# DIGITAL LIBRARY MANAGEMENT SYSTEM: AN ONTOLOGICAL APPROACH FOR E-RESOURCES MANAGEMENT IN ENGINEERING COLLEGE LIBRARIES

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***Abstract :*** Nowadays the frequency of access to the digital library both by teaching faculty and students has increased in an enormous way. The availability of e-resources in order to cater to the needs of these members is a highly prioritized job of both the librarian and the library administrator. The exploration of semantic relations that exist among various concepts of the e-library has its innate and immediate need in order to manage the e-resources of the digital library in an effective manner. Ontology engineering for building these semantic relations and thereby reasoning the expressed semantic rules on top of the engineered ontology alerts both librarian and library administrator in a temporal manner. This improves the concept of e-resources management in engineering college libraries in a better manner.

***IndexTerms*** **- Digital Library, e-resources, librarian, library administrator, semantic relations, ontology, and semantic web rules reasoning.**

## I. INTRODUCTION

An academic library plays a pivotal role in the teaching and learning process of an academic organization. The academic libraries today are supporting educational and research purposes through information and communication technology services [1]. The digitalization of crucial library resources namely books, hardbound scholarly communications (journals) and technical magazines and disseminating them in the form of services enabled the teaching fraternity and student community to reach out to the library in a virtual way. Since the launch of the Digital Library Initiative (DLI) in 1996 [2], this paradigm shift provided these members to access the information.

The availability of these electronic resources is the major task at hand to both the librarian and the library administrator. This is because the technology is evolving on a temporal basis raising the need of both the student and the faculty to get well equipped with it. The current digital libraries do not consider the semantic relations that innately exist among their concepts. The absence of these relationships is making the alert service regarding the availability of the e-resources work very late. In order to speed up the alert service, an ontology is engineered for the library that takes into account the semantic relationships and also helps to reason for alerts about the availability of the e-resources as and when the request arouses from either the student or from the faculty. This improves the concept of e-resources management in engineering college libraries in a better manner.

## II. RELATED WORKS

The digital library management systems (DLMS) share several similarities with web-based content management systems. However, the DLMS systems are different with regard to the information organization and availability by supporting digital library standards. The major practices in DLMS are digital documents storage and delivery to the request.

Candela et al. laid [3] the necessary foundations to facilitate the digital library services that provide diverse functionalities to its users. Tramboo et al. provided [4] a platform for ensuring the availability of essential services in their DLMS system. Awre and Cramer enhanced [5] the repository provision through multi-institution collaboration in order to accommodate the large collections of digital documents. Zhang and Gourley addressed [6] the availability of the existing content through redundant configurations. Kent developed [7] a platform named Islandora for providing access and supporting the preservation of existing digital library collection. LUNA [8], a cloud-based software today was adopted by academic libraries in order to efficiently manage the digital collections. LUNA works effectively as the collections published in it are search engine optimized.

The common limitation in all the existing works that are discussed above is that there is no alert mechanism involved that alarms the librarian and library administrator on the incoming request for the e-resource that is not yet made available. All these works concentrated on the management of the existing document collections and administering the existing databases. The "management" of the digital library database calls for continuous monitoring of the incoming requests that are to be served for better running of the digital library. This limitation has created an insight into connecting the crucial concepts of the digital library and reasoning them for better handling of the incoming requests in the form of ontology [9].

The rest of the paper is organized as follows. The semantic model of DLMS is illustrated and explained with respect to ontological analysis in section 3. Section 4 provides the experimental results and discussions. Finally, section 5 concludes the work by throwing light on the future prospects to this semantic model.

**1. The Semantic model for digital library management system**

The figure below illustrates the semantic model for DLMS. The members of the digital library namely students, teaching staff raises the request for their specific e-resource to the librarian through the DLMS search interface. The natural language query is transformed into the SPARQL Protocol and RDF Query Language (SPARQL) [10] query. The query is then applied on the connected DLMS ontology. The ontology nodes are indexed with the E-Resources Library Database data.

