Interactive Annotations in Web-based Learning Systems

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ABSTRACT

Web-based knowledge-transfer environments aim towards self-directed and collaborative learning. They not only require enablers for personalizing content and context-sensitive interaction, but also for collaboration. In order to overcome deficiencies of current approaches with respect to contextual knowledge transfer, we consider concept building to link content to communication essential. Our technical enablers are tuned and enriched features for personalization and collaboration which we term interactive annotations. They have been implemented as overarching concept to hypermedia handling and peer-to-peer communication in the Web-based knowledge-transfer platform ScholionWB+ \(^1\) [7, 8]. Our solution is highly flexible, coupling hypermedia content with common communication tools in traditional browsers settings.

1. Introduction

One of the long term goals in advanced distributed learning is to put learners in control of the knowledge-transfer process. Today’s knowledge-transfer processes occur increasingly through asynchronous as well as location-independent communication or interaction. Depending on the applied didactic principles and individual involvement they might occur in a many-to-many communication environment. They are also increasingly based on hypermedia, computer-mediated interactive software systems [1]. With respect to the learner control, both, the personalization of content, and context-sensitive communication in the course of knowledge transfer are critical to establish user-centered Quality of Service (QoS) [2, 3].

Annotations in electronic documents are considered to enable the aforementioned quality parameters [4]. In [5] this enabler function is described along the process of creating content in a collaborative way: “The author writes a prototypical paper, makes revisions and hands the paper over to one or more ‘critical’ users. Critical reading in this case means reading and annotating the document to give the author hints to remove mistakes and redesign the paper structure and hence improve the paper’s quality.” In a review and revision context, annotations can not only be suggestions for modifying a document, but might also point to related ideas in other resources, such as books or articles.

Interactive annotations enable individual electronic versions of content that can be utilized in the course of knowledge transfer and collaborative learning. There already exist empirical data on the increase of knowledge, when students work with the personalized content in networked, interactive hypertext systems [6]. Ideally, interactive annotations (i.e. electronic annotations on electronic content) should be manipulated similar to traditional annotations, e.g., overlaying some transparent slide, and thus, decoupling individual entries from the original material [7, 8]. So far, traditional, html-based web applications do not support interactive annotations, although the W3C-Annotation Working Group [9] has already specified their meaning in general terms: “In general, an annotation is defined as any object that is associated with another object by some relationship. The annotation object may be of any type and the relationship between the annotation object and the object it annotates may also be of any type.” In [10] we find annotations explained more specific as the „complement of a document in order to textual or graphical notes at meta level“. Finally, in [11] annotations are explained in the context of web-based content management: “An annotation of a web page is any object, which is displayed within or accessible from the original by accessing the original.”

Allowing learners to personalize content according to their needs and individual mental associations (cf. [2, 7]), an annotation concept should enable textual notes to content (elements), markings of content elements, and multimedia attachments to content. Those enrichments should become part of the content for context-oriented learning [3]. In this way, learners can adapt content to their individual knowledge and experience [12], as well as actively change it (as demanded in [1, 2, 13]).

Since self-directed knowledge transfer should also allow for communication, collaborative and context-sensitive learning (cf. [3, 14-16]), learners should also be able to interact from different locations and in different time periods. However, the respective technology should preserve the context of interaction at any time, without

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\(^1\) ScholionWB+ is a web-based knowledge-transfer environment developed at the Johannes Kepler University (cf. [8]).
respect to the location. Consequently, typical tools for communication, such as asynchronous discussion boards or synchronous text-/voice-chats, need to be enriched with links to the content they are referring to. Then, they facilitate virtual team building among learners and involve teachers as coaches in the course of effective collaborative learning [1-3]. A comprehensive annotation concept has thus also to capture references of communication entries to (individualized) content.

Although the World-Wide-Web facilitates sharing of information and distributed processing of data, none of the standard web-browsers has adopted any annotation functionality so far. However, the use of this mainstream technology allows to address a large user community.

