Modelling Assignment.

Word count: 963

Part 1. Explanation of Design.

During the research and development of the ontology for the local library, incorporating an AI-powered search engine, a wide array of ontologies (mmisw.org, 2023, De Smedt, 2023) and approaches (National Academies of Sciences, Engineering, and Medicine, 2022, Malik et al., 2015) were reviewed. The ontology designed in this context is grounded in the creation of classes, subclasses, attributes, relationships, and rules (Noy et al., 2001). This approach facilitates a more efficient organization of the data model, resulting in significantly enhanced accuracy, intuitiveness, clarity, and overall efficiency of the ontology.

Goal	Design a prototype ontology for a local library that empowers an AI-powered search engine to enhance the efficiency of library source searches for various internal and external stakeholders.
Domain	Library
Scope	AI-powered search engine
Structure	The structure of ontology is hierarchical, with classes organised into a tree-like structure (Noy et al., 2001).
Software	Protege v.5.6.3 (Protégé, 2023)
Language	To implement this ontology, developers have the option to utilise the OWL (Web Ontology Language) (w3.org, 2023) or any other language of their preference that is conducive to their technical requirements.

Table 1 Design Properties

The selection and organisation of classes was determined based on the goals of the ontology.

A. Superclass Library

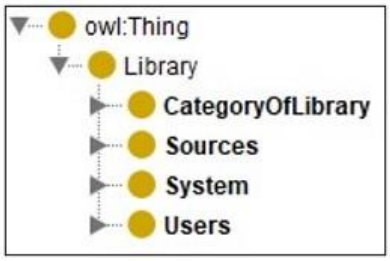
Superclass Library is the overarching class, serving as the foundation for the ontology, encompassing all other classes and entities within the library domain. **Library** consists of the main classes: **CategoryOfLibrary, Users, Sources, and System.** At a very high level, users interact with the search system by specifying their queries and search criteria. The system analyses these queries, taking into account the library category, and finds relevant resources. Sources represent the materials available in the library. Thus, the interaction unfolds as follows: users input queries, the system analyses them, and provides search results based on available sources and the library's category. This interaction ensures efficient searching in the local library.	

Table 2 Superclass Library

Let's examine each class in more detail.

B. Class CategoryOfLibrary *(print screens can be found in Appendix 1)*

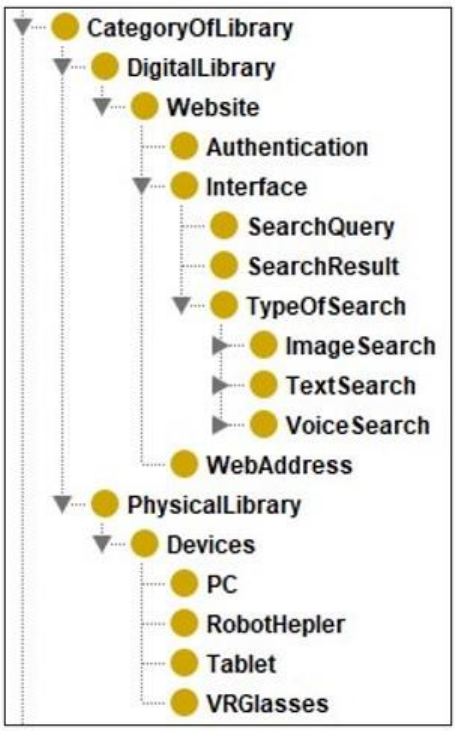
Class CategoryOfLibrary represents higher-level classification for two types of library: subclasses **PhysicalLibrary** (representing the physical space of a library) and **DigitalLibrary** (representing the virtual, online environment of a library). Subclass **PhysicalLibrary** has a subclass **Devices** (represents all types of devices (like **RobotHepler, PC, Tablet, VRGlasses**) that can be used within the library for various purposes; devices can include physical and digital tools that enhance the library experience.). Subclass **DigitalLibrary** has a subclass **Website** which serves as a virtual platform that provides information and services to library users online. **Website** has attributes **WebAddress** and **Authentication**. Additionally, it contains subclasses, including **Interface** with **TypeOfSearch (encompassing TextSearch , VoiceSearch, *and* ImageSearch), SearchQuery, and SearchResult.**	

Table 3 Class CategoryOfLibrary

Searching in the library can be organised in two categories:

Category 1	Category 2
In the **PhysicalLibrary**, searches are conducted within the physical confines of the library, where both physical and digital resource collections are available. Users can search for resources using either the library's **website** or its internal search **system**.	In **DigitalLibrary**, the search occurs in the virtual, online environment of the library (exclusively through the **website**). In this case, there is no physical location for the resources; the library exists solely in the digital realm. The digital library has a website through which users can access resources and conduct searches within the electronic collection.

Table 4 Physical and Digital Categories

Therefore, these two search options enable users to search for resources either within the physical library space or in the virtual environment via the website, depending on their needs and preferences. This enhances the interaction with the library's search engine and makes it more effective.

Moreover, in the PhysicalLibrary, users have the option to utilise various library devices integrated with AI (Subclass: Devices).

Devices	Explanation
Robot-Helper	Representing any robotic or automated devices used within the library to assist with tasks; this could include a robotic librarian or an autonomous device that aids users in locating books, providing information, or performing other tasks.
Personal Computers	
Tablets	
VR glasses	Representing virtual reality glasses that offer immersive experiences and may be available in the library for users to explore virtual reality content related to books, education, or entertainment.

Table 5 Subclass Devices

Additionally, users can access physical resources within the library.

