Towards a new vision of Information System Engineering

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***Abstract*—**

Information Technologies bear the potential of new uses. These uses provoke a new organization which induces a new vision of software engineering. Under the influence of globalization, and the impact of Information and Communication Technologies (ICT) that modify radically our relationship with space and time, the hierarchical company locked up on its local borders becomes an Extended Company, without borders, opened and adaptable. In this context, this paper proposes a shift in the way the design of information systems is viewed, so that the digital information system and potential user are in harmony right from the design stage of the system. The goal is to help to design systems that are useful. It will therefore be a matter of distributed intelligence of the situation in terms of interactions and cooperative partners rather than in terms of a more passive user. This means putting at the disposal of the user, seen as a "partner", a system that will help him or her think more efficiently about a situation. The approach adopted is a global philosophy based on business process management within the framework of all the methodological principles. The research described here is therefore a contribution to the software engineering.

Index Terms— **Digital Information System, Extended Company, Business Process Management, Information System, Software Engineering, User**

I. Introduction

Let us consider a theatrical company, an orchestra, a choir. They are made up of a number of actors, a number of players with similar or different instruments, a number of singers. At the outset, each member must have learned their lines or score by heart but although, taken separately, each one may be very good, taken together they may not be very harmonious. For harmony to be achieved they must be in tune with each other, they must work together. They must also know why and for whom they are playing together. Is it just to have a good time or is it to perform in public? In the latter case they must identify their audience and adapt to it. A band, for example, will choose different pieces depending on whether it is for a wedding, a senior citizens' party or a fund-raising gig, and the way they play will also vary. For the gig to be a success the group and the audience must interact, form a whole: in a word, they must cooperate and they must know in which process they are imply.

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By analogy, if the show is to go on we can say that the digital information system is the show itself, the user is the audience and the design of the digital information system is the preparation.

This paper proposes a shift in the way the design of information systems is viewed, so that the digital information system and the potential user must be in harmony right from the design stage of the digital information system. The research described here is therefore a contribution to the engineering of digital information systems.

The assumption underpinning this work is the fact that the elements of a digital information system are structured with a particular use in mind, and more precisely a user who will actually perform a task. A digital information system is one which is based on interaction between the User and the system. The analogy of the theater will be examined by looking at the functions of the director: adapting the scenario, choosing the actors, deciding what kind of show and venue... and even self-criticism as a result of audience feedback!

The goal is to help to design digital information systems that the user will see as a colleague, a partner that really collaborates, implied in a business process. The solution to the problem will issue from the interactions between all those involved and the digital information system. It will therefore be a matter of distributed intelligence about the situation in terms of interactions and cooperative partners rather than in terms of a more passive user. This means putting at the disposal of the user, seen as a "partner", a digital information system that will help him or her think more efficiently about the problem.

The approach adopted here is a global philosophy functioning 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 cooperative digital information systems and their conceptual framework.

A design method for digital information systems can be considered in four ways. The first is that a digital information system is a support of the organizational information system which is part of the business process. The modeling process is a support of company management system and management information system (see figure 1).

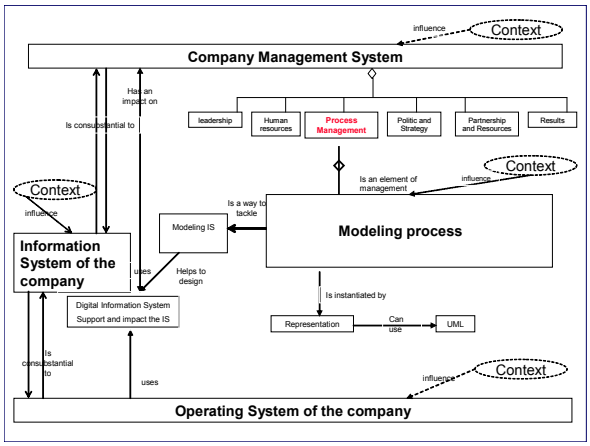

Figure 1: Modeling process: a support of company management system and management information system

The second is that a design method of a digital information system is a regular process in which design can be broken down into a series of coherent steps, the completion of one is not a starting point of the next, but the process is iterative and incremental. It must help identify the players involved in the development process, their role and skills; help them understand the problem and gather together all the data,the information and the knowledge [1]. The third is that of a problem analysis model which provides a description of the problem. The aim of this analysis model is to define and give specifications of the problem at a very high level of abstraction independently of the implementation of the digital information system. The fourth, an ergonomic or interface approach, considers the digital information system in terms of use. At this level the application is described through the interface and cooperation between the system and the user.

