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# Principles and Software Realization of a Multimedia Course on Theoretical Electrical Engineering Based on Enterprise Technology

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**Abstract:** The Department of Theoretical Electrical Engineering (TEE) of Technical University of Sofia has been developing interactive enterprise-technologies based course on Theoretical Electrical Engineering. One side of the project is the development of multimedia teaching modules for the core undergraduate electrical engineering courses (Circuit Theory and Electromagnetic Fields) and the other side is the development of Software Architecture of the web site on which modules are deployed. Initial efforts have been directed at the development of multimedia modules for the subject Electrical Circuits and on developing the web site structure. The objective is to develop teaching materials that will enhance lectures and laboratory exercises and will allow computerized examinations on the subject. This article outlines the framework used to develop the web site structure, the Circuit Theory teaching modules, and the strategy of their use as teaching tool**.**

**Keywords**: Multimedia teaching, Electrical Circuits.

## 1 Introduction

The Multimedia courseware has the potential to present basic engineering concepts and methods more effectively than traditional instructional approaches, such as textbook, lecture, laboratory and tutorial. The computer not only delivers textual content, but also can emphasize and expand the content through the use of interactive simulations, exercises and tasks, and gives opportunities for automated examination.

The collaborative efforts of lecturers and software designers in the department TEE are concentrated to produce interactive courseware equivalent to one-semester course on Electrical Circuits. The multimedia course consists of teaching modules embedded in a software system that controls the presentation of the material and the examinations. The modules can be used to supplement the course or can be used independently by the students. The module content is intended to provide the students with a theoretical basis and exercises that will enhance their ability to apply concepts in a variety of situations.

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The multimedia course is designed to be accessed via Internet or Intranet, with plans to be disseminated on CD-ROM, too. Currently, the courseware consists of nine modules, covering fundamental topics of Electric Circuit theory (Basic principles and notions, methods for analysis, theorems, sinusoidal steady state, phasors, power, resonance, inductively coupled circuits, two-ports, etc). In addition to the modules, numerical simulations have also been developed. These simulations consist of interactive Java Applets implementing basic methods for electric circuit analysis.

Nowadays, there are number of similar courses on Internet [1], [2], [3] which implement the principles of interactivity, simulations and distant learning. Here, an effort has been done to complete the learning process by including an examination phase in the multimedia course. This allows for the students to test independently their knowledge, and also automated examinations can be conducted, which are more objective and exhaustive.

## 2 The System Development Process

The system development process is based on the Rational Unified Process [4], which basic diagram can be seen on Fig. 1.

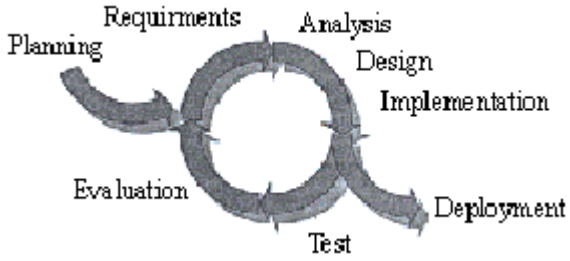


**Fig. 1** - *Rational Unified Process.*

This process consists of three main phases:

- Creating System Model;
- Software Implementation; and
- Test and Evaluation.

These three phases will be considered shortly:

### 2.1 Creating System Model

The aim of this phase is to create system model, which is an abstract representation of the system. The model has been created by using Unified Modelling Language (UML) [5]. This language is used for specifying, visualizing, constructing and documenting the artefacts of software systems. UML is an open standard language controlled by Object Management Group (OMG) which important member is Rational.

Creating System Model process includes 3 steps:

**Step 1**: Requirements Gathering – The main purpose of this step is to unambiguously express what the proposed system should do. This phase is implemented by con-

versations between developers and lecturers and the aim is developers to understand the problem from the lecturer's perspective.

**Step 2**: Analysis – This is a process of examination of the requirements and creation of a conceptual model of the system to be built.

**Step 3**: Design – The aim of this step is to make the analysis model of the system realizable in software.

### 2.2 Software implementation of the system - basic principles and steps

After system model has been created the next step of the Development process is to make software implementation of the model.

Before selecting the languages and technologies on which the system will be implemented, we consider some non-functional requirements obtained from Requirements Specification designed in Phase 1 – System Model Creating.

We aim to create a system that scales as the need for more teaching courses and more different simulations increases, and evolves at web system with high functionality, scalability, extensibility and reliability. As the system has to be platform independent, we choose Java and Java Enterprise Technologies as the most convenient software instruments to meet our demands.

