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# A VIRTUAL TEXTBOOK FOR MODELING AND SIMULATION

Thomas Wiedemann

Technical University of Berlin
Franklin Str. 28/29 FR 5-5
10587 Berlin, GERMANY

## ABSTRACT

The theory of modeling and simulation is well defined in result of about 30 years of research and practice. There are commonly accepted approaches and methods of working out successful simulation studies (see track "Simulation Basics" in Winter Simulation Conference 1999). The educational aspects of simulation are very complicated: there is no common accepted curriculum, nor a basic textbook. The situation at the web is even much worse – mainly as a result of missing time-resources the quality of the teaching material concerning simulation is very heterogeneous and does not fit. Often the work of producing teaching materials and exercises is done twice. The goal of this paper is to present a real working database system for managing links and generating collections of simulation related material for teaching and learning purposes.

## 1 INTRODUCTION

At the 1999 Winter Simulation Conference in Phoenix the basic theory of modeling and simulation was presented very well in the track "Introductory Tutorials", e.g. see (Banks 1999). Thus the content of a teaching course of modeling and simulation could be regarded as well defined. However the problem of "How to teach simulation" still remains open and is solved by every teacher in his own way. There are some serious disadvantages:

- In many cases the course of simulation is dominated by continuous or discrete simulation. Sometimes only one part is shown.
- The practical skills of the students in making a successful simulation study strongly depend on the used simulation tools in education.
- In result industrial firms are unable to understand and evaluate the quality of the courses and the students.

This situation of a very heterogeneous understanding of education of modeling and simulation is also visible in the Web. There is no reference site available for defining some basic curriculum. Developing teaching materials and exercises often take a lot of time (Horton 2000) (McCormack and Jones 1997). For there is already a lot of material available at the Web, the management of this distributed information source seems interesting as a first step to improve the quality of education in the simulation area. This paper introduces a database solution for this management. In order to receive some practical results, the presented solution is focused on the practical application and on a real working system for the simulation community.

## 2 STUDENT CLASSIFICATION

One reason for the different simulation courses could be seen in the very heterogeneous requirements and skills of the students in the simulation courses. There is a range from computer science experts ("freaks") to business experts. The classification of the students is important for two main factors of simulation teaching:

- First, the main goal of education differs widely. Computer scientists should be able to implement smaller simulation models and tools from the scratch. Business students should accept simulation studies as powerful tools for decision making.
- Second, the existing skills of the students are very different. We find a complementary knowledge in both groups concerning programming, mathematics & statistics, manufacturing processes and business sciences. Sometimes one of the mentioned knowledge is completely missing.

Between the computer scientists and the managers are groups of other experts, like business consultants, engineers with good mathematical knowledge and poor programming experience. Thus we need a fuzzy classification and selection of the appropriate teaching material.

## 3 CLASSIFICATION AND SELECTION OF MATERIAL FOR TEACHING M&S

The main goal of the virtual textbook is a better, user oriented selection of the appropriate teaching material. In difference to well known lists of Internet-links or simple search engines with only one search field, we also ask for the skills, individual characteristics and interests of the student. In the first version of the "Virtual textbook" the following classification attributes are used:

- user type (student of computer science, engineer, teacher, manager, ..)
- type of material (common introduction, details of M&S, mathematical basics, background knowledge, programming examples, case studies, M&S-software and tools, organizations and literature)
- knowledge of programming (CS)
- knowledge of mathematics
- language (one or more languages possible)

The attributes programming and mathematical knowledge slightly overlap with the main user type. But this seems to be useful, because in special cases a manager could be highly skilled in programming and a computer scientist may not have a good mathematical background or is not interested in mathematical details.

Inside the database system the knowledge requirements are stored as marks between 1 – 5, where 5 means "no knowledge necessary". So a pretentious material about continuous simulation, which is based on differential equations, is rated with 2 in math-knowledge. In order to achieve this paper, a students need very good (1) or appropriate (2) knowledge in mathematics.

