Modelling Assignment

Ontology Development

10 April 2023

Introduction

In a public library, browsing the library catalogue online, would help the users to efficiently select the book of their choice, to know the book availability and the book location on the shelf. The main purpose of this assignment is to design an abstraction of the library books for powering an online search engine, using ontology. Ontology provides a typical method of interpreting real world things to allow automatic interpretation by machines (Qaswar et al., 2022). Protégé version 5.6.1 is a free, open-source platform that provides a suite of tools to construct domain models and knowledge-based applications with ontologies (Musen, 2015) and the Web Ontology Language (OWL) which is the most recent development in standard ontology languages were used in this assignment for modelling ontology.

Ontology design

Sematic web knowledge representation approach is used, as it is a natural representation that conveys meaning in transparent manner, simple and easy to understand (AI Technologies of knowledge representation, 2023), which would suit well for the business problem of defining the library books categorisation, resembling declarative problem solving using answer set programming.

Design process

According to Noy & McGuinness (2001), the ontology development process involves the following steps. It is based on iterative approach such that as we progress through the steps we can go back a step to modify things to suit the requirement,

Step1: Domain and scope: Library, for user to efficiently identify the book of their choice. Questions to address: what are the selection characteristics/properties of the book? Who will be the users?

Step2: Re-use existing ontologies: Library ontologies were researched, suitable ontologies not available, hence decided to create a new ontology.

Step3: Enumerate terms: The terms related to library books were identified to be title, author, ISBN, publisher, year published, genre, language of the book, potential users of the library such as adult, children, book reviews, book location in the library shelf. It was thought these terms would help the users to navigate proficiently.

Step4: Define class hierarchy: The classes and sub-classes, as shown in Appendix Figures:1and 2 were defined, using top-down approach.

Step5: The object properties and the data properties as shown in Figures: 3 and 4 were defined. For the object properties, domain and range were defined as shown in table:1.

Table:1 Object properties and Data properties

Type	Name	Domain	Range
Object property	hasLocation	Book	Location
	hasReview	Book	Review
	prefers	User	Book

	isPreferredBy	Book	User
	provides	User	Review
	isProvidedBy	Review	User
Data property	hasTitle	Book	xsd:string
	hasName	Author	xsd:string
	hasEdition	Book	xsd:positiveinteger
	hasISBN	Book	xsd:positiveinteger
	hasPages	Book	xsd:positiveinteger
	YearPublished	Book	xsd:positiveinteger
	hasPublisher	Book	xsd:string

Step6: The datatype for the data properties were assigned, shown in Table:1, that describe the relationship between the individuals and the data values.

Step7: Individuals were created in each classes, example, defined individuals for language shown in the figure: 5

All sibling classes were disjoint to each other, such that the class individuals doesn't overlap.

Restictions: Setting restriction to user groups could help the user to choose their preferred genre of books directly.

Existential restrictions: classes with individial participating in atleast one specified relation with other class individuals. Example: 'Youngster' belonging to class Adult has property 'prefers' some 'Fiction' books, shown in Figure:6.

Universal restrictions: classes with individial participating in only one specified relation with other class individuals. Example: ‘PreSchooler’ belonging to class Children has property ‘prefers’ only ‘FairytaleFantasy’ books, shown in Figure:7.

ValuePartitions: Through value partition, 5 class reviews was set for individual books, ranging from fivestar to onestar. These ratings are made disjoint from each other and set a covering axiom such that each book is a member of one of the 5 ratings sub-clases. so that the user has the option to view the book review rating to decide to choose a book. Figure:8 shows the view displaying the class description of the Review class.

Throughout the process, annotations were created while creating classes and properties to annotate the purpose of adding them..

Analysis of output

Reasoner ‘HermiT’ version 1.4.3.456 was used to check the consistency in every step of ontology development process to make sure inconsistent hierarcies were ruled out. Figure: 9 displays the log after running the reasoner, with no inconsistency detected.. A simple DL query, as shown in Figure: 10 was excuted to test the functionality of the created ontology class expression and found to be ok.

Discussion

Ontologies are proving to be an useful tool in extracting knowledge and increasing the interoperability of real world concepts in any domain. Narayanasamy et al., (2022) had reviewed the utilisation of semantic web technologies in healthcare, virtual communities, and found that the integration of the semantic web and AI are required for dealing with unstructured data. Similar to ontology, a semantic network

known as knowledge graph represents a network of real-world entities, but its research interest were studied to be decreasing over the past two years due to poor data quality (Ryan et al., 2022)

Jing X, et al. (2023) had reviewed the benefits of sematic web based knowledge extraction in clinical decision support systems and also identified the need to improve ontology reusability and interoperability. It would imply the need for creating expert peer-reviewed ontology library, where the users can visit to re-use the existing ontologies.

Emphasis should be given on input of human domain experts into ontologies creation, to rule out the inconsitency and reduce the gap between AI and human intelligence, using hybrid intelligence (Pileggi, 2023).

Conclusion

Using the Protégé tool with OWL, sematic web based ontologies could be created and executed for library book search domain. The usefulness of ontologies were well proven and the need to incorporate ontology library to reuse ontologies and input of human domain expert knowledge are emphasied.

