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Academic Program Administration via Semantic Web – A Case Study

Qurban A Memon, Shakeel A. Khoja

***Abstract*—**Generally, administrative systems in an academic environment are disjoint and support independent queries. The objective in this work is to semantically connect these independent systems to provide support to queries run on the integrated platform. The proposed framework, by enriching educational material in the legacy systems, provides a value-added semantics layer where activities such as annotation, query and reasoning can be carried out to support management requirements. We discuss the development of this ontology framework with a case study of UAE University program administration to show how semantic web technologies can be used by administration to develop student profiles for better academic program management.

Keywords—Academic Program Administration, Semantic Web, Web Technology

I. INTRODUCTION

UNLIKE Content Management Systems (CMS) [1-2] for providing educational services, such as Virtual Learning Environments (VLEs), course repositories, library archives, online examinations, online coursework submission, the Academic Information and Management Systems (AIMS) [3, 4] are mostly used in academic environment to support information, finance, logistics, human resource and student services. Both types of systems create huge databases containing interrelated data. It has been observed that the academic and content management systems work in isolation (mostly maintained by different departments) and in many cases, not even designed to interact with each other at later stages. Thus decision making in such isolated systems would require tiring analysis of extensive data within faculty-administration nexus.

ERPs such as SAP, People soft etc work on fixed queries and return atomic results, whereas semantic web returns quasi queries. For ERPs databases have to be properly normalized, whereas semantic work on any relation which has been defined through ontologies. Semantic Web technologies aim to open up the data by providing more flexible ability of collaborative annotation and reuse of the learning resources. The semantic web [5] is a web of machine processable meanings underpinned by shared and formally defined ontologies. In order to coordinate different semantic web activities, an educational ontology is explicitly defined to share a contextual conceptualization of the educational domain, which can be then used to annotate educational artifacts such as lecture resources, program specifications, modules and assessments. This allows the users to make their resources more machine-processable by collaboratively constructing an enriched layer of the semantic web that links educational artifacts with formal semantics to support other semantic activities such as semantic query, aggregation and reasoning [6].

The UAE University [7], as an example, uses various sub-systems, most of them independent, to carry out specific tasks in an academic administration environment. These sub-systems along with respective functionality are listed below:

a. Blackboard system: contains course logs, student assessment data done by faculty, course evaluation done by students – users are students, faculty, and administration.

b. INB system: contains contracts and purchasing system, budget, student data for admission, semester grades, and transcripts – users are administration (mainly secretary general's office) and University Registrar.

c. Eservices: contains employee information (personal data, time sheets, benefits, job data, paystubs), entering grades by faculty, registration overrides, view class lists and student information, HR system – users are faculty, faculty as advisors, staff, administration…..this server derives student related data from INB system.

d. FMES system: contains faculty members' annual evaluation reports – users are faculty, administration.

e. Research Affairs system: contains data related to research grants related to faculty, local conferences – users are faculty, Research affairs management, public.

f. Email server: contains email logs – users are administration, faculty, staff, students

g. Web server: contains websites of colleges (and departments), faculty web pages, data related to industrial training of students, graduation projects of students – users are administration, faculty, students, and public.

h. College server: Each college has its own server containing logs about programs, courses, accreditation body, program assessments, etc.

These sub-systems, in all, yield long and repetitive work to reach a level of respective decision making, and thus do not open up the data for collaborative annotation and reuse of the learning resources to help reason a higher level intelligent query. In this paper, the context of the Higher Education (HE) scenario is set to demonstrate the best practice of semantic web activities such as semantic annotation, query and reasoning.

In section 2, typical academic program components of administration process at UAE University are briefly described to show some operational scenarios, some of which may be used effectively to develop ontology specification.

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Section 3 discusses the development of the ontology (UAEU-EE) that may be used for the practical implementation of the scenario, whereas section 4 discusses conclusions made during the implementation process.

