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Ontology and metadata for online learning resource repository management based on semantic web

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Abstract: An ontology and metadata for online learning resource repository management is constructed. First, based on the analysis of the use-case diagram, the upper ontology is illustrated which includes resource library ontology and user ontology, and evaluated from its function and implementation; then the corresponding class diagram, resource description framework (RDF) schema and extensible markup language (XML) schema are given. Secondly, the metadata for online learning resource repository management is proposed based on the Dublin Core Metadata Initiative and the IEEE Learning Technologies Standards Committee Learning Object Metadata Working Group. Finally, the inference instance is shown, which proves the validity of ontology and metadata in online learning resource repository management.

Key words: semantic web; online learning resource repository management(OLRRM); ontology; metadata

Growing up with the technology of the Internet, knowledge management with machine-processabitiy has been identified as a strategically important method. To overcome current web disadvantages (high recall, low precision, etc.) designed to be understood by humans not machines, the semantic web is used to extend information processing ability on the web, allow machine effective discovery, automation, integration, reuse across applications, and support more sophisticated software applications. Therefore, the semantic web plays an important role in an online learning resource repository which stores needed diversiform learning resources and is one of the vital components for a web-based learning system[1].

Ontology, whose purpose is knowledge sharing and reuse, and descriptions of the concepts and relationships between objects, expresses a common understanding of a domain that serves as a basis of communication among people or systems. It can provide the vocabulary for referring to the terms in certain subject areas, and the logical statements[2]. A set of documents about web-based education has been released, such as the Dublin Core Metadata Initiative[3], the IEEE Learning Technologies Standards Committee Learning Object Metadata (LOM) Working Group[4], Distance Education Technology Criterion, Technology and Criterion of Education Resource, etc[5]. But there are also some disadvantages, such as the lack of reasoning ability and machine processing ability. For example, general types of learning resources consist of diagrams, images, tables, exercises, narratives, texts and exams among others. LOM cannot describe all the above resources shown as a list from an instructional perspective, and it does not refer to the inherent structure representation as ontology. In addition, current standards without considering the semantic web cannot reach the full e-learning potential of the web[6]. So, this paper combines the ontology related to semantic web technology with the current predominant metadata standards as the solution for managing an online learning resource repository.

1 Ontology Design

Ontology entails entities, attributes, processes, their definitions and inter-relationships in online learning resource repository management (OLRRM).

1.1 Use-case diagram

To obtain a good description of an ontology, the function of an online learning resource repository should be explicit, as in the use-case diagram is shown in Fig. 1.

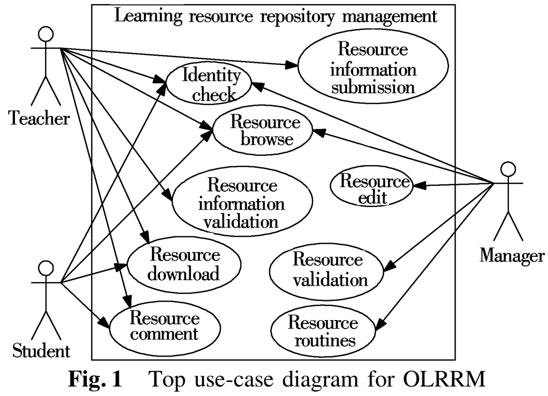

Fig. 1 Top use-case diagram for OLRRM

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There are three different types of actors: teacher, student and manager. "Teacher" can submit and validate resource information; browse, download and comment on resources. "Student" can browse, download and comment on resources. "Manager" can browse, edit and validate resources, and maintain routines of OLRRM. These actors should be registered, and have different operation rights according to different identity levels.

1.2 Building ontology

An ontology for OLRRM is shown in Fig. 2. There are two main parts of the ontology. One is "Learning resources repository" ontology concerned with the online learning resource repository. It includes a five libraries (media, case, exam problem, network courseware and reference) ontology, and each ontology represents a specific kind of the education resource. The other is a "User" ontology defined for operating the learning resource repository. The "User" ontology consists of student ontology, teacher ontology and manager ontology. The detail of ontology in OLRRM can be seen in Ref. [7].

