Modelling Co-operation in the Design of Knowledge Production Systems : the MADEIN'COOP Method - An example in the field of C^3I[1] systems[2]

MANUEL ZACKLAD
CNET Issy-les-Moulineaux

CNET PAA/TSA/UST/GESCOM
38-40, rue du Général Leclerc
92131 Issy-les-Moulineaux Cedex France
Phone : 45 29 66 75 - Fax : 45 29 65 57
e-mail : zacklad@laforia.ibp.fr

FRANCIS ROUSSEAUX
Thomson - SYSECA

SYSECA
315, Bureaux de la Colline
92213 Saint-Cloud Cedex France
Phone : 49 11 74 19 - Fax : 49 11 76 21
e-mail : Rousseaux_F@syseca.fr

Abstract

This paper presents the latest developments of the MADEIN'COOP method for modelling the man-machine and man-man co-operation process, and an application of this method for the design of a more co-operative version of the C^3I system CHEOPS. We first consider that the design of software systems for organizations is tied more and more to the perspective of 'compound' Knowledge Production Systems that link man and machines engaged in a co-operative problem solving process. After exposing the four principles upon which MADEIN'COOP rests for modelling co-operation, we present an artificial problem solving dialogue between CHEOPS and its users. Consistent with the *'Group Cognitive Processes Theory'* framework, we propose a dialogue analysis according to two complimentary points of view: the 'Collective Problem Solving model', and the 'Co-ordination model'. This analysis should help system designers to identify new system functionalities to assist problem solving.

Résumé

Dans ce papier, nous présentons les derniers développements la méthode de modélisation de la coopération homme-machine et homme-homme MADEIN'COOP et une application de cette méthode à la conception d'une version plus 'coopérative' du système d'Information et de Commandement CHEOPS. Dans une première partie, nous considérons que la conception des systèmes informatiques dans les organisations s'incrit de plus en plus dans la perspective du développement de Systèmes de Production de Connaissances 'composites' associant des hommes et des machines engagés dans un processus coopératif de résolution de problème. Après avoir exposé les quatre principes sur lesquels s'appuie MADEIN'COOP pour modéliser la coopération, nous présentons un dialogue de résolution de problème artificiel entre CHEOPS et ses utilisateurs. Conformément au cadre de la 'Théorie des Processus Cognitifs de Groupe', nous proposons une analyse de ce dialogue selon les points de vue complémentaires du 'modèle de résolution collective de problème' et du 'modèle de coopération'. Cette analyse doit suggérer aux concepteurs du système des fonctionnalités nouvelles d'aide à la résolution de problème.

Keywords : Co-operation modelling, Methodology, C^3I systems.
Mots-Clés : Modélisation de la coopération, Méthodologie, Systèmes d'Information et de Commandement.

1. INTRODUCTION

This paper presents the latest developments from the man-machine co-operation modelling method MADEIN'COOP [Zacklad & COOP 94]. The origins of MADEIN'COOP are rooted in the research and bibliographical work of the COOP group [COOP 92, 93], whose results were applied to the design of a more 'co-operative' version of the Command Control Communication Intelligence System (C^3I) CHEOPS [Rousseaux 95]. The first section of this paper formulates a hypothesis concerning the principal foundations in the design of co-operative computer systems for organization. We characterise these new systems, which rely more and more on an effective integration of man and machine, as *Compound Knowledge Production Systems*. Because in these

[1] (C^3 I) Command Control Communication Intelligence Systems
[2] In proceedings of COOP'95, International Workshop on the Design of Cooperative Systems, January 25-27, 1995.

systems the 'intelligence' is distributed between men and machines, their design relies on a basic understanding and modelling of group problem solving mechanisms (i.e., of the co-operation process).

The main objective of MADEIN'COOP is to model this co-operation process. By relying on present theoretical hypotheses such as the 'Group Cognitive Processes Theory' MADEIN'COOP creates tools for systematically identifying and describing a co-operative problem solving activity. Presently, the best models for providing a detailed analysis of co-operative activities are those based on problem solving dialogues. These dialogues have already been the object of several studies in the domain of cognitive psychology (for example, [Miyake 86], [Zacklad 87], [Falzon 89], [Karsenty & Falzon 92], [Darses & Falzon 93]). It is for this reason that we have centred our work on the analysis of a semi-artificial dialogue between systems and their users. This analysis allows us to propose several new categories for the analysis of problem solving dialogues that could be exploited by designers of Knowledge Production Systems.

2. KNOWLEDGE PRODUCTION SYSTEMS AND CO-OPERATION MODELLING

2.1. The Knowledge Production Systems

For an increasing number of industries the costs of computerisation no longer rest solely on the development of automated Information Systems, but rather upon the development of integrated man-machine systems. Moreover, these man-machine systems do not necessarily refer to a one-man one-machine system, but equally apply to several groups of users whose actions are partly mediated by a computer. In these situations, the computer is used not only to stock information and automate repetitive tasks but also to support collaborative action of its users. While recent work in the Computer Supported Cooperative Work (CSCW) domain [Baeker 93] emphasizes the supporting role computers can play in collective tasks, researches in the domains of Knowledge Acquisition and Artificial Intelligence [Buchanan 93] opens up new horizons for the modelling of technical skill and for the production of machines able to have sophisticated dialogues with their users. [Ellis & al.91], emphasize that AI is one of the fields that can bring, in the long term, significant contributions to CSCW by transforming 'machines from passive agents that process and present information to active agents that enhance interactions' (p. 15, in [Baeker 93]).

For their part, present management researchers stress the quick evolution of organizational structures and knowledge ([De Terssac 92], [Hatchuel & Weil 92], [Hatchuel 94]). For example, the notion of 'organizational learning,' as studied by Hatchuel, emphasizes that the evolution of an organisation can be seen as the progressive building of technical knowledge on one hand, and co-ordination skills on the other. To support this vision of an organization, computer systems of the future will have to facilitate the collective production of knowledge, or even to play an active role in this production by their ability to stimulate heuristic conversations.

