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Managing Educational Knowledge Using Visual Ontologies

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Abstract. Knowledge portal is an approach used to provide view onto domain-specific information on the World Wide Web. In this paper, we present one approach by using ontology engineering as a conceptual backbone and relationships for knowledge extracting, structuring and formalizing in a comprehensive way for building knowledge portal. For illustration of a practical ontology development for knowledge portal, the described ideas are implemented in a system for international student service.

Keywords. Knowledge portal, ontology engineering, international student service

1 Introduction

Today, data or information can be retrieved from many different sources, such as databases, World Wide Web, knowledge bases, and other specific information systems. Using web-based technologies, knowledge portals are an emerging approach for providing a single point of access to various types of information [3].

In this paper, we present an effective attempt to construct the knowledge portal, which aims to integrate and organize the data/information resources dispersed across web resources by using ontology technique that makes them useful, and a framework of user-centric design for accessing the requested information.

2 Portal Architecture

In this section we present main part of construction of ontology-driven knowledge portal.

Educational Knowledge Portal

The key to a successful knowledge dissemination strategy is to channel the knowledge to the communities of practice and at the same time provide means for information exchange and peer-to-peer collaboration [7]. One of the models for a virtual collaborative research environment that provides means for both, knowledge sharing and collaboration is the "Knowledge Portal" model. Or we can say that the aim of knowledge portals is to make knowledge accessible to users and to allow users the exchange of knowledge [1]. Knowledge portals specialize in a certain topic in order to offer deep coverage of the domain of interest and, thus, address a community of users.

As a ways and means of knowledge management, knowledge portal can be used in various areas. Our focus is put on to the higher education business for university routine activities. The aim of knowledge portal construction within the university is *To provide the knowledge management infrastructure and services those empower and promote the University's business.*

In this paper, we will discuss a practical ontology development which serves university education for international student service. A university portal is a one-stop client-oriented web site that personalizes the portal's tools and information to the specific needs and characteristics of the person visiting the site, using information from university information base. The portal should provide access to information relating to a wide variety of activities. In the first place it will probably concentrate on teaching and learning and student administration. Other areas will also come into play: library services, financial management, research administration, personnel administration and estate management.

Ontological Engineering

The basic philosophical definition and its further development are pointing that term ontology stands for study of "being" [14]. But in information science now ontology is a set of distinctions, explicitly made in order to understand and view the world (see Fig. 1). There are some of varieties of definitions of this milestone term [5, 6].

1) Ontology defines the basic terms and relations comprising the structured vocabulary of a topic area, as well as the rules for combining terms and relations to define extensions to the vocabulary.

2) Ontology is an explicit specification of a conceptualization or a hierarchically structured set of terms for describing a domain that can be used as a skeletal foundation for a knowledge base.

What is the reason or goal of developing ontology? Here are some enumerations [8, 11]:

- To share common understanding of the structure of information among people or software agents.
- To enable reuse of domain knowledge.
- To make domain assumptions explicit.
- To separate domain knowledge from the operational knowledge.
- To analyze domain knowledge.

This definition clarifies the ontological approach to knowledge structuring while providing sufficient freedom for open-ended, creative thinking. Often an ontology of the domain is not a goal in itself. Developing an ontology is akin to defining a set of data and their structure for other programs to use. Problem-solving methods, domain-independent applications, and software agents use ontologies and knowledge bases built from ontologies as data. For example, ontological engineering can provide a clear representation of a company's structure, human resources, physical assets, and products, and their inter-relationships. These structures and information could be used for company's progress analyzing and planning, sections collaboration and knowledge transfer. Therefore, ontology as a useful structuring tool may greatly enrich modeling process, providing users of KM-systems (knowledge management – systems) an organizing axis to help them mentally mark their vision of the domain knowledge.

