A.RIES - A Web Lecture and Online Exercise Management System for Applied Mathematics and Mathematical Modelling

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Abstract

A Learning Management System (commonly abbreviated as LMS) is a specialized type of CMS focused on lecture organization and educational management. It is an application designed for the administration, documentation, tracking, and reporting of training programs, classroom and online events, e-learning programs, and training content. At the Vienna University of Technology the learning management system TUWIS++ is used for administering users and courses. The TUWEL subsystem is used complementary, mainly to manage learning content and course contents. Additionally it has certain management functionality for grading and testing students. TUWEL is a generalized web-based e-learning application, which works well for various kinds of simple and standardized e-learning objects. Specialized applications and certain e-learning content like videos and podcasts or mathematical simulation examples cannot be integrated via TUWEL, they have to be embedded via external interfaces and specialized applications. The A.RIES LCMS application is a learning content management system designed for mathematical content and simulation examples. The LCMS is an advancement of the existing MMT e-learning infrastructure, which was necessary because of the growing number of learning objects and simulation examples. The A.RIES LCMS consists of a web application, a relational database backend and different application servers in the background. The application servers compute the model data and deliver the results to the A.RIES web frontend application. This paper shows the structure and implementation of our mathematical e-learning system as well as the integration of the application into existing web and e-learning resources (like TUWIS++ and TUWEL) at the Vienna University of technology.

Keywords: E-Learning, Blended Learning Modelling and Education, Learning Management, Content Management Systems, Web-based Simulation

Presenting Author's biography

Nicole Nagele. She finished a technical college for computer science (HTL) and started studying computer science at the Vienna University of Technology in the year 2006. She is on her way to finish the bachelor. The bachelor thesis is focused on e-learning implementations in the field of mathematics, modelling and simulation.

1 Introduction

Since starting the e-learning project with MATLAB at Vienna University of Technology in 2006 about 500 e-learning examples dealing with mathematics, numerical algorithms and simulation organized in more than 50 chapters have been implemented¨ They are now part of the lecture structure in mathematics for surveying and mapping as in the advanced lectures in modeling and simulation of dynamical systems. The e-learning environments' purpose is to explain numerical problems, computer numeric, as well as how to implement dynamical problems (especially the ARGESIM comparisons mechanical and dynamical physiological problems) and SIMULINK examples.

The core application of the MMT e-learning environment is a web-based demonstration system used for teaching in classes as well as for autonomous learning and experimenting with mathematical models. The demonstration examples presented are focused on the use of special methods and techniques in the field of modeling and simulation and demonstrate various kinds of rather basic mathematical operations and models. Generally the source code and model structure of the demonstration examples is available for the students and should serve as basis for an introduction to the programming language and further experimenting with the underlying models. The mathematical basics and techniques of modeling and their implementation are presented and explained textually and graphically within the content. This paper shows the technical details and the structure of the e-learning environment, the integration in existing web structures and resources (like the Moodle-based TUWIS and TUWEL) at the Vienna University of Technology and presents current developments and possibilities.

2 Integration of the A.RIES LCMS into the current VUT Web- Infrastructure

2.1 Content Management Systems

Generally speaking, a content management system (CMS) is the collection of procedures used to manage workflow in a collaborative environment.

The procedures are designed to:

- Allow to contribute to and share stored data
- Control access to data, based on user roles.
- Aid in easy storage and retrieval of data
- Reduce repetitive duplicate input
- Improve the ease of report writing
- Improve communication between users

2.1 Learning (Content) Management Systems

A Learning Management System (commonly abbreviated as LMS) is a specialized type of CMS focused on lecture organization and educational management [1]. It is a software application for the administration, documentation, tracking, and reporting of training programs, classroom and online events, e-learning programs, and training content. A learning content management system (LCMS) is a related technology to the learning management system, which is focused on the development, management and publishing of the content that will typically be delivered via an LMS. An LCMS is a multi-user environment where developers may create, store, reuse, manage, and deliver digital learning content from a central object repository. The LMS manages courses and grading, the LCMS holds the learning content. LCMS applications allow users to create, import, manage, search for and reuse small units of digital learning content and assets, commonly referred to as (reusable) learning objects. These assets may include media files developed in other authoring tools, assessment items, simulations, text, graphics or any other object that makes up the content within the course being created. An LCMS manages the process of creating, editing, storing and delivering e-learning content. An LMS is software for planning, delivering, and managing learning events within an organization, including online and instructor-led courses [6]. The focus of learning management systems is on managing students, keeping track of their progress and performance across all types of training activities. It performs administrative tasks, such as reporting to instructors and ERP systems but isn't used to create course content. In contrast, an LCMS is software for managing learning content. It provides the means to create and re-use e-learning content and reduce duplicated development efforts. In the remote

hosting approach, an LCMS may host the content in a central repository and allow multiple LMSs to access it.

