

Architectural Aspects of an Interactive Multimedia Environment for Teaching Chemistry in Secondary Education

John Garofalakis
Ioannis Hatzilygeroudis
George Papanikolaou
Spyros Sioutas*

*Department of Computer Engineering and Informatics
University of Patras, 26500 Rion, Patras Hellas (Greece)*
and
*Computer Technology Institute,
Kolokotroni 3, 26221, Patras, Hellas (Greece)*

*garofala@cti.gr
ihatz@cti.gr
sioutas@ceid.upatras.gr
gpapanik@ceid.upatras.gr*

Abstract: In this paper we present a multimedia-based system that facilitates teaching chemistry to pupils of Hellenic (Greek) high schools over a LAN. The system uses a variety of multimedia objects. An important aspect of the system is the central control the teacher can have over some aspects of a lesson. So, the teacher can enable the section to be taught and disable the rest ones, and design and deliver on-line tests to the pupils. The pupils are then able to submit their answers to a central database. This is achieved by using dynamic hyperlinking implemented as remote SQL queries over a LAN.

1. Introduction

Over the past few years, new technologies have been used in producing educational tools. The use of multimedia technology has given a great impetus to the training evolution in education. Multimedia systems provide an integrated environment for the creation, storage and presentation of a variety of media types (e.g. text, graphics, video and audio) enabling the development of a great number of successful prototype educational applications (Hopper 1990), (Fox 1991), (Narasimhalu & Christodoulakis 1991), (Faconti 1994).

In most cases, information technology is concerned with heterogeneous data both static and dynamic. Existing LAN (Local Area Network) development tools support efficient solutions for the integration of multimedia interfaces (static information) and database systems (mainly dynamic information) with impressive results (Narasimhalu & Christodoulakis 1991).

Today in Hellas (Greece), computer technology (e.g. multimedia systems) is not extensively used for educational purposes in subjects other than informatics in Secondary Education. When used, it is usually done on stand alone computer systems. However, due to recent introduction of LANs in computer labs in Hellenic high schools (Garofalakis et al. 1998), the need for educational software that exploits LAN capabilities has been arisen

This paper presents the architecture of an interactive multimedia-based environment to be used as an assistant for teaching chemistry in a classroom over a LAN. It incorporates a multimedia application, for manipulating static information, and a relational database, dealing with dynamic information. These two components intercommunicate via an application server over a LAN. The end-users (teacher and pupils) can access corresponding available information (static and dynamic). The static information resides in the multimedia

* The order of the authors is alphabetical.

application and is to be used during a chemistry course. The dynamic information is related to the tests designed and delivered by the teacher and the answers given by the pupils and resides in the database.

The paper is organised as follows. Section 2 presents the abstract architecture and design aspects of the system. Its functionality and interaction with the users are discussed in section 3. Section 4 deals with the implementation aspects of the system, while the last section, Section 5, presents the conclusions drawn and directions for further work.

2. System Description

The system is composed of three basic components (see Fig. 1), the *multimedia application*, the *application server* and the *relational database*. The multimedia application (front-end) interacts with the human users and the administrator of the system. The application server acts as an intermediate between the multimedia application and the database by conveying queries from the former to the latter over a LAN. The database (back-end) accepts data from various sources (mainly dynamic information), processes it, stores the results and pipes it to the front-end, when requested.

The system topology is illustrated in Fig. 2, where the front-end and the back-end of the system are indicated. The database resides on the central PC of the LAN (server), whereas a copy of the multimedia application and the application server exists on each of the rest PCs (clients).

