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Analysis and design of co-operative work processes: a framework — Source link

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Analysis and design of co-operative work processes: a framework

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Abstract

The main focus of this paper is demonstrating a methodology for capturing and designing co-operative work processes. We present a method, appropriate for group work analysis, and particularly well suited for the analysis and design of workflow applications. With this end in view, we have chosen the OSSAD method as a foundation for a specific method for co-operative applications analysis and design. We propose several improvements which consist in an organisational dimension to the models, and an information flow diagram. Within this framework, we propose the use of group-oriented models to describe steps of co-operative work which cannot be represented using a workflow model.

Keywords: Co-operative Work; Workflow; Group-oriented Models.

1. Introduction

Computer Supported Co-operative Work (CSCW) examines the possibilities and effects of technological support for humans involved in collaborative group communication and work processes. Co-operative work techniques become very important in the organisations. We note the emergence of many systems dedicated to develop workflow or groupware applications. However, there is no specific method supporting the development of these applications. Our purpose is to define a co-operative process analysis and design method using several of the concepts involved in groupware design. These are support for synchronous and asynchronous communication, predicted and unpredicted interaction.

We based our argument on existing methods/models for workflow and office automation systems development. We studied them in order to find improvements allowing us to build a co-operative process design method. The present work deals mainly with workflow applications. However, the framework must also allow the integration of co-operative work situations other than workflow.

In the second part, we present briefly workflow and groupware. We note that a number of organisational reasons justify the joint use of workflow and other types of groupware.

In the third part, we present an overview of models for co-operative work. First, we present some existing workflow and process models. Then, we introduce the OSSAD (Office Support System Analysis and Design) method. Finally, we describe group-oriented models which are able to represent communication and conversation procedures between the members of a group: conversation, communication and argumentation models.

The fourth part describes the construction of a method which is suited to the analysis of co-operative work, and particularly to workflow applications design. First, we analyse advantages and drawbacks of the selected method. Then, we propose to add an organisational dimension to models and we define a new model. Finally, we propose the use of group-oriented models introduced in the previous part, in order to represent steps of co-operative work (synchronous or not predefined asynchronous) which could not be represented using workflow models.

2. Computer supported co-operative work

2.1. Definitions

In the co-operative work area, the past decade has witnessed the emergence of many technologies. In addition to electronic mail and server technologies, two other terms have emerged in this area: groupware and workflow.

Groupware is defined in [1] as follows: "*Computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment*". Groupware is a large field that it is advisable to clarify. It seems interesting to divide it in sub-domains. A well-known categorisation is the division into synchronous or asynchronous activity and co-located or distributed activity represented in the Johansen's space/time matrix [2].

Workflow applications focus first on the control of the information flow between various objects in the office with respect to a predefined procedure. The objects could be office workers, database servers, application files, etc. The workflow concerns, at first, an activity of scheduling and coordination of work between implicated actors. *"A workflow management software is a proactive computer system which manages the flow of work among participants, according to a defined procedure consisting a number of tasks"* [3].

In a workflow application, co-operative work means that several persons are involved in reaching a common goal, but each of them acts individually in a different step of the work. Ellis definition specifies that the group work involves a common goal and a shared environment. In fact, if we take a general view of the procedure, there is a common goal to reach by a group of people which share information. According to the definitions of CSCW and groupware, workflow belongs to the CSCW family and is a groupware:

- *"..., workflow systems , and group calendars are key examples of groupware"* [4].
- *"... workflow is a subset of groupware"* [5].

2.2. The organisational justification for the integration of Workflow and Groupware technologies

There are two types of workflow applications [6]. The first concerns "ad-hoc" work processes. They are occasional and little structured. The essential preoccupation with this kind of application is the information and knowledge-sharing in the work group more than the coordination of their tasks: products dedicated to communication, to conversation and to argumentation are needed. On the other hand, most of the workflow products are entirely effective for well-structured and repetitive work processes having important coordination and automation needs. This is the case for office procedures in which file handling (paper documents) from one worker to another constitutes a great part of the activity.

Most groups exist for occasional organisational needs. They are defined for decision meetings, brainstorming or problem solving sessions, etc. These activities, often unpredictable, are not necessarily described as predefined processes of the organisation. They rather correspond to a need coming from one of these processes. In this way, a workflow product allows to connect the ad-hoc work of small groups to a well-structured process, the latter being the initiator of the former as shown in figure 1.

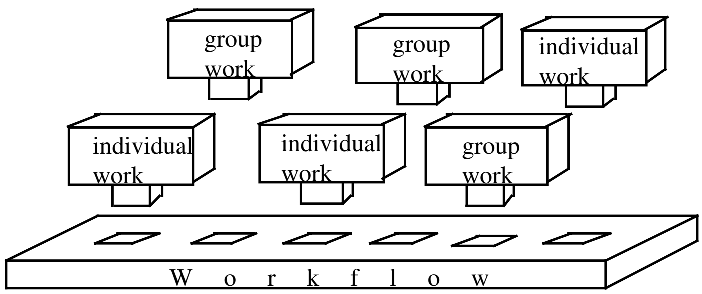

Fig. 1. Integration of ad-hoc group work in a workflow application

Generally, workflow products allow the representation of structured collaboration circuits for which workers may propose a process model. With most of the other groupware, it is a question of defining a personalised model for each case. In this case, we talk about specific or "ad-hoc" work processes.

Group size is an important feature for co-operative work [7]. We can regard the integration of groupware in a workflow application as an integration of small groups carrying out some tasks in a larger group required by the entire process (figure 1). For instance, the result of a well-structured process implemented using a workflow product could be a document collaboratively created in successive steps of (1) subject proposal by any person in the organisation to people having some interest in it (2) brainstorming for all participants and task distribution between the authors, (3) individual drafting by each of them, (4) integration and consistency checking and (5) validation. Let us suppose that the second step is a co-operative activity and requires the use of a synchronous groupware tool by the authors concerned with this redaction. In this step, the brainstorming allows to collect the key ideas that shall be put in the document and to prepare its outline; chapters are distributed to the authors; the principal author who has to integrate and to check the consistency and the reviewers who should validate the document are chosen. This step can also lead to the decision that the redaction is not possible. In the case when it leads to a plan of work and a distribution between authors, the drafting is done by each of the concerned authors using an individual word processing tool (step 3). The integration and checking are realised by the principal author using the same word processing tool during step 4. Finally, the last activity (step 5) requires a synchronous and distributed tool offering vote functions and group oriented editing facilities. The distribution characteristics is required because for some reasons, the reviewers can not meet in the same place. The organisation of meetings in the first and last steps concerns people whose decisions will allow the procedure to continue and/or to end. As we illustrated in this example, workflow applications contain predictable activities, but these activities can be individual (using individual software tools) or collective (using groupware tools) [8, 9].

Workflow and other groupware must give the company the necessary competitive advantages to maintain or to improve its position in the market by responding better and faster to customers [10]. The outcome of a new technology is always the opportunity to wonder about the most appropriate organisation with respect to the existing types of activities, the characteristics of the company and the social factors [11, 12].

3. Overview of models for co-operative work

3.1. Workflow models

Each workflow product proposes its own model to graphically represent procedures. Models are numerous but there are a few theoretical studies on which they are founded. Two types distinguish themselves: a) models coming from Petri nets (for instance, ICN), b) models coming from the Speech Act Theory (for instance, Action Workflow).

The ICN model (Information Control Net) was developed in the Palo Alto Research Center in the seventies [13]. An information control net is a set of procedures, steps, activities, roles, and actors with a valid set of relations between these entities. Relations include the *precedence* relation between steps; the *part-of* relation between activities and procedures; the *executor of* relation between activities and roles; and the *player of* relation between roles and actors. A procedure is a set of activities linked by *precedence* relationship. The ICN model allows the choice of the abstraction level in the representation and the building of a complex procedure by successive refinements. Alternative, parallelism and loop structures are used to describe procedures. The extended ICN model presented in [14] incorporates the notions of goal and unstructured activity.

In the Inconcert workflow model [15], a *job* represents a collaborative activity. A job consists of *tasks*, each of which is a unit of work that can be performed by one person. Tasks can be decomposed into sub-tasks, to obtain a hierarchical breakdown structure. Tasks at the same level may have ordering dependencies defined among them: a dependent task cannot be worked on until the precedent task has been completed.

VPL [16] is a graphical language to support a model for collaborative work processes. According to this model, work is decomposed into a network of requests for task assignments, which may be recursively decomposed to finer grained tasks. The process is modelled as requests for tasks. Stages represent the communications needed to co-ordinate tasks. Each stage represents a task request, commitment or question as a specific step in the process. A stage is a request from one person (the plan owner) to another person. The request may be expressed in any amount of detail; it is not constrained to a set of predefined tasks. This represents the Regatta philosophy of supporting communications without restriction [16].

