MANAGING MULTIMEDIA EDUCATIONAL CONTENTS IN DATABASES

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ABSTRACT

Methods of storing, managing and presenting educational multimedia data are proposed. Application of these methods to interactive synchronous and asynchronous Distance Learning systems is discussed. An example system based on the proposed solution is presented in details. The system uses clean organization of educational material and enables storage, management, and presentation of various types of multimedia contents. An important feature of the system is a flexible assigning of attributes to educational objects at different levels of abstraction. A powerful Web interface enables convenient access to data for local and remote users.

KEYWORDS

Multimedia databases, distance learning, Internet applications

1. INTRODUCTION

The significant progress in computing and networking technologies we have been witnessing during the last couple of years significantly broadened application areas of computer systems. Also, the unprecedented growth of Internet as a communication and application medium contributed both technically and socio-economically to the process of wider acceptance of computer systems for performing activities traditionally accomplished by other means. Furthermore, it has created a new class of application areas that could not emerge without these technologies. One of important examples of such application areas is Distance Learning.

Distance Learning systems permit dozens of interconnected users to take part in educational process. Distant leaning has become possible due to increasing speed and reliability of local-area and wide-area computer networks, increasing computational power of processors, support for multimedia data such as images, drawings, audio and video, and wide access to computers by both teachers and students. Although a simple educational system can be built using just basic Internet technologies, the initial results of such efforts clearly indicate that integration of the basic Internet infrastructure is not sufficient for implementing an efficient large-scale educational system. Hundreds of Web-based Distance Learning repositories have been created in the last couple of years. Most of them share characteristics common for the Internet: transient nature, incoherency, disorganization, poor searchability, lack of metadata, format incompatibility, and difficult management and maintenance.

Successful development and deployment of distance learning applications requires solving important problems. These problems can be categorized into the following groups: storage of rich multimedia data, management of data, and presentation of multimedia contents.

High-quality learning process requires use of large volumes of data and involves a variety of formats including texts, images, audio, and video. The organization of these data is a key issue for the usability of the system. Logical grouping of courses and lectures, alternate representations and sharing of educational objects between presentations and users are the most obvious requirements. A particular attention should be also paid
to user authentication, data access privileges and flexible assignment of properties to educational objects at different levels of abstraction.

Lack of efficient data management methods is one of the most important weaknesses of the simple Web-based systems and makes it difficult to continuously update the contents as it is usually required by the learning process. Educational data management system should provide methods of authoring multimedia contents including integration with widely used authoring tools (such as MS PowerPoint or Macromedia Authorware), importing existing, often large archives of presentations, and exchanging data between system instances.

Presentation of the multimedia educational contents requires addressing the following issues:

- the presentation should be platform-independent allowing users equipped with different computers and operating system to access data in a uniform way;
- users should be allowed to access data remotely often from distant locations;
- the data needs to be delivered to a big number of concurrently working users while applying authentication and access privileges;
- universal access to different types of stored data, including big binary files, has to be provided;
- customization of the presentation method should be possible;
- formatting attributes of the presented data should be independent on the delivered content.

In this paper we propose solutions to the above-discussed problems and illustrate their use in a prototype multimedia Distance Learning system. The system – called WebWisdom – has been successfully used for both synchronous and asynchronous Distance Learning for several years [Beca97a][Beca97b][Podg98][Walc02].

The reminder of this paper is organized as follows. In Section 2 an overview of the WebWisdom system is presented. In Section 3 organization of educational data storage is discussed. In Section 4 data management tools are described. In Section 5 methods of accessing the multimedia contents are presented. Finally, Section 6 concludes the paper.

2. Overview of the WebWisdom System

The WebWisdom system is an integrated set of tools supporting academic and corporate courseware storage, management, and delivery. The system can be used as a deployment engine for any network-based teaching and training system, as well as a database backend for educational portals.

The system is built on top of a database management system. Use of advanced data management techniques available in modern database systems like indexing, integrity enforcement, binary object management, and full-text search greatly improves the overall system reliability and usability.

Since the educational process can benefit from various types of multimedia contents, the WebWisdom system provides support for unlimited range of data types. Data types such as text, graphics, binaries, audio, and video are supported by default; the system offers a mechanism to expand the list by any other required data types without any software modifications. The system also provides tools for importing collections of multimedia data directly from the file system.

