

Novel Group Awareness Mechanisms for Real-time Collaborative Document Authoring

Gitesh K. Raikundalia

Hao Lan Zhang

School of Computer Science and Mathematics

Victoria University

PO Box 14428

Melbourne City MC 8001 Australia

Gitesh.Raikundalia@vu.edu.au

haolan@sci.vu.edu.au

Abstract *Group awareness has become important in improving the usability of real-time, distributed, collaborative writing systems. However, the current set of implemented awareness mechanisms is insufficient in providing extensive and comprehensive awareness in collaborative document authoring. Certainly, current mechanisms, such as telepointers and multi-user scrollbars, have contributed in providing awareness support in collaborative authoring. Yet, given the shortcomings of these mechanisms and the difficulty in providing rich interaction found in face-to-face collaboration, much more support needs to be provided for group awareness during authoring. This research extends the pool of all known awareness mechanisms (including those that have been discovered before but have yet to be implemented).*

This research discovered several awareness mechanisms not found and reported elsewhere, through conducting usability experiments with a real-time cooperative editor. This paper covers three of the mechanisms—Structure-based Multi-page View, Point Jumping Mechanism and User Info List—discovered from the experiments. The paper also provides quantitative results supporting implementation of such mechanisms.

Keywords Group awareness, awareness mechanisms, real-time collaborative document authoring.

1 Introduction

Real-time, distributed collaborative writing systems (RDCWS) allow distributed authors to work on documents at the same time. Examples of these systems include GROVE [1], SASSE [2] and ShrEdit [3]. In certain circumstances, RDCWS are very useful tools for a group that must carry out tasks on a

document simultaneously. An example of the use of a RDCWS is in synchronous composition of essays. Collaborative essays may be used in teaching, such as in learning about negotiation of meaning [4].

However, in a workplace situation, a RDCWS may not necessarily be used to write an entire document in one sitting. Participants may use email or workflow to write parts of a document in an asynchronous manner, whilst writing other parts together synchronously. Participants may have an initial meeting to agree and work on the structure and content of the document together at the same time, leaving participants to finish the document separately at different times. On the other hand, medical researcher colleagues of this paper's first author work on a document at different times, only to come together *at the end of the process* to finalise the document. These medical researchers find greater efficiency in finalising the document together at the same time rather attempting to finalise it separately at different times.

Group awareness (GA) is an important feature enhancing the usability of RDCWS. GA provides users with sufficient knowledge about the status of a document itself and all activities other users perform upon the document. GA plays an essential and integral role in cooperative work by simplifying communication, supporting coordination [1], assisting "anticipation" [5] and supporting "convention" [6].

In face-to-face interaction, it is naturally easy for people to know who is present, what are others' responsibilities and what others are doing. When group members are geographically dispersed, supporting spontaneous interaction is more difficult. To enrich GA in real-time collaborative authoring, various awareness mechanisms such as telepointers [7], radar views [8] and multi-user scrollbars [2] have been used. Unfortunately, these mechanisms were implemented in editors without prior research on what awareness information users actually need or desire when writing collaboratively. Consequently, some awareness mechanisms are implemented in an ad-hoc manner. Although these approaches have found some relevant awareness mechanisms, some other possible

mechanisms are easily overlooked or require excessive experimentation for their discovery. For instance, the emergence of a radar view reported in [8] is the result of a long process of improvement and enhancement, which could have been naturally avoided if the process producing the radar view initiated from end-users. Furthermore, previous research does not provide a potentially nearly full set of comprehensive awareness mechanisms; designers are often left without any clear sense of which awareness mechanisms should be implemented in RDCWS to support GA.

