CSCW from Coordination to Collaboration

Nabil Elmarzouqi, Eric Garcia, and Jean-Christophe Lapayre

LIFC – Computer Science Laboratory of Franche Comté University,
16 route de Gray,
25030, Besançon, France
{elmarzouqi,garcia,lapayre}@lifc.univ-fcomte.fr

Abstract. Working in a group consists of setting up an environment that allows the different participants to work together. The collaboration has now become then a discipline that fascinates the distributed environments as well as the Human/Machine interactions. The big challenge of the CSCW environments is to be able to give the necessary mechanisms in order to carry out effective collaborative work i.e. to put the actors together in a virtual room which simulates a real situation of groupware meeting. We would like to present a model of architecture that places the actors in a situation of virtual grouping centered on the awareness and that spreads on a Continuum of collaboration representing a continuity of the group work augmented by the functional spaces of the clover model. We have applied this model of architecture to the European project of tele-neurology (TeNeCi) which offers a platform of telecommuting enriched by several functionalities presented to the neurologists to assure a telediagnosis in the group.

Keywords: Awareness, CSCW, Collaborative Design, Collaborative work, Human Machine Interaction HMI, Distributed Interaction, Architecture Model.

1 Introduction

The platforms dedicated to distributed collaborative work must provide not only the support for the exchanges between actors, but also the tools which will make this work truly collaborative. These include: tools of communication, and especially tools of group awareness. These new platforms integrate not only Machine-Machine aspects, but also Human-Machine aspects for finally supporting Human-Human exchanges.

Several existing architecture models present different approaches to refine the group's work in terms of conception of group's workspace and functionalities offered by the groupware. Different aspects are required to conduct a collaborative work to facilitate the integration of group members in the environment and to promote the contribution of each actor in his belonging group. An example of these fundamental aspects is the existence of private space for each actor and flexibility of passage between the private space and the shared space. The determination of various functionalities and features specifically for the group environment remains also a very important aspect. Therefore, the establishment of a framework for the use and integration of the group's functionalities according to the adopted vision to conduct

W. Shen et al. (Eds.): CSCWD 2007, LNCS 5236, pp. 87–98, 2008.

collaborative work is the great need of groupware today. This framework must make the use of collaboration notion even more flexible and open to a wide number of types and modes of collaboration.

The goal of this work is to present a new model known as Augmented Continuum of Collaboration Model (ACCM). We would therefore first like to present the design models of these architectures for collaboration and their particular determinations. Section three exposes distributed Human-Machine interfaces which can be represented by the well-known clover model to which we contribute by adding regulation dimension. In the fourth section, we define the new architecture model "Augmented Continuum of Collaboration Model - ACCM" and its components for groupware application. Finally, the last part describes the application of our model in the European project TeNeCi which offers a platform of telediagnosis for the neurologists.

2 Design Models of Architectures and Interactions for Collaborative Environments

In order to show the important role of the Human-Machine interactions in a collaborative environment, we undertook a study on two scales, first beginning with an analysis relating to the conceptual models for the Human-Machine Interfaces (HMI) and secondly on the more advanced models of architectures.

2.1 Conceptual Models for HMI

The Interactive system requires an identification of system functionalities and structural organization of its components in order to achieve a high level performance of system interactivities and to assure different feautres such as extensibility, modularity and a high level of regular actions. The most used ontology consists of separating the user interface part from applicative modeling part resulting in three components: controller, view and data models. The user interface is then adaptable according to the platforms of implementation by keeping the same functional core. This concept is extended into multiple kinds of conceptual models: monolithic model with Arch Model [3], multi-agent model with MVC model [1], [2] and hybrid model with PAC-Amodeus which combines MVC and Arch.

Functional breaking down to a large extent (presented through Arch model), fine extent (within MVC in a multi-agent conceptual model) or a hierarchical fine extent (assured by the PAC agents on the hybrid model PAC-Amodeus) allows a gradation of interactive system structure into three main levels of abstraction. The first abstraction level is about the core application system and the second abstraction level presents the core management of user application view. The third level is the link between two other levels in order to interpret interactions happening at the application view.