The type of material is defined as an open list of options inside the database. Actually this list is maintained manually by a small database table TYPES. If a higher flexibility is required , this table could be maintained also by a web-based form. Handling of the user types is the most interesting feature in the database. In difference to all other classification parameters there is a 1:n relationship between the database entry and its assigned user types. In order to handle this relationship without additional efforts, the user types are stored as short string sequences in one database field. With his techniques we can define also sub-classes of one general class:

- ➔ If ENG defines materials for engineers
- ➔ Then CSENG defines special links for engineers of computer science.

A common request with the SQL-statement "`... usertype like "*ENG*"`" will extract all engineer-related links, where "`usertype like "*CSENG*"`" will extract only articles for computer science engineers.

## 4 THE WEB-BASED USER–INTERFACE

The main user interface for the student of simulation is realized as a HTML-form with more than 10 input elements (see Figure 1). In the presented version the users can select the appropriate entry by mouse clicks. Typewriting

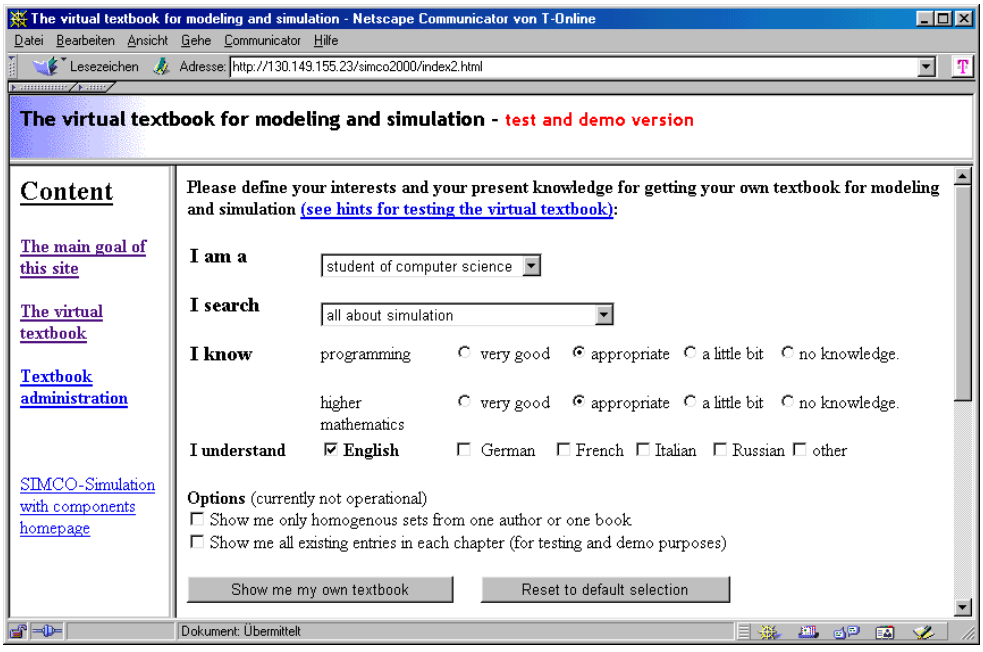


Figure 1: The Main User Query Form

is not necessary. The elements of the form are Windows-compliant. In the knowledge area only one entry can be activated. In the language-area one or more option boxes can be activated. Additional option boxes are defined for future usage as a personal textbook of a teacher, where only textbook-entries from one author or one source will be selected. (Please also see chapter 8).

After the described definition of his skills and interests the student selects the button "Show me my own textbook". The request is transfered to the web-server and is transformed in a SQL-statement. The results of the query are generated as a HTML page (see chapter 5 for some details). By using this user specific, dynamic web-page the student achieves his own text-book about modeling and simulation. (see Figure 2)

The presented content of the textbook is organized in chapters. The number of chapters depends on the specific request of the student. In general the chapters are presented from common articles to application specific papers and links. A example curriculum for the virtual textbook of simulation is discussed at the end of this paper.