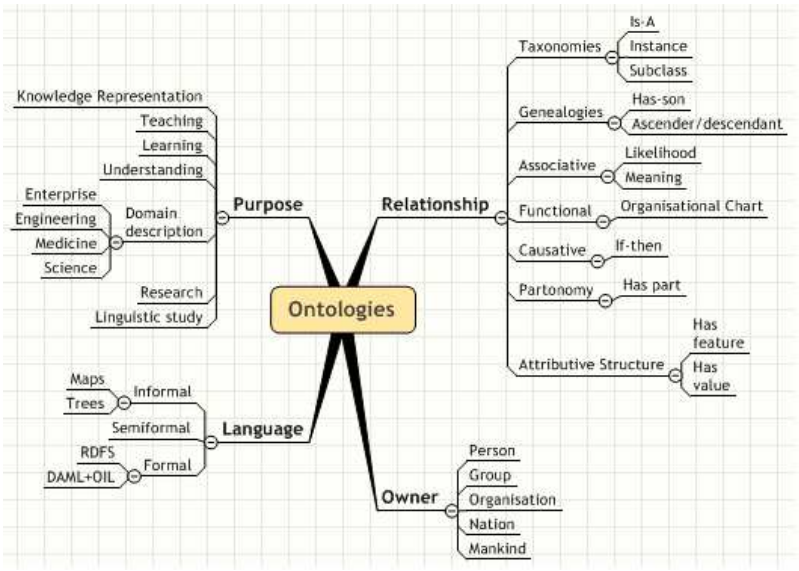

Figure 1. Classification of ontologies

In practical terms, developing an ontology includes:

- Defining classes in the ontology.
- Arranging the classes in a taxonomic (subclass–superclass) hierarchy.
- Defining slots and describing allowed properties (value) for these slots.
- Filling in the properties (value) for slots for instances.

Before we build ontology, we should distinguish the ontology and data schema. The trational data schema we can call it static approach, it concentrates on the fixed input and structure or framework, inconveniently queries, changes and reuse. On the contrary, the ontolgy structure is more flexible in these areas. We can consider ontologies as "schemas for knowledge bases" [10]. Having defined classes and slots in the ontology, we populate the knowledge base with instance data.

It works incoporating semantics which facilitate people searching and querying by nature language and logic. In addition, the flexibility of ontology is much higher. For example, many ontology languages and systems allow the specification of cardinality constraints, inverse properties, transitive properties, disjoint classes, and so on. Some languages add primitives to define new classes as unions or intersections of other classes, as an enumeration of its members, as a set of objects satisfying a particular restriction. Therefore, any detailed treatment of ontology changes must include a much more extensive set of possible operations.

It has been proposed several independent constructs which can be used as a basis for creating an ontology (see Fig. 2).

- **Class:** a generic concept similar to a frame.
- **Relationship:** a conceptual hierarchy allowing subsumption.
- **Property:** a property similar to a slot allowing for simple inference and inheritance.
- **Individual:** an instance of one or more classes by defining a relationship.
- **Axioms and constraints:** which is based on formal logic constructs such as axioms, constraints and inference rules.

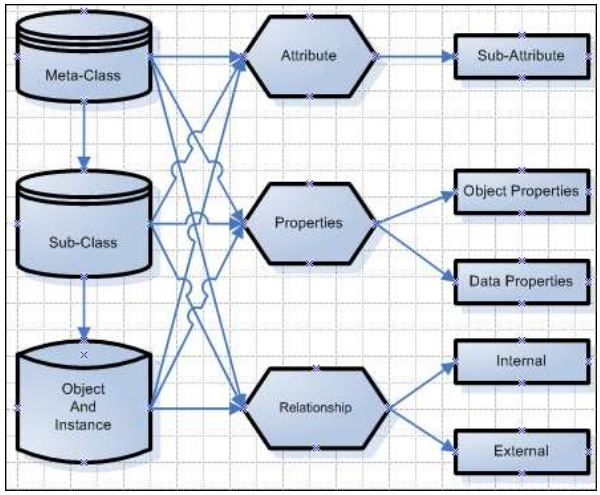

Figure 2. Basis constructs of ontology building

Usually, there is a *Four-step Algorithm* to create ontology for practical problem:

Step1. Goals, strategy and boundary identification: The first step in ontology development should be to identify the purpose of the ontology and the needs for the domain knowledge acquisition.

Step2. Glossary development or meta-concept identification: This time consuming step is devoted to gathering all the information relevant to the described domain.

