

The 3C Collaboration Model

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1. INTRODUCTION

Collaboration may be seen as the combination of communication, coordination and cooperation. Communication is related to the exchange of messages and information among people; coordination is related to the management of people, their activities and resources; and cooperation, which is the production taking place on a shared space. This model, which we call 3C model, was originally proposed by Ellis et al. [1991], with some terminological differences. Cooperation, which Ellis denominates “collaboration”, here characterizes a joint operation in a shared space.

The 3C model appears frequently in the literature as a means to classify collaborative systems, e.g. as done by Borghoff & Schlichter [2000]. However, a few attempts have been made to use it in the context of groupware implementation. An example is the Clover design model, which defines three classes of functionalities, namely communication, coordination and production [Laurillau & Nigay, 2002, Calvary et al., 1997]. These three classes of services appear in each functional layer of the model and, during the system design phase, they “must be identified and their access harmoniously combined in the user interface”. The Clover model shares the same usefulness of the 3C model in terms of groupware functional specification, because both deal with the three classes of functionalities that a groupware application may support.

Given its complex interactive nature, groupware testing has not yet achieved its maturity. The 3C model may also help evaluators focus their attention on the communication, coordination and cooperation aspects, guiding the detection of usability problems. A groupware evaluation approach based on a model similar to the 3C one is presented in [Neale et al, 2004].

We explore the 3C model as a means to represent a groupware application domain and also to serve as a basis for groupware development. Regarding this last aspect, communication, coordination and cooperation components could be plugged to the collaboration component frameworks.

2 . INSTANTIATING THE 3C MODEL

The relationship among the 3Cs of the model could be used as a guidance to understand a groupware application domain. We are focused on the group work domain represented in Figure 1. According to this instantiation of the 3C model, while communicating, people negotiate and make decisions. While coordinating themselves, they deal with conflicts and organize their activities in a manner that prevents loss of communication and of cooperation efforts. Cooperation is the joint operation of members of the group in a shared space, seeking to execute tasks, generating and manipulating cooperation objects. The need for renegotiating and for making decisions about non-

expected situations that appear during cooperation may demand a new round of communication, which will require coordination to reorganize the tasks to be executed during cooperation.

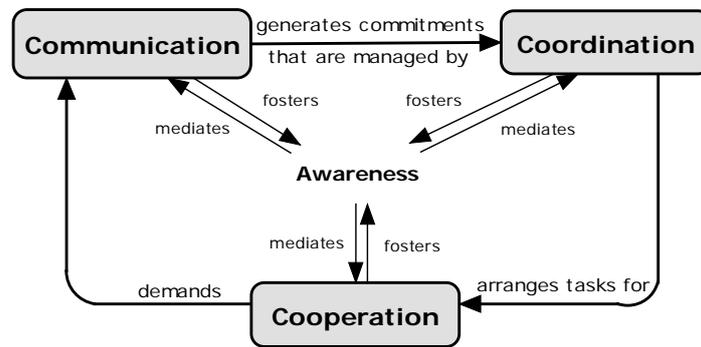


Figure 1. 3C collaboration model instantiated for group work

Moreover, the 3C model can be instantiated in a way that represents other groupware domains like Media Spaces and Family Calendars. Considering Media Spaces [Mackay, 1999], which are multimedia-enhanced spaces aimed at informal communication among people, the 3C model may be instantiated according to Figure 2a. The Media Space itself is the shared space. Since it is aimed at informal communication, its main goal is actually to create opportunities for informal meetings, which are coordinated by the standing social protocol, for example, by accessing the availability of remote colleagues. These meetings generate conversation, which may occur using the media provided by the system or any other available means, such as telephones.

Another example is the Family Calendar (Figure 2b). The main reason for the family calendar is to schedule family activities. Modern family members have a variety of conflicting interests that can render last evening defined schedules ineffective next morning. In order to restore proper family coordination, negotiation among family members is needed. “This process involves seeing what has already been scheduled, (...) and negotiating errand, ride and other responsibilities are needed” [Elliot and Carpendale, 2005]. The reconciliation obtained after the negotiation round is placed on the shared calendar. But as life never stops, next morning the cycle may start all over again.

