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Document-related Awareness Elements in Synchronous Collaborative Authoring

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Abstract *Simultaneous collaboration on documents by distributed authors has been supported by numerous synchronous collaborative authoring systems that are widely available. Originally, these tools were found to lack in providing rich enough interaction during authoring. As a result,* group awareness *in collaborative authoring arose as a very important issue in understanding how to provide comprehensive knowledge about other authors and activities they perform upon the document. To promote effectual authoring of documents simultaneously, group awareness is required to allow authors the best possible understanding of others' work on the document.*

This paper reports results about document-related awareness elements from an empirical and experimental study of group awareness. Awareness elements reflect fundamental awareness information in supporting group awareness. Such results teach us what sort of document-related awareness should be provided for collaborative authoring.

Keywords Document management, collaborative document authoring, group awareness.

1 Introduction

Real-time, distributed, collaborative writing systems (RDCWS) allow a group of geographically dispersed authors to work on a document simultaneously. Different RDCWS, such as GROVE [1], SASSE [2] and REDUCE [3], have been developed over the last two decades for users to author documents. Although these tools allow two or more authors to work on the same document at the same time, such a tool is not necessarily used to write an entire document (from beginning to end) in one session. Participants could use tools like email or workflow to write parts of a document asynchronously, whilst other parts are written together synchronously using the RDCWS. More importantly, these tools are not used as widely as they could possibly be used. One of the reasons for insufficient usage of RDCWS is that existing RDCWS have not supported the richness and diversity of interaction found face-to-face.

Figure 1 shows a screen capture of *REDUCE,* which was the RDCWS used in this research. The Figure shows two users writing a document with REDUCE. The two background colours highlight the text entered by each of the two users. Essentially, REDUCE can be understood as being a collaborative equivalent of a single-user word processor.

Understanding current, past or even future work on a document is essential for human interaction. People find it simple when face-to-face to gain a sense of awareness about who is present, what are their responsibilities, what they are doing and where they are located. When group members are dispersed, supporting interaction is far more problematic due to different reasons such as limited views or relatively poor communication [4]. Hence, there is a tremendous need for *group awareness* to provide the highest-quality collaborative authoring [5].

Group awareness (which we simply refer to as *awareness*) is defined as "an understanding of the activities of others, which provides a context for your own activity" [6]. Awareness is relevant to group interaction for various reasons, such as facilitating communication, support of coordination [1] and allowing use of "convention" amongst users [5]. In the case of collaborative authoring, users are provided with knowledge about the document and about past, current or future activities other users carry out with the document.
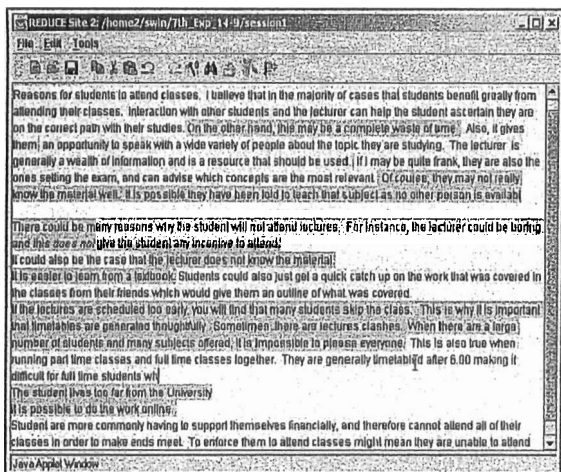
Figure 1: Collaborative authoring ([11])

Awareness elements have been contributed by Gutwin and Greenberg [4]. Awareness elements reflect foundational awareness information needed to support group awareness. Examples of document-related awareness elements include Knowing the parts of a document at which other users are currently looking, or Knowing the parts of a document on which other users are currently working. These elements are types of awareness strongly associated with the document as opposed to an element such as Knowing who is in the workspace which is knowledge of which other authors have joined the authoring session.

