Appears in *Proceedings 25th Hawaii International Conference on System Sciences,* Vol IV, 1992, 127-138.

How People Write Together

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Abstract

Builders of groupware writing technologies need a better understanding of collaborative writing if their systems are to adequately address user needs. This paper presents a taxonomy of joint writing based on an analysis of interviews with authors who have written documents together. The taxonomy describes joint writing in terms of four components: roles *played in the collaboration,* activities *performed in the writing process,* document control methods *used, and* writing strategies *employed. The paper concludes by outlining a set of design requirements for collaborative writing that are suggested by the interviews and the taxonomy, and by evaluating six existing systems with respect to these requirements.*

Introduction

A survey of 700 professionals, who spend much of their time writing, found that 87% of them write cooperatively (Ede and Lunsford, 1990). Much work in business and academia is performed by groups of people (Bair, 1985). Not surprisingly, the development of joint authoring systems has become a major focus in Computer Supported Cooperative Work. Most systems make assumptions about how joint documents are created (see the system comparison in Table 3). For example, some systems support synchronous writing, while others assume asynchronous document creation; some support outlining of ideas, others the writing of text, and still others annotations to existing text; some systems support several authors, while others assume a single author with several commenters. This paper examines the extent to which these approaches reflect the actual processes followed in joint writing.

Significant efforts have gone into studying the way individuals write (Flower, Schriver, Carey, Haas, and Hayes, 1989; Freedman, Dyson, Flower, and Chafe, 1987; Bereiter and Scardamalia, 1982). The interest in joint writing research arose in the late 1980's, manifesting itself in surveys conducted on professional writers (Ede and Lunsford, 1990; Allen, Atkinson, Morgan, Moore, and Snow, 1987). These surveys showed that a vast majority of written work is performed jointly. At the same time, research by Kraut, Galegher, and Egido (1986) and Kraut, Egido, and Galegher (1988) identified proximity as a key ingredient for successful scientific collaboration. Both Eveland and Bikson (1988) and Galegher and Kraut (1990) found that computer technology affected the communication between participants and the final jointly written product.

Although this existing work has uncovered ubiquity and consequence data on collaborative writing, it does not inform us about the joint writing process sufficiently to guide the design of collaborative writing technology. Our research, therefore, differs from past research in its focus on the joint writing process, a close examination of how the document text is created and controlled in the context of the events that lead to the completion of each project.

We used interviews to obtain a formulation of joint writing processes that take place (Posner, 1991; Posner and Baecker, submitted for review). This paper first describes some general observation about joint writing based on the interviews, and then presents in detail the emerging taxonomy of the joint writing process.

Interviews

To uncover the actual collaborative writing process we conducted interviews with individuals about their participation in several collaborative writing projects. The interviewees varied in their occupations, background interests, and levels of writing skill. The collaborative projects varied in the number of participants, previous joint work, status relationships in the collaborating group, and tasks performed.

Candidates were found through an informal referral process. We conducted a total of 10 tape recorded interviews, each approximately one hour in length, based on the questions listed in the Appendix. During these interviews 22 joint writing projects were discussed. Each person interviewed discussed at least two joint writing projects, thus demonstrating how the same individual worked on different projects, in different groups, and, in some cases, on both successful and unsuccessful ventures.

The individuals interviewed worked in medicine, computer science, psychology, journalism, and freelance writing. The joint writing projects included course assignments, journal articles, a TV script, and a best-selling book. Projects lasted from several days to several years. Groups consisted both of peers and student-supervisor teams. Some collaborations were formed voluntarily from a desire to work together, while other collaborations resulted from work demands.

Further details about the interviews appear in Posner (1991).

General Results

Participants in joint projects bring with them *expectations about joint writing*. These attitudes uncovered in the interviews range from "I don't like it! I don't write with others if I can help it!" 1[], to "I quite like it… It's fun working with other people, you're not lonely! … It's a lot more fun than working alone!" 10[]. (The numbers that follow quotations refer to the interview number [project number]. The square brackets are empty if reference is made in general and not to a specific project.)

Coauthors also bring expectations about the effects of group work on the *quality of the written document*. Most authors believed that a group generated document is superior to one generated alone:

> *"Working with others improves the final product … ideas are more refined - bad ones are removed or reworked." 3[6]*

Despite this positive attitude, a journalist had a different view:

> *"[Journalism is] a tough business to try to be accurate. You do your best to try and check things. You're often on deadline. It is often difficult to check and also we're very fallible individuals. With two people, you double the chances of making mistakes! …" 6[12]*

The interviews showed that *authorship conventions* vary widely between fields and even among groups within fields. In some cases name order in the author list indicated relative contributions to the paper:

> *"Authorship indicates who did most work on the project, who contributed most ideas. … It didn't matter who did the writing as long as the ideas got out." 4[]*

In other fields the order of authorship is predetermined; for example in medicine "the supervisor goes last as a rule" 5[]. In journalism, the division of credit is less definite:

> *"You only get a byline if you contribute a significant percentage of the story … Top line goes to who ever did more work. Sometimes it is alphabetical, and sometimes it's random … It's more like the luck of the draw." 6[]*

In psychology we discovered a disparity. In one psychology department the supervisor automatically receives first authorship on all joint papers, while in another such assumptions do not exist:

> *"Order of authors establishes a hierarchy. … First author does most of the writing and presents the paper at conferences." 3[]*

Another popular authorship convention is to alternate first authorship on different papers; this was seen mainly among well established groups of collaborators.