References

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Jing X, et al. (2023) Ontologies Applied in Clinical Decision Support System Rules: Systematic Review. *JMIR Med Inform* 11: DOI: http://dx.doi.org/10.2196/43053

Appendix: Screenshots of Ontology development process in Protégé

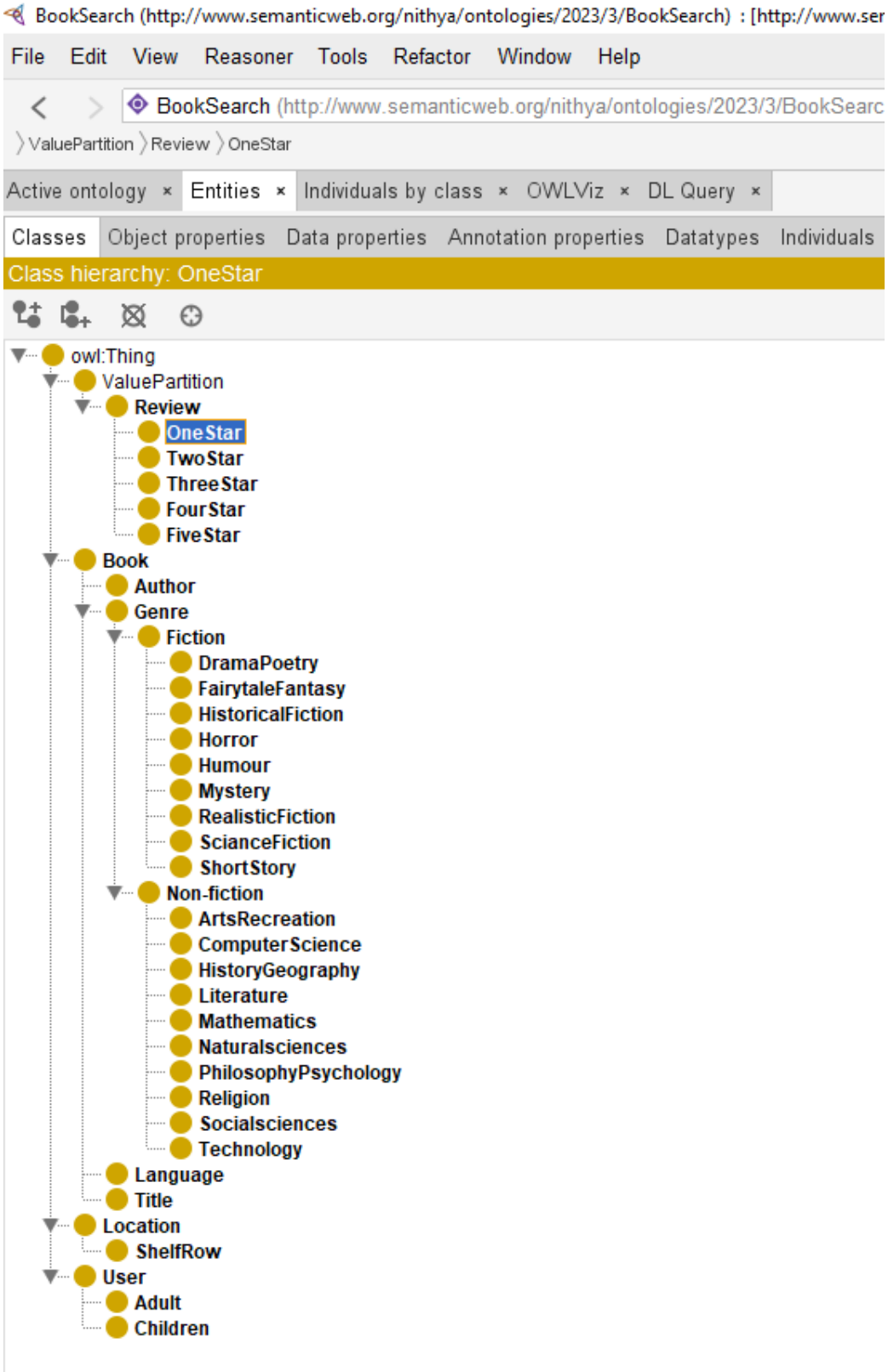