C. Class Users *(print screens can be found in Appendix 2)*

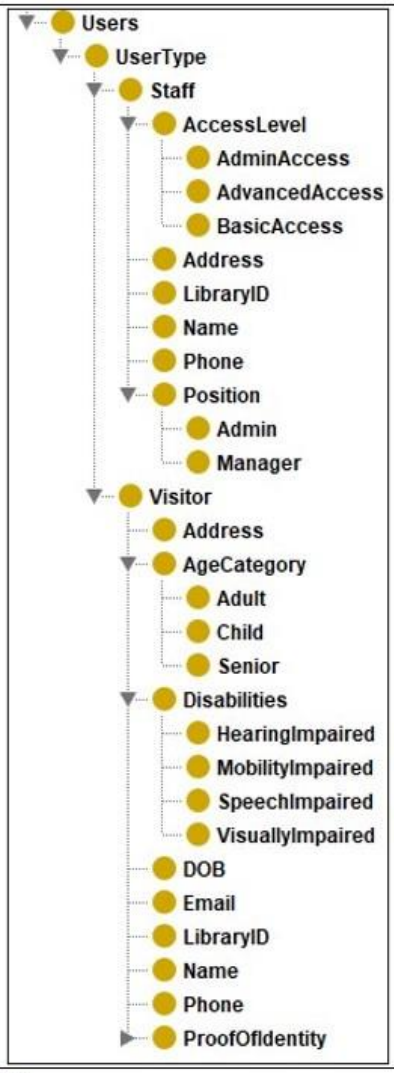
Class **Users** represent individuals who engage with the library system. It includes a subclass called **UserType**, which delineates various user types: **Staff** (representing library personnel) and **Visitor** (representing library patrons).	

Table 6 Class Users

Class, Subclasses, and Attributes	Explanation
Class Users	This class is crucial for the search engine as it represents the individuals interacting with the library system. It allows for user profiling, ensuring that the search experience is personalised and relevant to both staff and visitors. This personalization enhances user satisfaction and the efficiency of resource searches.
Subclass UserType	UserType categorises users into Staff and Visitor. This categorization streamlines access control and resource allocation, optimising the search engine for different user needs.
Subclasses Staff (with attributes such as Name, Position (e.g., Manager, Admin), Phone, Address, LibraryID, and AccessLevel (Basic, Advanced, or Admin)) and **Visitor** (with attributes like Name, Date of Birth, Phone, Address, Email, LibraryID, and Proof of Identity).	These subclasses further refine the user profiles. Staff attributes facilitate efficient management and communication within the library, while Visitor attributes ensure age-appropriate content and a tailored experience. This enhances resource search relevance and overall efficiency.

Table 7 Class, Subclasses, and Attributes of Class Users

Depending on the Visitor's age, they may be categorised within AgeCategory as Child (0-2, 3-5, 6-8, 9-12, 13-18 years), Adult (18+), or Senior (65+). These age groups aid the library's staff in organising and presenting materials that cater to the developmental and reading requirements of diverse demographics. It ensures that Visitors can access content suitable for their age and interests, thereby enhancing the library experience by making it more engaging and enjoyable.

Visitors and Staff may have various types of disabilities, such as Visual, Hearing, Speech, Mobility Impairments, and others. The integration of AI into the search system, along with the utilisation of devices, among other benefits, will not only expedite and enhance resource searches but also address the interests of diverse stakeholders, including individuals with disabilities.

Visitors represent external stakeholders, encompassing individuals, groups, or organisations with an interest in or influence over the library's operations but not formally part of the organisation itself. This group includes the Local Community, Local Schools and Educational Institutions, Media, and Journalists, among others.

Staff constitute internal stakeholders, directly involved in the library's operations and integral to the organisation itself. Examples include Library Trustees or Board Members.

D. **Class Sources** *(print screens can be found in Appendices 3,4 and 5)*

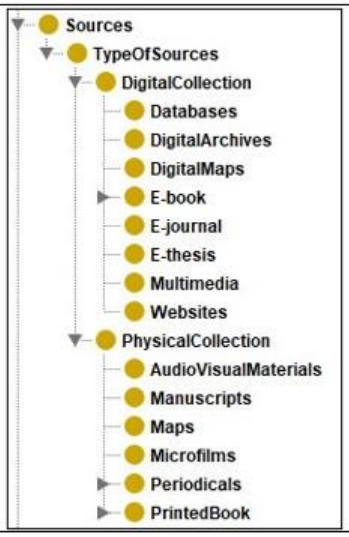
Class Sources represents a broad category encompassing all the materials and resources that can be found within a library. It includes a subclass **TypeOfSources**, which serves as the overarching category for all source types, **PhysicalCollection** (representing tangible physical sources in the library's collection) and **DigitalCollection** (representing digital sources in the library's collection).	

Table 8 Class Sources

Subclass **TypeOfSources** acts as an overarching category for all source types. It provides a structured framework for categorising all the materials and resources within the library. This organisation simplifies the process of searching for resources by allowing users to navigate through distinct categories, ensuring an efficient and user-friendly search experience.

Type Of Sources	**Example**
Subclass **PhysicalCollection** consists of the following subclasses: • PrintedBook • Periodicals (Magazine, Newspaper, and Journal) • AudioVisualMaterials • Maps • Microfilms • Manuscripts	Subclass: **PrintedBook** *Attributes:* • LiteratureCategory (Fiction, Non-Fiction, Poetry, Children'sLiterature, Drama, etc.) • Genre (Mystery, Science, Haiku, PictureBooks, Comedy, etc.) • Title • Author • Publisher • PublicationYear • Edition • Description • Language • ISBN • AgeCategory (Child, Adult, Senior) • Condition (New, Used, Damaged) • Status (Available, NotAvailable) • Location • Barcode • Price
It offers a finer level of granularity, enabling precise classification of physical resources. This granularity enhances the accuracy and efficiency of search results, ensuring users can quickly find specific physical items within the library.	

Subclass **DigitalCollection** represents digital sources, including: • E-book • E-journal • Databases • Multimedia • Websites • Digital Archives • E-thesis • Digital Maps	**Subclass: E-book** *Attributes:* • LiteratureCategory (Fiction, Non-Fiction, Poetry, Children's Literature, Drama, etc.) • Genre (Mystery, Science, Haiku, PictureBooks, Comedy, etc.) • Title • Author • Publisher • PublicationYear • Edition • Description • Language • AgeCategory (Child, Adult, Senior) • FileFormat (PDF, E-PUB) • FileSize • DownloadLink • AccessPermission (Borrowing, Purchase, FullAccess) • LicensingForms (DRM, LicensingAgreement) • OnlinePlatform
It caters to the modern digital landscape, ensuring that digital resources are well-organised and accessible. Users can efficiently locate digital content tailored to their needs.	