2.2 Principle of the Architecture Models for Groupware

The basic aspect of the groupware consists of the activity of the group. The study of the behavior of the actors is very important on this level as well as the produced task and the environment which includes the activity of the various actors. The comprehension of the produced behaviors is supported by the environment of coordination what makes the study of the groupware different from the mono-user systems because it includes not only the characteristic of the behaviors of each user, but also the contribution of the activities user-to-user. Public and private resources are immediately present in a group environment that allows each actor to handle both its own resources and group information.

The comprehensive study of the tasks carried out by the actors and their practices, consists of analyzing the framework of the interaction, the rules which govern it within the working group, the events which act on the interaction as well as different types of view of the multi-user workspace.

2.3 Panorama of the Architecture Models for the Groupware

According to several architectures carried out on the behavior of the collaborators in their exchange environment, different models are proposed in order to specify the collaboration workspace. The conceptual advancement of architecture models dedicated to groupware gave more importance to the interactions between the different actors. In accordance with the concept of shared states, a groupware is broken up according to four abstraction levels: state of the screen, state of the view, state of the model and state of the file. This conceptual vision presented by Zipper model [4] gives only a large-scale functional decomposition and does not give any details on the controller level. As well as ALV model [4] (or Abstraction-Link-View), there are not distinction between the components dedicated to individual actions and those dedicated to collective actions. Dewan Model [5], [6] as an overview of the Zipper model and Arch model, presents a generalization of abstraction levels in order to generate several layers representing a multitude of abstraction levels for the construction of the groupware. This given generalization in conformity with two kinds of level: semantic level and physical level, makes the model less precise because it does not give details on the functional role of each layer. Dewan Model distinguishes functionalities for collective actions and the ones recovering from individual actions. This Meta model enables also having groupware architecture without public components: that is not recommended for collaborative group which require at least one public component.

A similar approach to ALV model is presented by Clock and DragonFly model [9]. The only difference between the two models is that both sides view and controller do not communicate with each other in Clock Model. On the other hand, ALV model remain a restrictive approach since the shared abstraction and global view are immediately public and private component respectively.

An important distinction between collective and individual actions is introduced by Copac model [8] in view of using mono-user PAC agents and collaborative CoPAC agents. PAC* model [5] refines CoPAC model by integrating the functional spaces: production, communication and coordination. A PAC* agent is then made up of three agents which deal respectively with the control of the production, the communication and the coordination. Collective support and resources are provided by PAC* agents explicitly. Public and private context resources are not distinguished by this last model.

2.4 Discussion

The models of design and architecture presented above support the separation of the user interface and the applicative logic of the modeled systems. For the groupware, the requirements are even more advanced since the nature of the environments of collaborative work has several levels of congruence between the tasks presented and the functional approaches necessary for the collaborative environment. Table 1 shows the absence of the duality: "functional decomposition /workspace" in the studied models. A groupware must present several functionalities for the various actors in order to help them to carry out group work according to definite objectives.

Collaboration implies also several levels of collaborator participations while going from a simple resource sharing until the achievement of a task of the collaboration process. A workspace dedicated to the groupware must take into account several concepts which are essential in sharing the nature of the environment as being a workspace which:

- Takes into account several actors.
- Gives the possibility of communication between the collaborators.
- Manages several levels of collaboration ensured by the actors and presents several functionalities to contribute to the achievement of collaborative work.
- Makes it easier to complete the work ensured by the collaborators.

Table 1. Synthesis Table of Models. √ : present, x : absent

Architecture	Functional decomposition	Private Space	Exchange Space
MVC	x	x	x
Arch	x	x	x
Pac-Amodeus	x	x	x
Zipper	x	x	x
Dewan	x	√	√
ALV	x	x	x
Clock	x	√	√
Copac	√	x	x
Pac*	√	x	x

3 Distributed Human-Machine Interfaces, HMI

Having presented the architecture models of the groupware, in this section, we would now like to present the ontology of the Human-Machine Interfaces and their utilities in the contribution and the evaluation of the interactions of the group in the groupware. The environment of collaboration recommends a more advanced approach from the presentation point of view of information, interfacing with the workspace, interference within the groupware and functional aspect (determined by the applicative logic of collaborative work).