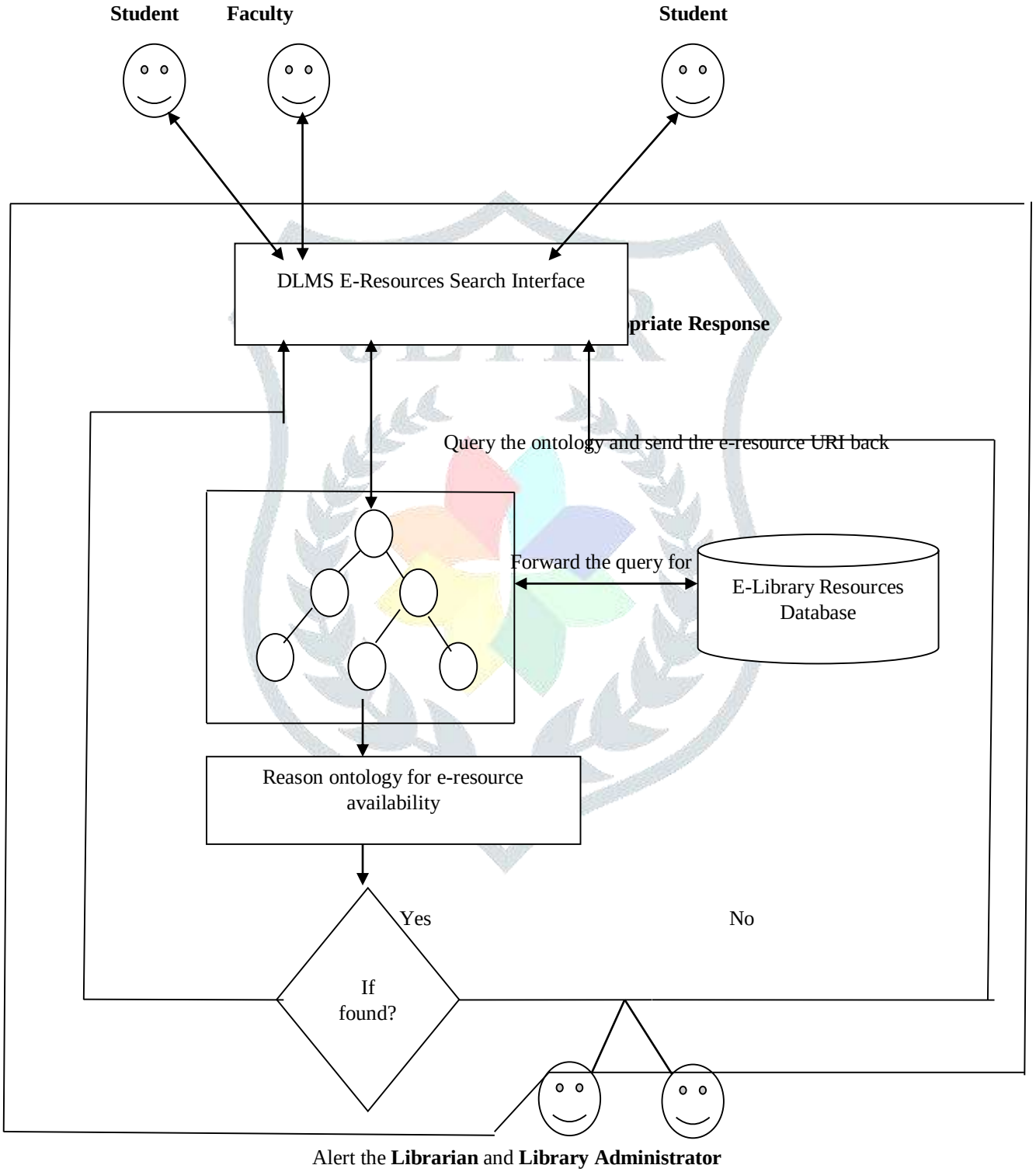



figure 1. proposed model

When the e-resource is found from the database, the URI of the e-resource is sent back as the response from the ontology to the member. Whenever the e-resource information is not found in the database, the query is sent for further reasoning. The reasoner then infers that there is no availability of the information regarding the e-resource in the database. This inference immediately