The Action Workflow [17] comes from Winograd's and Flores research aiming to study group work in relation to conversation, negotiation and decision making activities. Some conclusions of Speech Act Theory [18] have been used. The model uses a simple structure: it considers a task as a communication relationship between two participants, a *customer* and a *performer*. A task is represented as a loop composed of four phases: preparation, negotiation, performance and acceptance. The process model is built by successive refinements.

All these models have some common characteristics. They use a top-down approach which enables the choice of the abstraction level of the representation and the modelling of a complex process by successive refinements. They have the same finality: to divide a process into a finite number of stages and to describe their flow.

3.2. Process modelling

The I^* framework [19] has been developed to help supporting process modelling and reengineering. Processes are taken to involve social actors who depend on each other for goals to be achieved, tasks to be performed, and resources to be furnished. The framework includes a Strategic Dependency model and a Strategic Rationale model. The Strategic Dependency model describes the network of relationships among actors. The Strategic Rationale model describes and supports the reasoning that each actor has about its relationships with other actors. It shows "how" an actor meets its incoming dependencies or internal goals and desires by modelling actor's "ways of doing things" which are called *tasks*. A task is broken down into its components. Components are broken into sub-components, and so forth. The Strategic Rationale model recognises the presence of freedom and choice at each level of decomposition.

In [20] and [21], a meta-model is proposed as a basis for process model definition. Since a process meta-model carries information about the process model, an instantiation of it shall result in a process model. The meta-model can support different levels of granularity in decision making as well as non determinism in process performance. It identifies a decision in context as the basic building block of ways-of-working and permits their grouping into meaningful modules. Parallelism of decisions and ordering constraints are also supported. The co-operative process meta-model provides means to deal with secure and rather well-structured work processes and provides the flexibility to handle ill-structured co-operative processes. It allows us to represent co-operative work processes; to integrate conversations between agents; to guide and keep track of what happened in co-operative brainstorming sessions; to model the emergence of new contexts; all these being made in an homogeneous manner. The co-operative process meta-model allows us to deal with many different situations in a flexible, decision-oriented manner.

3.3. OSSAD

The information systems design methods in general use are data structuration and process automation oriented; organisational aspects are considered by fragments. These findings lead us to search among less common methods. In this way, we find the OSSAD method which is work organisation (rather than data organisation and treatment automation) oriented.

The OSSAD method (Office Support System Analysis and Design) [22, 23] has been developed within the context of an ESPRIT project whose aim was to find appropriate methods for the development of office automation systems. OSSAD is primarily concerned with the organisational functioning. It's aim is to conduct changes in the office, taking advantages of reorganisation opportunity offered by new technology. Computer science and office automation are considered as tools which assist the individual task. OSSAD proposes two levels of modelling: the abstract and the descriptive ones.

The abstract level aims to represent the organisation from the point of view of its objectives disregarding currently-used resources. The descriptive level aims to represent current or future realisation conditions in accordance with objectives expressed in the abstract level. It takes into account organisational (organisation choices, responsibility sharing, information flow), human (arrangement of workers in different departments) and technical (tools) means.

The approach is the following: analyse the current situation and design scripts of improvement. The development phase of the chosen solution is not realised in OSSAD and requires the use of another method like Merise [24, 25, 26].

Let us take an example to illustrate the construction of the abstract and the descriptive models: A client requests a loan. A clerk prepares documents for this request, and if the requested amount is greater than 10 000 $, sends them to the service director who will define the conditions for the loan. Then the clerk prepares the elements for the answer; the loan service assistant writes the offer and sends it to the client. The loan service director is responsible of the entire work process and has a global view of it. The bank undertakes that an answer will be sent to the client 2 weeks after the loan being requested.

3.3.1. The abstract model

It deals with objectives, trying to represent what must be done and why. It answers the questions: "Which objectives must be satisfied?" and "What is required for that?" disregarding the current solution. It definitively defines stable and durable characteristics of the analysed system that any organisation choice must respect. It is a framework for the construction of descriptive models. The abstract model is based on the division of the organisation into *functions*, in other words into *sub-systems* having coherent objectives. Each function may be divided into *sub-functions,* each subdivisable: this is the "zoom" principle. At the most detailed level of the analysis, functions not subdivided are called *activities*. An activity has only one objective. These sub-systems communicate with each other and with the environment exchanging information *packages* (disregarding their physical support).

Figure 2 shows the abstract model for the previous example. Rectangles represent functions and ellipses represent information packages. A star indicates an external function. This figure illustrates two activities: "to evaluate the loan request" and "to realise the loan". The first activity aims to find the most appropriate agreement between the client and the bank. The objective of the latter is to give the requested amount to the client after all necessary safety controls being realised.

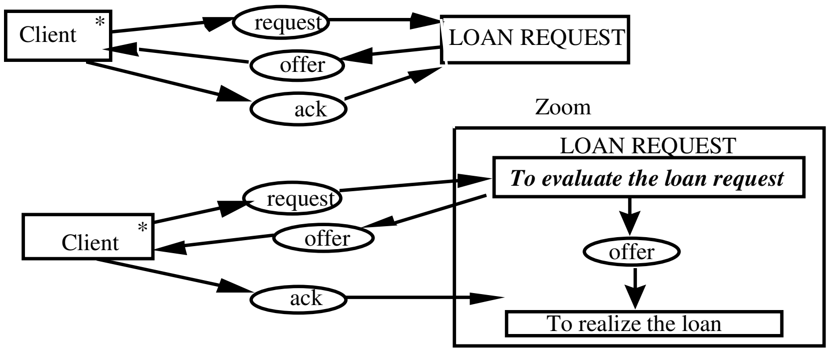

Fig. 2. Example of abstract model

3.3.2. The activity/role matrix

The link between abstract and descriptive levels is made by the activity/role matrix. Rows correspond to activities (abstract concept) and columns to roles (descriptive concept). A role is the definition of an organisational intention shared by a collection of users, all of whom have the same privileges and obligations to a set of work processes in an organisation. For example, the role of a reservation service clerk, that of an accounts officer, etc. For each activity, roles which participate by executing a task (a cross in the matrix corresponds to a task) must be indicated. Each activity of the abstract level corresponds to a procedure in the descriptive level.

Figure 3 shows the corresponding activity/role matrix for the loan request example. Rows correspond to activities and columns to roles for the "loan request" function. A star indicates an external role. In the following, we will illustrate only the first procedure : "to evaluate the loan request".

	Client *	Loan service assistant	Loan service clerk	Loan service director	Account service clerk
To evaluate the loan request	X	X	X	X	
To realize the loan	X		X	X	X

Fig. 3. Example of activity/role matrix

3.3.3. Descriptive models

The descriptive level contains different models describing procedures under different aspects. These models deal with the organisational, human and technical means implemented to reach the objectives of the organisation. They represent the way the work is done currently or will be done in the future. They respond to the question "Who does what?". The representation level is the procedural one.

• ***The roles descriptive model*** shows the current organisational structure chosen by the company (or the one which is proposed) to carry out its activities. It uses concepts of *role*, *unit* and *resource*. A unit represents a set of roles assembled for the convenience of modelling. This can correspond to an administrative unit of the analysed organisation or to a work group created for an occasional organisational need such as decision meetings or brainstorming. Information exchanged between roles, external roles (illustrated by a star) and/or units appear as resources. Figure 4 shows the roles descriptive model for the previous example.

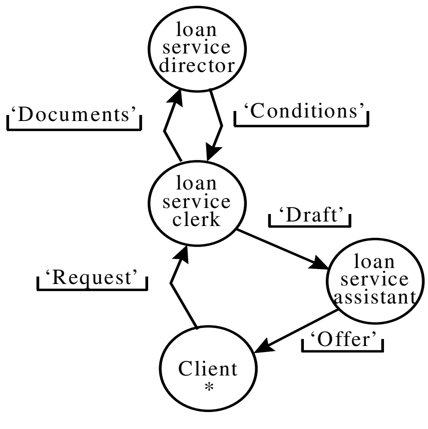

Fig. 4. Example of OSSAD's roles descriptive model for the procedure "to manage the loan request"

• ***The procedures descriptive model*** shows the functioning of the organisation, in other words, the current or future work organisation. It uses procedure and resource concepts. This model provides a global view of relationships between procedures. It also shows resources which are not represented in the other models.

