Int. J. Engng Ed. Vol. 25, No. 5, pp. 1020–1028, 2009
Printed in Great Britain.

0949-149X/91 $3.00+0.00

Semantic Web Approach to Academic Program Assessment*

QURBAN A. MEMON
College of Engineering, UAE University, Al-Ain, 17555, UAE, E-mail: qurban.memon@uaeu.ac.ae

SHAKEEL A. KHOJA
Learning Societies Lab, School of Electronics and Computer Science, University of Southampton, Southampton, UK. E-mail: sk07v@ecs.soton.ac.uk

Generally, the engineering program assessment process in line with an accreditation body involves some cyclic and tiring paperwork before any weakness is identified in the system. Additionally, the current state of such systems is that the assessment data are spread over many sub-systems, and there is no way to use them intelligently for better academic process management. It has been a desire of academic institutions to develop these processes in such a way that program management is also facilitated through an integrated system connecting all stakeholders of the program. This paper describes an electrical engineering program assessment process that has been developed and implemented using web semantics to provide intelligent services through an integrated system. The integrated system provides a value-added semantics layer where activities such as annotation, querying and reasoning can be carried out to support management. The framework is developed with a case study of a United Arab Emirates (UAE) University program assessment process to show how semantic web technologies can be used to facilitate program management.

Keywords: semantic web; program assessment; program administration; web technology

INTRODUCTION

IN THE ACADEMIC SECTOR, Academic Information and Management Systems (AIMS) [1, 2] are mostly used to support information, finance, logistics, human resource and student services, whereas Content Management Systems (CMS) [3, 4] are used to provide educational services, such as Virtual Learning Environments (VLEs), course repositories, library archives, online examinations and online coursework submission. These types of systems create huge databases containing interrelated data. For example, in a University an AIMS may contain information about a teacher's academic qualifications, affiliations, expertise, research activities and teaching work load, whereas the CMS provide data and information regarding courses, delivery of courses, notes, and exam dates with which the teacher is currently associated. Generally, it has been observed that the academic and content management systems work in isolation (mostly maintained by different departments) and, in many cases, are not even designed to interact with each other at later stages.

The semantic web is a web of machine processable meanings underpinned by shared and formally defined ontologies. It is also used in the context of providing intelligent and meaningful logical connections between interoperable systems. At its core, the semantic web comprises a set of design principles, collaborative working groups, and a variety of enabling technologies. Other elements of the semantic web are expressed in formal specifications including Resource Description Framework (RDF), a variety of data interchange formats (e.g. RDF/XML, N3, Turtle, N-Triples), and notations such as RDF Schema (RDFS) and the Web Ontology Language (OWL), all of which are intended to provide a formal description of concepts, terms, and relationships within a given knowledge domain [5]. In an academic environment the main outcomes of semantic web technologies are considered as information gathering, its handling and publishing, collaborative teaching and learning activities, such as team building, computer mediated discussions and experiments, content creation and formation of well formed metadata for content.

Enterprise Resource Planning (ERP) systems such as SAP, People soft, etc. work on fixed queries and return atomic results, whereas a semantic web returns quasi queries. For ERPs databases have to be properly normalized, whereas semantic works on any relation that has been defined through 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 then be used to annotate educational artifacts such as lecture resources, program specifications, courses and assessments. This allows the users to make their resources more machine-

* Accepted 19 April 2009.

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.

Typically, a higher education institution like the UAE University uses various sub-systems, most of them independent, to carry out specific tasks in an academic administration environment. The sub-systems at UAE University along with respective functionality are:

- Blackboard system: contains course logs, student assessment data done by faculty, course evaluation done by students—users are students, faculty, and administration.
- 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.
- 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.
- FMES system: contains faculty members' annual evaluation reports—users are faculty, administration.
- Research Affairs system: contains data related to research grants related to faculty, local conferences—users are faculty, research affairs management, and public.
- Email server: contains email logs—users are administration, faculty, staff, students.
- Webserver: 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.
- College server: Each college has its own server containing logs about programs, courses, accreditation body, and program assessments. The EE department at UAE University maintains its own repository of program assessment documents as an archive at a separate server.

These sub-systems, in all, perform 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 scenario is set to demonstrate the best practice of semantic web activities such as semantic annotation, query and reasoning.

In the next section, the academic program assessment process at UAE University is briefly described to show some operational scenarios, some of which may be used effectively to develop ontology specification. We then discuss the development of (UAEU-EE) ontology that is used for practical implementation of the scenario, and discuss related work on this topic. The conclusions reached during the implementation process are presented in the last section.