Some interviewees noted the effects of *group size and composition* on the outcome of the joint writing project:

> *"Should have a maximum of* one *collaborator. … It is good to have someone to bounce ideas off. Ideally this person should have special expertise." 1[2]*
>
> *"Good to have a supervisor to help focus on the concepts. … I would have been happier on my own or with* one *other person." 5[10]*
>
> *"With just two people working on the project it is harder to confront problems without endangering the work … It's good to have more than two, an* odd *number of people to settle disputes." 8[16]*

The *status of group members*, either similar or different, can lead to problems in working groups. We recorded reports of differences in status impairing the work progress:

> *"When working with a supervisor, you might take the supervisor's view and accept it, then later realize this is not necessarily true. Where as with a peer, you can work out the issues right away, which may save time." 3[5]*

Equal status groups run into different but equally serious problems, including struggles for leadership and the problems of confronting members who are not contributing their expected share of work:

> *"One writer on a team has the dominant push … I think that there will always be one that's slightly dominant." 10[]*
>
> *"Hard to deal with different levels of commitment to the project. You feel like the other guy is slacking off but it is very difficult to bring this up with just the two of you …" 8[16]*

Among other factors that can cause problems on group projects are different *individual working styles*:

> *"Different working styles were an issue. One of us liked to have things done in advance, while the other liked to leave things till the very last moment. … A good compatible work team makes all the difference." 8[16]*

In another group, where participants had different working styles, one of the members avoided this problem by carefully managing to suppress several individual preferences for the good of the group progress:

> *"I very consciously tried to stay out of the way, not to nit pick." 7[14]*

The factor that was most often mentioned as important to the success of a group was *trust among the participants*. When individuals are willing to contribute a significant amount of their time and energy to a project, they need to be certain that their efforts will be appreciated and rewarded. One project failed because of this:

> *"Trust was a problem. … People worried about getting enough credit. … People killed it not the ideas." 4[9]*

Groups that succeed despite lack of trust, result in difficult experiences for the participants:

> *"There are people who don't have integrity and they can be dangerous, if you're on a project with them … sharing a byline. … It was a nightmarish experience … I could not trust that the stuff appearing under my*

name was the type of stuff that I'd want my name associated with." 6[12]

Technology and distance can contribute to this lack of trust and, thus, need to be carefully managed to facilitate group projects.

Criticism is another sensitive issue that can lead to interpersonal problems which can be detrimental to the success of a group project. Relative status of group members can influence the ease of criticizing someone's work. Interviewees discussed several conflicts that arose as a result of criticism by members of equal status:

"It is difficult to critique and be criticized by fellow students … each ego bound. The supervisor would have more leeway to criticize." 5[10]

"It was a bit of a strain … your skin can't be too thin when you are a writer … He had little experience as a writer … He was very protective of his ideas … He would always raise his voice. … We had a producer who would arbitrate and he'd bow to her." 10[22]

The interviews also revealed the *use of technology* by collaborating groups. All groups used word processors to produce their documents. The vast majority had face-to-face meetings, with only one exception. Attitudes towards face-to-face meetings varied, especially in valuing their effectiveness for getting work done:

"Most productive work came out of face-to-face discussions. … Best ideas come when you are outside of a meeting, talking about something totally unrelated." 3[6]

"Embellishments, new ideas, new ways of looking at things are discovered alone … brought to the meetings. … About 5 minutes of work gets done in an hour of collaboration [face-to-face meeting]." 4[8]

Many interviewees discussed frustrations with *technology*, including the drawbacks of *writing tools*. The use of conventional editors in a joint writing project posed problems:

"I would get email saying change page 4 line 2, but in my version page 4 is completely different … [incorporating the changes by comparing different paper versions] was very awkward, time consuming, and error prone." 3[6]

Use of different machines by collaborators introduced other difficulties:

"We had to transfer the electronic file from one machine to another which was very complicated … Then I had to change the format of the new sections … by hand. … It was all very time consuming." 2[4]

Communication tools were seen as obstacles to smooth group interaction. The communication medium used to transmit a message may influence the structure of that message or the way that message is received (Sproull and Kiesler, 1986). One group ran into this problem when participants received both electronic and verbal messages:

"There is a very big difference between getting an electronic message and a verbal one. … The result is confusion. … Technology gets in the way. It always gets in the way. Very few situations where technology makes things better." 4[9]

Many groups that spent some time working at a distance faced problems with communication bandwidth:

"Communication bandwidth problems … long delays waiting for documents to arrive … logistically very difficult. Proximity would have saved time." 7[14]

Interviewees seemed to agree that proximity was the solution to many of these problems, which is suggested by the work of Kraut et al. (1988). Proximity was sought even if the collaborators had to travel a great distance at significant financial and personal cost:

"If this work required a more collaborative contribution, I would have been tempted to just fly there instead of trying to cope with it over a distance." 3[5]