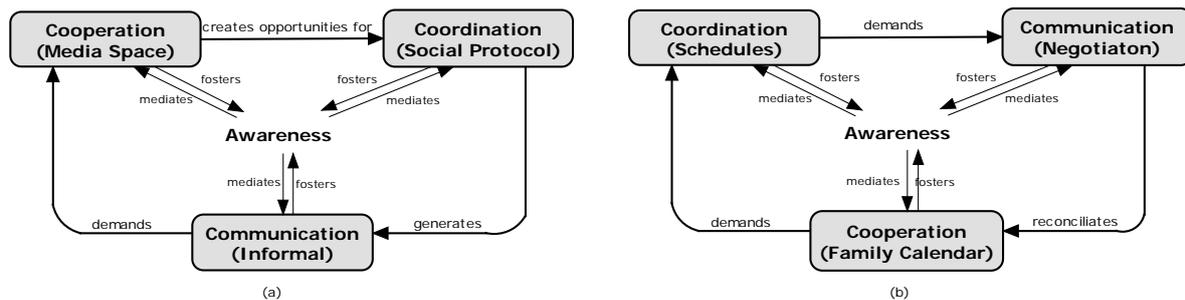


Figure 2. 3C collaboration model instantiated for the Media Space and for the Family Calendar domains

These cycles show the iterative nature of collaboration. The participants obtain feedback from their actions and feedthrough from the actions of their companions by means of awareness information related to the interaction among participants [Gerosa et al., 2003]. This awareness information mediates each of the 3Cs, which are detailed in the next sessions.

3. COMMUNICATION

The designer of a communication tool defines the communication elements that will define the communication channel between the interlocutors, taking into consideration the specific usage that is being planned for the tool (time, space, purpose, dynamics and types of participants) and other factors

such as privacy, development and execution restrictions, information overload, etc. Then, these elements are mapped onto software components that provide support to the specific needs.

The first communication element that must be considered is the choice of **media**. They can be textual, spoken, pictorial or gestured, e.g., in a video or avatar form. The media adopted restrict and influence the vocabulary used in the conversation, which is also influenced by the context.

The **transmission mode** defines whether the information is transmitted in blocks or continuously. In an audio or videoconference and in some chat tools the information is transmitted continuously as it is generated. In asynchronous and in other chat and messenger tools the information is transmitted in blocks: the author edits the message and it is only sent with an explicit command. Asynchronous communication tools are used when one wants to enhance reflection by the interlocutors, since they will have more time before they act, while synchronous tools are used for communication bursts. **Restrictions policy** is another communication element. For example, it is possible to restrict the text's size, characters allowed, bit rate (for video and audio), allowed vocabulary, etc. These restrictions are used in some tools to reduce information overload and to save bandwidth.

Meta-information complements the information being transmitted in the body of the message. Common meta-information available in communication tools are the subject of the message, its date, priority and category.

Conversation structure defines how messages are structured, which can be in a linear, hierarchical or network form. The conversation structure makes the relations between messages, which are usually implicit within the text, visually explicit. The linear form is used when there are not so many message interconnections, the chronological order of the messages is relevant and fluency in the conversation is desired. Hierarchical structuring is appropriate when the relationships between messages, such as questions and answers, need to be quickly identified. However, as there is no way to link messages from two different branches, the tree can only grow wide and, thus, the discussion takes place in diverging lines [Stahl, 2001]. Network structuring can be used to seek convergence in the discussion.

Conversation paths can be used to restrict the possible directions the conversation can take. Conversation paths formalize the conversation and it is not recommended when fluency is desired.

In order to provide proper support to communication, the designer should also take into account coordination and cooperation elements. Coordination elements deal with access policies to the communication channel, while cooperation elements deal with information rendering and registration.