EE ACADEMIC PROGRAM ASSESSMENT PROCESS

The Department of Electrical Engineering at UAE University has embraced the general philosophy of Outcome Based Education and has engaged in an ongoing assessment process to establish and review the Program Educational Objectives (long term objectives) and Program's Outcomes (at the time of graduation) by using a set of tools that make direct and indirect measurements of program assessment components. The program outcomes that have been established as goals of the EE program follow closely the Accreditation Board for Engineering Education (ABET) required outcomes, as achievement of these outcomes in the context of an electrical engineering program would meet the program objectives. Thus, the Electrical Engineering program is specifically designed to provide the EE graduates with the knowledge and skills needed to succeed in today's workplace and in advanced studies. The desired outcomes of the EE program require that every student graduating from this program should demonstrate the following abilities [6]:

- the ability to apply knowledge of mathematics, statistics, science and engineering principles;
- the ability to design and conduct experiments safely, as well as to analyze and interpret data;
- the ability to design electrical components, systems or processes to meet desired specifications and imposed constraints;
- the ability to work in multidisciplinary teams;
- the ability to identify, formulate and solve problems encountered in the practice of electrical engineering;
- an understanding of professional and ethical responsibility;
- the ability to communicate effectively orally and in writing;
- the ability to understand the impact of engineering solutions in a global and societal context;
- recognition of the need for, and an ability to engage in life-long learning;
- knowledge of contemporary issues;
- the ability to use the techniques, skills, and modern engineering tools necessary for electrical engineering practice.

Effectively, the Department of Electrical Engineering at UAE University has established an assessment process that is used for continuous improvement of the undergraduate program and the department's educational operations. This process may be visualized as in Fig. 1.

In fact, the program assessment consists of two parts: an annual report prepared by the assessment

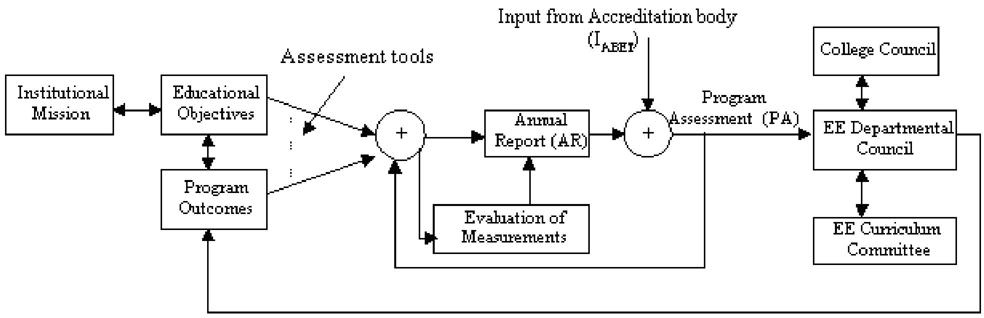

Fig. 1. EE program assessment for continuous improvement.

committee and the input from accreditation body from its previous visit i.e.:

$$PA[j] = W_1 AR[j] + W_2 I_{\text{ABET}}[j-1] \quad (1)$$

where PA, AR, and I_{ABET} stand for program assessment, annual report, and input from ABET respectively. The term j indicates the current year, W_1 and W_2 are assigned weights based on a particular criteria set by the EE departmental council during that year. There is a dependency between W_1 and W_2 in cases when there are corrective measures to be taken based on ABET comments on the assessment process. This, in turn, depends on how well stakeholders' opinion has been incorporated at various levels of the assessment process. In short, it can be said that the annual report combines ABET feedback to generate program assessment, whereas the annual report is prepared using previous program assessment combined with assessment measurement results obtained by various tools in the current year and from at least previous one year. This can be written as:

$$AR[j] = PA[j-1] + \frac{1}{N}\sum_k T_k[i] + \frac{1}{N}\sum_k T_k[i+1] + \frac{1}{N}\sum_k T_k[i+2] + \ldots\ldots \quad (2)$$

where T_k $[i]$ stands for measurement result using a specific tool i for the measurement k, and N stands for number of measurements considered for averaging. The assessments are measured twice per year (i.e., once per term of the year), and thus term k typically may range from 1 through 4, so N would equal 4 in this case. The various tools (i.e., direct and indirect approaches) are implemented to assess the program outcomes. The annual program assessment followed by its local (college and department) evaluation and the input from the (external) accreditation body set the benchmark performance limits of the program assessment. These two components form the two feedback paths in Fig. 1. In fact, there exists another outer loop that refines the program educational objectives set by its constituencies.