Today digital information systems are different from other systems in that they have a more active role in user/system interactions.

The work considered in this paper is based on the methodological approach of information sciences. Decision support and cognitive sciences also provide elements of reference.

COOPERATION DEFINITION

Cooperation is an action with a purpose which is carried out over time, has a beginning and an end, and only has a meaning by identifying the process to which it is a party.

The cooperative digital information system is a means to accompany the problem solving process and it is the quality of the system and the way it interacts with users that will provide a good solution by creating a new society made up of these two players (the user and the system), interacting with the surrounding social system. The interaction itself changes the two players who model each other and together build the solution to the problem in relation with the environment. Cooperation is therefore the very process by which the cooperative partners will build the solution; it is all the different operations and experience used to solve problems interactively with the environment. Cooperation between two or more individuals may either increase and enhance the abilities of one single individual or allow an individual to be more or less fully replaced. Instead they cooperate with their users to perform the tasks as well as possible, especially as these tasks are complex since they come from the real world and have to be performed in a specific context. What are known as cooperative digital information systems fit into the organization and takes into account a certain number of constraints. The partners find themselves in situations where either the decision making or the problems solving process rely on complex cognitive activities. The interactions between the different players in their different organizational contexts, with their different means of solving problems and their own modes of communication, are all allowed for. A cooperative digital information system is one that is "adapted" to its user, i.e. "understood by" the user, not only in terms of style but also content. The common task, in this case, is the cooperative solving of the problem [2].

The user, as a partner in the user/system interaction, is at the heart of the matter and the goal is to enable users to express themselves as they normally do, in their own words and using their own culture while at the same time respecting the nature of the problem being addressed.

Cooperative digital information systems are one of the major challenges for industrialized societies because of their ability to manage complex situations. It is therefore important, indeed essential, to consider the concept of cooperation when designing a digital information system for a user. With ever advancing technologies, studying such systems will become more and more necessary. We need tools with which we can interact.

The goal of this work is not to take the place of traditional methods but to correct their weak points by combining certain steps or refining others. We shall see what must be added to produce this new cooperative situation. This new framework for interpretation makes it possible to bridge a certain number of gaps designers come up against, particularly in terms of needs analysis and the reactivity of digital information systems, so that the software thus designed becomes as supportive a "collaborator" as possible for the human partner, despite all the constraints. The approach discussed here suggests a new way of seeing the problem.

A cooperative digital information system is therefore a system that has been designed using a cooperative design approach on the basis of a) based on business process analysis, b) three paradigms taken from decision support systems, c) a problem analysis model taken from artificial intelligence and, more particularly, from knowledge acquisition and d) an ergonomic analysis model in terms of interactions and collective work (unlike the ergonomics of user/system interfaces based on explanation and individual capacity) taken from cognitive ergonomics.

A cooperative digital information system does not have its own architecture model, since the user is fully part of the "cooperative digital information system", a component of the system. A cooperative digital information system is only cooperative because, when it is designed, the intelligence of the problem is seen above all in terms of interactions between the human partner and the system, and it is the wide variety of these interactions which makes it impossible to give one single architecture model. The system, isolated like one of its partners, may have architecture similar to that of a digital information system, an interactive decision support system or a knowledge-based system, or even a combination of two or three systems. The user can be seen as a component of the system [1].

II. THE EXTENDED COMPANY

Under the influence of globalization, and the impact of Information and Communication Technologies (ICT) that modify radically our relationship with space and time, the company increasingly develops its activities in a planetary space with three dimensions:

- a global space covering the set of the organization that are the geographic places of implantation,
- a local space corresponding to the subset of the organization situated in a given geographic zone, and
- a space of influence that covers the field of interaction of the company with the other organizations.