There are many differences between the interfaces of group and those mono-users: not only because they represent the actions of a group, but also because they are controlled by the users of the group. Nevertheless, they must manage the problems of competition but more particularly decrease the disturbances inherent in handling of the other members of the group, and even more so for the videoconference [9] software.

3.1 First Approach

The most used construction approach of group interfaces is known under the name of WYSIWIS: What You See Is What I See. This rather established concept [10], guarantees that the environment will appear in an identical way among all members of the group. However, this mode is very restrictive from the point of view of its installation because the users wish to have certain independence and the strict WYSIWIS interface implies permanent operations of multi-diffusion: each site emits actions towards all the others because all the actions must be seen.

This leads us to show how the concept of released WYSIWIS can be applied in four dimensions:

- **Space:** each participant has the possibility of personalizing the arrangement of the windows on its screen and of opening new common windows.
- **Time:** in Strict WYSIWIS, the actions are synchronized. Time makes it possible to define the particularities of the co-operation.
- **Population:** a cooperative operation can be restricted with a sub-group. A dynamic management makes it possible to account for the fact that a sub-group is formed often only for the time of a transitory task. This group disappears as soon as the common task is finished.
- **The congruence of views:** the views of participants can differ, i.e. posted information is not the same on each screen. This makes it possible for each participant to select the best view of the document adapted to his work.

3.2 Three Basic Spaces of the Clover Model

In order to be able to compare different groupware, Ellis defines in [13] a formed conceptual model of three functional dimensions. Each exchange between actors is influenced by the activities of the others, by the possibilities of interactions and by the production of messages. This gives us three basic functional spaces of the clover model: production, coordination and communication:

- **Production space:** identifies any object resulting from the activity space of the groupware system as well as the functionalities of production of shared objects. The management of the access to the produced objects is ensured at this level. This space offers a static vision of the system.
- **Coordination space:** represents all the means of coordination in the workspace, which are based mainly on the tasks and the activities, the actors and their abilities to moderate their production.
- **Communication space:** includes all the functionalities which ensure the exchange of information between the actors of the groupware. This makes it possible to define the Human-Human communication meditated.

This model was included and refined in order to define the model of three C's: Co-production, Coordination and Communication. B. David adds in [13] the fourth space: Conversation. We have defined a new space: Regulation like orthogonal to the others. It makes it possible to define laws of interaction concerning various spaces. The regulation term means the totality of mechanisms which make it possible for the participants to be organized in a shared environment. We have added to this definition the concept of flexibility. In the course of execution the regulation service allows the modification of the organization of the participant, but also of the particularity of the application, and the mechanisms of management of competition.

4 Augmented Continuum of Collaboration Model, ACCM

According to the previous study carried out on the various existing models, if we study the table of synthesis of models below we can distinguish (cf. Table 1) the absence of the duality: {**Private/Public Space**}/{**Functional Decomposition**}.

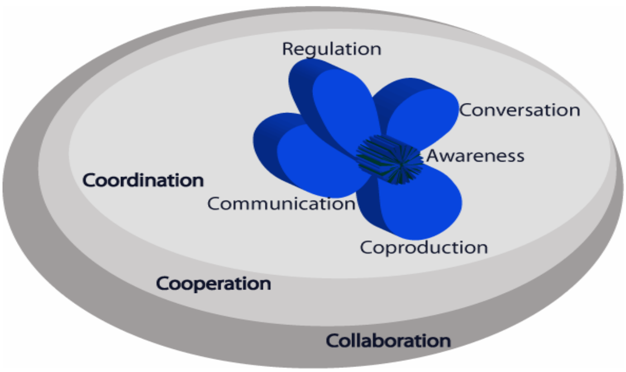

Fig. 1. ACCM Model

4.1 Definition of the ACCM Model

The model of clover was defined for the Human-Machine interfaces; we propose to re-use this paradigm for the model of architecture, by injecting it into the Continuum of Collaboration to determine Augmented Continuum of Collaboration Model, ACCM.