It is highly pertinent to study such elements as these elements reflect the information authors require to provide them awareness. This information indicates the support of awareness during collaboration, and therefore reveals the types of functionality provided by *awareness mechanisms*. Awareness mechanisms developed over the years include those such as radar views [7] or modification director [8]. For instance, radar views describe a high-level view of a document, showing where authors are located in the document. Therefore, if from experimental results for collaborative authoring there is support for the element, Knowing the parts of a document on which other users are currently working, it means that a mechanism is required to show where in the document other users are either currently entering, modifying or deleting text.

The aims of this project are to determine:

- which awareness information is relevant for support of group awareness, and
- the relative importance of these types of awareness information.

Gutwin and Greenberg have very usefully prescribed a set of awareness elements in their conceptual framework for workspace awareness. This paper contributes experimental results for document-related awareness elements, which yield findings for awareness support from these results. These findings are applicable to developing novel awareness mechanisms extending the present set available for awareness support. The results are indicative of which awareness information is in comparison more relevant for design of mechanisms than other less relevant awareness information. A further contribution is placed at the end of this paper: using these results to form an explication of how an effective collaborative authoring session can occur. Such an explication can be included because the results teach us about how document-related awareness can be supported in a real-world authoring session.

2 Related work

As mentioned previously, Gutwin and Greenberg proposed group awareness elements. However, we have computed empirical, quantitative results for these elements to determine their relative importance, and therefore, which types of awareness are more pertinent for support.

We have published results from this same experiment that are for *non-document related awareness elements* [9]. Examples of these elements include: Knowing if other users are satisfied with what you have done and Being able to view the list of past actions carried out by a specific user. Such elements are not associated specifically and strongly with work on a document unlike a document-related element such as Knowing the parts of a document at which other users are currently looking. Results for non-document related awareness elements are presented in [9], whereas this paper concentrates on results for document-related awareness elements. A separate experiment with a different number and set of users is reported in [11].

In addition, some major awareness mechanisms that provide awareness support in collaborative authoring are covered in related work. Each of these mechanisms in its basic essence is providing information related to some awareness element(s).

Radar views [7] are awareness mechanisms that support a high-level view of a document. A radar view displays the places in a document where all authors are working. One of the problems with radar views is the gap existing between low-level details and the global structure of a document.

To overcome the problem of this gap, the extended radar view [8] has been developed. The extended radar view uses the over-the-shoulder view, which allows content to be more readable than in the radar view, yet is lower resolution than in the actual document. Authors are able to pick up much content from the over-the-shoulder view without having to use the actual document itself.

Telepointers [10] are a mechanism allowing several cursors—a cursor for each author—to be used within a document. Telepointers assist in showing all

		Experimental sessions											
		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12
Silence first	CW				T1/T2		T1/T2						
	DP			T5/T6					T5/T6				
	BS		T3/T4			T3/T4							
Verbalisation first	CW	T1/T2										T1/T2	
	DP							T5/T6					T5/T6
	BS									T3/T4	T3/T4		

Table 1: REDUCE experimental sessions

the parts of a document that all users are working on concurrently.

Multi-user scrollbars [7] use the well-known scrolling facility of a window to allow an author to see where in a document other authors are working. In this case, there are multiple scroll bars—one bar for each user. A user uses the scroll bar to scroll up and down the document whilst viewing where other users are working on the document.

Modification director [8] is a mechanism that tracks changes in a document. However, since authors are working simultaneously on the document, these changes need to be notified to authors as they occur in time. Details that are notified to authors include the text being modified, the page where the modification takes place, the time elapsed since the modification took place, the type of deletion (if the modification was a deletion) that occurred, etc.

Various other awareness mechanisms have been developed over the years, hence, the above list is by no means exhaustive.

3 Experimental design

The RDCWS used in our laboratory-based experiment was the REDUCE editor [3], which basically contains almost no awareness support. The Swinburne Usability Laboratory of Swinburne University of Technology, Melbourne, Australia, was where the usability experiment was carried out.