In the near future, it appears that the design of *Compound Knowledge Production Systems* that integrate human and machine agents, collaborating to discover new means to achieve their tasks, will be an important goal when developing computer systems for organizations. While the notion of an 'Information System' conveys a clear separation between a *physical* production system and an information control sub-system, the concept of Knowledge Production Systems[3] (KPS) emphasises the added value of intellectual work, supported by new cognitive computer tools, that

[3] There still remain to carry out detailed analyses of the functional characteristics of these systems to position them in respect to other classes of identified systems: information systems, decision support systems, CAO, PAO, different classes of CSCWs, etc...

is the production of new knowledge that can increase organizational performance and suggest new methods for solving problems. Therefore, designing KPS requires the elaboration of the evolutionary aspect of organizational modes of work, while at the same time identifying characteristics of computer tools that will insure an efficient communication network for storing and using knowledge for 'intelligent' user interactions.

2.2.Modelling Co-operation

We believe the main difficulty met in the design of KPS is to identify methods that allow designers to describe, at the conceptual level, the man-machine and man-man co-operation mechanisms. In their studies of the man-machine interaction, most of the researches done in the fields of CSCW or HCI (Human Computer Interaction) focus on the communication processes rather than the co-operative processes. They do not take into account the semantics of the domain in question nor of the users present knowledge or level of understanding. It is mainly in the field of Knowledge Acquisition that we find some work that addresses the modelling of the co-operation at the level of the semantic of the problem processed by the KPS. For example, the KADS methodology suggests, for single user systems, that we combine the domain model with a co-operation model to create a conceptual model for the Knowledge Based System [De Greef & Breuker 92]. This explains MADEIN'COOP's roots in the field of Knowledge Acquisition. Thus, it should come as no surprise that these origins manifest themselves in the modelling principles proposed by the method.

3. MADEIN'COOP MODELLING PRINCIPLES

The modelling of the co-operation process in MADEIN'COOP can be summarised by four propositions:

3.1. Proposition #1: It is necessary to design and model the co-operative activity of a man-machine group as a whole at the 'knowledge level'.

This idea comes from the notions of the KPS expressed above. System designers can no longer be content to simply model the behaviour of the system, but must model and define the co-operative activity of the man-machine system as a whole. This will force them to prescribe new approaches to work within organizations and to fully integrate specialists in the social science domains as co-designers of the co-operation models. In addition, co-operation must be modelled at the 'knowledge level' [Newell 82]: description of system and user behaviour should focus on goals and knowledge rather than referring to the technical characteristics of these systems--an analysis of the program in the case of the machine agents.

3.2. Proposition #2: It is necessary to establish co-operation goals in an organizational context.

Co-operation modelling begins by defining a Global Model of the Collective Activity (GMCA) that describes the organization, its tasks, and the characteristics of the human and machine agents involved. This initial modelling identifies the set or group of agents working together by means of '*periodic co-operation meetings*' in the pursuit of a common goal. In the power plant process control field, for example, we can imagine three types of stereotypical periodic co-operation meetings :

- Shift change meetings between the two team leaders and the computer process supervisor,
- Maintenance meetings where the maintenance supervisor and the computer process supervisor are present,
- Diagnostic meetings between a team leader, operators, and the computer process supervisor.

Through an understanding of the roles played by these periodic co-operation meetings a detailed modelling of the co-operation process is possible. At the GMCA level the co-ordination modalities between agents are viewed at a macro-level. This approach is supported by similar research in organizational science ([Mintzberg 79], [Malone 87]).

3.3. Proposition #3: It is necessary to provide a detailed description of the co-operation processes from a 'rational actor' point of view.

During the detailed modelling of the co-operation process, we will choose a particular viewpoint on the human and artificial systems that, instead of being centred on their internal procedures and representations, will allow us to analyze them from the viewpoint of their *interactions*. While description at the 'knowledge level' consists of describing the systems as *'rational agents*' trying to reach their goals by managing their knowledge, in MADEIN'COOP we try to view them as '*social actors*' committed to a collective activity and sharing their goals with their partners. If an agent is searching for an efficient co-operation with its partners, we will consider his behaviour as that of a '*rational actor'* trying to maximise the group s'chances of attaining the common goal.

Adoption of the rational actor perceptive, thus, consists of focusing concurrently on two aspects: the interactions between the agents, and their co-operative behavior without considering their possible non-co-operative motivations. Thus, the rational actor approach deviates greatly from Crozier's and Friedberg 'strategic actor' [Crozier & Friedberg 77], for instance, who tries to maximise its autonomy and its power inside an organization. These two approaches for analyzing an actor's activity are necessary for a general understanding of the studied situations, but each approach responds to a different need. However, they also have certain interactions that can help explain dysfunctions. Indeed, agents involved in a co-operative activity sometimes have goals or interests that are divergent from the 'official' aims of the group and that can, in some cases, be responsible for the failure of the group to attain its objectives.

3.4. Proposition #4. It is necessary to describe the co-operative activities of the rational actor according to three points of view.

Modelling the rational actor's activity is done according to three points of view corresponding to three models : the model of Collective Problem Solving (CPS), of co-ordination (at a more detailed level than the GMCA), and of communication. According to each point of view we can identify acts of problem solving, co-ordination, and communication. To analyze these 'co-operation acts'[4] we rely on the framework of the *'Group Cognitive Processes Theory'* in which individuals verbal protocols, from co-operation tasks, are analyzed in terms of the participation of the subjects in a virtual collective agent: a Virtual Group Information Processing System (virtual GIPS).

Rather than going into the details of the *'Group Cognitive Processes Theory'* framework, which is still in a preliminary stage of development, we prefer to provide a survey of the principle hypothesises that make up the foundation. When agents are engaged in co-operative situations which are, according to a broad consensus, characterized by a collective search for the attainment of a goal, we consider that the agents are integrated in a common virtual Group Information Processing System (virtual GIPS). The virtual GIPS will include, in particular, a common collective task memory constituted by a shared memory of the dialogue in which the agents participate. We can examine the history of the dialogue from three perspectives:

[4] These terms come from [Falzon & Darses, 1992] but we use them with a slightly different meaning because of the more detailed division of the co-operation acts that we introduce.

- from a problem solving perspective, which corresponds to the progressive exploration of the group problem space,
- from a co-ordination process perspective, which corresponds to a trace of an agent's progressive involvement with the different themes evoked in the dialogue, while playing a control role in respect to problem solving,
- and from a communication process perspective, which permits the progressive and communal construction of a collective discourse.