Both Equations (1) and (2) are implemented each term of an academic year to measure the outcomes using various assessment tools. Some of the assessment tools use information from faculty, students (present and graduates), and industry (employer, alumni, Internship supervisors), whereas some of the outcomes are best measured through a capstone course, internship and extra curriculum activities. Finally, the quantitative (Q), the faculty (F), student (S) assessments, and those from industry are combined in an Excel sheet to produce outcome data for all courses and programs. Many of these measurements are collected and compiled at different levels of the assessment process. For example, surveys from industry are collected manually over a period of time and then are complied to be incorporated in the assessment process. The (local) college evaluation is typically generated within the same year, but those from industrial advisory board and the external accreditation body are usually available after a couple of years during their visit to the college.

The whole continuous assessment process generates a lot of cyclic and (some of the time) redundant data due to feedback cycles, and thus is termed tiring because of its nature (as in Fig. 1, or in Equation (2)). Moreover, the whole data resides at multiple servers at different locations (i.e., department, college, University), and currently there is no semantic way to link these archives. The main objective of using web semantics for the academic program process is to connect all these datasets to provide support to all stakeholders of the academic system for solving their intelligent queries (automatically). The following are some of the example tasks that this work is expected to perform successfully:

a) The department is interested in making a comparative assessment of senior year project taken by the last three graduating batches. The assessment will give the 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.
b) The department is interested in evaluating the performance of delivery of core courses of various programs offered in the department.

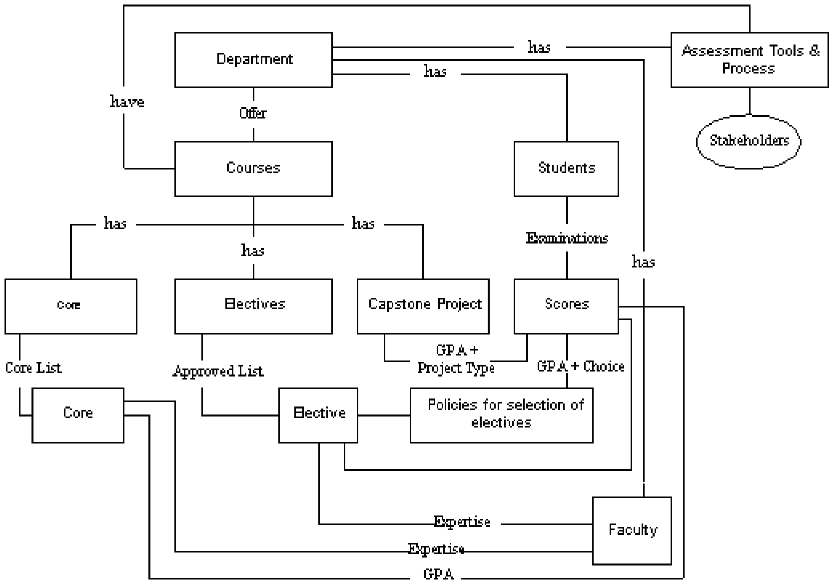

Fig. 2. Conceptual map showing various entity relationships.

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.

c) 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 the last five years in each program with an alumni survey conducted each year (for the last five years) and input from the departmental industrial advisory board.

d) With the aim of safeguarding and helping improve academic standards, quality assurance and the accreditation agency, ABET for example needs to work closely with the University to refine academic standards and quality procedures. The repository framework of the developed system, in particular the educational ontology as the conceptualization backbone, needs to reflect the ABET standard procedure for possible accreditation. This requires them to access assessment materials such as coursework (the instructions supplied to students, the student work submitted, and the marks/feedback obtained) and exams (both the papers supplied to students and the marked student scripts). In addition, the accreditation agency needs to understand the learning infrastructure (timetables, library provision, lab provision—hardware and software, CVs of academic and technical staff, number of students enrolled, minutes of academic committees, etc.).

It is easy to see that most of the data in cases above are inter-related and seem to be standard database queries. However, it should be noted that the relevant datasets are at multiple servers at different locations, and typically have no semantic link amongst them. Currently these are mostly looked into rigorously to find inter-related required information, typically involving a number of people. It can be argued that the existing information systems (management or educational) are generally designed to provide the information required for the above mentioned scenarios; however the provision of 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 a semantic web framework, it can be argued that the role of an intelligent user can be supported to replace gathering all required information manually.

THE SEMANTIC WEB FRAMEWORK

The semantic web technology aims to provide a machine processable semantics layer that enriches the underlying data layer with well defined meaning. In this section, techniques used in Protégé [7] 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 scenarios.