Thus, we had to enrich existing browsers with the features enabling personalization of content and context-sensitive collaboration. We did that as part of the ScholionWB+ (scaleable technologies for teleteaching/learning web-based) project that is also described in the following. In section 2 we review related work with respect to personalization and context-sensitive communication through annotation systems. In section 3 we elaborate our concept for annotation systems and introduce technical enablers. In section 4 we discuss the implementation of the annotation concept meeting the requirements listed above. Section 5 concludes the paper, reframing the results of the presented work.

2. Related Work

Although, at a first glance at benchmark and evaluation studies [19], the migration of hypermedia concepts with features for personalization or vice versa does not seem to be highly developed, there exist some concepts to that direction. For instance, using Adobe’s Acrobat Reader [20] readers can individualize PDF-documents, entering arbitrary text as a note to a document page. The note can then be dragged to any position on the document and edited. Notes can be exported and imported, thus requiring to send only small note files from the annotator to the author of a document instead of the entire PDF document. Acrobat Reader also allows creating a note summary document, but does not support context-sensitive communication at all.

In Hyperwave [17] annotations are part of the Information-Server-6 functionality. They enable users to attach annotations to documents regardless of their write permission. Annotations can be attached to single words, phrases or parts of a document. Notes may also be bound to specific positions within the document, an entire document, or a collection of documents. Although Hyperwave also provides communication support, it does not allow to trace back discussions to content elements. In contrast to Hyperwave, Kolumbus [3] enables computer-supported collaborative learning (CSCL) primarily by means of communication. Students give feedback to others’ content through annotations. Evaluation results show that this concept is highly appreciated. Students add annotations to singles items and use existing content as (explicit) contextual information.

Amaya [18] is a software system for browsing, authoring and individualizing web pages. Using Amaya users can create web pages and upload them onto a server. Authors can either create a document from scratch, or browse the web to find information they need to create individual content. They might copy and paste Web content to their pages, and create links to other web sites within their pages. All those actions can be performed in a straightforward way within a single environment. In this way, maintaining the consistency of content is facilitated. Amaya allows users to display the document structure at the same time as the layout. The system allows annotations to be shown as external comments, notes, or remarks that can be attached to any web document or a selected part of the document. This feature is based on the Resource Description Framework (RDF), XLink, and XPointer [9] recommendations.

Besides the technology-driven approaches to interactive annotation systems (resulting in systems as listed above), in the field of CSCW the early recognized need for socially adaptive technologies has led to a well established tradition of empirical and conceptual investigations to that respect. Empirical results indicate, e.g., [21], that the lack of socially responsive developments can be caused by the isolated use of tools.

From these results we understand that an annotation system has to be an integral and context-sensitive part of any interactive transfer environment. So far, there exists no method support for the accurate embodiment of annotation features into transfer environments, in particular, on how to derive concrete design requirements from annotation concepts. To our knowledge, (hypermedia-) environments for self-directed learning have not incorporated conceptual and empirical findings to the extent that teachers and learners have reported an added value when using these enriched technologies.

3. Conceptual Design and Enabler Prospectus

The annotation concept has been developed in the course of the ScholionWB+ project, and is instantiated through features for individualization (ind), collaboration (coll), and linking content to communication (concom) in the knowledge transfer platform. The individualization of content should enable the customization of content to learner needs with respect to mental maps, networked thinking and information linking [8, 14, 15]. The ScholionWB+ developments are based on common e-learning and metadata specifications and standards (e.g.

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*4 Instruments and results of the evaluation are available at [http://scholion.cc.jku.at](http://scholion.cc.jku.at)*
LOM, IMS, SCORM). They have been extended for annotation purposes.

