The Shared Multimedia Notebook: A Java Tool for Cooperation in Learning Environments

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Abstract: Learners and tutors in cooperative learning environments need a shared tool for preparing material, taking notes and exchanging thoughts synchronously. To this aim, we developed a Java tool, the Shared Multimedia Notebook, which supports shared user operations on static and time-based media objects. Cooperative tasks are supported by enabling collaborative interaction among users and offering perception of a shared context. Results are stored by object persistency and by exportation to various formats. This provides an integrated way for content creation, manipulation and management inside a cooperative setting.

Keywords: Shared multimedia tools, Multimedia Notebook, CSCL tools, Groupware

1 Introduction

In conventional learning scenarios each learner has an individual notebook for taking notes in the classroom and doing homework after class. Similarly, in e-learning environments, it is desirable that learners have their notebook-like software tool as well. Tutors could use their notebook tools for preparing new courses, showing the prepared materials to learners online. Furthermore, in cooperative e-learning environments, learners and tutors can share the content of the notebooks and interact via the notebook to exchange their ideas synchronously. This will be particularly interesting for scenarios like cooperative project design or interactive seminars.

Taking notes and drawing sketches is probably the oldest and most widely spread utility in (traditional) learning scenarios. Constructing knowledge in the sense of dealing with the learning material in an active manner rather than consuming and absorbing information is a successful approach in the field of instructional design. Learners memorize knowledge better if they interacted with the material. In e-learning environments, when studying in distant distributed groups, learners need support for this type of interaction and communication.

In this context, we see the need for a tool that supplies online learning groups with a shared notebook. Its fundamental requirement is the support for sharing data and views so that one user's operation upon the data object will be visible for the whole group. The research on CSCW and groupware has already used the term Shared Workspace to describe this paradigm, and there exist many research prototypes. TeamWave [GB98] based on Tcl/Tk, for example, provides collaborative groups on the Internet with meeting places using a room metaphor . VITAL [PWHS99], which is based on Smalltalk, offers virtual places that support in-house online courses. Our Java-based tool, the Shared Multimedia Notebook, supports joint documentation and annotation of multimedia learning material and therefore supports this type of collaborative knowledge construction.

The Shared Multimedia Notebook serves as a tool for documentation and annotation. This is similar to the function of Adobe Acrobat [AA] in the e-Document market. A PDF edited by Acrobat can contain the main body of document, mostly text and pictures, plus annotations to the document, consisting of static media like text and graphics as well as time-based media like audio and video. In this way, it meets the claim for supporting rich content of various media types. But Acrobat doesn't offer a shared workspace for e-learning.

We regard multimedia as an important element here, because both the static media and time-based media are often used in the field of education. We are exploring technologies, that equip shared workspaces with multimedia. The notebook includes multiple media types in cooperative learning environments.

Another requirement for a shared notebook tool is that it provides a semantic representation for external access and common formats as output.

In this paper, we present the Shared Multimedia Notebook (SMN when referred below), a Java-based cooperative tool for e-learning environments. We use an integrated representation of objects of various media types. Audio and video are taken as a first-order data type [K97]. In that way, all elements are represented explicitly and are easy to handle. Furthermore, creation, manipulation, representation and exportation of elements can be performed within a SMN, thus no other application is needed.

In the next section, the motivation for the SMN is provided. In section 3, the system architecture concerning mainly the structural and behaviour model and collaborative multimedia interaction are presented. Section 4 introduces an implementation of the tool. A discussion on our work and a comparison with related work are given in section 5. The last section concludes the paper.

2 From Paper-Based Notebooks to Shared Multimedia Notebooks

Today, the integration of multimedia (streaming media) elements into online courses is becoming more and more common. In the beginning of the e-learning era multimedia content was desired, yet could hardly be used because of practical constrains. Due to the

technical improvements over the last years, learners at home are better equipped and can now make use of more advanced (streaming) media types offered in online courses.

There are indicators that multimedia affects the learning process in a positive way, especially when it comes to teach process knowledge or learning by observation, e.g. how to operate a machine. In some areas, teaching without multimedia would mean a great loss in the quality of a course. One might think of language learning: audio will help to learn how to pronounce a word; video will even demonstrate typical gestures that belong to a foreign language. Therefore we aim to support multimedia content in a shared notebook to provide the learner with the means to take notes, exchange ideas combined with all types of media.

