Supporting Collaborative Drawing with the Mask Versioning Mechanism

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Abstract. This work presents a synchronous collaborative graphical editor that implements a proposal of an awareness mechanism of a collaborative artifact evolution. The graphical editor allows real-time, highly interactive collaborative work, using the mask metaphor to help participants in creating new diagram versions without interrupting the interaction as also to provide awareness of the diagram versions created. This paper describes the mask metaphor, the collaborative editor that implements this metaphor and discusses a case study conducted with the use of the tool.

1 Introduction

Collaborative editors aim at providing communication channels, coordination and awareness functionalities for helping participants in recognizing the action of others in the artifact being built. In only one work session, this artifact passes through many stages or versions representing the steps taken for its construction. Basically, a workspace is shared where the artifact under construction is disposed. Each participant can act on the artifact, changing it according to his need or following any coordination protocol.

This work focuses on the issue of artifact evolution. The construction of collaborative work artifacts – especially diagrams – are burdened by the absence of mechanisms that help participants to discuss different alternatives, to make decisions and to follow the evolution of the artifact being built. Some proposals address this issue providing functionalities for changing and version control but few of them help participants to generate parallel alternatives of the same diagram and to discuss, compare and evaluate the content of each version in order to take specific decisions.

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It is argued that a collaborative editor can provide a set of functionalities aiming at: a) representing participants' consensus over the whole diagram or part of it; b) allowing parallel work and discussions by subgroups analyzing new alternatives that can be merged on the common product; c) helping participants to reach consensus and viewpoint convergence based on the alternatives outlined throughout the editing interaction.

This paper presents the proposal of such collaborative editor – CO2DE –, which aims at achieving the objectives outlined above. The concept underlying CO2DE functionalities is the *mask metaphor.* This concept implements a versioning mechanism for collaborative graphic editing where changes on the artifact can be created independently or not from the overall work, the change context can be identified, and, finally, the participant can discuss and make decisions about those changes.

The paper is structured as follows: Section 2 addresses some issues for being aware of changes in collaborative editors. Section 3 depicts the CO2DE editor functionalities. Section 4 describes case studies conducted to evaluate the use of CO2DE. Finally, conclusions are presented in Section 5.

2 Awareness and Discussion of Changes in Collaborative Editors

Text editors are the most popular software tools used in organizations. Products like Microsoft Word or similar offer functionalities for collaborative reviews such as: the creation of annotations in the text, the assignment of colors for modifications made by each author and different text styles to show participants that a review was introduced in the text - for instance, the removed text is stroked through and new text is underlined. However, since each author can only make each modification on his turn, a coordination process or a work protocol must be defined among authors in order to review the text being constructed.

2.1 Knowing What Is Going On

In collaborative editing tools, mechanisms adapted from single-user text editors provide useful awareness information for the group. Telepointers, multi-user scrolling bars and fisheye viewers are examples of awareness mechanisms aimed at showing participants' position in the collaborative text [1].

Collaborative graphical editors also provide shared workspaces where authors share the same drawing or diagram and the modifications are broadcasted to each participant individual view. *Graphical Fisheye Views* [2] is an example of awareness mechanism for helping co-authors in focusing on detailed portions of the workspace and being aware of what are the others' position and focus. *Radar Views* is another awareness mechanism that shows a minimized view of a diagram. On this view it is delineated each user's working area at that specific moment [3].

Whatever is the awareness mechanism provided by a collaborative editor, its main objective is to offer what is called *feed through* [4] – any change in the shared objects at the workspace must be remotely reflected to other users.

As much important as the possibility to reflect changes, is the possibility of retrieving the sequence of actions taken by the group over the shared text or diagram.

The possibility of being aware of the versions an object passed through is important information for helping authors to understand the obtained results and to continue their interaction.

The *Stick*-Ons [5] can be considered as a proposal of an awareness mechanism for text versioning in a collaborative editor. The *Stick-Ons* are based on the adhesive tape metaphor. To substitute a part of the text, the reviewer "glues" a *stick-on* over it and fills it with a new text. Lately, if any reviewer wants to know what the original text was, he can remove the *stick-on* and see what is behind it. While doing that, the original text is presented with a shadowed texture, as if pieces of glue have remained over it after the *stick-on* had been removed.

A text being reviewed by a group is presented in Figure 1. The various parts of the text with different background color scales represents texts that were replaced by authors by gluing *stick-ons* and writing on them.