Annotations

Users require a variety of easy-to-understand types of annotations [8]:

(i) Markings allow for highlighting individually important text passages. They also concern the text layout - bold, italic, big, small etc. (ind)

(ii) Textual annotations support adding (public or private) text that can be inserted directly into the content or laid over the content as layered annotations. (ind)

(iii) Multimedia annotations link multimedia files to content when adapting hypermedia to personal needs. (ind)

(iv) Link annotations embed links to internal (targets inside content) or external resources (e.g. www-URLs) into content. (ind)

(v) Library annotations enable links to library entries, e.g., for details provided by the teacher. (ind)

(vi) Discussion and Chat annotations link communication to content. (ind, coll, concom)

(vii) Knowledge-atom annotations: Learners may search knowledge atoms from a content pool, e.g., structured as semantic network, and link it to content elements. Additional resources from standard textbooks, e.g., selected by a coach, might also become part of individual content (ind, concom).

Views

Annotations, such as the ones mentioned above, can be stored in user-specific views, in order to separate interaction from content. A view can be compared to a transparent slide laid over content. All annotations become part of the transparency. Users might use either existing views (slides) or an empty slide and start a new series of annotations. For personalization (and collaboration), users always have to select a view before content can be loaded and displayed. Users might also remove views, put them to a public directory (to all users or to a group of users), or copy a public slide for private use and append own annotations to that slide. This principle of cascaded viewing is illustrated in figure 1.

Cascaded viewing is considered to be one of the key concepts to support collaboration. Since views can be set public to become available for others, users might apply annotations of various types of other users or communities. They also might benefit from the comments and supplements of others as provided through the annotations to an identical content. Annotations can also be linked to content items according to the context of use, i.e. representing context-sensitive collaboration through communication links.

Finally, the view concept is also crucial for achieving high performance. Once content has been loaded, further data transfer is only required for view data (rather than content). Hence, technical communication is kept minimal.

Technology Prospectus

Increasingly, web-based applications strictly separate presentation from the business logic and from data management, mainly through the use of XML and XSLT. Unlike the HTML-based architecture which leads to maintenance problems when web sites grow in size and complexity, an XML-based architecture is highly beneficial. Using the latter there is minor impact on maintenance as content becomes more complex. The ease of content management results from the basic property of XML. It provides a total separation of content (source) and style. The separation can be accomplished by combining Java servlets and XSL style sheets.

In association with graphical user-interface editors, model-view-controller (MVC) frameworks seem to be a precondition for high productivity keeping a 3-tier architecture. Most of the common browser technologies should be capable to support annotation features, namely the Microsoft Internet Explorer 5.0, Mozilla compatible browsers (Mozilla 1.2, Netscape 6.0). In ScholionWB+., the only precondition to achieve that goal is the support of DOM 1.0 and CSS 1.0 (2.0). Otherwise learners are only able to browse through content, and can not utilize annotation features.

The implementation of annotation features for the Microsoft Internet Explorer (MS IE) is facilitated through enhanced concepts of DOM 1.0 that have been integrated in this web-browser. Accordingly, MS IE supports various possibilities modifying (X)HTML content (pages). Textual content can be manipulated easily by addressing selected content parts. For instance, a content part can be marked by selecting appropriate words and then change its textual (re)presentation using Microsoft’s DOM implementation. In contrast to Microsoft’s Internet Explorer, Mozilla-compatible web browsers do not support manipulating web content in this way. However, annotation concepts can be implemented by pre-annotating content pages. Therefore, content has to be
complemented introducing (X)HTML elements (meta tags). They grant indirect approachability, and consequently, the implementation of various annotation concepts. The pre-annotation process (i.e. inserting meta-tags) is based on a recursive client-side algorithm. It decomposes a DOM/(X)HTML document (content and style) into smaller chunks (e.g., words) and encapsulates each chunk through an actively acting start and close element. These elements allow to reflect user interactions (e.g., when users select content elements) by saving temporary data of selected elements. By means of this procedure each user interaction can be traced through the (pre-annotated) DOM/(X)HTML document, similar to MS IE.