One of our research emphases is the support of remote collaboration through the use of video and audio connections. We proposed this possibility in the interviews and received encouraging feedback:

"You can really develop a fairly good relationship with somebody over the phone, without ever talking to them [face to face] … Generally, the people that I really want to keep up with I'll go to lunch with … A video connection would be almost like meeting them in a way." 6[]

"I love the phone! … I have many telephone relationships. … We spend a lot of time on the phone when neither of us wants to write. We do cryptics on the phone. … But to have a picture! To have actually not only a voice but a face, it would be wonderful! I think a video screen would be great, especially when working overseas." 10[]

However, not everyone was enthusiastic about this prospect:

"[Generally, I don't actively seek out people] but when it comes to collaboration I like to have the people in the same room. … I find that technology gets in the way." 4[]

Writing Process and Taxonomy

One of the most complex aspects of group writing is the writing process itself. Initially it seems that each project and each group employs a unique process that is not repeated by any other group. Yet through a closer examination of the interview results we have been able to develop a taxonomy which helps us see the similarities and patterns amidst this diversity.

The results are summarized in Table 1a, with the help of a supporting legend presented in Table 1b. Further details appear in Posner (1991). Of particular value was the production of a set of *writing process diagrams*, which are explained and illustrated in Posner (1991) and in Posner and Baecker (submitted for review).

The taxonomy is composed of four different categories: *roles, activities, document control methods,* and *writing strategies.* Each of these provides a different perspective for examining the joint writing process.

Roles looks at the process from the individual's point of view, analyzing the part played by each individual on the writing team. Activities categorize the actions performed while working on the project. Document control methods describe how the writing process is managed and coordinated. Finally, writing strategies focus on the text creation process.

Among the previous research, the work that most closely resembles our findings is Ede and Lunsford (1990). They also see writing divided into several related activities, including brainstorming, notetaking, organizational planning, writing, revising, and editing. They discovered that groups have different ways of assigning responsibility for the product, including having one person responsible, sharing the responsibility, and having a superior responsible. They recognized several organizational patterns used in group writing. Two patterns, for example, are "One member plans and writes draft. Group or team revises." and "Team or group plans and outlines. One member writes the entire draft. Team or group revises." There are many such patterns possible. The writing strategies and document control methods of our taxonomy allow a finer-grained and more complete description of these patterns and can therefore be used to define more precisely the collaborative writing process.

Roles

The interviews demonstrated the existence of different roles within groups. The way that roles are assigned to individuals varied between groups. Some of the roles were decided by organizational hierarchies, while others resulted from time constraints on the group members.

The consultant role was found in fourteen groups. In supervisor-student groups the supervisor often played the consultant role, while the student wrote the text [1,6,9,10]. Similar role assignment was seen in the producer-writer group [22]. In other groups, all members started out with the intention of contributing by writing but later the group member with the least time to dedicate to the project, usually the busiest member, fell into the consultant role [4,5,7,11,14].

Roles of some group members were sometimes imposed by the available technology. If all group members did not have access to similar software, the writing work was given to the individuals with the technology and the remaining members worked as consultants or reviewers [13,16,17,21].

The editor role had varying respect. Among journalists, for example, it is well accepted that, "Editor gets the final say" 6[]. In mature groups, editors' comments were well received. In these situations editors made small corrections without notifying the writer, while bigger changes were explicitly discussed [5,6,17,19,20]. In newly formed groups where the participants had equal status, the editor's role was more difficult:

Table 1a: Writing Process Details

Interview results encompassing the four categories: roles, activities, document control methods, and writing strategies.

Project Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Interview Number	1	1	2	2	3	3	4	4	4	5	5	6	6	7	7	8	8	9	9	10	10	10
Roles																						
Writer	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
Consultant	y	.	.	y	y	y	y	.	y	y	y	.	y	y	.	y	y	.	.	.	y	y
Editor	.	y	.	.	y	y	.	.	y	y	.	y	y	.	.	y	y	.	y	.	.	y
Reviewer	.	.	.	y	.	y	.	.	.	.	.	.	.	y	.	.	.	.	.	.	y	.
Equal work [y]	n	.	.	n	n	n	n	.	na	.	na	.	n	n	.	.	.	.	.	.	.	.
Activities																						
Group Size N=	2	3	2	3	2	3	3	2	5	4	3	2	4	3	2	2	3	2	3	2	3	3
# brainstorm [N]	.	.	.	2	1	.	2	.	2	.	2	.	2	2	.	.	.	.	2	.	.	2
# research [N]	.	.	.	2	1	2	1	.	.	3	1	.	3	2	.	.	.	.	2	.	2	2
# initial plan [N]	.	.	1	2	1	.	2	.	.	.	2	.	2	2	.	.	.	.	2	.	.	2
# write [N]	1	.	.	2	.	2	1	.	3	.	2	.	3	2	.	.	.	.	2	.	.	2
# write most! [N]	1	.	.	2	1	1	1	.	3	.	1	.	1	2	.	1	1	.	2	.	2	2
Control change[n]	.	.	y	y	y	y	.	y	y	y	.	y	y	y	y	y	y	y	y	y	.	y
# edit doc. [N]	1	.	.	2	.	2	1	.	3	.	1	.	2	2	.	.	.	.	.	.	.	2
# final edit [N]	1	.	.	1	1	.	1	.	na	1	na	1	1	1	.	1	1	.	1	.	.	2
# review [N]	.	.	.	.	.	.	1	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.
Document control	# represents priority of ranking																					
Centralized	1	.	.	1	1	1	1	.	.	1	1	.	1	1	.	1	1	.	.	.	2	.
Relay	.	.	2	.	.	2	.	2	.	.	.	.	.	.	1	.	.	2	2	1	.	2
Independent	.	1	.	2	.	.	.	.	1	2	2	1	2	2	2	2	2	.	.	2	1	1
Shared	.	.	1	.	.	.	.	1	2	.	.	2	.	.	.	.	.	1	1	.	.	.
Writing strategy	# represents approximate order of occurrence																					
Single writer	12	.	.	2	12	1	12	.	.	3	2	3	2	2	.	34	14	1	.	.	.	.
Scribe	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	.	1	1	12
Separate writ.	.	1	2	1	.	2	.	13	12	1	1	1	1	1	12	1	3	3	2	3	2	3
Joint writing	.	2	1	.	.	.	.	2	.	2	.	2	.	.	3	.	.	2	13	24	.	.