Ontology map and specification

Based on this discussion, the ontology can easily be developed using, for example, the scenarios (a)–(d) given above. In order to formally develop the ontology, a conceptual map is drawn first by connecting various entities in respective scenarios (a)–(d). This is shown in Fig. 2.

The semantic web has the power of connecting

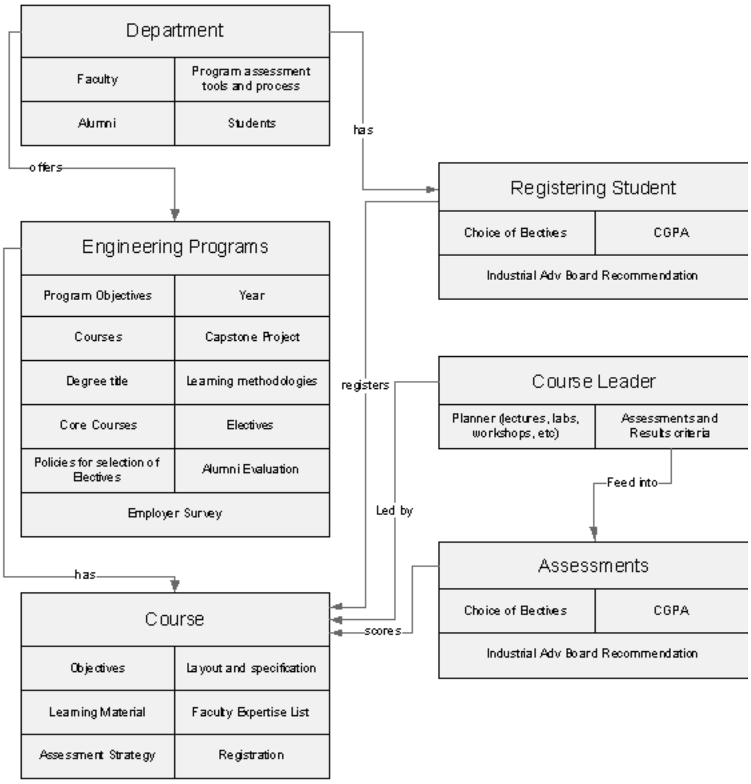

Fig. 3. Ontology specification for allocation of elective courses.

any entity with any link and developing the ontology for it, based on the developed map. Next, these mapped entities are entered into Protégé [7] to develop ontology specification for the mapped scenarios. As an example, the ontology specification for allocation of elective courses is shown in Fig. 3. The framework will be a set of such ontologies working together to run intelligent queries.

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 Fig. 4, by generating semantic instances. The UAE-EE ontology is loaded in Protégé to allow annotating elective courses 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.

Generating semantic annotations

The Electrical Engineering Elective courses instances are created under *uae-ee:course-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.*, <*ELEC 561, uaeu-ee:course teacher, Shakil Laghari*> and <*ELEC 561, uaeu-ee:course_title, Java Programming and Applications*>, with assessment strategy defined as a two hour final exam, one hour midterm exam, one take home assignment and three in-class quizzes. Similarly learning outcomes are defined as Introduction to Java Programming Style and formats, Understanding of Object Oriented Programming Concepts, Application of Java to mobile applications and Advanced Java programming, as:

```
<uaeu-ee:Module rdf:ID="ELEC 561">
<uaeu-ee:hascourse rdf:resource="#Course_teacher"/>
<uaeu-ee:course_teacher rdf:resource="#Shakil Laghari"/>
<uaeu-ee:course_title rdf:resource="#Java Programming and
  Applications"/>
<uaeu-ee:assessment rdf:resource="#2 hours final exam"/>
<uaeu-ee:assessment rdf:resource="#1 hour midterm exam"/>
<uaeu-ee:assessment rdf:resource="#1 take home assignment"/>
<uaeu-ee:assessment rdf:resource="#3 in-class quizzes"/>
<uaeu-ee:learning outcome rdf:resource="#Java Programming
  style"/>
<uaeu-ee:learning outcome rdf:resource="#Understanding of
  Object Oriented Programming Concepts"/>
<uaeu-ee:learning outcome rdf:resource="#Understanding of
  Java Formats"/>
<uaeu-ee:learning outcome rdf:resource="#Java and mobile
  applications"/>
<uaeu-ee:learning outcome rdf:resource="#Advanced Java
  Programming"/>
</uaeu-ee:Course>
```