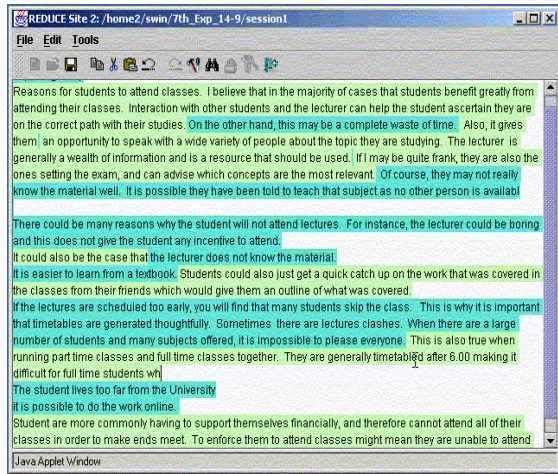


Figure 1: REDUCE collaborative editor

To produce a usable system, a designer must be directed by the principles of user-centred design [2]. Therefore, this research involves study of users' needs and identifies highly suitable candidates for mechanisms in providing GA. This involves conducting laboratory-based, usability experiments with REDUCE—Real-time Distributed Unconstrained Cooperative Editor [9]. REDUCE is a real-time and multi-user text editor allowing geographically distributed people to interact synchronously upon the same document without constraints (Figure 1). This research ensures that awareness mechanisms are developed in the light of users' needs.

New awareness mechanisms have been discovered by this research. These mechanisms have been proposed totally by end-users and have not yet been implemented. Hence, the mechanisms presented in this paper are mock-ups and still require implementation, evaluation and improvement before final implementation in any RDCWS. The main emphasis of this paper is to describe the following mechanisms found in this research:

- *Structure-based Multi-page Preview*
- *Point Jumping Mechanism*
- *User Info List*

This paper begins with coverage of major existing awareness mechanisms. It then describes the research

methodology, the usability experiments conducted in this research, and finally, the mechanisms discovered.

2 Related work

The growing interest in GA results from the fact that awareness support has increasingly been identified as a crucial part of successful collaboration [3, 5]. Perceiving and understanding the activities and intentions of other members of a group is a basic requirement for human interaction. As in any groupware system, GA is a major concern in real-time collaborative authoring. Previous research has found a number of different awareness mechanisms supporting collaborative authoring.

Telepointers [7] are a mechanism allowing multiple cursors of users to be shown within the document. Telepointers usefully show all the sections of a document all users are working on in parallel. However, telepointers are only capable of providing other users' cursor positions when they are located in the same portion in the document. Consequently, if telepointers are removed from a local user's view, it is difficult for this user to gauge the location at which a remote user is working and how active is that user.

Radar views are miniaturisation techniques that provide an overall view of a document to show where all users are working on a document. Radar views have been proven to be useful in maintaining GA [8]. The major problem with a miniaturisation technique is that of limited scalability; a miniature view of a very large data space contains too little detail to be useful.

To overcome a radar view's limitations, especially to bridge the gap between local details and the global structure of a document, a fisheye view can be used [10]. A fisheye view is a distortion-oriented view that presents a single view displaying both local detail and global context on a continuous "surface". A fisheye view provides a seamless and smooth transition between local details and the global structure. When each user has a focal point, the location of other users and the details of their actions performed upon the workspace are provided. Remote users' focal points can be out of a local user's view when a document is too large to fit in the local user's view. The local user apparently loses track of the remote users' whereabouts. Also, when more than two enlarged areas overlap they hide one another, so part of the document appears lost.

Multi-user scrollbars allow a user to see the different parts of a document worked on by other users via scrolling within the document. In the literature, there are two different variations of multi-user scrollbars: version 1 in [2] and version 2 in [8]. In version 1, each remote scrollbar is located in a different vertical region; however, in version 2, all remote scrollbars are located in the same vertical region. The major problem of multi-user scrollbars occurs when a large number of users are working in

the workspace. In version 1, the display of a large number of remote users' scrollbars causes space constraints; it forces the area of the document portion viewed to be smaller. In the case of version 2, when views of more than two users intersect, it is hard to know exactly the location of remote users because many remote scrollbars overlap one another.

The Split Window View [11] is a mechanism that allows the user to view both working and viewing areas of other members of the group. In some cases, a user's working and viewing areas can be different as the user may be working on a particular part of the document, yet be looking somewhere else in the same document. Therefore, this mechanism allows a user to see both of these areas of all other users. When any of these other users' working areas are exactly the same as their viewing areas, this one area is only shown. This mechanism has not yet been implemented, but it is clear what are the major drawbacks are of this mechanism. There are space constraints in presenting possibly many working and viewing areas at the same time within the mechanism. The more areas that have to be displayed, the more screen space is required, which may mean making the areas smaller to fit them onto the screen. Also, when a large number of areas are shown, a low-fidelity display is used, meaning it is more difficult to read the text within an area.

