A COOPERATIVE APPROACH FOR INTELLIGENT DECISION SUPPORT SYSTEMS

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ABSTRACT

Our purpose is to improve the design of Decision Support Systems (DSS), Knowledge Base Systems (KBS) and Intelligent Decision Support Systems (IDSS). To achieve this goal we define life-cycle processes of designing DSS and the actors they involved. We would like to provide support to knowledge engineers at the beginning of the process. This paper presents a conceptual framework to model man-machine cooperation in the knowledge acquisition stage. It proposes a shift in the way the IDSS design is viewed, so that the system and the user are in harmony right from the design stage of the system. We describe knowledge engineers' decision process ; when and how our cooperative approach may be integrated in this process. The aim is to help to design a system that the user will see as a real partner. It will therefore involve sharing intelligence about the situation by interacting and collaborating with partners rather than remaining a passive user. This means putting at the disposal of the user, a system that will help him or her more efficiently with this problem.

To achieve this goal, we define a Cooperative Approach to assist knowledge engineers in this task by providing a guideline. The approach adopted here is a global philosophy which functions within the framework of all the methodological principles underlying information, support or knowledge-based systems and cognitive ergonomics. Certain approaches will be compared and combined with one aim : to develop useful and usable systems and their conceptual framework. The aim of this research is not only to make systems more « intelligent » but, above all, to make people more efficient through cooperating with them. We applied this approach to a specific case. Finally, we outline possible further development of such an approach.

Keywords : Decision Support Systems, Knowledge Acquisition, Decision Support System design process, Man-Machine, Interaction, Cooperation.

1. INTRODUCTION

Decision Support Systems (DSS) stem from both management information systems and operational research. « Decision Support implies the use of computers to :

• assist managers in their decision process in semi-structured tasks.
• support, rather than replace, managerial judgement.
• improve the effectiveness of decision making rather than its efficiency ».

Expert Systems (ES) came from Artificial Intelligence (AI) and can be defined as follows Expert Systems simulate the human reasoning process. In the beginning, these two kinds of systems were seen as completely opposed. The first one was built to assist users, whereas the second was developed to replace them. Nevertheless, Expert Systems developed characterics that assist users. It led to expert systems or Knowledge Based Systems that integrate a knowledge acquisition module among other modules. These systems have two kinds of purpose :

◊ create an automatic decision process or problem-solving process (replace human tasks)
◊ support the end-users in their decision process.

We focus on the second kind of Knowledge Based System.

At present, some authors consider Decision Support Systems and Knowledge Based Systems as no longer opposed but as complementary (see Pfeifer and Lüthi 1987).

Such systems can be improved by integrating the two kinds of techniques. Hence, a new generation of Decision Support Systems was born : Intelligent Decision Support Systems (IDSS) or Knowledge Based Decision Support Systems (KBDSS) (for more details see Despres and Rosenthal 1992). In a general way, the purpose of IDSS is to support users' decisions interactively. Users play a prominent part in decision-making. These systems can be seen as support systems.

Note that Knowledge Based Systems are developed for supporting end-users in their decisions. Thus, we have associated the two kinds of systems by giving them the same name : Support Systems. In this paper , we consider Decision Support Systems, Knowledge Based Systems and Intelligent Decision Support Systems as Support Systems.

In designing Support Systems, the first step of the life-cycle is the bottleneck. The major problem is in the modelling process of Support Systems.

The paper is organised as follows. In section 1, we present all the actors involved in a support system design process. We try to make both the actors involved in a Decision Support System design process and those who are involved in a Knowledge Based System design process communicate. In section 2, we start from some life-cycles of Information Systems. All these processes lead us to define a life-cycle process for Decision Support Systems. In section 3, we focus on the first step of these life-cycle processes : the knowledge acquisition phase. Our contribution consists in improving this part of the process. In section 4, we define the knowledge engineering decision process. In section 5, we present a cooperative approach, which must support the knowledge engineer in the knowledge acquisition phase. We conclude this paper by presenting two case studies and by outlining further development of this project.

2. ACTORS IN THE DESIGN PROCESS OF SUPPORT SYSTEMS

Our objective is to improve the quality of Support systems by bringing all the parties involved in the design process closer together. For each kind of systems we define the actors as follows :

- ◊ for Knowledge Based Systems : Nassiet defines the expert and user groups to include a leader ; the design staff which includes a knowledge engineer, a design engineer ; the maintenance group and a management committee ;
- ◊ for Decision Support Systems : Zaraté distinguishes the initiators ; the analysts ; the developers (or designers) ; the testing staff ; the users and the decision makers.