Instances are created for all electives, as per the relations defined in Fig. 2. 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 that will be used to create student's profile; and course assessment mechanisms that

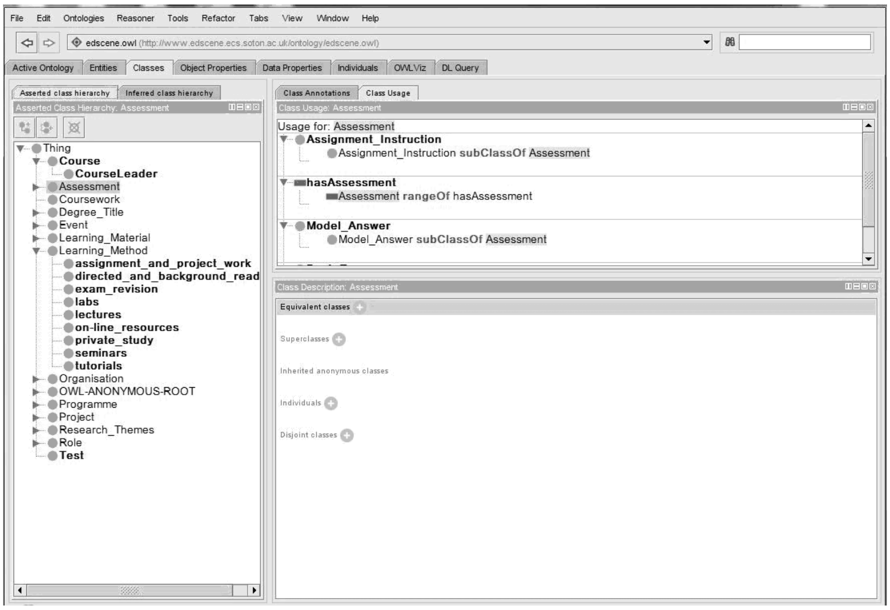

Fig. 4. Ontology development in Protégé environment.

are used to develop assessment strategies. Similarly all related instances are to be re-used to extract intelligent information.

Reuse of the semantic annotations

In this section we discuss a part implementation of a student's scenario, it is assumed that a student is interested in selecting electives to enhance his/her profile in one particular area of expertise, expertise of the faculty member who will be teaching the course, assessment load, and popularity of the course when it was offered in the past. Developing semantic relations between elective courses, their learning outcomes, course feedback, faculty's expertise, and student profile, makes it possible to make such a high level query. Given the fact they have been sufficiently annotated using a shared ontology, ontology driven match-making can be carried out through carefully designed semantic web queries into these semantic annotations in the form of RDF triples. SPARQL [8] is a query language designed for querying semantic web triples. The most straight-forward solution to realize the scenario is to carry out a set of SPARQL queries and post-processing operations. The following steps are used:

1. Query regarding student profile to check his area of expertise (e.g. in which subjects he has taken good scores)
2. Query regarding electives to be offered by the Department, in particular its subjects' annotations and learning outcomes
3. Query regarding teachers who are offering electives in their areas of expertise
4. Query regarding feedback of the course
5. Measuring the distance of the student profile to the elective courses been offered
6. Measuring the distance of the subject map of the electives and expertise of faculty members, and its previous feedback
7. Rank the candidate elective course by the distance.

Below are some examples of the SPARQL queries to retrieve semantic description of teachers and courses annotated at the semantics layer. By referencing to the predefined ontology, it is possible that any other party recognizing the ontology can understand and easily reuse these semantics.

PREFIX uaeu-ee_ins:
<http://www.uaeu-ee.ae /uaeu-ee_ins.owl#>
PREFIX uaeu-ee: <http://www.uaeu-ee.ecs.ae/ontology/uaeu-ee.owl#>
SELECT ?s ?p ?o
WHERE {uaeu-ee_ins: Joe Blogg? o? scored A }
ORDER BY ?o
1 (?p = uaeu-ee:firstName) (?o = "Joe"^^<http://www.w3.org/2001/XMLSchema#string>)
2 (?p = uaeu-ee:lastName) (?o = "Blogg"^^<http://www.w3.org/2001/XMLSchema#string>)
3 (?p = uaeu-ee:assessment-grade) (?o = uaeu-ee_ins:ELEC 330)
4 (?p = uaeu-ee: assessment-grade) (?o = uaeu-ee_ins:ELEC 335)
5 (?p = uaeu-ee: assessment-grade) (?o = uaeu-ee_ins:ELEC 451)
6 (?p = uaeu-ee:assessment-grade-level) (?o "A"^^<http://www.w3.org/2001/XMLSchema#int>)