## 5 CONTENT ADMINISTRATION

As mentioned at the beginning, the textbook-system is declared as a link management system concerning the world-wide distributed material for teaching simulation and modeling. The content itself is NOT stored in the system. The actual content and the quality of the material depends on the authors. Changes of the material at the authors web-site appear immediately in changes of the related text-books.

The success of the virtual textbook for teaching simulation depends on three major points:

- the ease of use for the authors, when they define or modify entries,
- the quality of the existing entries,
- the completeness of the simulations topics and the relationships between them (There should no antagonistic themes or papers).

The first two points are solved by a web-based content management system with password restrictions. Only teachers and firms with some level of reputation in the simulation community will obtain the passwords.

The third question needs some communication between the teachers and participants concerning missing topics or over-represented themes. In fact, this problem is not just a technical (deleting or inserting entries is done in seconds) but more a political problem, there should be a discussion about creating a small group of content administrators. This group will monitor the database and will remove non-adequate entries.

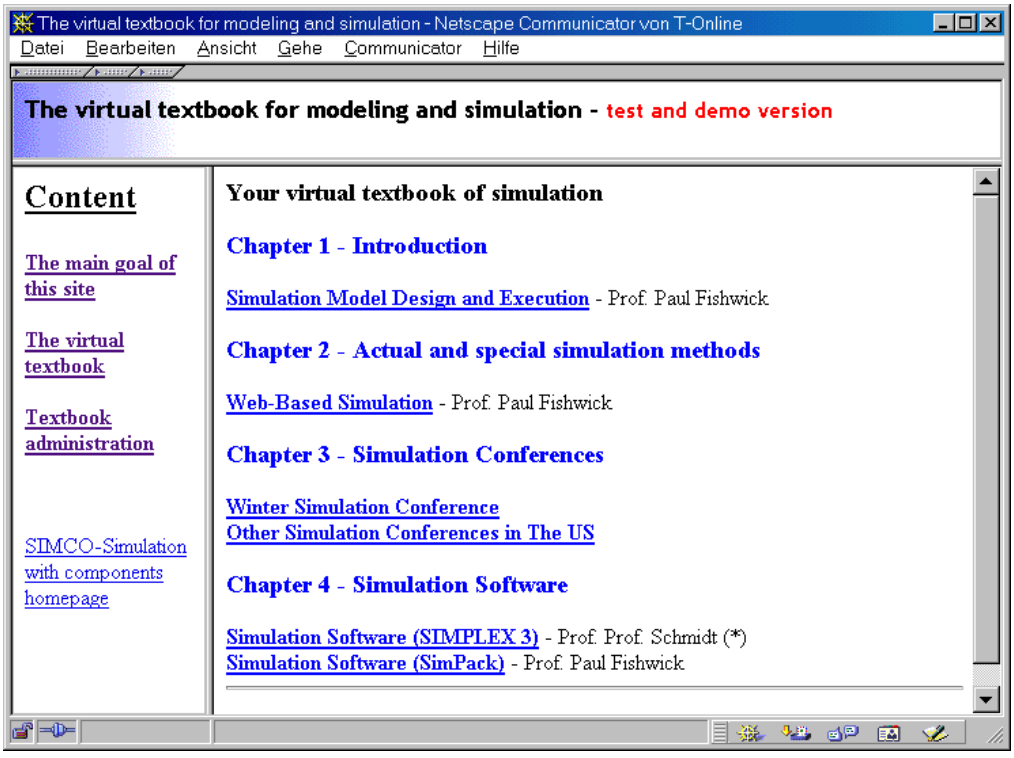


Figure. 2: A Virtual Textbook for Common Usage

In the present version, the textbook administration page is entered from the home-page which is secured by a password check (see Figure 3).