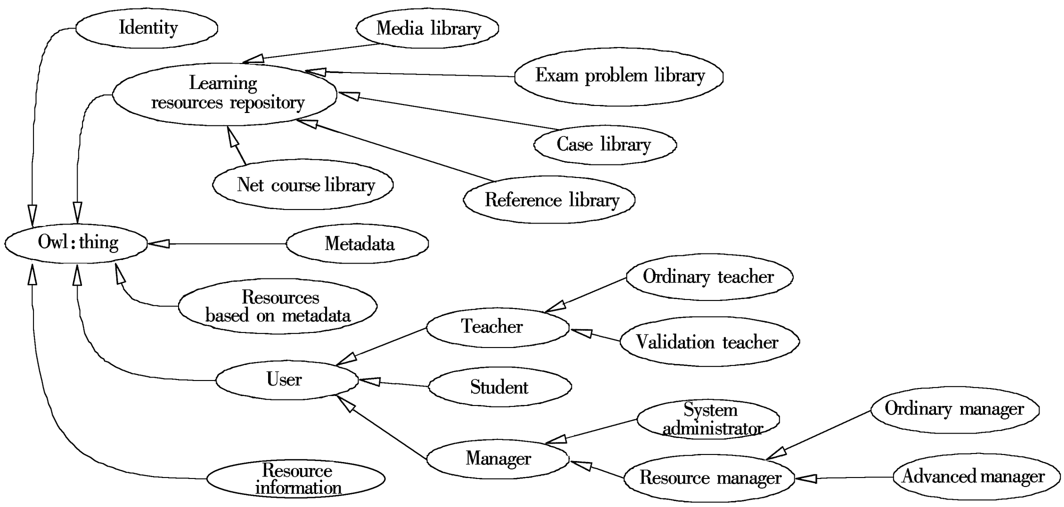

Fig. 2 Ontology for OLRRM

1.3 Evaluation of ontology

In order to make a technical judgment of the ontology, the associated software environment and documentation with respect to the reference in specifications, competency questions, and the real world, two methods of evaluating the ontology are used to analyze the relationships between the ontology and the classes. Tab. 1 shows the function evaluation for each class when different methods are chosen; Tab. 2 shows the running status for each class when different evaluation methods are chosen.

Tab. 1 Evaluation for ontology function

Upper class	Student	Ordinary teacher	Validation teacher	Ordinary manager	Advanced manager
Identity check	✓	✓	✓	✓	✓
Resource information submit	✓	✓			
Resource information validity			✓		
Download resource	✓	✓	✓		
Evaluation resource	✓	✓			
Browse resource	✓	✓	✓	✓	✓
Edit resource				✓	
Validation resource					✓
Resource routines				✓	✓

Tab. 2 Evaluation for ontology implementation

Upper class	Class	Attribute	Variable
Identity check	5	10	10
Resource information submit	1	4	7
Resource information validity	1	3	6
Download resource	3	3	90
Comment resource	2	2	60
Browse resource	5	5	150
Edit resource	1	3	32
Validation resource	1	2	31
Resource routines	2	2	76

1.4 RDF of OLRRM

The resource description framework (RDF) is a framework for metadata description developed and employs a triplet 〈object, attribute, value〉. Protege 3.1 is as ontology design tool, and the RDF scheme is shown as follows:

⋮
〈rdf: RDF xmlns: rdf = "&rdf;"
xmlns: rdf_ = "&rdf_;" xmlns: rdfs = "&rdfs;"〉
〈rdfs: Class rdf: about = "&rdf_; Additionalinfo" rdfs: label = "Additionalinfo"〉
〈rdfs: subClassOf rdf: resource = "&rdf_; Metadata"/〉
〈/rdfs: Class〉
⋮
〈rdf: Property rdf: about = "&rdf_; educationLevel" rdfs: label = "educationLevel"〉

〈rdfs: domain rdf: resource = "&rdf _ ; CaseLibrary"/〉
〈rdfs: domain rdf: resource = "&rdf _ ; ExamProblemLibrary"/〉
〈rdfs: domain rdf: resource = "&rdf _ ; NetwrokCoursewareLibrary"/〉
〈rdfs: domain rdf: resource = "&rdf _ ; Student"/〉
⋮
〈rdfs: domain rdf: resource = "&rdf _ ; Teacher"/〉
〈/rdf: Property〉
⋮
〈/rdf: RDF〉

2 Metadata

2.1 XML bindings

XML, extensible markup language, is used to combine the metadata with a resource on the web. It can define an exchange format for the metadata. The metadata might be contained in a database and an XML representation is usually generated on demand. Thus, an XML metadata record is a self-contained entity with a well-defined hierarchical structure. The XML schema is shown as follows:

〈?xml version = "1.0" encoding = "UTF – 8"?〉
〈xsd: schema
〈xmlns: xsd = "http://www.w3.org/2001/XMLSchema#"〉
〈xsd: element name = "Student" type = "User"/〉
〈xsd: complexType name = "User"〉
〈xsd: sequence〉
〈xls: element name = "user _ name" type = "xsd: string"/〉
〈xls: element name = "user _ pwd" type = "xsd: string"/〉
〈xls: element name = "user _ request" type = "user _ function"/〉
⋮
〈/xsd: sequence〉
〈/xsd: complexType〉
〈/xsd: element〉
⋮
〈/xsd: element〉
〈/xsd: schema〉

2.2 Metadata format

The metadata creates a new representation where it contains meta-information which usually does not appear in the original resource, that is, metadata about the original information (data). The relationship between metadata and ontology is shown in Fig. 3. Based on the Dublin core metadata and LOM metadata, the metadata format in OLRRM is listed in Tab. 3.