2.1 **Elearning Infrastructure at the VUT**

The learning management framework used at the Vienna University of Technology since 2002 is called TUWIS++.

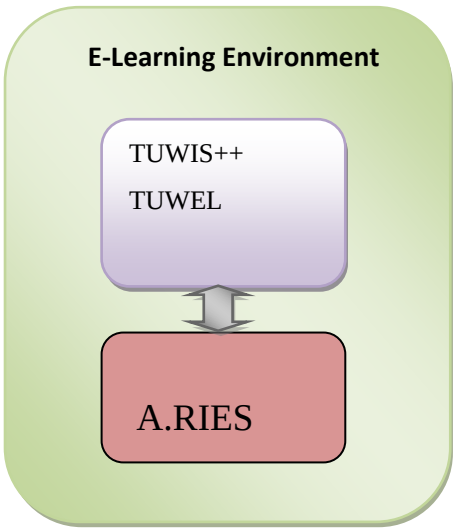


Fig 1: E-Learning for Mathematical Training

TUWIS is a Moodle-based LMS and administrative backend used for grading and lecture management, TUWEL is a subsystem and enhancement of the TUWIS system. TUWEL was developed 2006. It is the LCMS-enhancement of TUWIS, which contains learning content and allows collaboration between students [7].

3 System Architecture of A.RIES LCMS

The structure of TUWEL (Figure 2) is quite intuitive and thereby students do not need extra explanation to get used to the important features

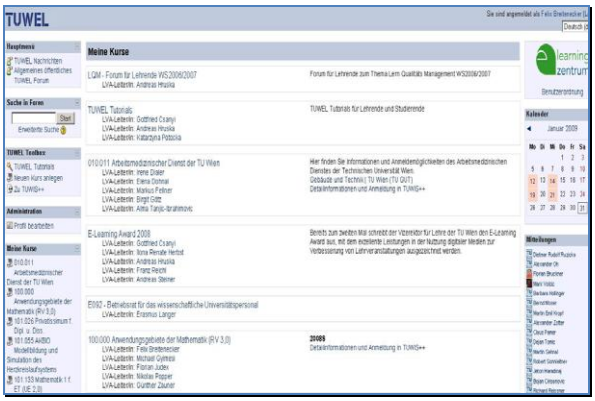
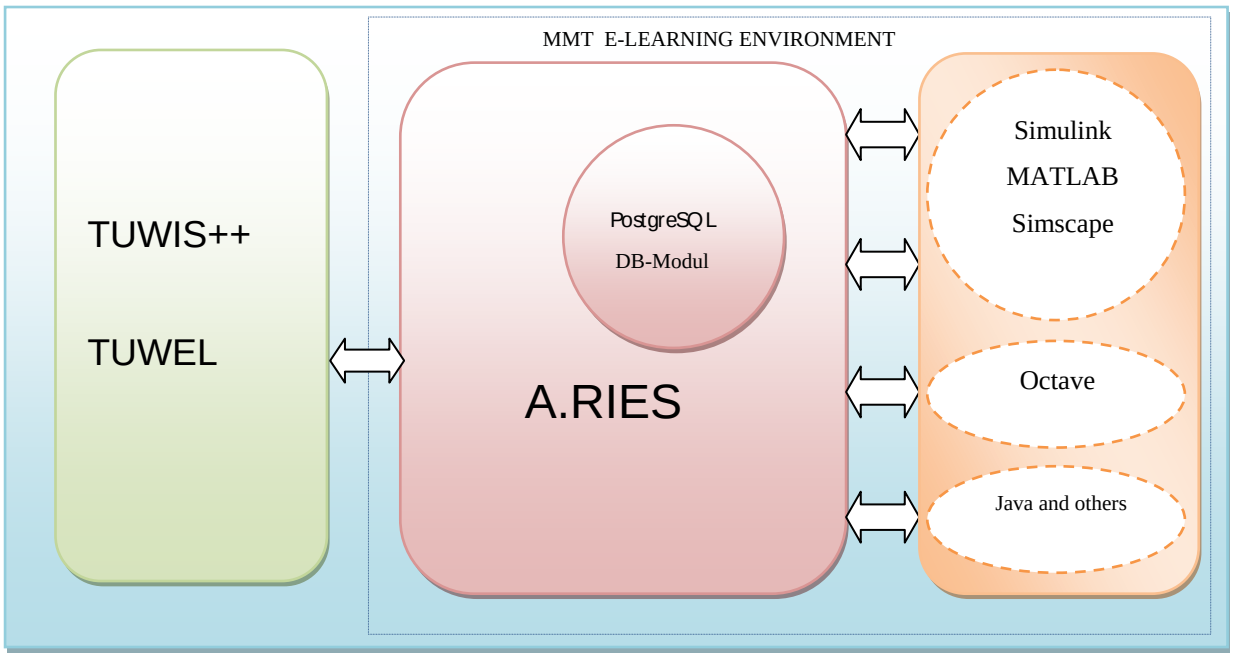