Table 9 Subclass TypesOfSources

In summary, these subclasses provide a systematic and well-structured approach to organising and categorising the library's resources, whether they are physical or digital. This enhances the efficiency of resource searches and ensures that users can easily find the materials they need, whether they are in physical or digital formats.

E. **Class System** *(print screens can be found in Appendix 6)*

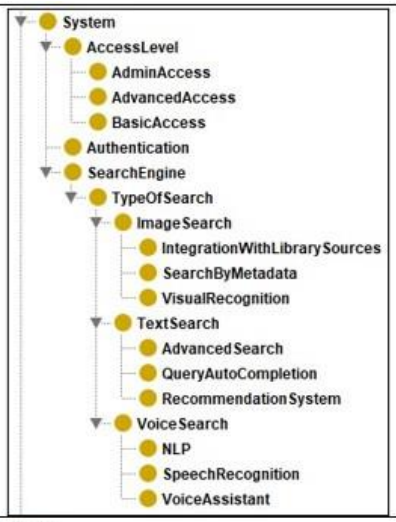
Subclass **System** manages the system's technical aspects and includes three subclasses: **AccessLevel** (for access control), **Authentication** (user identity and login management), and **SearchEngine** (core search functionality).	

Table 10 Class System

Subclass **AccessLevel** has three levels: BasicAccess, AdvancedAccess, and AdminAccess.

Subclasses **Authentication** and **AccessLevel** play a crucial role in securing the search engine and its resources, ensuring that users have the appropriate level of access while maintaining the integrity of user identities and data.

Subclass **SearchEngine** has subclass **TypeOfSearch** with three methods: **TextSearch** (text-based), **VoiceSearch** (voice-activated), and **ImageSearch** (image-based). These search methods are seamlessly integrated with AI technologies to enhance the search capabilities of the local library's search engine:

Type of search	Explanation
TextSearch includes: • AdvancedSearch • QueryAutoCompletion • RecommendationSystem	**TextSearch** leverages AI-driven **AdvancedSearch** to provide users with intelligent search suggestions and relevant results. The **QueryAutoCompletion** feature predicts and completes search queries, streamlining the search process. The **RecommendationSystem** employs machine learning algorithms to suggest personalised resources based on user behaviour and preferences.
VoiceSearch includes: • SpeechRecognition • NLP • VoiceAssistant	**VoiceSearch** uses **SpeechRecognition** to convert spoken words into text for search queries. Natural Language Processing (**NLP**) algorithms analyse and understand the user's spoken language. The **VoiceAssistant** is powered by AI to provide interactive and voice-guided search experiences, making it easier for users to find what they need.
ImageSearch includes: • VisualRecognition • IntegrationWithLibrarySources • SearchByMetadata	**ImageSearch** employs **VisualRecognition** to recognize and interpret visual content, such as images or graphics, as part of the search process. **IntegrationWithLibrarySources** allows the search engine to link image-based searches with the library's sources. **SearchByMetadata** utilises AI to extract and use metadata associated with images to improve search accuracy.

Table 11 Subclass TypeOfSearch

Incorporating these methods with AI technologies enables the search engine to provide advanced search capabilities. AI algorithms enhance the accuracy and relevance of search results, making it easier for library users to find the resources they seek. Additionally, the common attributes such as **Algorithm**, **InputData**, and **OutputData** ensure consistent data handling across all search types, contributing to a seamless and efficient user experience.

Relationships.

All relationships (Object Properties) with corresponding print screens can be found in Appendices 7, 8, 9, 10 and 11.

Part 2. Analysis of the outputs with evidence of testing.

Let's consider a task search case:

"An adult (18+) individual visited the local library with the intention of locating and borrowing the physical book 'Cosmos' by the author Carl Sagan. This person had an injured hand and wished to use his voice for searching. Additionally, he wanted to utilise the RobotHelper device to assist in locating the bookshelf and to aid in transporting the heavy book to the area where he intended to read it."

The search process can be described with some **rules** as follows:

"Adult individual"	**IS-A**	Visitor (subclass: Visitor) with Age Category (Subclass: AgeCategory) equal "Adult".
"*the physical book 'Cosmos' by the author Carl Sagan*"	**IS-A**	Book (Subclass: PrintedBook) with Title (attribute Title) "Cosmos" and Author (attribute Author) "Carl Sagan".
"*wished to use his voice for searching*"	**IS-A**	Voice Search type (Subclass: VoiceSearch) equal "VoiceAssistant ".
"*he wanted to utilise the RobotHelper device*"	**IS-A**	Device (Subclass: Devices) equal to "RobotHepler".

Table 12 Search Task Explanation

In the local library, visitor (Subclass: Visitors) can use the library's website (Class: Website) or the internal library system via a PC or tablet available on-site. Visitor interacts with the interface (attribute: "Interface"), logs into the system (Subclass: Authentication), selects preferred search method (Subclass: TypeOfSearch), verbally pronounces a search query (Subclass: SearchQuery) using their voice. Search query includes a printed book (subclass: PrintedBook), with the title "Cosmos "and the author "Carl Sagan".

Step	Process
1	In the local library, visitor (Subclass: Visitors) can use the library's website (Class: Website) or the internal library system via a PC or tablet available on-site. Visitor interacts with the interface (attribute: "Interface"), logs into the system (Subclass: Authentication), selects preferred search method (Subclass: TypeOfSearch), verbally pronounces a search query (Subclass: SearchQuery) using their voice. Search query includes a printed book (subclass: PrintedBook) , with the title "Cosmos "and the author "Carl Sagan".
2	The entered search query (Subclass: SearchQuery) is transmitted to the search system (Class: SearchEngine). The search system analyses the query and performs a search within the resources (Class: Sources).
3	The resources (Class: Sources) conducts the search and returns the search results (Subclass: SearchResult). These results contain information about resources that match the user's query. Specifically: LiteratureCategory, Genre, Title, Author, Publisher, PublicationYear, Edition, Description, Language, ISBN, AgeCategory, Condition, Status, Location, Barcode, Price.

4	The visitor (Class: Visitor) selects a resource and can request it for study or other actions, such as borrowing.

Table 13 Search Task Steps

In this manner, the visitor progresses through actions from one class to another, starting from the library's website, through the search system, the resources, and returning the results to the website, enabling them to find the desired resource.