Tab. 3　Metadata format in OLRRM

Metadata item	Metadata description
Rights information	Statement for rights management to provide information about rights management for the resource
Classification information	Classification statement links to subject, keywords for identification of the resource
General information	Statement of the content for identifying the resource, classifying and indexing attributes, and nothing with the context
Coverage information	Coverage the spatial and/or temporal characteristics of the intellectual content of the resource
Lifecycle information	Statements of life cycle of the resource, such as version, status, data, release information
Format information	Textual description of the format of the resource, including data type, class, identifier and roles narration, etc.
Relation information	Identifier of a second resource and its relationship to the present resource
Annotation information	Statements of comment and explanation on related resources after applying them
Education information	Statements for returned improving education after using resource
Additional information	Statements of cost, price and restriction information about the resource

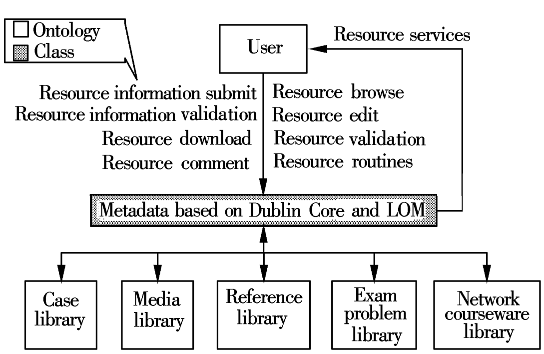

Fig. 3　Metadata in OLRRM resource information submit

3 Ontology Inference Layer

3.1 Description of OIL

OIL is a proposal for a web-based representation and inference layer for ontologies, which combines the widely used modeling primitives from frame-based languages with the formal semantics and reasoning services provided by description logics[8]. It is compatible with the RDF schema (RDFS), and includes precise semantics for describing term meanings. OIL presents a layered approach to a standard ontology language. Each additional layer adds functionality and complexity to the previous layer. This is done for agents that can only process a lower layer and can still partially understand ontologies that are expressed in any of the higher layers. Fig. 4 sketches the relationship between the OIL dialects and RDFS.

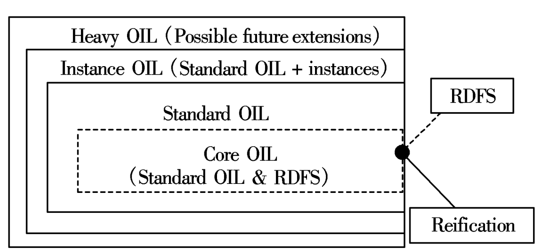

Fig. 4　Relationship between OIL dialects and RDFS

3.2 Instance inference

The class diagram of learning resource repository management is shown in Fig. 5. Let us take an example as an instance. Considering that a student would