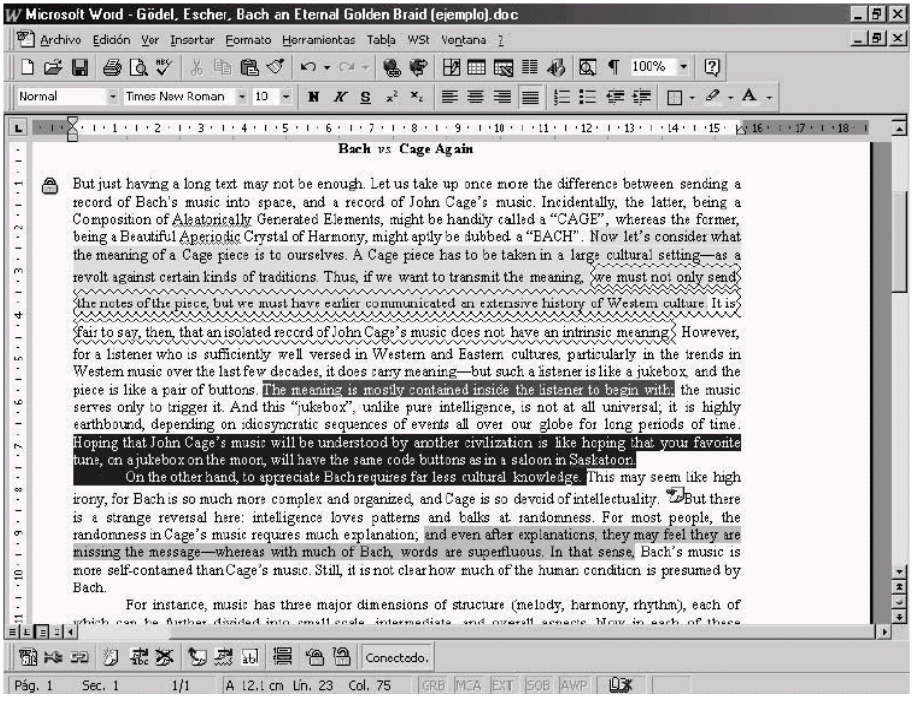

Fig. 1. Stick-Ons [5]

Tam et. al [6] present an evaluation of a set of awareness mechanism for representing changes on artifacts, what is called *Change Awareness*. Figure 2 shows how the effects of change in a diagram can be expressed. Changes in positions are represented by shadows; strong colors indicate that the artifact suffered a great number of changes. Other mechanisms show the nature of the change (modification or movement).

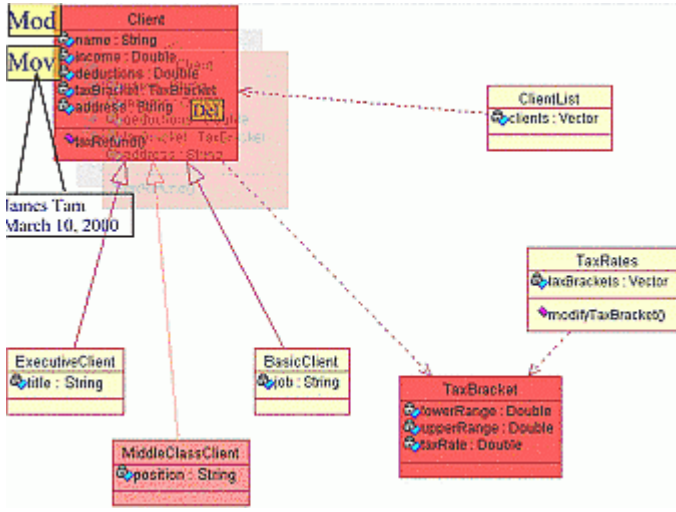

Fig. 2. Change awareness [6]

2.2 Discussion and Convergence of Viewpoints

During a collaborative editing session, participants have the opportunity to add their contributions simultaneously in order to build the final product. Being aware of each contribution usually leads to discussion, to the need of clarifying viewpoints as also to the generation of new ideas.

Santoro, Borges and Pino address such issues in the CEPE cooperative editor [7]. This tool supports process elicitation and modeling, providing features for participants to discuss the problems and to add comments, like in a "brainstorming" session. Its communication facilities allow participants to exchange messages, referring to an element in the diagram. Opinions and ideas can be attached to the elements, using a set of icons to distinguish comments, suggestions, inquiries, mistakes and a scratch-pad for discussion. Awareness capabilities are also available using colors, telepointers and multi-user scrollbars.