3.4.1. Collective Problem Solving Model

When we adopt the problem solving process perspective, which corresponds to the CPS model, each agent's participation is justified by his functional role vis-à-vis the attainment of the goal. In order for co-operation to exist the participating agents must share, in part, a common mental model of the problem solving method selected by the group. It is this method that serves as the integrating mechanism for the different interventions and provides the structure for the virtual collective memory of the group. It functions similar to a 'black-board' where different zones are reserved for specific inputs from different knowledge sources. While the CPS model allows us to examine the *'semantics'* of the interventions, from the point of view of goal attainment, it does not permit us to take into consideration the more *'pragmatic'* dimensions of the interaction. The pragmatic dimensions correspond to the methods of agent intervention vis-à-vis the other group members and to the themes being introduced. They are examined in the co-ordination model.

3.4.2. Co-ordination Model

According to a co-ordination model perspective, the temporal and cognitive resources of the group are limited and the principle problem is to arrive at a collective solution within a reasonable time frame. These constraints bring to light the 'competitive' and even 'antagonistic' aspects of co-operation. It is not possible to freely explore the group problem space while looking at all possible alternative paths. Since we examine the situation in a context where time resources are limited, where each turn-taking (within an on-going conversation) consumes some measure of time, no intervention can be considered free. From the perspective of a co-ordination model we see the interaction between group members in a more 'argumentative' light and consider each intervention as defending a solution. Our hypothesis is that this perspective places the accent on the mechanisms of control over the collective resolution of a problem.

3.4.3. Communication Model.

The third model is a model of communication[5], and could in one sense be considered the first perspective. In order for exchanges to take place in a group setting, it is necessary for the group to share one or several communication languages and possess the necessary media support. Natural language communication, as we know, is multi-modal and in problem solving situations agents often use external memory aids such as environmental cues, or paper, chalkboards, and diagrams to help illustrate the solving of a problem. The complexity of natural language stems from its several layers of meaning. From the point of view of the semantics of the problem Falzon's operative languages [Falzon 89] are an example of the extreme schematizations that can be put into communication. From the pragmatic point of view of co-ordination, speech acts are an example of how language carries with it implicit organisational instructions [Winograd & Flores 86]. The shared knowledge about conversational rules, that allow interlocutors to play with the different layers of meaning into a dialogue, makes the analyse even more complex: a question can

[5] In Zacklad & COOP [1994] this is called a Dialogue Model.

in fact be an order, an affirmation can replace a question, an explanation can serve as a critique, etc...

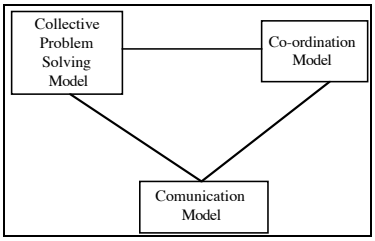


Fig. 1 - The three models of co-operation.

The primitives of the communication model, that should come to a great extent from the field of semiotic, are not yet well defined in MADEIN'COOP and so, we did not include this model in the scope of our example. The important point on which we insist upon in MADEIN'COOP is that the modelling of man-machine communication process goes beyond considerations relative to the design and the functional mechanisms of an interface and has narrow interactions with the CPS and Co-ordination models.

4. DETAILED MODELLING OF CO-OPERATION DYNAMICS RELATIVE TO THE COLLECTIVE PROBLEM SOLVING AND CO-ORDINATION MODELS

4.1. Example of a Crisis Management Help System : CHEOPS

Our presentation of the MADEIN'COOP method is founded in the GEOCOOP project [Zacklad & al. 93]. This project aims to add to the C^3I system CHEOPS developed by SYSECA intelligent decision support functions. These functions require constant interactions between the man and the system and their development has motivated a detailed study designed to deepen the understanding of the co-operation modalities of this system with its users. CHEOPS works in concert with a Geographical Information System destined for use in risk analysis and rescue planning for disaster management (military risks, fire hazards, pollutants, etc...). An object oriented data base is stocked with geographical and non-geographical objects for examining and visualising various disaster events. The data base provides varying degrees of graphical and textual support so that users can view the events from multiple points of view.

In addition to the Geographical Information System, CHEOPS integrates several pieces of software including, most notably, a sophisticated message system; a scenario simulator that can evaluate ground forces and calculate the mobility of these objects in terms of time and ground conditions; a documentary search system; and a help system for analyzing textual situation updates. An important piece of software, the Argumenter, is currently under specification with the help of the MADEIN'COOP method. Argumenter is a knowledge based system for situation diagnostics that relies on qualitative reasoning. The Argumenter, otherwise known as ARGU, should start off from a strategic hypothesis for seeking corresponding events that have a bearing on the situation and inversely analyze these events to help determine a strategic hypothesis that helps to explain the present situation.

4.2. Elements of the Model Addressed in this paper.

In this paper, we will not present the global organisational context of the *periodic co-operation meetings*, that is to say that we wont present the GMCA[6]. We will focus on the CPS and co-ordination models. If we had presented the GMCA we would have developed the following aspects :

- a task-model of the crisis management task and of the situation-interpretation sub-task;
- a agent-model of the human and computer agents involved in the crisis management task;
- an organizational-model that defines the different agents engaged in the 'periodic co-operation meeting' of situation-interpretation and their co-ordination modalities with the other actors of the crisis management task.

So that the reader can follow the example, we will just present an extract of the human agent model from the local Command Post (local CP), situated in proximity to a crisis site, along with the artificial agents of the CHEOPS system.

The human agents of the local CP:

- One or two Military Attachés (MA) responsible for collecting data from local sources, send it out in reports augmented with situation updates.
- Computer Technicians (CT) responsible for the installation and operation of the software and transmission devices.

The software agents of the prototype system (identical at Central CP and Local CP sites)

- The object oriented data base management system (GESTEV) : charged with classifying each event.
- Geographical data base management system (GESTCART) : assures the visualisation of key events on maps. With each map users are allowed to 'zoom' and to apply different thematic layers: means of communication, military forces, demographics, relief, weather, etc…
- The message system (MESSAG) : charged with the transmission of textual electronic messages. These messages can be in the form of textual situation up-dates, or in pre-established formats from the data base.
- Situation Update Report Analysis (ANALYS) : analyzes the textual situation up-date messages in order to format them for the data base.
- Tactics Simulator (SIMUL) : conducts simulations to estimate ground force levels and their potential mobility.
- The Argumenter (ARGU) : should start off from a strategic hypothesis for seeking corresponding events that have a bearing on the situation and inversely analyze these events to help determine a strategic hypothesis to help to explain the present situation. ARGU directly interacts, through a common data base, with the GESTEV and GESTCART systems. This explains why GESTEV and GESTCART do not intervene in the dialogue analysis presented below.