The WebWisdom system enables storing additional metadata describing the educational contents. Examples are titles, authors, dates, and events associated with the presentations. Availability of these data in the database significantly enhances the system search capabilities. The particular metadata schema used in the system can be modified by run-time configuration of data attributes to make them compliant with the emerging standards for description of educational objects such as IMS [IMS], Dublin Core, or SCORM.

The system smoothly integrates with Microsoft PowerPoint. Support for this de-facto industry standard greatly enhances the usability of the system. All existing PowerPoint presentations can be imported directly into the database, with elements of the internal PowerPoint document object model becoming elements of the educational objects. PowerPoint can be also used for preparing new contents. Operations on slides, like editing and printing, whenever possible, are performed by the use of PowerPoint. In addition, any PowerPoint-originated presentation can be exported to a PowerPoint-compatible file. The WebWisdom system allows also importing and exporting presentations in XML format, which is the emerging industry standard for data interchange [XML]. The XML presentation files can be used for moving or copying contents between different databases and for off-line content delivery.
Presentations stored in the database are automatically made available on the web by the Dynamic Web Interface and can be accessed by a standard web browser. The output generated by the WebWisdom Web interface is created dynamically based on templates. This approach enables different presentation of the contents depending on the user or author preferences, privileges, or computer system capabilities.

An important feature of the WebWisdom system is separation of contents and output formatting. Authors can prepare educational material without worrying about the visual design of the prepared contents. The visual formatting can be modified without modification of the actual contents. Moreover, contents prepared by different authoring tools can be presented in a uniform way. This clean separation of content and GUI follows the best guidelines used in programming methodologies.

The architecture of the WebWisdom system is presented in Figure 1.

![Architecture of the WebWisdom system](image)

The system is composed of three main parts: WebWisdom Database, WebWisdom Manager, and Dynamic Web Interface. The WebWisdom Database is the core of the system. It is responsible for storing all kinds of data used in the educational process. The WebWisdom Manager is the main contents-preparation and management tool. It enables management of the database contents, importing data to the database (in form of HTML, PPT, or XML files), and exporting data from the database to the file system. The WebWisdom Manager cooperates with PowerPoint for importing, editing, and printing of PowerPoint slides and presentations. The Dynamic Web Interface is a set of tools enabling instantaneous access to data stored in the database through the WWW interface. A special set of XML-based templates is used to dynamically create web pages delivered to the client browsers.

### 3. STORAGE OF MULTIMEDIA EDUCATIONAL CONTENTS

#### 3.1 Types of Data

Two kinds of data are stored in the database: educational contents and presentation data. Educational contents are used in teaching process and typically include:

- slides with associated educational objects: images, text, sound, video, external links, etc.,
- presentations in form of lists of slides and/or other presentations,
- the data describing hierarchical structure of presentations,
- metadata describing the educational contents, and
- information about various events like conferences or lectures related to presentations.

Presentation data is used by the WebWisdom system and includes:

- visual formatting parameters (preferred screen size, colors, font sizes, location, etc.),
- user access rights, and
- images used by the Dynamic Web Interface.
3.2 Educational Data Hierarchy

In the proposed solution, certain organization of the educational contents is assumed (cf. Figure 2). The basic building blocks of the educational material are called educational objects. Different types of educational objects may be used in the system including text, graphics, binary files, word processor documents, spreadsheets, audio, video, web pages, external links, etc. Educational objects may be used in two ways – either to present the same information in different forms, e.g., textual and graphical versions, or to enrich the presentation by introducing some additional elements, e.g., associated audio, sample application or external links.

Educational objects are grouped into slides. Each slide has also a list of attributes (e.g., title, preferred method of presentation, time of use). A list of slides ordered by their intended sequence of appearance forms a presentation. Usually a presentation contains the amount of educational material used during a single lecture. Presentation has its own list of attributes (e.g., name, title, type, owner).

Presentations are logically grouped into educational domains. The same presentation can be in more than one educational domain at the same time. Educational domains may be nested and form a tree-like structure. The depth of the tree is not limited. Educational domains are also the units of user access control. A user can have no access to an educational domain, read-only access, or full access. The structure of the tree may correspond to the structure of the educational institution, e.g., departments, programs, courses.