We define the Continuum of Collaboration as being a continuity of the collaborative workspace which is spread out over 3 dimensions going from Coordination to Collaboration while passing by Cooperation. This continuity is augmented by a functional clover which gathers several spaces which define dimensions composing collaborative work.

Our model of basic architecture for the working groups is composed of (cf. Figure 1):

- **Three functional spaces:** Co-production, Communication and Conversation.
- **The regulation space:** This is orthogonal to the three functional spaces.
- **The awareness space:** The awareness group which is centered.
- **Continuum of collaboration:** This is spread out from coordination to collaboration while passing by cooperation.

4.2 Abstract Spaces: Coordination, Cooperation and Collaboration

We must distinguish three spaces for groupware in order to describe the continuum of collaboration: coordination, cooperation and collaboration (cf. Figure 2). Several approaches exist for these three abstract spaces [15], [16], [17] which characterize collaboration by the realization of team work according to a common objective which implies several actors according to the duration and closeness of mutual relations. The cooperation is distinguished by abstract relations and without definite structure. We distinguish some specificity for each space.

Coordination space. For groupware workspace, this dimension gathers all the shared objects as well as the common objectives which make the principal matter of the regrouping of the various actors. Personal work is most present in the coordination space. Each actor can evaluate the result of the work of coordination in order to lead to the objectivity of collaborative work. This space is intended to be used by a simple system and does not require a complex capacity to establish the functional coordination of collaborative work.

Cooperation space. It is an intermediate space between the coordination space and collaboration space. Coordination can lead to cooperation if the need to exchange the field of work through the various actors of the workspace is capital in order to improve or to make adjustments to completed work.

We can then specify the concept of the co-operation group in the direction of the organization of the field of work according to domain of competences required.

The exchange between the participants is essential in co-operation and it is ensured by several tools such as instantaneous transport and audio-visual tools (cf Figure 2.b)... the common analysis is an essential aspect for co-operation. It introduces a perception of all the data relating to the common goals as well as the suitable methods for the resolution of the problem dealt with by the groupware.

Collaboration space. The cooperation rises to collaboration if we introduce the notion of the "process domain of exchange for collaborative work". The communication on this level is complementary to the exchange of the "field of coordination work" between the various actors.

The direction of engagement of the actors characterizes the collaborative work and which is concretized by durable and continuous relations between the participants. The achievement of collaboration work can take place only if the actor is an active member of the group. The realization is very important on the level of collaboration as well as sharing a common vision for the installation of a solution. In collaboration, the working group seeks a better solution to its problem (cf. Figure 2.c). The emergency direction is present if the working group seeks an immediate solution especially when he treats applications in telemedicine for example. Several tools are installed for collaboration such as brainstorming, questionnaires...

The continuum ensures continuity in the collaborative work which is expressed by these three levels while starting with the coordination which is implicit in the cooperation space, which is still implicit in a collaboration space.

Group work is always guided by shared objectives, which requires several mechanisms in the coordination phase for the realization of the common tasks: shared tasks, scheduling and temporization of the contributions... In coordination, it is extremely