24 experimental subjects were placed into twelve pairs and worked on three writing tasks. The writing tasks were *creative writing* (CW) (e.g., writing short essays from scratch), *document preparation* (DP) (e.g., writing a software manual) and *brainstorming* (BS) (i.e., idea generation). The two reasons for using these particular categories are that these categories:

1. reflect a variety of collaborative authoring tasks

2. require different styles of collaboration

The tasks of CW, DP and BS were carried out by the twelve pairs in the following way: 4 pairs worked on CW, 4 pairs worked on DP and 4 pairs worked on BS. The Appendix shows the actual tasks used in experiments. The combination of tasks used by a pair in a session is conveyed by Table 1. As an example, two DP tasks are allocated to the pair in session E8. The first DP task given to the E8 pair is task T5 (T5 is shown in the "Experimental tasks" part of the Appendix) where there is no communication via telephone. The second task given to this pair is task T6 where communication is allowed during collaboration.

Each individual subject of a pair was placed in one of two separate subject rooms. As would occur in real-world distributed collaboration, subjects were unable to view each other from their rooms. From an observation room where notes could be taken, a research assistant observed each pair. The two-and-a-half hour session in which each pair participated included the following activities.

Training subjects in REDUCE (1/2 hour). Subjects learnt how to use REDUCE to author collaboratively.

Experiment (1 hour): Subjects worked together on one task for half-an-hour without verbal communication (silence) and for half-an-hour on another task with verbal communication (verbalisation). Conducting the experiments with and without verbal communication allowed the possibility of determining problems users had when there was only silence and the methods they adopted to address this difficulty.

Questionnaire and interview (1 hour): Each subject filled in a semi-structured questionnaire containing nineteen six-point scale (closed-ended) questions and thirteen open-ended questions. Closed-ended questions were asked to discover if subjects

Awareness elements	Mean	Std dev.	Awareness elements	Mean	Std dev.
In the case of nonverbal communication, having a communication tool that supports communication between users	4.50	0.60	Being able to view the list of past actions carried out by a specific user	3.72	0.98
Knowing the tasks for which other users are responsible	4.33	0.87	Knowing what actions other users are going to take in the future	3.70	1.02
Being able to comment on what other users have done	4.30	0.75	Knowing if other users can know what you have been doing	3.68	0.99
Knowing the parts of a document on which other users are currently working	4.22	1.00	Knowing to what extent a portion of a document has been completed	3.64	1.05
Knowing what actions other users are currently taking	4.08	1.02	Knowing which part of a document at which other users are currently looking	3.36	1.14
Having voice communication	4.04	1.22	Having video communication	3.30	1.29
Knowing who is in the workspace	3.91	0.97	Knowing how long other users have been in the workspace	3.00	1.14
Knowing if other users are satisfied with what you have done	3.91	1.11	Knowing how much time has elapsed since other users have used REDUCE	2.78	1.09
Seeing the position of other users' cursors on the screen	3.78	1.24	Knowing where other users are physically located	2.04	1.30
Knowing to what extent you have completed your work compared to the extent others have completed their work	3.74	1.02			

Table 2: Results for awareness elements ([9])

believed certain types of awareness were relatively important or unimportant for supporting collaborative authoring. The results for awareness elements in this paper were determined from these questions. Open-ended questions discovered from subjects the mechanisms they believed were useful for supporting group awareness. The open-ended questions are not relevant to this paper. Each subject could further clarify these mechanisms during the one-on-one interview held by the research assistant whilst filling in the questionnaire. Audiotape was used to record interviews with subjects for assistance with data analysis.

4 Results of analysis

We now present the results of analysis of the close-ended questions. The results assist to differentiate the necessity of different awareness elements. This paper focuses only on results for document-related elements. The mean and standard deviation of all close-ended questions are computed and the distribution of responses for each question is constructed. Each closed-ended question corresponds to an awareness element. Therefore, the mean and distribution of responses of a question reflect the relative importance of an awareness element.