The purpose of the Modification Director [11] is to show to a user that another user is modifying their work. The mechanism is helpful in conveying who the other user is that is altering their work and how they are altering it. The mechanism provides a document-related form of GA. It works based upon a flashing colour icon to indicate another user is modifying text, and clicking on the icon pops up a read-only window to show the modified text. An issue that has to be resolved in this mechanism's implementation is how to show multiple areas of a user's text being modified by the same user.

The Dynamic Task List [12] is a task-based technique for supporting document-related awareness.

The mechanism provides a frequently-updated list of group members' tasks. A user is able to comment on other users' tasks and the author responsible for a task is informed of which other users are viewing their part of the document. This mechanism may prove to be more difficult to implement.

3 Research methodology

To produce a usable editor for supporting collaborative authoring, much research has exploited the user-centred approach in the study of how people write together [2]. Similarly, to provide usable *awareness mechanisms* for real-time collaborative editors, a designer must be directed by such principles. Therefore, this research conducted laboratory-based experiments with REDUCE. At present, REDUCE supports almost no GA features; hence, conducting experiments with REDUCE allows determination of awareness information users really need to perform a collaborative authoring task effectively and efficiently. The results of the experiments lead to the discovery of new awareness mechanisms that are potentially capable of supporting GA in real-time collaborative authoring. These mechanisms are discovered with a view to implementing them so that further usability experiments with REDUCE can be used to evaluate the mechanisms. That future set of experiments determines the effectiveness of the mechanisms through real-world use by end-users.

The usability experiments were carried out in the Swinburne Usability Laboratory of Swinburne University of Technology in Melbourne, Australia, in April 2004. The experiments involved twelve pairs of subjects working on three writing tasks, including *creative writing* (CW) (e.g., writing short essays from scratch), *document preparation* (DP) (e.g., writing a manual on REDUCE) and *brainstorming* (BS) (e.g., generating ideas). This research used these three categories for two main reasons. First, these

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

Table 1: Experimental sessions with REDUCE

categories represent a wide range of collaborative document authoring tasks. Second, the categories require different styles of collaboration. The types of awareness mechanisms that are needed in different contexts of collaborative authoring are found by using these varied tasks. The twelve pairs were allocated to perform the three tasks as such: 4 pairs worked on CW, 4 pairs worked on DP and 4 pairs worked on BS. The actual tasks used in experiments are shown in the Appendix. Table 1 shows the tasks used by each pair in the different sessions. For instance, in session E1, the first task given to the E1 pair is task T1 (see the “Experimental tasks” sub-section of the Appendix) of verbalisation, that is, communication via telephone. The second task given to this E1 pair is task T2 where there is silence during collaboration.

Subjects worked in pairs where each member of a pair was located in one of two separate subject rooms. A profile of the computer skills of subjects is shown in the Appendix. Subjects could not see each other from their rooms as is the case in distributed collaboration. A research assistant observed each pair from an observation room. Each pair participated in a two-and-a-half hour session that included:

- *Training in REDUCE* (30 minutes).
- *Experiment* (1 hour): Subjects worked in pairs to work on one task with verbal communication (verbalisation) for thirty minutes and on another task without verbal communication (silence) for thirty minutes. Conducting the experiments with and without support of verbal communication allowed identification of problems users had and the workarounds users resorted to when verbalisation was absent.
- *Questionnaire and interview* (1 hour): Subjects filled in a questionnaire, which included nineteen six-point scale (closed-ended) questions and thirteen open-ended questions. The closed-ended questions were questions asking subjects if they believed certain types of awareness were or were not important in collaborative authoring. These questions were analysed to provide results shown in histograms in this paper. The open-ended questions sought from subjects mechanisms they would appreciate being available for supporting GA. *It is from the open-ended questions that the proposed mechanisms of this paper were discovered.* The questionnaire is shown in the Appendix. Each subject filled in a questionnaire during an interview held by the research assistant where they could clarify the mechanisms they desired. Subjects drew onto the questionnaire their ideas of mechanisms they believed were useful to them in providing group awareness. Interviews were recorded onto audiotape for verification of subjects’ responses during data analysis.