Figure: 1 Defining classes and sub-classes

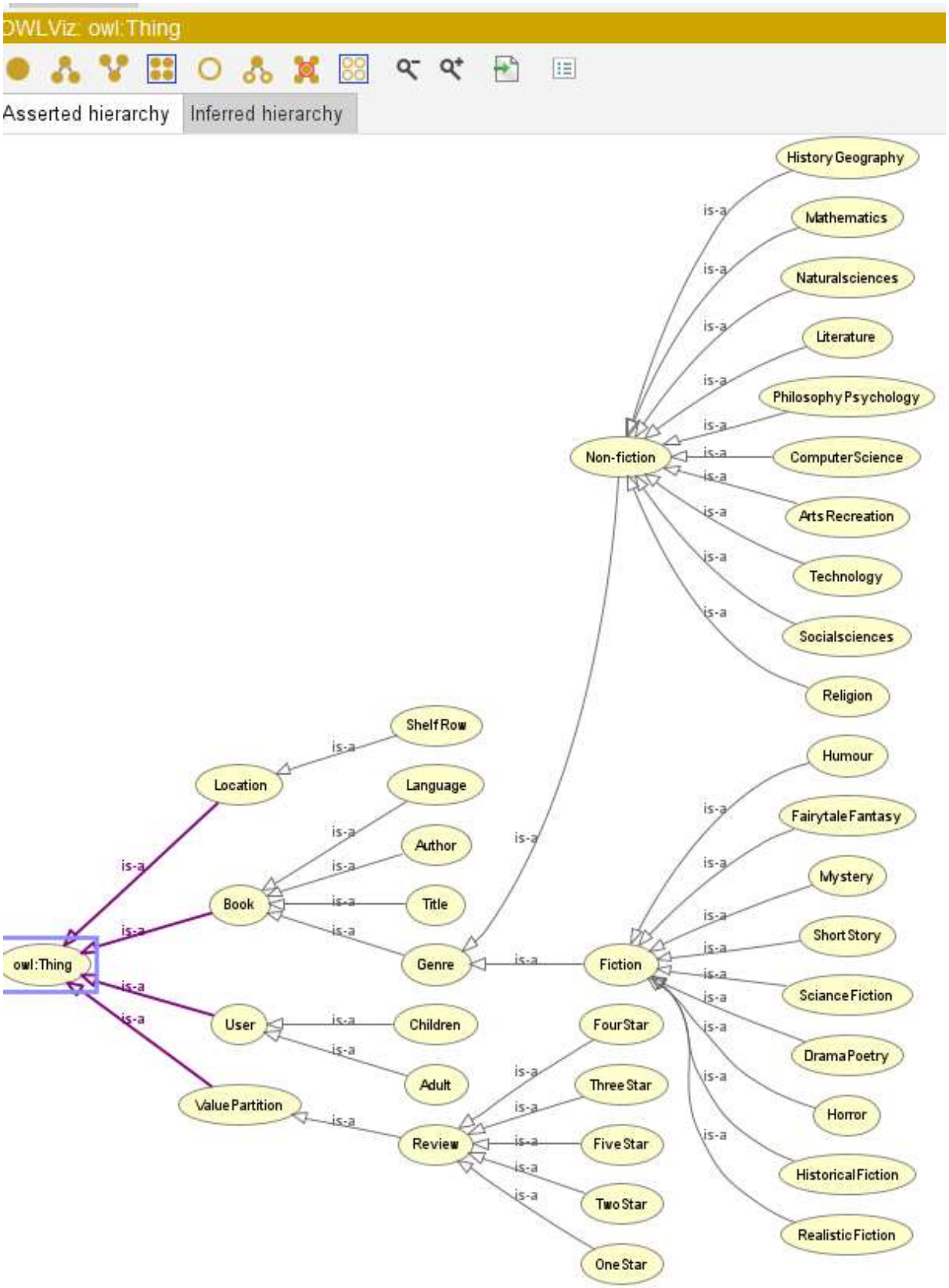

Figure:2 Graphical visualisation of classes and sub-classes

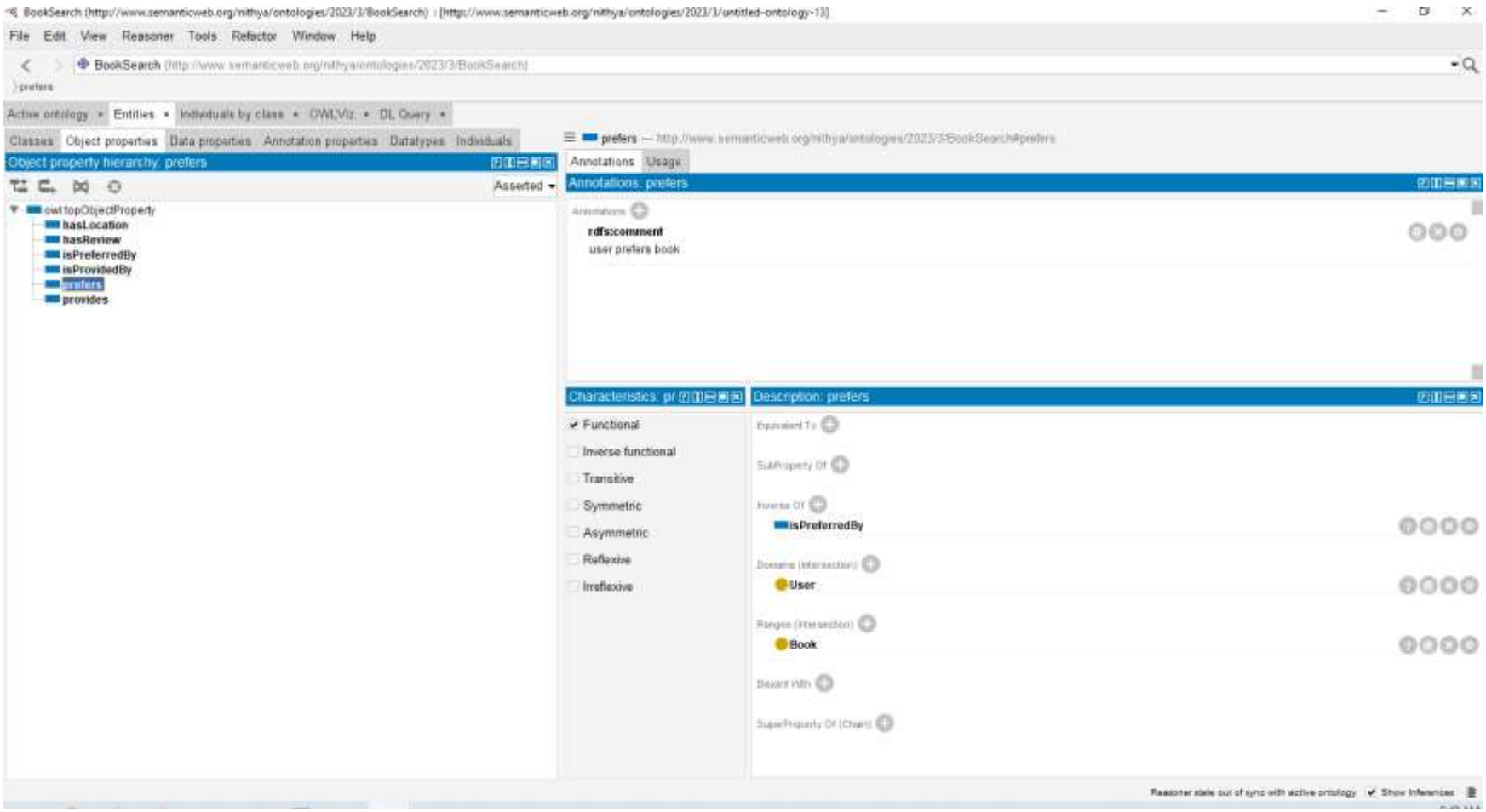