Fig 2. TUWEL Course and Grading System

For standardized and common learning content like pictures and text, it is possible to directly embed the objects via TUWEL. Text and illustrating pictures are easily added and presented. One of the restrictions of TUWEL is that specialized content like videos, mathematical models and animations cannot be integrate directly via TUWEL/TUWIS. Specialized content has to be integrated via subsystems and external interfaces. Our mathematical content and demonstrations linked and presented via TUWEL courses, are therefore organized and stored in the A.RIES LCMS interface.

Fig.3: E-learning System: Integration of the A.RIES LCMS and Application Backbones



The A.RIES LCMS application is a learning content management system designed for mathematical content and simulation examples. The LCMS is an advancement of the existing MMT e-learning infrastructure, which was necessary because of the growing number of learning objects and simulation examples. The A.RIES LCMS consists of a web application, a relational database backend and different application servers in the background. The application servers compute the model data and deliver the results to the A.RIES web frontend application.

3.1 A.RIES Web-Application

The A.RIES LCMS is programmed in PHP [7] with a relational database backend. PHP is a wide-spread and popular server side scripting language and a common choice for content-management web services. It is a general-purpose scripting language that is especially suited to server-side web development where PHP generally runs on a web server. PHP can be deployed on most web servers, many operating systems and platforms, and can be used with many relational database management systems. It is published under the GNU public license. At present the PHP application runs on a Linux system with an Apache web server.

Requirements and key features of the PHP application:

- Reusability of resources (learning objects)
- Organization and search capabilities
- Access control for editing
- Grouping and structuring of learning objects into chapters and types

3.2 Relational Database

Due to the use of an abstraction layer for the database component the database backend of A.RIES can be as well MySQL[8], PostgreSQL[9] or other database types depending on existing infrastructure and system requirements.

As database abstraction layer module the ADODB [10] library release 5.09 has been used. The integrated ADODB module works with PHP 4 and higher.

The database model consists of following tables:

Table / Entity	Description
User	User
Group	Usergroups
Member	Users linked to Groups
Object	Learning objects , generalization of chapters and examples
ACU	User Access
ACG	Group Access
Ressource	Resources like pictures and animations
Chapter	Collection of examples
Class	Class or Type of data
Class_Content	Chapters and Examples assigned to Classes

Table: Database Layout

The database model stores information about learning objects, external resources and user data and permissions.

3.3 Application Server

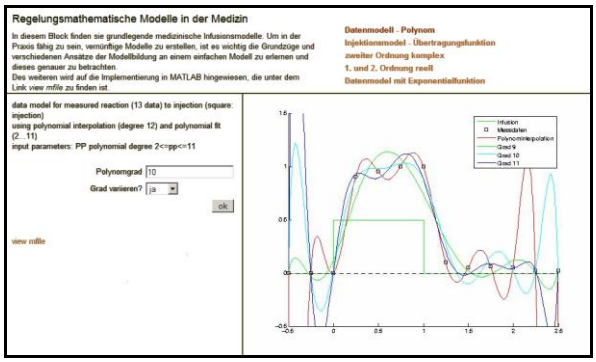


Fig. 4: Matlab Demonstration Example

Matlab : Most of the 500 e-learning examples are implemented in MATLAB. In 2009 year the MATLAB application server was ported from a MATLAB web server 2006a version to a normal MATLAB engine, because Mathworks, the developing company of MATLAB, does not support the web server any more. An additional benefit of the new architecture is that more instances of MATLAB can work in parallel (one per core), which leads to better performance and improved stability.