The next section describes three new awareness mechanisms identified in this research: *Structure-based Multi-page Preview*, *Point Jumping Mechanism* and *User Info List*.

4 Awareness mechanisms

4.1 Structure-based Multi-page View

A mechanism was suggested during interviews that could be used for supporting awareness of knowing the parts of the document on which other users are currently working (see Appendix). This mechanism, which the authors have named *Structure-based Multi-page View* (SMV), allows an overall view of the document. The SMV is shown in Figure 2.

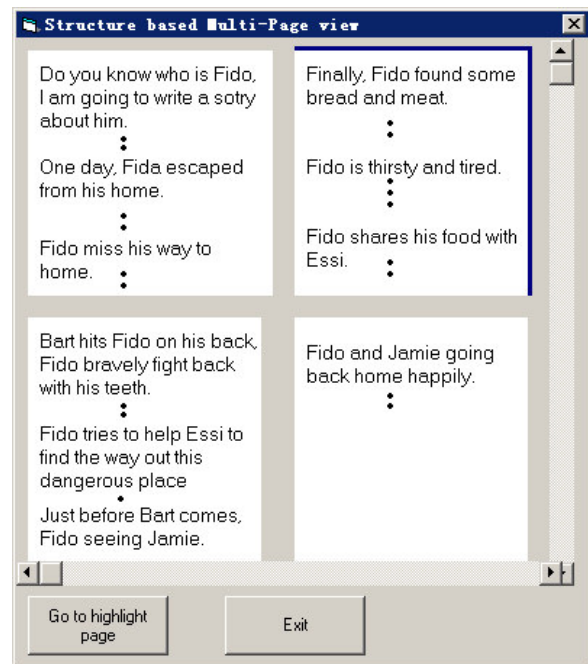


Figure 2: Viewing other’s contributions with SMV

The mechanism shows how four users (there is one area in SMV for each user) are working on different pages of the same document. The user can click on an area to highlight that area (a border is shown around the area that has been selected). Then, the user can click on the “Go to highlighted page” button to be taken to that page of the document in the RDCWS. An amendment that the authors make to this mechanism, that was not thought of by the subject suggesting this mechanism, is to add details of which user is working on which page of the document. The users and their working areas are not indicated in the subject’s suggested GUI in Figure 2.

The closed-ended question from the Questionnaire (see Appendix) that corresponds to the SMV is Knowing the parts of a document on which other users are currently working. Figure 3 shows the distribution of responses to this question from the subjects. 45% of subjects (almost half of them) found that a mechanism informing them of the parts of a

document on which others currently work to be a highly relevant mechanism. One third of subjects (33%) found such a mechanism to be “fairly important”. Thus 78% of subjects believed that such a mechanism is useful in supporting them in collaborative authoring. The remaining one-fifth of subjects did not provide responses favourable for the existence of such a mechanism. These results indicate that designing and implementing a mechanism such as the SMV is worthwhile to support users. It must be noted that not all users are expected to use any single awareness mechanism during an authoring session. Each mechanism provides one specific type of awareness support, and is available to users if they wish to use it during an authoring session.

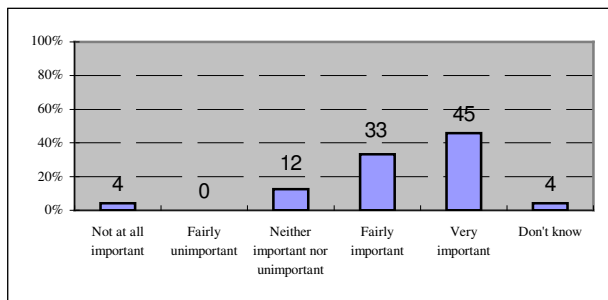


Figure 3: Knowing the parts of a document on which other users are currently working

The experimental subject’s suggestion of this awareness mechanism has clearly been influenced by the Print Preview feature found commonly in software nowadays (for instance, in word processors, Web browsers, etc.). The subject that suggested this mechanism has thought that a familiar single-user GUI would be helpful in understanding who is working on which parts of the document. Suggesting a mechanism based on familiarity with another known GUI is an unsurprising result as users desire GUIs and functionality that make sense to them and are easy to learn and use. Indeed, the mechanisms of telepointers and multi-user scrollbars, which have been researched a number of years ago and are well-known mechanisms, have not been total innovations in that single-user pointers and software using scrollbars preceded the research on telepointers and multi-user scrollbars. In fact, familiarity with pointers and scrollbars has assisted the acceptance of these two awareness mechanisms and made them easier to learn.