II. ACADEMIC PROGRAM ADMINISTRATION ENVIORNMENT

The objectives of this project included providing support for all stakeholders of an academic system to solve intelligent queries. The following are some of the example tasks that the project is expected to perform successfully:

a. The Electrical Engineering (EE) department wishes to allocate a course, for which no straight matching to any lecturer is available. A semantic layer can be used to identify near matching of skills of lecturers to teach a course. Similarly course load database can be attached to check the loading of the teachers.
b. A group of students have covered all core courses and are in final year for elective courses. The department wants to know the size of students to decide a group of elective (and specialized) courses based on relative strengths (say a GPA of 2.8 and above) in design and simulations involving hardware or software. The students belong to different programs: EE general, Communications engineering and computer engineering.
c. The department is interested in comparing relative strengths in programming of two groups (one of EE general program and other is communications engineering). The students have graduated recently, and criterion of comparison would be the number of elective courses and respective senior design title.
d. The college is interested in comparing (based on their performance in science and mathematics) the relative strengths of students belonging to various departments, and select a group to send to a science exhibition.
e. The department is interested in knowing comparative assessment of senior year project taken by last three graduating batches. The assessment shall tell number of students, grades obtained, project type (whether design and simulate or design and build) and opinion about UAE graduates (as employees) from different employers in the country.
f. The department is interested in evaluating the performance of delivery of core courses of various programs offered in the department. For this, it intends to compare the quantitative assessment of core courses taken by students, with student assessment and instructor assessment of each core course.
g. The department is interested in identifying the potential and prospective employers of its graduates, based on the data from five years. For this, it intends to compare the number of students per elective course offered in last five years in each program with alumni survey conducted each year (for last five years) and input from departmental industrial advisory board.
h. In order to improve academic standards, the department wishes to develop repository of periodic data related to program assessment that includes coursework, exams, analysis of learning outcomes and objectives.

The scenarios '*a-h*' may be related to academic administration of the department to develop student profiles. Generally, student information in existing information systems (management or educational) is available in multiple systems; however providing the right information at the right time to the right user has remained a serious problem and input from an intelligent and experienced user is always required to gather the required information. With the help of semantic web framework, it can be argued that the role of an intelligent user can be supported to minimize the time to gather all required information.

III. THE SEMANTIC WEB FRAMEWORK

In order to enrich underlying data layer with well defined meaning, a machine processable semantics layer can be provided using semantic web technology. In this section, techniques used in Protégé [8] are used to simulate various semantic web management activities such as ontology management, semantic annotation and semantic query of annotation triples. All of these activities are designed to demonstrate the potential usefulness of semantic web technologies in supporting the UAEU-EE academic administration environment.

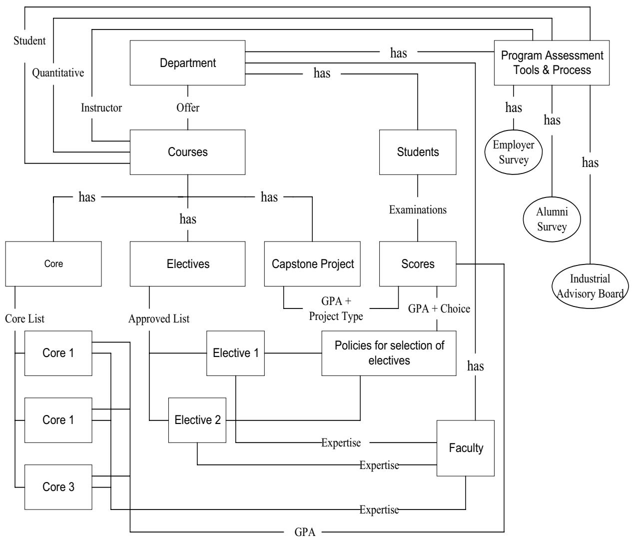

Fig. 1: A Conceptual map showing EE-entity relationships

A. *Ontology Map and Specification*

In order to formally develop ontology for typical scenarios, say for example *a-h* in section 2, a semantic conceptual map is drawn first by connecting various entities in the respective environment. For UAEU-EE department, this is shown in Figure 1. The semantic web has the power of connecting any entity with any link and developing ontology for it, based on the developed map (in Figure 1). In order to proceed further, names of lead players are identified in the environment, shown in Figure 2. Next, these mapped entities are entered into Protégé [8] to develop ontology specification for the mapped scenarios. As an example, the ontology specification for developing profile of students registered in the department is shown in Figure 3. The framework will be a set of such ontologies working together to run intelligent queries.