Part 3. Further recommendations

Strengths	Efficient Data Organization: The ontology efficiently organizes data, enhancing the accuracy and efficiency of resource searches. Personalization: It allows for user profiling, ensuring personalized search experiences for both staff and visitors. AI Integration: AI technologies improve search capabilities, making it easier for users to find the resources they seek.
Areas of Improvement	Usability Testing: Conduct thorough usability testing to refine the user experience. Scalability: Design the ontology with scalability in mind to accommodate growth and emerging technologies. Maintenance Plan: Develop a long-term maintenance plan for regular updates and improvements.
Reusability	Libraries, educational institutions, healthcare systems, government agencies, AI developers, and community organizations can benefit from adapting the ontology to enhance information retrieval systems.

Table 14 Further Recommendations

Conclusion.

The ontology's strengths lie in efficient data organization, personalization, and AI integration. Addressing usability, scalability, and maintenance will ensure its continued success. Its reusability potential extends to various domains and stakeholders, making it valuable for improving information retrieval systems in diverse fields.

References

De Smedt, J. (2023) *The ESCO ontology.* Available from: https://ec.europa.eu/esco/lod/static/model.html [Accessed 22 September 2023].

Malik, N., Sharan, A. & Hijam, D. (2015) Ontology development for agriculture domain. *In 2015 2nd International Conference on Computing for Sustainable Global Development (INDIACom)* (pp. 738-742).

mmisw.org (2023) *Ontology Registry and Repository.* Available from: https://mmisw.org/ont [Accessed 20 October 2023].

National Academies of Sciences, Engineering, and Medicine (2022) *Ontologies in the Behavioral Sciences: Accelerating Research and the Spread of Knowledge: Digest Version*. Washington (DC). National Academies Press (US).

Noy, N. & Mcguinness, D. (2001) Ontology Development 101: A Guide to Creating Your First Ontology. Knowledge Systems Laboratory. 32.

Protégé (2023) Protégé 5.6.3 [Software]. Available from: https://protege.stanford.edu/software.php [Accessed 05 October 2023].

w3.org (2023) *OWL 2 Web Ontology Language.* Available from: https://www.w3.org/TR/owl2-overview/ [Accessed 20 October 2023].

Appendices.
Appendix 1.

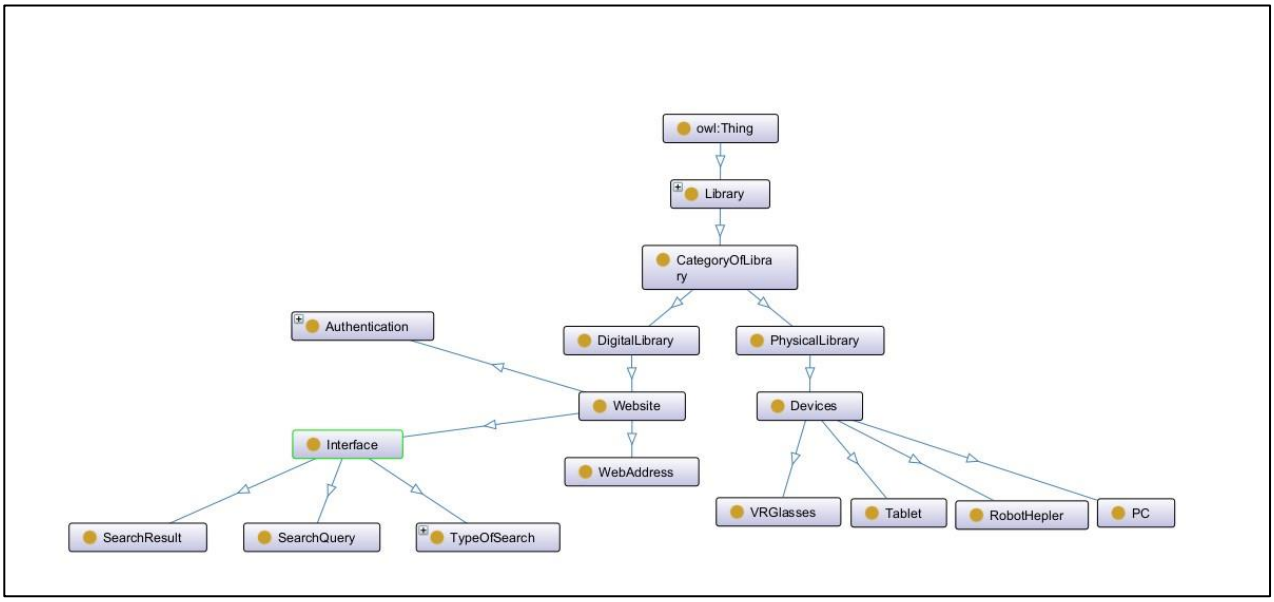


Figure 1 Class CategoryOfLibrary

Appendix 2.