We designed the Shared Multimedia Notebook for small distributed learning groups consisting of 3 – 5 learners. These groups are studying synchronously as well as asynchronously. Each group is supervised by one tutor. Thus, the Shared Multimedia Notebook has to support tutor activities as well as learner tasks.

Learners need to be able to take notes while studying, sharing their ideas and questions with each other and relate notes to the actual course material or comments from others. While collaboratively editing and commenting on material or ideas the learners need awareness about the other learners' activities, e.g. where they are located within the notebook or on the present notebook page. In the SMN the learners can take a snapshot of the current context and paste it into the notebook. There s/he can annotate the picture not only with text or drawings but also with audio or video. This adds a new dimension to online discussions.

When simultaneously watching a video, users can control and annotate the data as they view it together. For assignments, a group can cooperatively prepare for and work on a project and elaborate on a field of common interest. Additionally, a function to store the results of the session is needed, so that learners can analyze the outcome of a session later on. In addition, absent group members get the chance to take a look at the activities they have missed.

Tutors need to assemble the material and monitor the collaborative notebook session. If necessary or upon request, the tutor can join in to answer questions or add material to introduce a new topic or perspective. The saved notebook session allows the tutor to evaluate the effectiveness of the learning material. The learning flow (the procedure) can be kept flexible or structured by the tutor: she can divide a session into three different phases: authoring, discussion and annotation. The tutor may also wish to limit a session to one activity and allow for instance authoring only. Hence, while the SMN supports flexible learning scenarios, stricter learning flows can be mediated by the tutor.

3 Architecture

SMN is a tool with which users prepare material, take notes, rearrange and review the content. It is not just another Word or alike. We want it to support quick-note-taking, rich media types and multiuser usage.

The right side of Fig. 1 lists features important to the users of the SMN. To satisfy the requirements reflected in the user's view, a set of conceptual elements as modules in the