2.3 Working in Parallel

As mentioned above, by being aware of each participant contribution and the discussions conducted within the context of an editing session, participants may be caught by new ideas that should be explored as a relevant alternative for bringing quality to the collaborative artifact. However, the functionalities available in synchronous collaborative editors, for instance, usually force participants to contribute each one on its turn and the entire group must be focused on his idea in order to discuss it. In asynchronous interaction, on their turn, participants express their ideas to be known by others but it is often difficult to report the editing context where the idea took place.

Additionally, concurrent manipulation of shared objects often leads to conflict situations. Usually, conflicts are considered as an undesirable situation. However, it is

possible to understand a conflict as an opportunity for interaction since at least two participants are interested in the same portion of the collaborative artifact [8]. Instead of avoiding or controlling conflict through blocking mechanisms, what about allowing each participant to build their own version or alternative of the shared artifact and supporting them in negotiating their viewpoints?

For these situations, it should be interesting if the collaborative editor offers functionalities to support independent and parallel sub-group work. Each sub-group could work on a different piece of the shared workspace without bothering the main discussion. Meanwhile, the discussions conducted by this sub-group could also be registered and, if acceptable, even incorporated to the main collaborative artifact.

3 CO2DE

This work discusses the idea of providing mechanisms to collaborative editors that aims at promoting parallel work, treating conflict as opportunities for new ideas and providing memory about the versions of the artifact being built. A collaborative drawing tool was developed, supporting the creation of UML diagrams. The editor is called "CO2DE", a reduction for the term "Collaborate to Design", mentioning the collaborative activities of a group to design a diagram [9].

CO2DE provides functionalities for marking the versions of the diagram being constructed using the concept of *masks*. Some group facilities are offered to provide awareness of others' activities, communication and coordination in order to support both synchronous and asynchronous interactions. By providing functionalities to deal with the mask concept, CO2DE supports participants in its collective knowledge building about the artifact being constructed: it is a way for brainstorming and representing multiple viewpoints; and it supports the comparison, discussion, combination and convergence of these different viewpoints.

3.1 The Mask Metaphor

The mask concept [9] allows representation of multiple versions of a diagram designed in collaborative session. This concept is based on the presentation slide metaphor. Once a version of the diagram is developed, a new version can be built, by putting a slide upon it and drawing on its surface like a mask. The new mask may contain new symbols and changes to the symbols of the previous version. Removing the mask shows the contents of the subjacent diagram version.

The process of constructing a diagram may consist of a sequence of versions or masks, each one representing one stage in the evolution of drawing process. Each mask is considered the child of its predecessor. To keep consistency, a mask cannot be modified if another one was generated from it – we say that the mask is closed or frozen.

Also, a mask can evolve into two or more alternatives, when the alternatives are built upon the same original mask. This way, the collection of all masks created during a drawing session can be organized as a tree, each node reflecting one version or mask (Fig. 3). This metaphor, applied to collaborative drawing, offers the facility for

a group to distinguish relevant stages in the artifact evolution, as also to explore and evaluate concurrent versions raised during their interaction.

The mask metaphor uses the same concept of Stick-Ons to create a diagram version starting from an existing version. Although Stick-Ons are applied in a portion of the document text (a word, phrase or paragraph, for instance) and masks reference the whole artifact (diagram).

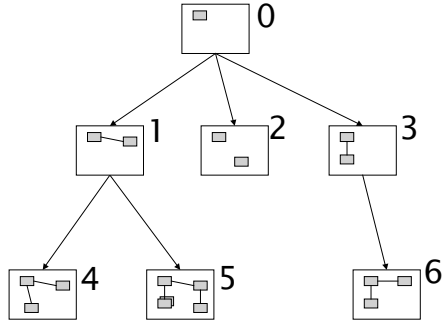

Fig. 3. Masks evolve in a tree structure

3.2 Functionalities

User Interface

Similar to other editors, the CO2DE functionalities can be accessed through its graphical interface, selecting an option in its menu or tool bar, or using its mouse sensitive drawing panel. The main window consists of three main areas (panels) as shown in Fig. 4. The Drawing Panel is the biggest one, with horizontal and vertical scroll bars, where the diagram can be edited using mouse events in conjunction with menu editing functions. Symbols in the diagram can be created, modified, moved and deleted. It has a WYSIWIS interface, providing work awareness over a shared mask.

The Mask Panel is presented in the upper right corner of the window, as a list of masks for the diagram being constructed during the collaborative drawing work. The item selected in the list is the mask currently selected by the user, which is shown in the Drawing Panel. In this panel, users manage the mask hierarchy. This functionality is better explained in section "Versioning".