These definitions are starting points for us. We emphasise the fact that three categories of actors are common in Support Systems design : end-users, experts and knowledge engineers. Knowledge engineers are specific actors in the design of Knowledge Based Systems and Knowledge Based Decision Support Systems but can be linked with the designers (or analysts) who must model the problem in the Decision Support Systems development process. We note that the initiators mentioned for Decision Support Systems can be present in the Knowledge Based Systems design process. These actors (initiators) play an important part for the system to be accepted in the organisation. The actors' proximity can be enhanced if we improve communication among them. « The communication is the cement of the organisation and the greater the need for co-ordination and cooperation, the greater the necessity for communication » (Brehmer, 1991, p.9). In the design process of Support Systems communication is costly in term of task knowledge of each actor. « The agents cooperate via information space (data, beliefs, concept, heuristic) with direct communication and knowing each other or by knowing of each other... We assumed that the cooperating ensemble of actors is a relatively closed and fixed collective sharing the same goal and engaged in incessant and direct communication » (Schmidt, 1991, pp.76-77).

3. LIFE-CYCLE PROCESSES

Various life cycles are described for Information Systems. Boehm described a linear life cycle based in the waterfall diagram (see fig 1).

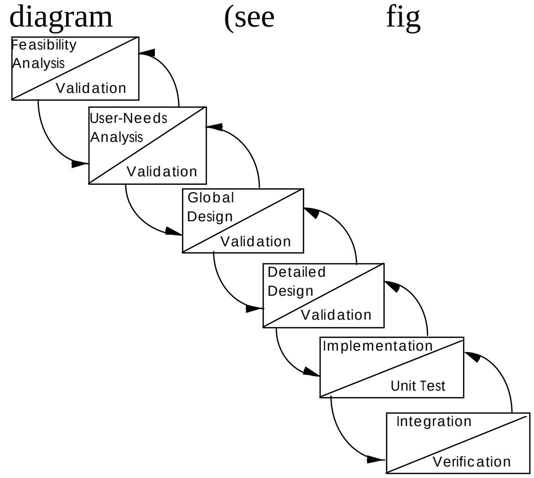

Figure 1 : Waterfall diagram.

In this process end users intervene in the beginning steps at a conceptual level. They validate the operational system at the end of the process. The knowledge engineer intervenes in the following phases : the feasibility analysis, the user-needs analysis and the integration and verification step.

In literature, a variety of definitions exists for the life cycle of Information, for example : the V life cycle and the W life cycle, the spiral life cycle (Boehm (1988)).However, the waterfall is the most frequently used. Several development approaches have been proposed for Decision Support Systems. Sprague and Carlson defined the ROMC approach "as a framework to identify the required characteristics and capabilities... It is a process-independent approach which does not require the users to be able to describe how they make decisions." The components of this approach are representations :"any activity in a decision-making process takes place in the context of some conceptualisation of the information used in the activity... Representations provide a context in which users can interpret outputs and invoke the operations" ; operations :"intelligence, design, and choice is a well-known paradigm which can help classify the operations used in decision making...Note that an operation may be used in more than one activity and there is no prespecified ordering of the operations. The operations may involve complicated decision aids, such as simulation models or forecasting algorithms." ; memory aids :"several types of memory aids can be provided in a DSS to support the use of representations and operations. (for example data base, views of the data base...)." ; control mechanisms :"the DSS control aids are intended to help decision makers use representations, operations and memories to synthesize a decision-making process based on their individual styles, skills, and knowledge.". The well-known process of decision-making : "intelligence, design, choice", defined by Simon is present in the three first components representations, operations and memory aids.

Courbon et al defined an evolutionary approach which is summed up as follows :

1) establish a dialogue between the designer and the decision -maker.
2) shorten the cycle "analysis, design, implementation, use and evaluation..." A prototype must be presented quickly to the decision-maker to make him or her react.
3) let the system evolve through several cycles.
4) evaluate the elaboration process frequently.