4. COORDINATION

Coordination may be viewed as the link connecting the other two C's in order to enforce the success of collaboration. This is more clearly observed when we analyze the elements that need to be coordinated, namely people, resources and tasks. The coordination of people, for example, is deeply related to communication and context. The coordination of resources, on the other hand, is related to the shared space (i.e., cooperation). For this reason, coordination aspects also appear in the discussion about the other C's of the model. In this section, we focus on the coordination of tasks. The management of the tasks being carried out consists in managing interdependencies between tasks that are carried out to achieve a goal [Malone & Crowston, 1990].

Some computer-supported collaborative activities, the so-called *loosely integrated* collaborative activities are deeply associated with social relations and are generally satisfactorily coordinated by the standing social protocol, which is characterized by the absence of any computer-supported coordination mechanism—"a specialized software device, which interacts with a specific software application so as to support articulation work" [Schmidt & Simone, 1996]—among the tasks, trusting the users' abilities to mediate interactions. Coordination, in these situations, is contextually established and strongly dependent on mutual awareness. Through awareness information, the participants detect

changes in plans and understand how the work of their colleagues is getting along [Dourish & Belloti, 1992]. However, there are also the so-called *tightly integrated* collaborative activities, whose tasks are highly interdependent, as the name suggests. They require sophisticated coordination mechanisms in order to be supported by computer systems.

The great challenge of the designer in designing coordination mechanisms in groupware is to achieve flexibility without losing the regulation, which is necessary in some situations in which the social protocol is not enough. The system should not impose rigid work or communication patterns, but rather offer the user the possibility to use, alter, or simply ignore them. Thus, coordination flexibility and accessibility should be pursued by groupware designers. Flexibility is related to the possibility of dynamically allowing redefinition and temporary modifications in the coordination scheme. Accessibility is related to exposing the coordination mechanisms to system users rather than having them deeply embedded in the system's implementation.

Coordination can take place on the temporal and on the object levels [Ellis & Wainer, 1994]. On the temporal level, coordination defines the sequence of tasks that makes up an activity. On the object level, coordination describes how to handle the sequential or simultaneous access of multiple participants through the same set of cooperation objects [Raposo & Fuks, 2002].

Communication and coordination, although crucial, are not enough. Given that coordination is required to manage the tasks, according to the 3C model it is also necessary to provide a shared workspace where cooperation will take place.

5. COOPERATION

Cooperation is the joint operation during a session within a shared workspace. Group members cooperate by producing, manipulating and organizing information, and by building and refining cooperation objects, such as documents, spreadsheets, artwork etc. The shared workspace provides a number of tools for managing these artifacts, such as the recording and the recovery of previous versions, access control and permission. By recording the information exchanged, the group is able to count on collective memory, which can be consulted whenever necessary to recover the history of a discussion or the context in which a decision was made.

Production is dependent on how the shared workspace is structured to present the cooperation objects and the interaction that is taking place there. In a face-to-face situation, a large part of how we maintain a sense of who is around and what is going on is related to being able to see and hear events or actions with little conscious effort. On the other hand, in a computer-supported workspace, awareness support is less effective since the means for making information available to sensory organs are limited; however, irrelevant information can be filtered in a way that reduces distractions that usually affect face-to-face collaboration.

Individuals seek the awareness information necessary to create a shared context and to anticipate actions and requirements related to their collaboration goals. Thus, it becomes possible to interpret the intentions of the members of the group in such a way that one can provide assistance in terms of their work whenever it is convenient and needed [Baker et al., 2001].

The designer of a digital environment must identify what awareness information is relevant, how it will be obtained, where it is needed and how to display it. Excessive information can cause overload and disrupt the collaboration flow. To avoid disruption, it is necessary to balance the need to supply information with care to avoid distracting the attention required to work. The supply of information in an asynchronous, structured, filtered and summarized form can accomplish this balance [Kraut & Attewell, 1997]. The big picture should be supplied and individuals could select which parts of the information they want to work with, leaving further details to be obtained when required. There must also be some form of privacy protection. The shared space must be conceived in a way that group members could seamlessly move from awareness to work (Figure 3).