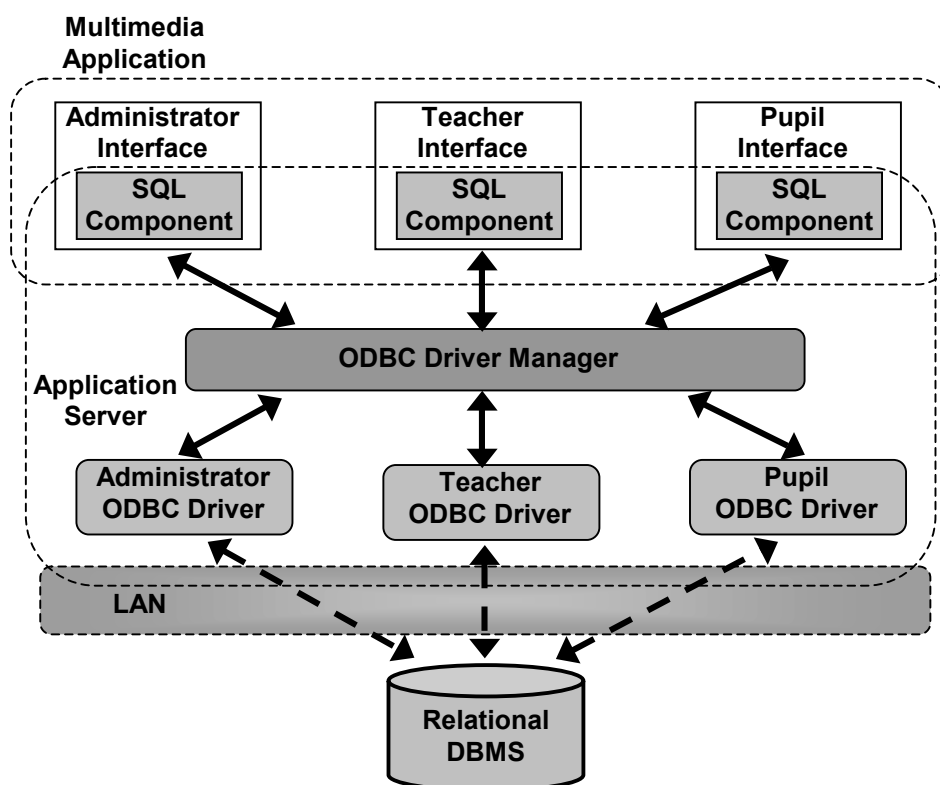


Figure 1: The architecture of the system

2.1 Multimedia application

The static information provided by the system is included in the multimedia application and presented in a variety of ways, such as hypertext, special sounds, appropriate images and animations, hypermedia object, educational games or quizzes, video recordings of real chemical experiments and interactive simulated chemical experiments. Every screen follows one of some predefined presentation screen patterns. Common to all, on the top area of the screen the logo of the application, at its left, and the title of the specific section or subsection, at

its right, lies. Also, at the bottom of the screen, there are several buttons (or options) facilitating the interaction between the user and the application. The main content is displayed at the central area of the screen, the active screen (see Fig.3).

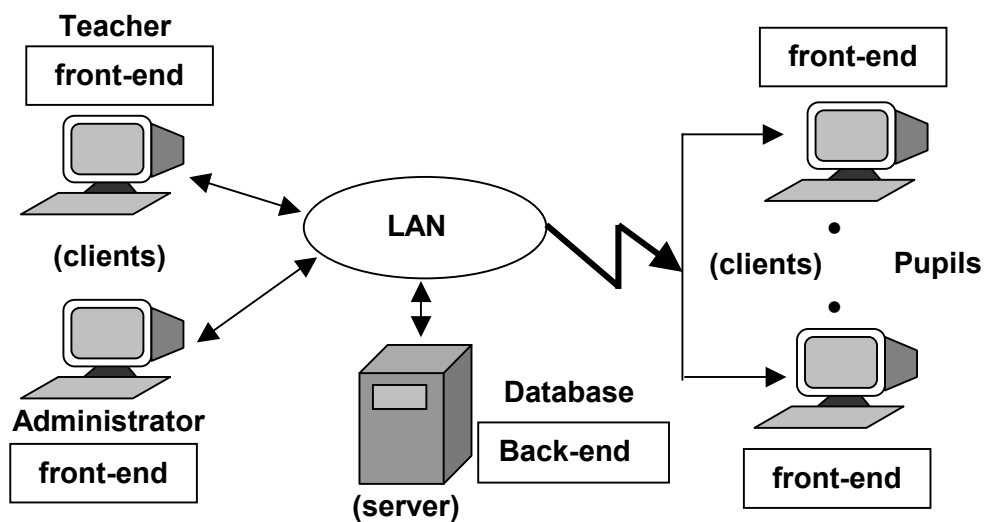


Figure 2: The topology of the system



Figure 3: A screen for topic selection in a subsection

Navigation scheme is a mixture of the hierarchical and linear models. The content is distributed in sections, subsections and topics. Its topic comprises a series of screens containing information in any combination of the above mentioned ways of presentation. The user determines the presentation flow in a degree, by using hot area selections as well as buttons. For example, in Fig. 3 there are three hot (selection) areas, one for each of the three topics. On-line help is available, usually via messages at the bottom of the active screen, where necessary, thus making use of the system as simple as possible to even a novice user.

There are different components of the interface of the system (front-end), related to the administrator and the end-users (teacher and pupils) of the system. These components are related to the user views, described in section 3. The interface of the multimedia application allows use of both the static and the dynamic information. Access to dynamic information is achieved via *dynamic hyperlinking*. That is, links to objects are defined not as local references but as remote queries to the database. This means that some hyperlinks are established dynamically, at run-time, assuming that the information is structured appropriately in the database. This reduces the cost of static hyperlinking and results in ease of tailoring, since it permits data/schema update and evolution (needed for on-line applications) via the database. In addition, it makes the presentation stable, since the hyperlinked objects are subject to the integrity control of the database.

Dynamic information concerns a) activation of the section to be taught and deactivation of the rest ones, b) creation, modification and selection of multiple-choice type questions for each section to form a test, c) storage of the answers of the pupils to the test and d) access authorisation checking.

2.2 Application Server

The Application Server comprises the ODBC Driver Manager, the SQL components and the ODBC drivers. SQL queries to the database are directed via the ODBC Driver Manager to the corresponding ODBC driver and then to the database. ODBC Driver Manager is necessary in case we have more than one ODBC driver for each of the administrator, the teacher and the pupil. This happens when we have more than one database or database partition. In case we have a single database, ODBC manager degenerates to direct connections of the ODBC drivers to the corresponding SQL components.