raises an alert to the librarian for the availability. Further, the reasoner infers for alerting the e-resource request to the library administrator by debugging the crucial data about the librarian raising the request to the library administrator. These inferences are drawn in terms of alerts to both librarian and library administrator. This is because as the alert information is expressed as high-level rules built on top of the engineered ontology. The DLMS ontology is engineered in the following manner.

### 1.1 The domain and scope of DLMS ontology

The domain that DLMS ontology covers are the digital library. DLMS ontology answers the queries on e-resources available in the e-resources library database, the members who are in need of e-resources, the librarian, the library administrator and the e-resource attributes.

### 1.2 Classes in DLMS ontology

The classes in DLMS ontology are delineated in the top-down approach. The general classes are namely E-ResourceAttribute, E-Resource, E-ResourceRequestAlert, Librarian, Library, Libraryadministrators and Member. The specific classes created are namely Student, TeachingFaculty, Guest, Author, Publisher, Title, Venue, YearofPublication and so on. The DLMS classes and their taxonomy is shown in below figure.

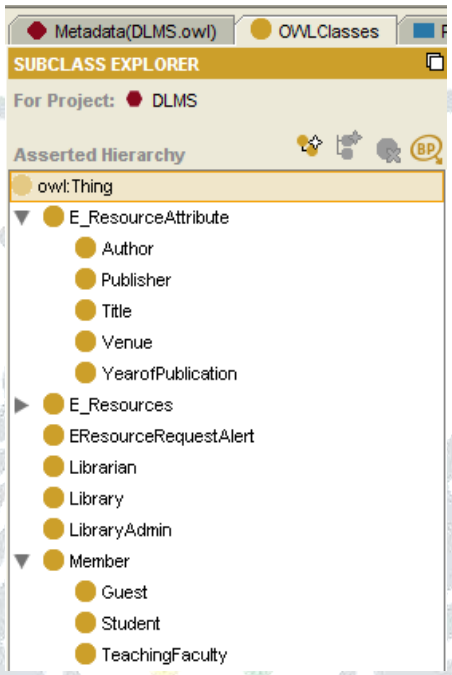



figure 2. dlms class taxonomy

### 1.3 Object and Datatype properties in DLMS ontology

Once the classes are delineated, the internal structures of these classes are described. These are called properties for the classes. These properties help to answer the competency questions raised by the members for their corresponding e-resources. The object properties are namely accessedBy, checksReservation, placeRequest, validates, issueResource, newArrival and so on. The datatype properties are availability and raisedRequest respectively. The object and datatype properties are shown in the below figure.

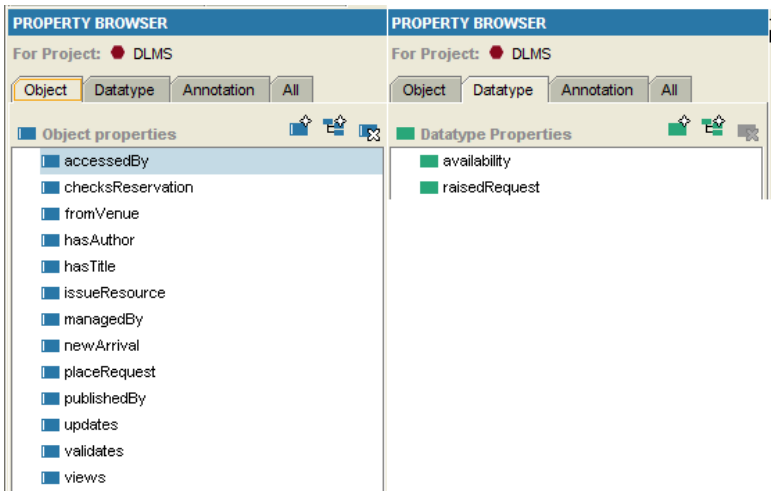


figure 3. object and datatype properties

**1.4 Creation of instance values for classes**

The final step is creating individual instances of classes in the hierarchy. The instances are the records from the e-resources library database that are attached to the classes using the indexed information. The instance creation for the class is shown in the below figure.

