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Dynamic Workflow Model for Complex Activity in Intensive Care Unit

Nathalie Bricon-Souf[a], Jean-Marie Renard[a,b], Régis Beuscart[a]

[a]CERIM: Centre d'Etude et de Recherche en Informatique Médicale, Faculté de Médecine, Université de Lille 2, France.
[b]Hopital Avicenne, Département d'Anésthésie et de Réanimation, 93 000 Bobigny - France

Abstract:

Cooperation is very important in Medical care, especially in the Intensive Care Unit (ICU) where the difficulties increase which is due to the urgency of the work. Workflow systems are considered as well adapted to modelize productive work in business process. We aim at introducing this approach in the Health Care domain. We have proposed a conversation-based Workflow in order to modelize the therapeutics plan in the ICU [1]. But in such a complex field, the flexibility of the workflow system is essential for the system to be usable. In this paper, we focus on the main points used to increase the dynamicity. We report on affecting roles, highlighting information, and controlling the system We propose some solutions and describe our prototype in the ICU.

Keywords

Groupware; Workflow; Activity process; Dynamic control; Intensive Care Unit

Introduction

In the medical field, the communication of information is often based on two different spaces: one is the space which represents the actors, the other is the one which represents the information. Based on this information paradigm, a lot of progresses were made on Hospital Information Systems (HIS), improving management of information and access control to the data. Nowadays the need of communication is more and more important. In our complex society, collaboration between different specialists is a criterion to improve the quality of work. This is particularly significant in the Intensive Care Units where different care specialists are working together to save people. In the same time, new technologies allow new way of work. Complex cooperative computer-based systems now take into account the human cooperation.

We have noticed [2] that to perform a good cooperation between different actors, a system has to involve the representation of the activity process. We based our research on an activity paradigm, which deals with Activities, Information and Actors.

One of the activity-oriented models proposed to manage the cooperation and particularly the coordination of several actors is the Workflow Model (WFM). *In a workflow application the process knowledge that applies to the information is also managed, transferred, shared, and routed.* ***The key ingredient is the process*** *[3].* Some different types of workflows are able to solve a great variety of problems.

We have introduced the concept of computer-supported cooperative work (CSCW) in the design of medical telematics system. We have proposed an asynchronous model based on Action Workflow Approach [4]: a conversation-oriented workflow. The medical cooperative activities are particularly complex due to the mobility of the actors, time constraints, urgency of care. The usefulness, helpfulness, efficiency of the Workflow System leads on its real adaptation to the medical task. But human control is nevertheless a necessity, because of this high complexity: in case of vital risk, the care strategy has to be modified in real time.

In this paper, we report on our study of a new Model of Workflow to perform coordination between distributed actors in a very dynamic activity process. First, we explain about the difficulties our studies reveals in such a situation. Then we propose a new model of workflow to take into account these facts. In the last section we deal broadly with the global architecture of PLACO (PLAnification for COoperation).

Materials and methods.

The workflow model is a " process-centered " model as opposed to an " information-centered " model [3] Workflow management deals with the coordination of productive work. A Workflow Management System is characterized by: 1- integration of procedure and tools. 2- ability to analyze the information flow, 3- description of the productive work process.

We focused on the third point during our study on the therapeutic plan in ICU. Workflow is often used in a well-defined organization system. We are working in a very complex environment, due to urgency in ICU. We need a lot of dynamicity and reactivity in our system. Three main points are improved to obtain a system adaptable enough to be used in ICU. It deals with actors and roles, actors and information, and actors and control.

Some Workflow concepts.

In this chapter we shall present three main points handled with a cooperative task through a Workflow system. The first one is the necessity of affecting roles to the actors, the second one is the way of notification for the information, and the third one is the control in such a system.

Actors and Roles

In a cooperative work perspective, actors need to have a right perception of the tasks to be done and of the information they can reach. As shown in Fig 2, actors require a visibility on both the activity process and the information domain. But, in fact, nobody can be informed on all the activities to be done. Two main reasons for this fact: the first one is that human ability is limited, the second one is due to the activities of the actors which are often limited to authorized data. Fig 3 illustrates this point.