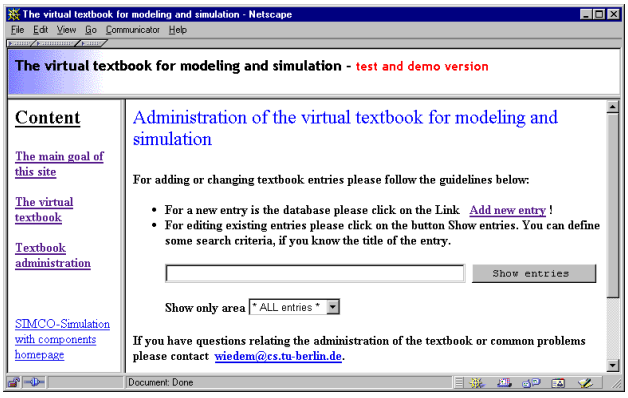


Figure 3: The Entry -Page for Textbook-Administration

Main options for the author are the definition of a new entry and the modification of existing entries. Existing entries are first presented as a list, similar to the textbook with an additional "EDIT"-button.

New and existing entries in the database are edited with the same HTML-form. The meaning and content of the edit fields correspond with the fields in the main text-book mask for selection of the users (see Figure 4).

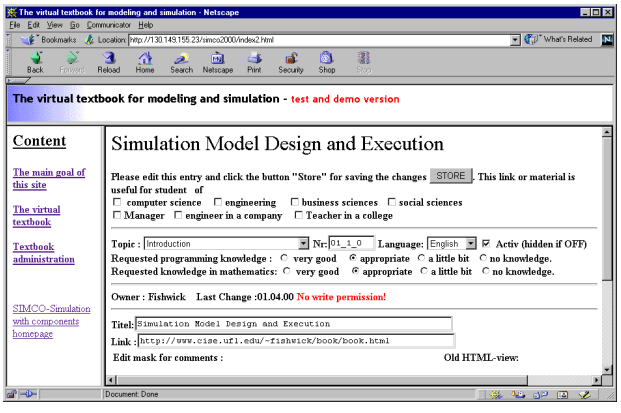


Figure 4: The Content Management Web-Form

## 6 IMPLEMENTATION DETAILS

The internal structure of the information management system of the virtual textbook is similar to known web-based applications. Due to this, an existing web-server and database - information system was re-used from a industrial project. In result the development efforts were small and the system was running after one day of additional work.

In the current version all data are stored in a MS-Access database. The web-interface between the database and the used web-server from O´Reilly Inc. is build with a CGI-program (see Figure 5). Some of the HTML pages were created with a HTML editor and imported into the visual basic code of the CGI-program. In a future version of the industrial project, this CGI-Interface will be replaced by a self-developed web-server, based on the Winsock-component and a flexible code-generator. This new interface eliminates some of the main disadvantages of CGI-interfaces, such as slow response times and inefficient data-handling and output-generation. The selection of the links coming from the database is made by a SQL-statement, which includes the classification attributes in AND-clauses. Additional clauses or the usage of special selection statements are possible.

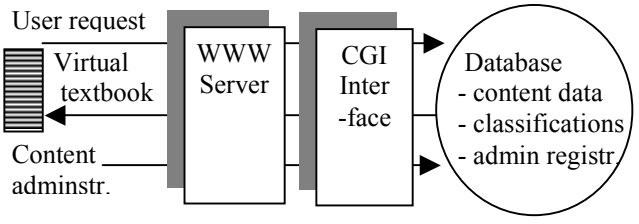


Figure 5: Software Architecture and Information Flow

## 7 FUTURE CONTENT MANAGEMENT

The main content administration of the textbook is done by the authors and a small group of content administrators. If the database system is filled with a larger amount of information, there will be some additional problems in managing the textbook:

- After the initial period the system will store more than one link in every chapter. Like the information overflow in large Internet-search engines it produces a very large number of entries in the generated textbook file. In result we need an efficient way of selecting or combining only the best links. In technical terms this secondary filtering could be done by selecting only the first item of each sub-chapter for output. The only question is - how will the first item be defined ?

  One possible solution is a quality attribute, which is defined by the authors committee or the content administrators. This way could reveal to problems concerning a different understanding between the authors and the administrators.

