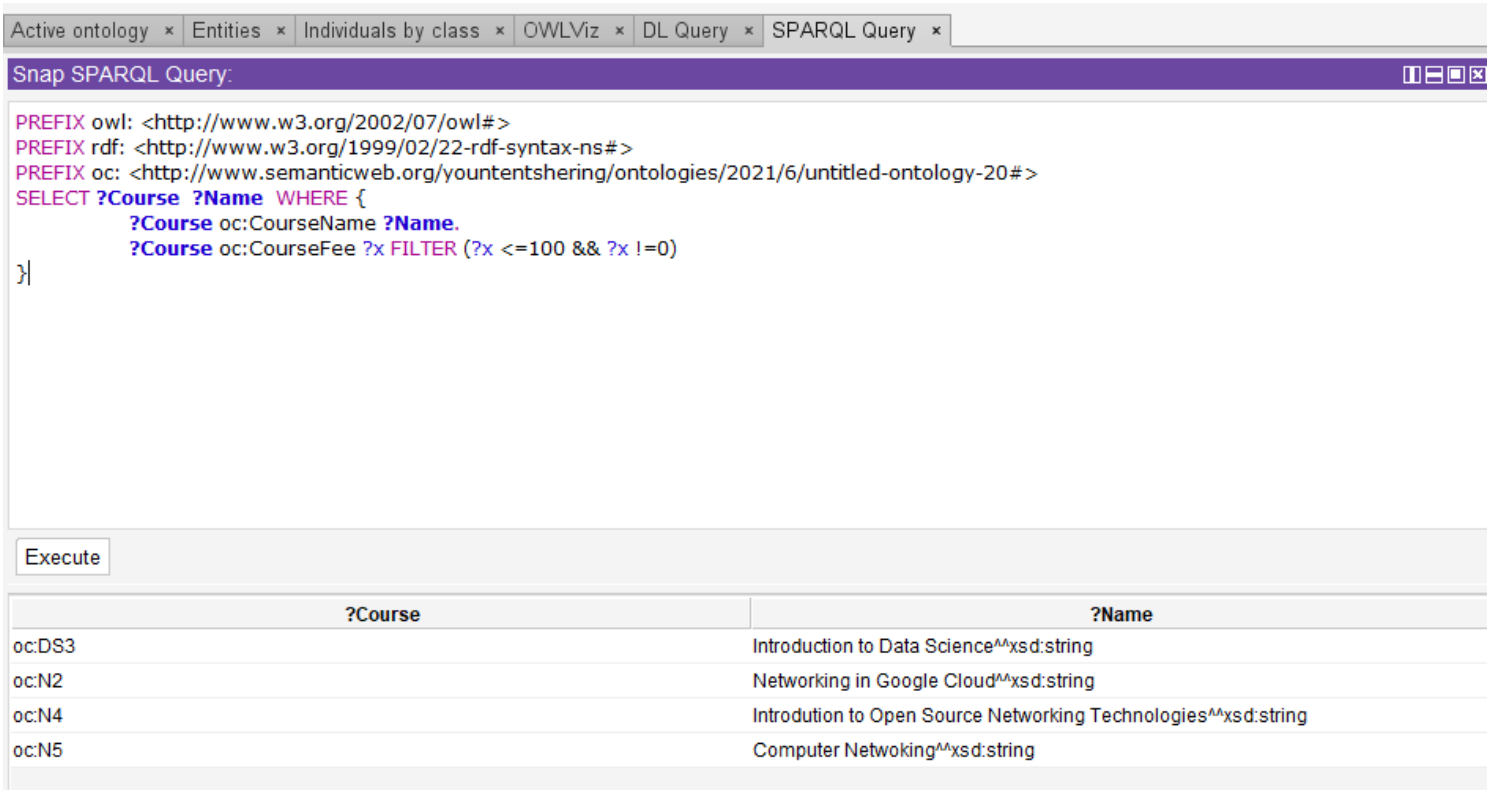


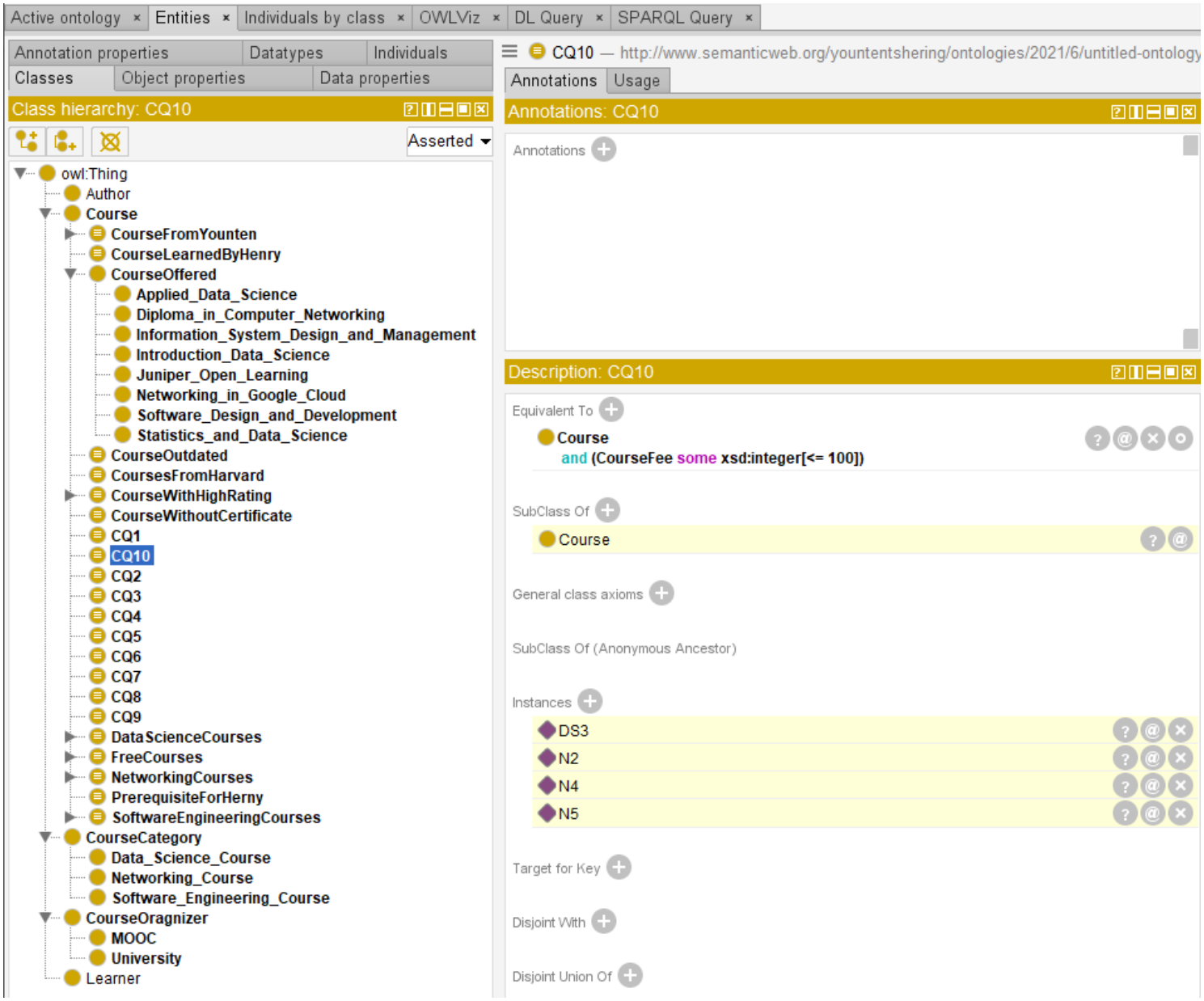
?Course	?Name	?Advancement	?AName
oc:DS1	Applied Data Science with Python^^xsd:string	oc:DS2	Python for Data Science and Machine Learning Bootcamp^^xsd:string
oc:DS3	Introduction to Data Science^^xsd:string	oc:DS1	Applied Data Science with Python^^xsd:string
oc:N4	Introdution to Open Source Networking Technologies^^xsd:string	oc:N5	Computer Netwoking^^xsd:string
oc:SE3	Learn Software Design and Development^^xsd:string	oc:SE4	Software Architecture and Design^^xsd:string