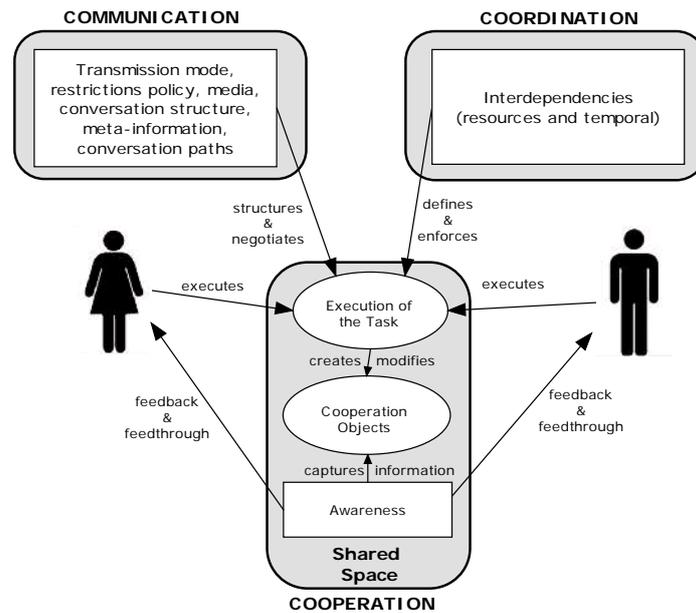


Figure 3. Interacting on a Shared Space

The register of group interactions is filed, catalogued, categorized and structured within cooperation objects. Ideas, facts, questions, points of view, conversations, discussions, decisions, etc. are retrievable, providing a history of the collaboration and the context in which learning took place.

6. DESIGN AND IMPLEMENTATION ISSUES

The 3C collaboration model has been used as a basis for the development of the AulaNet Learning Management System. AulaNet is a freeware web-based environment for teaching and learning. It has been under development since June 1997 by the Software Engineering Laboratory of the Catholic University of Rio de Janeiro (PUC-Rio) [Fuks et al., 2005].

The AulaNet environment's services are subdivided into communication, coordination and cooperation services, as can be seen in Figure 4. The communication services provide tools for forum-style asynchronous text discussion (*Conferences*), chat-style synchronous text discussion (*Debate*), instant message exchange between simultaneously connected learners (*Instant Messaging*) and individual electronic mail with the mediators (*Message to Participants*) and with the whole class, in a list-server style (*Message to the Class*).

Coordination services support the management and the enforcement of group activities. In AulaNet, coordination services include tools for notification (*Notices*), evaluation (*Tasks* and *Exams*) as well as a tool that allows monitoring group participation (*Follow-Up Reports*). Cooperation services in AulaNet include *Lessons* and *Documentation*, a list of course references (*Bibliography* and *Webliography*) and course co-authoring support, both for teachers (*Teacher Co-Authoring*) and for learners (*Learner Co-Authoring*).

During the design and implementation of groupware, the designer must have in mind that collaborative applications must be flexible enough to adapt to group characteristics and to the evolution of work processes. Although there is no way to foresee all features that will be demanded from a groupware application, different groupware products share a number of characteristics.