The User Panel is simply a list of all participants logged in the session, which is continuously updated as new member joins in or leaves. This panel is located in the lower right corner of the window, and is just a static panel – no user action is available on it.

Modeling

The editing functions available for users are very similar to the ones in a typical graphical editor. There are operations to create a new diagram, to open an existing

diagram, and to save the diagram. There are editing operations to insert, modify, move and delete symbols in the diagram. In the CO2DE context, those operations are applied to the mask currently selected by the user, as described further.

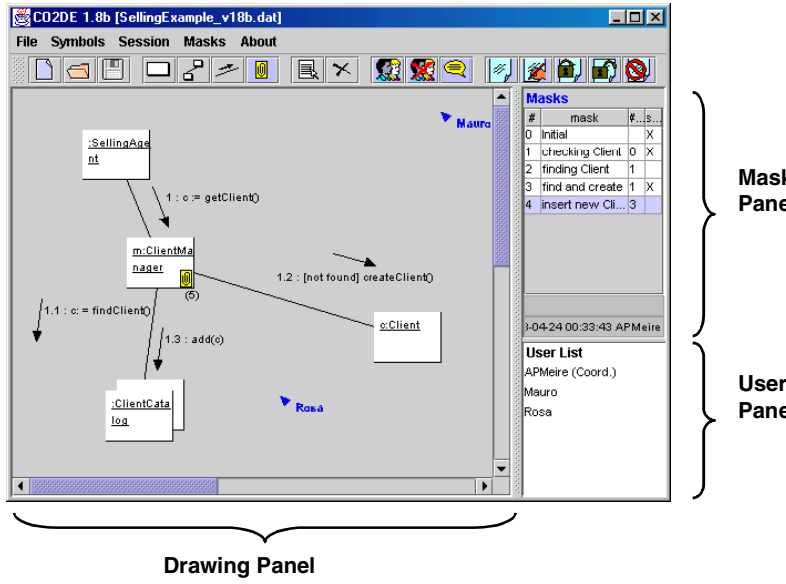

Fig. 4. CO2DE main window

Collaboration

In the user panel, one of the participants is indicated as the coordinator of the session, as seen by the "(Coord)" after his name. The coordinator is the user who first logged into the CO2DE session. If he has a diagram in his drawing panel, this is used as the diagram to be shared during the session. The other users receive this diagram in their drawing panel automatically, as they join the session, with the list of masks built so far.

When a participant joins the session later on, he can see through the mask structure how work has evolved. Navigating through this structure, he can be aware of and compare versions. He can analyze the contributions, changes made, alternative proposals, and negotiation between participants, registered in the communication facilities, chat and annotations, presented in the session.

CO2DE provides awareness functionalities through a WYSIWIS interface, where all editing operations made by one of the participants are immediately reflected in the others' shared workspace as shown in Figure 5. This is true for all participants working in the same diagram mask. For participants working in other masks, those operations can only be perceived when they select the corresponding mask, which characterizes a WYSIWID interface (Figure 6). Telepointers are also implemented in the tool, allowing participants to see in which part of the shared workspace other partici-

pants are located. As mentioned above, only telepointers of participants who selected the same mask are shown.

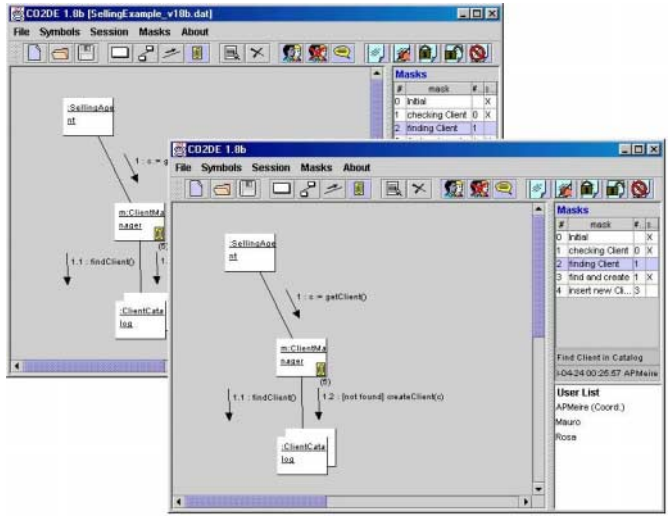

Fig. 5. Two participants working in the same mask (WYSIWIS interface)