The hierarchical company locked up on its local borders becomes an Extended Company, without borders, opened and adaptable. Furthermore, this Extended Company is placed under the ascendancy of the unforeseeable environment that leads towards uncertainty and doubt (see figure 2).

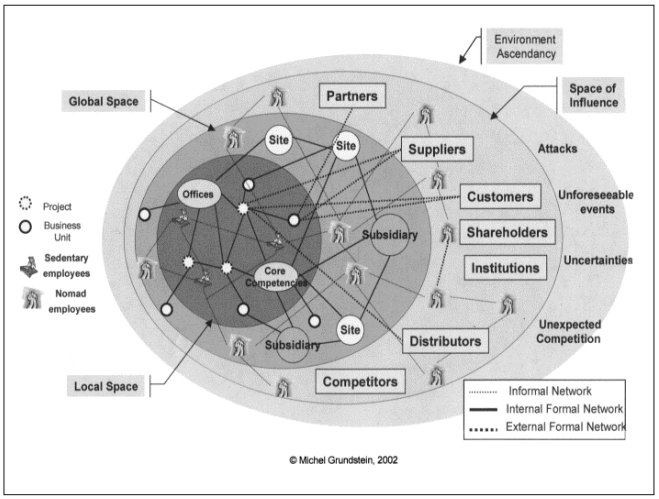

Figure 2: The Information Networks within the Extended Company

The Extended Company meets fundamental problems of information exchange and knowledge sharing among, on the one hand, its formal entities distributed in the world (offices, core competencies, business units, projects) and on the other hand, the company's employees (nomadic or sedentary), bearers of diversified values and cultures according to the places of implantation.
Two networks of information overlap:

1) A formal information network between the internal or external entities, in which circulate data and explicit knowledge; this network is implemented under intranet and extranet technologies.
2) An informal information network between nomadic or sedentary employees; this network favors information exchange and tacit knowledge sharing. It is implemented through Information and Communication Technologies as Web 2.0 [3].

The problem is that the boundaries of the extended company are fuzzy and undefined. Some problems occur when nomadic employees placed in new, unknown or unexpected situations, needs to get "*active information's*" that are information and knowledge they need immediately to understand the situation, solve a problem, take a decision, and act.

III. THE DIGITAL INFORMATION SYSTEM DESIGN APPROACH

The cooperative digital information system design is a question of cooperative engineering, which can be defined as the discipline which studies the different cooperative system design approaches and methods. In other words it is the science of the elaboration of cooperative software programs. What is important is to give the information system engineers the means to successfully develop cooperative systems and this requires a cooperative approach. In order to design a cooperative system, work should be focused on its methodology rather than on its functional characteristics, an approach called cooperation centered design by Zacklad [2]. The issue is therefore to work on the intelligence of the problem as this is the crux of the matter. The difficulty is not always one of solving the problem but more something to be

considered before the problem solving process even begins. The question is to define the problem, define the context of the problem, and define the players who will interact with the problem and its environment. Once the "right" problem has been put "correctly", the solution has already come closer. The originality of this approach lies in the very way in which the question is put and the solution is looked for. Indeed, the solution to the problem emerges from the way the problem is actually put and the way the different players interact when the system is run, and this is what constitutes the distributed intelligence. It should be remembered, however, that those who intervene when the system is run are not necessarily the same as those who were involved in designing it.

What is being done here is to position the problem, which means identifying all the players, defining the organization and context within which the cooperative system will be integrated and highlighting the true goal.

A knowledge acquisition and formalization approach is used for specification purposes during the development of the cooperative system and different methodologies and tools may be used. As for the identification and modeling of needs, the various methodologies and tools used in Artificial Intelligence to build a conceptual model of knowledge acquisition have all been considered. Knowledge acquisition, when designed as a modeling activity, is a perfectly appropriate support for the design of cooperative knowledge-based systems.

A proposal for a cooperative approach to cooperative digital information system design

Five steps are required in order to design a digital information system. This paper only deals with the two first steps of the analysis process of design: business process modeling and problem analysis with the cooperation analysis.

Step one: Business process modeling. This first step is essentially based the business process modeling with BPMN or whatever other notation.