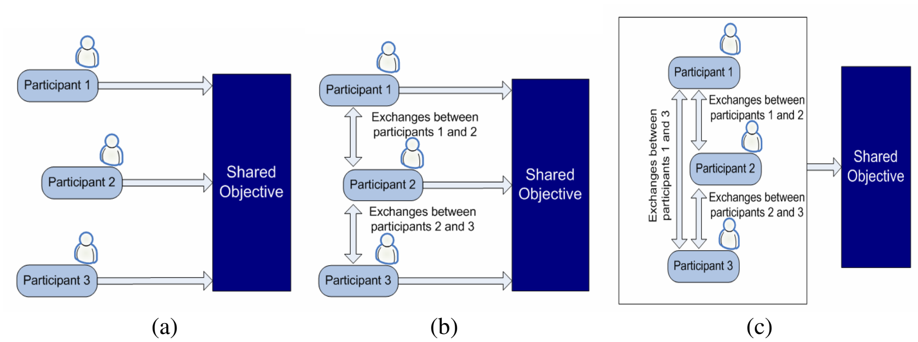

Fig. 2. ACCM Model – (a) Coordination, (b) Cooperation, (c) Collaboration

important to specify all the tasks carried out as well as the assignment of each task to the suitable actors as shown in the figure 2. Each actor follows rules defined to contribute according to actions determined by the community and which define its functional profile, or according to the actions adjusted by the actor at the time of his contribution and which is adapted to deal with the problem according to its initiatives.

The passage from one level to another is ensured by the need for collaborative work characterized by the participation of the working group members during all the data processing runs of the problem in question.

4.3 The Space of Awareness: Center Clover of the Augmented Continuum of Collaboration Model

By definition, a groupware is presented as being a multi-user system which supports the actions of the user group, and in particular the conscience of other participants [18]. It deals with an environment which recommends collaboration for the realization of the tasks and the handling of the components in order to complete a collaborative process.

The Awareness deals with four principal factors:

- **Time:** as being a major factor for the realization of the collaborative tasks.
- **Space:** This represents the handling of the data visualized and processed in the workspace.
- **Population:** which gathers all the users of the work environment and which determines who is in relation with who.
- **The task:** as being an important unit of collaborative work within the groupware and which implies the activity of each participating member.

The effectiveness of the awareness rises from the capacity of perception and cognition in the collaborative work environment. It is independent of the capacity to include/understand but especially to conceive, impress, distinguish and perceive in a multi-user space.

Several approaches treat the awareness as being a design related to the working group [18], [19], [20]. Thus one often speaks about the awareness of the colleagues

(Awareness of Co-workers) or of the awareness of the workspace (Workspace Awareness). Our approach shall raise the following points:

- **The knowledge** of the data handled in the collaborative workspace as well as the conscience of the other users.
- **The activity** as the result of the coordination work of each user by taking account of the knowledge aspect to define: who does what? With which aim? And according to which mode (asynchronous or synchronous)?
- **The context** which specifies the field of work for each activity carried out by the participants in collaborative work by taking account of the various preset options for each activity.
- **The participation** which defines the level of implication of each user in the workspace as well as the various states of availability in the collaborative environment.

5 Application to Telemedicine

5.1 Presentation of the TeNeCi system

TeNeCi (Co-operative Tele-Neurology) is a computerized decision-making system dedicated to the field of neurology and more particularly to neurological emergencies. The VCD: Vascular Cerebral Diseases are one of the main causes of deaths at the emergencies. The CHU (University Hospital Complex) of Besancon (France) and the Vaudois CHU of Lausanne (Switzerland) had the initiative to create this European project with the aim of providing an effective system to the doctors to be able to establish a collaborative diagnosis remotely.

The TeNeCi platform offers the necessary tools to particularly establish the meeting of several doctors, so that they reach essential relevant information in real time and particularly at the time of the decision-making when the assistance presented by the system becomes necessary. The TeNeCi system proposes two modes of cooperation: asynchronous and synchronous. All information necessary to the diagnosis which must be carried out by the experts is compacted and kept in a file, which is the principal subject of the asynchronous mode. In synchronous mode, several mechanisms are realized to facilitate the meeting of the experts, in order to carry out a diagnosis on-line in a virtual meeting room. This mode consists of managing the various opinions of the speakers and diffusing their interventions in real time to all participants. A great number of treatments are carried out on the images treated by using several tools such as the zoom, the contrast management...