4.2 Point Jumping Mechanism

The Point Jumping Mechanism (PJ) is another awareness element enables a user know where other users are working in the document. Figure 4 shows where a given user is looking at, at the moment, in the document. PJ captures the same content as shown in REDUCE (including the different background colours for different users). Assume the user is Jennie. Jennie wishes to see where Kana is currently working in the document. PJ will allow Jennie to go instantaneously

to the point in the RDCWS where Kana is working. Jennie will then highlight Kana in the list of users in the top right-hand corner of the PJ GUI. Jennie will click on the Jump to User” button.

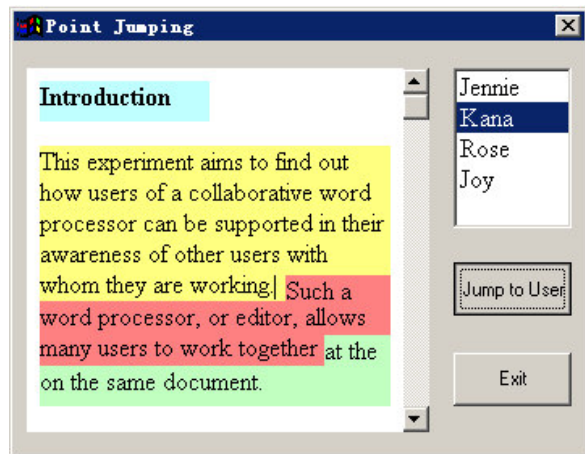


Figure 4: The PJ before Jennie jumps to Kana’s working area

Figure 5 shows the result carrying out these steps. Jennie has been taken instantaneously to where Kana is working in REDUCE (note the vertical cursor at the bottom of Figure 5). It may be noted that the jump has been made within the awareness mechanism and not in REDUCE.

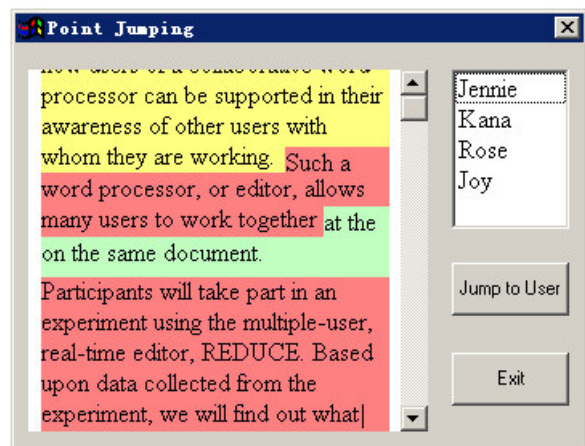


Figure 5: The PJ after Jennie jumps to Kana’s working area

Since PJ also handles the awareness of where other users are working like the SMV, the support for PJ is also drawn from Figure 3. Thus, PJ is an alternative mechanism that also needs to be implemented and tested in real-world authoring to determine its effectiveness in supporting authoring.

4.3 User Info List

A mechanism was suggested to provide details about other users. This mechanism, the *User Info List* (UIL), is shown in Figure 6. The left-hand part of the GUI shows the contents of the RDCWS, whilst the right-hand part shows a panel with various details (User