5. SPECIFICATION OF THE CO-OPERATION MODELS FROM THE ARTIFICIAL PROBLEM SOLVING DIALOGUE.

In the example, we present an artificial problem solving dialogue[7] between agents at a local CP crisis management site situated in Tchoud. By presenting this dialogue, we do not want it misunderstood that this type of natural language man-machine dialogue, which is highly complex, must be the goal of the CHEOPS developers. This dialogue serves simply as a model for identifying certain principles of problem solving and co-ordination. These principles should be used in a communication model specific to the man-machine communication context. Natural language is the implicit communications model for this artificial dialogue to which we add gestural information and visual support material: electronic maps, documents, etc.

[6] See [Zacklad & Rousseaux 95] for a general outline of GMCA relative to this study.

[7] We created this dialogue ourselves from scenarios provided by a domain expert.

5.1. Dialogue Context.

Tchoud is in a state of civil war with rebel forces, supported by Labiens, opposed to the 'legitimate' government. The French army is engaged on the government's side to protect itself from the Labien menace. Several recent events have justified an increased level of alert at the local CP site charged with providing situation updates. There are two potential interpretations of the events: recent troubles are essentially considered an interior affair between the government and opponents allied with the rebel forces; or recent troubles are instigated by the Labiens as part of a military invasion--justifying French military intervention. If an invasion takes place, it will most likely be in the southern regions of the country where the rebel forces and several regiments of the Labien army are located. The recent events presented in chronological order are as follows:

- The troubles began in a military barracks in Biltin, situated near the southern frontier. It is unclear weather the incident stems from a mutinous group of soldiers, poorly treated and badly paid, or from an attempted rebellion supported by traitors.

- The airport in the Tchoud capital, N'djamena, was bombed by an unidentified aggressive force. The MA has asked experts to analyze pictures of the explosive impacts. The rebels possess two Soviets made devices capable of bombardment.

- Streets fighting were reported around the parliament buildings and military forces, stationed in the South, were moved to the capital. Again the precise nature of the troubles is unknown. The dialogue analysis begins with information recently provided to the CP.

In this dialogue a MA (Military Attaché) defends the 'interior affair' hypothesis which corresponds to an implicit wish of the French government to avoid military involvement. ARGU defends the opposite position.

5.2. Collective Problem Solving Model

Conforming to the GMCA, the Collective Problem Solving model rests primarily upon the group's shared mental model of the problem solving method. Our example is one of 'structural induction' ([Simon & Lea 74], [Hoc 87]); see Fig. 2. Once we identify the problem solving method used by the group, we can define the 'problem solving acts' and the 'problem oriented' structure of the group's task memory.

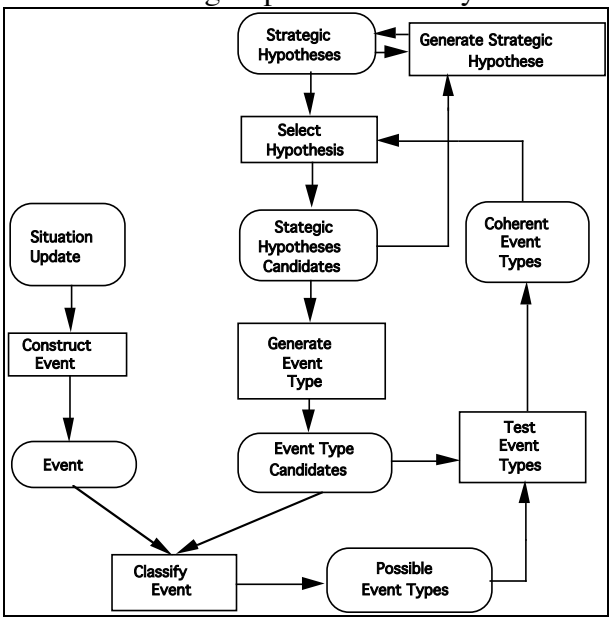


Fig. 2 - An Inference Structure inspired by [Simon & Lea 74] as applied to situation interpretation. (see Fig. 4. for an explanation of specific categories)

The problem solving acts correspond to a description of an agent's intervention from the point of view of his contribution to the exploration of the group problem space (i.e., actions taken as part of the problem solving process). This perspective has been adopted by several psychological taxonomies designed to classify the contributions of interlocutors participating in a problem solving dialogue (for example, [Zacklad 87] [Darses & al. 93]). Darses et al. define 'co-operation acts' such as 'inform', 'generate,' or 'critique.' As you shall see we do not use the categories 'inform' or ' critique' for acts of problem solving. We also do not stick with the category, which we see as too general, 'acts of co-operation', but rather we prefer a more detailed segmentation consisting

of ‘problem solving acts’, ‘communication acts’, and ‘co-ordination acts’. Identifying the problem solving methods followed by the group allows us to simultaneously define the structure of the groups virtual task memory. This structure facilitates the memorisation of the history of the exchanges (Fig. 2 & 3).