5.2 Model ACCM Applied to TeNeCi System

A distribution of the basic functionalities of the TeNeCi system according to the continuum of collaboration components (cf. Table 2) shows the three levels of collaboration and the tools suggested for each space in order to ensure the suitable tasks.

Coordination space gathers all the tools for DICOM image processing as well as the means delivered by the system to transfer the file from diagnosis and the documents necessary to the patient treated.

Table 2. Breakdown of the basic functionalities of TeNeCi system according to ACCM

TeNeCi functionalities	ACCM Component	Collaboration level
DICOM explorer, Toolboxes	Co-production	Coordination
Electronic mail, File transfer Management of diagnosis file versions	Communication	
Management of the profiles	Regulation	
Awareness of the modification made to the diagnosis	Awareness	
Videoconference, audio conference, Shared Whiteboard, Instant messaging	Conversation	Cooperation
Regularization of sound, video and workspace	Regulation	
Actions observer, Tele-pointer Presence of a doctor	Awareness	
Tele-annotation, Remote control	Co-production	
Diagnosis tele-edition	Co-production	Collaboration
Diagnosis alarm Diagnosis locking in the course of treatment	Regulation	
Doctors' real time actions	Awareness	

Moreover cooperation space supports the conversation tools: audio-visual conference, whiteboard and instant messaging as well as the awareness mechanisms of the workspace which is a need for the work of the groupware and especially for the deployment of the virtual meetings of the doctors in the virtual rooms of examination (the Tele-pointer and the observer of the carried out actions).

Collaboration space gathers all the tools for the realization of a remote collaborative diagnosis: we use the remote diagnosis (tele-diagnosis) which implies several doctors on-line who fill out a questionnaire relating to the reactions of the treated patient. The result of the brainstorming of the various reports is very favorable for the opinion of the doctors. The awareness of the doctors' presence is required also especially to join a neurologist so that they take part in the virtual examination room.

6 Conclusion and Future Work

We have presented a new architecture model dedicated to groupware. The effectiveness of a collaborative platform lies in the capacity which it will have to make highly collaborative work i.e. to place the actors in a situation as near as possible to a virtual examination room. The awareness of the human cooperator is the primary importance.

Many architectural models are confused between private/public components and centralized/distributed components what is the implementation of the architecture which is related to how the different processes are allocated (as Zipper, PAC*, ALV and COPAC). Clock and DEWAN models in terms of private/public components lead to the mixing up of group actions with individual actions. ACCM model is dedicated to collaborative work and presents different levels of collaboration and that is not limited to the concept of public and private components, but is spread to a level of continuity that promotes individual work in terms of coordination while it highlights the group work in the collaboration level. Pac* and Copac models are the only two models providing a functional breakdown taking into account the three functional areas of the clover model. The other models such as Zipper, Clock and ALV remain to be very large in terms of functionalities. ACCM Model is augmented by a developed clover model with five functional spaces perpendicular to the continuity of collaboration levels. The usability of those spaces on different levels depends on the needs of the group tasks and coordination contribution.

One particular important notion in groupware is therefore awareness. This requires the introduction of awareness notion such as their variations. Initial work for considering this notion as the center of functionality spaces has been carried out in the present model. Implementation of this essential notion to guide the realization of collaborative work in this different continuity levels involves further investigation.

Acknowledgments. The authors would like to thank the Institute for Sciences and Information Technologies (ISTI of Besançon) as well as the European Community (for the TeNeCi INTERREGIII project), which allowed the financing of this work.