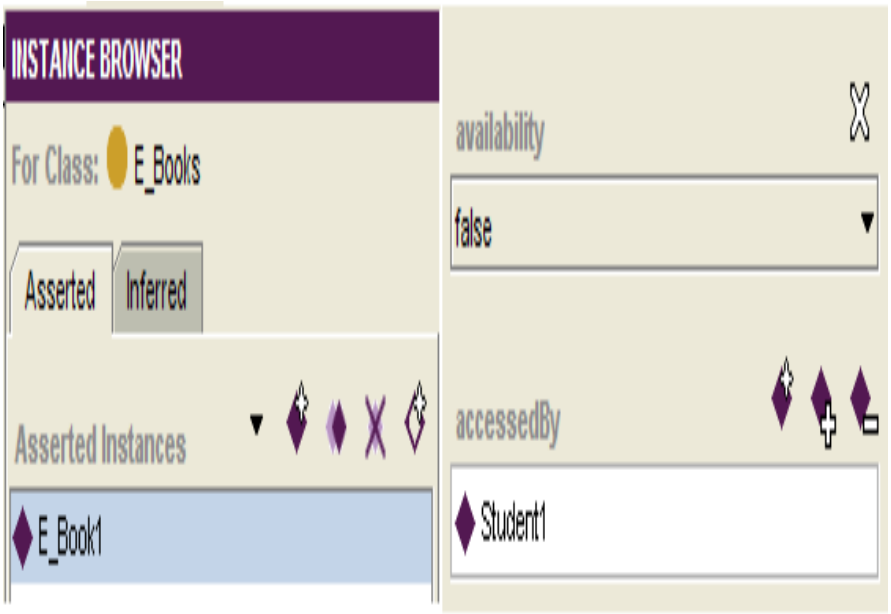



figure 4. e-book instance

The visualization of DLMS ontology forming a knowledge base is presented in the below figure.

