Learning Objects Repository for Training of Power Systems Operators

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Abstract. An important problem to be faced by power systems is the training of operators and the updating of their knowledge and skills. An operator must comprehend the physical operation of the process and must be skilled in handling a number of normal and abnormal operating problems and emergencies. We are developing an intelligent environment for training of power system operators. This paper presents the architecture of the intelligent environment and describes one of its components: the Domain Knowledge Module. The general aim of our work is to provide operators of complex industrial environments with a suitable training from a pedagogical and affective viewpoint to certify operators in knowledge, skills, expertise, abilities and attitudes for operation of power systems.

Keywords: Intelligent tutorial systems, learning objects, power systems.

1 Introduction

Derived from governmental policies related to training management and considering its strategic planning objectives, CFE (Comisión Federal de Electricidad –the National Electric Utility in Mexico) has establish an strategic program to improve its human capital and to align it with its mission and future vision. CFE is responsible for generating, transmitting and distributing electricity through out the Mexican nation.

As part of this program, CFE has generated an ambitious program for learning and training of personnel. The training impact is direct on the production efficiency increase and in the decrease of non-planned production equipment outages and failures. The constant technology changes make it necessary a permanent training of the CFE personnel. In general, the traditional training systems are used: classroom instruction, laboratory practices, workshops, training in specialized simulators, organized seminars, and short courses lectured by specialists, and annual congresses like IEEE, CIGRE, etc.

These training traditional systems have shown effectiveness and consistency for decades. However, CFE has a clear view of its training needs according with its expansion plans and modernization; some actions are mentioned as follows [1]:

B. Apolloni et al. (Eds.): KES 2007/ WIRN 2007, Part II, LNAI 4693, pp. 1138–1145, 2007.

- Construction a collection of 150 Job Skills Technical Standards (JSTS).
- To have the distance training technology consolidated, including the technological infrastructure (Internet and Intranet) and the design of courses (self-instruction and traditional) to satisfy the requirements of the JSTS.
- To have an environment with a suitable training from a pedagogical and affective viewpoint to certify personnel in knowledge, skill, expertise, abilities and attitudes for operation of power systems.

The training requirements for utilities ask for powerful interfaces, a more efficient and better adaptive training, by means of incorporating artificial intelligent (AI) techniques, adaptive interfaces, simulation tools, learning objects based on multimedia and virtual reality components.

Intelligent Tutoring Systems [2] are interactive learning environments that have the ability to adapt to a specific student during the teaching process. In general, the adaptation process can be described by three phases: (i) getting the information about the student, (ii) processing the information to initialize and update a student model, and (iii) using the student model to provide the adaptation.

After a summary of the architecture of an intelligent environment (IE) for the training of operators presented in [3], this paper describes in detail one of the components of the IE, the Domain Knowledge Module. In contrast with a traditional training system, the main goal of the intelligent environment is to certify operators in knowledge, skills, expertise, abilities and attitudes for operation of power systems.

2 Architecture of the Intelligent Environment

The architecture of the intelligent environment is based on dynamic course generating systems proposed by Brusilovsky [4]. The intelligent environment is composed of four main components (see Figure 1): the domain knowledge module, the tutor, the operator model, and the learning management system (LMS).