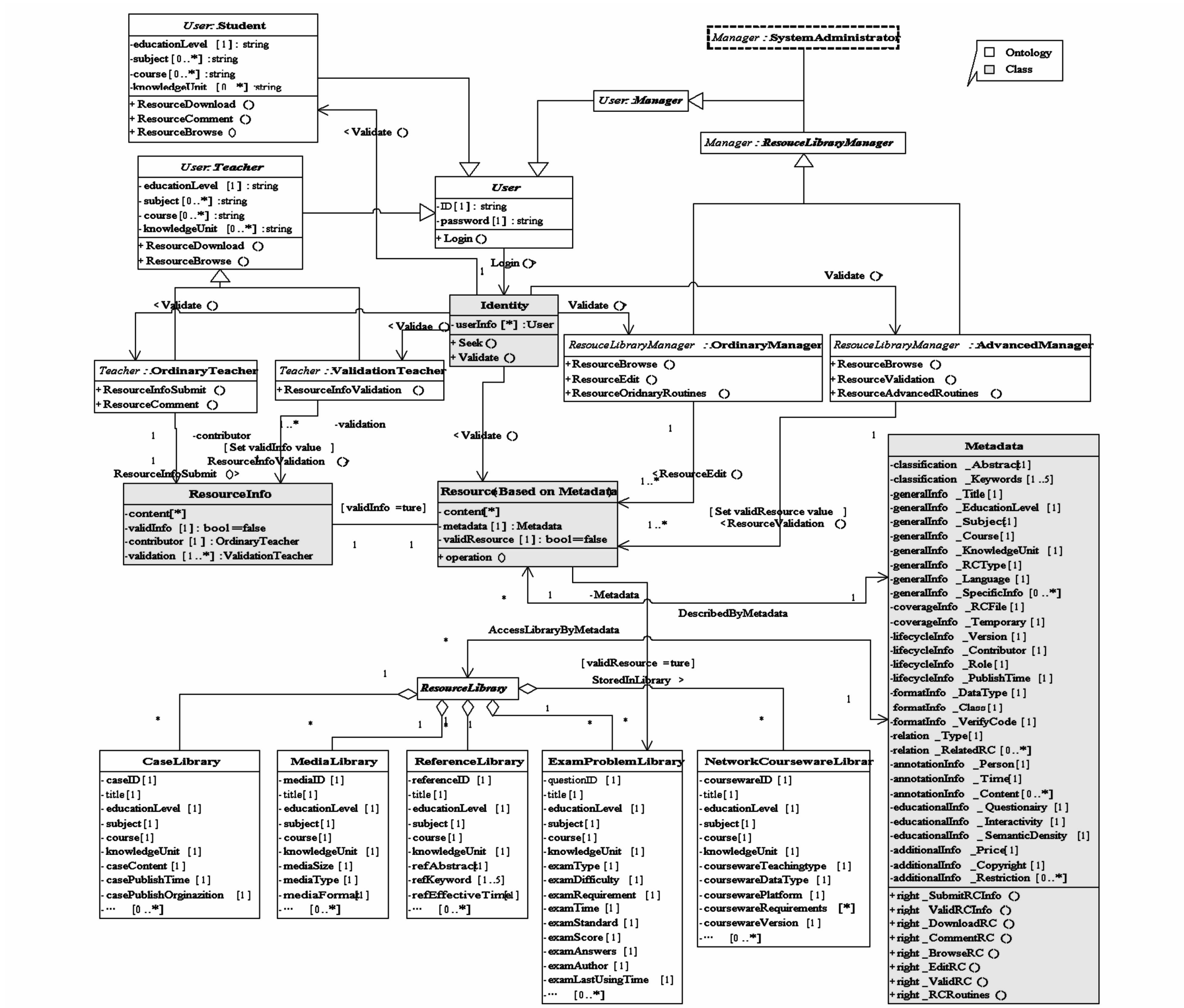

Fig. 5 Class diagram

like to browse some resource, its instance is shown in Fig. 6. The detail of inference is as follows:

Input data: student01 is an instance of "User: : student".

Task: Browse NetcourseLibrary _ 01 resource in learning resource repository.

student01→User: : Login( ) →Identity: : Validate ( )→student01 is legal.

student01→Resource: : operation( ), where some information will be transformed in another class named "Resource" whose format is organized by class "Metadata".

→Metada: : right _ BrowseRC( ) to get the corresponding resource.

→ResourceLibrary →NetCourseLibrary _ 01 to locate the corresponding resource.

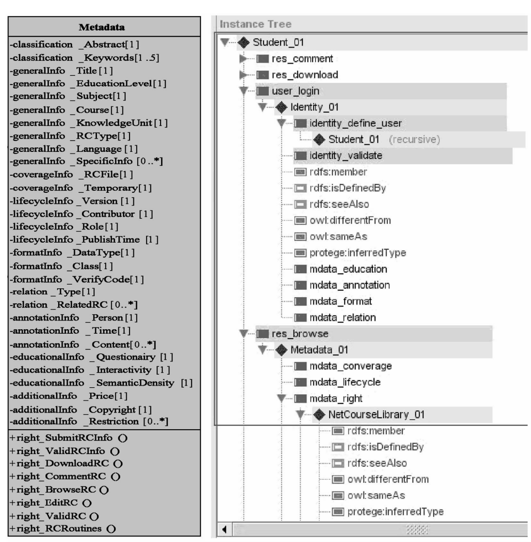

Fig. 6 Instance inference

4 Conclusion

Online learning resource repository management based on the semantic web is very important for the machine-processable and intelligent management of education. This paper presents an ontology after analyzing the use-case diagram, and discusses the upper ontology, its class diagram, RDF scheme and evaluation. Based on the Dublin Core Metadata Initiative and LOM metadata, the metadata format is defined, which combines education factors with technology factors. The instance example confirms the validity of ontology and metadata.

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基于语义 web 在线学习资源管理的本体和元数据

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摘要:构造了在线学习资源管理系统的本体和元数据. 首先,在分析系统用例图的基础上,给出了网络在线学习资源和用户的顶层本体、RDF 模式描述和类图,并从功能和运行 2 个方面对给出的学习资源本体和用户本体进行了评估;然后结合 Dublin 核心元数据和 IEEE 的 LOM 元数据模型,给出了本系统的元数据格式;最后通过实例证明了所给出的本体和元数据的有效性.

关键词:语义 web;在线学习资源管理;本体;元数据

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