Consulted	2	.	.	2	2	1	2	.	1	13	12	3	2	2	.	4	4	.	.	.	2	23
Project Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22

Table 1b: Legend Explaining the Categories in Table 1a

Roles	The types of roles played by individuals on the writing projects.
Writer	Responsible for transforming abstract ideas into coherent and organized text.
Consultant	Works very closely with writers but does not take part in writing of text.
Editor	Makes changes to documents that were written by someone else.
Reviewer	Gives comments about document, which are accepted or ignored by the writer.
Equal work	This indicates whether all the team members contributed equal efforts to the project. "y," the default response means yes, the effort was equal, while "n" means it was not, and "na" means that the information was not available.
Activities	This describes the writing process used by the group or activities performed by individual members. The default value in this section of the table, indicated by a period ".", is "N," the "Group Size". The numbers indicate how many individuals, other than N, participated in certain activities.
# brainstorm	Number of people that took part in brainstorming at the start of the project.
# initial plan	Number of people that participated in initial planning of the document.
# write	Number of those that contributed to creating the document text.
# write most!	Number of those that wrote significant parts of the document.
Control changes	indicates transfers of document control between individuals during writing.
# edit doc.	Number of people who made changes to the electronic document.
# final edit	Number who took part in editing the final version of the document.
Document Control Methods	
	This section examines control methods used on each project. The numbers appearing in this section are used to rank the priority of each control method. For example, on Project 3 the primary control method used was "shared" while the secondary strategy was "relay."
Centralized	One individual controls the document throughout the project.
Relay	One person at a time is in control, but control passes between team members.
Independent	Each team member works on a separate part of the document and maintains control of this part throughout the writing process.
Shared	Simultaneous and equal access and writing privileges are available to several team members at once.
Writing Strategies	
	This section describes the means or steps by which the text was created. Throughout projects, different writing strategies are used; their order of occurrence is indicated in the table. For example, the first project used the "single writer" strategy at first and then the "single writer(consulted)" strategy. The entries in this section should be read as all single digit numbers, "1" and "2", not "12."
Single writer	One person writes the document based on discussions with other group members.
Scribe	This is used in a group meeting where one individual takes the role of writing down the group's thoughts.
Separate writers	This is used by individuals who break up the document into parts with each one writing and being responsible for a different part.
Joint writing	This is used by a group that writes the document together, deciding on the exact wording and sentence structure used in the text.
Consulted	This category is to be read in conjunction with the entry in the writing strategy sections. For example, on project 9 the initial writing strategy is separate writers (consulted), where individuals are working separately on the segments of the text but their work is closely guided by a consultant; afterwards, the consultations cease and the separate writers strategy is used.

"Most writers are very sensitive about their work … I remember how it used to hurt any criticism … You have to realize that you're writing something for people to change." 10[22]

Different roles exist on joint writing projects. The interviews indicate that their occurrence and distribution depend on discipline expectations, group composition, time constraints, and available technology.

Activities

The interviews supported our belief that the roles people play and the activities that they perform are closely

related. However, several activities can be performed by one individual in a single role.

The activities which are synonymous with certain role names are performed by individuals playing those roles; for example, writers write, editors edit, reviewers review. We also observed that brainstorming and planning of the document are performed by writers together with their consultants. If a group needed to conduct research, this activity was assigned in a way that minimized the cost to the group; that is, the least busy member or the member of lowest status did the research on behalf of the group. The review of the final manuscript was conducted by all group members. The only exceptions to this were in groups where the participants were geographically dispersed, time was extremely limited, and transmission of the manuscripts and the comments was difficult.

Writing Strategies and Document Control Methods

In the joint writing process the writing strategies and document control methods are very closely related. The writing strategy is the *process view*, which describes how the text is created, by whom, and when. The document control method is the *object view*, which describes how the document is managed, by whom, and when. Because these two topics are interrelated, we will address the interview results using the writing strategies and deal with the document control issues in the context of each writing strategy.