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-           < rdfs:subClassof>
            <owl:Class rdf:ID="OutComes"/>
   </ rdfs:subClassof>
 </ owl:Class>
-             < rdfs:subClassof>
            <owl:Class rdf:ID="Ability_OutComes"/>
             < owl:disjointwith>
            <owl:Class rdf:ID="Intellectual_OutComes"/>
             < owl:disjointwith>
            <owl:Class rdf:ID="Learning_OutComes"/>
   </ rdfs:subClassof>
 </ owl:Class>
  < rdfs:subClassof>
            <owl:Class rdf:ID="Course_Specifications"/>
   <rdfs:subClassof>
-             < rdfs:subClassof>
            <owl:Class rdf:ID="Program"/>
   < rdfs:subClassof>
            <owl:Class rdf:ID="BS_Program"/>
  < owl:disjointwith>
            <owl:Class rdf:ID="MS_Program"/>
             < owl:disjointwith>
  < rdfs:subClassof>
            <owl:Class rdf:ID="PhD_Program"/>
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   </ rdfs:subClassof>
 </ owl:Class>
  < rdfs:subClassof>
            <owl:Class rdf:ID="Course"/>
  < rdfs:subClassof>
            <owl:Class rdf:ID="CourseLeader"/>
   </ rdfs:subClassof>
  < rdfs:subClassof>
            <owl:Class rdf:ID="Assessment"/>
   </ rdfs:subClassof>
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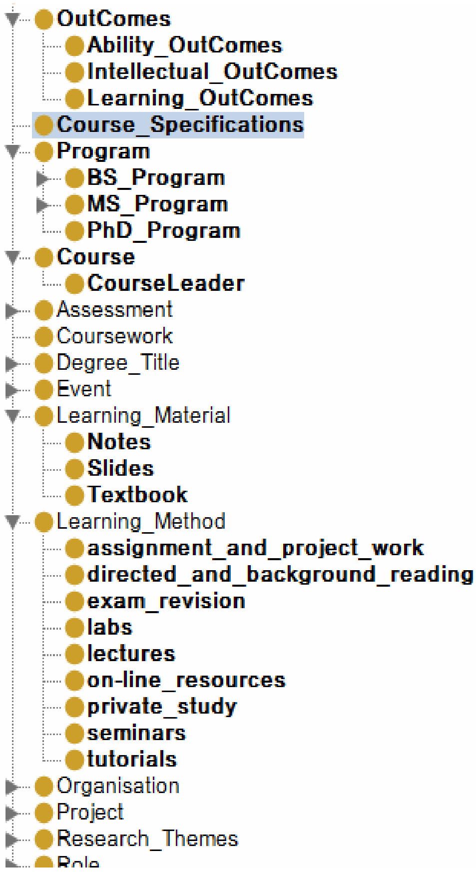

Fig. 2: Lead Players for Ontology Development

B. Semantic Annotation

In UAE-EE, we envisage end users using the ontology to annotate resources in the scenarios. To demonstrate this practice, some queries are simulated in Protégé, as shown in Figure 4, by generating semantic instances. The UAE-EE ontology is loaded in Protégé to allow annotating student information available in the Electrical Engineering Department. An ontology driven template-based instance generation method is used in Protégé to allow semantic annotation through matching instances with ontology definitions.

C. Generating Semantic Annotations

We created Student Profile Rating courses instances under *uae-engg:program-ware* object. The semantic annotations refer to the RDF (Resource Description Framework) triple statements using instance URI (Uniform Resource Identifier) and ontology property as their subject and predicate respectively, *e.g., <MSc EE, uaeu-ee:MS Program,Electrical Engineering>* and *<ELEC 616, uaeu-ee:course_title, Digital Image Processing>*, with objectives and outcomes defined as:

Program Objectives and Outcomes:

- Provide graduates with a high level of analytical and applied skills necessary to actively participate in technology innovations in addition to maintaining the present ones in the UAE and abroad.
- Promote the interaction between UAE University and the local industry. The industry is encouraged not only to actually participate in selecting the various courses and their contents but also to have an effective role in endorsing the research themes of the students especially those on study leave from the industry. Consequently, co-supervision from qualified scientists and researchers from the industry is encouraged.
- Promote the creative thinking skills among graduates necessary for life-long learning.
- Promote scientific research and development (R&D) activities.