• ***The operations descriptive model*** makes the dynamics of the organisation explicit. It provides the detail corresponding to a procedure. It shows who does what and in which order, in other words, it represents the work distribution between roles. Figure 5 shows the operations descriptive model for our example.

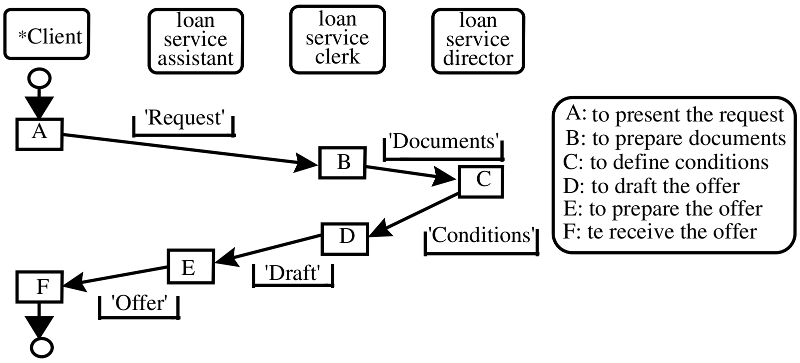

Fig. 5. Example of OSSAD's operations descriptive model

A different column is attributed to each concerned role. Operations carried out by roles are described in the corresponding columns. Operations placed in the same column constitute the task -in the OSSAD sense of the term- carried out by the concerned role. This model uses a formalism similar to Petri nets. In addition to the order relationship between operations, the formalism allows three possibilities of operation flow: parallelism, alternative and loop.

Certain operations of a procedure may be gathered together (horizontally or vertically) to make *macro-operations*. This gives a simpler general view. Afterwards, each macro-operation can be detailed in another diagram. The horizontal macro-operation concept enables us to represent a co-operation. Roles can perform operations without simultaneous presence or using a synchronous communication between co-operating actors (figure 11, § 4.4).

Resources (information) and tools which are necessary to the execution of the operation can also be represented on this diagram. To model in detail resources required by an operation (resources, tools, starting conditions, management rules applied to the operation), OSSAD provides the operation detail diagram.

3.4. Three models for representing group activities - Some extension propositions

3.4.1. Conversation models

Many technologies for co-operative work appeared, requiring formal models to represent conversations. These models are based on the speech act theory, and consequently on the principle that each sentence expressed by someone represents an intention, a commitment. The speech act theory is a kind of conversational analysis [27, 28]. The basis of the theory says that an elocution is characterised by the action that it evokes. Each conversation is supported by the participants' actions. The transmitter acts and asks to the receiver to do something for him/her. The conversation is built from a set of individual acts.

The action-coordination systems are based on a theory of the language developed by Flores and Winograd [18]. This theory supposes that when you talk or write a sentence you execute speech acts which have consequences on your own future action and on the actions of people to whom you speak. When traditional language theories show how words transmit information, the speech acts theory shows how expressions are connected to future possibilities and consequences.

The Action model [17] is amongst action-coordination systems. It defines a structure to represent the conversation relationship between two participants: a customer and a performer. The commitments are contained within these structures which can be depicted as ellipses divided into four phases of interaction: preparation, agreement, performance and acceptance.

This representation gives a general view of conversations between roles implicated in a group work. It must concern a limited number of exchanges, otherwise the model becomes rapidly illegible. The ellipse structure can help to understand the work process. Optimisation possibilities can also be considered. In fact, highlighting the organisational reasons which cause the communications between some roles can justify changes of procedures.

3.4.2. Communication models

The representation of communications consists in describing groups of people participating in the network and the reasons for their communication with each other. Communication links can be durable as in a project team or short-lived as for occasional meetings. These models allow the company representation in terms of the treatments and the resources, and provide an opportunity to reconsider current organisation in its weak points. They provide a way to describe information flow in the organisation as well as between organisations. These descriptions pinpoint critical communications, bottlenecks, risks of flow overloading and places where coordination must be improved using advanced communication techniques.

The network analysis approach in order to model communications caught our attention. This approach is based on graph theory with nodes representing the network participants and links representing the information flow. The analysis of a communication network involves the relationships between network members and the frequency and density of the communications. Exchanges between individuals participating to the communication network are represented using a matrix notation. The rows and the columns of the matrix are network members. A matrix element shows if the network member represented by the current row communicates with the network member represented by the current column.

We propose the following extensions for these models. When a person tries to communicate with another one: is the communication ending or not, sometimes or always, when it happens (predictable or not), for which duration, which reason and which content? According to the types of communication, the network has to be implemented in different ways. This kind of representation requires weighting each link in two directions.

In addition, characteristics of these links must be represented. We propose to use the communication matrix extended with the characteristics which have been introduced by J. Grudin. The notion of unpredictable place (or role), for the transmission as well as for the reception, enables us to apply one of the dimensions of Grudin's matrix (predictable or unpredictable different place) [29]. In the same way, a distinction for the time enables us to complete the lines of the communication matrix.

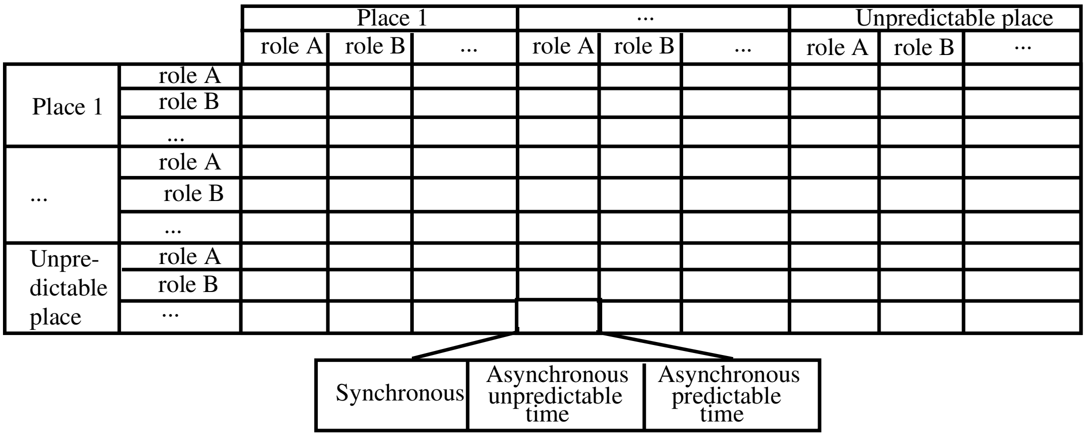

Fig. 6. The use of the Grudin's 3x3 matrix in communications modelling

The communication matrix shown in figure 6, describes which technologies must be implemented according to existing communications or future objectives. It can be used to represent the company's minimal communication architecture. Density calculation applied to the matrix cases enables us to make a choice for priorities and to control the relevance of each communication. The process is the following. First, all cells of the matrix are filled with a value reflecting the importance of communication between the two involved roles. Second, a threshold is chosen for differentiating between essential and less important communications. Third, based on the threshold, the matrix is updated : a cell having a value grater (respectively smaller) than the threshold receive a 1 (respectively 0). Links of type 1 imply a communication need between two roles. The weighting can also be used. For example, different kinds of link (absolute need, important, weak need, no need) could be represented according to the density value.

3.4.3. Argumentation models

Argumentation models are based on the representation of an argumentation for problem solving. The approach considers that any exchange results from a problem submitted to a group. Each participant brings his/her solutions and a set of arguments which constitute the exchange. When some person makes a choice, the choice corresponds to a rational reasoning which can be explained. It is necessary to show options which have been chosen as well as those which have been rejected. The design rationale is based on the following principle: To understand the reasoning of the result obtained, one should understand how it could be different and why the choices made are appropriate [30].

Methods based on the argumentation approach provide an explanation facility for the problem solving process [31]. The conception space consists of a decision space corresponding to a set of possible options (alternatives) for a question and an evaluation space with explicit criteria allowing to choose an option rather than other options. Each node in the representation corresponds to a category describing specific information. The use of different types of links with different meanings (C validates O, C rejects O, O responds to Q, Q is suggested by C, …) seems also interesting to us.

Argumentation models seem well adapted to the representation of design activities. For instance, the IBIS method allows to memorise the path leading to a decision or a set of actions using the question-option-criterion model [31, 32]. This method structures the objectives, the related questions, the arguments and the given responses.

An argumentation model provides a shared information oriented framework and enables us to construct a group memory. This approach gives an overall view of communications by specifying both the adopted solutions and the logical progress during the problem solving. It constitutes an aid to problem solving: that means you can express several possibilities, compare them and choose the better ones. These models could be used as tools favouring the complementarity of team members. They allow us to trace the decision making [33] in a structured manner and increase the motivation and the implication of each member.