The awareness elements are sorted by their means in Table 2. The elements which are document-related and for which results are reported here include:

- Knowing the parts of a document on which other users are currently working
- Knowing to what extent you have completed your work compared to the extent others have completed their work
- Knowing to what extent a portion of a document has been completed
  Knowing the parts of a document at which other users are currently looking

An awareness mechanism is suggested as worthwhile to develop if, on balance, there is a larger proportion of subjects favouring the element from the results. A
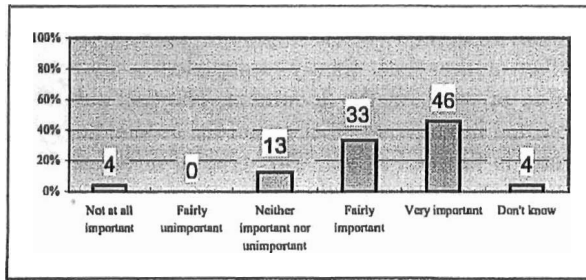
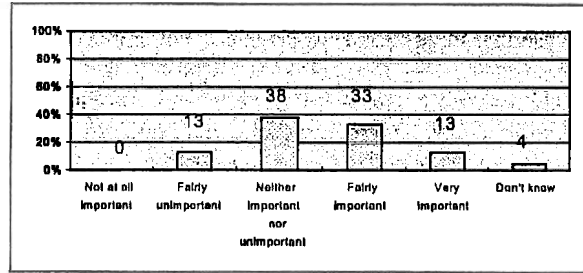Figure 2: Knowing the parts of a document on which other users are currently working

Figure 3: Knowing to what extent you have completed your work compared to the extent other users have completed their work

potential mechanism has to be evaluated experimentally to determine if it is truly effective before the mechanism is used in real-world authoring.

4.1 Parts on which other users work

As can be seen from Figure 2, almost half of the subjects found that knowing all the parts of a document that other authors are working on, at the current point in time, to be a very pertinent form of awareness. Also, a third of the subjects found this awareness to be reasonably important. Therefore, mechanisms that provide awareness of where others are currently working are viewed as important. Telepointers, radar views and multi-user scrollbars provide this awareness. The issue here is not that awareness mechanisms showing where users are working do not exist and need development, but that given the shortcomings of these mechanisms, there is much more scope for providing such awareness. Indeed a mechanism for providing this awareness was discovered from this experiment and is shown in the Appendix. We have called the mechanism *Structure-based Multi-page View*.

4.2 Completing your work compared to others' work

Figure 3 shows the distribution of responses when subjects were asked about the importance of knowing how much of their work on the document has been

done relative to how much others' work has been done on the document. Such a characteristic could be measured in different ways; what is intended by such an awareness element is the actual concept of being knowledgeable of how far other users have reached in completing their work compared to you.

The distribution shows that 46% of participants believe there is high or reasonable importance in having this knowledge. Thus, in a collaborative authoring session, half of the subjects could be expected to use, to varying degrees, a software mechanism providing this type of awareness. Such a mechanism is not expected to be one of the more highly utilised and popular mechanisms according to our results. However, for the purpose of enhancing users' experience as much as possible and supporting them flexibly, such a mechanism would be provided, even if 60% – 70% of users do not make use of it. An aim of general research on group awareness for collaborative authoring is to offer a "palette" of awareness mechanisms from which users choose appropriate mechanisms to provide them with awareness—all users will not use exactly the same mechanisms during an authoring session.

4.3 Portion of document completed

As can be seen from Figure 4, half the subjects believed that being aware of how much has been completed of each of the different parts of a document is of importance. Thus, from their
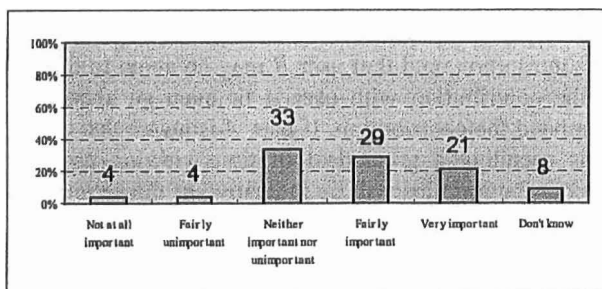