The above query (select the courses where student x scored A in previous subjects) will yield the result: 'scored A in ELEC 330 Computer programming, ELEC 335 Digital Logic Design, and ELEC 451 Microprocessors', suggesting that the student is developing a profile in a computer systems related courses. In the next query we are trying to match the expertise of faculty members with the learning outcomes of the elective subjects:

```
SELECT ?s ?p ?o
WHERE {uaeu-ee_ins: ELEC561 ?p ?o }
ORDER BY ?p
1 ( ?p = uaeu-ee:hasLearningOutcomes ) ( ?o = uaeu-
   ee_ins:ELEC561_Learning_Outcomes )
2 ( ?p = uaeu-ee:has_subject ) ( ?o = uaeu-ee_ins: Computer
   Programmng )
3 ( ?p = uaeu-ee:has_subject ) ( ?o = uaeu-ee_ins: Digital Logic
   Design )
4 ( ?p = uaeu-ee:has_subject ) ( ?o = uaeu-ee_ins:
   Microprocessors)
5 ( ?p = uaeu-ee:has_subject ) ( ?o = uaeu-ee_ins: Embedded
   Systems )
6 ( ?p = uaeu-ee:expertise ) ( ?o = uaeu-ee_ins:Shakil Laghari )
7 ( ?p = <http://www.w3.org/1999/02/22-rdf-syntax-ns#type> )
   ( ?o = uaeu-ee:Course )
```

In this way, complex queries can be jointed to calculate the academic staffs' expertise and finally match-making the right expertise to the electives and then offered to the student, matching his/her academic profile that was generated querying his/her scores. Data in the traditional repository are then opened up through a set of semantic activities.

Ontology documentation

We have used OWLDoc plug-in to produce text based documentation, shown in Fig. 5, of the OWL ontology so that all entities in the ontology can be browsed easily and consistently on the web to help circulating and finalize the ontological definition within the team.

RELATED WORK

A significant level of work has been reported in the literature on the assessment process in a higher education institution. There exist two active areas of research: one covers theoretical research and development in assessment processes and models; the other spans the development and automation of the corresponding systems. In the area of theoretical research, the authors in [9] discuss a way to develop and implement an effective assessment plan using a case study. The objective of the research seems to include a wide variety of approaches to assessment to make sure that no important component of a successful plan is overlooked. In another work [10], the authors have highlighted a primary impediment to the usefulness of systematic assessment by describing the culture of assessment interactions with norms of organization. The authors argue that building trust in the process is a key factor for the long term success of assessment at the institution. The authors in [11] expose readers to several strategies for objective setting, an attribute database for use, and example of technology-enabled systems that provide constituencies with timely results. The respective authors emphasize the need to expand exploration on enhancing the assessment process to support the validity and effectiveness of

