The Why and Wherefore of the LENO System

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January 14, 2005

Abstract

This article describes the rationales and thoughts behind LENO, which is a tool for production of web-based teaching materials. The actual tool, and the characteristics of the materials produced by the tool, are first briefly described. Following that, *the why and wherefore* of a number of key properties are discussed. This discussion is relevant for users of LENO teaching materials. The discussion includes the idea of overlapping views at different levels of abstraction and media considerations regarding audio and animations. The article also touches on aspects of LENO which are relevant for authors of web-based teaching materials. These aspects include single source considerations and complexity problems.

1 Introduction

The World Wide Web has pervaded most areas of university educations. Today it is a natural expectation that teachers arrange web pages with all the practical informations pertaining to the courses they give. Besides such *course home pages* a variety of other web-based materials play significant roles in almost any university course and project.

LENO [14, 13, 18] is tool for creation of web-based lecture notes, with special emphasis on computer science materials. The name of the tool is formed by the initial letters of "LEcture NOtes." The author of a LENO teaching material writes an XML document [3] which describes the properties of the material, and which holds its textual contents. The XML document is processed by the LENO tool which creates a set of interlinked HTML pages. Thus, the LENO tool can be seen as a transformation program from the LENO XML language to HTML. The students who use LENO lecture notes access the HTML pages from an Internet browser.

Lecture notes have existed for decades on paper form. Today, it is attractive to publish such materials in electronic form, in part to accommodate the needs for frequent changes of the material, and in part to make it available to students—both on campus and off campus—in a cheap and timely fashion. In this context it should be noticed that paper editions of lecture note material are still useful as supplementary means to the electronic editions.

From a teaching point of view, the role of a LENO teaching material is similar to the role of traditional paper-based lecture notes. Both are supposed to represent the thoughts and insight of a given lecture using a structure which is similar to the oral presentation, as given by the teacher. In its most simple form, a LENO material is similar to a slide presentation. In a more elaborated form, a LENO material spans the spectrum from a slide presentation to a comprehensive coverage, as known from a text book of central importance to the course. In any case, the material is not intended to replace the teacher by technological solutions. Good teaching in terms of fruitful dialogues, common understanding, and professional enthusiasm always comes first. Web-based lecture notes are supposed to keep and remind the students of these elements, and to make them available via the Internet.

From a methodological point of view LENO can be characterized as an *operational prototype*. General ideas and patterns related to web based teaching materials have been implemented in the LENO tool.

The main goal of this article is to describe the rationales and thoughts behind the LENO system rather than explaining the features of LENO-based materials. The article is mainly oriented towards educators who produce complex, web-based teaching materials. Throughout the article we emphasize the values of open, textual standards (such as XML and HTML) in contrast to proprietary, binary formats. We will argue that these values are assets to both authors and students.

LENO is available as free software from the LENO homepage [18].

2 A brief overview of LENO

In order to set the scene for the rest of this article we need to describe the most important properties of teaching materials produced with LENO. For a more detailed account on the LENO system, the reader should consult the paper *Web based Lecture Notes - the LENO approach* [14].

A LENO teaching material is structured as a number of *lectures*, each of which consist of a number of *note pages*. A note page is composed of a variety of different *elements*, such as title, items, concepts, programs, and exercises. The elements of a note page are presented in different views, which are distinguished by the amount of information, the level of detail, and the typographical layout. In addition, a number of different overviews and indexes are produced. The qualities of the different views are discussed in section 3.1.

A LENO material integrates text, static images, animations, and audio sequences. As a contrast to the textual contents, the images, animations and

audio sequences are external to the LENO XML document. Using audio sequences it is possible to produce web-based lectures which automatically shifts from one page to the next while the teacher's explanations and discussions are be transmitted as streaming audio. The task of the LENO tool is to manage the external image and audio resources, and to incorporate these into the resulting materials.

On a more experimental basis, it is also possible to integrate LENO materials with various kind of *dialogue support*. As one possibility, it is possible to discuss and debate each note page. This is made possible by providing links to a separate *annotation server*. As another possibility, the exercises in LENO can be managed and discussed via two different tools. For synchronous use on campus, an *exercise manager* [13] makes it possible to to monitor the status and progress of many students who work on the exercises at the same point in time. For asynchronous use off campus, a locally developed *distance education tool* (IDAFUS) can cooperate with LENO in order to mediate discussions of exercises.