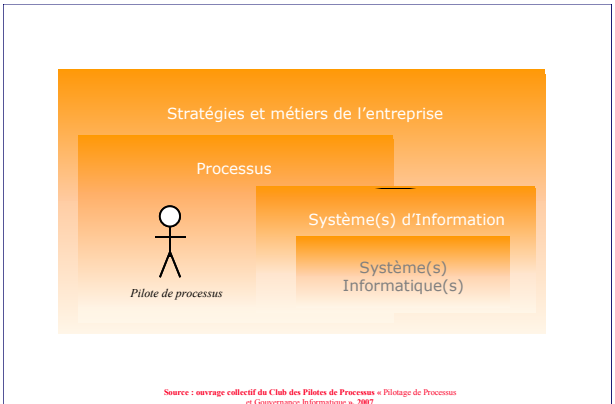

Figure 2: The strategies and business, the business process modeling, the information system and the digital information system within the Extended Company

Step two: positioning, analysis and modeling of the problem. Elaboration of the conceptual model of the problem (CMP) and the conceptual model of cooperation (CMC)

When a problem occurs repeatedly, a user in a company or office will feel the need for a system to help find a solution. The goal of this second step is therefore to identify the problem, the domain and the principal players with their precise roles, and the levels at which they act and interact. This means analyzing the problem itself and the ergonomics of the system.

The aims are therefore twofold: modeling the problem using the conceptual model of the problem (CMP) and modeling the interaction of the user/system pair using the conceptual model of cooperation (CMC).

This second step is based on three paradigms taken from decision support:

> "Limited rationality": in this sense the knowledge engineer or software engineer will work with whatever they have at their disposal: the methodology they know best, that which the organization requires them to use or whatever is available in an existing tool. The problem can therefore be formulated in several ways but this must be consistent with the process chosen to represent the problem, not with an objective that may not have been formulated or may not even exist (unlike a global rationality which has an objective to be optimized). The analysis process itself of the design of efficient and implement able cooperative digital information systems has a "limited rationality". It is only once the designer has found a satisfactory modeling of the problem that the step is complete and they can go on to the next step. The problem also changes over time, the formulation of the

problem following suit.

The "constructivist" nature of the approach: The problem analysis model can and must evolve, as B. Roy [5] said, and is therefore "constructivist", i.e. it is a changing process, each change having to be accepted by the end users. It is therefore quite possible to return to step one more than once.

The problems of choice: Designing cooperative digital information systems means choosing the "right" model, the one that is best adapted to the problem solving process. This also means choosing the "right" dialogue module. Designing a system means choosing, deciding which the «best» design tool is. Since the problem of choice is one of the problems of decision support, a design support system is also a decision support system. Designing a cooperative digital information system means finding the most suitable model for a given context, thus helping better to understand the process of which the user is part. The idea is therefore to have a tool kit of modeling techniques from which to choose the best one. All that remains then is to validate the model that has been chosen. "Building a good model often requires the implementation of real expertise and often a certain amount of creativity. In this domain, as in many others, no one solution exists; many models may be more or less suitable as candidates. Knowing how to compare the different models, how to assess their suitability or potential weaknesses is a delicate matter. Little research has been carried out to date on this particular aspect. Understanding what a good model is - and building it - is today among the most important and maybe the most difficult problems facing us. A good model is the cornerstone of a system.

Step three: making the mock-up

A mock-up usually refers to an interface. It is reduced in size and can be applied to very different models. A mock-up is a "surface" approach.

Once this third step has been completed the software engineer will design a mock-up which can evolve or even change completely later on.

Step four: making the prototype

A prototype is a more finished product, even if the system is not yet operational for the company and must still be tested over a number of months or even longer. A prototype is an "in depth" approach.

Step five: full requirement specifications

Once the modeling stage is complete and the mock-up has been modified to produce an acceptable prototype, the full requirement specifications can be handed over to the User in charge of implementing the digital information system.

The design process forms the classical cycle of system design; it is a cyclical, circular or spiral process [6]. Risks are analyzed and assesses at each step (financial risks or risks with respect to implementation deadlines).

Note that the designer must be aware of the different contexts in which decisions are made. These digital information systems must therefore be expandable to allow for robust solutions, i.e. solutions that remain valid even if the context changes.