Step3. Laddering, including categorization and specification: Having all the essential objects and concepts of the domain in hand, the next step is to define the main levels of abstraction.

Step4. Refinement: The final step is devoted to updating the visual structure by excluding any excessiveness, synonymy, and contradictions. Meanwhile, we also follow Gestalt (good form) principles by M. Wertheimer [15] to achieve the harmony. As mentioned before, the main goal of the final step is try to create a harmonical ontology.

3 Implementation

In this section, for illustration of a practical ontology development for knowledge portal, the described ideas are implemented in a system for international student service.

International Student Service

International students are continually facing the problem of searching and applying through which is needed to analyze massive volumes and varieties of data. This situation is not limited to students, but is took place in educators and organizations. Thus, with web-based technology, knowledge portal is required and developed facilitating users to find relevant, domain-specific information using university database.

The portal should provide access to information relating to a wide variety of activities [12]. Primarily it will probably concentrate on teaching and learning and student administration. Other areas will also come into play: student's life service, financial assistant, passport and visa service, etc.

Members of students and visitors will have different system requirements. But in general, there are some similar parts could be regarded, the following table summarizes the most highly ranked (see Table 1):

Table 1. General Student Service Requirement

Study Information	
	New Student
	Current Student
	Graduating Students
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Life Service Information	
	Student Services
	Employment
	Student Union
	Entertainment
---	---
Passport and Visa Service	
	Passport Service
	Visa Service

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Financial Service	Scholarships Graduate Assistantships Loans

Ontology Design

In this part we describe the development of ontology of information technology skills and knowledge, following the aforementioned 4-step algorithm. We have tried to report the exact practical procedures we followed at each step by including all the visual structures.

Step 1. Purpose and Goals Identification. It is important to first analyze the purpose and proposed usage of the ontology early in the process of its development. User requirements analysis is a part of the user-centered design process, which increases the likelihood that an implemented system matches users' needs and behaviors [4]. If adopted, it could help to overcome some of the obstacles to a successful portal implementation within the university.

Goals analyze: A university is seeking to provide useful information for international student. Each parts should be integrate, tactic and available. The data will help student to:

- Providing useful and up-to-date information about university and program.
- Helping and guiding news to apply the program and make consultation.
- Information for current and graduating student.
- On arrival service, daily service and activity consultation.
- Passport and Visa service
- Financial Assistant

Step 2. Glossary development or meta-concept identification. The second step is devoted to gathering all the information relevant to the described domain. To achieve this, we collected the terms of two sides which are from the point of view of student and university expecting to cover all the possible situations that will be occurred (see Table 2).

The terms and concepts from each of these sources were combined to build a single glossary.

Table 2. Glossary of terms and concepts

New Students	Student Services	Transportation and Address
Current Students	Employment	Information about Accommodations
Graduating Students	Student Union	International Interchange of Students
Program Introduction	Entertainment	Certification of Russian Language as Foreign Language

Applications and Applicants	Medical Service	Preparatory Test
On Arrival	Dormitory Service	Full-Time Service
Applications Flow	Security Service	Entrance Check-up
Applicants Requirement	Information about Employment	Equipment and Network
Orientation	Off-campus Employers	Celebration
Housing	Activities	Time Table
Health Insurance	Communion with Foreigners	International Semester
Contract Preparation	Concert	Information for Student from Preparatory to Ph.D
Expenses and Finances	Sports	Enrolment
Graduate Assistantships	Tour	International Education Projects
Important Message for Graduating Students	Passport Service	Education Certificate Assessment
Academic Attestation for Back	Visa Service	Loans
FAQ and Contact	Scholarships	Consultation and Help

Step 3. Laddering, categorizing and specifying. After creating all essential objects and concepts, the next step is build practical ontology of the system. First we built an initial visual structure of the glossary terms. We attempt to create a set of preliminary high level concepts and the categorization of the glossary terms into those concepts.

Utilizing MindGenius [9] we build initial categorization or meta-concept which is to build ontology from point of view of university which includes all faculties, departments and staffs, it's a complete and exact description of the university (see Fig. 3).