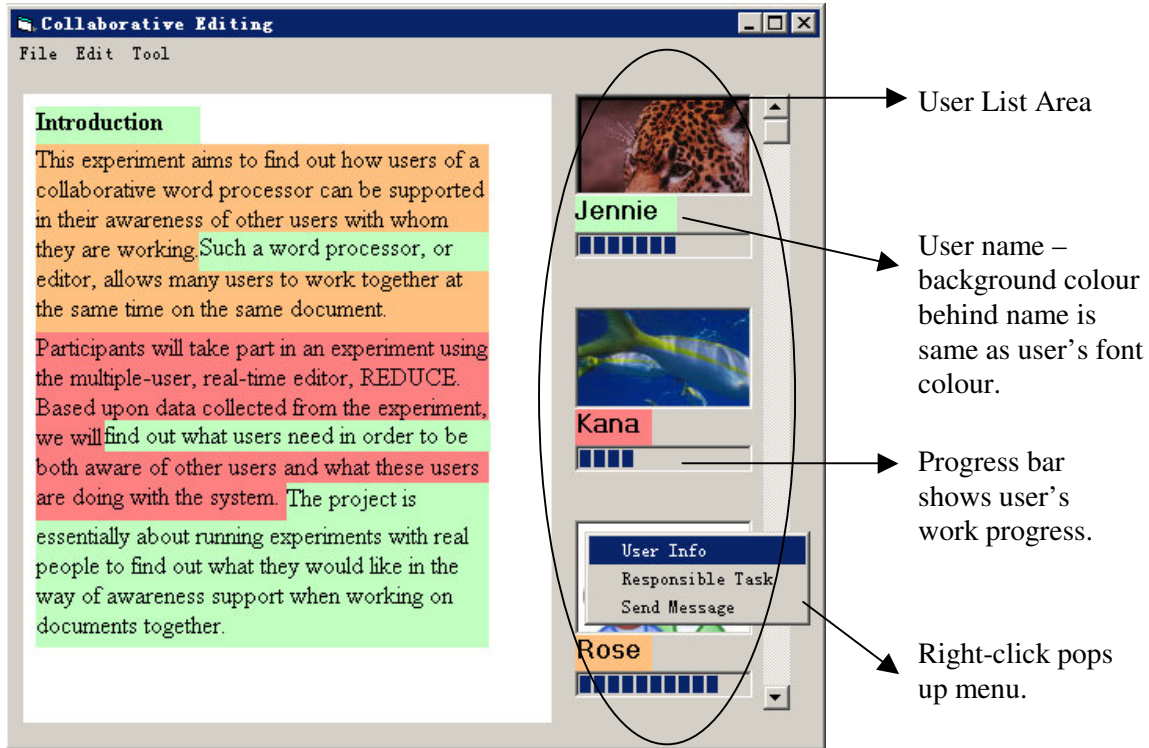


Figure 6: The User Info List and display of user information

List Area). The User List Area contains user's photographs. Below each area is the user's name on a background colour that is also their background colour in the RDCWS. Below the name is a progress bar that reflects how much of the assigned work of a user has been completed so far.

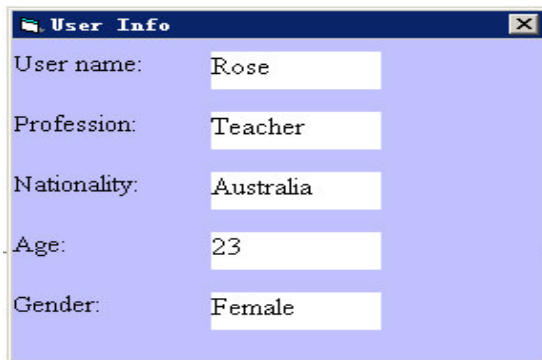


Figure 7: GUI providing awareness of who are the other users

Right-clicking on a user's photograph will pop up a menu as shown in Figure 6. This menu allows a user to either find out details about another user (selecting the "User Info" option will pop up the window shown in Figure 7), find information on the tasks the user is responsible for or to communicate a message to the user. The subject suggesting this UIL mechanism unfortunately did not provide an idea of what the GUIs looked like for determining others' tasks or sending messages.

This mechanism provides knowledge of how a user is progressing in their contribution to the

document compared to the other users. A user can look at the progress bars of users and compare the completion of the individual contributions by comparing the number of blue notches in the progress bars. A closed-ended question asked of the subjects deals with this form of awareness. This is question number 12 in the Questionnaire, and its distribution of responses is shown in Figure 8. The distribution shows that 45% 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, the UIL.