4. A method for co-operative work processes analysis and design

Our purpose is to obtain a method appropriate to the analysis and design of any group work by using at best the existing ones. In this section, we present first OSSAD's features which are suited to the analysis of co-operative work processes. Then, we propose improvements in order to build an appropriate method, allowing the analysis and design of co-operative applications, and particularly workflow applications [9, 34].

4.1. OSSAD's advantages according to workflow applications needs

OSSAD is founded on a systemic approach. That concerns the study of sub-systems which communicate with the others, but which are relatively autonomous. The system's objectives are more important than its functioning. This is one of the essential principles of Business Process Reengineering [12, 35]. The approach requires a general analysis in order to examine why things are difficult for the actors. Then, successive refinements are performed in order to go deeper into these points until the desired detail level is reached. That corresponds to the top-down analysis which is suitable for workflow applications development.

Workflow applications produce changes in work organisation, and they are not always easily accepted by the users. OSSAD allows users to participate in the analysis of the existing situation. They may also suggest solutions in order to resolve current problems. When final users participate in the analysis, the solution is more easily accepted. Workflow applications need also a strict modelling of procedures. OSSAD's simple formalism facilitates an effective validation of procedure models in order to avoid failures during the execution.

The representation of a company with OSSAD's concepts leads to the modelling of procedures using a formalism like Petri nets. This formalism provides a powerful description for every type of task flow which can be implemented using a workflow product. Thanks to the macro-operation concept, OSSAD also offers the possibility of highlighting the work steps which must be performed by several actors (Cupertino). The macro-operation is the most detailed modelling level allowed by OSSAD for representing synchronous and not predefined asynchronous Cupertino. In section 4.4, we propose to integrate at this level some group work models in order to represent ad-hoc group activities.

4.2. Improvements

We argued in the previous section that OSSAD, to a great extent, responds to workflow application development needs. However, there are many points, important in these applications, that this method does not allow to model.

4.2.1. An organisational dimension: customer/performer relationship

OSSAD does not allow us to represent the relationship existing between the person which requires some work and the person which performs it. The customer/performer relationship underlying the Action Workflow model [17] describes the existing organisation.

In the Regatta project [16], an interesting representation of this relationship was proposed. The representation is founded on the principle of responsibility and a subdivision mechanism. A task is divided up when the assigned role asks other roles to perform more elementary tasks. The results of these tasks will constitute the result expected by the initial task. The role which is assigned to the task T is responsible for the tasks coming from the division of T.

The advantages of this modelisation principle are many-fold: a) It allows an organisational division instead of a functional one. Problems due to the organisation (a lot of delegation) are better detected; b) Each diagram corresponds to the view a person has on the work for which he/she is responsible. So, he/she is the most appropriate person to validate its representation and even to define it; c) During the modelisation, we can take into account the functions that workflow products offer. For example, when a task execution sets a problem (not executed within the agreed time…), the system can warn the responsible for the concerned division level in the procedure; indeed, he/she is the most appropriate person to decide.

In order to represent the customer/performer relationship dimension of co-operative work, we propose two variants, respectively, for the roles descriptive model and the operations descriptive model (section 4.3.1).

4.2.2. Information flow understanding

There is a second need for which OSSAD does not have appropriate models: it concerns the information flow and the representation of tools which handle them. There is a gap between the operations descriptive model which describes who does what and in which order and the operation detail diagram which defines data and tools used in the operation. Where do they come from? Where are they going?

Workflow products allow a significant time saving on the information flow (documents, forms,…). But, with this end in view, we have to analyse the flow before proposing improvements. In the case of reengineering purpose, it is important to know the exact role of each document and to detect if each created document is really used.

We propose the use of information flow diagrams (section 4.3.2).

4.3. Extensions to OSSAD and a case study using the improved method

We use OSSAD's adaptability feature [22] to build a method more specifically appropriate to workflow applications development. We adopt the existing models and propose to complete the roles descriptive model and the operations descriptive model using the organisational dimension (section 4.3.1). Then, we propose a new model: the information flow diagram (section 4.3.2).

In this section, we use the example introduced in section 3.3 where the abstract model and the activity/role matrix are presented. In the following, we only illustrate the extensions that we propose on the procedure "to evaluate the loan request".

4.3.1. Descriptive models

We illustrate the roles descriptive model and the operations descriptive model with the proposed improvements.

• ***The roles descriptive model***

This model shows information exchanged between different roles which take part in the procedure. OSSAD's roles descriptive models has two principal weaknesses: non-indication of the order in which exchanges are performed and the organisation which justifies them. We bring two new dimensions to the model: a chronological dimension and an organisational one.

We call organisational the dimension which emphasises different responsibility levels in a procedure. In order to represent this dimension, we define plans in the roles descriptive model. A plan is a part of the model containing a responsible role, roles with which he/she communicates (vertical flow), and other roles with which he/she does not communicate directly but which uses or produces intermediate resources for the result that he/she needs (horizontal flow). A plan represents:

• resources that the responsible for a plan communicates to the other roles allowing them to perform the work that he/she needs: descending vertical flow,

• resources which are exchanged between roles (other than the responsible for this plan) in order to perform the expected work: horizontal flow,

• resources that the other roles communicate to the responsible and which constitute the result of their work: ascending flow.

Each role in a plan (other than the responsible for this plan) can in its turn become responsible for another plan. We describe the communication flow between roles by dividing responsibility levels. We have three rules concerning this division:

• rule 1 : all flow in a plan is chronologically subsequent to the flow which is received by the responsible for the plan from a greater responsibility plan,

• rule 2 : all flow in a plan is chronologically prior to the flow which is sent by the responsible for this plan to a greater responsibility plan,

• rule 3 : there are no other resource exchanges between plans.

Henceforth, on the roles descriptive model: the vertical axis allows the representation of different responsibility levels (from top to bottom to express decreasing responsibility); the time passes horizontally from the left to right, but also vertically following the communication flow directions. Figure 4 (§ 3.3.3) has presented the OSSAD's roles descriptive model corresponding to the example. Figure 7 illustrates how we represent it when integrating responsibility and time dimensions.

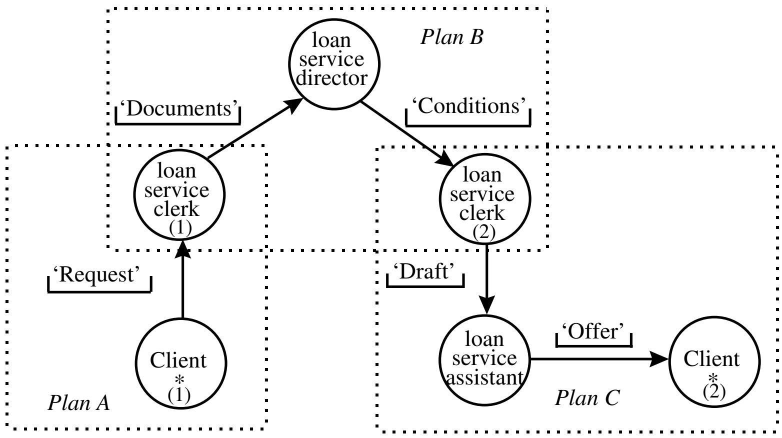

Fig. 7. Example of improved roles descriptive model for the procedure "to manage the loan request"

The information which is given in figure 7 and which figure 4 lacks is the following:

1) the order in which the flows are connected;

2) the fact that the loan service director manages the procedure and that he orders the clerk:

a) to provide him with the documents concerning the loan,

b) to supervise the sent of the loan offer to the client when he defines the conditions.

Each plan corresponds to the view of a role on the work that he/she is responsible. Plan B corresponds to the loan service director's responsibility on the procedure, plan A and plan C correspond respectively to the clerk's responsibilities for preparing the loan request and for passing the offer. The respect for the division rules led us to mark the role names when they must appear several times (client and loan service clerk).

We emphasise that this kind of model provides a general idea about the chronology. The fact that some information flow can be simultaneous is not represented. As a matter of fact, the objective of the model consists in finding responsibility levels in the procedure and in defining communication flow which is required for the performance of the work at each responsibility level.

• ***The operations descriptive model***

This model describes (for each procedure) the order in which operations are executed and the assigned roles. The model is built by successive refinements breaking down macro-operations into operations (and/or macro-operations). OSSAD does not propose anything to guide this breakdown.

We propose to breakdown an operation only when the assigned role asks to others to perform more elementary operations. The global result will be the result of the initial operation. The role assigned to the macro-operation becomes responsible for the operations which are obtained by breakdown. Figure 5 (§ 3.3.3) has presented the operations descriptive model corresponding to the example. Figure 8 shows the same procedure using the breakdown rule that we have defined.