III CONCEPTUAL MODEL OF THE PROBLEM OF DIGITAL INFORMATION SYSTEMS

The problem analysis model of cooperative digital information systems is the conceptual model of the problem. In order to build it, the following have to be determined.

1) The type of problem to be solved (diagnosis, design, classification, etc.).

2) The domain (medicine, insurance, process supervision, etc.).

3) The partners (end users, cognitive engineers or designers, systems analysts, experts, those who initiated the project and those who pay).

Note that those who pay are rarely mentioned but are indispensable if the project is to see the light of day. Although they are not as present as the end users, experts or knowledge engineers, without them a project will never get off the ground. Some of these different partners are immediately cooperative, others are less directly involved (the payer, for instance). The framework of the puzzle has to be built bit by bit to situate the problem.

4) The model of the problem.

This model can be built using Kads, Kod, Commet, generic tasks or other methods. Validating the conceptual model of the problem is also a step in the cooperative approach. It requires adapting the vocabulary so as to be compatible with that used by the expert, thus guaranteeing a good match between the problems as it really is seen by the user and the conceptual model proposed by the designer. Here, too, close cooperation is required between the user and the designer. Validating the conceptual model is important in that this in turn validates the modeling of the problem at a conceptual level, independently of its implementation.

IV CONCEPTUAL MODEL OF COOPERATION

(ERGONOMIC ANALYSIS MODEL)
Designing a cooperative digital information system doesn't mean being more ergonomic but thinking about ergonomics differently, in terms of cooperation and therefore interactions between the digital information system and the user. Cognitive ergonomics usually requires more explanations whereas in a cooperative approach, although explanations are not ruled out, it is more a question of adapting the mode of reasoning and communication to the user. Some work in cognitive ergonomics shares this idea. The main ideas of the ergonomic analysis model are:
The analysis of user/system cooperation: Cooperation does not follow any predefined plan but rather a notion of intention and a certain distribution of tasks among the different players, taking into account their various skills. It is an analysis in a real world situation where the degree of formalization of the cooperation (both formal and informal) is brought to the forefront. "The concept of cooperation depends on the level of abstraction at which the analysis is carried out".

The taking into account of organizational aspects in the problem solving process: This means taking into account the corporate culture, structure, hierarchy and the material means at the disposal of the end user in the organization.

The taking into account of the end user in the problem solving process: This means taking into account the skills of the end user and the kind of dialogue customarily used. It means determining the sequences of user/system dialogue so that the partner can take control of the problem solving process whenever he or she wants and thus co-pilot the process. The partners (user/system) are in a symmetrical relationship, neither one having precedence over the other. Results must be presented explicitly, in accordance with the partner's normal mode of reasoning and thinking.

What must be underlined here is the new cooperative situation in which the end user is integrated.

Designing the Conceptual Model of Cooperation (CMC) is therefore a question of:
1) Analyzing the type of organization (service sector, industry, etc.), the way it functions (traditional hierarchy, structured, etc.), and its size. The place of the system within the organization must be considered. There are few types of organization (TO). A large, highly structured organization implies strong constraints such as lack of flexibility, longer response time between management and employees; a small organization has shorter deadlines, greater flexibility, and faster response times. Today just these two categories of organization will be used but others may be added in the future.
2) Analyzing the type of cooperation between the user and the system. The research described in this paper suggests a typology of user/system cooperation in order to distinguish the different possible interactions between the two players. Cooperation is considered in terms of interactions.
Many authors have underlined the importance of how cooperation is considered in the framework of a cooperative system design approach. They include:
A mode of cooperation as a set of indications about the way the different roles are allocated to the users and the digital information system. Each mode of cooperation will be more relevant in certain problem solving contexts and the mode can be changed during the problem solving process if the context requires this.
This paper gives different possible types of cooperation which will serve as a basis for the cooperative approach. Each type of cooperation will be examined in terms of five criteria: the general goal, breakdown into tasks, task allocation, task interruption and task control.

The central idea of cooperative digital information systems is that of interactivity between digital information system and partner. The digital inforamtion system at the service of the user and the user at the service of the digital information system: here we see the notion of symmetry in the relationship between user and digital information system. Interactivity is well and truly part of cooperation, and a Cooperative Approach (CA) implies interaction between all the different players. Note, however, that there may be a strong interactivity between a user and the digital information system without there being any real cooperation.