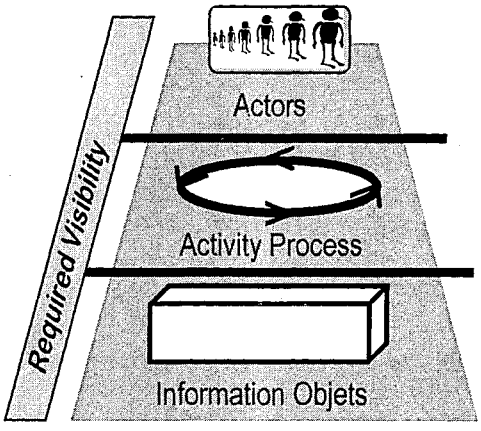

Figure 1 - Through the WFS, health care actors require a good visibility of the care activity process and the medical information.

A general solution is to introduce some roles so that the visibility of the data or of the activity is reduced to the competent and authorized persons. By using Workflow, a communication is built during a complex task between all the actors concerned. " *Only workflow products focus on the issues and problems inherent in process automation, such as the analysis of processes and the definition of role relationships* " [3]. The role could be precisely defined as " *responsible role (authorize) and performing role (qualify)" [5].*

So, some sets of actors which are supposed to perform a rôle, are defined. This organization was proved to be very interesting in many domains, but it could not be sufficient in the ICU problem. In fact, even if actors are supposed to shoulder a responsibility, for example a nurse is able to make a dispensation of a drug but not a prescription, the system has to manage some exceptions so that the life of the patient will be preserved. A nurse exceptionally makes a drug prescription immediately followed by dispensation in an important urgency. Actor's flexibility must be preserved. Workflow System (WFS) often proposed some static associations between role and actors, it is not well adapted in ICU.

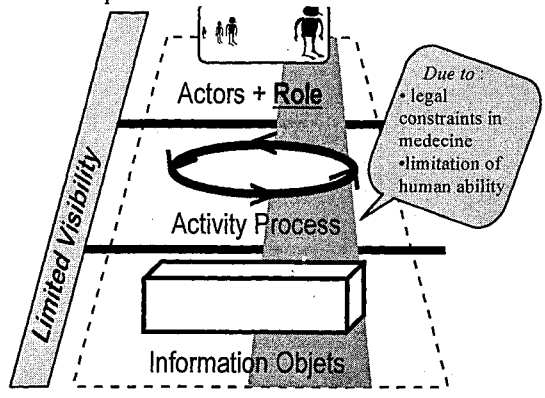

Figure 2 - At a given time, a role limits the visibility of the actors to secure the system by giving authorized access, to limit the amount of information so that it could be usable.

Actors and information

As shown in an European project [6] laying on cooperation in ICU, breakdowns often occur in those medical units, not due to the competence of the Health Care Actors but more principally due to a lack of communication. We aim at improving the notification of information in such care environment. A Workflow System can automatically give information about which task to perform. But if Workflow systems give information to coordinate the activities, actors sometimes need to add complementary information. Those information focus on a task to be urgently done, or explain the reason of an unusual action. For example, an antibiotic therapy is modified because of the persistence of fever. These pieces of information are essential to the other members of the therapeutics team to understand what is happening at any time.

Actors and control

A Workflow system defines the sequence of actions to be done to perform a complex task. If we consider the definition of cooperation, three types of cooperation are mentioned by Schmidt [7]. Our work handles with integrating cooperation, in which the actors cooperate in a controlled system where people know the finality of the whole task so that they adjust their own work better. In a natural situation of human cooperation each actor performs his task but also controls the system. For example, a chief-nurse notifies a nurse that a dispensation has to be done. With a workflow system, actors have to perform the tasks but they not yet assume the control: the Workflow notifies the relevant actors of the tasks to be done. It seems to be very efficient in a normal use, each actor consults what to do and executes his own work

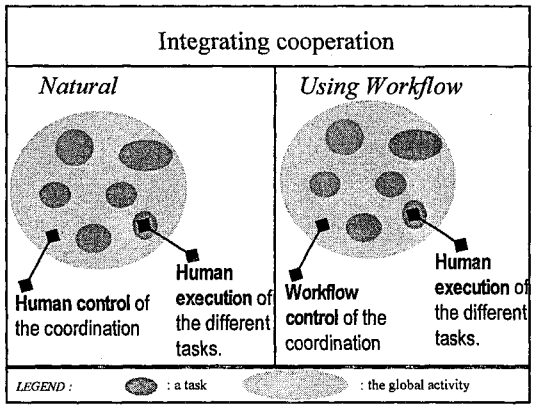

Figure 3 - .In human cooperation, actors both execute and control the tasks, with a WFS, the system takes charge of the cooperation control.