According to this rule, there can be only two types of macro-operations:

• macro-operations assigned to a unique role: they are built using the breakdown principle,

• macro-operations containing several roles: they represent a co-operation (synchronous and/or asynchronous) between roles. Some types of co-operation (synchronous or not predefined asynchronous) cannot be more detailed using operations descriptive models. In paragraph 4.4, we propose the use of group-oriented models.

We have created two macro-operations. The loan service clerk is responsible for both of them. On account of clarity, we identify alphabetically the macro-operations and the operations with respect to their breakdown level and execution order (figure 8).

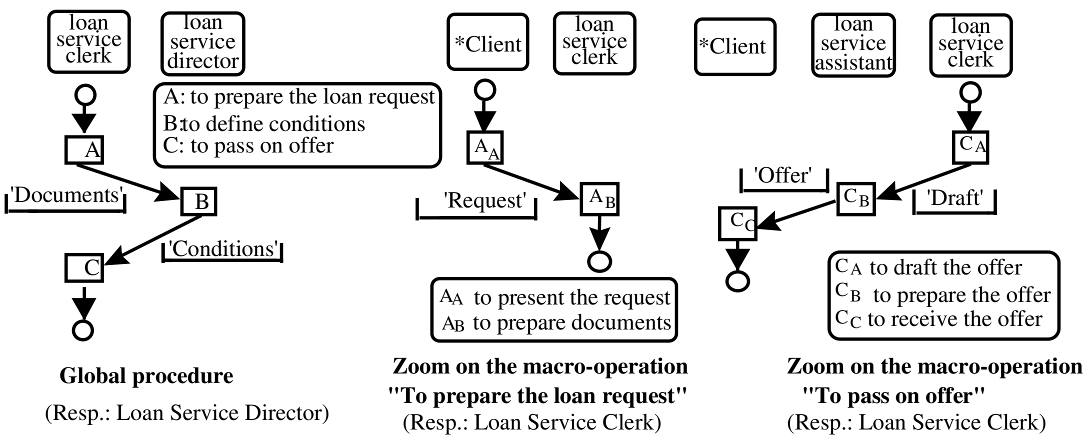

Fig. 8. Example of improved operations descriptive model

The operations descriptive model includes a set of diagrams. Each of them corresponds to a macro-operation breakdown (the procedure can also be shown as a macro-operation). There is only one responsible for the diagram which represents the view of this person on the work for which he/she is responsible. It is advisable to indicate the responsible role on each diagram as shown in figure 8.

4.3.2. The information flow diagram

The model that we have chosen comes from the CORIG method [36]. It represents a procedure as a set of operations, and between them information (documents) flows. The principles of representation are as follows:

- each column represents a place involved in the procedure (actor, role, service…)
- time passes vertically from top to bottom,
- the circulation of documents is represented using broken lines which can be horizontal (change of place) and vertical (time).

The list of the document and tool symbols used in this model is not exhaustive: it is possible to add symbols corresponding to needs (figure 9). A document symbol is mentioned only once, when it appears the first time.

The information flow diagram of CORIG can easily be adapted to the operations descriptive model:

- the columns representing different places in the information flow diagram correspond to the columns representing roles in the OSSAD's operations descriptive model,
- the flow diagram operations correspond to the (macro-)operations in the OSSAD's operations descriptive model.
- the document symbols correspond to OSSAD's resources,
- the tool symbols correspond to OSSAD's tools.

As discussed in section 4.2.2, there is a gap between the operations descriptive model which describes who does what and in which order and the operation detail diagram which defines data and tools used in the operation. The information flow analysis, by highlighting the exact role of each resource (information, document, …), could suggest some improvements for the analysed work process or could detect some anomalies (for instance, a document is created but never used).

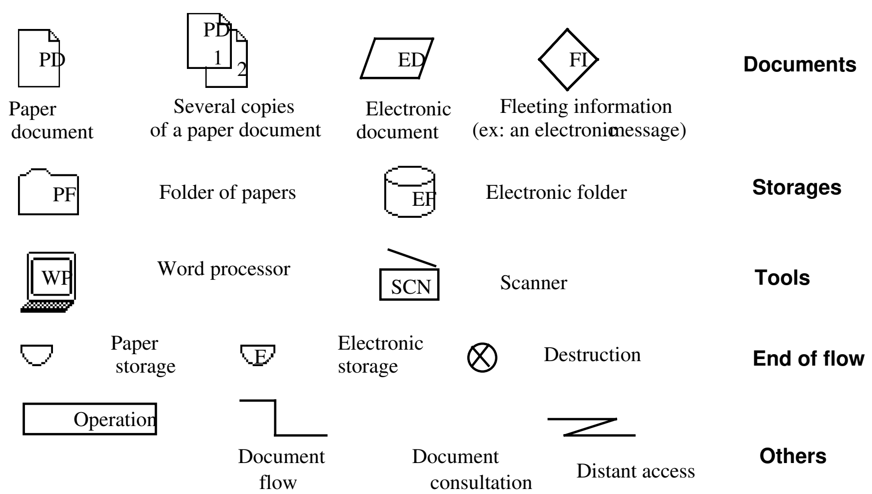

Fig. 9. Document and tool symbols used in the information flow diagram

We construct an information flow diagram for each operations descriptive model. Figure 10 shows this principle. The construction of the information flow diagrams is similar to the construction of the operations descriptive model diagrams: each diagram is broken-down into other ones using macro-operations.

In figure 10, the diagram entitled "global procedure" represents the procedure "to evaluate the loan request". The clerk has to send the documents (DOC) to the director in order to allow him/her to establish conditions (CO) that the clerk needs. The second diagram makes a zoom on the macro-operation "to prepare the loan request". The clerk prepares documents according to the loan request. The last diagram illustrates the macro-operation "to pass on offer". The clerk prepares the offer according to the conditions established by the director, the loan service assistant writes the offer letter and sends it to the client.

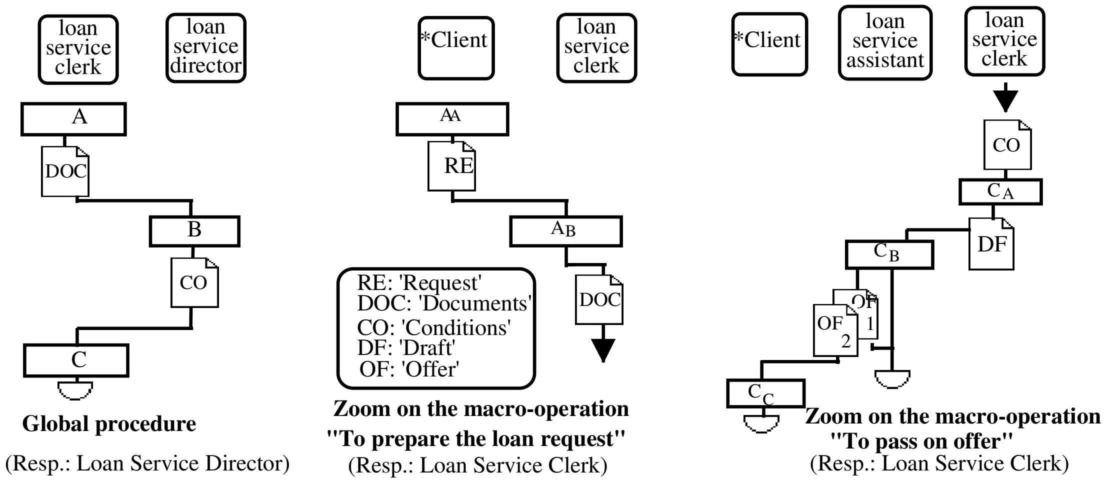

Fig. 10. Example of flow diagram adapted to OSSAD

This breakdown into sub-diagrams poses a graphical representation problem in the following cases: a) a document which is used in the diagram has its origin outside the diagram; b) the end of flow of a document which is used in the diagram is outside the diagram.

We created two symbols to indicate the imaginary origin and the imaginary end of flow:

- an imaginary origin is represented with an arrow preceding the document symbol. In the diagram which shows the zoom on the macro-operation "to pass on offer", the origin of the document "CO" is outside this diagram.
- an imaginary end is represented with an arrow following the end of flow of the document in the current diagram, when the real end of flow of the document is outside this diagram. In the diagram which shows the zoom on the macro-operation "to prepare the loan request", the end of flow of the document "DOC" is outside the diagram.

4.3.3. Some guidelines for the use of the presented models

The OSSAD method with the proposed extensions offers a descending modelling approach based on the breakdown principle.