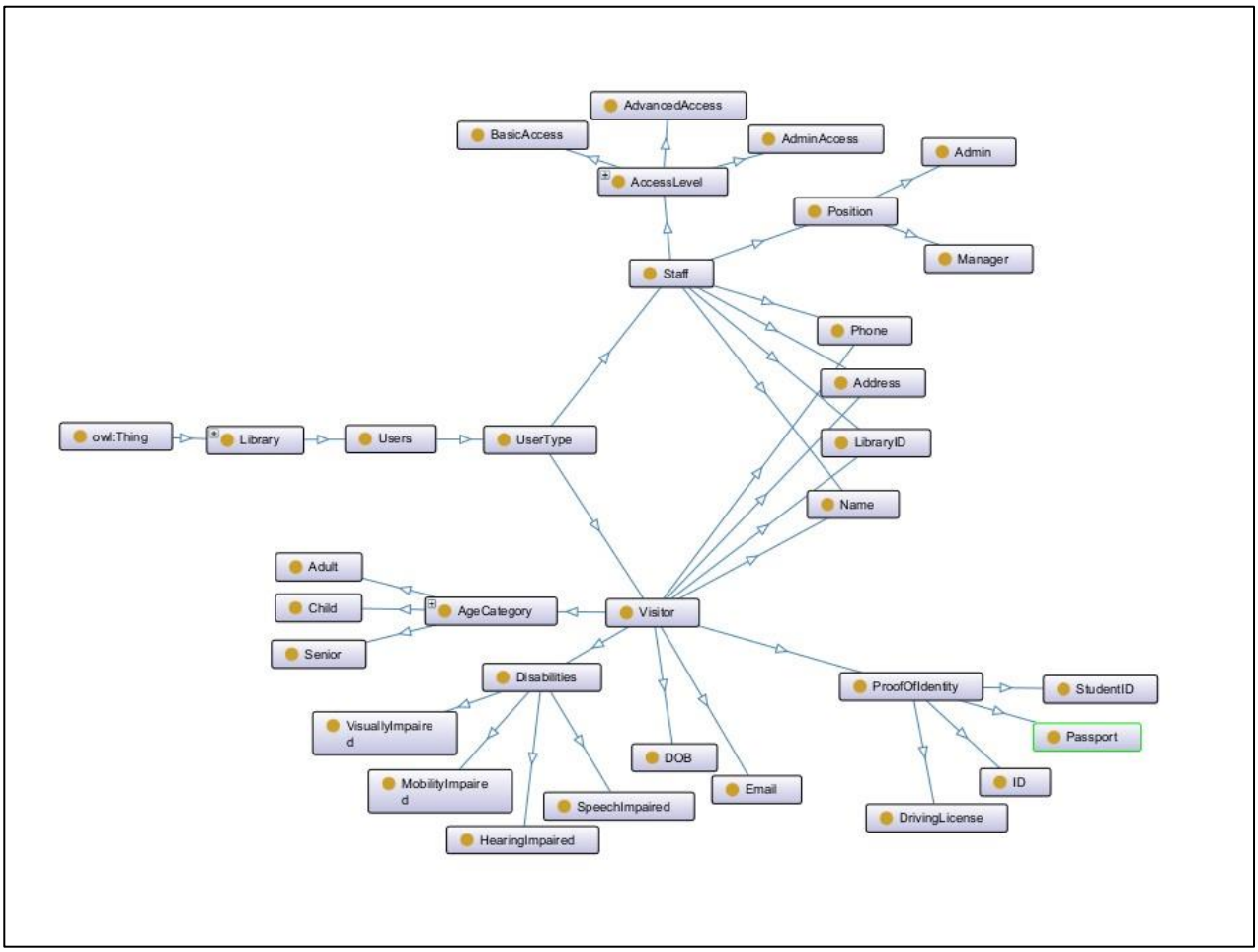


Figure 2 Class Users

Appendix 3.

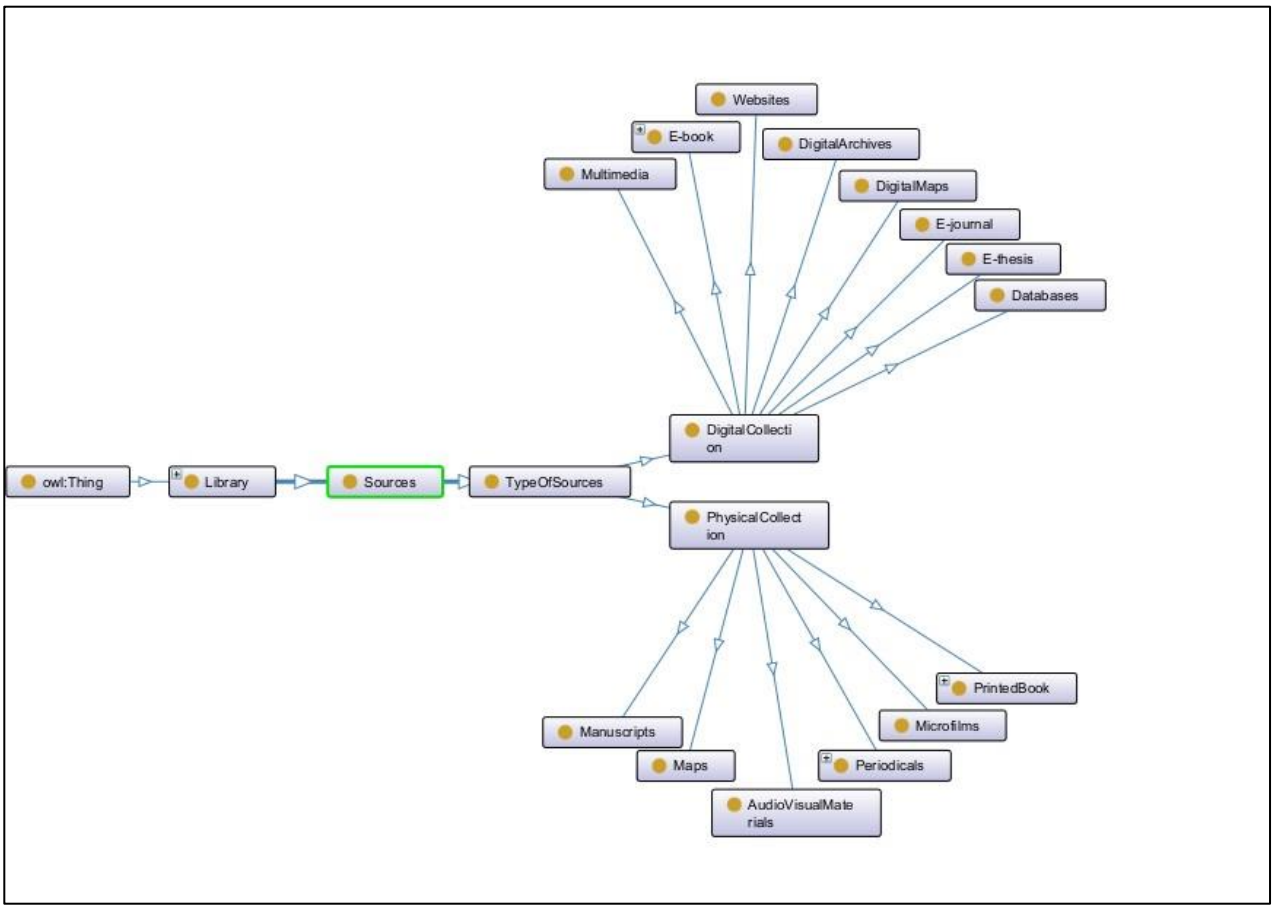


Figure 3 Class Sources

Appendix 4.