Using the evolutionary concept, Zaraté integrated this approach in a linear life cycle based on the waterfall diagram. This life cycle is shown in Figure 2. This life-cycle consists of three steps and possibly of one or more steps of the waterfall diagram :

• analysis and modelling,
• evolutionary mock-up (model) design,
•prototype[1]

[1] for this process see Partridge (86).

possibly, waterfall diagram (one or more steps).

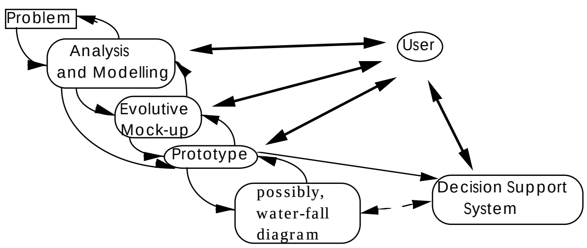

Figure 2 : DSS life-cycle process.

Note that this life-cycle process has been defined only for Decision Support Systems, but we believe that it can be applied to Intelligent Decision Support Systems, and more generally to Support Systems. Our approach is based on classical methodologies but integrates the user during the whole process.

4. THE KNOWLEDGE ACQUISITION PHASE

Several methodologies and tools for knowledge acquisition have been designed to improve the knowledge engineer's task. The modelling process is an important step in all life-cycle processes of Support Systems. For better cooperation among all the actors, we emphasize the knowledge acquisition process at the beginning of the life-cycle of Decision Support Systems. We want to model man-machine cooperation at this stage. To achieve this objective we introduce a knowledge acquisition module. Our starting point is the following Knowledge Based Systems life-cycle:

analysis, design, implementation, installation, use, maintenance.

The knowledge engineer intervenes in the analysis phase of this process. His or her task consists in a knowledge acquisition process which can be defined as follows : identification, knowledge elicitation, knowledge structure, validation, knowledge base codification, generation.

We define the links between these two processes as follows :

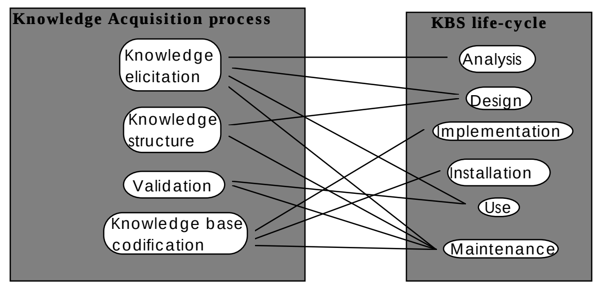

Figure 3 : Knowledge Acquisition process and KBS life cycle links.

Voß (1990) defines three different tasks in knowledge acquisition : knowledge elicitation, structuration and implementation ; he establishes relations between software engineering and these tasks (for more details see Voß, 1990).

We introduce links between the previously defined knowledge acquisition process and the life cycle Decision Support Systems design process.

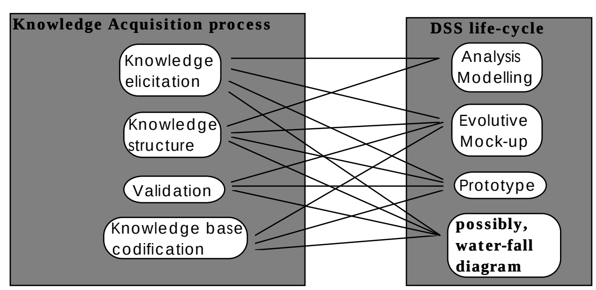

Figure 4 : Knowledge Acquisition process and DSS life cycle links.

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We provide support for the knowledge engineer in this process by including the end-user.

5. KNOWLEDGE ENGINEER DECISION PROCESS

We integrate the end-user's activities in our study. This analysis would be possible by precisely defining knowledge engineers' decisional process and the exact nature of the decisions that he or she has to make. In a more general way, we believe that the knowledge acquisition process can be defined by referring to the decision process described by Simon (1981) as follows :

- ◊ intelligence,
- ◊ design,
- ◊ choice and
- ◊ review.

For the knowledge acquisition process, the steps corresponding to the knowledge engineer's tasks, are the following :

- ◊ knowledge elicitation consists in collecting domain knowledge of the expert and the user. This phase is the intelligence phase and the actors involved are the knowledge engineer, the expert and the user.
- ◊ the knowledge structure is related to the design and choice phases. During this step, the knowledge engineer must classify the collected information and also has to refer to his or her own mental models ; only the knowledge engineer intervenes in this phase. This is where our model comes in. We provide the knowledge engineer at this level with shell models so that he or she can use analogical reasoning.
- ◊ the validation and knowledge base codification are sometimes seen as only one step called operationalization. This is the review phase. The knowledge engineer and the expert are traditionally involved here ; but in our approach it is fundamental that the user also should be taken into account.