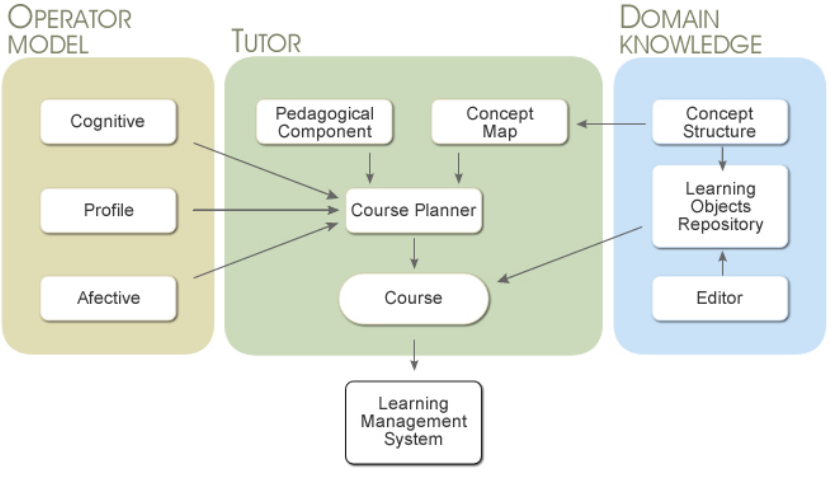

Fig. 1. Architecture of the intelligent environment

The first module contains the knowledge of the domain in form of learning objects and concept structure maps. The tutor module is the component that generates the sequence of learning objects to be presented to operator in form of course. Taking as a basis the concept map, the pedagogical component and the operator model, the training course planner generates a specific course for each operator. The operator model is used to adapt the intelligent environment (IE) to each specific operator. The operator model is divided into three subcomponents: cognitive component, operator profile and affective component [5]. Finally, the LMS controls the interactions with the operator, including the dialogue and the screen layout. The main purpose of an LMS is to present to the operator the learning materials in the most effective way. In this paper a detailed description of the domain knowledge module is presented and the three other modules will be described in a future paper.

3 Domain Knowledge Module

The domain knowledge module has three main components: the concept structure map, the editor and the repository of learning objects. The domain knowledge contains the expert's operation abilities in procedure and malfunction operations and its representation considers both theoretical and practical concepts.

3.1 The Concept Structure Map

The concept structure contains the concept/topic structure of the subject knowledge to be taught (see figure 2). It is possible to organize the domain concepts/topics into a set of smaller, possibly interrelated AND/OR graphs, representing relatively independent sub-areas of the knowledge, different views, or different levels of granularity.It is represented as an AND/OR graph, where nodes represent the concepts domain or elements of knowledge, such as electrical topics, components of control board, rules, procedures and so on; and arcs represent relationships between concepts, such as a prerequisite for learning a concept or a sequence. Every node is associated with a set of teaching and testing materials labeled as Reusable Learning Object (RLO), which instantiate different ways to teach the concept/topic (e.g. introduce, explain, give an example, and give a simulation, exercise, or test).

For the training of power plant operators, the concept structure map is made based on the structural decomposition of the generation process of electricity. The generation process can be divided in unit, structure, systems, subsystems, equipment and component. The concept structure has a higher expressive power because it allows representing not only prerequisites, but also many different types of relationships between concepts; and it enables the use of AI planning techniques for the generation of alternative courses. Therefore, it guarantees a wide variety of different teaching goals and several courses for achieving these goals.

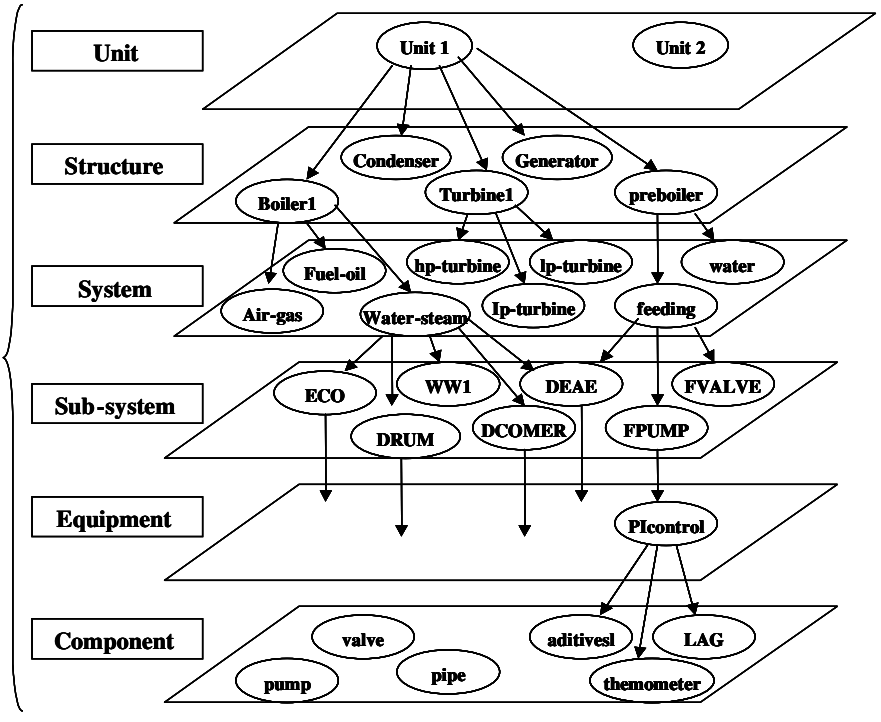

Fig. 2. Concept structure map for training of power plant

3.2 Editor

The editor contains tools for edition of teaching and testing materials based on learning objects. These learning materials consider both theoretical and practical concepts contained in: electronic books, simulation tools, multimedia and virtual reality tools, to present to the operator pedagogical actions such as explanations, exercises, tests, and so on. Each material is labeled as Reusable Learning Object (RLO) or Shared Content Object (SCO) according with the SCORM (Sharable Content Object Reference Model) terminology [6]. Learning objects are self-contained learning components that are stored and accessed independently. RLO are any digital resource that can be reused to support Web-based learning using learning management systems (LMS). The authors or learning developers can create, store, reuse, manage and deliver digital learning content. The same object may be used as many times and for as many purposes as is appropriate.