Course Ability Outcomes:

- To compare and use different tools for image analysis in a transformed domain (wavelet vs. Fourier transform)

- To implement with Matlab image processing algorithms aimed at compression, segmentation, representation, description, and object recognition
- To apply the notions learned in the course to practical image processing problems.

<uaeu-engg:Program rdf:ID="MSCEE">
<uaue-engg:hasobjective=”#1analytical skills for handling technology”/>
<uaue-engg:hasobjective=”#2interative skills for factory environment: local and global”/>
<uaue-engg:hasobjective=”#3creative thinking skills for life long learning”/>
<uaue-engg:hasobjective=”#4research and development skills”/>
<uaeu-engg:hascourse rdf:resource="ELEC 616"/>
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<uaeu-engg:courseoutcome:resource="#1 implement Matlab image processing algorithms"/>
<uaeu-engg:courseoutcome:resource="#1 handle real world image processing problems"/>
</uaeu-engg:Program>

Instances are created for all possible student related operations, as per the relations defined in Figure 3. The instances are then used for classification of courses; defining relation between the course and the course teacher and are re-used to calculate teaching load; listing course outlines which will be used to create student’s profile; and course assessment mechanisms which are used to develop assessment strategies. Similarly all related instances are to be re-used to extract intelligent information.

IV. CONCLUSIONS

The effort exercised in this work is an elicitation of typical academic scenario in Higher Education sector. Specifically, the integration of various sub-system functionalities within a typical university is demonstrated using semantic web to help support various program management functions. The demonstrated objectives are reduced cyclic and tiring work, for example during accreditation process of the program, and support of intelligent queries set by various stake holders of the program. There is still a need to extend the semantic query to include more complex semantic reasoning capacity. It can be viewed that this can further be developed to provide functionalities in the form of web services or using a web portal so that it can be utilized more conveniently at service level and for the end users.

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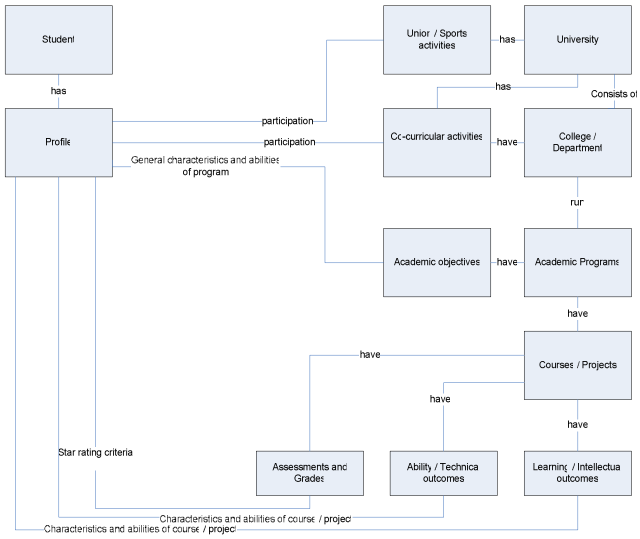

Fig. 3: Ontology Specification to develop student profiles

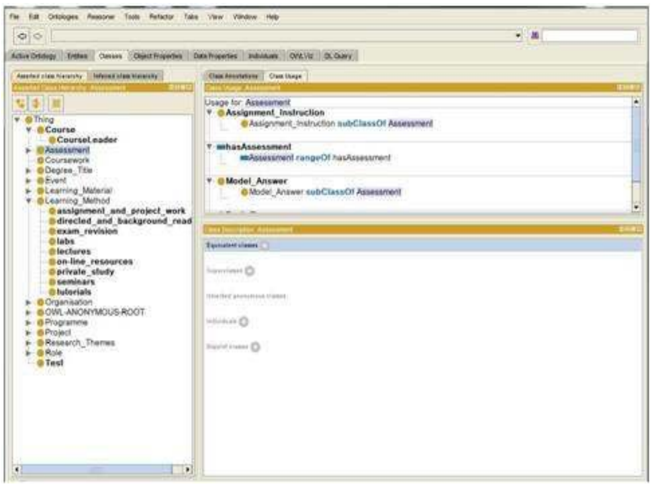

Fig. 4: Ontology Development in Protégé environment