Single Writer Strategy

The single writer strategy is the case of one team member writing the document, while the others assist.

This strategy was very popular. Thirteen of the twenty-two groups used the single writer strategy at some point in the project [1,4-7,10-14,16-18]. For example, Project 1 consisted of a student working with his supervisor on a paper for a journal. The student wrote the document while the supervisor consulted, staying closely involved throughout the project.

On six projects, using single writer strategies, we observed a hierarchical difference among participants [1,5-7,10,11]. In four of these projects a lower status member played the writer role, while the higher status individual consulted [1,5,6,10].

The single writer role was also assigned to the individual most familiar with the required format or the structure of the final document. Four projects [6,7,16,17] used this assignment strategy, where the standard formats included write-ups of experiments and a paper submitted to a particular conference.

Some groups made a conscious decision to use the single writer strategy [6,10,13,17] in order to have a uniformly written document, with one individual's style of writing present in the text:

> *"When I write it has to be under my control or I cannot write effectively … If two people write separate sections, the sections sound completely different." 3[6]*

On two of these projects [10,13], the single writer strategy was used following other strategies. The final version of the document was produced by one individual; this, the journalist claimed, was the standard approach used in his field. Both of these groups had writing assistance from others in form of text, much of which was changed by the final writer to reflect that individual's writing style.

Not all groups selected this strategy voluntarily. In seven cases, the available technology guided the selection of the single writer strategy. Two groups [1,16] did not have access to compatible technology and had no way of transmitting information between their computers. This limitation was a large factor in the implementation of the single writer strategy. The single strategy also occurred when group members were geographically dispersed [4,5,7,13,14]. In each case a single writer composed the document while other participants assisted the writer.

The use of the single writer strategy usually implies the use of the centralized document control method. In eleven of the above thirteen groups the writer maintained control of the document. In two cases [12,18], there was a single writer, but the control was shared because group members had access to networked computers and thus equal access to the joint document. In such situations social protocols often guide the accessibility to the document. For example, the amount of involvement with a document is related to the access to the document: the writer has full access, a co-writer and consultant may have read and comment access, a reviewer may have read only access, while outsiders may not have any access.

Scribe Strategy

The scribe writing strategy is used when individuals are working together and one of them writes down the group's thoughts and decisions, while the others are engaged in a general discussion of the ideas to be expressed in the document (Austin, Liker, and McLeod, 1990).

In the interviews, five projects [16,17,20-22] used the scribe strategy. One interviewee described this writing approach as "driving on the keyboard." The interviewee explained:

> *"I did most of the writing when we were working together. Once I made him write, or what I call 'drive' on the keyboard, then he realized how hard it is to transform ideas into words." 10[22]*

All the uses of the scribe strategy that we encountered occurred early in the project life during the brainstorming and planning activities. This strategy is usually adopted out of necessity to record the meeting information. The scribe has a very difficult job, participating in the meeting, and at the same time, transforming the group discussion into a document. As a result, the product of the scribe's effort is used as an

extension of the group memory and results in guidelines for the team rather than a document draft.

The application of the scribe strategy is often technology driven. If different technology had been available to these groups, the joint writing strategy could have been an option.

The document control used in conjunction with the scribe strategy was divided between centralized and relay control methods. Three projects [16,17,21] used centralized control with the scribe writing strategy,

> *"When I was at the keyboard typing I was really in control … my words were used and my style." 10[21]*

In the other two groups [20,22], the writer or scribe position was interchanged between the participants. First one would work as a scribe, then the other implying a relay control method; Mantei (1989) refers to this as the "alternating scribe" method and notes that this method occurs frequently when the technology supports it.

Separate Writers Strategy

If the document is divided into parts and different individuals write the various parts, then the separate writers strategy is being used.

The separate strategy is very popular in joint projects. Only three of the twenty-two projects did not use the separate strategy at least once [1,5,7].

By partitioning the document, the group can work in parallel, thereby speeding up the writing process. Time pressure was responsible for the use of the separate writers approach on twelve projects [8-12,16-22].

Many projects demand expertise in different areas and subgroups are often formed to represent complementary skill sets. In the interviews we observed eleven such cases [2-4,6,11-16,21].

Some interviewees had different reasons for preferring the separate writers strategy. One individual felt it easiest to work in a group when the responsibility was divided among group members [14]. A freelance writer admitted that separate writing entails fewer distractions:

> *"We tended to sit around and chat and do cryptic crosswords together. This way [by working apart] we'd separate and we knew that we had to do the work. You'd have to do the work and bring it in for others to see." 10[21]*

The journalist explained that the separate writers strategy often followed by the single writer strategy is most popular in his field:

> *"It's very rare when two people write together. Usually one writes one part another writes another part. Then, they send it to a third person who puts it together or one of them puts it all together." 6[13]*

In three instances the separate writers approach was influenced by the available technology [2,10,21]. One interviewee discussed such an experience:

> *"We all had different computers … We just wrote differently [separately], met talked about each others ideas, took the suggestions, rewrote, and compiled it all. … We didn't have the time to have a secretary retype it all. … The producers objected to the lack of consistency in style … they said, 'One of you is more prose, one of you is funny, and one of you is more mythological'." 10[21]*

This quotation demonstrates the major problem with the separate writers strategy. Following the separate work there still remains the need to unite the resulting segments in order to create a uniform style.