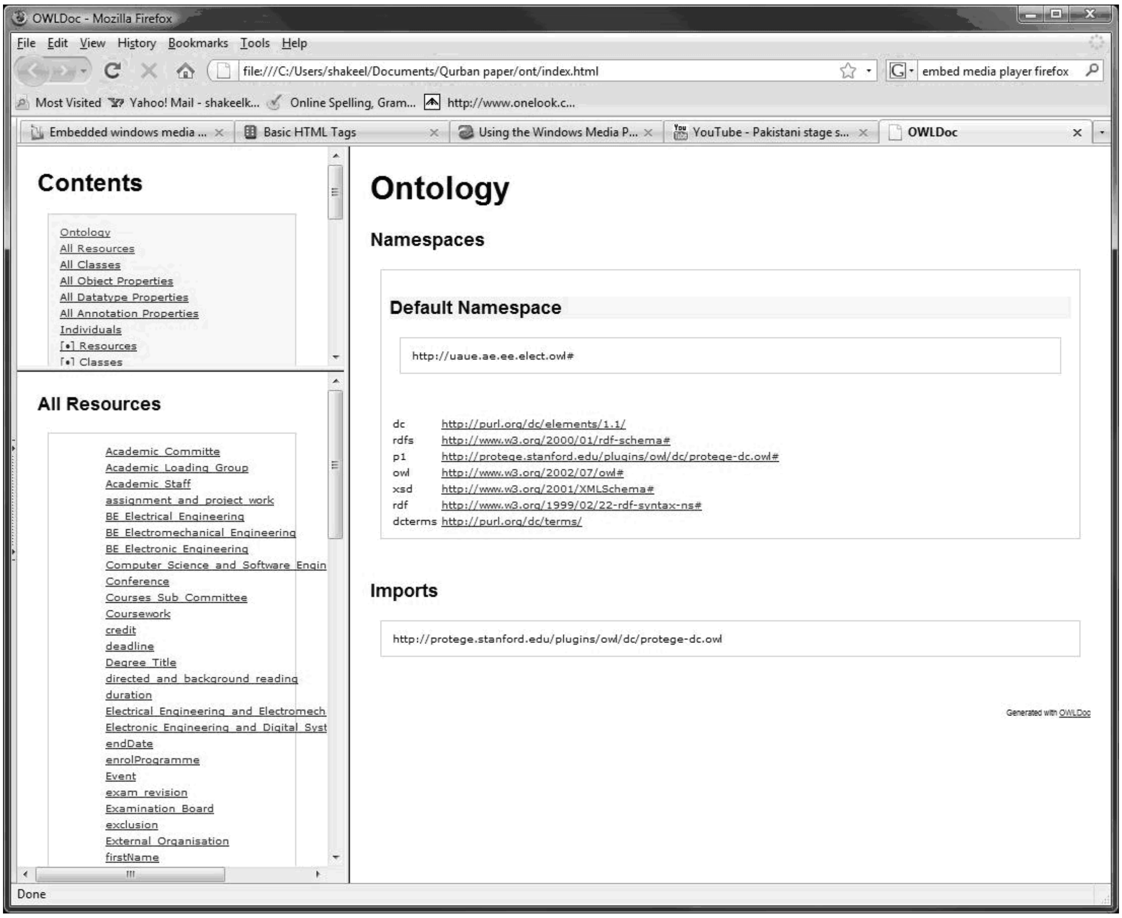

Fig. 5. Ontology documentation.

comprehensive assessment process in a university setting to benefit all of the constituents.

Typically, the decision-making in the field of academic program assessment involves extensive analysis of large data volumes originating from multiple systems. The better system is expected to normalize the assessment work within the faculty/administrative nexus [12], integrate data from relevant sources into a data representation to lead to significant acceleration of assessment and administrative procedures, deepen the insight into the data and provide for more efficient academic program administration [13].

In order to automate the academic process, various efforts targeted at certain academic environments or programs, as in [14–15] have been reported in the literature. In [14], the authors discuss a computing tool that is tied directly to program outcomes. This tool presents statistics on program outcomes on the web to facilitate review and blackboard style comments by program constituents. The authors in [15] discuss development of the online automatic program assessment system for computer science education. The system uses dynamic testing to check the program, and gives a score of the program at last. In a similar development, the authors [16] discuss online program assessment development for courses that are run over geographically distributed campuses with varying numbers of enrolled students. The work seemed to virtually reduce the distance between faculty members teaching the same courses, and encourage faculty participation.

On the use of the semantic web, Autology [17] enables students to access and search over a large number of pre-selected and semantically match to the curriculum online resources including books, audios, videos, resources from encyclopedias. These resources clustered as per students' age group are automatically 'pushed' to students whilst they work. Course Picker [18] is a scheduling tool to help students at MIT to plan their course subjects using a semantic data source. Course Picker uses the well formed metadata of the University's official course catalog, generating time tables, course loads, and folksonomy of student's rating for a particular course. SKUA [19] is developed to prototype a distributed network of semantically aware shared annotated services, in the form of RDF stores. SKUA works as a semantic layer to support a cluster of applications that will either directly support users in finding and recovering useful resources in a particular academic domain, or indirectly support students by supporting user-facing applications. In another effort, Ed-Scene [20] combines the information and data available in an academic system through semantic web technologies to support various roles in an academic system.

In all the above examples it is very evident that semantic technologies aspire to making substantial reuse of existing data and ontologies, shaping them as linked information space in which data is being enriched and added. Semantic technologies also claim to enhance intelligence and provide meaningful information for searching and browsing, for which more intelligent ontologies are required. But there exists the issue of ontology consensus resulting from implementing semantic technologies. This is mostly due to different implementation procedures across departments or across organizations.

CONCLUSIONS AND FUTURE WORK

The effort exercised in this work is an elicitation of collaborative use of various academic systems used by various program management layers in the higher education sector. Specifically, the integration of various sub-system functionalities within a typical university setting is projected using a semantic web to help support various management functions, for example, in a program assessment process. The benefits gained through this approach include the participation of all stakeholders of the program to the system; and access to all datasets in an integrated system that opens data for intelligent queries set by academic program management. There is still a need to extend the semantic query to include more complex semantic reasoning capacity. It is viewed that this can be further developed to provide functionalities in the form of web services and on a web portal so that they can be used more conveniently at service level and for the end users.