3 The why and wherefore of LENO

In this section we will discuss a number of aspects of LENO-based teaching materials. We will first discuss issues which are related to the materials produced by LENO. These are all aspects which are important for students who use teaching materials made from a LENO source. These aspects include the presentation modes, navigational issues, media considerations regarding audio and animations, and the format of delivery.

Next we will argue about a number of properties, which are relevant primarily for authors. These aspects involve the virtues of single sourcing, complexity challenges, and the format used by the author for creation of the lecture notes.

3.1 Overlapping views

As described in section 2, one of the key characteristics of LENO is the support of overlapping views at different levels of abstractions: The slide view, the annotated slide view, the aggregated view, and the thematic view. The main rationale of having several views with overlapping contents is to allow the material to serve several different needs.

For seminar use, the *slide view* is used. In slide view only the main points in the material is emphasized through a few, concise statements.

For use after a seminar, or for seminar preparation, the *annotated slide view* is useful. The annotated slide view makes it possible to get access to additional explanations of the points stated in the slide view. On the left part of the screen the slide view is available in a clearly recognizable form (relative to the slide view) and on the right part of the screen a number of textual annotations can appear. In order to allow easy mental navigation in between the main elements

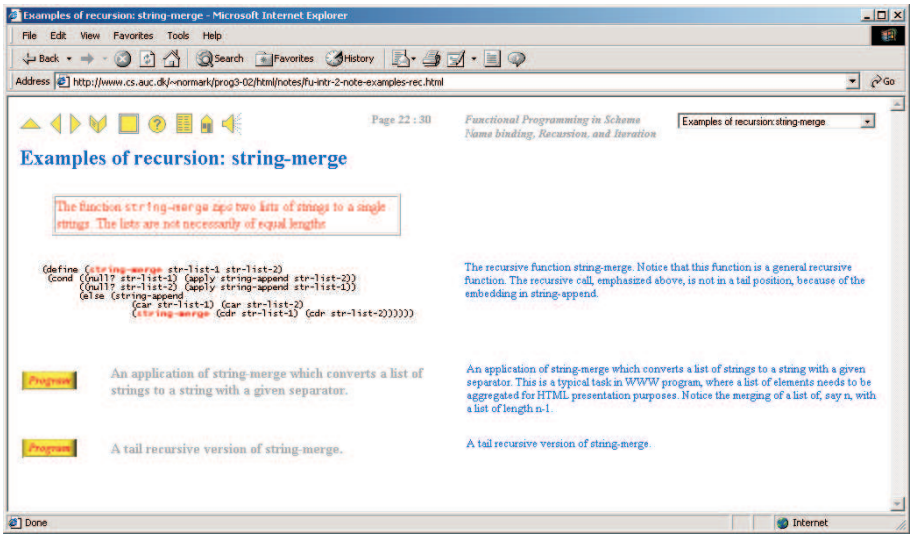

Figure 1: *An example of the annotated slide view of a note page.*

and the annotations, the textual annotations are horizontally aligned with the slide items. Figure 1 shows an example of the annotated slide view.

The *aggregated view* of the material contains the same information as the annotated slide view, but it is presented differently. The main rationale behind the aggregated view is to collect the material in one scrollable view instead of the rather fragmented presentations in the two first mentioned views. Among the students, the aggregated view is popular as a printing format.

The *thematic view* (see [15] for an example) provides a presentation in the style of a text book. The author is free to rearrange the elements in the thematic views in relation to the ordering of the elements in the other views. In addition it is possible to add extra elements to the thematic view. Such extra elements are primarily used to make a more complete and coherent coverage. The layout used for the thematic view is intentionally kept simple such that it is easy to provide for good paper hard copies. The page layout of the thematic view has been chosen as a compromise between the annotated slide view and the aggregated view. A given theme is meant to be analogous to a section in a book. LENO organizes PDF versions of the thematic views (one file per lecture), but it takes some extra manual work of the author to produce the PDF files, mainly due to page breaking concerns. Figure 2 shows an example of a thematic view. Figure 2 covers the same aspects of the lecture notes as shown in the annotated slide view of Figure 1.