When using the separate writers strategy, there are several possible document control options. The most common combination is with independent control, used in fifteen groups [2-4,9-17,20-22]. In this combination, the individuals writing continuously control their segments of the document. As we saw in the above quotation, the result of this approach can be a segmented and disjoint document.

A combination that appears to be more effective is the relay control method. For example, in the case of a supervisor-student team that wrote a paper together. The interviewee explained:

> *"I don't usually write things so closely intertwined. … What struck me is how seamlessly we could exchange the documents back and forth between us. It worked very well … We were thinking along parallel lines. I didn't really expect this. It just worked out very well." 7[15]*

In another case, we have an example of how separate writing can be used effectively when the writers understand one another. A pair of researchers who worked together for many years, spent much time developing ideas, debating alternatives, and trying to prove their theories. When the time came to write the details were clear:

> *"When one got down to writing, there was no question about what had to get down on paper." 4[8]*

While actually writing they follow a tightly interwoven process:

> *"We ping ponged the paper back and forth. … We'd get mad at each other. Work things out … it was a very pleasant experience until the very end … The actual collaboration was very fluid, very pleasant." 4[8]*

Four other groups also combined separate writers strategy and relay document control methods [3,6,18,19].

In five other groups separate writers was used, but the documents were available to several group members simultaneously, implying a shared control method [3,8,9,18,19]. In work on a best-seller book [19], the interviewee explained their work process:

> *"It wasn't like we took ownership of any one chapter. We knew what we wanted to do, so we just did it. … Whoever started something would usually continue it until it was at a point where it*

can be edited easier. But there were places where I would start it and he'd continue it and vice versa; you'd get some block and you don't know how to do it…" 9[19]

Here, we see the subtlety of the difference between relay and shared control methods: shared means both have access, whereas, relay means only one at a time has access. In the case of the joint book, project [19], where both coauthors had access to the latest version of the document, but only used it one at a time, we see shared control.

Joint Writing Strategy

Joint writing is a strategy in which several group members compose the text together, and even minute components of the text are decided by a group effort.

In the interviews, nine groups worked on some parts of their documents jointly [2,3,8,10,12,15,18-20]. We observed that joint writing can have different effects on group cohesion. Some groups enjoyed the joint writing experience while others found it frustrating and harmful to group unity. The maturity of the group influenced the success of the joint writing session; an experienced group was able to work together more smoothly than a new group. All old groups that utilized this strategy had a pleasant experience [3,8,15,19]. Two new groups found this strategy beneficial [18,20], but three others found it frustrating [2,10,12].

We examined at what point in the project life the joint strategy was used and discovered that the groups who attempted joint writing late in the project were the same new groups that described this approach as ineffective [2,10,12]. In each of these cases, the joint writing attempts resulted in conflicts between group members and disrupted the group cohesion. One interviewee described these conflicts:

"Everyone gave comments on everyone else's work … We argued about every sentence. The final decision went whoever yelled loudest!" 1[2]

The interviews suggested that, early on in a project, groups can write jointly to produce an outline of their ideas, at which point opinions are still forming. Later in a project's life the individuals' ideas are better defined and more difficult to integrate.

Another important aspect leading to the success of the joint writing strategy is the document control method that is used with it. Groups 8, 18, and 19 used a shared control method. Each team of two writers used a shared work space consisting of a white board and two markers. Four groups combined joint writing with relay document control [3,15,19,20]; the control passed between the participants while both decided on the changes that should be made. The final and the least successful combination of joint writing occurred with independent document control [2,10,12]. In each case we saw group members of equal status trying to decide on changes to be made to parts of the document that were written and controlled by one individual. The suggestions and changes that were brought up during these interactions were badly received by the writers and owners of the segments. These observed difficulties resulted from a combination of factors including the newness of the group, the equal status of the members, the lateness of the attempt at joint writing, and the individual control methods.

Consulted Strategies

The consulted approach is not a complete strategy in itself but a combination of the other writing strategies. A strategy represented as single(consulted), for example, implies that there was a single writer who worked very closely with a consultant throughout the project, as opposed to the single strategy where the document reflects the work of one person with minimal assistance from others.

In the interviews we observed fifteen projects using consulted strategies: single(consulted) [1,4-7,10-14,16,17], separate(consulted) [9-11,21,22], and scribe(consulted) [22]. We did not encounter an example of the theoretically possible joint(consulted) strategy, where a group is divided into subgroups with one subgroup writing while the other participants consult.

Several groups used more than one type of consulted strategy. For example, on project 22 the team members were two writers and a producer with the product being a series of scripts for television. The two writers started out working together using the simple scribe writing strategy, with the senior writer working as scribe. They decided to switch roles and the junior writer became scribe but had difficulty with this role. The senior writer felt obliged to assist:

"Once I made him write, or what I call 'drive' on the keyboard, then he realized how hard it is to transform ideas into words. … Even when he was writing I was helping him with how to phrase things." 10[22]

This is an example of the unusual scribe(consulted) combination strategy. Later in this project the separate(consulted) writing strategy was adopted, with the producer serving as a consultant and an arbiter to guide the progress and settle disputes.