Java is a small, tightly written object oriented language, very suitable for client-server Internet applications, with excellent support of exception handling and concurrency built-in. This language run on a platform independent virtual machine that allows Java Systems to run on everything from a Palm Pilot to an AS400 computer with about a dozen operating systems in between. Java 2 Enterprise edition [6] provides full specification for true cross-platform enterprise computing.

The software implementation process consists of two steps:

**Step 1**: Choosing Technologies for the boundary, control and entity classes.

The boundary classes control the system interaction with users or another system. When evaluating candidate technologies for the boundary classes we must consider the following constraints described in Requirements Specification:

1. Deployment constraints for the user interface:
   - Last version web browsers on the Internet; and
   - Last version web browsers on the network.
2. User interface complexity:
   - Simple data input;
   - Static view of data;
   - Dynamic view of data; and
   - Interactive simulations**.**
3. Available bandwidth:
   - Dial-up Internet connection;
   - Fast Internet connections; and

- Intranet connections.

The constraints specified above outline the most convenient languages and technologies as: HTML, Java Script, Java Applets, Java Servlets and Java Server Pages.

The control and entity classes comprise the second group of analysis classes we have identified in designing the system model. They build business logic of the system. The technologies we evaluated were Remote Method Invocation (RMI), Java Data Base Connectivity (JDBC), and Enterprise Java Beans (EJB). Among them we selected JDBC and EJB as the most convenient technologies for implementation of the control and entity classes of our system.

**Step 2**: Applying software development tools to a virtual system, which includes writing and compiling code, using different instrumental environments depending of technology being implemented.

### 2.3 Test and evaluation

The whole system is deployed in the department local network and is subjected to extensive tests to validate the correct fulfilment of the specified characteristics and checks of the correctness of the teaching modules.

## 3 Functional Characteristics of the System and Types of System Users

The system allows four types of users (actors):

### 3.1 System administrator

System Administrator can add, modify or delete users from the system. He is engaged also to manage recovery options of the system and set coefficient for converting the score to grade (2-6).

### 3.2 Course administrator

Course administrator can add, modify or delete courses and self-examination modules.

### 3.3 Examinations administrator

Examination administrator can create, modify or delete examination profiles, that include managing examinations, examination questions (Fig.2), configuring question lists and setting some additional examination parameters. Examination administrator can also search passed examinations by some parameters and can examine the full examination record including the examination statistics.

### 3.4 Student

Student has possibility to work in two different modes of operation:

a) Reading the course content (Fig. 3) and solving the problems offered (learning phase); and

b) Participation in real-time computer examination (answering quiz questions, solving test problems and receiving scores and grade for the examination).

# 4 Adopted Teaching Strategy and Structure of a Multimedia Teaching Module

## 4.1 Teaching strategy

The use of the multimedia course includes the following activities from a student, topic by topic:

- Browsing the lecture of the topic;
- Doing exercises, which include interactive Java applets, simulating basic principles covered into the lecture;
- Solving the unsolved examples and answering the quiz questions which covers the material of the current topic; and
- Running separate self-examination module, which covers the material of the whole course.