  A much more democratic solution is the definition of the quality attribute given by the readers of the textbook. Like as in other web-sites (see book reviews at <www.amazon.com> or the certification process at the internet auctions <www.ebay.de>) this could be an interesting and objective way of improving the quality of the textbook entries and of giving some feed-back and motivation to the authors.

A second problem is the dynamic structure of the web. Web-sites disappear or change without any notice. For teaching purposes we need a stable, non-changing collection of material for 3 months at least. Solutions are:

- If a teacher needs some specific course, which is not defined by some simple selection procedure, the database can store a specific list of marked links or a special SQL-statement made by the teacher. New material is only manually added by the responsible teacher.
- The database is able to compare the actual file date of the external document with its internal data about the document. When a difference is detected, the system can mark the entry in the textbook. If a changed entry is included in a special selection of a teacher, the system could send a short email to the teacher.

## 8 EXAMPLE CURRICULUM

A possible content index for the virtual textbook of simulation is shown in Figure 6. The times shown are minimal needed times in order to understand the material. Material at the first level is only for common information. Theoretical teaching material is located at the 2nd level. All materials at the third level are optional or application-specific.

The shown example curriculum satisfies teaching courses between a summary lesson about simulation (2 hours) and a standard course of about 30 hours. For an in-depth study of simulation additional exercises and modeling tasks are recommended.

## 9 CONCLUSIONS

The first version of the virtual textbook is already running at <http://www.aedv.cs.tu-berlin.de/simco/> In result of the small development efforts this system is open for all teachers of the simulation community and other areas. The success of the system depends only on the cooperation of the participating scientists and teachers. Thus any comment or critical remark concerning the future development are highly appreciated.

## REFERENCES

Banks Jerry 1999: Introduction to simulation. In *Proceedings of the 1999 Winter Simulation Conference* ed. P. A. Farrington, H. B. Nembhard, D. T. Sturrock and G. W. Evans. Piscataway, NJ: Institute of Electrical and Electronics Engineers, pp. 7-13.

Horton, William K. 2000. *Designing Web-Based Training : How to Teach Anyone Anything Anywhere Anytime*. New York: John Wiley & Sons.

**Textbook of Modeling & Simulation**

**Common introduction**

- **When should you use simulation ? (20*)**
- **modeling & simulation basics and definitions (30)**
  - 💻 put your company in your PC (animation) (5)
  - model validation and verification (30)
  - input and result statistics (60)
    - 💻 determine the random distribution (20)
  - modeling random processes (120)
    - 💻 define your own random # generator (30)

**Details of simulation technologies**

- **Continuous simulation (30)**
  - modeling with differential equations (30)
    - 💻 using VENSIM – pendulum model (30)
    - 💻 define a simple production model (45)
  - calculation errors and solutions (45)
- **Discrete simulation (30)**
  - How does it work (event lists) (30)
    - 💻 Have a look a TAYLOR II (30)
  - Simulation languages (e.g. SLX) (60)
    - 💻 Change parameters in a SLX-model (30)
    - 💻 make your own factory (120)
  - **Application specific simulators (10)**
    - 💻 Simulation of manufacturing systems (20)
    - 💻 Logistic network simulation
    - 💻 Network (WAN / LAN) simulation
    - 💻 FEM – Crash-Simulation
- **Simulation books and links**
- **examples and successful projects**
- **simulation software and tutorials**
- **Conferences**

** minimal requested time in minutes for study*

💻 *= exercises with simulation software*

Figure. 6: Example Content Structure of the Textbook

McCormack Colin, and David Jones. 1997*: Building a Web-Based Education System*. New York: John Wiley & Sons.

## AUTHOR BIOGRAPHY

**THOMAS WIEDEMANN** is a scientific assistant at the Department of Computer Science at the Technical University of Berlin. He has finished a study at the Technical University Sofia and a Ph.D. study at the Humboldt-University of Berlin. His research interests include simulation methodology, tools and environments in distributed simulation and manufacturing processes. His teaching areas include also intranet solutions and database applications. His email address is: <wiedem@cs.tu-berlin.de>.