In some materials we do not want to support all four views. It is therefore possible to generate exactly those views which are wanted, and to appoint one of them as the *primary view*. The primary view is used for hierarchical navigation

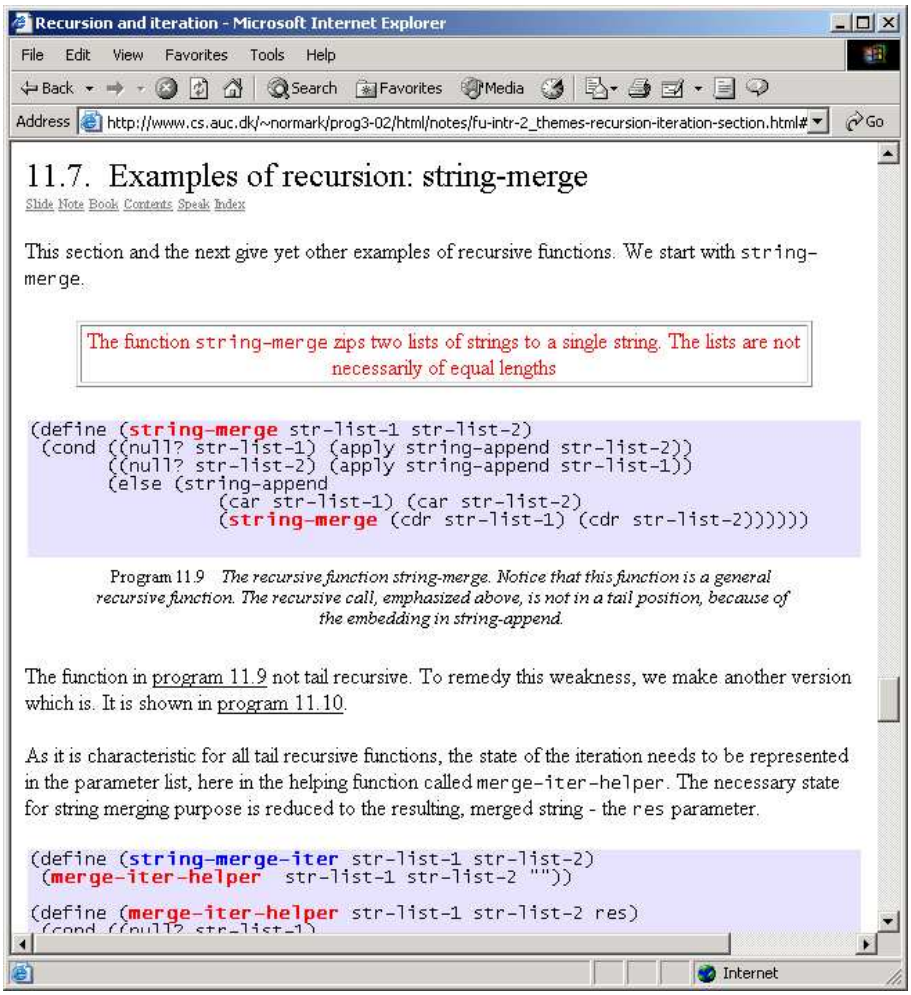

Figure 2: *An example of the thematic view of a set of note pages.*

into the details of the material. The main reason behind this part of the design is not to impose more complexity on the user than actually needed.

From an overall teaching perspective we find that the four lecture note views support the different and varying needs of the students. This includes students who only need to recall the overall outline of a lecture (using slide view); students who need to to recall some details of a lecture (using the annotated slide view); students who need to read a coherent coverage of the subjects (using the thematic view); and students who were not able to join the lecture (using slide view with audio annotations, cf. section 3.3).

3.2 Navigational issues

A LENO material is a hyperstructure formed by many pages and even more links. Navigational design is one of the main challenges of such a material. More concretely, it is important to achieve a good balance between *navigational simplicity* (relatively few well-arranged links) and *navigational completeness* (links to all relevant neighbor pages).

Another topic is *navigational flexibility*, especially in the subset of the system where it is necessary to navigate linearly through many pages (slide view, annotated slide view, and to some degree the thematic view). LENO materials support navigational icons (left, right, up icons) together with selected (textually anchored) "down links." As an important supplement to this kind of navigation, a LENO material is almost hundred percent keyboard navigatable. Using the keyboard navigation it is fast and flexible to navigate both back, forth, up, and down in the material.