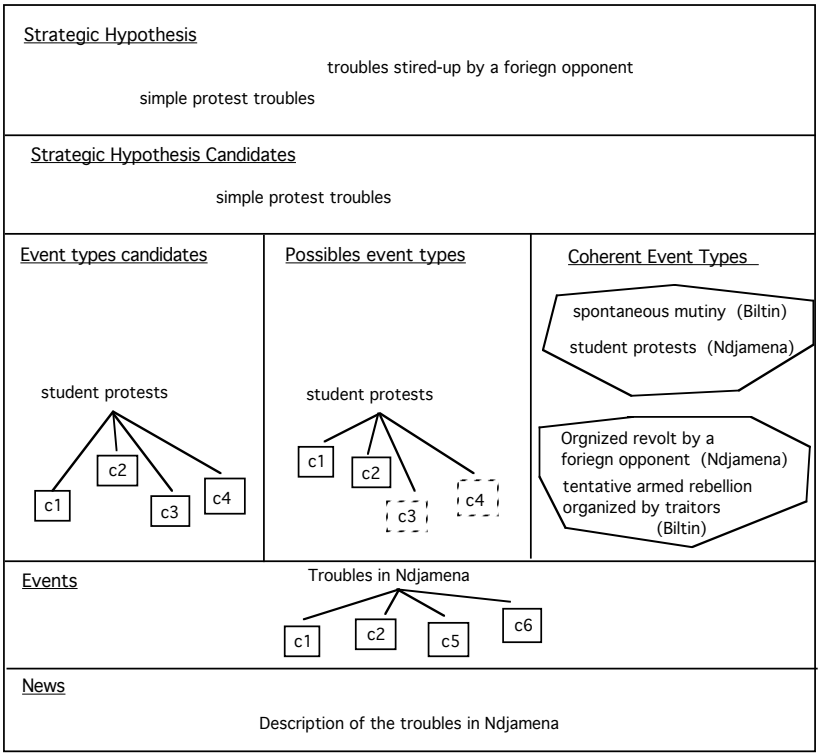


Fig. 3 - Structure of the virtual task memory in a local CP crisis management unit with a schematic data example. For the example presented above two strategic hypotheses were generated. The MA selects the hypothesis ‘simple protest troubles.’ The process starts from a situation update to construct an event by picking-up specific characteristics from the descriptions (c1, c2, c5 and c6). Starting from a candidate hypothesis the MA generates an event-type candidate which possesses the characteristics c1, c2, c3 and c4. Comparing them with ‘troubles in N’djamena’ he concludes that ‘student protest’ is a possible event-type to explain the disturbance (even if it doesn’t possess all the pertinent characteristics : c5 = armed protesters, should not be present, and c3 = presence of student unions, is missing). The next step consists of testing the possible event-types to verify that it permits us to define a group of event-types that are coherent with other candidate event-types (not represented in the Fig.). The test conclusion is favourable since there exists a possible interpretation of the events in Biltin which is compatible with the hypothesis ‘simple protest troubles’ as well as ‘student protests’[8].

Depending on the method of problem solving selected by the group the problem solving acts identified in the dialogue are as follows (the categories within brackets signify categories defined by multiple instances) :

- **Construct-Event** (news, {event })
- **Classify-Event** (event, {event-type candidate}, {possible event-type})
- **Test Event-Type** ({possible event-type}, {event-type candidate}, {coherent-event-type})
- **Select-Hypothesis** ({strategic-hypothesis}, {coherent-event-type}, coherent-strategic-hypothesis)
- **Generate-Event-Type** (strategic-hypothesis-candidate, {event-type candidate})
- **Generate-Strategic-Hypothesis** ({existing-strategic-hypothesis}, strategic-hypothesis-candidate, (new)-strategic-hypothesis)

For example, the coding of a tirade is done in the following manner:

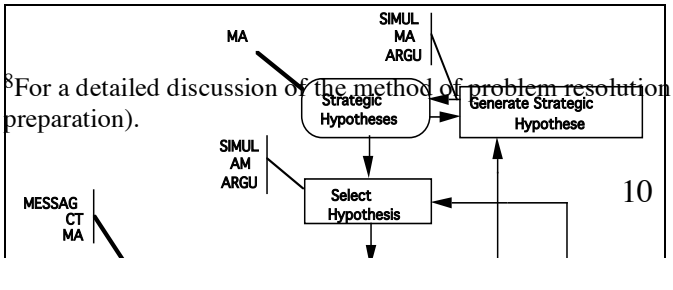
MA : Have you received the description of the events in N’djamena? It seems that it was a protest organised by students close to the opposition. This confirms that the events in Biltin are probably only the consequence of problems linked to the wages of the soldiers and it is clearly an interior affair.	**Construct-Event** (situation update of the events in N’djamena, {troubles in N’djamena } **Classify-Event** (troubles in N’djamena, {student protests, revolt organised by a foreign opponent}, {student protest}) **Test-Event-Type** ({student protest}, {student protest, revolt organised by a foreign opponent, spontaneous mutiny, tentative revolt by traitors}, {student protest, spontaneous mutiny}) **Select-Hypothesis** ({trouble supported by foreign opponent, protest troubles}, ({student protest, spontaneous mutiny}), protest troubles)

If we wish to code the questions (this is not necessarily required for the CPS model) we can introduce a question mark in the space corresponding to the logical argument. For example, tirade 5 could be coded in the following fashion :

MA: What do you think the consequences are ? (the consequences to the participation of rebels in the event in N'djamena)	**Generate-Strategic-Hypothesis** ({recent reinforcements to the Labien rebels, rebel desire for revenge, verbal provocations from the Labien government etc...}, recent troubles supported by a foreign opponent, ?).

The next table presents a dialogue extract analyzed according to the CPS model. The argument details are not presented.

An interpretation according to the Collective Problem Solving Model		
1	MA : Have you received the description of the events in N'djamena? It seems that it is a protest organised by students close to the opposition. This confirms that the events in Biltin are probably only the consequence of problems linked to the wages of soldiers and are clearly an interior affair.	Construct-Event Classify-Event Test-Event-Type Select-Hypothesis
2	ARGU : I don't agree. The principle cause of the events in Biltin is not known, and the M'Boutoul ethnic group (implicated in the Biltin affair) has strong ties to the rebels.	Classify-Event
3	MA : Can you prove that the rebels are implicated in the recent events.	Test-Event-Type
4	ARGU: Yes, let me show you. (a demonstration follows)	Classify-Event Test-Event-Type
5	MA: What do you think the consequences are ?	Generate-Strategic-Hypothesis
6	ARGU to SIMUL (communication unseen by the MA): Can you estimate troop strength ratios in the southern region while taking into account recent events ?	Generate-Strategic-Hypothesis
7	SIMUL to ARGU (communication unseen by the MA): By integrating the rebel forces and Labien regiments troop strengths ratios go against the Tchoudiens.	Generate-Strategic-Hypothesis
8	ARGU to MA : If the rebels and the Labiens are involved, this signifies that an attack in the southern zone is possibly imminent while the Tchoudiens defence potential is limited.	Generate-Strategic-Hypothesis
12	Intervention of MESSAG : I just received the message we have been waiting for. It seems that the planes that bombed N'djamena are Marquettis.	Construct-Event
13	MA to ARGU : You just might be right.	Generate-Strategic-Hypothesis
14	ARGU : Why this change in opinion?	Generate-Strategic-Hypothesis
15	AM: Because it seems the bombardment was conducted by the Labiens, which signifies that a large scale invasion may be in the works.	Construct-Event (Classify-Event) (Test-Event) Select-Hypothesis



[8]For a detailed discussion of the method of problem resolution see [Rousseaux 95] and [Zacklad & Rousseaux 95] (in preparation).