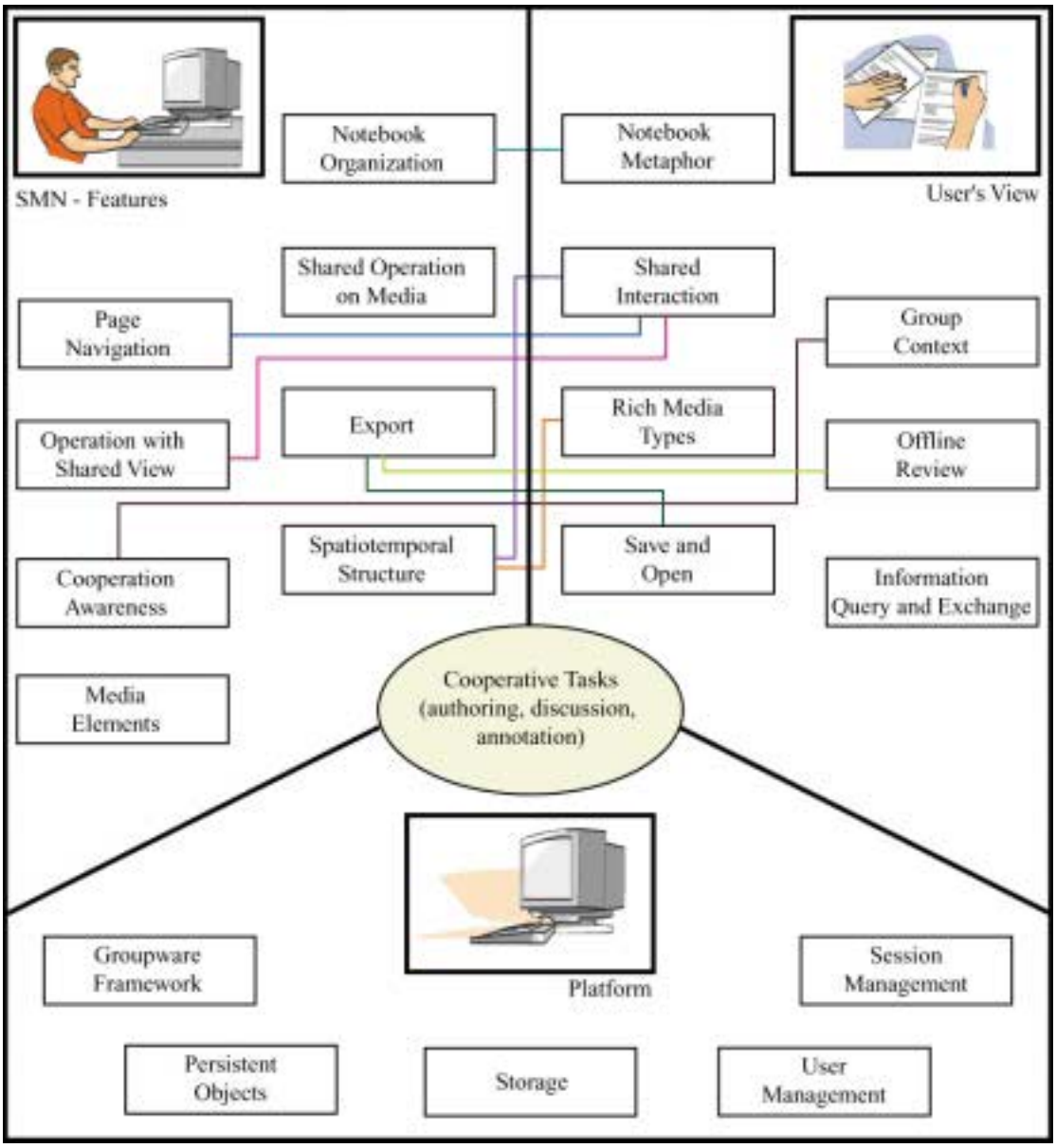

Fig.1: A set of conceptual elements as modules in the software architecture was identified and the mapping between the user's view and the designer's view was set up.

software architecture were identified and the mapping between the user's view and the designer's view was set up. The lower part of the figure contains supporting services such as groupware framework and storage.

In the following subsections, we describe the software architecture in terms of the structural model, the behaviour model and the media interaction.

3.1 Structural Model

We constructed a hierarchical structure to represent an SMN in our software. As shown in Fig. 2, a SMN contains a sequence of Page objects, just as a traditional notebook consists of pages. Inside a page, layers are piled one on top of each other. Each layer has the same size as the containing page. Layers are transparent, so that all the included elements are projected to a virtual "bottom layer". Thus, this forms what the page is perceived, as illustrated in Fig. 3.

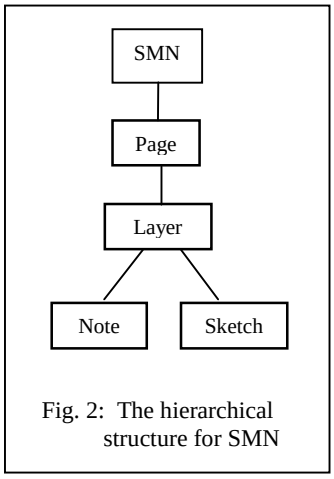

Fig. 2: The hierarchical structure for SMN

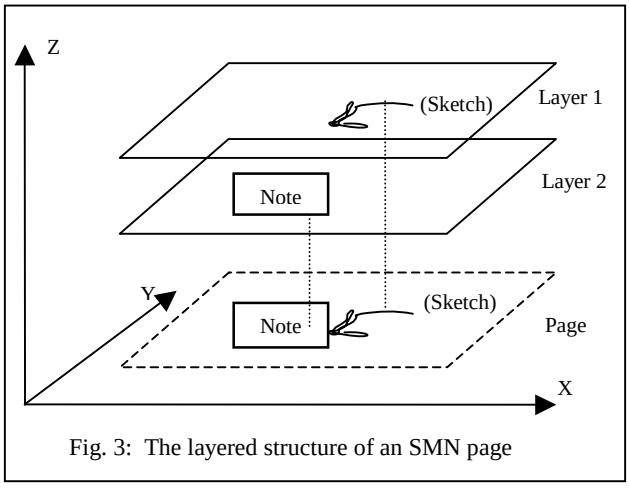

Fig. 3: The layered structure of an SMN page

In a page, the basic elements to be operated are the notes and sketches. More specifically, notes are rectangular components containing different media types, e.g. text, image, audio and video. Sketches are graphical components, e.g., freehand drawing and straight lines. All elements reside in the corresponding layer. The vertical projection maps them to the page.