In some editions of the material we entirely remove the navigational icons in order to get more screen space for the content elements. Such editions are only useful for relatively skilled users who know the keyboard shortcuts. Novices are likely not to be able to use such editions of the material.

Besides the interliking of the teaching material, the definition of links to external web resources is very important. It is often the case that students are overwhelmed of the amount of relevant resources on the Internet. It is therefore a valuable contribution of web-based lecture notes to select and organize a subset of these resources. Care must be exercised in the actual anchoring of these external links in the material. LENO supports different kinds of cross reference elements, includings means to categorize these by visual clues.

3.3 Audio facilities

The main intended use of the audio facilities of LENO is to provide automatically playing and progressing lectures, where the teacher "tells the story" while the students are looking at the material in slide view. Due to the automatically progress through the slide pages of a lecture, any kind of user navigation disrupts the audio of the current page.

Given the observation that most university lectures are one way communication (from teacher to the listening students) we hypothesize that a web-based lecture is a valuable supplement to the real lecture, and in some special cases even a reasonable substitute for it. Some aspects are lost, however, not least the immediate feeling of the audience's reaction to the exposition. Also, some students complain that it is boring and non-inspirational to listen and follow a presentation from the web. Other aspects are gained, such as *just in time lectures* (not too early, and not too late in relation to the time where the material is actually needed), freedom of time and place, and the possibility to have repetitions of the lecture (just before an exam for instance).

From the perspective of the author, it is rather demanding to create, edit, and manage the audio sequences. As a concrete procedure, we created the

audio files, basically sentence for sentence, without any written manuscript. This approach made it easy to re-record a single sentence, in case of clutter. During the production of the audio tracks of LENO lectures we have observed that some aspects are natural and easy to explain using audio (complicated or voluminous explanations of various kinds) whereas others are more natural to explain in writing (such as explanations that require great rigor and use of mathematical precision).

In addition we hypothesize that in some situations the audio track and the slide exposition complement each other in valuable ways. This is, for instance, the case in situations where the students are supposed to understand a computer program. On the screen the student can see the program with appropriate colored highlightings. During the loud speakers the students get explanations of the different aspects of the program. It would be more difficult to grasp such explanations if they were given textually, because it would call for shifting the attention between the written explanations and the program.

As an alternative to following an automatically progressing slide presentation with audio, LENO supports the playing of the speaker's sound more selectively. This can be activated from all views. As an important twist, this mode of audio makes free navigation possible while listening to the teachers explanations.

Streaming recorded video of "the real lecture" is an obvious alternative to an automatically progressing slide show with accompanying streaming audio. However, it is not easy to follow a slide presentation in such a video recording, unless the slide presentation and the video streams are synchronized explicitly after the lecture, and presented in separate frames. It may take a substantial amount of resources to produce and edit good video lectures, and to synchronize them with the slide presentations. On the other hand, the students may experience a more lively presentations, in contrast to an "audio-only approach."

3.4 Animations

In a traditional lecture the black board is often being used to illustrate dynamically progressing scenes. I.e, while time is progressing an illustration is changed or extended in such a way that a temporal development is illustrated. We do not find that the blackboard is the ideal medium for dynamic expositions, but it is simple and straightforward to use, and it is almost always available.

In a web-based teaching material it is desirable to supplement static text, static graphics, and audio with animations. Based on some recent development of course materials using LENO, we hypothesize that some complicated concepts or scenarios can be explained much better with use of animations. LENO supports both the handling of Java applets (which can be used for animative purposes and other purposes as well), Flash animations, and animations made in SVG [5].

We have experienced various difficulties with animations. First, animations are relatively difficult and time consuming to produce. Second, in the current setup of LENO, it is not easy to synchronize the audio track with the timing of the animation. It means that we cannot comment directly on the temporal

evolution of an animation in the audio track. We see two different solutions to alleviate this problem. Either we should use an approach where the sound and the animation can be synchronized in a better way. SMIL [6] from the W3C represent one such approach. Flash can also take over the job, but use of Flash would easily imply that more materials are drifting into binary and proprietary formats; We are opposing this development (see also section 3.5 and section 3.8). Finally, we could extend the audio presentation to video presentations, and in that way achieve a synchronization of the animative aspects with the sound. But as discussed in section 3.3, current streaming technologies make it difficult to transmit video with sufficient resolutions to suit the animations.