Figure 4: Knowing to what extent a portion of a document has been completed
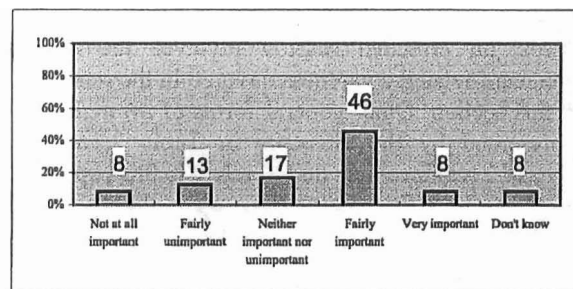
Figure 5: Knowing the parts of a document at which other users are currently looking

experience in the experiment, half the other subjects did not provide the authors with a convincing response that there was need for such awareness. This means that half the subjects would like the availability of a software mechanism providing updated progress of completion of parts of the document. The definition of a portion or part of a document is open and depends on the document being created. Although given that a fifth of the subjects found such awareness to be highly important in collaborative authoring, discovery of a software mechanism that provides this awareness is worth pursuing.

4.4 Where others are currently looking

Clearly, when users are collaborating on a document, they will be viewing somewhere inside the document. A user could be viewing the portion of the document that they are working on (e.g., where this user is adding text, removing text, etc.) or could be viewing somewhere that they are not working on, such as some other user's work. Thus, there can be a difference between a user's working area and their viewing area.

Figure 5 shows that almost half the subjects found it fairly important to know, at a given point in time, where the other subjects were looking in the document. Therefore, there was not an overwhelming need for awareness support to know where other users are viewing currently, but more than half of all subjects found reasonable or high importance in having such support. The conclusion here is similar to the conclusions for the previous two awareness elements: investigate what sort of software mechanisms would provide this awareness and develop them for the palette of mechanisms for users; however, anticipate them to be less used than mechanisms supporting the first awareness element in this section.

5 A group awareness-supported collaborative authoring session

The above histograms and associated discussion provide results informing us about group awareness during authoring. Therefore, from these results, we obtain an idea of the awareness needed for an effectual collaborative authoring session. In other words, an effectual session involves the use of document-related awareness covered in the remainder of this section. Other general forms of awareness, as represented by the elements in Table 2, are not covered here since they do not relate to this paper.

Many users find during the session that they need instant and easy access to information about which user is working on which part of the document. There could be a host of reasons for desiring such information during the session. For instance, an author wants to refer to a section being written by another author, and the first author needs to find out if the second author has finished writing the section yet. Another example is where an author wants to know if another author has finally completed a particular section of work on the document. The first author is interested in know whether or not the second author's section is finished as yet. This type of information is undoubtedly fundamental when a group is working as a team on the contents of a document. Current mechanisms such as telepointers and radar views already provide this awareness, thus, the authors' results confirm the relevance of these mechanisms. However, developing new mechanisms that provide this awareness in more relevant ways is also justifiable.

Some users feel they want to know the progress of others' work on the document. These users wish to know how far from completion are other users' work on various parts of the document. It may be that user A cannot work on part a of a document until user B has completed part b of the document as completion of part b is a pre-requisite to commencement of work on part a. Also, user C needs to apply content from part d, worked on by user D, to their own part, part c. Thus, user C needs to know when user D completes part d. An awareness mechanism for representing this type of progress is used by users A and C during authoring.

Additionally, a mechanism is used by some users to determine how far they have progressed in their work on the document in comparison to how far others have progressed on the document. Used at different points by some of the users during co-authoring, such a mechanism assists a user either to:

- feel more confident and fulfilled when the user is ahead in their contribution compared to others, or
- know they are progressing satisfactorily in their contribution compared to others, or
- feel concerned if their contribution is progressing more slowly compared to others.

Some users may want to know where other users are viewing within the document. A user may want to know if other users, who have some right to evaluate their contribution to the document, are viewing their contribution. In another case, user A may be able to determine if another user, user B, is viewing their contribution for a long period of time. This would notify user A that user B is taking interest in user A's contribution, and that user B may be about to discuss the contribution with user A or even go ahead and amend the contribution. If user A is aware that user B is spending a great deal of time viewing user A's contribution, this will be indicative of the seriousness (whether it be positive or negative) behind user A's contribution.