Figure 3. Main meta-concepts for knowledge structuring

As we know, the portal need to be much more attended to the practical problem, also, we composed more precise concepts and hierarchies by analyzing the glossary and previously built visual structure. Students from this visual map can not easily gain the information or message about their university and campus life, it is should not only from the view of university but more concerned with students.

Meanwhile, there still seems to be some disadvantages that may need to be adjusted further. One of them is too many branches used in the map which may lead visitors to disordered corner. Users sometimes doesn't have enough time and endurance to navigate from one place to another to find information he want, therefore, a specific, ordered and well-structure configuration is more significant and needed. We modify the previous map to make it more effective and humanizing (see Fig. 4).

Figure 4. Adjusted portal's structure design

Since we have already thought over all the situations that may occur when the foreign students are coming to the university, there still exist problem to guide or help them. "What's the real help they want to gain from university, not what's the help university wants to give?" ----- that's the only way to solve the problem.

The following diagram shows us the solution (see Fig. 5), it's obvious that it completely comes from the point of view of the students which presents the think of user-centered design.

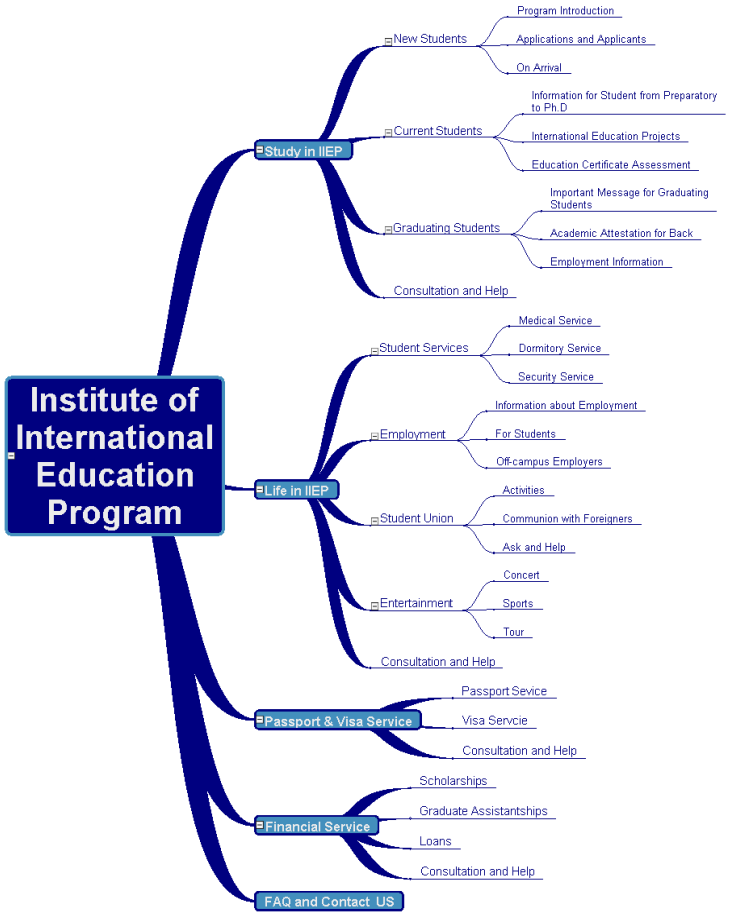

Figure 5. User-centered portal's structure design

Here we use Top-Down structuring strategy [2] to create basic relationship between concepts via filling with term of glossary. The output of this step is a large and detailed map, which covers the domain hierarchically.

Step 4. Refinement and Harmony. To access refinement and harmony, we should update the ontology by taking into consideration of balance and clarity. We removed all the excessiveness, synonymy, and contradictions, then use standard, consistent relationships to simplify understanding.

By using the ontology building software Protégé, finally we can implement our work on the computer for future semantic web construction (see Fig. 6).

