Medical Informatics Europe '96
J. Brender et al. (Eds.)
IOS Press, 1996

An Asynchronous Cooperative Model for Coordinating Medical Unit Activities

F. YOUSFI, R. BEUSCART, N. SOUF
CERIM, faculté de Médecine, 1 place de Verdun, 59045 Lille-Cedex, France.

Abstract. CSCW is devoted to the analysis of interactions among humans when performing together their work [2]. The main application fields are work organization, healthcare, education and training. Our main goal is to study the cooperative models allowing task coordination and conflict management between actors within a distributed environment, in particular medical units. We do not aim to produce a practical system suitable for near-term deployment in the Intensive Care Units (ICU), but rather an experimental system that performs and coordinates a range of intelligent planning tasks in ICU activities. The emphasis will be put especially on asynchronous cooperation. We apply the Workflow approach to ICU organization through the analysis and propose of a cooperative model.

1 Introduction

In the field of intensive care, a growing body of research has been developed aiming at improving intensive care with computer-based systems [3]. Many of these systems offer practical solutions to intensive care problems. While useful, these efforts do not answer the need for coordination between care-providers which remain the most difficult issue for the physicians.

PLACO (PLAnification COopérative, i.e. Cooperative Planning) is a computer-based system supporting cooperative planning in Critical Care Environment (CCE). The objectives of the PLACO project are to analyze CCE tasks from the cooperative perspective and to introduce the concept of Computer-Supported Cooperative Work (CSCW) in the design of medical telematic systems. PLACO does not aim at providing a stable and mature system for use in the field of critical care. We aim at introducing the cooperative dimension in the medical domain. We have reported in [1], the usefulness of CSCW in CCE through the analysis of **breakdowns** , which occur in the daily functioning of ICUs, and have proposed an asynchronous model based on the conversation-oriented workflow. We have also made a proposal for the global architecture of PLACO which is aimed at supporting our model [7].

In this paper, we will report on our study of cooperation in CCE, and will briefly deal with breakdowns, sources of errors, which cause many conflicts between actors (physicians, nurses, etc.). In the next part, we shall detail the proposed model, as defined in [7], and then we shall deal broadly with the global architecture of PLACO.

2 The Conceptual Framework of PLACO

2.1 Cooperative work in ICUs

Team work is the essence of medical and nursing activities in critical care domain. People cooperate to collect and exchange information; they share responsibilities, delegate activities, etc. The lifeblood of an organization is not data or computation [6]; it is interaction among team members and with the outside world (hospital management, laboratories, technical departments, etc.). The essential elements are people and the actions carried out by them.

Health care is a field where close collaboration between different members of the medical team is the rule. This is why CSCW concepts seems to be fundamental for the design of future software architectures for the medical world. Incorporating the CSCW paradigm into medical units computer systems requires a prior analysis of the commitment network in addition to the classical analysis of the data and information flow.

2.2 Definition of the breakdowns

Breakdowns are deviations from the normal safe course of things. They do not necessarily mean catastrophic or harmful events, but just disturbing or potentially harmful deviations of what is the normal operation of an ICU.

The analysis of the breakdowns, performed by a team of psychologists during the first phase of the project [1], demonstrated the necessity of cooperation between care-providers in ICUs. This analysis also brought some insight on the breakdowns of direct and interpersonal cooperation. Breakdowns come from synchronization failures between people, or from the absence of useful information, or from abnormalities in transmission (excess of information, partial or total lack of data, distortion during exchanges, no clear decisions taken).

2.3 Workflow Model

Considering the hypothesis that many breakdowns are the result of dysfunction in human interactions, we think that groupware can be one of the efficient means for solving some of the problems connected with cooperation within medical units. We need to develop a conceptual model, in particular a model of human-human interaction in medical activities (deciding, organizing, acting, observing, reporting, assessing, etc.).

The basic element of coordinated work is the transfer of *things* and a transfer of responsibilities between two actors [6]. Among the various underlying paradigms, we are favoring the workflow analysis which is mainly based on the *Language/Action perspective* developed by Winograd & Flores [6], itself derived from the Speech Act Theory of Austin and Searle [5].

In the cooperative work perspective, human activities are grouped in scenarios, i.e. recurrent organizations of work in which personnel and resources are engaged. They have a goal, a starting point and a well-defined end. The goal when describing them is to highlight the structure in which work is completed. A scenario could be, for instance, a blood gas analysis, from the decision of the physician to order such an analysis until the availability of the results in the patient's record and the acceptance of these results by the physician. We propose to modelize scenarios by the WFC [7].

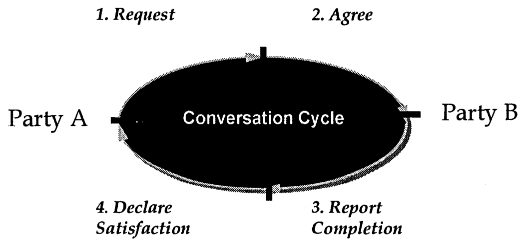

Figure 1. The phases and transitions of the workflow cycle (WFC).

The workflow cycle (WFC), as shown in figure 1, describes the activities of one or several individuals. The structure of a workflow cycle is made up of four steps or phases and four transitions. It is initiated by the individual who wants to transfer the objects, activities, the knowledge and responsibilities. The workflow model presents the mediation of information by computerized systems which enable the control of information flows (coherence, availability, completeness, synchronization) to diminish or to suppress the recurrent breakdowns. We shall use the model of the workflow cycle as a conceptual framework for interpreting breakdowns in critical care activities.

The four phases: One or several actors are involved. Their role is to carry out each phase and be responsible for it.