Simulink and Simscape SIMULINK AND SIMSCAPE are Matlab-Tools. SIMULINK is an environment for multidomain simulation and Model-Based Design for dynamic and embedded systems. It provides a set of blocks presenting data in- and output, mathematical and logical operations. Connectors stand for the flow of data between the separate blocks. In SIMULINK equations can be implemented combining these

blocks. SIMSCAPE is another block-structured simulation tool of MATLAB. SIMSCAPE extends SIMULINK with tools for modeling systems spanning mechanical, electrical, hydraulic, and other physical domains as physical networks. It simplifies representing physical structures because it is not necessary to formulate underlying mathematical equations.
SIMULINK and SIMSCAPE models use the MATLAB application server with the corresponding toolboxes. The model is published via HTML output. It would also be an option to download the source file like the m-Files of the MATLAB examples.

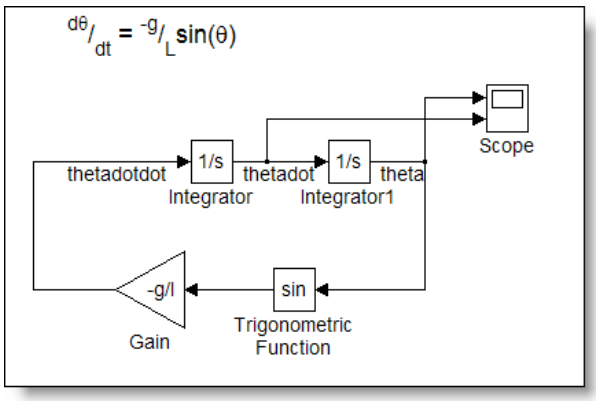


Fig.5: SIMULINK Model

Alternative Application-Backends

Server-side Java: Corresponding to the Matlab Application Server a Java Application Server can process requests and deliver calculation results. This can be realized with server-based Java [8],[11]. A Java Servlet is a Java class which conforms to the Java Servlet API, a protocol which enables Java classes to respond to web requests. Servlets are used to add dynamic content to a web server. Servlets can maintain state in session variables across many server transactions by using HTTP cookies, or URL rewriting. The servlet API defines the expected interactions of a web container and a servlet. A web container is essentially the component of a Web server that interacts with the servlets. The Web container is responsible for managing the lifecycle of servlets, mapping a URL to a particular servlet and ensuring that the URL requester has the correct access rights. A servlet receives a request and generates a response based on that request. The basic servlet package defines Java objects to represent servlet requests and responses, as well as objects to reflect the servlet's configuration parameters and execution environment. The package servlet.http defines specific subclasses of the generic servlet elements, including session management objects that track multiple requests and responses between the server and a client. Servlets can be generated automatically by Java Server Pages (JSP) compiler, or alternately use template engines to generate HTML.

Octave: GNU Octave is a structured programming language and supports many common C standard library functions, and also certain UNIX system calls and functions. Its syntax is very similar to MATLAB, and careful programming of a script will allow it to run on both Octave and MATLAB. As part of the GNU Project, it is free software under the terms of the GNU General Public License. MATLAB Octave is open source software. The Octave software structure is very similar to MATLAB. In contrast to the integration of an Octave backend would correspond to the existing MATLAB integration.

4 Conclusions and Outlook

During the last decade E-learning and Blended Learning techniques and electronic Learning Management Systems (LMS) gained importance and asserted their position very well.

The LMS applications used at the Vienna University of Technology, TUWIS++ and TUWEL help to administer student and course data. TUWEL can handle simple course content and learning objects. Specialized content like our mathematical simulations have to be realized within external applications, which can be integrated into or combined with TUWEL. The presenting and managing core of our MMT e-learning environment will be the A.RIES LCMS. Content and learning content management has become essentially because of the growing e-learning infrastructure and learning object repositories. The number of simulations and mathematical demonstrations available and the increasing number of workers and students made necessitate it not only to present but to organize content and collaboration within the system. The A.RIES LCMS holds and administers the learning content. The calculations for the simulations are executed by backend applications. Currently most of the examples are

realized with MATLAB and SIMULINK. Generally it is possible to integrate all kinds of server-based modeling and programming languages or applications. Current developments and research include the connection with other simulators and programming languages. Different simulation languages and realizations provide opportunities to realize comparative models.

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Additional Web Resources

[12] MATLAB environment: http://www.mathworks.com

[13] PHP hypertext preprocessor:

http:// www.php.net

[14] MySQL database engine:

http://www.mysql.de

[15] PostgreSQL database environment: http://www.postresql.org

[16] JAVA programming language: http://www.java.com

[17] Octave/ GNU Octave language: http://www.gnu.org/software/octave