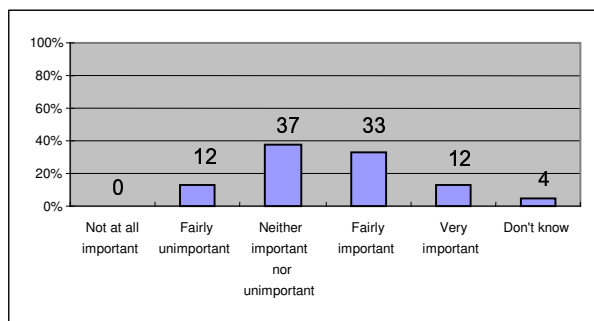


Figure 8: Knowing to what extent you have completed your work compared to the extent other users have completed their work

Another form of awareness is provided by this same mechanism. This is the awareness of Knowing the tasks for which other users are responsible (closed-ended question number 2 in the Questionnaire). In whatever user interface form this mechanism would take, it would be expected to be

used tremendously according to the results in Figure 9. Figure 9 shows that just over half the subjects wanted this form of awareness, with almost a third of them finding it reasonably important. In other words, being knowledgeable of what other users are going to contribute to the document and how they are going to do this, is overall important to subjects in being able to author a document together successfully. More than 80% of subjects find it of high or reasonable importance to be aware of others' responsibilities over a document.

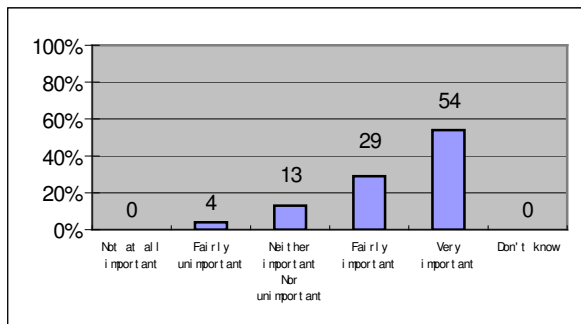


Figure 9: Knowing the tasks for which other users are responsible

5 Conclusion and future work

This paper has presented the three recently-discovered GA mechanisms of *Structure-based Multi-page Preview*, *Point Jumping Mechanism* and *User Info List* for collaborative document authoring. A series of experimental sessions in a usability laboratory—involving creative writing, (technical) document preparation and brainstorming tasks—was carried out with twelve pairs of subjects. Through usage of the REDUCE editor followed by interviews with experimental subjects, these mechanisms were discovered as proposals from these subjects. Mockups of these mechanisms and their functionality were explained in the paper. Analysis of closed-ended questions provided understanding of how many users did or did not favour different types of awareness support. These results supported the mechanisms presented in this paper.

However, the mechanisms need to be implemented and experiments with these implementations need to be carried out. Experiments are needed to determine in which cases the mechanisms are effective in assisting collaborative authoring. Experiments would involve subjects carrying out tasks with the mechanisms and being interviewed to determine how useful the mechanisms were in carrying out the tasks.

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Appendix

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 scale closed-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.

Open-ended questions

- How would you expect REDUCE to show you who is in the workspace?
- How would you expect REDUCE to show you which tasks other users are responsible for?
- How would you expect REDUCE to show you how long other users have been in the workspace?
- How would you expect REDUCE to show you the list of past actions carried out by a specific user?
- How would you expect REDUCE to show you which parts of a document other users are currently working on?
- How would you expect REDUCE to show you what actions other users are currently taking?
- How would you expect REDUCE to show you what actions other users are going to take in the future?
- How would you expect REDUCE to show you where other users are physically located?
- How would you expect REDUCE to show you which parts of a document other users are currently looking at?
- How would you expect REDUCE to show you to what extent a portion of a document has been completed?
- How would you expect REDUCE to show you an overall view of the document?
- How would you expect REDUCE to show you to what extent you have completed your work compared to the extent other users have completed their work?
- What communication tools do you think can be used to support communication between users?

User profile

User Level	Number of subjects
Strong computer knowledge (Expert level)	4
Good computer knowledge (Advanced level)	3
Average computer knowledge (Average level)	9
Modest computer knowledge (Less-than-average level)	6
Non-computer user	2

Mechanism discovery

SMV

Twelve subjects suggested interest in a mechanism that provides an overall view of the document. A representative response by a subject, written in their own copy of the questionnaire, was:

"I want to see many pages in one screen."

This subject also drew a diagram of the mechanism. The authors' mockup of this subject's diagram is shown in Figure 2 of this paper.

PJ

Four subjects suggested this mechanism in different ways. One subject drew a mechanism that resembles the mockups shown in Figure 4 and Figure 5.