At the abstract level, the breakdown is based on the objectives of the analysed system. This stage is crucial for workflow application analysis but not easy to bring into operation. Indeed, people are inclined to observe the company organisation chart in order to determine functions and sub-functions. Consequently, we must take care at this modelisation stage which constitutes the foundation for the descriptive models construction.

For the descriptive models, we propose a breakdown using the responsibility levels. This stage leads the modelisation up to operations. Our aim is to obtain models corresponding to the view of the users on the work for which they are responsible. For each represented flow, besides its origin and its destination, the responsible for this flow must also be known. The following questions can be helpful: Who imposes this flow? Who must be advised in the case of breakdown of the flow? …

The organisational dimension that we added to OSSAD provides a guide for the modelisation at the descriptive level. It particularly enables us to bring to the fore the tasks which exist only because of the current organisation (verifications, validations…) and which can be suppressed when they have no real value. The organisational dimension also allows better detection of any dysfunctioning due to the work organisation. It constitutes an important discussion basis for a reengineering activity.

Information flow diagrams bring indications about the circulation of documents and particularly rigour to the modelisation. They require the definition of the origin, the destination and the nature for each document which is used during an operation. Each document must have an origin and an end of flow. This implies a fineness of the analysis which was not required for the construction of operations descriptive models.

4.4. The use of macro-operations and group-oriented models for the workflow/groupware integration

As we have seen in section 2.2, workflow can be the thread of applications running with individual software tools or groupware tools. The integration of groupware products in a workflow application can be seen as an integration of small groups carrying out ill-structured collective tasks in a larger group processing a globally well-structured procedure.

On the other hand, the formalism used in the OSSAD's operations descriptive model provides a powerful description for task flow which can be implemented using a workflow product. The horizontal macro-operation concept offers the possibility of highlighting the procedure steps which must be performed by several actors, and by this way, enables us to represent a co-operation (see section 3.3.3). When two or several roles act in the same macro-operation, squares representing operations are included in a rectangle representing the macro-operation. This corresponds to a horizontal macro-operation representing a co-operation (figure 11). Such a co-operation can be asynchronous or synchronous. In the first case, there are exchanges between several roles without simultaneous presence. If exchanges are predefined, they can be described in another diagram which details the macro-operation. In the second case, the co-operation requires simultaneous presence of actors and cannot be more detailed.

Fig. 11. Graphical representation of a horizontal macro-operation

The macro-operation constitutes the most detailed modelling level that OSSAD can represent when the co-operation is asynchronous ad-hoc or synchronous. Indeed, for this type of co-operation one could not define models in terms of partially ordered tasks (section 3.1).

Consequently, it seems necessary to have models which are able to represent communication and conversation activities, in other words ad-hoc co-operative activities, between members of a group [37]. This type of co-operative work can be in fact supported using groupware tools. Then communication, coordination and argumentation models seem relevant to us (section 3.4) in order to deal with *some* aspects of the group work.

Figure 12 shows our understanding of the integration of groupware products in workflow applications. The purpose of the models which are introduced in section 3.4 is to represent the communication, coordination and argumentation aspects of the co-operative work. They do not constitute an exhaustive list of the group work characteristics. They are only the ones which seemed significant to us in a first approach of groupware/workflow integration.

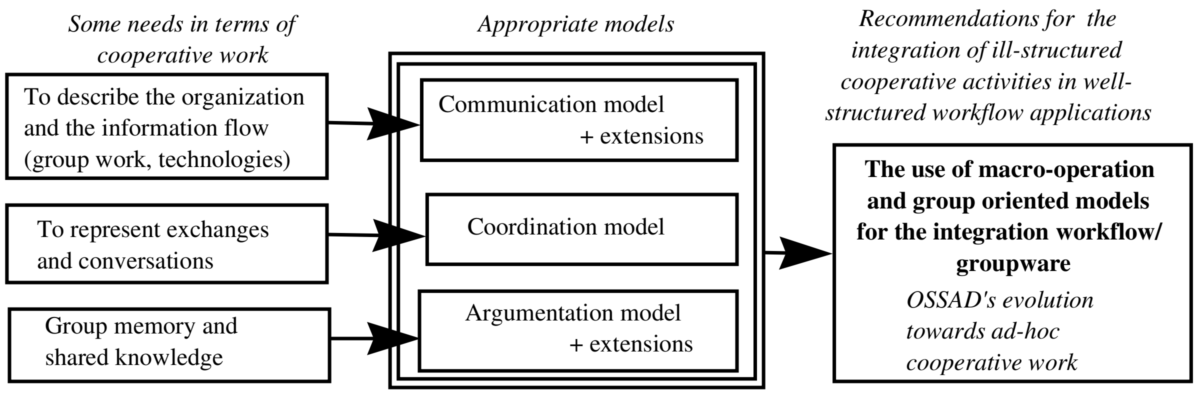

Fig. 12. Integration of groupware with workflow applications

We propose a stage giving first greater importance to communication by the use of a relatively technical representation of the communication networks which support the exchanges. This stage allows us to find a compromise solution between real needs and existing technologies. Coordination-oriented models like Action will allow the representation of exchanges between members of a team [17, 18]. Finally, an argumentation model will provide a tool which is shared information (i.e. group memory) oriented [27,28]. Each model could be used to get on to a particular class of group applications having characteristics which justify representations to be chosen [37].

Group-oriented models are integrated to this framework at the level of the OSSAD's macro-operation (figure 12). In fact, a co-operation which is represented by an horizontal macro-operation and which cannot be more detailed in terms of flow of tasks, requires the use of group-oriented models. An example of the integration of these models in the extended OSSAD method is given in [9].

5. Conclusion

We built a method, appropriate for group work analysis, and particularly well suited for the analysis and design of workflow applications. With this end in view, we proposed some improvements to the OSSAD model at the descriptive level consisting in:

- adding a new organisational dimension to descriptive models,
- defining an information flow diagram, in order to bring indications about the circulation of documents and particularly rigour to the modelisation,
- proposing group-oriented models at the level of the horizontal macro-operations.

For ill-structured co-operative activities which cannot be represented in terms of flow of tasks, the horizontal macro-operation constitutes the most detailed modelling level that OSSAD allows us to obtain. We integrated in this framework models allowing us to represent this type of co-operative work. We proposed the use of different group-oriented models in order to describe synchronous or not predefined asynchronous corporations. The use of communication models enables us to represent the communication network to forecast in priority with respect to the current situation and the expressed needs. The representation of the conversation between roles allows a new approach of the organisation considering it as a transition of conversations. Argumentation models enable us to construct the necessary shared memory for work groups.

Co-operative work tools can be instrumental in reaching quality requirements which are defined in the ISO 9000 standard [10]. Our aim is to take into account these requirements during the conception stage and to improve the method in this way.

Workflow application developments are often preceded by a business process reengineering stage [38]. The improvement of the method in order to guide the BPR activity seems also necessary.

Our future work consists first in defining the ways-of-working describing the design processes underlying the methodology presented in this paper. The definition of these design processes will be done following the process meta-model (§ 3.2) developed within the context of the ESPRIT project NATURE [39, 40, 41]. Their enactment will be performed within the MENTOR guidance engine [42, 43]. Therefore, enacting the ways-of-working will support the design of co-operative work processes.

The next step will consist in validating our methodology, using the MENTOR tool with the ways-of-working we just mentioned, on a real case study that we currently perform within the context of the ESPRIT project ELEKTRA [44]. In this project, we describe co-operative processes that take place in the distribution section of a European electricity company [45]. Therefore, we will be able to demonstrate the power and effectiveness of our methodology putting forward the complementarity of the different view points of the stakeholders. This will be reported in a future research paper.