In real educational environments, often the same material is used more than once in different contexts. For example, the same slide is used in two presentations, the same lecture is presented in two courses, or the same course belongs to two different programs. To avoid physical copying and to ensure integrity of the data, a complex system of logical links is used. It allows accessing the same educational material from different presentations and educational domains.

3.3 Presentations

The organization of presentations is shown in Figure 3. There are two types of presentations: master presentations and script presentations. Master presentations are lists of real slides (such as PowerPoint slides). Each slide has a number of educational objects. Scripts are lists of shadows. Shadows are entities that have their identity (like a slide) but they also refer to a source slide or source shadow. When created, a
shadow inherits educational objects and properties from its source. A shadow may override some or all of the educational objects of its source. Shadows may also define different properties or property values.

### 3.4 Hierarchical Scripting

To assure educational objects reusability the hierarchical scripting concept was introduced. Hierarchical scripting defines the method of finding the set of educational objects for a slide shadow. This method assumes that each presentation component (slide or shadow) inherits all educational objects of its predecessor. In the Figure 4, a sample set of components and their educational objects is presented. Consider one slide with two educational objects: Text1 and Image1. Shadow A uses this slide as the source and adds one more educational object: Sound1. Shadow B uses Shadow A as the source and adds one more educational object: Annotation1, and overrides one of the educational objects: Sound2 replaces the Sound1. Shadow C overrides one educational objects of the Shadow B: Text2 replaces the Text1 inherited from the original slide. As the result, the Shadow C has the following educational objects: Text2, Image1, Sound2, and Annotation1.

### 3.5 Properties

One of the fundamental concepts of the proposed solution are properties. The properties allow precise customization of both behavior and the look of the presented pages. Properties are used by the Dynamic Web Interface to extract values needed for proper publishing of the page. They are also used as configuration parameters of the system.

A property is a pair of key and value associated with an object. The keys are represented by character strings, while values may belong to several different data types – Boolean, numeric, string, color, font, etc. The keys are defined in a global key repository together with corresponding default values. Then, for each user, presentation, slide, etc., it is possible to override those default settings by supplying new ones. When determining the value of a given property for an object, the system will follow object hierarchy searching for the most relevant property definition.
A particular value of a property for a slide is determined using the following algorithm (compare Figure 5):

**Step 1.** Check if the property value is defined for this slide. If not, proceed to Step 2.

**Step 2.** If the slide is a shadow, proceed to the predecessor of this slide shadow, check if the property value is defined for this component. If not, repeat Step 2 until the master slide is reached. If the property value is not defined for the master slide, proceed to Step 3.

**Step 3.** Check if the property value is defined for the presentation (master or script) that contains the slide. If not, proceed to Step 4.

**Step 4.** Check if the property value is defined for owner of the presentation. If not, proceed to Step 5.

**Step 5.** Take a default value of the property.

In case of presentation properties, if the particular property is not defined, the system tries to locate the user-defined property, then, if not defined, takes a default value (steps 3-5).

Properties are different from attributes, which are also used in the system. Attributes simply describe element of a particular type; e.g., each slide has a title and a creation date. The set of attributes is constant and they are implemented as table columns in the database schema. As opposed to attributes, properties are not directly represented in the database schema and an appropriately privileged user can change the list of properties (without modifying the database schema.)

### 3.6 Data Interchange Format

The system uses a special XML-based file format for exchanging and off-line use of presentations. The XML files contain presentations with all data needed for their re-import and display. XML files can be used by the WebWisdom Manager, which contains tools for import and export of presentations, thus enabling data exchange between systems instances; and by the Dynamic Web Interface as a data source that can be used instead of the database in off-line working mode.

Format of the XML file satisfies IMS CP and IEEE LOM standards [IMS][IEEE]. Each presentation is kept in a separate ZIP file called package, which consists of a manifest – an XML file containing the actual data as well as metadata describing the contents, and multiple files containing raw binary data (e.g., image data or educational object data.)

Zipped presentations used by the Dynamic Web Interface are stored in the file system in a user-defined directory or its subdirectories as it is presented in Figure 6. The main directory is used as a root folder for all presentations (in the same way as document root used in typical Web server for all HTML files). The root folder must contain a special presentation that contains default values for properties.