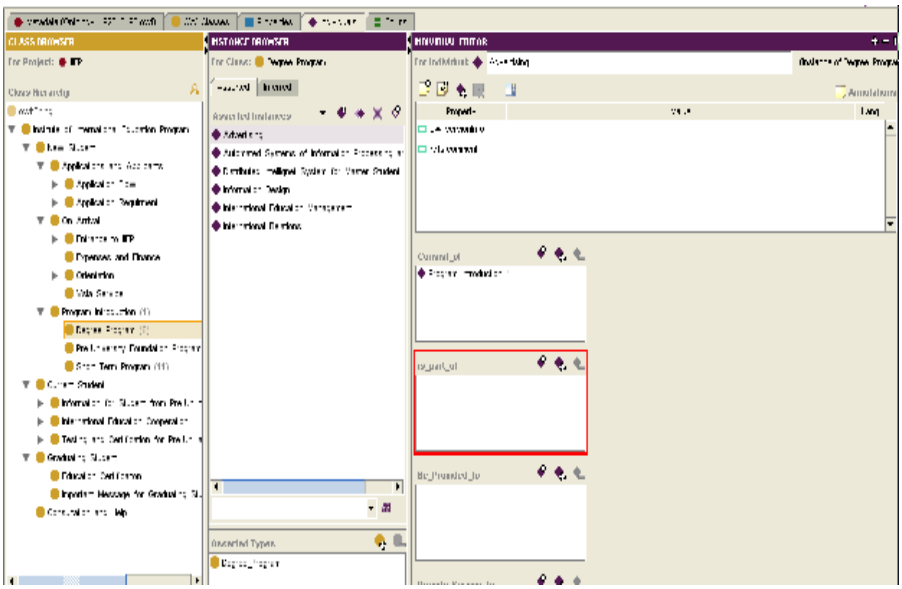

Figure 6. Adjusted portal's structure design

System Construction

In this design, the system includes three parts: Educational Server, Ontology System and Database. The Education Server includes User Adaptation, registering, publishing and executing the education service (including content utilization); Ontology System is responsible for reasoning service with educational ontology and returning. Using Tomcat and JAVA servlets we construct a simulative environment that runs the knowledge portal in practical, then we use some JSP techniques embedded OWL file to generate corresponding web pages. Figure 7 depicts the mechanism of whole system usage and development process (see Fig. 7).

The brief work flow of the system is as follows:

1) The user, with any device at any place, accesses the education server and searching for information or sends the specific request and context to education server. The user request can be described with concepts.

2) The education server receives the user request and reasons with the ontology system and gets the returned function description; and then composes it into the target system description, in which the requested function is implemented with macro and atomic services.

3) The reasoner in ontology system executes query and inference operation with education ontology and return the result to the server.

4) Education server collects all the results and transforms these results into the proper format according the device context.

5) User client receives the result and gives a perfect display.

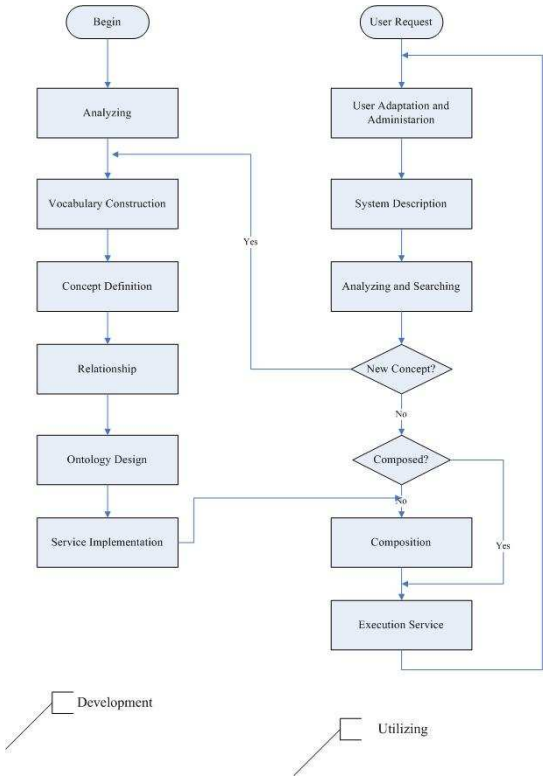

Figure 7. Mechanism of portal development and usage

4 Conclusion

The knowledge portal is a user-centered environment through which a user can gain access to information and tools from a single internet location. To achieve this goal, we have demonstrated the strategy for designing a system for international student service by using ontology technique which may lay a conceptual foundation and supports the building of knowledge portals.

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