The learning objects are either dispensed to users individually or used as components to assemble larger learning modules of full courses, depending on individual learning needs. The instructional output may be delivered via the Web, CD-ROM or printed materials. Lately, some work has been done at CFE to create a valve maintenance course and an energized power-line maintenance course using RLO based on virtual reality [7]. Also, and only for the generation process, CFE has a

collection of more than 400 instructional courses developed in house during the last 10 years, these RLO will be integrated to the Domain Knowledge Module.

The editor allows the repository manager to take learning content, generate a SCORM 2004 compliant label o manifest and to compress all together in a zip file (see Figure 3). The result is a SCORM compliant Learning Object (SLO) that can be managed by any SCORM compliant LMS.

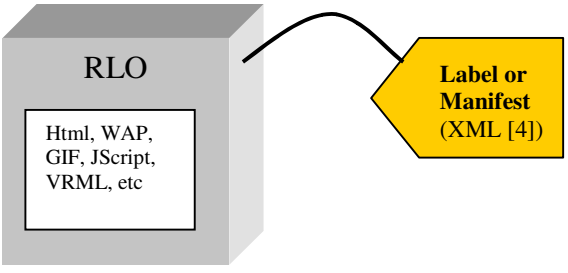

Fig. 3. SCORM complaint learning objects (SLO)

The SCORM compliant manifest contains metadata for the classification and recovery of the SLO. The classification categories have been extended to satisfy the needs of CFE, some were inspired from Figure 2. The nine categories of SCORM meta-data elements are: *General, Life Cycle, Meta-metadata, Technical, Educational, Rights, Relation, Annotation, and Classification.* This extended classification categories are as follows.

Activity branch, it identifies established criteria according to the labor contract.
Specialty, the department, area or worker's function with acquired specialty along their labor life.
Process, generation, transmission, control, distribution, or support processes (management).
Equipment, the equipments are classified as main, auxiliary and miscellaneous according to their importance in the electric generation process.
Career Plan, it is the functional position in the activity branch and specialty in which the worker is currently assigned and that he can ascend in terms of his knowledge, abilities and attitudes or demonstrated competence.
Functional position, it identifies the role of the worker's formation in his current position and immediate higher position according to his career plan.
Course type, it is institutional, foundation, development, or others. A course type is also self training or traditional.
Activity type, it is traditional or distance learning.
Department, it is the workspace according to the conceptual and functional organic structure.
Functional level, Directives, controls means, supervisors and operative.

The SLO is a set of items to structure a course, workshop, or other aggregation of learning resources, the organization of the SLO is as shown in Figure 4.

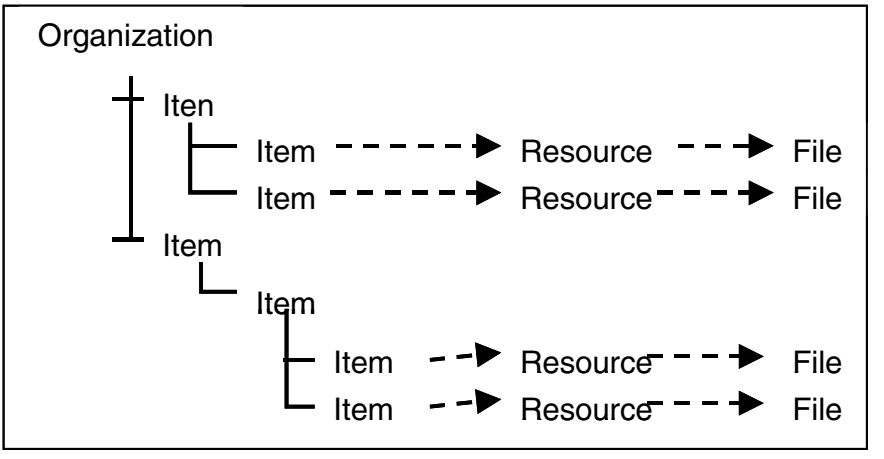

Fig. 4. The organization of a SLO

The editor has an interface with the instructor an a presentation manager that allows the user to search the repository for a SLO that fits his needs, and once the user selects a SLO, the system presents the SLO index and the user can display the learning content objects using hyperlinks to these resources as show in Figure 5.