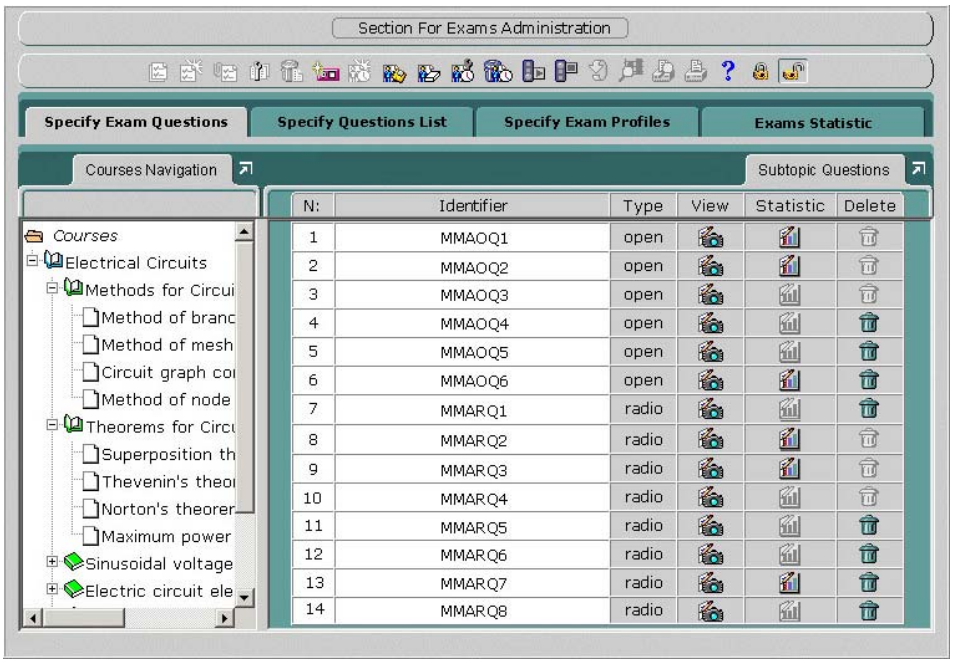


**Fig. 2** - *Screenshot of Examination Administration Section - Specification of Examination Questions.*

## 4.2 Structure of a teaching module

Each teaching module consists of:

- Lecture material, explaining basic notions, methods or facts;
- Analytically solved example, elucidating the method, formula or notion exposed; and

- Interactive Java applet, showing a circuit with slider controls, serving to change the circuit parameters. The applet has a solver that analyses the state of the circuit and gives the results as displays of digital voltmeters or ammeters.

Self-examination module, which covers the material of the current topic. It contains unsolved examples, which the student can solve and supply the result in provided boxes, after that his result is checked and a suitable message is taken out. Quiz questions with 5 answers each are provided also, to check the knowledge of the basic definitions, notions and principles.

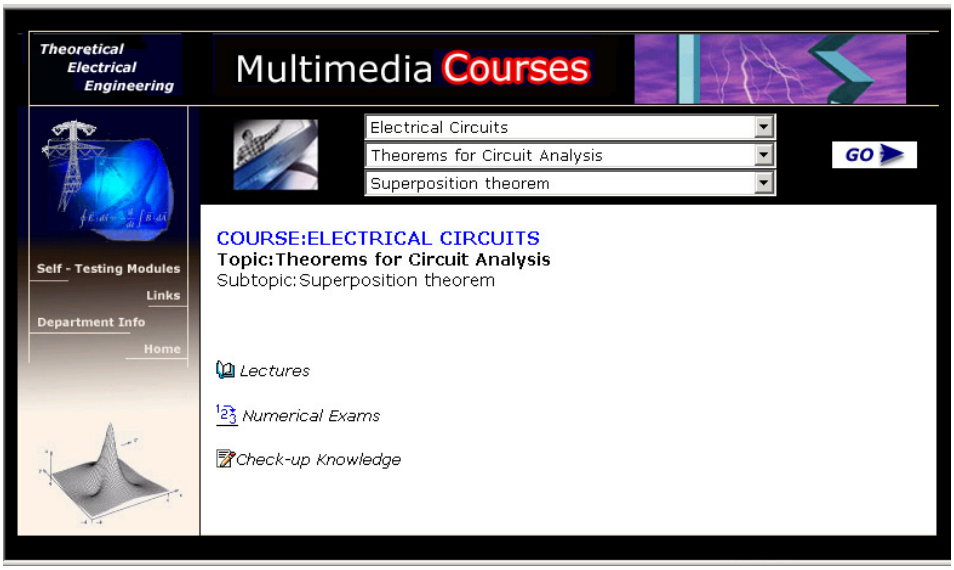


**Fig. 3** - *Screenshot of Student Section – selection of course, topic and subtopic.*

### 4.3 Mathematical aiding tools

A software scientific calculator with complex number arithmetic is built into the system. It supports basic mathematical operations and solves linear system of equations up to $5^{th}$ order with complex coefficients. The mathematical operations in this calculator are based on the mathematical library JAMA [7].

The solution of unsolved problems, which have to be solved by the student, can be helped in great extent by this built-in scientific calculator.

## 5 Conclusions

A versatile multimedia-learning course on Theoretical Electrical Engineering (Electric Circuit Theory) has been developed. It is intended to help the electrical engineering students to master the course content, to prepare them for computerized examination and to conduct the examination, ensuring security and objectivity. The software system embracing the course is content-independent and can be used for other courses, corresponding to the accepted teaching format.

The course can be useful for full-time students, and especially for part-time students and for distant learning.

The test of the course and the whole system in real teaching conditions is imminent.

The following directions for future work are chosen:

- As a next step multimedia modules for Electromagnetic Fields course will be included;
- More interactive problems and simulations will be created and programmed;
- Animations will be included also, using Macromedia Flash; and
- The scientific calculator will be enriched with possibilities to work with variables and to output graphs.

## Acknowledgements

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