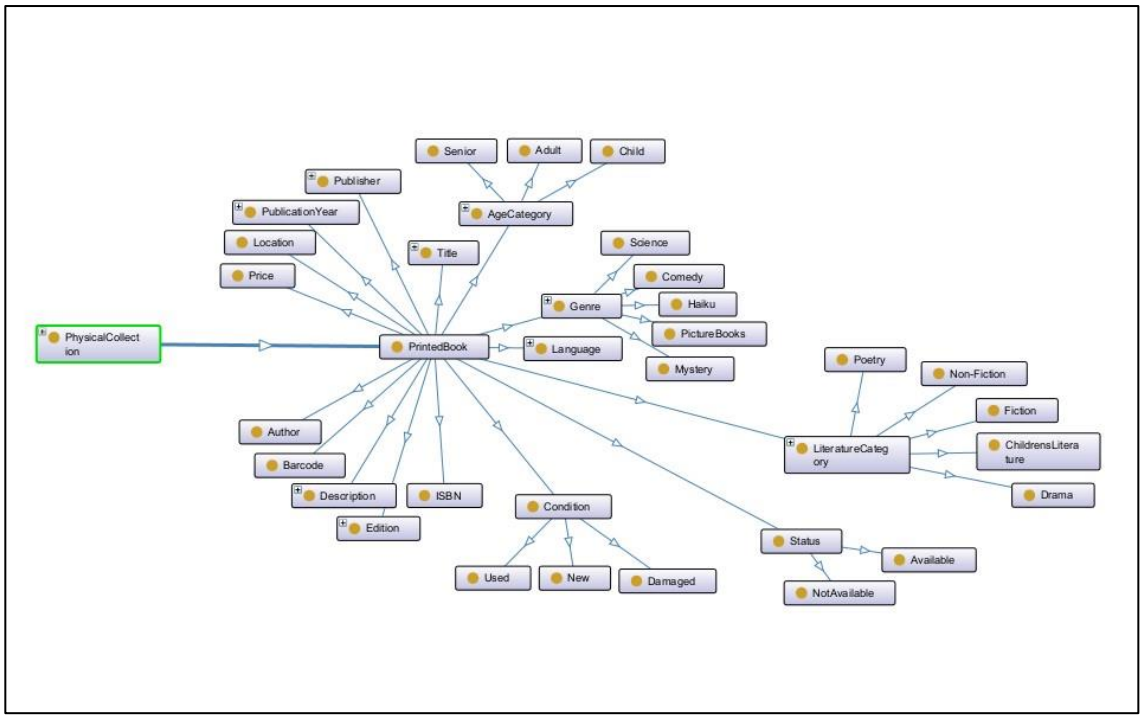


Figure 4 Subclass PrintedBook

Appendix 5.

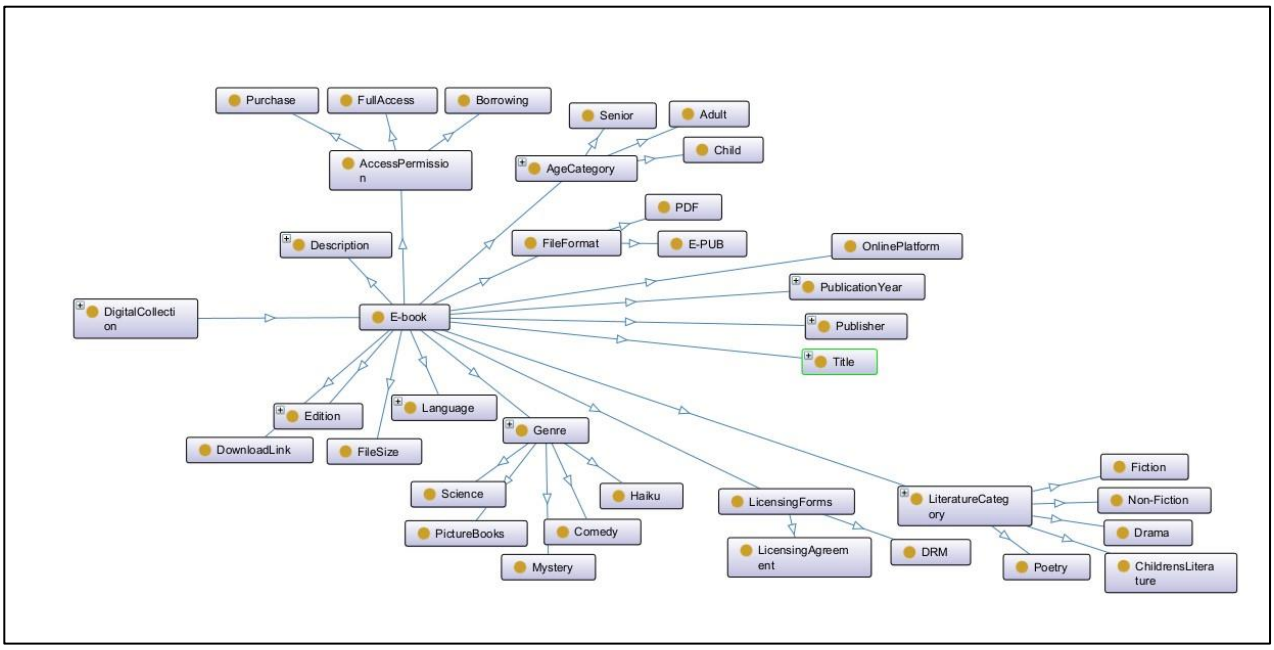


Figure 5 Subclass E-book

Appendix 6.