LENO has been used as a web integration framework in an ECIU project on web-based learning [8]. The creation of animations (with Java applets, Flash, and SVG) was the main focus of this project. Because of the relatively high development costs, and because animations do not depend heavily on the language of the teaching material (whether English, Finnish, or Danish for instance) international cooperation makes good sense for production of a collection of animations within some selected area.

3.5 Delivery format

In our work on LENO and LENO-based teaching materials we have gone for production of teaching materials using HTML (concretely HTML4.0, [4].) There are several reason for that.

First, HTML is the core format of information on the World Wide Web, and as such HTML material integrates well with other informations on the Internet. Most important, it is straightforward to link the created materials with other web resources, because of the underlying information model is hypertext [2, 11].

Second, HTML documents are perceived as "lightweight information" which can brought up and used immediately. As a contrast the "paper on screen formats" such as Postscript, PDF, and Microsoft Word are more heavyweight formats, which rely on plugins that may or may not be available or present on the user's computer. A standard HTML document can be handled by almost any computer in the world, without any need of prior software installation, setup, complicated registration procedures, and similar frustrations.

Third, HTML is an open, textual format defined by the International Web Consortium (www.w3c.org) which controls the standardization process. We oppose use of binary, proprietary document formats because they limit the broad use of the lecture notes. An HTML document can, if necessary, be read in any text editor and parsed, processed, and presented by a variety of different tools. As a contrast, binary formats are often not documented, and they can only be handled by few programs, which typically are in the commercial domain. This limits the freedom to experiment with new and alternative uses of educational materials. Even worse, it binds the author to a specific tool, and it makes it difficult to transfer the materials to other tools in the future.

Sound formats are problematic because textual formats do not make sense. In addition, the playing of sound is not well standardized in Internet browsers;

Plugins of various kinds are needed. Therefore it is relatively difficult to reach a wide audience with sound-augmented materials.

The situation of animations is somewhat similar to the problems with sound. However, XML technologies such as SVG and SMIL are promising, at least in the sense that they are open, textual formats which fit well with HTML-based web materials. Of that reason we currently prefer the use of SVG for simple animations.

3.6 Look and feel

It is relevant to compare the graphical appearance of web-based presentations with the presentations in dedicated presentation systems, such as Powerpoint.

The model of page layout in a web-based presentation differs from the layout model used for a Powerpoint page. The latter always fits on a single page (screen or paper) whereas the former may need scrolling on the screen. Worse—perhaps—the appearance of a web-based presentation is affected by use of different screen resolutions. Apart from very large note pages (on which scrolling is desirable) the scrolling model seems to be the loosing one for slide presentations. In the longer run a scalable approach, like the one supported by SVG, should be preferred.

LENO supports two basic modes of presentation. The first and the original one uses pure HTML rendering of the material. The second and the most recent one relies on cascading style sheets, CSS [1]. With the use of CSS it is possible to approach a more professional look of web-based slide presentations. Equally important, it is possible decouple the structure and contents of a note page from its visual appearance.

The basic "interactional feel" of a page in a LENO presentation is dominated by the possibility of following links, many of which are anchored in designated LENO icons (see figure 1). As already argued in section 3.2 we find it important also to support keyboard navigation along the most important structural relationships of the material. This facility of LENO makes it faster and more flexible to browse through a collection of teaching material.

3.7 Single sourcing

In this and the following sections we will discuss aspects of the LENO system that are of interest primarily to the authors of lecture notes.

The idea of *single sourcing* is to use a single representation of the source document to produce a variety of derived documents [10]. Successful single sourcing depends on an appropriate structuring of the original source format of the document, such that different variants of the document can be extracted.

In LENO, the slide view, the annotated slide view, and the aggregated view provide the most basic example of single sourcing. Because of the massive information overlap among these presentations it would be unwieldy and inconvenient for the author to create each of the views from separate source descriptions. In contrast, the thematic view is created on the basis of a secondary

source which allows the author to control the selection and sequencing of the note page elements. A skeleton secondary source (with trivial mentioning of all note page elements in their original order) can be made automatically by LENO. Most of the elements in a thematic view just refers to existing elements in a given lecture and note pages, but supplementary elements and "theme text" can be added as well.