Fig. 5. An example of actual screen showing a SLO organization

3.3 Learning Object Repository

The Domain Knowledge module has a Learning Object Repository (LOR). The LOR is a central database in which learning content (SLO) is stored and managed (see Figure 6). The Repository main component is the database.

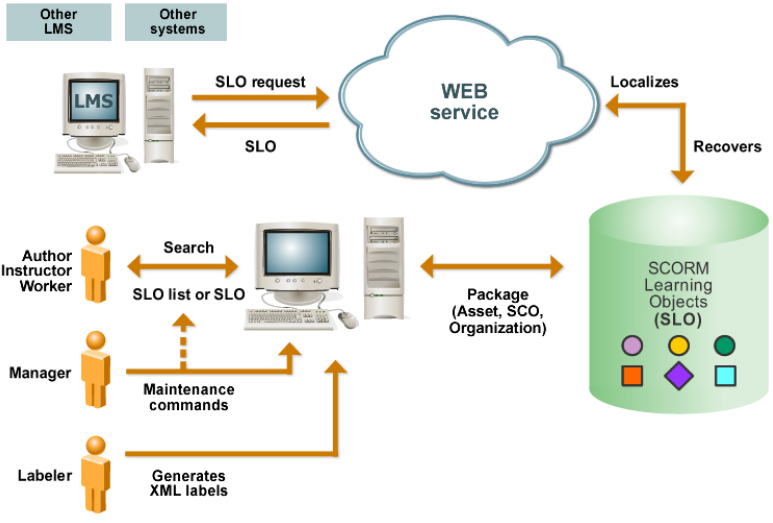

Fig. 6. The environment for the Learning Object Repository

The repository is modeled as a semantic network (see Figure 7) and implemented using a relational database management system. The learning objects are packed and an SCORM compliant LMS can access them through the Web using either an HTML page or a Web service [8]. The organization component of the manifest is a sequencing map that the LMS uses to present to the trainee the different learning items. Each item has objectives to be satisfied and rules to evaluate if a tree of learning items in the organization is completed by the student or not. Also, rules are used to allow the trainee to follow a different order than the linear top-down left-to-right order and skip items if he shows that he already has the appropriate competence to satisfy the objectives of the items to be skipped.

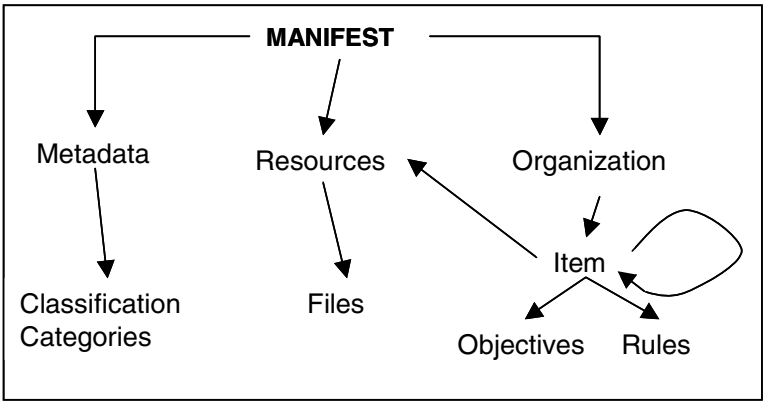

Fig. 7. The semantic network for the database structure

By the end of the year 2006, the database is loaded with 115 power plant courses wrapped as SCORM complaint Learning Objects. The repository can be accessed nation wide through Internet.

4 Conclusions and Future Work

In this paper we have presented the architecture of an Intelligent Environment for training of Power Systems Operators. One of the components was described: the Domain Knowledge Module that contains the Learning Object Repository. The concept structure map of a power plant domain, where the nodes represent concepts of the domain and the links relationships between concepts was used as the basis to build the semantic network that supports the storage and retrieval of SCORM compliant Learning Objects (SLO).

Currently, the repository is loaded with 115 power plant courses wrapped as SLO and it is fully operating at CFE.

The other two modules of the Intelligent Environment: the intelligent tutor module based on course planner, and the operator models based on cognitive and affective components are under development. In contrast with a classical ITS, the IE builds a course based on cognitive, affective and pedagogical aspects. The intelligent tutor module will be a dynamic course generating system interacting with the operator model to produce training material specific to each operator.

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