The three components of the SQL server, that are related to the user views (section 3), are as follows:

- **SQL component for the administrator:**
This component is responsible for the security of the system, since it enables the administrator to establish passwords for the pupils and the teacher. The passwords are stored in the database. It also deals with database updates.
- **SQL component for the teacher:**
This component allows the teacher to take control over some aspects of a lesson. The teacher can enable the section to be taught and disable the rest ones. Also, it allows the teacher to handle the set of the test questions. He/she can insert new questions, modify existing ones, delete old ones and select a subset of them to set up a particular test.
- **SQL component for the pupils:**
This component is responsible for checking pupil identification, by examining their particulars, like name and password. Also, it has the task of on-line delivering the test designed by the teacher. Finally, it is responsible for recording the answers of the pupils in the database.

It is the last two components where dynamic hyperlinking is mainly used.

3. User Views

We can distinguish four different ways information can be viewed, that is four basic views, as far as the users are concerned:

- **General view:** In the general view, the user can access all available chemical information by navigating through the sections, subsections and the topics of the multimedia application. For this purpose, the screen is divided into hot spots (specific regions) for every section or subsection and the user can select a specific region and access the related information (Fig. 3).
- **Administrator view:** In the administrator view, the user can establish passwords for the users of the system and update information in the database.

- **Teacher view:** In the teacher view, the user is able to specify the content of a lesson, design and insert new questions in the question set, select a subset of the existing questions and deliver it to the pupils and view their answers.
- **Pupil view:** In the pupil view, the user can identify himself/herself to the system and answer to the test questions that have been delivered by the teacher.

The administrator of the system can use only the administrator view. The teacher can use the teacher view, the general view and the pupil view, whereas the pupil can use the general view and the pupil view. A third person can use only the general view.

4. Implementation aspects

The system, in the form of an advanced prototype, has been developed under the Windows 95 operating system and has been tested on a variety of workstations. The multimedia application was developed using the Macromedia Authorware and Macromedia Afterburner authoring tools that use icon-based scripting. Some additional code was written using Visual Basic.

The database application was developed using the Access RDBMS. The image format is BMP while the videos are formatted as AVI and compressed using the Intel Indeo(R) Video R3.2(32) encoder. The animations are formatted as AVI files as well. Finally, any sounds were digitised and compressed into WAV files.

The application that handles the communication between the user interface and the database comprises a number of SQL components. In particular we used the ODBC functions (ODBCOpen, ODBCConnect and ODBCExecute) that Authorware offers for opening a database, closing a database and executing insertions, deletions and updates respectively. These functions are called via calculated icons. Dynamic hyperlinking is implemented by connecting Authorware parameters to database items.

5. Conclusions and further work

In this paper we present the architectural aspects of a multimedia-based system that facilitates teaching chemistry over a LAN to high school pupils. It enables a high level computer-based teacher-pupil interaction using multimedia and hypermedia technology.

An important feature of our system is the use of dynamic hyperlinking, which facilitates on-line control in some aspects of a lesson by the teacher. The teacher can disable all irrelevant sections, so that the pupils cannot “play around” the application, but concentrate on the specific section. Also, the teacher can design new questions, review or delete old ones and select which questions will form a test for a certain lesson. All these are done from a unified user interface, offering different views to different users.

We intend to improve our system in two directions. One concerns extension of the flexibility of the teacher, in making changes to the content of the application other than to questions, such as to text, images, videos etc, in a predefined way. To this end, object-oriented database and authoring technologies may be used (Thuraisingham 1992). The other concerns use of the application over the Internet, additionally equipped with teleconference capabilities to provide a kind of a virtual high school class (see e.g. Hiltz & Wellman 1997). To this end, a number of technical problems should be solved (Wilson 1994).

References

- Faconti, G. P. (1994). Consistently Presenting Multimedia Information from Heterogeneous Data Sources. *ERCIM News*, 17.
- Fox, E. (1991). Advances in Interactive digital multimedia systems. *IEEE Computer*, 9-20.
- Garofalakis, J., Sirmakessis, S., Tsakalidis, A., Tziavas, P., Tzimas, J., & Vassiliadis, V., (1998). An Interactive Web-based Approach for Environmental Science Courses in Secondary Education. *Proceedings ED-MEDIA & ED-TELECOM 98*, Freiburg, Germany, 381-386.
- Hiltz, S. R., & Wellman, B. (1997). Asynchronous Learning Networks as a Virtual Classroom. *Communications of the ACM*, 40(9), 44-49.

Hopper, A. (1990). Pandora – an experimental system for multimedia applications. *ACM Operating Systems Review*, 24 (2), 6-8.

Narasimhalu, A. D., & Christodoulakis, S. (1991). Multimedia information systems: the Unfolding of Reality. *IEEE Computer*, 6-8.

Thuraishingham, B. (1992). On developing multimedia database management systems using object oriented approach. *Multimedia Review*, 3 (2), 11-19.

Wilson, M. (1994). Consistently Presenting Multimedia Information from Heterogeneous Data Sources. *ERCIM News*, 19.