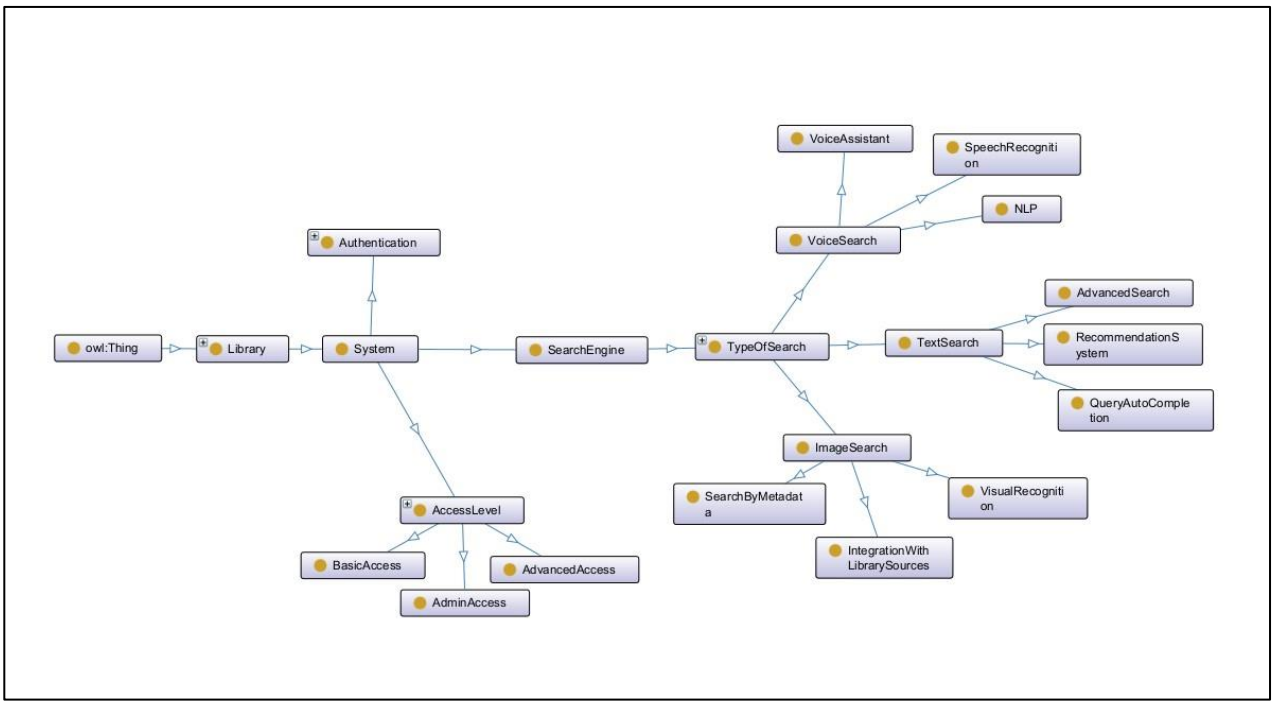


Figure 6 Class System

Appendix 7.

Relationship	Inverted Relationship
Superclass Library	
Library has Users	Users interactsWith Library
Library isPoweredBy System	System belongsTo Library
Library has Sources	Sources belongsTo Library
Library has CategoryOfLibrary	CategoryOfLibrary belongsTo Library
Users signIn, searches, uses System	System usedBy User
Users uses, search, borrows, explore Sources	Sources usedBy Users
System contains **Sources**	**Sources** containedBy **System**
Class CategoryOfLibrary	
CategoryOfLibrary has PhysicalLibrary	PhysicalLibrary belongsTo CategoryOfLibrary
CategoryOfLibrary has DigitalLibrary	DigitalLibrary belongsTo CategoryOfLibrary
PhysicalLibrary has Devices	Devices belongTo PhysicalLibrary
Devices has RobotHepler	RobotHepler belongTo Devices
Devices has PC	PC belongTo Devices
Devices has Tablet	Tablet belongTo Devices
Devices has VRGlasses	VRGlasses belongTo Devices
DigitalLibrary has Website	Website belongTo DigitalLibrary
Website has Interface	Interface belongTo Website
Website has WebAddress	WebAddress belongTo Website
Website has Authentication	Authentication belongTo Website
Interface has TypeOfSearch	TypeOfSearch belongTo Interface
TypeOfSearch has TextSearch	TextSearch belongTo TypeOfSearch
TypeOfSearch has VoiceSearch	VoiceSearch belongTo TypeOfSearch
TypeOfSearch has ImageSearch	ImageSearch belongTo TypeOfSearch
Interface has SearchQuery	SearchQuery belongTo Interface
Interface has SearchResult	SearchResult belongTo Interface

Figure 7 Relationships and Inverted Relationships

Appendix 8.

Relationship	Inverted Relationship
Class System	
System has AccessLevel	AccessLevel belongsTo System
AccessLevel has BasicAccess	BasicAccess belongsTo AccessLevel
AccessLevel has AdvancedAccess	AdvancedAccess belongsTo AccessLevel
AccessLevel has AdminAccess	AdminAccess belongsTo AccessLevel
System has Authentication	Authentication belongsTo System
System has SearchEngine	SearchEngine belongsTo System
SearchEngine has TypeOfSearch	TypeOfSearch belongsTo SearchEngine
TypeOfSearch has TextSearch	TextSearch belongsTo TypeOfSearch
TextSearch has AdvancedSearch	AdvancedSearch belongsTo TextSearch
TextSearch has QueryAutoCompletion	QueryAutoCompletion belongsTo TextSearch
TextSearch has RecommendationSystem	RecommendationSystem belongsTo TextSearch
TypeOfSearch has VoiceSearch	VoiceSearch belongsTo TypeOfSearch
VoiceSearch has SpeechRecognition	SpeechRecognition belongsTo VoiceSearch
VoiceSearch has NLP	NLP belongsTo VoiceSearch
VoiceSearch has VoiceAssistant	VoiceAssistant belongsTo VoiceSearch
TypeOfSearch has ImageSearch	ImageSearch belongsTo TypeOfSearch
ImageSearch has VisualRecognition	VisualRecognition belongsTo ImageSearch
ImageSearch has IntegrationWithLibrarySources	IntegrationWithLibrarySources belongsTo ImageSearch
ImageSearch has SearchByMetadata	SearchByMetadata belongsTo ImageSearch

Figure 8 Relationships and Inverted Relationships

Appendix 9.