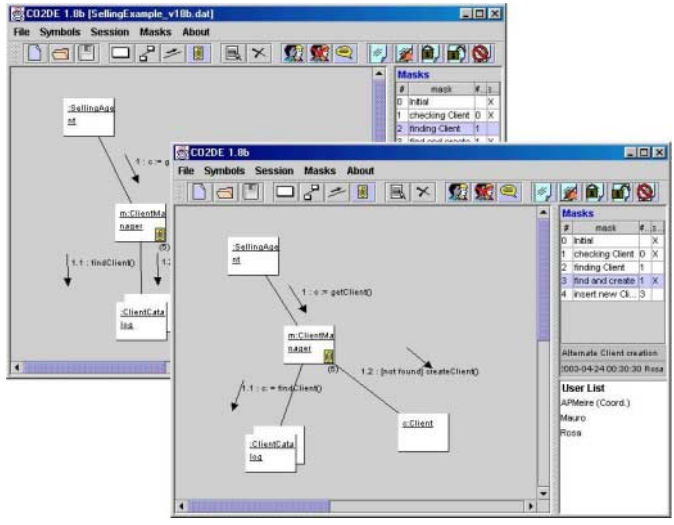

Fig. 6. Two participants working in different masks (WYSIWID interface)

Versioning

Working with diagram versions in CO2DE seems as virtually manipulating presentation slides upon the shared work area. Once connected to a session, the user has one diagram version (mask) drawn in his drawing panel. This mask represents the stage of the diagram since it was first created in the beginning mask, with all modifications in the sequence of masks, until the current one (figure 7). The user may select another available mask, and the diagram is redrawn to show the selected version.

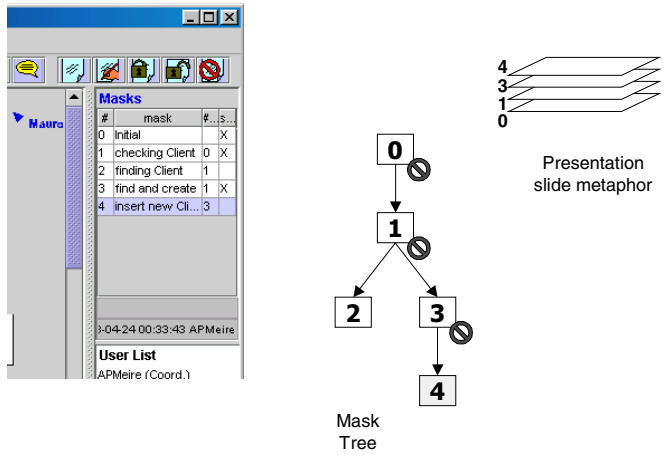

Fig. 7. Each mask represents an evolution path

Masks with "children" cannot be modified. Only masks that represent "leaves" in the tree structure are editable. In those ones, the user is allowed to insert, to move, to modify or to delete symbols, on his drawing panel. Every change is instantly reflected in the work area of other users connected to the session, working on the same mask. Each one of these operations is associated to the currently selected mask, being represented in this mask and its successors. The deletion operation of a symbol, in special, is done logically – the symbol is removed from the current mask, but continues to be drawn in its predecessors. This helps capturing its representation thereafter and avoids loosing its context about modifications during the design evolution [8].

To manipulate the mask structure, the user has to use the mask panel and its corresponding operations. Those are operations to manipulate the masks, allowing masks selection, creation, closing, blocking and unblocking. When a participant wants to create a new mask, he must select the mask, which will be the parent of the new one. The new mask will be created as its child. Then, he chooses the operation 'New Mask', either in the menu or in the toolbar corresponding button. The creation is only allowed if the parent is closed.

Closing a mask is as simplest as selecting it and calling the 'Close Mask' operation. There is a restriction here; only the creator of the mask or the coordinator of the session is allowed to close the mask. This operation cannot be undone and, once closed, no more editing operations can be done in this mask. Blocking a mask gives the exclusive editing of the mask to a participant. Other participants can select the

mask, but are prohibited of modifying it. The mouse pointer is changed to a padlock icon when passed upon a symbol by other participants, indicating that editing operations are temporarily unavailable. Later, the exclusive user can unblock the mask, turning it modifiable again.

Participants can add annotations using the clip symbol, attached to object symbols or to an area in the diagram. Comments can be inserted in the clip cumulatively, as free text. When opening the clip, the contributions annotated in all masks in this same path are presented in chronological order. This helps to keep track of the context of discussion during the evolution of the editing activity.