Different notes and sketches can be grouped together to be manipulated as a composite of elements instead of individual elements. For example, sketches inside a note are linked to that same note, because we assume that the user intends to let the sketch "belong" to that note when s/he draws sketches inside it.

Dividing a page into several layers vertically makes the nature of annotation more explicit. In the current design, we put all sketches to the first layer, all notes to the second layer, and the background image (if any) to the third layer. Actually, more flexible assigning of elements to layers is possible. It also facilitates the software

development, because it is more straightforward to manipulate the elements belonging to a certain layer.

3.2 Behaviour Model

Based on the structural model, which is the static façade of the architecture, the behaviour model represents the dynamics of the user's interaction with the pages and elements.

User activities include collaboratively adding or deleting a page, navigating to a page; adding and deleting notes, drawing sketches, adjusting notes and sketches in terms of position and size; annotation of audio and video, and presenting audio and video.

For the SMN, a toolbar is provided for adding or deleting page and for page navigation. A second toolbar allows e.g. selecting the operation mode (selecting vs. adding elements), choosing a note or sketch type, as well as other operations on the properties of an element.

User's mouse events and key events are at first applied to the corresponding shared element data model. The updates to the shared data model are broadcasted to the clients in the same session. When notified of the changes, the remote sites update their views to stay consistent with the shared data model. Thus, shared interaction among users is realized.

By means of Object-Oriented software design principles (encapsulation, polymorphism and inheritance) the SMN results in an application that is flexible, maintainable and extensible.

3.3 Collaborative Media Interaction

With an SMN, a user can modify the geometric properties (e.g. location and size) of notes inside a page. This user activity of arrangement applies to notes of all allowed media types, including time-based media like audio and video. Users can furthermore play the media in a coordinated way. This can be done by sharing the media control functions among the users.

With that in mind, an informal system model is set up to guide the development of the software. Fig. 4 shows a diagram illustrating the software modules and the interactions between them. The system consists of four modules. The user interaction module maintains shared graphical objects. It is responsible for displaying the graphical views, receiving and interpreting user input events (mouse events and keyboard events) and sending the commands to the shared data model. The layout specification module maintains the spatial layout of the media notes being show. The presented media will be rendered according to the specified geometric properties. The presentation module offers media control functions (e.g. play and stop) that can be used collaboratively by the

participants. The media module maintains the real media data. It is in charge of storing, sending and modifying the prepared audio and video materials.

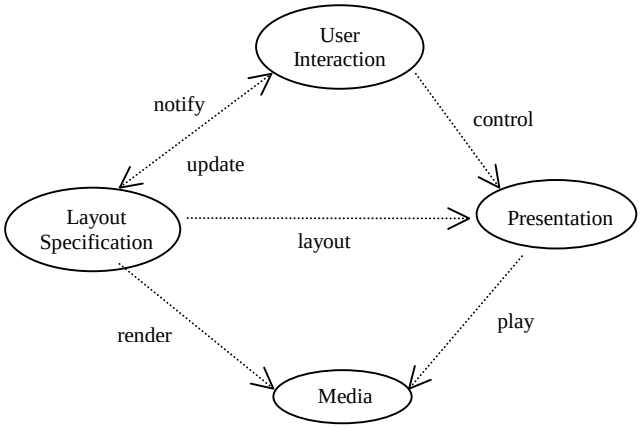

Fig. 4: This diagram illustrates the interaction between modules involved in collaboration media presentation embedded in an SMN.

For recording, the SMN allows participants to record the audio and video locally, and make them available to be presented collaboratively in the shared learning space.