The steps described for the design of interactive decision support systems and knowledge-based systems remain relevant: in addition, in a cooperative approach they are strengthened by the distributed intelligence of the problem in terms of interaction and also by the specification of the type of cooperation.

There are three types of cooperation, this typology serving as a basis for Cooperative digital information Systems (CDIS):
"Complementary" type cooperation, "interdependent" type cooperation and "negotiated" type cooperation.
These types have been defined according to the different possible interactions between the partners, i.e. players (mentioned above) involved in a cooperative approach. The types range from the least cooperative - complementary cooperation - to the most cooperative - negotiated cooperation.
The type of cooperation determines the way in which the system and potential user (U) will work and interact and, to begin with, will be chosen from the three types given above (complementary, interdependent, and negotiated). Moving from the problem to the type of cooperation is a task of understanding the user/system relation.

The Conceptual Model of Cooperation (CMC) is built not only on the basis of the type of organization and type of

user/system interaction but also on a user model in terms of problem solving and communication modes.

3) Adapting the system to the user through a user model, by specifying the user's normal problem solving and communication methods. There are two models, the user's problem solving model (UPSM) and the user's communication model (UCM).

THE CONCEPTUAL MODEL OF COOPERATION (CMC) IS MADE UP OF:

1) THE TYPE OF ORGANISATION (TO)
2) THE USER TYPE OF COOPERATION (UTC)
3) THE USER MODEL WITH THE USER'S PROBLEM SOLVING MODEL (UPSM) AND THE USER'S COMMUNICATION MODEL (UCM).

The particularity of the CMC is that the analysis is done mainly in terms of interactions.

V CONCLUSION

Whenever a digital information system is to be designed, it is essential to focus on user/system performance in a business process rather than on the performance of the system taken in isolation. The system and the user are partners who are both involved in a query-answer process or a decision making process. This type of system transforms the way work is organized. At the beginning, systems attempted to automate certain complex or fastidious tasks; today cooperative digital information systems try to open the frontiers and to raise the intellectual content of all work,specially in extended companies. Progressively work will call on the ability to understand, react to, organize and enhance information. .

A cooperative digital information system is therefore a system that responds to the needs of the user both through its ergonomic components and its ability to solve problems. The design, validation and maintenance of such a system require an interdisciplinary approach and the definition of new concepts focusing on the characteristics of cooperation between individuals and the system.
The aim of the work described in this paper is to use business process modeling, 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 centered" design since it integrates right at the start of the design process a "cooperative" organizational dimension. [4]

The analysis of digital information systems engineering for extended companies highlights new employees' information needs. More particularly, the digital information system as an essential instrument to provide the users as workers with information and knowledge those are required to accelerate and improve the reliability and the quality of their decisions. [6]
That leads to consider the vision of the digital information system engineering, which distinguishes four steps. Therefore, the digital information system centered on the users and the systems cooperation becomes a new way to design the architecture of a Digital Information System adapted to an Extended Enterprise. [7]

From this view point, for information system engineering, it is very important to take into account: Business process modeling, production and deployment of software, like the *Unified Modeling Language* (UML) [8] and The *Unified Software Development Process* [9] ERP contribution, technologies for distributed and shared treatment (Groupware, workflow, CSCW…).
Our vision consists on:

1. Information System is the heart of the enterprise
2. Word-wide economies depend more and more on computers
3. Application become more et more big, important, complex, distributed
4. Business requires more and more productivity, more and more quality with development more and more short
5. Management of requirements is easier
6. Process modeling induce a global view of business

The advandages of this vison is that is based on a modeling language standardized, the usability is at the heart of the approach, towards a Knowledge Management vision with Knowledge taken into account thanks to the approach, the dialog technicians-analysts-users, the serenity of models and documentation, and finally the capabilty to handel the complexity of the system. The difficulty is a radical change for digital information system design

The stake becomes to find the best methods, techniques and tools in order to design a Digital Information System (DIS) with all these characteristics. A DIS designed with these different aspects provides companies with the fundamental support corresponding to a voluntarily and aware process and user centered approach. This is the sense that we give to our research group.

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