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FIGURE LEGENDS

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Figure 1

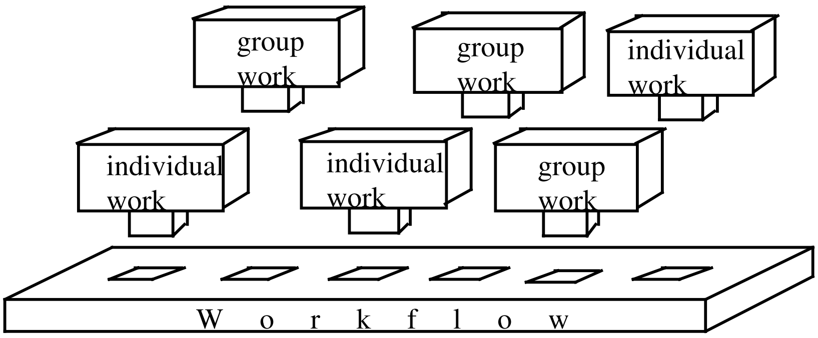

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Figure 2

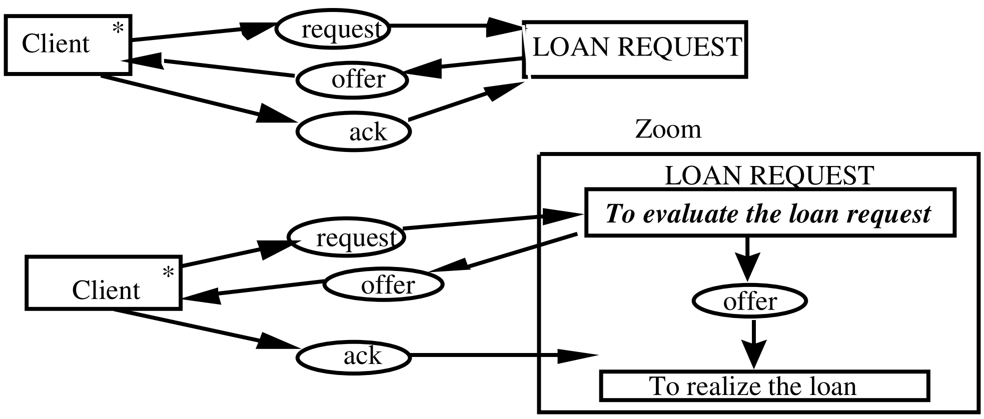

Figure 3

	Client*	Loan service assistant	Loan service clerk	Loan service director	Account service clerk
To evaluate the loan request	X	X	X	X	
To realize the loan	X		X	X	X

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Figure 4

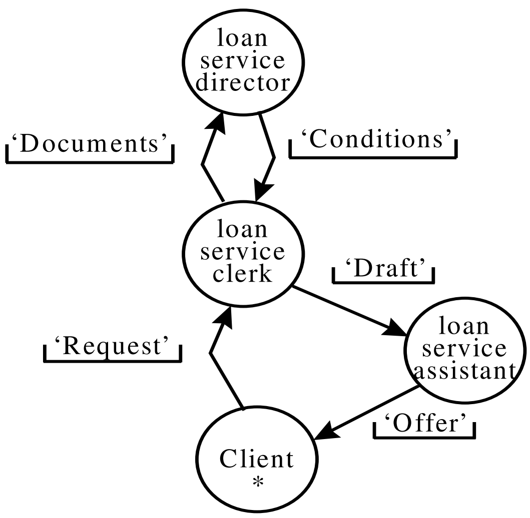


Figure 5

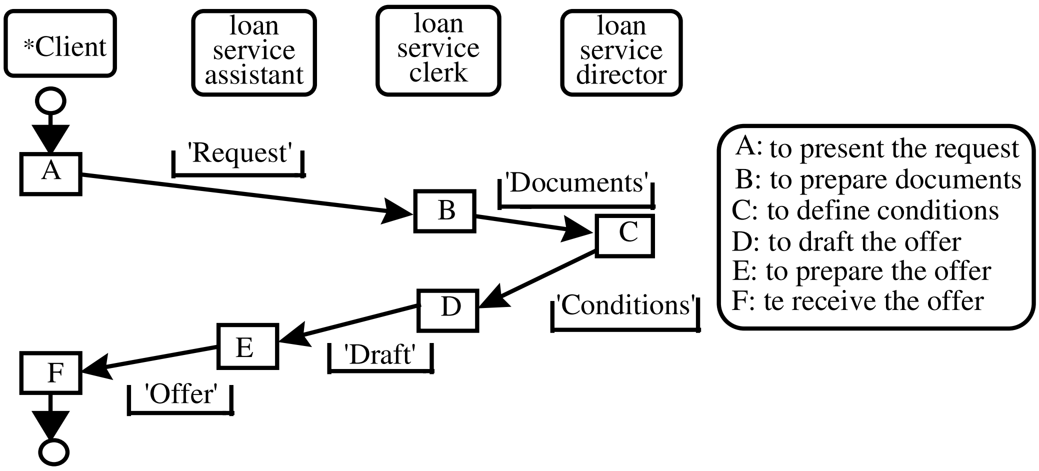

*Client
loan service assistant
loan service clerk
loan service director
A
'Request'
B
'Documents'
C
D
'Conditions'
E
'Draft'
F
'Offer'
A: to present the request
B: to prepare documents
C: to define conditions
D: to draft the offer
E: to prepare the offer
F: te receive the offer

Figure 6

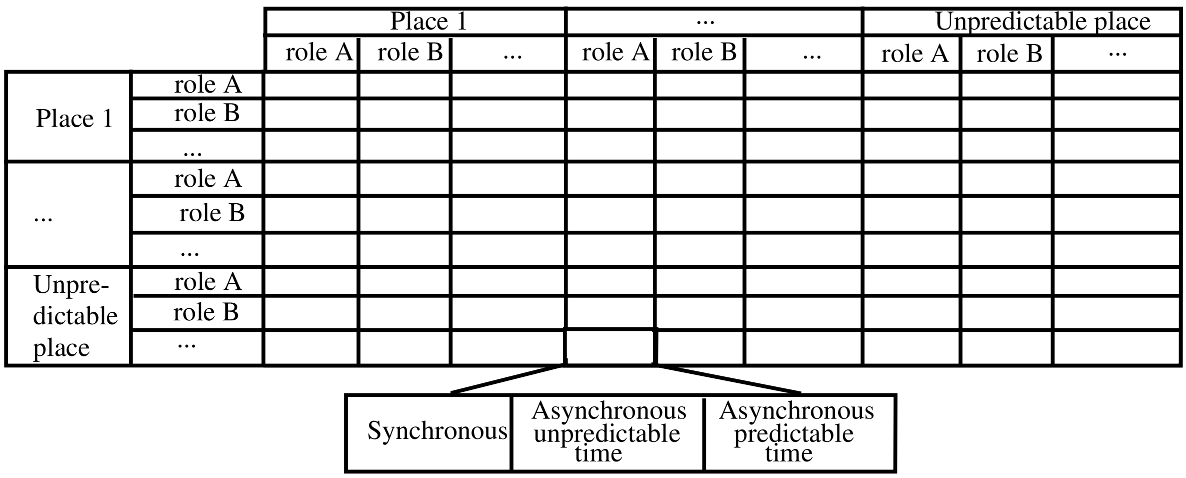

Place 1
...
Unpredictable place
role A
role B
...
role A
role B
...
role A
role B
...
Place 1
role A
role B
...
...
role A
role B
...
Unpre-dictable place
role A
role B
...
Synchronous
Asynchronous unpredictable time
Asynchronous predictable time

Figure 7

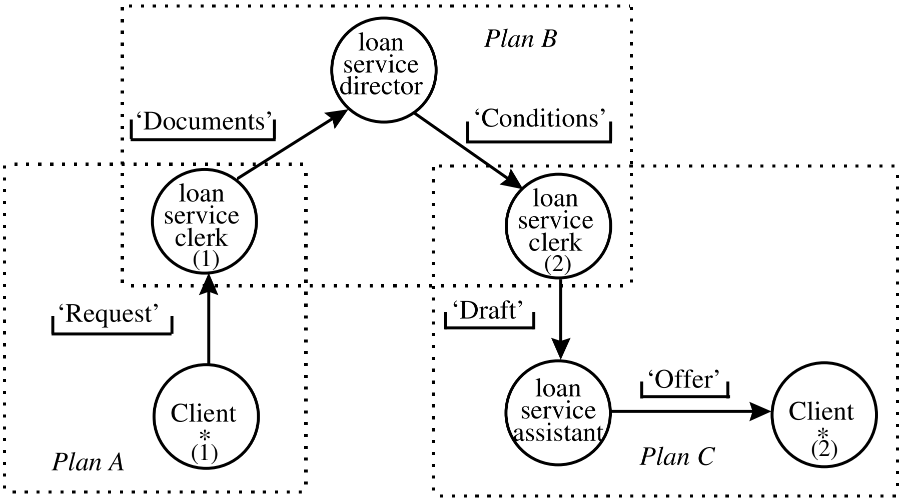
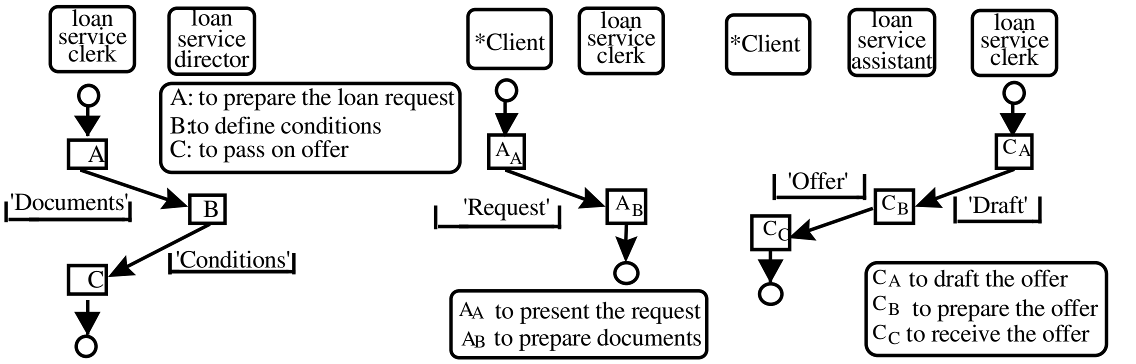

loan service director
Plan B
'Documents'
'Conditions'
loan service clerk (1)
loan service clerk (2)
'Request'
'Draft'
Client * (1)
Plan A
loan service assistant
'Offer'
Client * (2)
Plan C