The Chat function in CO2DE is based in the mask context. Every message sent is associated with the mask currently selected by the sender. The chat window shows only the messages generated in the current mask and its predecessors (Figure 8). With this resource, we try to keep the communication based in the context of the discussion. Users working in the same mask are not annoyed by messages exchanged on other masks.

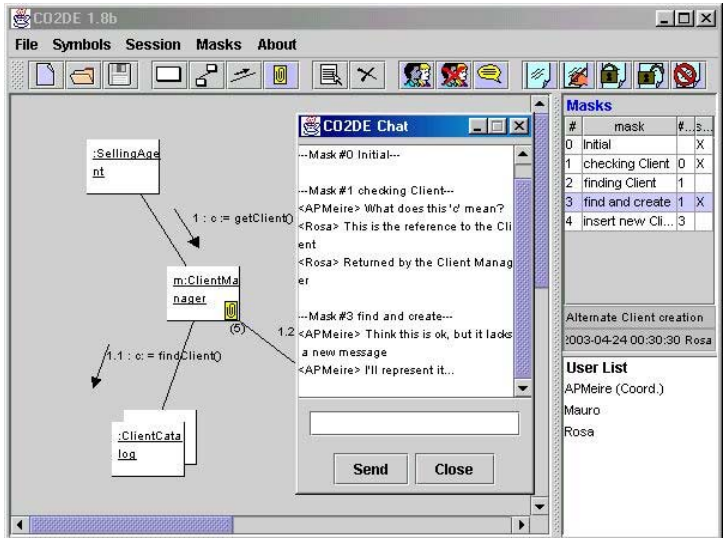

Fig. 8. Chat in CO2DE

CO2DE allows saving in disk all the work generated during a group session, recovering it a posteriori to be used in another session, or for analytical purposes. All contributions are saved – the diagram built, with each mask created, and the messages sent through the chat.

3.3 Using CO2DE

CO2DE was designed to help software developer groups to interactively build an UML diagram. Its aim is to explore the use of groupware features on collaborative

modeling activities, giving participants the opportunity to create and discuss alternatives for evolving the diagram in a real-time fashion, like a brainstorm session.

Although there are communication and coordination functionalities available, it seems necessary to previously prepare the group before the drawing session, explaining the meeting objectives. A closure meeting may also be important in order to discuss and evaluate the alternatives created and to decide on the final version of the diagram.

4 Evaluation

In order to evaluate CO2DE, case studies were designed and conducted. The evaluation observed how the use of the mask concept helped a work group to evolve in the drawing process, creating and improving the sketches of the diagram, and converging to a common solution, supported by the collaborative editor features. We aimed to evaluate not only the technology aspects but also, and more important, the interaction issues, such as decision-making, the conflicts that occurred and how the group managed to solve them.

4.1 Design

The evaluation design and discussion followed the guidelines suggested in CSCW Lab proposal for groupware evaluation [10] and are described in the following sections.

Evaluation Hypothesis. The research hypothesis of the case studies could be stated as: the functionalities available in CO2DE aided group participants in creating different alternatives for a diagram and converging to a common artifact based on these multiple versions.

Issues. In order to verify this hypothesis, some issues were outlined:

I1. Did the mask mechanism available in the tool allow participants to easily create different alternatives of a diagram?
I2. Could participants be able to discuss among themselves within the context of a specific mask?
I3. Did the mask mechanism and associated discussion help participants to take decisions about which mask better represents the group work result?

Dimensions of Evaluation. According to CSCW Lab, a groupware evaluation can focus on one or more of three dimensions: evaluating the tool usability; evaluating if the tool helped participants to reach an appropriate collaboration level; evaluating the cultural impacts the tool brought to each individual, to the group or to the organization. Whatever is the evaluation aim, the CSCW Lab suggests that the group context must be well understood in order to interpret each evaluation result.

The main focus of CO2DE evaluation design was on the level of collaboration and the tool usability issues. Therefore, it addressed these dimensions using the following variables:

Group Context: Three case studies were conducted for the evaluation of CO2DE. In each case study a different group was invited to participate. Previous experience in OO software development, use of CASE tools and use of groupware tools were considered as important variables to characterize the groups.

Usability: This version of CO2DE was a prototype and the case studies also aimed at verifying its viability while being used. However, it was not the main focus of this evaluation to conduct a deep analysis on the tool usability. Thus, these case studies could be classified as what we call "pilot-evaluations" [10][11].