In human cooperation, actors both execute and control the tasks, with a WFS, the system takes charge of the cooperation control.But actors need to obtain different and flexible views on the system: from a very restrictive one, which indicates strictly the next task to perform, to a very large one on the global activity. It is pertinent to delegate the control to the system in an usual use, it is necessary to allow human control in critical situation. In ICU, those situations often appear, the WFS must treat them in real time. For example a prescriptor should stop a dispensation by understanding there is no more use of it.

One of the principal difficulty of our work in ICU is that the system has to be used in normal activity when health care actors only have to know about what task to perform, as well as in unusual situation where the human actors have to take urgent decisions and need to be informed about all the authorized system.

The conceptual framework of PLACO system.

In this chapter we shall describe the choices we have made to increase the flexibility of the WFS.

Dynamic affectation between actors and roles

As linking a role to a set of actors is not sufficient to manage the intensive care activitv, our Workflow System dynamically designs which actors are concerned by a task. First, the system informs the roles which are linked to the different tasks. Then, a complex management system routes the information from the role to the actors, taking into account not only the professional status of the actors, but also the urgency of the task, the local customs, and more if useful. Adding this possibility increases the power of the system because it allows the treatment of exceptional delegation which often happens in ICU.

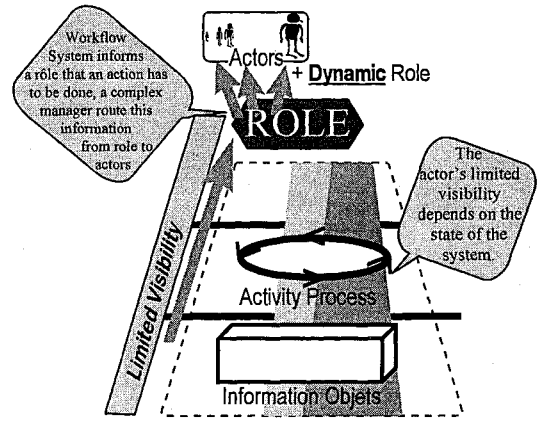

Figure 4 - The professional status of an actor is well known, but the role it is authorized to depend on the state of the patients. The system affects dynamically actors to a role to avoid deadlocks.

Highlighting of the pertinent information

To assume that users are permanently informed of all changes on pertinent objets, we have introduced the concept of post-it. A post-it is a generic vector of information. It represents a visible reference on something new that happens and that is pertinent to know. Three types of post-it have been defined:

- Free-post-it assumes the transmission of information from one actor to another. Information doesn't need to be really connected with the workflow activity.
- Coordination post-it assumes a good sequence of tasks. Those post-it are strongly connected with the Workflow since they sequence the different actions to perform.
- Information post-it highlights the modifications which are important to notice. Those post-its assure the quality of care since they give pertinent information useful to take good decisions.

For example, a coordination post-it notifies that a dispensation has to be done and an information post-it reveals the fever of the patient. By using a post-it, it becomes easier to spot on the relevant information.

Allowing actors to control the system.

The two points mentioned above introduce flexibility in the Workflow Management System. But it is very important to notice it couldn't be sufficient. In a complex field like medical care, Workflow improves the coordination between actors. But there is no benefit with such a system if it prevents actors from taking decisions. That's why we have introduced a control level which allows human actors to change the tasks, to take care of the working system and avoid breakdowns. Our system favors the control of the exceptions, it doesn't block or ignore them.

Results

In this chapter we describe some results of our work, we explain the context and the global architecture of our prototype.

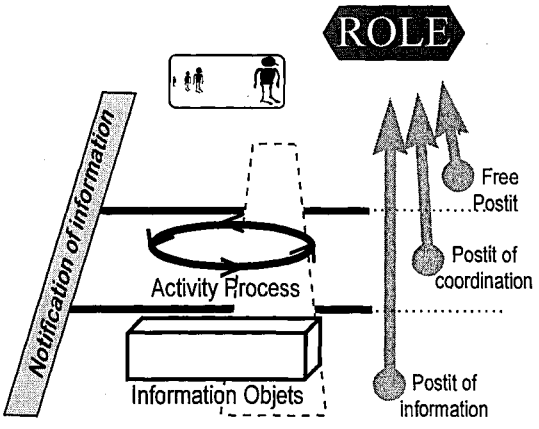

Figure 5 - Post-it: a generic vector of information notifies the important changes on the domain objects, coordinates the task, and allows free communication between actors