4 Implementation

We implemented the Shared Multimedia Notebook with Java. The fundamental group communication is supported by DyCE [T01], a transaction-based groupware framework. Multimedia presentation and processing are based on the Java Media Framework (JMF) [JMF]. Currently the formats and codecs supported by SMN are constrained by the capability of JMF.

Fig. 5 shows the GUI of SMN. Here the elements of the tool are illustrated as follows:

- A notebook consisting of a list of pages, which can be turned sequentially or randomly by using the navigation tool buttons.
- A toolbar for creating notes (containing text, image, screenshot, drawings, audio and video), and switching between the selected mode and creation mode.
- Shared direct manipulation over notes with mouse operations, including selecting, moving, resizing, and changing properties (e.g. color and line width) of notes.
- Audio and video notes with individual recording and shared control functions.

- Adaptive page size that is changed dynamically to fit the content of the page.
- An index popup window showing the content of the notebook in a tree-like structure view.
- An overview window which is useful for the orientation on large-sized pages.

Fig. 5: The GUI of the SMN, the index tool and the overview window.

The pages of a notebook can be exported and saved in three different formats: SMN-XML (a self-defined XML), SVG graphics and JPEG image. Pages and complete notebooks can be printed out.

For the user it is helpful to view all available functionality of the notebook at a glance. Therefore we decided to represent the most important actions in the toolbar at the top of each page. The navigation features are located at the bottom: the user can browse the notebook with the “back” and “forward”-buttons, add and delete pages and go directly to a desired page by entering the page number. In this way, reading, browsing and editing can be done intuitively. The index (the smaller window on the upper-right) allows the user to navigate directly to a certain page or object. Besides the advantage of free navigation the index gives an overview of the media objects used in the notebook. The overview (“Übersicht”) helps to gain awareness about the other learner’s view of a notebook page: In the screenshot, the outer dashed line shows User 1’s view of the notebook page whereas the inner line visualizes the view of the second user. Thus one can see that User 2’s focus is most likely on the map, since this is the only object completely visible to her/him.

5 Discussion

Some groupware applications ([GB98] [PWHS99]) use a room metaphor. These virtual rooms are supposed to substitute real meeting rooms. [GB98] points out that TeamRoom is significantly more complex than previous groupware application, providing groupware components running within an embedded window. There are similarities between the TeamRoom and the SMN. The SMN is based on a notebook metaphor: which fills the role of a notebook for group members as learners and tutors. A notebook is organized as a pile of pages which can be seen one at a time. A page has a similar role in a SMN as a whiteboard in TeamRooms. Represented in a two dimensional space, notes are the primary elements and drawing annotations are the auxiliary elements for a shared page. The concept of layers adds customization in the 2.5th dimension. The temporal characteristics serve as another dimension in the space by which a SMN is represented.

In some of the existing groupware applications (e.g. [SSGS03]), multimedia in cooperative tasks is supported. But the degree to which multimedia data and function are integrated into the shared environment in those applications are not comfortable for the user: static media and audio/video can not be handled in the workspace at the same time. Compared with it, the SMN offers user interactions with objects of different media types as well as the related awareness in a unified way.

The work in [V98] presents an integrated framework for Interactive Multimedia Documents (IMDs) for single users, that covers most of the life cycle of an IMD from modelling and authoring to execution and rendering. The method of using the IDM is rather complicated for the user and therefore not appropriate for the notebook.

Based on the current work on SMN, some advanced functionalities are possible. Undo/redo could be realized with the usage of the command design pattern. Since a single page can be saved as an image now, a high performance video codec will allow the recording of a session when required, and to replay it.

6 Conclusion

The Shared Multimedia Notebook offers a shared learning space for users (learners and tutors) in cooperative learning environments. Its structure is designed as a composition of shared media objects called notes and the associations among them. Based on the spatiotemporal structure, shared operations on single notes and composition of notes and interaction among users are possible. Therefore, cooperative as well as individual tasks including authoring, annotation and discussion are supported. Group awareness as well as the shared interaction provides users with the perception of a shared context. Exportation and object serialization make the results persistent, produce the output in common formats, and facilitate content management. With this tool, users may create, arrange, store and query their individual input and cooperation results in an integrated way.

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