Designing Structured Annotations to Support Collaborative Writing Workflow

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ABSTRACT
Current writing tools support basic annotations, such as edits and comments, which are anchored directly in the document, but these tools are not sophisticated enough to support the full collaborative writing workflow. We propose annotation bundles, which are comprehensive annotation structures that better support the collaborative writing process.

KEYWORDS: collaborative writing, annotation, workload, and workflow.

INTRODUCTION
Collaborative writing, especially the reviewing stage, in which most of the collaboration effort is spent [3] [4], often involves co-authors passing an annotated document back and forth. In addition to making basic annotations such as inserting, deleting, and commenting, which are supported by current writing/reviewing tools, co-authors also need to communicate at a "higher-level" about a document; e.g., commenting on the tone of a document, giving more explanation about a group of basic annotations, or having a document-related discussion. These communications are a form of annotation, which we call complex annotations. They often take place "outside" of the document (e.g., in email), in part because they are not supported by current tools. The goal of our research is to support all annotations activities uniformly using structured annotations to facilitate workflow management during collaborative writing.

To explore this goal, we began by establishing user-centered requirements for annotation support. Then, in light of these requirements, we defined more precisely what constitutes an annotation and what attributes link annotations to their context either within the document or among related annotations.

REQUIREMENTS ANALYSIS
In order to understand the full range of annotations, we first analyzed email exchanges (including document attachments) from three different groups of co-authors. Based on the results we found, we identified the set of annotation tasks that co-authors engage in. This resulted in a list of ten requirements, focused on complex annotations, that a reviewing tool should support.

We then evaluated these requirements against current reviewing tools such as the "Track Changes" and "Comment" features in Microsoft Word XP and the reviewing functions in Adobe Acrobat Professional 6.0. We found that current tools fail to fully support many of the requirements. We discuss four of the critical requirements for complex annotations.

1. *The ability to make overall comments.* Many co-authors prefer to write comments that pertain to the entire document in email. For example, they comment on the tone of the document or make suggestions about the document structure.

2. *The ability to annotate a group of existing annotations.* Co-authors often point out an issue that arises at multiple places in the document. Currently, co-authors can only describe the associated annotations using text. There is no way to annotate multiple annotations directly.

3. *The ability to direct annotations to a specific co-author.* Questions to co-authors are common annotations included in emails because it is easier to direct them to a specific co-author and get a quicker response.

4. *The ability to prioritize annotations.* Co-authors describe in email how their annotations should be handled. They point out important ones in the email and often prioritize them since there is no trivial way in current reviewing tools to do that.

We believe that creating a comprehensive understanding of annotations is the first step towards having tools that support the full collaborative writing workflow. Most importantly, any definition of annotations needs to somehow describe the structure of an annotation. How an annotation relates to the document and to other annotations is critical to supporting workflow.

COMPREHENSIVE ANNOTATION DEFINITION
The word "annotation" carries different meanings in the literature. Marshall [2] classified paper-based annotations into four categories depending on their anchors and ranges in the document. Later, Brush et al. [1] defined digital annotations to be a marking made on a document at a

particular place. Each annotation has two components: an anchor and content. However, these two definitions only include document-embedded annotations, ignoring unanchored annotations and meta-comments about other annotations.

We have constructed a comprehensive annotation definition in which every document-related marking is a "bundle," so basic and complex annotations are just different kinds of bundles.

A bundle has the following attributes (some may be empty):

A1. *Elementary attributes*: name, creator, time stamp, recipients (i.e., who will see the annotation).
A2. *Comment*: notes that are related to the annotation.
A3. *Anchors*: indicating the annotation's location and range relative to the document or other bundles.
A4. *Modifications of the document*: the textual changes that the bundle makes in the document. This attribute will only be meaningful when the bundle is an insertion, deletion, or a replacement.
A5. *Sub-structures*: a list of earlier annotations that this annotation links (refers) to.

We can now illustrate how different types of annotations fit into our comprehensive annotation definition. Note that A1 is common to all bundles.

- Edits: bundles with non-empty A1, A3, and A4.
- Comments: bundles with non-empty A1, A2, and A3. A comment can have one or more anchors in the document. A special type of comment is a Global Comment, which anchors on the entire document.
- Meta-comments: one type of complex annotations that have attributes A1, A2 (optional), A3, and A5.

Using the comprehensive definition, we can build a structure with all annotations related to a document in which basic annotations are anchored directly to the document text and complex annotations are linked to other annotations.

HIGH FIDELITY PROTOTYPE – THE BUNDLE TOOL

We built the "Bundle Tool" using Java Swing. It illustrates all our design ideas within a simple editor. There are at least three ways that the Bundle Tool fulfills our list of requirements and enhances the notion of a comprehensive annotation.

1) Besides the basic functions that a typical document editor has, such as insert, delete, comment, the Bundle Tool has specific functions designed to create complex annotations. These annotations are stored with the document and linked to various places in the document or to basic annotations. For example, users can insert a global comment, a comment about a group of edits and comments (See Figure 1.), or they can filter annotations on author and annotation type and then save the resulted annotations as a bundle.

2) Another enhancement to the bundle idea is the way we display annotations in our simple editor. In order to capture the structure of annotations, we use a threaded display for annotation groups in the reviewing panel, which is a panel just below the document displaying detailed information about annotations. Users can expand or collapse any bundle to view or hide the annotations belonging to the bundle. The annotation display scheme within the document text highlights the various annotation attributes. Moreover, we provide users with the option to focus on just one or more particular bundles of interest and ignore other annotations.

3) Our navigation techniques help users create a mental model of the document and their annotations. Users can select multiple bundles at a time and perform an operation (e.g. setting their reviewing status) on all the chosen annotations. If a bundle is selected, all its sub-annotations will be highlighted in the document. Users can also have several bundles active at the same time, and switch between them. In addition, users have the option to prioritize bundles according to their importance.

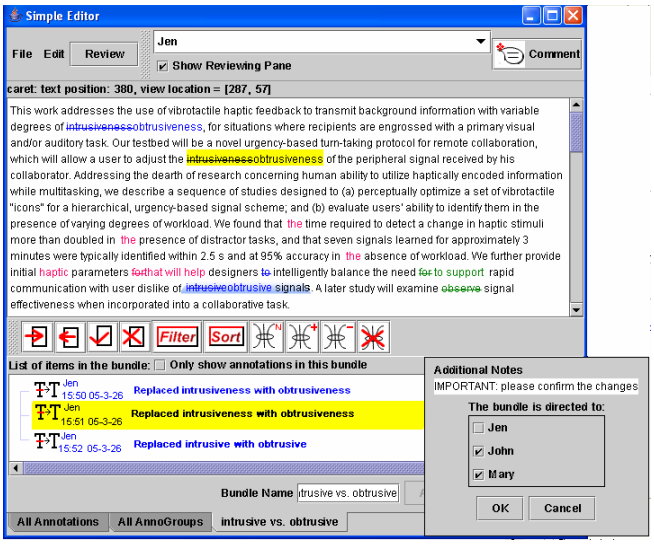

Figure 1: Simple Editor embedded with the Bundle Tool.

FUTURE WORK

Our next step is to conduct a usability study and test to what extent our bundle tool can reduce the individual reviewer's workload and support the collaborative workflow as a whole. One approach that we are considering is to use our tool to compare three different annotation structures.

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