Implications for System Design

The interviews and the taxonomy demonstrate that approaches to joint writing vary considerably (see Table 2). Further details on the taxonomy, as well as findings from a laboratory study of collaborative writing (carried out through a variety of communications media) that corroborate the results from the interviews, appear in Posner (1991) and Posner and Baecker (submitted for review).

These results also suggest a set of design requirements that collaborative writing systems should support. All of these requirements need not necessarily be supported in software technology; some can be incorporated into the larger social system in which the

technology is used. The requirements are now listed followed by a description of how existing groupware writing tools satisfy the requirements.

Table 2: Interview Results Summary

Summary of the percentages of the 22 projects studied in which a particular strategy or method occurs. Since multiple strategies and methods often occur in a project, percentages do not add to 100%.

Writing strategies		Document control methods	
Separate writers	86%	Independent	64%
Single writer	59	Centralized	55
Joint writing	41	Relay	36
Scribe	23	Shared	27
Consulted	68%	Document control changes	77%
Single writer	55		
Separate writers	23	Work equally divided	59%
Scribe	05		
Joint writing	00		

Design Requirements

Collaborative writing projects often depend on several individuals contributing to the writing; feedback is most effective when directed to the author of a segment:

Requirement 1: Preserve collaborator identities.

Group writing differs significantly from individual writing by the amount of communication among the participants. Communication includes messages dealing with the document text, project scheduling, and social interactions; systems should facilitate these communications:

Requirement 2: Support communication among collaborators — document annotations, synchronous interactions, and asynchronous messages.

Roles

Roles that individuals play on projects define their contributions and commitments to the project. Misunderstanding of commitments can lead to conflicts within a group:

Requirement 3: Make collaborator roles explicit.

Activities

Activities occur in different sequences and combinations on collaborative writing projects:

Requirement 4: Support the six primary writing activities: brainstorming, researching, planning, writing, editing, reviewing.

It is unrealistic to expect that one tool will be sufficient to support all the different activities. To compensate for this shortcoming systems must provide smooth transitions between the different activities:

Requirement 5: Support transitions between activities.

Varieties of information are required throughout the writing process. Systems can facilitate the organization and the access to information:

Requirement 6: Provide access to relevant information.

Planning is crucial in collaborative writing. Effective plans can reduce redundancy, misunderstandings, and even the work load for the group:

Requirement 7: Make plans explicit — process and outline plans.

With several individuals working on a document, it is important to be able to quickly discover what changes were made, who made them, and when they were made:

Requirement 8: Provide version control mechanisms — change indicators.

Document Control Methods

Participants on a project may want to access the document at the same time or in sequence; systems should allow flexible access:

Requirement 9: Support concurrent and sequential document access.

Different types of document access may improve the writing process. If consultants can read the document and provide comments early in the writing, the overall project time may be reduced:

Requirement 10: Support several document access methods: write, comment, read.

Many collaborative documents are subdivided. Each segment can have different individuals working in different roles, on different activities, and using different document control methods and writing strategies. Systems should allow flexibility for several document segments but maintain connections for the entire document:

Requirement 11: Support separate document segments.

Writing Strategies

Writing strategies used on collaborative projects fall into two categories, using either one writer or several writers:

Requirement 12: Support one and several writers.

Writing can be done by several individuals working either at the same time or at different times:

Requirement 13: Support synchronous and asynchronous writing.

Design Requirements and Existing Systems

We shall now briefly describe six existing systems that support collaborative writing, and see how well they conform to the proposed requirements for collaborative systems (see Table 3).

Aspects, by Group Technologies (1990), is a collaborative conferencing system that runs on networked computers and provides writing, drawing, and painting tools. **ForComment** (Edwards, Levine, and Kurland, 1986) supports asynchronous annotations by several people, with each collaborator accessing a different layer for creating annotations using text, voice, or hand drawings. **GROVE** (Ellis, Gibbs, and Rein, 1989) is an outlining tool designed for users at remote sites working on networked computers. **PREP** (Neuwirth, Kaufer, Chandhok, and Morris, 1990) is a writing tool that provides asynchronous access to documents and can be thought of as a "spreadsheet for documents," because it provides a column based interface where text is presented in columns of visually linked chunks. **Quilt** (Fish, Kraut, Leland, and Cohen, 1987; Leland, Fish, and Kraut, 1988) is a multi-user hypermedia communications and coordination tool which combines computer conferencing with multi-media email. **ShrEdit** (Killey, 1990) is intended for simultaneous writing by several users working on networked computers in a conference room. **SASSE** (Mawby, 1991; Nastos, 1992), a shared editor based on our research, supports synchronous and asynchronous writing over local and wide area networks, and uses color to distinguish contributions from individual writers.

Although most of these systems satisfy a number of our requirements, it is clear that progress can still be made (Mawby, 1991; Nastos, 1992).