Active ontology
Entities
Individuals by class
OWLViz
DL Query
SPARQL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: CQ9
Asserted
owl:Thing
Author
Course
CourseFromYounten
CourseLearnedByHenry
CourseOffered
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
CourseOutdated
CoursesFromHarvard
CourseWithHighRating
CourseWithoutCertificate
CQ1
CQ10
CQ2
CQ3
CQ4
CQ5
CQ6
CQ7
CQ8
CQ9
DataScienceCourses
FreeCourses
NetworkingCourses
PrerequisiteForHerny
SoftwareEngineeringCourses
CourseCategory
Data_Science_Course
Networking_Course
Software_Engineering_Course
CourseOragnizer
MOOC
University
Learner
CQ9 — http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-2
Annotations
Usage
Annotations: CQ9
Annotations
Description: CQ9
Equivalent To
Course
and (isAdvancementOf value DS1)
SubClass Of
CourseOffered
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
DS2
Target for Key
Disjoint With
Disjoint Union Of

10. Mrs. E has some budget limitation; recommend some courses which are below or equal to 100 Euro to her.

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course  ?Name  WHERE {
        ?Course oc:CourseName ?Name.
        ?Course oc:CourseFee ?x FILTER (?x <=100 && ?x !=0)
}
```




Active ontology
Entities
Individuals by class
OWLViz
DL Query
SPARQL Query
Annotation properties
Datatypes
Individuals
Classes
Object properties
Data properties
Class hierarchy: CQ10
Asserted
owl:Thing
Author
Course
CourseFromYounten
CourseLearnedByHenry
CourseOffered
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
CourseOutdated
CoursesFromHarvard
CourseWithHighRating
CourseWithoutCertificate
CQ1
CQ10
CQ2
CQ3
CQ4
CQ5
CQ6
CQ7
CQ8
CQ9
DataScienceCourses
FreeCourses
NetworkingCourses
PrerequisiteForHerny
SoftwareEngineeringCourses
CourseCategory
Data_Science_Course
Networking_Course
Software_Engineering_Course
CourseOragnizer
MOOC
University
Learner
CQ10 — http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology
Annotations
Usage
Annotations: CQ10
Annotations
Description: CQ10
Equivalent To
Course
and (CourseFee some xsd:integer[<= 100])
SubClass Of
Course
General class axioms
SubClass Of (Anonymous Ancestor)
Instances
DS3
N2
N4
N5
Target for Key
Disjoint With
Disjoint Union Of

11. Extra: Check the recent updated course.

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course  ?Name  ?Update WHERE {
        ?Course oc:CourseName ?Name.
        ?Course oc:CourseLastUpdate ?Update
}
Order By DESC(?Update)
```

Active ontology × | Entities × | Individuals by class × | OWLViz × | DL Query × | SPARQL Query ×

Snap SPARQL Query:

```
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX oc: <http://www.semanticweb.org/yountentshering/ontologies/2021/6/untitled-ontology-20#>
SELECT ?Course  ?Name  ?Update WHERE {
        ?Course oc:CourseName ?Name.
        ?Course oc:CourseLastUpdate ?Update
}
Order By DESC(?Update)
```

Execute

?Course	?Name	?Update
oc:SE2	Information System Design and Management^^xsd:stri...	2021-12-01T09:00:06^^xsd:dateTime
oc:SE1	Software Engineering Training^^xsd:string	2021-12-01T09:00:03^^xsd:dateTime
oc:DS3	Introduction to Data Science^^xsd:string	2021-12-01T09:00:02^^xsd:dateTime
oc:N1	Juniper Open Learning^^xsd:string	2020-12-01T09:00:06^^xsd:dateTime
oc:N2	Networking in Google Cloud^^xsd:string	2020-12-01T09:00:06^^xsd:dateTime
oc:N4	Introdution to Open Source Networking Technologies^^...	2020-12-01T09:00:06^^xsd:dateTime
oc:SE4	Software Architecture and Design^^xsd:string	2020-12-01T09:00:05^^xsd:dateTime
oc:DS2	Python for Data Science and Machine Learning Bootca...	2020-12-01T09:00:01^^xsd:dateTime
oc:DS1	Applied Data Science with Python^^xsd:string	2020-12-01T09:00:00^^xsd:dateTime
oc:SE3	Learn Software Design and Development^^xsd:string	2019-12-01T09:00:04^^xsd:dateTime
oc:DS4	MicroMasters Statistics and Data Science^^xsd:string	2019-12-01T09:00:03^^xsd:dateTime
oc:N3	The Bits and Bytes of Computer Networking^^xsd:string	2017-12-01T09:00:06^^xsd:dateTime