Relationship	Inverted Relationship
Class User	
Users has UserType	UserType belongs to Users
UserType has Visitor	Visitor belongs to UserType
Visitor has Name	Name belongs to Visitor
Visitor has DOB	DOB belongs to Visitor
Visitor has Phone	Phone belongs to Visitor
Visitor has Address	Address belongs to Visitor
Visitor has Email	Email belongs to Visitor
Visitor has LibraryID	LibraryID belongs to Visitor
Visitor has ProofOfIdentity	ProofOfIdentity belongs to Visitor
ProofOfIdentity has ID	ID belongs to ProofOfIdentity
ProofOfIdentity has Passport	Passport belongs to ProofOfIdentity
ProofOfIdentity has StudentID	StudentID belongs to ProofOfIdentity
ProofOfIdentity has DrivingLicense	DrivingLicense belongs to ProofOfIdentity
Visitor has AgeCategory	AgeCategory belongs to Visitor
AgeCategory has Child	Child belongs to AgeCategory
AgeCategory has Adult	Adult belongs to AgeCategory
AgeCategory has Senior	Senior belongs to AgeCategory
Visitor has Disabilities	Disabilities belongs to Visitor
Disabilities has VisuallyImpaired	VisuallyImpaired belongs to Disabilities
Disabilities has HearingImpaired	HearingImpaired belongs to Disabilities
Disabilities has SpeechImpaired	SpeechImpaired belongs to Disabilities
Disabilities has MobilityImpaired	MobilityImpaired belongs to Disabilities
UserType has Staff	Staff belongs to UserType
Staff has Name	Name belongs to Staff
Staff has Position	Position belongs to Staff
Staff has Phone	Phone belongs to Staff
Staff has Address	Address belongs to Staff
Staff has LibraryID	LibraryID belongs to Staff
Staff has AccessLevel	AccessLevel belongs to Staff
Staff has Disabilities	Disabilities belongs to Staff
Disabilities has VisuallyImpaired	VisuallyImpaired belongs to Disabilities
Disabilities has HearingImpaired	HearingImpaired belongs to Disabilities
Disabilities has SpeechImpaired	SpeechImpaired belongs to Disabilities
Disabilities has MobilityImpaired	MobilityImpaired belongs to Disabilities

Figure 9 Relationships and Inverted Relationships

Appendix 10.

Relationship	Inverted Relationship
Class Sources	
TypeOfSources has PhysicalCollection	PhysicalCollection belongsTo TypeOfSources
TypeOfSources has DigitalCollection	DigitalCollection belongsTo TypeOfSources
PhysicalCollection has PrintedBook	PrintedBook belongsTo PhysicalCollection
PrintedBook has LiteratureCategory	LiteratureCategory belongsTo PrintedBook
PrintedBook has Genre	Genre belongsTo PrintedBook
PrintedBook has Title	Title belongsTo PrintedBook
PrintedBook has Author	Author belongsTo PrintedBook
PrintedBook has Publisher	Publisher belongsTo PrintedBook
PrintedBook has PublicationYear	PublicationYear belongsTo PrintedBook
PrintedBook has Edition	Edition belongsTo PrintedBook
PrintedBook has Description	Description belongsTo PrintedBook
PrintedBook has Language	Language belongsTo PrintedBook
PrintedBook has ISBN	ISBN belongsTo PrintedBook
PrintedBook has AgeCategory	AgeCategory belongsTo PrintedBook
PrintedBook has Condition	Condition belongsTo PrintedBook
PrintedBook has Status	Status belongsTo PrintedBook
PrintedBook has Location	Location belongsTo PrintedBook
PrintedBook has Barcode	Barcode belongsTo PrintedBook
PrintedBook has Price	Price belongsTo PrintedBook
PhysicalCollection has Periodicals	Periodicals belongsTo PhysicalCollection
Periodicals has Magazine	Magazine belongsTo Periodicals
Periodicals has Newspaper	Newspaper belongsTo Periodicals
Periodicals has Journal	Journal belongsTo Periodicals
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E-book has LiteratureCategory	LiteratureCategory belongsTo E-book
E-book has Genre	Genre belongsTo E-book
E-book has Title	Title belongsTo E-book
E-book has Author	Author belongsTo E-book
E-book has Publisher	Publisher belongsTo E-book
E-book has PublicationYear	PublicationYear belongsTo E-book
E-book has Edition	Edition belongsTo E-book
E-book has Description	Description belongsTo E-book
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E-book has LicensingForms	LicensingForms belongsTo E-book
E-book has OnlinePlatform	OnlinePlatform belongsTo E-book
DigitalCollection has E-journal	E-journal belongsTo DigitalCollection
DigitalCollection has Databases	Databases belongsTo DigitalCollection
DigitalCollection has Multimedia	Multimedia belongsTo DigitalCollection
DigitalCollection has Websites	Websites belongsTo DigitalCollection
DigitalCollection has DigitalArchives	DigitalArchives belongsTo DigitalCollection
DigitalCollection has E-thesis	E-thesis belongsTo DigitalCollection
DigitalCollection has DigitalMaps	DigitalMaps belongsTo DigitalCollection

Figure 10 Relationships and Inverted Relationships

Appendix 11.

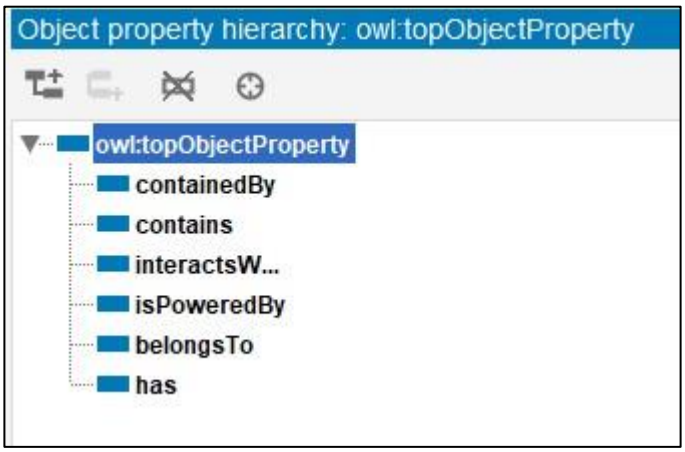

Figure 11 Protege Relationships