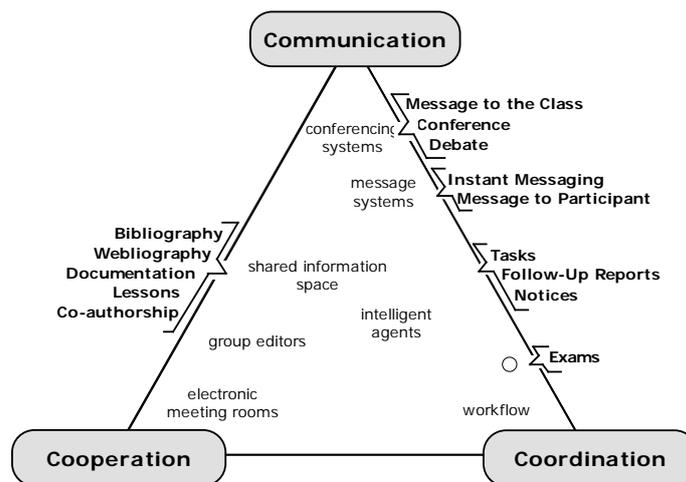


Figure 4. Classification of AulaNet services based on the 3C Model.
The 3C triangle appears in Borghoff & Schlichter [2000]

This scenario is suitable for the application of component-based development techniques, which provide the flexibility needed in projects with changing requirements. Groupware services can be seen as groupware components that are plugged and unplugged from the system. The system's architecture comprises component frameworks, which define overall invariants and protocols for plugging components.

AulaNet services were developed using a component-framework-based architecture, as can be seen in Figure 5. There is a common structure implemented by the collaboration framework, which defines the skeleton of the services, and plugged to this framework there are the communication, the coordination and the cooperation component frameworks, which support each C of the 3C model. Class frameworks are used to implement components, which are plugged to the corresponding C-framework and implement the specific functionalities of the service.

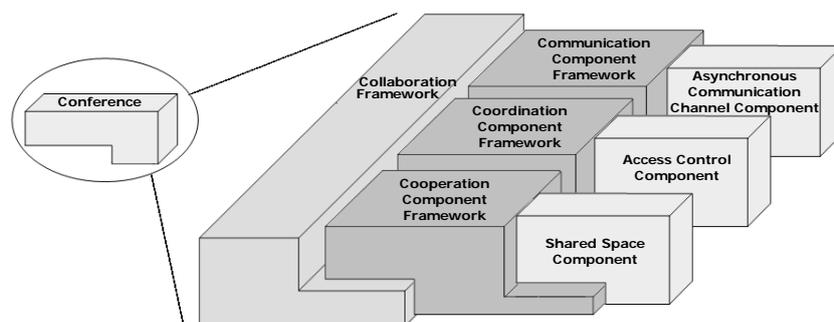


Figure 2. Architecture of a collaboration service.

For example, using the communication class framework, the developer implements components for synchronous and asynchronous communication, message transmission etc. Using coordination class framework, components for task management, participation follow-up, workflow, etc. are implemented. Using cooperation class framework, components for managing the shared space and its awareness elements, version management, among others are implemented.

7. CONCLUSION

Groupware systems are evolutionary because the composition and the characteristics of workgroups change with time, as well as the tasks that need to be executed. For this reason, even if a

groupware designer is able to develop an “optimal” application for a group, it will eventually become inadequate due to new situations and problems that certainly will appear.

Ideally, groupware should be prototyped because collaborative systems are especially prone to failure [Grudin, 1989], hence demanding iterative evaluation during their development. However, given the excessive cost of throwing code away, as demanded by “pure” prototyping [Brooks, 1975], an incremental model can be considered more adequate, leading to the development of more advanced prototypes in the subsequent cycles.

In face of construction and maintenance difficulties, the groupware developer spent more time dealing with technical difficulties than moderating and providing support to the interaction among users. Such problems led to the need to create a quicker and more effective way to develop groupware in which low-level complexities resulting from distributed and multi-user systems were encapsulated into infrastructure components of the architecture. Besides, the concepts of the domain’s modeling should permeate all other activities and artifacts of the application’s development. This way, the modeling done during the domain analysis could be mapped to implementation, thus increasing productivity in groupware development and maintenance and making the applications more adequate to the users’ collaboration needs.

The 3C collaboration model defines three types of services that a groupware may support. The concepts and representation models described in this paper can be used to guide the functional specification and to provide a common language for representing and describing the collaboration aspects of a workgroup.