References

1. Lay, P., Lüttringhaus-Kappel: Transforming XML schemas into Java Swing GUIs. In: Jahrestagung, G.I., Dadam, P., Reichert, M. (eds.) Informatik 2004. LNI, vol. 50, pp. 271–276 (2004)
2. Veit, M., Herrmann, S.: Model-view-controller and object teams, a perfect match of paradigms, pp. 140–149. ACM Press, New York (2003)
3. Lachenal, C.: Introspac un outil pour enseigner et comprendre pac-amodeus. In: Proceedings of the 15th International conference on IHM 2003, Caen France, pp. 212–215 (2003)
4. Gaëlle, J.C., Nigay, L.: From single-user architectural design to pac*: a generic software architecture model for CSCW. In: Proceedings of International Conference on Human factors in computing systems, Atlanta, Georgia, United States, pp. 242–249 (1997)
5. Laurillau, Y., Nigay, L.: Clover architecture for groupware. In: Proceedings of the 14th French-speaking conference on Human-computer interaction, vol. 32, pp. 113–120. ACM, New York (2002)
6. Dewan, P.: An integrated approach to designing and evaluating collaborative applications and infrastructures. Int. CSCW J. 10, 75–111 (2001)
7. Graham, R., Urnes, T.: Efficient distributed implementation of semi-replicated synchronous groupware. In: Proceedings of UIST 1996 symposium, pp. 1–10. ACM, New York (1996)
8. Daniel, S.: De l'interaction individuelle aux systèmes multi-utilisateurs, l'exemple de la communication homme-homme médiatisée. PhD. dissertation, Joseph Fourier University. Grenoble, France (1995)
9. Greenhalgh, C., Benford, S.: Massive a collaborative virtual environment for teleconferencing. ACM Transactions on Computer-Human Interaction (TOCHI) 2, 239–261 (1995); special issue on virtual reality software and technology
10. Stefik, M., Bobrow, D.G., Tatar, D.: Wysiwis revised early experiences with multiuser interfaces. ACM Transactions on Information Systems (TOIS) 5, 147–167 (1987)
11. Hinckley, K., Sinclair, M.: Touch-sensing input devices. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, CHI, pp. 223–230. ACM, New York (1999)

12. Neuwirth, C.M., Chandhok, R., Kaufer, D.S., Morris, J.H., Erion, P., Miller, D.: Computer Supported collaborative writing: A coordination science perspective. In: Olson, G.M., Malone, T.W., Smith, J.B. (eds.) Coordination Theory and Collaboration Technology. Lawrence Erlbaum Associates, Mahwah (2000)
13. Ellis, C., Wainer, J.: A conceptual model of groupware. In: Proceedings of the ACM conference on CSCW, pp. 79–88. ACM, New York (1994)
14. Betrand, D.: Ihm pour les collecticiels. In Réseaux et Systèmes Répartis, vol. 13. Hermes Sciences, 169–206 (2001)
15. Godart, C., Halin, G., et al.: Implicit or explicit coordination of virtual teams in building design. In: Proceedings of CAADRIA 2001 conference, Sydney, Australia, pp. 429–434 (2001)
16. Kvan, T.: Collaborative design: what is it? Automation in construction 9, 409–415 (2000)
17. Hanser, D.: Proposition d'un modèle d'auto coordination en situation de conception, application au domaine du bâtiment. PhD. dissertation. Institut National Polytechnique De Lorraine (October 2003)
18. Gutwin, C., Greenberg, S.: A descriptive framework of workspace awareness for real-time groupware. In: Computer Supported Cooperative Work (CSCW), Computer Science and Humanities, Social Sciences and Law, 3-4 edn., vol. 11, pp. 411–446 (2004)
19. Adams, R.M.: Situation awareness and the cognitive management of complex systems. In: Human Factors, 1st edn., vol. 37, pp. 85–104 (1995)
20. You, S.Y.: Meeting others - supporting situation awareness on the www. In: Decision Support Systems, vol. 32, pp. 71–82. Elsevier Science Publishers B. V, Amsterdam (2001)
21. Garcia, E., Bogousslavsky, J., Bonnans, V., Cammoun, L., Chatelain, S., Droz-Bartholet, L., Devuyst, G., Guyennet, H., Haberbush, J.L., Lapayre, J.C., Moulin, T., Thiran, J.P.: Collaborative tele-neurology for remote diagnosis. In: Proceedings of 3rd Int. Conference on Sciences of Electronic, Technologies of Information and Telecommunications, SETIT (2005)