6. A COOPERATIVE APPROACH

The cooperative approach is designed to support the knowledge engineer and more specifically the decisional process described in the previous section. Note that this approach could be defined first as a set of instructions which will then be formalised as procedures or as a heuristics package, or as a guideline for knowledge engineers. Figure 5 shows how this approach can be included in the DSS design process.

A cooperative approach must :
• involved the end-user's task.
• be justified by the end-user's objectives.

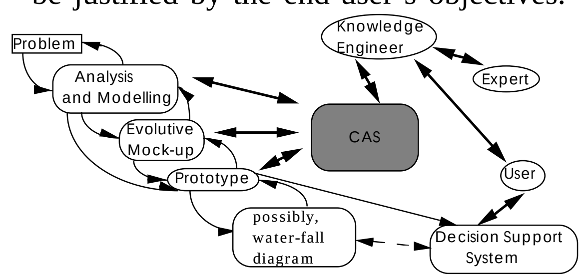

Figure 5 : CA and Actors relations in the DSS life cycle.

The Cooperative Assistance is, for us, a means of communication among the three kinds of actors ; it acts as a mediator between the actors and the process itself.

By introducting a cooperative approach in the Decision Support System design process we want to strengthen relations among the actors.

The cooperative assistance is the link, on the one hand, among all the parties involved ; and on the other hand, between the Decision Support System and the actors. Communication is established between the end-user and the knowledge engineer. The end-user is taken into account during the whole DSS design process. The knowledge engineer acts as a mediator among the parties involved.

In fact, our cooperative approach is a process defined by different stages as follows :

- ◊ actors definition
- ◊ general aim definition
- ◊ tasks decomposition
- ◊ tasks assignment.

The first step, actors definition, consists in considering all the parties involved in the process. These actors are generally included in the following list : end-users, knowledge engineer, expert.

In the second step, the main purpose is to design the general objective. The cooperative approach gives a shared language among all the parties involved.

For tasks decomposition, the cooperative approach describes how the general is broken up into different tasks.

Tasks assignment consists in the allocation of the tasks to the various actors. This step answers the question : Who makes what ? A second part is then defined as the management of this allocation. Allocation management concerns by two aspects : the arrangement of the tasks among themselves and the control. The arrangement of the tasks answers the question : At which moment must tasks must be done ?

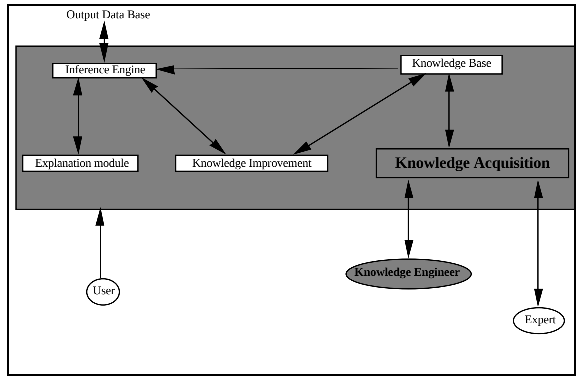

Figure 10 : Knowledge Base System Architecture

In a more general way, the cooperative approach is part of the knowledge acquisition module. In our approach, anew architecture of KBS could be designed as follows :

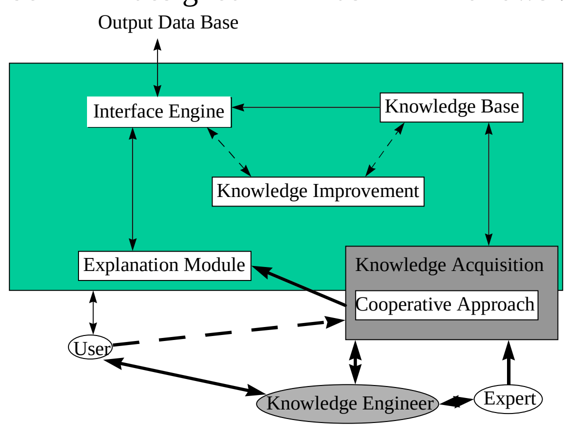

Figure 11 : Cooperative Approach and Knowledge Base System Architecture

Communication exists between the knowledge engineer, the expert and the user and is formalised in the figure 11 by the continuous arrows. The dotted arrows show potential communication between the user and the system on the one hand ; and between the expert and the system on the other hand. In this case the Knowledge acquisition module which can be used by the user and the expert directly ; the knowledge engineer will then play the role of a mediator.