6 Conclusion

The awareness element of Knowing the parts of a document on which other users are currently working received the strongest support. This suggests that not only are mechanisms providing this type of document-related awareness important for providing to users, but that they will probably be the most used document-related mechanisms during authoring. The other remaining elements whose results were presented in this paper received enough support to justify discovery of mechanisms providing these types of awareness (since few mechanisms currently provide these types of awareness).

A mechanism that supports the element, Knowing to what extent you have completed your work compared to the extent others have completed their work, appears to provide emotional support rather than support of the work itself. However, even in face-to-face interaction, we can see that satisfaction, disappointment and other emotional effects are experienced through awareness of others during work.
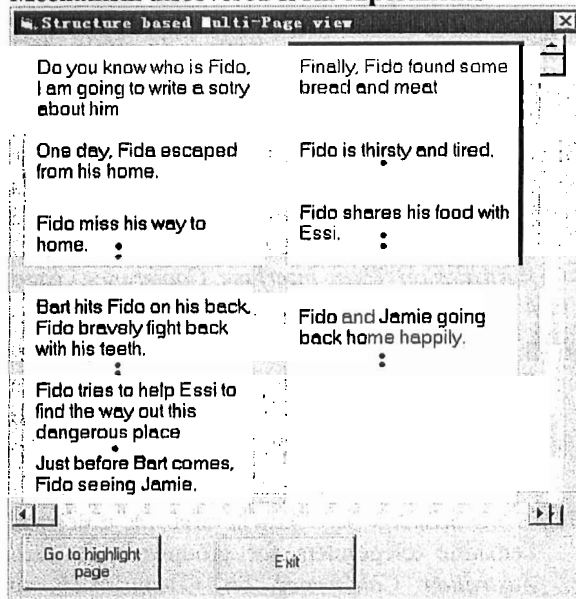
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Appendix

Mechanism discovered from experiments

Experimental tasks

Creative Writing

T1: "Fido is a dog living in Melbourne and owned by a boy, Jamie. Write a fictional story about the adventures of Fido."

T2: "Write a fictional story about the various events that occur in a sports team playing in a particular match. For instance, a soccer team or a cricket team or a basketball team, etc. playing a particular match."

Brainstorming

T3: "Stress affects people in modern life. There are clearly many different ways of escaping the stress and difficulties of modern life. Write down and explain various ways of reducing stress."

T4: "Write down different problems and difficulties that you feel occur when being taught in an educational setting (e.g., university lecture, workshop carried out in a company, etc.)"

Document Preparation

T5: "Write a research paper on an agreed topic with the other participant."

T6: "Write a manual or guide about REDUCE. This manual/guide must instruct and teach the reader how to use REDUCE."

Questionnaire – six-point closed-ended questions

A response to each one of the close-ended questions below will be one of the following six points, as indicated by the experimental subjects in the questionnaire:

1 – Not at all important   4 – Fairly important

2 – Fairly unimportant   5 – Very important

3 – Neither important nor unimportant   6 – Don't know

Close-ended questions

1. Knowing who is in the workspace
2. Knowing the tasks for which other users are responsible
3. Knowing how much time has elapsed since other users have used REDUCE
4. Knowing where other users are physically located
5. Knowing how long other users have been in the workspace
6. Being able to view the list of past actions carried out by a specific user
7. Knowing the parts of a document on which other users are currently working
8. Knowing the parts of a document at which other users are currently looking
9. Knowing what actions other users are going to take in the future
10. Knowing what actions other users are currently taking
11. Seeing the position of other users' cursors on the screen
12. Knowing to what extent you have completed your work compared to the extent others have completed their work
13. Knowing to what extent a portion of a document has been completed
14. Knowing if other users can know what you have been doing
15. Being able to comment on what other users have done
16. Knowing if other users are satisfied with what you have done
17. Having voice communication
18. Having video communication
19. In the case of nonverbal communication, having a communication tool that supports communication between users