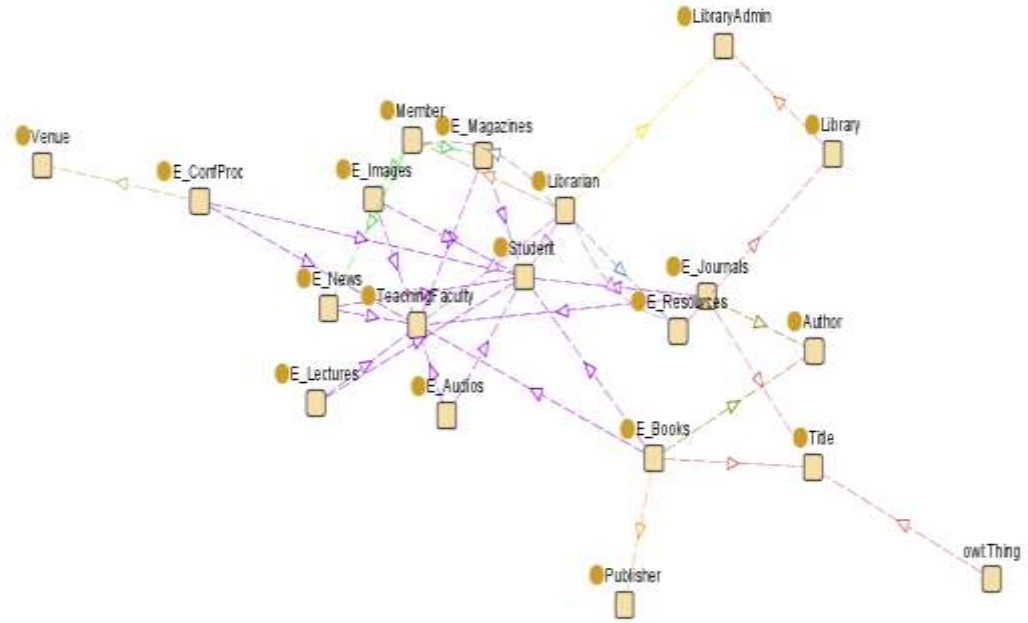



figure 5. visualization of dlms ontology

The engineered ontology is not expressive in terms of providing alerts to both Librarian and Library Administrator on the e-resources availability. In order to improve the expressiveness of the DLMS ontology, Semantic Web Rules (SWRL) [11] is built on the top of the DLMS ontology. These rules use the description logic (DL) [12] predicates written in the form of object and datatype properties from the ontology to build themselves to look like first-order Horn clauses. The SWRL rules are given below.

Rule-1: accessedBy(?x, ?y) ∧ availability(?x, ?z) → EResourceRequestAlert(Librarian1)

The SWRL rule expressed above uses the accessedBy object property and availability datatype property to build DL way of an inductive logic form of rule that gets reasoned towards alerting the Librarian for e-resource availability request.

Rule-2: EResourceRequestAlert(Librarian1) ∧ raisedRequest(Librarian1, ?y) → EResourceRequestAlert(LibraryAdmin1)

The SWRL rule expressed above uses the raisedRequest datatype property in order for the Librarian to build DL way of an inductive logic form of rule that gets reasoned towards alerting the Library Administrator for e-resource availability request.

The debugged rules for the sample instance data are presented in Appendix-A.

## III. EXPERIMENTAL RESULTS AND DISCUSSIONS

The ontology-based DLMS has proved to be very useful in the digital library e-resources dissemination. The results are given below.

The simple query namely "What is an E-Book?" is responded with the answer the name of the E-Book class instance. It is shown in the figure below.

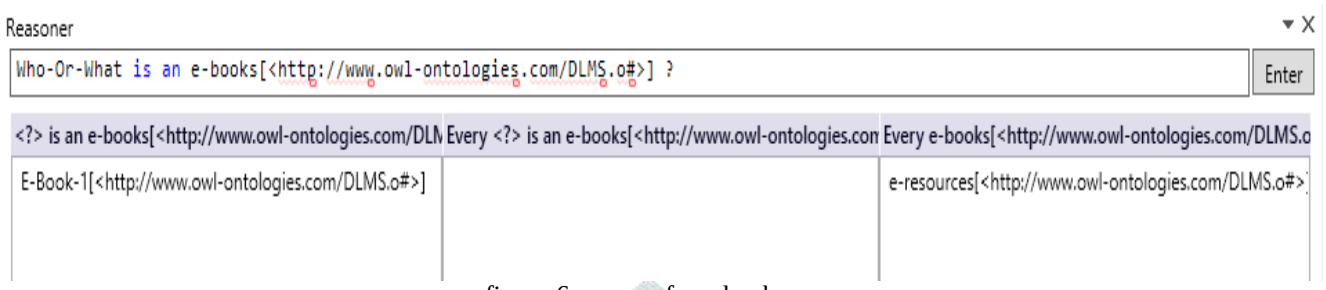



figure 6. answer for e-book query

Next to simple question is "Who views E-Book class instance?". This is responded with the general class "Member". It is shown in the figure below.