REFERENCES

1. R. Mair, *Knowledge Management Systems: Information and Communication Tech for Knowledge Management*, 3rd edn, Springer-Verlag, (2007).
2. G. Lopez, Technological capabilities indicators of the state university, new organizational tools for its management guiding and strengthening, and knowledge building and transfer, *Managing Technologically Driven Organizations, The Human Side of Innovation and Change*: *Proceedings of IEEE Engineering Management Conference,* 2–4 November, (2003).
3. C. Botev, H. Chao, *et al*., Supporting workflow in a course management system, *Proceedings of ACM Technical Symposium on Computer Science Education*, February 23–27, (2005).
4. P. Moule, Developing the communities of practice, framework for e-learning, *Electronic Journal of E-Learning*, **4**(2), (2006).
5. T. Berners-Lee, J. Hender and O. Lassila, The semantic web, *Scientific American*, 2001.

6. ABET-Engineering Accreditation Commission, Criteria for accrediting engineering programs, http://www.abet.org/Linked%20Documents-UPDATE/Criteria%20and%20PP/E001%2007-08%20EAC%20Criteria%2011-15-06.pdf
7. The Protégé ontology and knowledge acquisition system, http://protege.stanford.edu
8. SPARQL Query Language for RDF: W3C Recommendation, http://www.w3.org/TR/rdf-sparql-query/, 15 January 2008.
9. R. Miller and B. Olds, Lessons learned in developing and implementing a program assessment plan, *International Journal of Engineering Education*, **18**(2), (2002), pp. 217–224.
10. J. Hoey, E. Nault, Trust: The Missing Ingredient in Assessment, *International Journal of Engineering Education*, **18**(2), (2002), pp. 117–127.
11. J. McGourty, L. Shuman, M. besterfield-Scare, C. Atman, R. Miller, B. Olds, G. Rogers, H. Wolfe, Preparing for ABET EC2000: Research-based Assessment Methods and Processes, *International Journal of Engineering Education*, **18**(2), (2002), pp. 157–167.
12. L. Schachterle, Faculty governance embraces outcomes assessment, *Proceedings of 34th IEEE/ASEE Annual Frontiers in Education Conference*, DOI: 10.1109/FIE.2004.1408544, Savannah, GA, October (2004).
13. S. Mansmann, Decision Support System for Managing Educational Capacity Utilization, *IEEE Transactions on Education*, **50**(2), (2007), pp. 143–150.
14. F. DePiero, NetExam: a Web-based assessment tool for ABET2000, *31st Annual Conference on Frontiers in Education*, **2,** (2001), pp. F3A–F13.
15. Y. Xu, L. Mu, H. Zan, Design of Online Automatic Assessment, *International Conference on Computer Science and Software Engineering,* **5,** (2008), pp. 1275–1278.
16. J. Wise, Work in progress: Effects of an online instrument for ABET Assessment: M.E.E.T., *36th Annual Conference on Frontiers in Education*, (2006) pp. 17–18.
17. Autology Personalized learning, http://autology.org/index.html
18. MIT Course Picker (beta), http://picker.mit.edu
19. N. Gray, T. Linde, K. Andrews, The SKUA project and the semantic web, *Proceedings of Astronomical Data Analysis Software and Systems*, Canada, November, (2008).
20. EdScence Project, http://www.uaeu-ee.ecs.soton.ac.uk

Qurban A. Memon received his Masters and Ph.D. degrees from Department of Electrical Engineering, University of Florida, Gainesville, and Department of Electrical and Computer Engineering, University of Central Florida, Orlando, US in 1993 and 1996 respectively. Currently, he is Associate Professor at Electrical Engineering department of UAE University, Al-Ain, UAE. He has a professional career of over thirteen years and more than sixty research publications to his credit in international journals and conferences. His research interests include Networks, and Digital Systems. His biography has been included in millennium edition of *Whos' Who in the World*.

Shakeel A. Khoja received his Ph.D. from the University of Southampton, UK, in 2002 and his Bachelor's degree from the Mehran University of Engineering and Technology, Pakistan in 1995. He has a professional career of over 15 years and has thirty research publications to his credit. He is working as a senior researcher at Learning Societies Lab, ECS, University of Southampton. His research interests include Digital Media, E-learning and exploring new avenues of knowledge management in web2.0 applications. He is a Commonwealth Academic Fellow and an adjunct faculty at Bahria University, Pakistan.