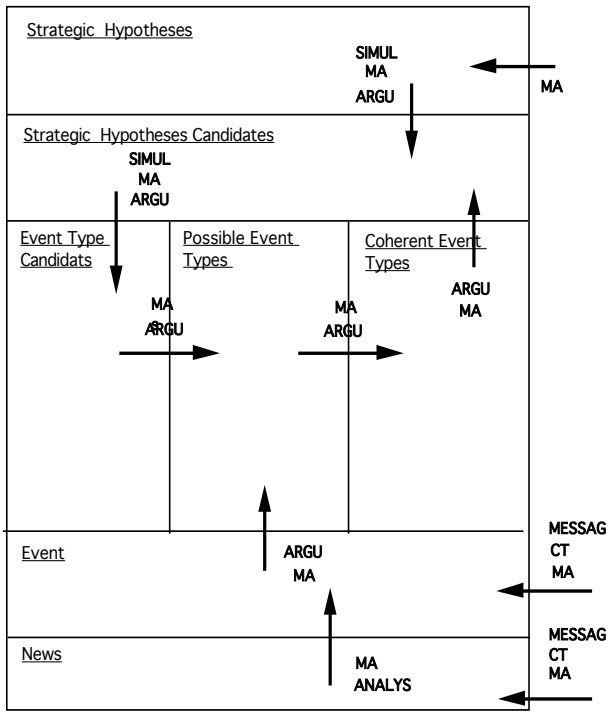


Fig. 5 - Different intervention possibilities of the agents upon the virtual task memory of the group (the arrows coming from the exterior correspond to the direct insertion of a category's instance).

Detailing the allocation of agent roles

On the basis of the CPS approach we are able to allocate the roles of the different agents more precisely than is possible with the organizational model alone (Fig. 4). With CPS this allocation is essentially based on the knowledge of the agents. We can easily transfer this allocation to the virtual task memory of the group and note that the dialogue contributions of the different partners are thematically different (Fig. 5). These aspects are described in more details in the co-ordination model below.

5.3. Co-ordination Model.

While the CPS model analyzes agents exchanges from the perspective of their functional roles in attaining a goal, the co-ordination model examines their exchanges in respect to controlling the problem solving process. According to the co-ordination point of view, the objective is not to explore the problem space in order to increase the number of possible solutions but to rapidly converge on a solution. The co-ordination model reflects the well known 'limited rationality' axiom which states that the time allowed to solve a problem is limited and that it is important to make a decision even if it is not the optimal one.

The co-ordination analysis is directly related to the distributed decision making process in the sense that the differing positions taken by group members can be competing or incompatible. The actions of the partners, as in the CPS model, exert influence on the virtual task memory of the group. Nevertheless, we consider that while we adopt the co-ordination point of view, the virtual task memory of the group appears to be structured differently than in the problem solving perspective. Rather than consider that there exist two task memories, as in the [Hayes-Roth & Hayes-Roth 79] dual blackboard system BB1, we prefer to consider that two different perspectives co-exist and impose different blackboard structures (different organization of the zones) as well as different access methods.

Thus, given the co-ordination perspective, different zones are reserved for registering common and individual positions (indivual positions differ from that of the group's). Decisions or

arguments unanimously endorsed by the group are registered in the common position zone and, thus, reflect the common 'official' or 'public' position. According to the mode of co-ordination used by the group, registering a decision in a communal zone must be preceded by an official vote or other informal arrangements. Within certain co-ordination mechanisms, take for example some case of Mintzberg's mutual adjustment, all positions expounded in the name of the group are supposed to be accepted in the absence of explicit opposition. At the end of the discussion period the position of the group will be that of the non-contradicted opinions found in the common position zone. The co-ordination process analysis will start with a description of the co-ordination acts, which in turn will shed a different light on the interventions than that provided by the problem solving acts perspective.

5.3.1. Structure of the Co-ordination acts.

We use two principles to guide our analysis of co-ordination acts. The first consists of removing, as much as possible, the characteristics introduced by the language mode used in the interaction. Essentially, the co-ordination analysis must be as independent as possible from the communication modality used, in order to leave room for innovative approaches in this domain. The second principle consists of staying within the framework of *'Group Cognitive Processes Theory'*. In other words, to interpret communication not as an action designed to modify agents beliefs or goals, but as a contributing to the building of the virtual task memory shared by the group.

These principles bring us not to propose an interpretation which develops hypotheses based on the intentions of the agents vis-à-vis their partners. We also want to distance ourselves from interpretations in terms of 'explanations' given by one member of the group to another. Spontaneously provided or requested explanations may constitute 'indirect' speech acts within an argument strategy. According to our point of view, by adopting the co-ordination perspective, it is possible to consider that an explanation, a critique, a praise or agreement registers on the virtual task memory of the group arguments either in favour or in opposition to a decision.

Therefore, the coding of co-ordination acts will primarily be determined by the actions of group members upon virtual task memory. The structure of virtual task memory is of the type ACTION(OBJECT, PLACE, RIGHT, SEQUENCE). *Places* refer to the different memory locations where interventions are registered. *Objects* are the themes investigated; as seen from the point of view of their impact upon the final decision. *Rights* are the conditions that authorise an interlocutor to intervene upon a collective or individual virtual task memory. *Sequence* is the characteristics of the intervention which 'represent an initiative or a reaction according to the their position in the configuration of a speech act' ([Armengaud 85], p.92).

Actions

The defined actions are directly linked to intervention upon the virtual Task Memory (TM) of the group:

Category	**Comment**
To write a position on the TM : WRITE	Advance a group or individual position.
To delete a position from the TM : DELETE	Retract a group or individual position.
To force to write a position on the TM : FORCE-TO-WRITE	An action taken to lead a partner to defend a position (group or individual).
To force to delete a position from the TM : FORCE-TO-DELETE	An action taken to lead a partner to retract a position (group or individual).