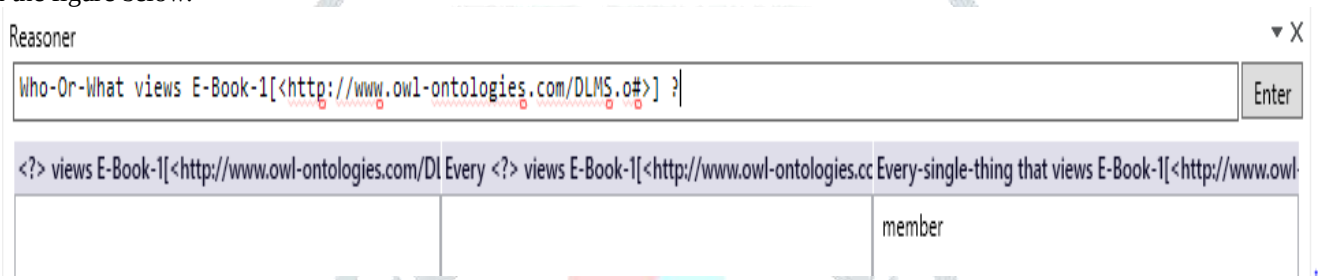



figure 7. answer for views object property

The next immediate question is "Who is a member?". This is responded with the three subclasses and one instance. It is shown in the figure below.

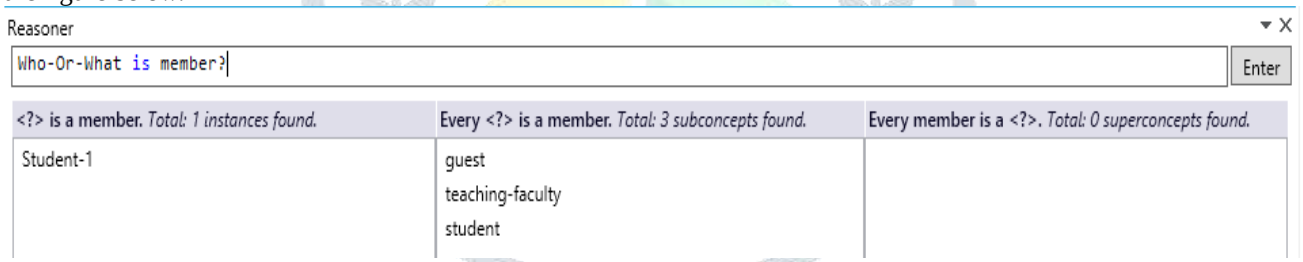



figure 8. answer for member query

The simple question "What has author ABC and is an E-Book?". This is responded with the name of the E-Book instance.

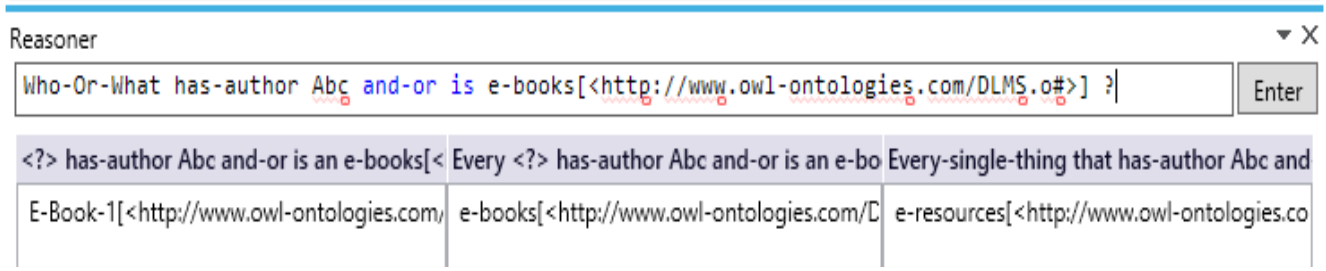


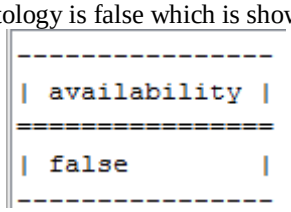

figure 9. answer for finding the e-book instance with a particular author name

In order to know whether the requested e-resource is available to the member, the member specified natural language query is transformed to SPARQL query as follows.