The inclusion of external text files in a LENO material is another example of the use of single sourcing principles. In our use of LENO, the primary example of such external text files are computer source programs, which are exposed and discussed in the teaching materials. If the source file of a computer program is copied into the teaching material *during the authoring process*, we end up having two copies of the program: One which can be compiled and executed, and another which is part of the teaching material. In such a setup it is very difficult to keep both versions up-to-date when modifications of the program are carried out.

Using LENO, the inclusion of a source program is done *during the document derivation process*. It means that the primary copy of the program is always the same as the one being compiled and executed. Each time the material is being regenerated, a fresh copy is included in the teaching material. The inclusion is based on information about the source file location, which portion of the file to include, and how to decorate the extraction with fonts and colors.

The LENO approach to inclusion of computer source programs assures that the version of the program, which is exposed in the material, is the same as the version which is applied and running outside the material (at document derivation time, at least). This is usually what we are interested in. There may, however, be special situations where we want to isolate ourselves from frequent—and perhaps irrelevant—changes of the external materials. In these situations the LENO document should refer to a protected copy instead the original source file.

During the life time of a teaching material, the material is often used in several different educational contexts. Some of these may require in depth discussions, whereas others call for a more superficial and overall treatment. Again, it is useful if we can accommodate both uses from a single source of the material. If not, we end up with two or more copies of the material which are difficult to maintain separately.

In LENO it is possible to define a *trail* through the pages of the material which *selects a subset* of the pages, and which *controls the ordering* of these in an alternative presentation of the material. Technically, trail pages are represented as HTML framesets, which refer to the original LENO pages. The frameset pages can be linked together in an order which is independent of the linking of the original pages. The trail facility of LENO has proven its value in the creation of material to open university overviews of courses, which are taught at a more detailed level on campus.

At a more fine grained level, LENO supports a repetition of single elements of note pages without actually repeating the element in the document source description. Use of repeated elements is useful in situations where we need

to recapture a concept or an idea be reviewing some details that already have been covered earlier in the material. Using LENO, it is possible to manage fine grained repetitions by referring to the original elements via use of unique lecture ids, page ids, an element ids.

Seen from a student perspective, the use of single source ideas will improve the quality of the teaching material, because certain inconsistencies are unlikely to occur. From the teacher perspective the use of single sourcing helps to reduce the complexity of the authoring process, because information only needs to be changed in a single place.

3.8 Authoring format

In section 3.5 and section 3.6 we argued about the delivery format (HTML and CSS) of a web-based teaching material made with LENO. In this section we will discuss the format used by the author of the material. This aspect is of central importance for the teachers who create educational materials with LENO.

A LENO material is authored in an XML language [3]. More specifically, we have created an XML document type definition (DTD) for LENO. The LENO authoring approach is similar to the use of markup languages in the style of TeX or LaTeX. Many authors, who use to work with contemporary word processing tools (like Star Office, Word, and Word Perfect) will not feel comfortable writing raw XML markup in a text editing context. Such users should—now and in the future—rely on modern XML authoring tools, which will be able to produce the XML LENO format on the ground of the document type definition.

The creation of (static) graphic elements impose particular authoring problems. In the delivery formats, static elements of graphics are represented in one of the bitmapped representations, such as PNG, GIF, or JPG. From an authoring perspective, it is difficult to avoid use of an external, pixel-based drawing program. The use of such a tool is not likely to integrate well with a text editor or an XML authoring tool.

The LENO XML language is mirrored into a functional programming framework using the LAML software package [17] and the Scheme programming language [9]. As such, a LENO material can be authored in a programmatic context. The main reason to use programmatic authoring [16] is to cope with various kinds of document complexities. In our own use of LENO we have consistently made use of programmatic authoring. We will now give an example of document complexity and the solutions that we apply in LENO.

Web-based teaching materials are likely to exist in a number of different variations. One important variation is bound to be the edition on a web server. Another common variation we have dealt with is an edition on CDs, which can be distributed to the students. Other variations may be a printable edition, and an edition on the teacher's laptop computer. The interlinking of LENO pages with external resources is the main difference that distinguishes the different variations. In local editions on CDs and laptop computers, some of the external resources may be included on the local disk. On a web server edition the links will go to resources on the Internet (located at other web servers).