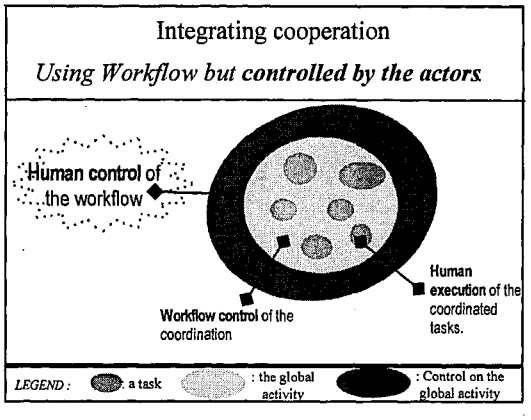

Figure 6 - a human control is necessary so that actors could control the workflow system and not only execute the different tasks

Drug prescription

We based our prototype on the drug prescription which concerned all the therapeutic team and which is one of the principal activities in ICU.

This process deals with nurses and physicians who cooperate to make a prescription, choose a planification of the drug, make the dispensation and evaluate the result of the prescription as well as the patient's state of health. As we said before, we have chosen a conversation-oriented WF, inspired from the Winograd and Flores one [4].

In the context of the ICU drug prescription, our WF cycle is made of four phases and involves four roles. The different phases of the WFC are the following:

- **Prescription**: a physician takes the role of prescriptor, a message is sent to the role of the next phase.
- **Planification**: a nurse takes the role of planificator: she chooses at what time and how many drugs have to be delivered. A message is sent to the role of the next phase.
- **Delivery**: a nurse takes the role of dispensator. She gives the drugs to the patient, a message is sent: the evaluation has to be done.
- **Evaluation**: a physician takes the role of evaluator. He evaluates the efficiency of the treatment. If necessary, the prescription is renewed or modified.

Architecture.

Dynamic routing.

For a given patient, dynamic routing will affect one task to one actor, depending on the role needed, the status and the availability of the actor and the different constraints of the care. This complex system is one aspect of our actual researches.

Postit

In the PLACO approach, post-its are the key-elements for coordination. Our post-its are represented with semi-structured messages. They are made of some structured fields and some unstructured ones. The first ones are filled out automatically by the system and the user fills out the other ones. Semi-structured messages can be automatically computed and filtered by the system. They enable actors to add informal knowledge which cannot be done automatically.

Control

An information postit transmits information about the Health Care of the patient, independently of the state of the coordinated tasks. A Health Care actor can analyze those data and decide to modify or ignore the sequence of the proposed tasks. As our postits are generics, an information system point on patient as well as a coordinating one. Health care actors used them to keep control on the system.

Simulation

In order to evaluate the model of PLACO, we simulate its comportment with clinical data. We use ICU patient records to build scripts. We study the workflow cycle and the message streams by increasing the complexity of the medical data step by step. The model gives us satisfaction. The support of the task flow is efficient, the exceptions are well treated.

Implementation

To develop our prototype, we have used an object-oriented approach. The coordination of medical activity in ICU is often distant and asynchronous. Our application will need a computer in each patient room. We decided to use CORBA technology, through an Ethernet network, to implement a distributed application. We used the CORBAWEB script language [8] to develop the prototype, the WEB interface provides the generic client devoted to the healthcare actors. The behavior of this system meets the results of the simulation.

Discussion

The three main characteristics of a Workflow system on which we have focused, are fundamental to use the Workflow concept

on a very complex environment. We have tried to implement the therapeutic plan with Staffware™, a software proposed to manage Workflow. This software did not fully answer to the specifications mentioned above. The dynamicity of the system was too low. A normal working process was very well taken into account, information flow was well defined, but it becomes difficult to use the system in abnormal case.

Conclusion

The cooperative dimension of the work is obvious in medical teams and particularly in ICU. The cooperation management system could provide better efficiency in a complex working process. Our study shows that the benefit of a cooperation management system depends on its flexibility and its adaptability. In medical field, due to the complexity of the tasks, human control is very important. We have mentioned two ways to improve it, the first way is to facilitate the diffusion of information, and the second one is to allow a human level of control on such systems.

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Address for correspondence

Nathalie Bricon-Souf
CERIM. Faculté de médecine
1, place de Verdun - 59045
Lille- France
souf@univ-lille2.fr