Collaboration Level: CO2DE was conceived to help editors to generate multiple views of the collaborative artifact, to allow parallel work and to support discussion and decisions about the created versions/views. In order to evaluate it, the case study considered variables such as: the number of masks created by group participants (the degree of multiple views); the number of levels presented in the resultant mask tree (indicating group convergence/divergence); the degree of change between the created mask (indicating relevant contributions/changes); and if the final product reflected a relevant result in respect to the work problem complexity.

Measurement Instruments. All information about the interaction is registered in CO2DE database, including a log document of user actions. This record was the main source of quantitative information for measuring the variables outlined above. Additionally, after each work session, participants filled out a questionnaire where other information, mainly subjective, could be retrieved.

Scenario. The case study scenarios comprised the task of building UML collaboration diagrams for a pre-defined system use case [12]. A document describing the use case was distributed to the group along with its oral presentation in a meeting right before the interaction with CO2DE. After reading the use case and solving any doubts, participants started the interaction using the tool.

Each evaluation scenario comprised two working sessions (with two different use cases to be detailed as UML collaboration diagrams) in order to compare their outcomes. In the first session, groups were limited to open new versions of the shared diagram in a linear sequence, i.e., multiple views of the diagram were not allowed. Thus, participants had to follow altogether the artifact evolution. In the second session, participants were able to freely use the mask mechanisms.

Participants worked synchronously in the same room, although it was suggested not to talk to each other in a face-to-face manner. It was supposed that they should use the communication channels available in CO2DE – chat and annotations.

Results and Observations. These were the findings obtained with the case studies, based on the CSCW Lab dimensions:

Group context: Three groups of six members performed this evaluation scenario. Post-graduate students composed the first two groups. The other group was composed by IT professionals (system analysts and programmers) of a government agency. Participants of all groups had previous experience in software development. The par-

ticipants in the first two groups had previous experience in using groupware tools. The last group, however, was more experienced on the use of CASE tools.

Another important aspect to be observed is that the post-graduate students had less experience in working together while the third group was composed by members who knew each other well and had plenty of experience of working as a group.

Usability: The experiments were the first occasion to apply the CO2DE tool in groups of six participants, working simultaneously, manipulating the shared workspace with a high number of contributions. The first session, especially with the pos-graduating students, were quite unsatisfactory in terms of usability. Every single operation like clicking, dragging-and-dropping, navigating on menu options took many seconds. It seems the group were working in slow motion. A lot of noise could be heard inside the groups, as people complained, questioned and requested technology support.

That situation led us to review the implementation of workspace redraw functions, specially the telepointers. A new version of CO2DE were built and applied in the second session, solving the mentioned problems and resulting in a more stable and smooth work. These were reflected in a substantial noise reduction, with a complete silence in the laboratory environment – communication between participants occurring basically through the chat facility.

Most of the participants had not experienced interactions through synchronous tools. In all three groups, the first contact with the tool led participants to use some resources lately, like dragging-and-dropping. Some of them got confused when seeing all telepointers moving around inside the drawing panel.

The awareness resources were positively evaluated, like telepointers, although some pointed out that it works fine for the people working in the same mask, but not for people situated in other masks (affirmative 5, table 1). Again, the result reflects the difficulties of interaction of the second group, in its four concurrent masks.

Collaboration Level: The two groups of pos-graduated students made a very discreet use of the masks. While we expected a large structure, with many concurrent masks, conflicts, discussions, detaching the different points-of-view between members, the number of masks created was very limited.

In the second session, when that facility was to be explored, one group developed a sequence of three masks only. An unique concurrent mask was created, but only one member worked on it, with minimum contribution. Mainly, work inside this group was conducted with all participants together, evolving throughout the represented sequence. Conflicts would have occurred only in graphical editing, punctual level. The unique concurrent mask was not relevant as an alternate version of the diagram.

Inversely, another group developed four concurrent masks, all created from the initial one. This situation characterized a subdivision in the joint work, forming four sub-groups, some of them with just one member. Although some discussion has occurred among the sub-groups, co-authoring (activities) happened in a limited way in the masks. We believe this situation caused a weakness in the interaction possibilities between the sub-groups.

The table in table 1 lists the main results from the questionnaire submitted to the participants to capture their opinions and feelings in this study. A list of affirmatives was proposed where participants should classify it in a scale from 1 to 4 - (1) completely disagree, (2) disagree, (3) agree, (4) completely agree. Each column presents the average value for the corresponding group of participants.