Figure:3 Defining object properties

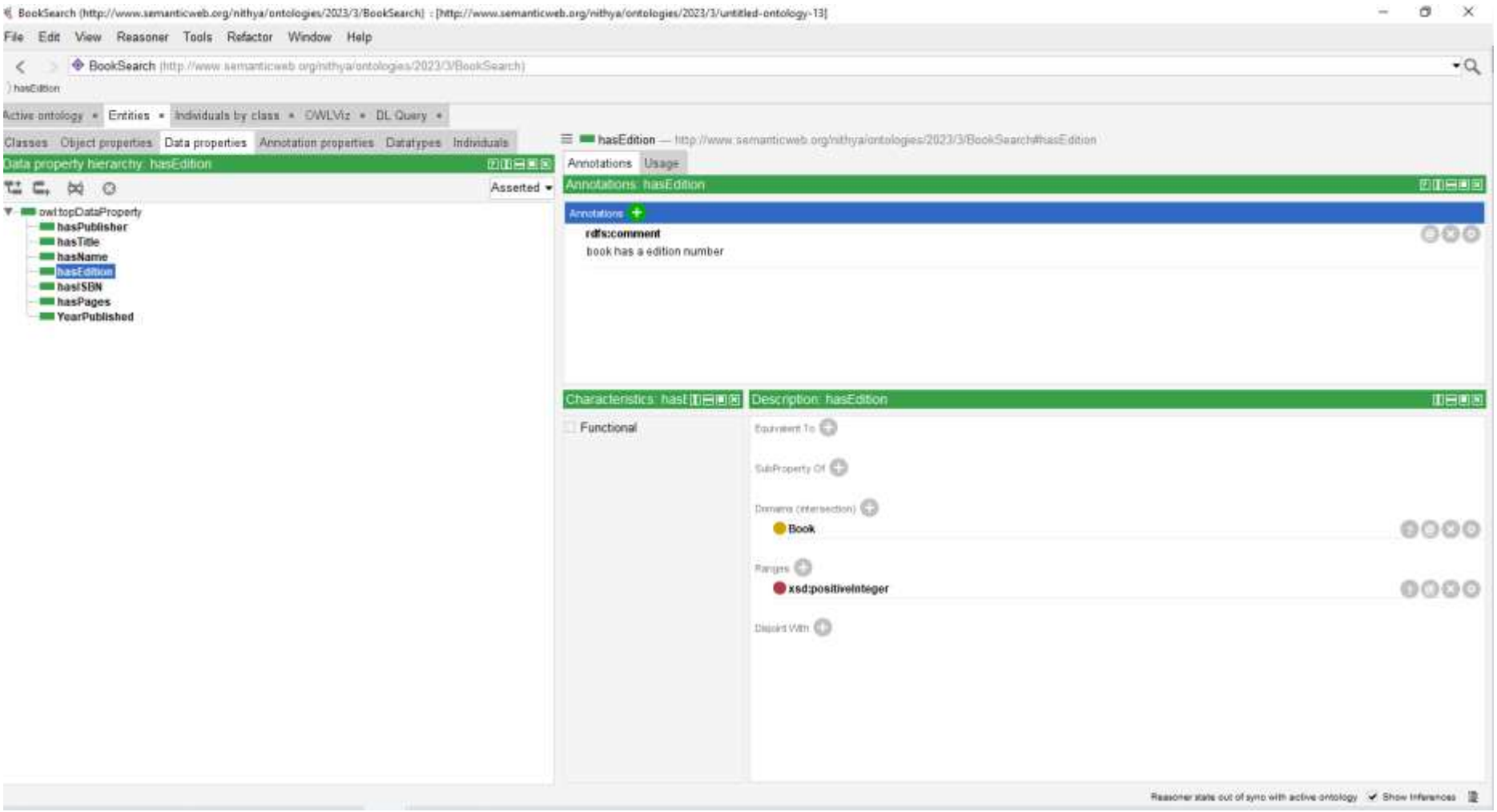

Figure:4 Defining Data properties

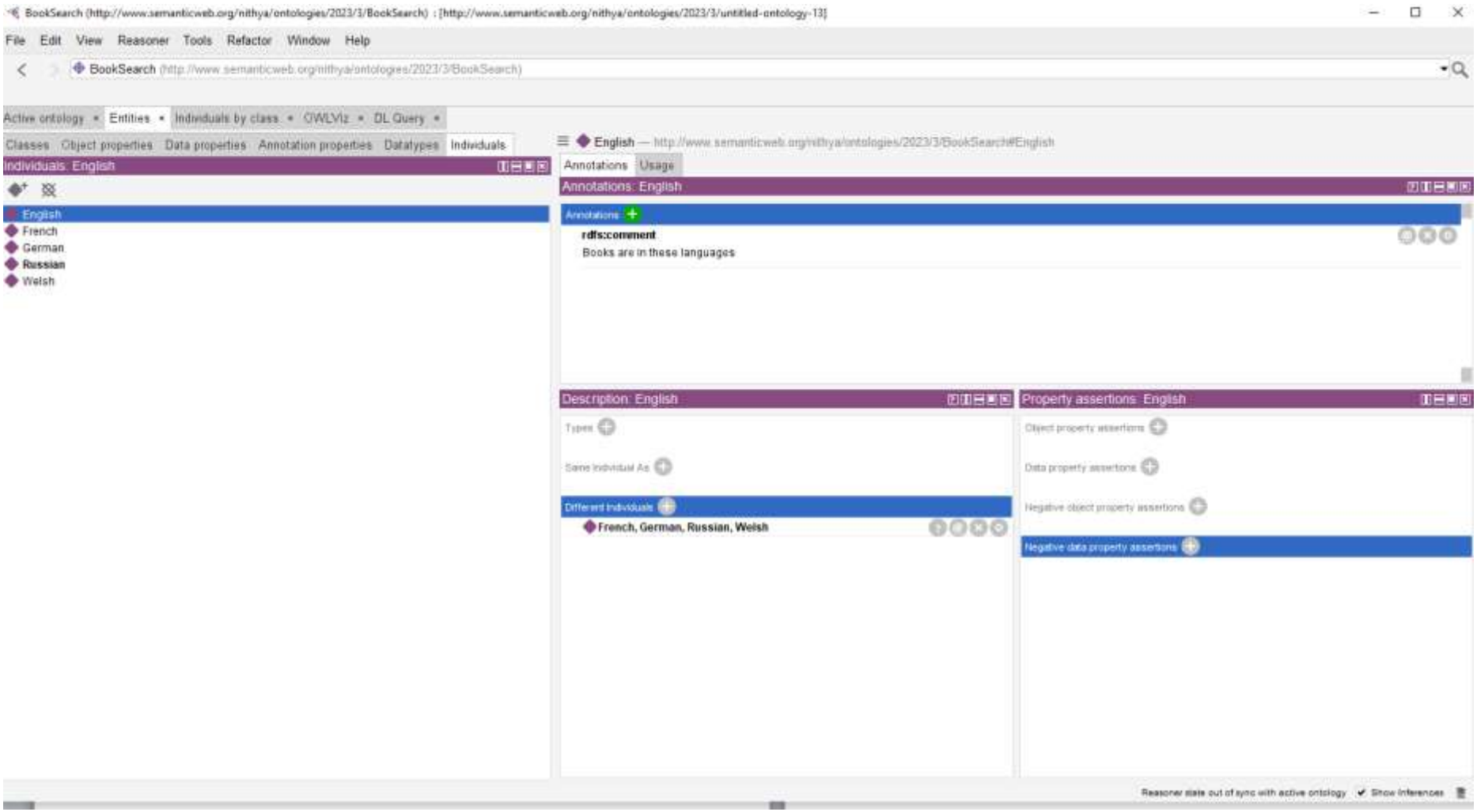