Table 3: How Existing Collaborative Writing Systems Satisfy the Design Requirements

Requirement	Aspects	ForCom.	GROVE	PREP	Quilt	SASSE	ShrEdit
1. Preserve identities	++	++	++	+	++	++	++
2. Enhance communication							
Annotations	.	++	++	++	++	++	++
Asynchronous	.	++	.	.	++	++	+
Synchronous	++	.	.	+	.	++	++
3. Make roles explicit	++	.	++	.	++	+	.
4. Variety of activities							
brainstorming	++	.	+	+	+	++	++
researching	.	.	.	.	.	.	.
planning (outline)	+	.	++	++	+	++	+
writing	++	.	.	++	+	++	++
editing	++	.	.	++	+	++	++
reviewing	.	++	.	++	++	++	+
5. Transitions between activities	+	.	.	++	++	++	+
6. Access to relevant information	+	?	?	+	++	.	+
7. Make plans explicit							
Process plans	.	.	.	+	.	.	.
Outline plans	.	.	++	++	+	++	.
8. Version control mechanisms	++	.	.	+	.	++	.
9. Document access							
Synchronous	++	.	++	.	.	++	++
Sequential	++	++	++	++	++	++	++
10. Several access methods							
Write	++	.	++	++	++	++	++
Comment	.	++	.	++	++	++	+
Read only	++	.	++	++	++	+	.
11. Separate document segments	++	.	?	+	++	.	.
12. Number of writers							
One writer	++	++	?	++	++	++	++
Several writers	++	.	++	++	++	++	++
13. Writing approach							
Synchronous	++	.	++	.	.	++	++
Asynchronous	++	++	++	++	++	++	++
	Aspects	**ForCom.**	**GROVE**	**PREP**	**Quilt**	**SASSE**	**ShrEdit**

Notation:

++	system provides support
+	system can handle but does not specifically support
.	system does not support
?	not clear if support is provided

Conclusions

This study has demonstrated the rich variety of methods that groups use to write collaboratively. Technology therefore needs to be flexible and permissive, allowing groups to change strategies and processes at any time during the project with minimal distraction. Smooth transitions should be supported between using technology and conventional methods of writing, between individual work and group work, between planning, outlining, writing, and annotating the document, and between synchronous and asynchronous work by group members (Baecker, 1991). Technology that strictly enforces limited approaches and that is not sufficiently flexible will constrain the group writing process and likely lead to frustration and eventually lack of use of the prescriptive technology.

Acknowledgements

We gratefully acknowledge the support to our laboratory from the Natural Sciences and Engineering Research Council of Canada, the Information Technology Research Centre of Ontario, the Institute for Robotics and Intelligent Systems of Canada, Apple Computer's Human Interface Group and Advanced Technology Group, Xerox PARC and EuroPARC, Digital Equipment Corporation, the IBM Canada Lab Centre for Advanced Studies, and Alias Research. We are indebted to Marilyn Mantei for assistance with this work and for valuable comments on a draft of this paper. We'd like to thank Gary Olson, Lola McGuffin, Robert Fish, David Kaufer, Ravinder Chandhok, and Dimitri Nastos for help with the table comparing collaborative writing systems.

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Appendix: Interview Questions (slightly abridged)

The following questions were asked in each interview, not necessarily in this order, but as they arose naturally in the context of the conversation.

I am studying how people write together. I would like to talk to you about the most recent (one especially memorable) joint authoring project you participated in. Statement re confidentiality...

Background

• When did this take place? How long did the entire project take?
• What type of document were you working on? How long was the final document?
• Who were the participants? Were these people peers/subordinates/superiors? How were they chosen? Personalities...? Special skills...? (known previously, not, ...) How important was it for everyone to work together?
• What were you doing at that point in your life? (type of job, educational training, ...)
• Describe in detail one day that you were working together on the project (the time of year, weather, location, purpose of meeting, productiveness of meeting, outcome of the meeting, ...)

Process

• Did the writing proceed in stages or steps? What were the stages (planning/writing/revising/...)? What happened at each stage of the writing process?
• How did you share the work? Who did what? Was the work evenly divided? How was this decided on? Which stages of the writing (planning, drafting, revising, ...) involved groups of people and which were done by individuals?
• Was the process planned at the start or decided on over time? Was the plan followed?
• Was the process explicit? (Decide to do A,B,C then do A,B,C.) Or did individuals just do things?
• Was the process used similar to your usual writing style when writing alone or when writing with others?
• Would you say the process used was a success? Why or why not?

Control

• Sometimes one or more persons take charge of the document. Did this type of thing happen during your writing? Who was this person? How was he/she chosen?
• How did you find the errors? How did you fix the errors? Did everyone take part in reviewing the document and suggesting changes? How were the changes done? (permissions...)
• How was the final document compiled? Was anyone in charge of this stage?
• Afterwords, how was credit divided? Was this discussed early on during the writing? (How many authors? Who's first?)

Problems

• How did the relationships work out? What other types of problems did you encounter during the writing?
• How did you handle/settle your disagreements?

Technology

• What is your educational/technical background?
• What type of technology was used in the project? (Computers/typewriters/telephone/fax) At what stages of the project was technology used?
• What did you like/dislike about available technology? Did it ever get in the way? What would have made it easier to use?
• What type of technology would have facilitated the writing process?

• What else would you like to be able to do with the technology?

Is there anything else? Have I covered everything?
• Would you say that this project was a success?
• Would you choose these people to work with again?
• What is your attitude towards joint writing? (positive/negative)