Objects

From the point of view of co-ordination of a dialogue the categories are essentially relative to the collective decision process. We retain only three categories:

Category	**Comment**
Decision(s)	In the context of the example, decisions are relative to the strategic hypothesis which must be defended.
Directed arguments	When two contradictory decisions A and B exist, the arguments in favour of A are also arguments against B.
Neutral arguments	Identification the risks and benefits (pros and cons) involved in a decision.

Places

Paces allow us to introduce differentiation of two types:

- a differentiation between communal and individual zones in the virtual task memory (individual zones are used to write positions that are not shared by the group),
- a differentiation between the public and private dialogue space of the group. Private zones allow agents to communicate without being 'heard' by other group members. We consider that private dialogues generate private virtual task memories (i.e., reserved for a small number of the group's interlocutors).

The places analyzed in our example are:

• Common zones of the virtual task memory of the GIPS[9] : COMTM
• Individual position zones of task memory of the GIPS : INDTM
• Private task memories of agents who temporarily constitute a sub-group of the GIPS : SUBTM

Intervention Rights

The rights of intervention depend of the zone of the virtual task memory, of the agent and of the 'moment' when interventions occur. To analyze our example we use the three following categories:

Category	Comment
Co-authority	While group members do not have authority over one another, they have authority over the final decision. They may intervene in a conversation at any moment if intervention respects the rights of turn-taking and pertinence to the decision process.
Direct authority	According to the functional dependencies between agents, agents have the capacity to force certain task memories for themes related to their role.
Thematic authority	Close to the direct authority intervention right it adds conditions of intervention related to the current theme.

We should note that, according to the situation, intervention rights can correspond to standard institutional policies, local interaction conventions, or to a particular 'meeting'. For example, we can name a 'session president' who has total intervention rights of direct authority only for a given meeting.

Sequence

The sequence will simply be labelled as 'Initiative' or 'Reaction (x),' where (x) points back to the initiative that motivated the reaction[10].

[9]Group Information Processing System

[10]Inspired by a classification of Wunderlich as cited in [Armengaud 85].

Thus the coding of a tirade, in terms of co-ordination acts, will have the following form:

MA : Have you received the description of the events in N'djamena? It seems that it is a protest organised by students close to the opposition. This confirms that the events in Biltin are probably only the consequence of problems linked to the wages of soldiers and are clearly an interior affair.	• WRITE (decision(interior affair hypothesis), COMTM, co-authority, initiative)

5.3.2. Interpretation of the dialogue according to the co-ordination point of view

The coding of the dialogue, analyzed according to the co-ordination model, will have the following form:

An interpretation according to the co-ordination point of view		
1	MA : Have you received the relative description of the events in N'djamena? It seems that it is a protest organised by students close to the opposition. This confirms that the events in Biltin are probably only the consequence of problems linked to the wages of soldiers and are clearly an interior affair.	WRITE (decision(interior affair hypothesis), COMTM, co-authority, initiative)
2	ARGU : I don't agree. The principle cause of the events in Biltin is not known, and the M'Boutoul ethnic group (implicated in the Biltin affair) has strong ties to the rebels.	DELETE (decision(interior affair hypothesis), COMTM, co-authority, reaction (MA-1)) WRITE (direct argument(troubles supported by foreign opponent) ARGU-INDTM, co-authority, reaction (MA-1))
3	MA : Can you prove that the rebels are implicated in the recent events.	FORCE-TO-WRITE (direct argument (consequence of troubles supported by foreign opponent) COMTM, co-authority, reaction (ARGU-2))
4	ARGU: Yes, let me show you. (a demonstration follows)	WRITE (direct argument(consequence of troubles supported by foreign opponent) COMTM, co-authority, reaction (MA-3))
5	MA: What do you think the consequences are ?	FORCE-TO-WRITE (neutral argument (consequence of troubles supported by foreign opponent) COMTM, co-authority, initiative)
6	ARGU to SIMUL (communication unseen by the MA): Can you estimate troop strength ratios in the southern region while taking into account recent events ?	FORCE-TO-WRITE(neutral argument (consequence of troubles supported by foreign opponent) SUBTM-ARGU-SIMUL, direct authority, initiative)
7	SIMUL to ARGU (communication unseen by the MA): By integrating the rebel forces and Labien regiments troop strengths ratios go against the Tchoudiens.	WRITE (neutral argument (consequence of troubles supported by foreign opponent) SUBTM-ARGU-SIMUL, direct authority, reaction (ARGU-6))
8	ARGU to MA : If the rebels and the Labiens are involved, this signifies that an attack in the southern zone is possibly imminent while the Tchoudiens defence potential is limited.	WRITE (neutral argument (consequence of troubles supported by foreign opponent) SUBTM-ARGU-SIMUL, direct authority, reaction (ARGU-6))
12	Intervention of MESSAG : I just received the message we have been waiting for. It seems that the planes that bombed N'djamena are Marquettis.	WRITE (neutral argument (troubles originating in N'djamena), COMTM, thematic authority, initiative)
13	MA to ARGU : You just might be right.	DELETE (decision (interior affair hypothesis), AM-INDTM, co-authority, initiative) WRITE (decision (troubles supported by foreign opponent), COMTM, co-authority, initiative)

14	ARGU : Why this change in opinion?	FORCE-TO-WRITE(direct argument (troubles supported by foreign opponent) COMTM, co-authority, reaction (ARGU-13))
15	AM: Because it seems the bombardment was conducted by the Labiens, which signifies that a large scale invasion may be in the works.	WRITE (direct argument (troubles supported by foreign opponent) COMTM, co-authority, reaction (ARGU-14))

6. CONCLUSION

If this initial employment of the MADEIN'COOP method to the CHEOPS application has allowed us to solidify our model, there still remains for us to show how this method can have an impact on communication models, on the selected engineering solutions, and ultimately on the modes of system use. There remains also a series of theoretical analyzes to do before we can precisely define valid domain areas for the model and its assumptions. While we are unable at this time to present significant results in these directions, we can, however, briefly provide three reflections among the many possible avenues.