Figure:5 Defining Individuals for class: Language

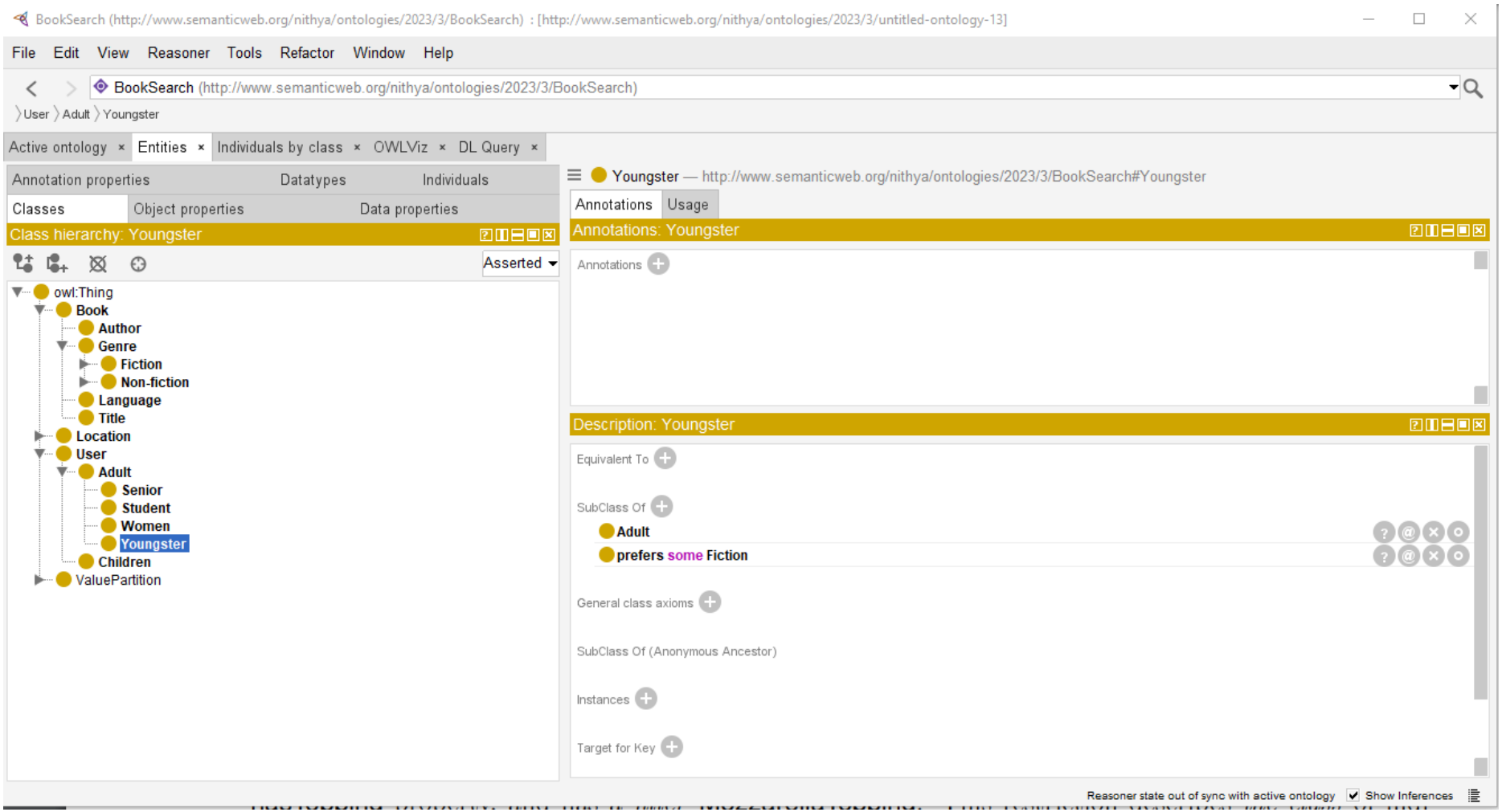

Figure:6 Example of Existential restriction

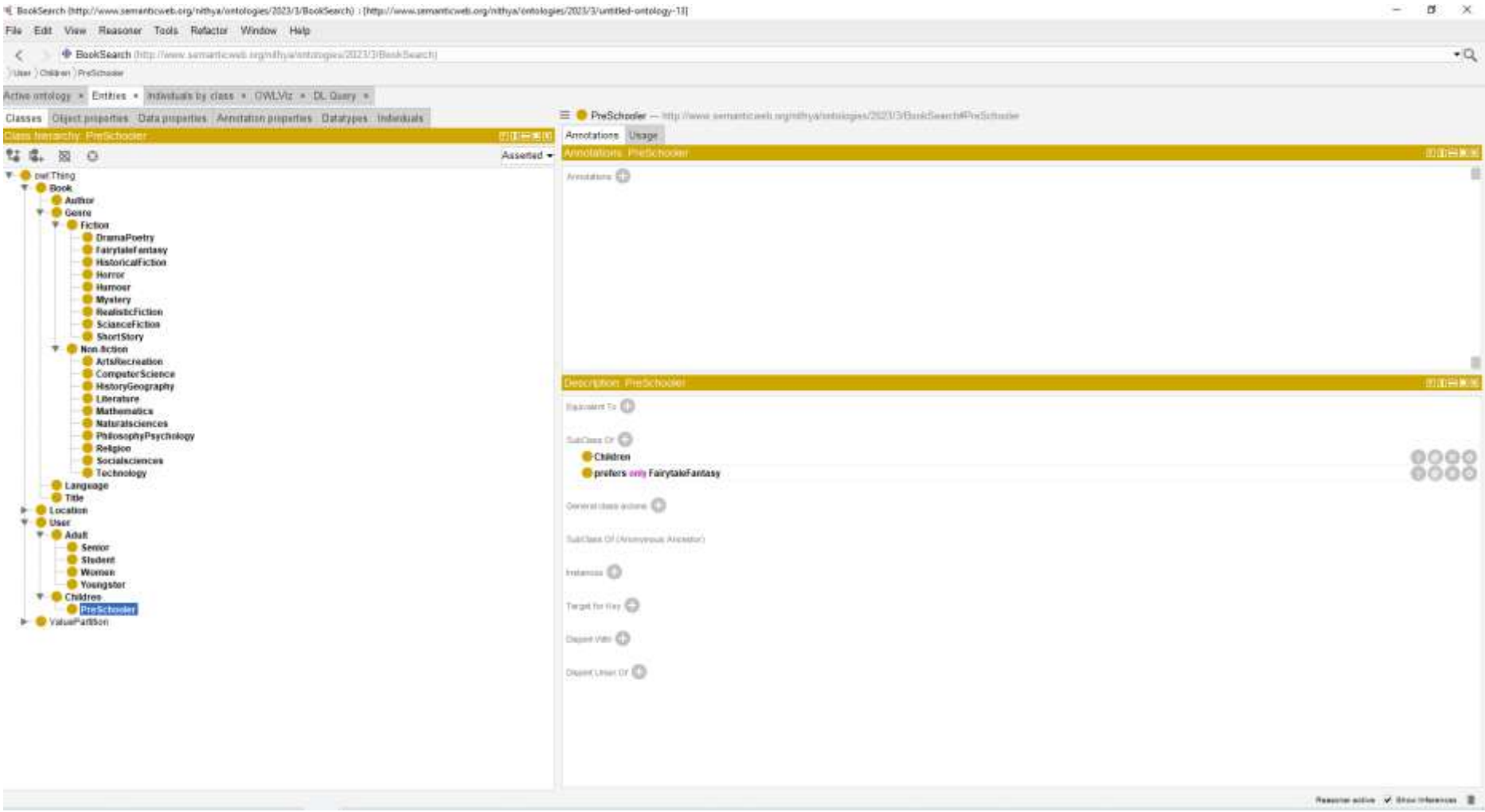