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsp: <http://www.owl-ontologies.com/2005/08/07/xsp.owl#>
PREFIX myont: <http://www.owl-ontologies.com/DLMS.owl#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>

```
PREFIX xsd:   <http://www.w3.org/2001/XMLSchema#>
select ?availability
{
?E_Book1 rdf:type ?E_Books ;
      myont:availability ?availability.
}
```

The response obtained from DLMS ontology is false which is shown in the below figure.



```
----------------
| availability |
================
| false        |
----------------
```

The response is forwarded to the reasoner in order to raise the e-resource request alert to both the Librarian and Library Administrator.

The DLMS ontology is developed with Open World Assumption (OWA) [13]. The SWRL rules are possible to be expressed to infer new conclusions as the ontology is with OWA which supports the extensibility of the domain knowledge. This DLMS ontology is DL-safe as the inferences are drawn with the instances present in the ontology itself. The observation that is made from the results is that the SWRL rules are not debugged unless all the instances of the participating DL predicates that include classes as well as the literals are explicitly annotated.

The current work is the first of its kind as per the knowledge of the author. This is because the work presented in [14] specified the need for the provision of alert services for new additions into the library. The work carried out in [15] provided the interesting observation that the behavioural intention of the library member depends on the frequent accessing patterns to the digital library for e-resources. The reasoner and the SPARQL results obtained from the current ontology-based work have answered the first requirement for alerts. These experimental outcomes are verifying with the observation about the library member frequent access patterns to the digital library for the e-resources.

## IV. Conclusions

The Digital library management system with the support of ontological analysis is carried out successfully. The engineered DLMS ontology by following the steps of ontology development has answered the domain-specific competency questions. In the process of this work, it is observed that the ontology is possible to improve the expressiveness of ontology as the ontology is developed with OWA. This way of analysis improves the concept of e-resources management in engineering college libraries in a better manner.

In future, the DLMS ontology is used to recommend similar e-books to the members of the digital library by using case-based reasoning approach.

## References

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**Appendix-A**

**SWRL rules for DLMS Ontology**

The SWRL rules are written to improve the expressiveness of the DLMS ontology. These rules are used to alert both the Librarian and Library Administrator whenever there is non-availability of the e-resources that are requested by the digital library member. The Reasoner of the Ontorion Fluent Editor helps to query the ontology in the Controlled Natural Language with its corresponding grammar for understanding classes, properties and instances. The SWRL reasoned conclusions from Ontorion Fluent Editor is illustrated in Figure A1 and is given below.

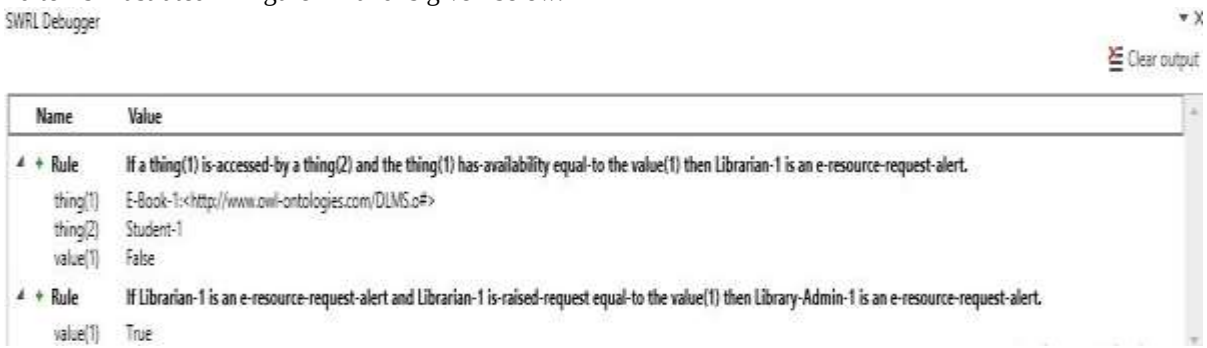


figure a1. debugging s