In order to accommodate different linking structures, *conditional processing* of the LENO source is important. Instead of complicating the LENO XML language with such aspects (and other related aspects) we use the programming language, in which LENO is embedded (and implemented) to deal with the conditional processing. In concrete terms, the details of many URLs are encapsulated in functions, which take the concrete variation of the material into account when a URL is returned. In that way we are able to control the document complexity that stems from variations of the overall linking structure of the material.

The concerns about the authoring format LENO should be seen in contrast to a systems that are strongly connected to a single, commercial authoring tool. Using a commercial authoring tool, the author of the materials is in reality bound to this tool, because the documents are represented in a binary and proprietary format, the details of which are not publically available. As such, the concerns about the authoring format and delivery format (as discussed in section 3.5) are quite similar.

XML languages, like LENO, are textually represented in a framework which is controlled by the international web consortium W3C. It means that LENO authors are free to chose their favorite XML authoring tools (some of which exist already today, but many more are to be expected in the future because of the growing importance of XML). Use of existing HTML editing tools, such as FrontPage, is not of any help to LENO authors. Even though more and more authors use contemporary "What You See Is What You Get" (WYSIWYG) editors, there are still many who prefer document formatting tools that are based on explicit textual markup. We believe that the future use of LENO will be seen among these authors, and in particular among those who master programmatic authoring.

4 Related work

In a broad sense, course web pages cover the area of course home pages and lecture notes as discussed in this article. A recent ACM SIGCSE (Special Interest Group on Computer Science Education) panel reflects this understanding [7]. One of the concerns raised by the panel is the time consumption of establishing course web sites. The use of LENO does not eliminate this factor, but it represents a move in the right direction, mainly because it is based a high-level and domain specific XML model as opposed manual authoring of a set of HTML pages.

LENO can also be related to commercial e-learning systems, such as WebCT (www.webct.com) and Blackboard (www.blackboard.com). Both Blackboard and WebCT are content management systems, which on a grand scale support the distribution of learning materials to students together with communicative aspects in relation to the materials. This includes the management of access rights and tracking of the student's use of the materials. In comparison, LENO is a more limited system which emphasizes the organization of the content as

a contrast to more overall management tasks. LENO does not support any student tracking, and it leaves the access policy to be decided by contextual mechanisms.

There is also a large and diverse set of non-commercial (free or open source) systems which can be related to LENO. As examples of such systems, we will mention Claroline and SiteLite. Claroline (www.claroline.net) is a course management system which emphasizes ease of use for both teachers and students, mainly due to use of web interfaces for both kinds of users. LENO support management of the lecture notes, but the use of LENO requires certain XML competences on the teacher's part. SiteLite (http://www.ia.hiof.no/~borres/sitelite/-ver30/) is a general purpose system for creating complex web sites. SiteLite can be used to organize lecture notes, but the scope of the system is actually much broader than the scope of LENO. Like LENO, SiteLite version 3 is based on XML.

5 Status and conclusion

The LENO system has been used in the Computer Science Department at Aalborg University, by the author of this article (and a colleague) for delivery of teaching materials since 1998. LENO is still in active development, side by side with its use to create new lecture notes.

The XML authoring interface of LENO has been created as part of the ViLL project. The goal of creating the XML interace, which replaced an older ad hoc interface, has been to broaden the applicability of LENO in relation to people who work with XML formats. During the ViLL project, LENO has been discussed and tested by a number of project participants. Some of the feedback has already been taken into account (ease of installation, for instance) whereas the implementation of other kinds of feedback is still pending.

The main contribution of the LENO system is the unified support of different views, ranging from an overall slide view to the detailed, textbook-like thematic view. The use of single sourcing ideas to create consistent and complex materials is also novel. In particular, we find that the idea of different trails through an existing material is promising. The use of a secondary source for the thematic view, which in part is automatically derived from the primary source, is also interesting.

We find it important to provide a common infrastructure for delivery of teaching materials using standard web technologies. LENO represents our attempt in this direction. In order to ensure unproblematic delivery of the material it is important to be conservative with respect to use of "bleeding edge technologies." In that respect we have succeeded with the kernel of the material, but it is not yet easy to find good solutions for the audio and animation media.

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