Group work supported by the mask mechanism favored establishing the stages through which work evolved. This result was reported positively by all three groups, as can be seen in the first affirmative in the table above (table 1).

All groups indicated that masks favored to follow the evolution of group work, except group 2. This would be a symptom of the sub-division that happened with this group, creating four concurrent masks, with little interaction between them.

Table 1. Qualitative evaluation applied to group members after the case studies

	Affirmative	**Group 1**	**Group 2**	**Group 3**
1	Using masks made it easy to define the stages of work, adequately indicating the version of the diagram	3,3	3	3,8
2	Using more than one mask in a session, establishing concurrent versions, favored to follow group work	3,3	2,5	3,4
3	When a participant selects one mask, he can easily identify the contributions added to it	2,7	2,7	3,2
4	Telepointers favored awareness of other activities.	3,5	3,2	3,4
5	The features allow identifying other participants, and where are they working exactly	3,7	2,5	3,2
6	Group work using a shared workspace with a WYSIWID interface can be considered productive	3,6	3	3,6
7	Using chat, it was possible to establish a channel of communication between participants	4	3,2	2,8
8	Context-based chat favored participants communication	3	1,8	3,2
9	The context-based chat records the message sequence in an understandable way, allowing participants to recall them lately and understand them clearly	3,3	2,7	3,6
10	During the sessions, establishing a coordinator role was important to conduct work	2,2	2,3	3,4

In a joint session, the pace of work follows the pace of communication. During our study, we observed how groups proceed to interact, discuss, negotiate and make decisions, and which way they preferred to communicate and accomplish their tasks. Affirmatives 7, 8 and 9 tried to evaluate communication features.

The first group adopted the chat functionality as their communication channel, rarely making use of some verbal or gesture to interact. That's why their evaluation of chat was greatly positive.

The second group had tried it the same way, but have experienced some trouble, some way because of bad performance in the first session, but also explained by the sub-division in four masks, turning their conversation into four separated chat rooms,

as CO2DE does not join messages from concurrent masks. This explains their low value when questioned about context-based chat.

The third group deliberately adopted the verbal, face-to-face communication in their sessions, perhaps because of their lack of experience with groupware.

Limitations. As we started the first laboratory sessions, we observed a difficulty in all groups to understand the scenarios. Some participants reported that too much time was wasted during the collaborative work, discussing and explaining concepts that have not yet been understood. This observation showed us the need to prepare each group with a pre-meeting, clarifying doubts.

In CO2DE, one participant is established as the coordinator, with some special rights in mask manipulation. This designation is suggestive and informal. We lacked for a formal coordination role in our study, guiding other participants in their tasks, and asking for commitment. The coordination happened in a distributed way during the sessions, through negotiation between team members, especially with the pos-graduated students groups.

5 Conclusions

This paper presented a collaborative graphical editor as a proposal to address the problem of evolution awareness in a group editing session. The CO2DE tool is based in the concept of masks to establish the versions or stages through which a diagram evolves during its elaboration, allowing participants to work in the same or in concurrent versions – which characterizes WYSIWIS and WYSIWID interfaces, respectively. We identified some key issues in collaborative work, such as discussion and negotiation of viewpoints, conflict handling, and change awareness, citing related studies in the literature. The CO2DE functionalities are described, showing how it tries to approach the same issues. At last, some case studies are presented, in which the editor was submitted to use by three groups, trying to evaluate some of the target issues.

The study has shown that the masks would be a useful feature for evolution awareness, although we faced limitations of time and resources, and a deeper research in this sense should be conducted. During the sessions, we observed a moderate use of the mask feature by the groups of designers. This would be explained by the short period for participants to get practice in the new tool, as well as the fact that people do not have the habit to establish versions, as the work evolves. In fact, analyzing the chat discussions, it comes clear that members try to coordinate their actions, negotiate the accomplishment of tasks before proceeding to the next step, but this rarely result in a concluded version.

Well-known collaborative features like telepointers and chat were explored, based in the mask context. Using the masks to support collaborative work offer groups the opportunity to divide in smaller sub-groups, favoring concurrent work but making it difficult to communicate between sub-groups. The case studies gave as the chance to evaluate not only the technological facilities of CO2DE, but, even more relevant, how people manage to collaborate and complete their tasks when faced with the mask capabilities.

Some future work would benefit from this study, extending or reusing the results achieved. The most evident is preparing and realizing other case studies, considering more sessions or longer sessions, groups with more participants or geographically dispersed groups. CO2DE tool would also be used in researches from other areas, like context, group memory or communication.

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