### 4. Managing Multimedia Database Contents

Management of the database contents can be significantly simplified by the use of an integrated content management tool. Such tool has been built in the WebWisdom system. It offers an intuitive in use, integrated environment for developing and managing educational contents. The management tool is equipped with a graphical interface providing methods of visualization of data stored in the underlying database. It smoothly integrates with office systems linking the potential of the PowerPoint-like applications with the power of the relational database model. The tools constituting the management tool address all the most important issues
in managing educational data. In the Figure 7, the internal architecture of the WebWisdom Manager is presented.

![WebWisdom Manager Architecture](image)

**Figure 7. WebWisdom Manager Architecture**

**Presentation Manager**
Presentation Manager is the main content-management tool of WebWisdom Manager and permits to browse hierarchy of educational domains and presentations; create new educational domains, new presentations, and new slides; import and export of presentations in native and XML formats; editing presentations and slides, and their metadata; copying and moving presentations between educational domains; editing educational objects; editing source PowerPoint files; and launching all other WebWisdom Manager tools.

**Educational Domain Manager** is used for managing the hierarchy of educational domains. It allows creating educational domains, copying and moving educational domains inside the hierarchy, renaming and deleting educational domains, changing the owner of the educational domain and access privileges etc.

**Presentation Loading Wizard** is used for interactive loading of PowerPoint presentations. Interactive loading allows specifying presentation metadata at the time of loading. All metadata attributes can be later changed by the use of the Presentation Manager. The system supports four import modes: a wizard-like importer for importing presentations in WebWisdom and HTML formats, a fast importer for importing directly from a PowerPoint file, a wizard-like importer for importing directly from a PowerPoint file and setting metadata values, and XML importer for importing from compressed XML packages.

**User Manager** allows managing the list of users and authors in the system. User manager allows creating a new user, changing user data, changing user privileges, and removing users.

**Event Manager** is used for maintaining the list of teaching events associated with the presentations. Event Manager allows adding new events, modifying existing events, removing events, associating people with events and defining their roles, etc.

**Image Manager** is an application that allows managing technical images available in the system. Technical images are not associated with the educational contents but can be used in the Dynamic Web Interface. Examples of technical images are: “image for next slide button”, “image for index button”, “background image”, etc. Image Manager allows loading new images, editing properties of the existing images, removing images, etc.

**Property Editor** is used for managing the list of properties defined in the system. Property Editor allows creating new properties, creating categories of properties, moving properties between categories, setting default values of properties, defining use contexts for properties, etc. Technically Property Editor is a part of the Property Manager.

**User Preferences Editor** allows defining default values of properties at the level of a user. The values defined by user defaults are used when neither the slide nor presentation specifies the value of the particular property.

**XML Importer/Exporter** tool allows exporting presentations in the form of compressed XML packages. These packages can be later imported by the same tool to the same or another database or used by the Dynamic Web Interface as off-line data repositories instead of the database system.

### 5. Accessing Multimedia Contents

Local and remote access to the educational contents is possible by the use of the Dynamic Web Interface [Wiza00][Cell01]. It allows retrieval of educational data from the database and displaying them in the form
of Web pages. The architecture of the Dynamic Web Interface is presented in Figure 8. It consists of the TDL Subsystem and the Data Delivery Subsystem.

The TDL Subsystem is responsible for dynamic generation of web pages from specially prepared templates. During the dynamic generation process, the templates are filled with educational data and formatted in accordance with visual properties read from the database. By the use of these properties, a user can control the appearance of the generated Web pages. The same presentations may be displayed differently when accessed by different users.

The Data Delivery Subsystem is responsible for delivering binary multimedia data retrieved from the database (e.g., images, sound files, binary files, and video sequences) to the client browser.

![Figure 8. Dynamic composition of WebWisdom web pages](image-url)

6. CONCLUSIONS

The prototype system was built using Java on top of the Oracle Server 8i ORDBMS. During the first two years of use, the system reached about 20 GB of data including approximately 1000 presentations, 30 000 slides, and 80 000 educational objects. Examples can be found in [WWNT].

The system has proven its functionality both as a course preparation tool for teachers and as a learning system for students. The system has been extensively used by non-technical users. The feedback obtained from users was positive. In particular, the seamless integration of PowerPoint and the database was praised as a high-usability feature.

REFERENCES


[XML] Extensible Markup Language (XML) 1.0, http://www.w3.org/TR/REC-xml