Figure 8



Global procedure
(Resp.: Loan Service Director)

Zoom on the macro-operation "To prepare the loan request"
(Resp.: Loan Service Clerk)

Zoom on the macro-operation "To pass on offer"
(Resp.: Loan Service Clerk)

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Figure 9

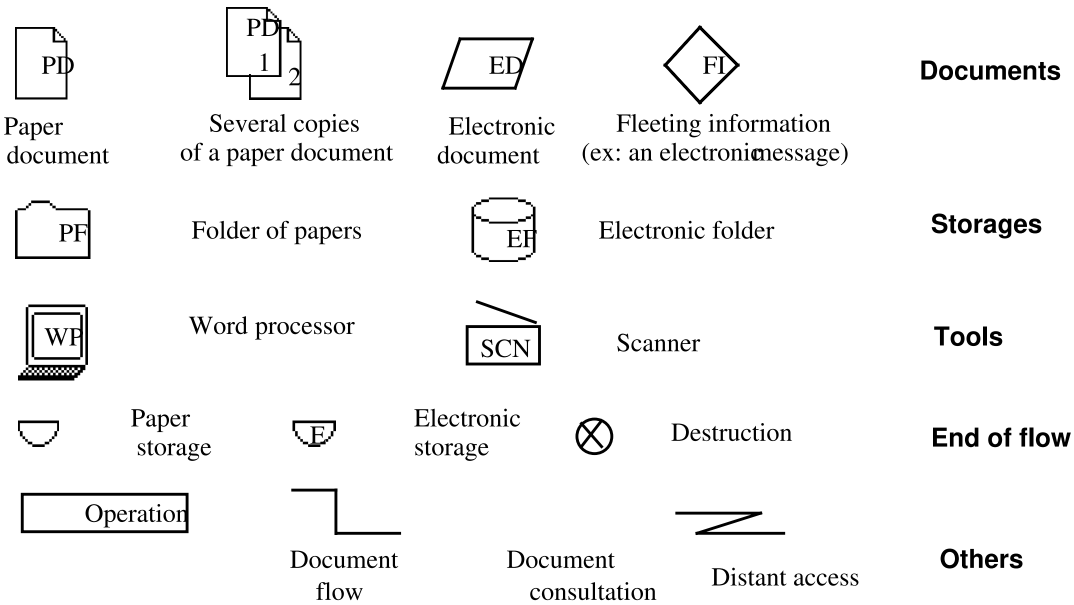


Figure 10

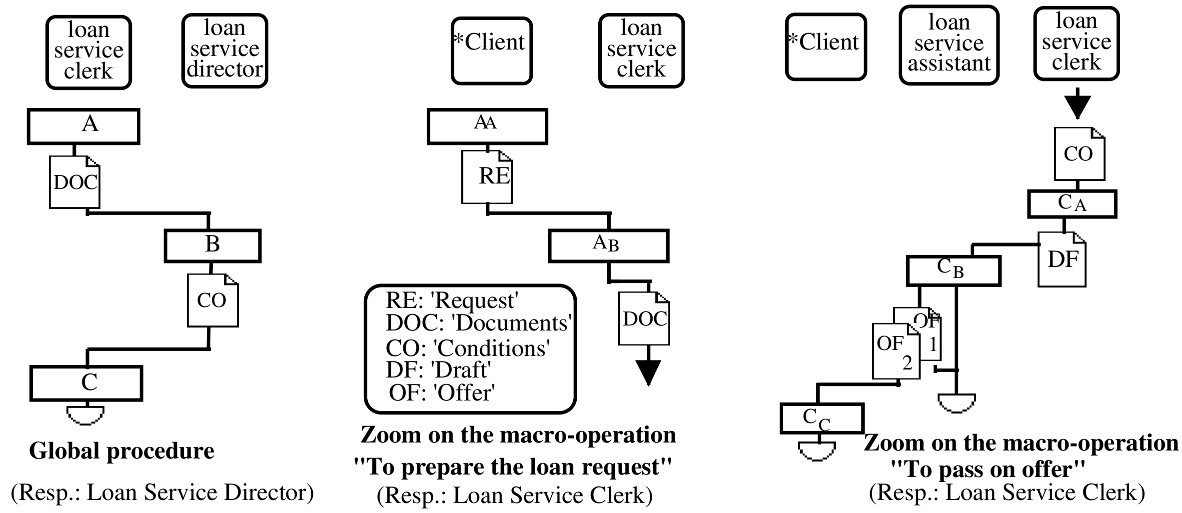
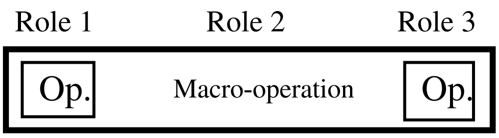
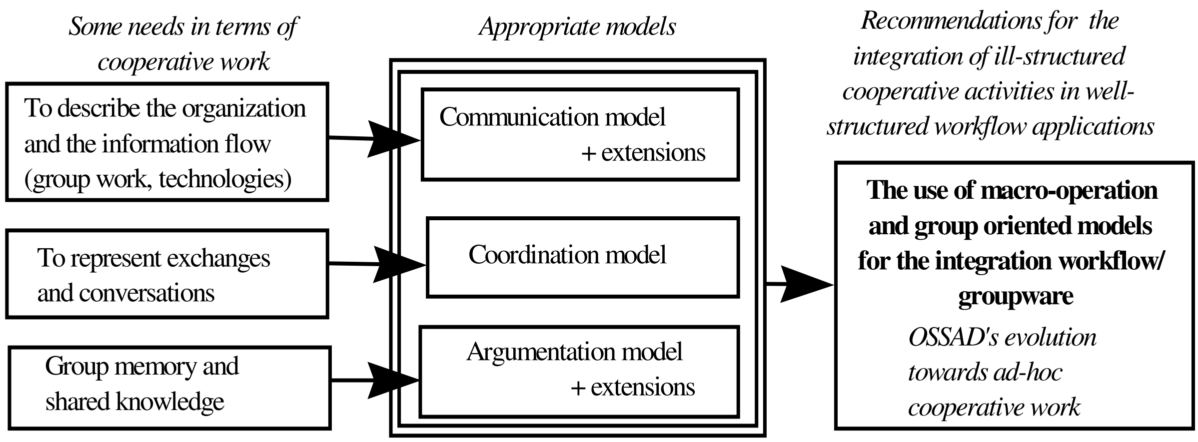

loan service clerk
loan service director
A
DOC
B
CO
C
Global procedure
(Resp.: Loan Service Director)
*Client
loan service clerk
AA
RE
AB
DOC
RE: 'Request'
DOC: 'Documents'
CO: 'Conditions'
DF: 'Draft'
OF: 'Offer'
Zoom on the macro-operation
"To prepare the loan request"
(Resp.: Loan Service Clerk)
*Client
loan service assistant
loan service clerk
CO
CA
DF
CB
OF 1
OF 2
CC
Zoom on the macro-operation
"To pass on offer"
(Resp.: Loan Service Clerk)

Figure 11



Only roles 1 and 3 act in the macro-operation

Figure 12


Some needs in terms of cooperative work
To describe the organization and the information flow (group work, technologies)
To represent exchanges and conversations
Group memory and shared knowledge
Appropriate models
Communication model + extensions
Coordination model
Argumentation model + extensions
Recommendations for the integration of ill-structured cooperative activities in well-structured workflow applications
The use of macro-operation and group oriented models for the integration workflow/ groupware
OSSAD's evolution towards ad-hoc cooperative work