Figure:7 Example of Universal restriction

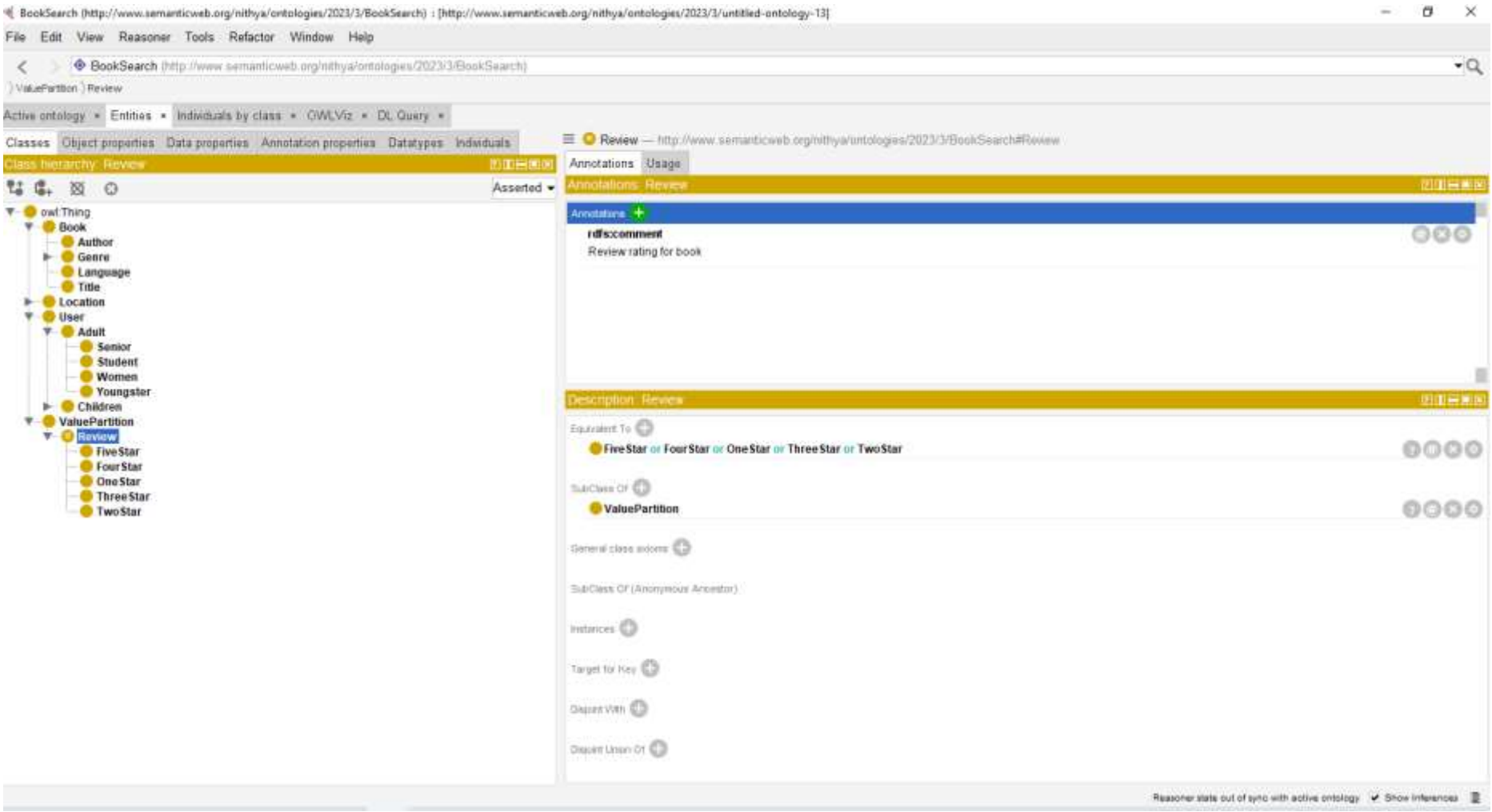

Figure 8: Setting value partition based on book review rating