In the KADS methodology, a flexible life-cycle model is provided for structuring and controlling the development process. «Central to the KADS approach is the fact that thorough implementation-independent analysis and design are conducted before implementation, instead of the more commonly-used rapid prototyping approach » (Hickman).

The characteristics of the DSS, i.e., the interactivity of the system and the permanent communication between all the parties involved through the prototype, could be used in the KADS approach. That is why, in our approach, we consider that a prototype or an evolutive mock-up and the shell models are necessary for improving knowledge acquisition methodologies such as KADS for example.

7. CASE STUDIES AND FURTHER DEVELOPMENT

We carry on this approach by developing the expert-model and the knowledge engineer-model, and then by improving the end-user model.

The end-user's integration in the design process of a Support System now seems to be a necessary step that leads us to improve the research in the field of man-machine cooperation. In this framework we resorted to several methods and methodologies taken from several disciplines : Artificial Intelligence, Information Systems, Psychology. Thanks to multidisciplinarity we can design Support Systems which better meet the end-users needs.

We could go one step further in this research by emphasising the initiator's role which is crucial to the successful integration of the system within the organisation.

We applied this approach to a specific case study in a supervisory control problem. The operator has to supervise the French National Electric network. He must diagnose and remedy troubleshooting in a powerplant . The cooperation between three kinds of models - the model of the end-user, of the problem and of the resolution has been the basis of our research (see Gandibleux et al.1992, Rosenthal et al 1992).

A second application, in a pension fund, where the end-user model has been included in the knowledge acquisition process, has been implemented in this framework. In this work three dimensions are present : the design process, the intelligence of the problem and its cooperative resolution. The approach consists of three stages : Firstly a situation positioning with a global and a local situation analysis, secondly a problem analysis and finally a conceptual cooperation model (see Rosenthal 1996). The target of this application was to design a system that the user will see as a partner. This system is designed to assist pension fund administrators in commercial agencies when proposing. The pension fund administrator is concerned with social security, insurance , tourism (special target) and the activity is spread around the country. The system is a major issue for the firm in terms of productivity and reactivity. Our first stage : the global and the local analysis of the situation, gives us an idea of the dimension of the task and the actors involved in the system. The time required to carry out the task was just over six months. The actors involved in this project were : the general manager, the EDP manager, the users (commercial agencies) and indirect actors (central agencies). The second stage is a problem analysis using the Information System with a classical data modelling. The third stage gives : an organisation type coming from Mintzberg typology in terms of reactivity and force of inertia, a cooperation type in terms of tasks, task allocation and control (see Rosenthal et al 1995) and finally a user type in terms of user model and communication model (see Rosenthal 1996b). This system is now operational and has been accepted by the end-users very well, with a great gain in productivity. The end users are central to the design process. But moreover, the aim of this research is to use software engineering, interactive decision support, artificial intelligence and cognitive ergonomics to their best advantage in order to enhance *cooperative* engineering. This goes beyond the general question of *User Center Design* since it a *cooperative* organisational dimension integrates right at the start of the design process.

8. CONCLUSIONS

This work was elaborated to answer to the arising problem that is to manage the cooperative work in organisations. The communication means evolution have consequences in the organisation framework ; this evolution implies a complexification of the work environment. However, the organisation knowledge becomes more and more large which implies that each actor is more and more specialised, that interactions between actors are more and more precise and numerous. In organisations, this phenomena is increased by universal exchanges and markets. In that sense, studies are conducted for analysing cooperative activities and necessary resources for a suitable development of this kind of activity. Computer Support Cooperative Work are developed in this framework.

This paper is a part of the CSCW field. Our aim is to provide a support to model man-machine cooperation. However, limitations of this studiy have to be underlined.

Collective Activity has to considered along three orientations : the problem (or task), the organisation and the agents belonging to this organisation The work has now to be investigated in these three key points.

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