4. Implementation

The annotation concept has been implemented in the ScholionWB+ advanced distributed knowledge-transfer environment. Its technical architecture is based on 3 tiers, utilizing the MVC framework and providing database-management-system independency for data management, presentation and the business logic. Most instances of ScholionWB+ use a Oracle 9i (10g) database capturing all data (including all media files and slides stored in BLOBs) and Tomcat 4.1.30. The application’s servlet technology is based on Java 1.4 and generates a XML meta language, similar to HTML, however, independent from styles and web-browser specific characteristics. The language is rendered to XHTML 1.0, DOM 1.0 and CSS 1.0 (2.0). ScholionWB+’s architecture enables personalization of the graphical user interface as well as annotations and individual views. ScholionWB+’s architecture grants the following benefits:

(i) Re-use of model components: The separation of model and view allows multiple views using the same model.
(ii) Enabling high design complexity
(iii) Support for new types of clients
(iv) Clarity of design
(v) Efficient modularity

![Figure 2: Annotations for Individualizing Content](image)

Annotations for personalising content

In order to illustrate the interactive and integrated use of the addressed annotation features, figure 2 shows a browser-window with the different kinds of annotations available in ScholionWB+. They comprise highlighting, textual layer annotations and hidden textual annotations, links to discussions (as discussion annotations), multimedia and library annotations, link annotations and the corresponding menus for manipulating the annotations. On the left side of the screen shot the annotation icon bar gives an overview of the different types of annotations currently available in ScholionWB+.

Linking Content to Communication

Communication can be considered to be most important for collaborative learning procedures. Features to that respect can be implemented in advanced distributed knowledge-transfer environments in various ways. ScholionWB+ supports the currently predominant synchronous and asynchronous communication features. Figure 3 shows an instant messenger (right hand side of the figure) and a discussion forum (center part of the figure).

![Figure 3: Annotations, Communication and Collaboration](image)
In addition to conventional communication elements, the ScholionWB+ system provides several possibilities to link content and communication, thus enabling context-sensitive interaction:

(i) Annotations in the content which refer to discussion contributions or chat logs – see figure 3 ‘Linking Content to Communication’ and ‘Discussion Annotation’. Note that the discussion forum is directly opened in the content, exactly at that position that matters for the individual user.
(ii) Links to content elements from the chat forum, the discussion board or the infoboard
(iii) Links to library entries or to multimedia files in chat contributions, discussion contributions or infoboard entries
(iv) Insert capability for content elements from a semantic network into discussion contributions (knowledge-atom annotations)
(v) Cascaded viewing (see figure 1)

5. Conclusion

Putting learners in control knowledge transfer processes requires increased Quality of Service of distributed learning environments. Making advanced use of annotations for supporting the individualization of content and collaborative learning allows to bridge the gap between content management and communication. As demonstrated through the Web platform ScholionWB+ learners might (re)design content individually, as well as learn in collaborative and highly interactive knowledge-transfer settings without having to care about context-sensitivity and consistency. In addition, the sophisticated view concept provides firsthand feedback from learners to teachers for the sake of continuous quality management and content improvement. The implemented concept does not only comprise several features for enhancing content (through text comments, questions, media files etc.) for individual link management, but also the capability to adapt, share and cascade views (that are required for individual as well as group task accomplishment).

The results of an evaluation of ScholionWB+4 [22] concerning the adjustment of learning materials to individual needs clearly show that the provided functionality influences learning habits of learners in a positive way. In particular, the annotation tool enabling a link between content and communication was highly appreciated by the students. Additional value has also been perceived when multimedia functions for collaboration have been combined with hypertext documents. Expecting an increased use of digital documents, annotations have to be considered crucial for user acceptance of web-based knowledge-transfer applications. Our future research will focus on developing further personalization features, and integrating annotation functionalities into mobile learning devices5 (e.g., PDA and Phone).

6. REFERENCES


5 see http://www.mobilearn.at, http://scholion.ce.jku.at