- *Phase 1:* the problem is stated and analyzed; a conclusion is drawn and a decision for action is taken.
- *Phase 2:* the decision is confronted with practical constraints.
- *Phase 3:* the action plan is carried out and the obtained results are observed and reported.
- *Phase 4:* the obtained results are assessed, i.e. compared with the expected ones.

The four transitions: They represent the control components of the workflow cycle at the meta-control level. They authorize the shift from one phase to the next one.

- *Transition 1:* acceptance of the decisions for action.
- *Transition 2:* acceptance of the action plan.
- *Transition 3:* acceptance of the activity report.
- *Transition 4:* acceptance of the outcome of the confrontation between expectations and reality.

The workflow model seems relevant to explain the breakdowns occurring in CCE during the patient care. The model showed that the most frequent errors occur during the transition between phases. This preliminary study was essential to get a clear idea of information exchanges between the actors of an ICU, before programming any software to support cooperation between people in a medical environment.

3 PLACO: the Coordination Management Issue

In this section, we will deal with the coordination issue for illustrating how can PLACO manage coordination tasks between care-providers in a medical unit.

As mentioned by MALONE, «*semi-structured messages are surprisingly useful for* *coordination support systems*». Our messages are constituted of some structured fields and some unstructured ones. The first ones are filled out automatically by the system and the other ones are filled out by the user. This technique allows actors more flexibility and more reliability to coordinate their work. Semi-structured messages are able to be automatically computed and filtered by the system. They enable actors to add informal knowledge which cannot be done automatically.

In PLACO approach, the message is the key-element of coordination. The essential role of messages is to save the complementary information which is needed by actors to perform their tasks safely. Complementary information can be a simple explanation of a drug change in a prescription. This piece of information is very useful to the other members of the therapeutic team to understand what is happening at any time. Messages are then considered as a sort of knowledge which complements the understanding of different events occurred during the run-time of the whole system. This approach makes users permanently informed of all changes of objects. They could act in the right way according to these changes, and thus avoid breakdowns and failures.

We highlight the utility of messages by integrating them in the WFC. There exists four messages containing the information related to the four actions which are to be completed during the WFC.

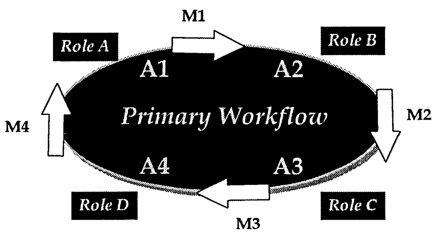

Figure 2. The conversation-oriented model of PLACO with the coordination messages.

As illustrated in figure 2, the message *M1* is sent to describe how the next action *A2* has to be done by the actor which plays the role *B*. The message *M2* is intended to detail how the action *A2* was done, and to specify that the next action *A3* is to be completed by the actor playing the role *C*. The message *M3* aims at providing the next actor, who will play the role *D*, with the information concerning the next action achievement (*A4*). The last message *M4* contains the explanation of what and how to do in the next phase (the action *A1*). It specifies also how the last action was achieved.

4 Prototype

A prototype represents the first part of a cooperative therapy plan, following the specifications resulting from the workflow model and the first evaluation of a preliminary attempt. To allow an object-oriented approach, we have written the new application using **SMALLTALK/V** language, on PC workstations connected through Ethernet network to an application server. **PCs** represent the clients. The main server contains the kernel of PLACO. Domain-objects are distributed in clients because in an ICU, actors require one workstation (PC) per patient room.

5 Conclusion

The cooperative dimension of the work is obvious in medical teams and particularly in ICUs. The work carried out within the PLACO project must have an impact on the conception and development of the future pilots.

The benefits that users generally expect from using groupware are the better efficiency for the decision process, time and money saving and the rapid solving of crisis situations.

In developing new applications, it will be essential to identify which parts of the software will be modified if we have a cooperative conception of the work. Consequently, some processes will be best candidates for the implementation of groupware. As an example, for the management of ICU, the therapy plan could be a first trial area for this new technology.

References

[1] R. Beuscart, V. Carre, F. Westrelin, S. Dalmas et al. *«Interim Report on Cooperative Work in CCE (Methodology)»*. AIM - TANIT (A2036) Project, COOP Workpackage. Deliverable #D2, Public Report, July 1992.

[2] C.A. Ellis, S.J. Gibbs, and G.L. Rein. *«Groupware: Some Issues and Experiences»*. Communications of the ACM, n° 1, volume 34, pp. 38-58, 1991.

[3] B. Hayes-Roth, R. Washington, D. Ash, R. Hewett, A. Collinot, A. Vina, A. Seiver. *«Guardian: a Prototype Intelligent Agent for Intensive-Care Monitoring»*. Journal of AI in Medicine: Special Issue on Expert Systems for Intensive-Care Setting, 4: pp. 165-185, 1992.

[4] T. Malone. *«What is Coordination Theory?»*. National Science Foundation Theory Workshop. Cambridge, Massachusetts, February 1988.

[5] J.B. Searle. *«Expression and Meaning - Study in the Theory of Speech Acts»*. Cambridge University Press, N.York, 1986.

[6] T. Winograd, F. Flores. *«Understanding Computers and Cognition: A New Foundation for Design»*. Addison-Wesley Publishing Company, Inc. New York, 1987.

[7] F. Yousfi, J-M. Geib & R. Beuscart. *«A new Architecture for Supporting the Group Work in Health Care Domain»*. Proceedings of the 3rd IEEE Workshop on Enabling Technologies: Infrastructures for Collaboratives Enterprises (WET'ICE 94). April 94, WV-Morgantown, USA.