ACKNOWLEDGMENTS

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Term 1 – 3C Collaboration Model

- **Also appears in text as:** 3C Model.
- **Also known as:** n/a
- **Similar to:** n/a
- **Associated in the manuscript with:** “Groupware”, “Computer Supported Cooperative Work”, “Collaboration”, “Communication”, “Coordination”, “Cooperation”
- **Notable appearances of this term can be found on:**
Page 1 - This model, which we call 3C model, was originally proposed by Ellis et al. [1991]
Page 1 – The relationship among the 3Cs of the model
Page 5 - The 3C collaboration model has been used as a basis for the development of the AulaNet

Learning Management System

Page 7 - The 3C collaboration model defines three types of services that a groupware may support.

Term 2 – Collaboration

- **Also known as:** n/a
- **Similar to:** “Computer Supported Cooperative Work”
- **Associated in the manuscript with:** “Groupware”, “3C Collaboration Model”
- **Notable appearances of this term can be found on:**
Page 1- Collaboration may be seen as the combination of communication, coordination

Term 3 – Groupware

- **Also known as:** n/a
- **Similar to:** “Computer Supported Cooperative Work”
- **Associated in the manuscript with:** “3C Collaboration Model”, “Collaboration”
- **Notable appearances of this term can be found on:**
Page 1 - We explore the 3C model as a means to represent a groupware application domain and also to serve as a basis for groupware development.
Page 1 - The relationship among the 3Cs of the model could be used as a guidance to understand a groupware application domain.
Page 2 - the 3C model can be instantiated in a way that represents other groupware domains
Page 6 - Groupware systems are evolutionary because the composition and the characteristics of workgroups change with time, as well as the tasks that need to be executed.

Term 4 – Communication

- **Also known as:** n/a
- **Similar to:** “communication elements”, “communication components”, “communication channels”
- **Associated in the manuscript with:** “3C Collaboration Model”
- **Notable appearances of this term can be found on:**
Page 1 - Communication is related to the exchange of messages and information among people
Page 2 - The designer of a communication tool defines the communication elements that will define the communication channel between the interlocutors

Term 5 – Coordination

- **Also known as:** n/a
- **Similar to:** “coordination mechanisms”, “coordination components”
- **Associated in the manuscript with:** “3C Collaboration Model”

- **Notable appearances of this term can be found on:**

Page 1 - coordination is related to the management of people, their activities and resources

Page 3 - Coordination elements deal with access policies to the communication channel

Page 3 - Coordination may be viewed as the link connecting the other two C's in order to enforce the success of collaboration.

Page 4 - The great challenge of the designer in designing coordination mechanisms in groupware is to achieve flexibility without losing the regulation

Page 4 - Coordination can take place on the temporal and on the object levels

Term 6 – Cooperation

- **Also known as:** “production”

- **Similar to:** “cooperation elements”, “cooperation components”, “cooperation objects”

- **Associated in the manuscript with:** “3C Collaboration Model”

- **Notable appearances of this term can be found on:**

Page 1 - and cooperation, which is the production taking place on a shared space.

Page 1 - Cooperation, which Ellis denominates “collaboration”, here characterizes a joint operation in a shared space.

Page 3 - cooperation elements deal with information rendering and registration.

Page 4 - Cooperation is the joint operation during a session within a shared workspace.

Term 7 – Awareness

- **Also known as:** n/a

- **Similar to:** “awareness elements”, “group awareness”, “action awareness”, “workspace awareness”, “presence awareness”, “social awareness”

- **Associated in the manuscript with:** “3C Collaboration Model”

- **Notable appearances of this term can be found on:**

Page 2 - The participants obtain feedback from their actions and feedthrough from the actions of their companions by means of awareness information related to the interaction among participants

Page 2 - This awareness information mediates each of the 3Cs

Page 3 - Through awareness information, the participants detect changes in plans and understand how the work of their colleagues is getting along

Page 4 - Individuals seek the awareness information necessary to create a shared context

Page 4 - The designer of a digital environment must identify what awareness information is relevant, how it will be obtained, where it is needed and how to display it.