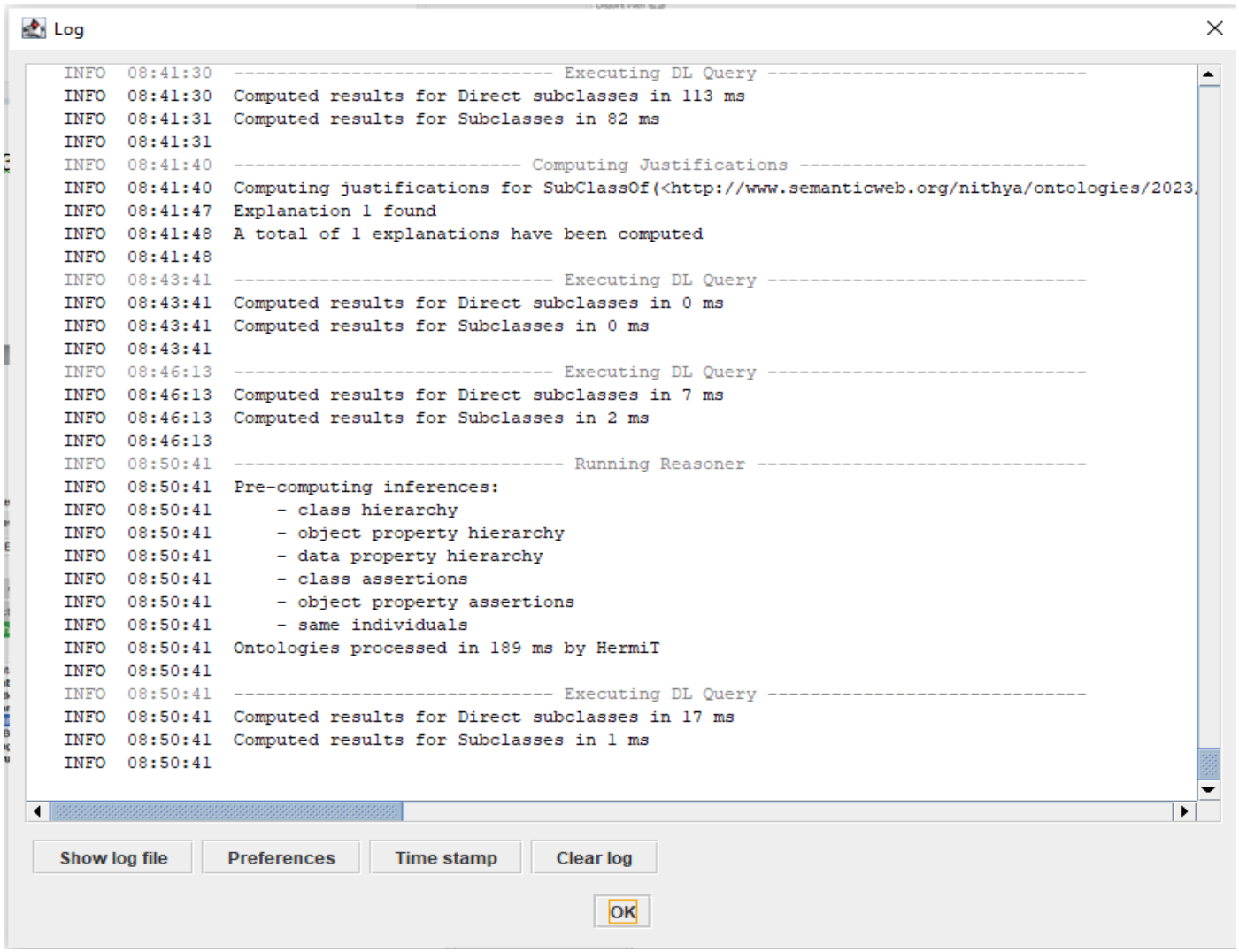

Figure 9: Log of running reasoner before DL query

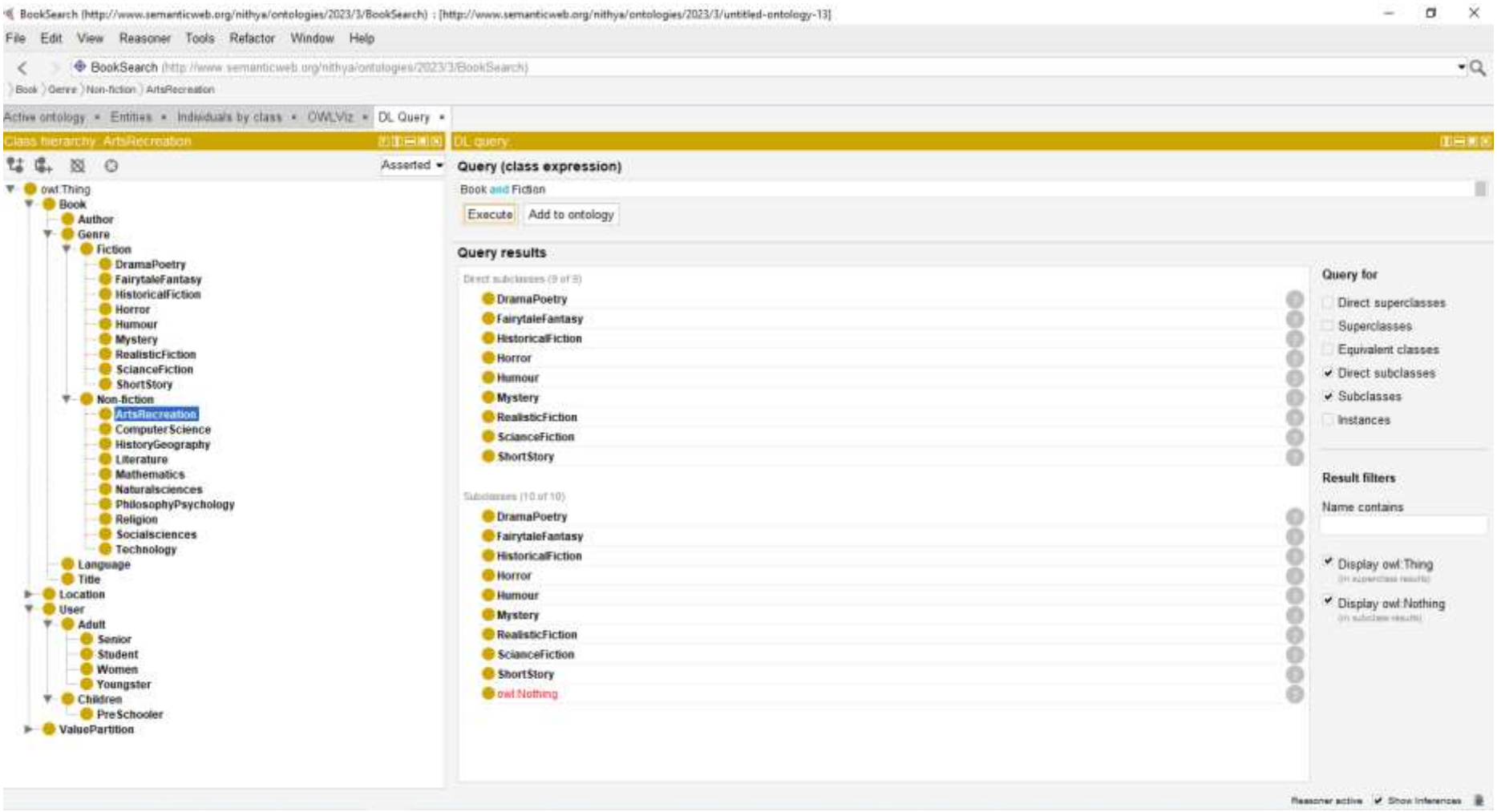

Figure:10 Executing simple DL query