Situations of problem solving 'Standardised' vs. 'New' : In the perspective of the CPS model we consider that the agents share, in part, a common representation of the method. This representation can only be constructed by training or experience. In certain situations, we must also consider the process of constructing a common method which is often the object of negotiations between partners. This perspective equally could allow us to better understand the nature of the explicit organizational and psycho-social knowledge used by the actors to design and to manage the co-ordination process.

A better understanding of the relationship between a problem centred activity analysis point of view and a co-ordination mechanisms analysis : In particular, we must be able to show how certain co-ordination problems depend on the problem solving strategies and reciprocally, how certain faults in the mechanisms of co-ordination complicate the resolution of certain problems. This type of reflection is in the same vein, adding a social perspective, as the research dedicated towards the relationships between 'knowledge' and 'meta-knowledge' or 'control-knowledge.'

A better concept of the interactions between the rational actor and the strategic actor perspectives: In some situations, where the roles of the different partners are not clear or are rapidly evolving, the rational and strategic actor perspectives are closely linked. For example, [Hatchuel 94] introduces the notion of 'co-ordination by actor construction' to designate situations where negotiations about status and roles lead to the definition of new modes of co-ordination. Our interpretation of these works brings us to consider the behaviour of the strategic actor as more 'rational' (in the sense that it is centred on problem solving) than it appears to be at first glance.

7. BIBLIOGRAPHY

Armengaud F., La Pragmatique, Que sais-je ?, PUF, Paris, 1985.

Baeker R.M., Readings in Groupware and Computer-Supporter Cooperative Work, Morgan Kaufmann, 1993.

Buchanan B.G., Wilkins D.C., Readings in knowledge acquisition and learning, Morgan Kaufmann, San Mateo, 1993.

Cahour B., La modélisation de l'interlocuteur : élaboration du modèle et effets au cours de dialogues de consultation, Thèse de l'Université de PARIS VIII, 1991.

Cohen P.R., & Levesque H.J., Rational Interaction as the Basis for Communication, in 'Intentions in Communication', MIT Press, pp. 221-255, 1990.

COOP, Bibliographie commentée du groupe COOP (Version 1): Modélisation de la coopération homme-machine dans la résolution de problème pour représenter et acquérir les connaissances dans les systèmes d'assistance, Rapport de Recherche EHEI n. 92-11-3, 1992.

COOP, COOP research group project : Modeling of Man-Machine Co-operation for the Design of Knowledge-Based Support Systems, rapport de recherche 93/25, LAFORIA, Université Pierre et Marie Curie, 1993.

Crozier M., Friedberg E., L'acteur et le Système, Edition du Seuil, Paris, 1977

Darses F., Falzon P., Robert, **J.M.,** Cooperating partners : investigating natural assistance, Proceedings of HCI'93, Orlando, USA, August 8-13.

De Greef H.P., Breuker J.A., Analysing System-User Cooperation in KADS, Knowledge Acquisition, 4, 89-108, 1992.

Ellis C., Gibbs S., and Rein G., Groupware: Some Issues and Experiences. Communications of the ACM, 34(1), pp. 38-58, 1991.

Falzon P., Ergonomie cognitive du dialogue, Grenoble : Presses Universitaires, 1989.

Falzon P., Darses F., Les processus de coopération dans les dialogues d'assistance, 27 eme congrès de la SELF, Lille, 23-25 Septembre 1992.

Hatchuel A., Weil B., L'expert et le Système, Economica, Paris, 1992.

Hatchuel A., Apprentissages Collectifs et Activités de Conception, Revue Française de Gestion, pp. 109-120, Juin-Juillet-Aout 1994.

Hayes-Roth B., Hayes-Roth F., A Cognitive Model of Planning, Cognitive Sciences, 3, 275-310, 1979.

Hoc J.M., Psychologie Cognitive de la Planification, Presses Universitaires de Grenoble, Grenoble, 1987.

Karsenty L., Falzon P., Spontaneous explanations in cooperative validation dialogues. Proceedings of the ECAI-92 Workshop on Improving the use of knowledge-based systems with explanations, Vienna, August 4 1992.

Malone T.W., Modeling Coordination in Organizations and Markets, Management Sciences vol. 33, n°10, pp. 1317-1332, 1987.

Mintzberg H., The structuring of Organization, Prentice Hall, 1979.

Miyake N., Constructive interaction and the iterative process of understanding, Cognitive Science, 151-177, 1986.

Newell A., The Knowledge Level, Journal of Artificial Intelligence, 18, 87-127, 1982.

Rousseaux F., Contribution à une méthodologie d'acquisition des connaissances pour l'ingéniérie des Systèmes d'Information et de Communication : l'Exemple de CHEOPS pour l'Aide à la gestion de crises collectives à caractère géographique, Mémoire d'habilitation à diriger des recherches, Université Paris 6, 1995.

Simon H. A., Lea G., Problem Sovling and Rule Induction : A Unified View, In Gregg L. G. (ed.), Knowledge and Cognition, pp. 105-28, Lawrence Erlbaum, 1974.

Terssac G., De, Autonomie dans le travail, Paris, PUF, 1992.

Winograd T., Flores F., Understanding Computers and Cognition, Addison-Wesley, USA, 1986.

Zacklad M., Contribution à une psychologie cognitive des activités de résolution de problème en groupe, DEA Processus Cognitifs, Université Paris 8, 1987.

Zacklad M., **Groupe COOP, Rousseaux F.**, Projet GEOCOOP: Conception d'une méthode d'acquisition des connaissances contextuelles et de modèles de coopération : application au développement d'un système géographique d'aide à l'estimation du risque et à la gestion de crises, Rapport de Recherche de l'INRIA N° 2052, Octobre 1993.

Zacklad M., **Groupe COOP**, MADEIN'COOP : Préliminaires pour le développement d'une méthodologie de modélisation de la coopération Homme-Machine, in actes de la conférence Ergo-IA, pp. 406-421, Biarritz, 26-28 Octobre 1994..

Zacklad M., Rousseaux F., Modéliser la Coopération dans la Conception des Systèmes de Production de Connaissances : La Méthode MadeIn'Coop, Exemple d'Application au Développement d'un Système d'Information et de Commandement, Rapport de Recherche du LIFAC 1995 (à paraître).