A TEMPORAL FRAMEWORK EMBEDDED IN DECISION MAKING SYSTEMS

Vasile MAZILESCU
vasile.mazilescu@ugal.ro
Dunărea de Jos University of Galati, Romania

This paper shows that the influence of knowledge on new forms of work organisation can be described as mutual relationships. Different changes in work organisation also have a strong influence on the increasing importance of knowledge of different individual and collective actors in working situations. After that, we characterize a piece of basic formal system, an Extended Fuzzy Logic System (EFLS) with temporal attributes, to conceptualize Distributed Knowledge Management Systems (DKMSs) based on human imprecise for distributed just in time decisions. The approximate reasoning is perceived as a derivation of new formulas with the corresponding temporal attributes, within a fuzzy theory defined by the fuzzy set of special axioms. In a management application like the prototype REFK2, the reasoning is evolutionary because of unexpected events which may change the state of the DKMS. In this kind of situations it is necessary to elaborate certain mechanisms in order to maintain the coherence of the obtained conclusions, to figure out their degree of reliability and the time domain for which these are true. These last aspects stand as possible further directions of development at a basic logic level for future technologies that must automate knowledge organizational processes.

Keywords: Temporal framework, Extended Fuzzy Logic System, Decision Making Systems

1. Introduction

Work organisation is a complex concept used in a variety of ways in different disciplines, research traditions and language contexts. It encompasses the technical, functional and social structures of work within the workplace and beyond. Usually the term refers to the ensemble of task structures, divisions of labour, forms of control and co-ordination, and forms of co-operation. Often the concept also includes the deployment of personnel in functional, temporal and social dimensions and the use of skills. Economic and social life became dependent on knowledge, so it is essential to accurately explore and understand the significance of the real processes and phenomena and their consequences. One consequence is the growing importance of knowledge. It is discussed more than ever on intelligent products, knowledge-based services, intelligent systems (connectionist systems, fuzzy systems, multi-agent systems, systems for evolutionary computation, hybrid systems) expert systems and / or knowledge based systems, intelligent enterprise, intelligent houses, workers who use knowledge, organizations based on intensive knowledge, continuously learning organizations, knowledge economy, etc. All these are related to the fact that the products, services and all social activities will include increasingly more knowledge in order for problem solving, process development, decision making etc., to take place supported by the newest technologies. For some processes, knowledge (fuzzy or temporal) is the very basic raw material, subject to creation, storage and transfer. Information Society has revolutionized the work making it an intellectual work, where efficiency needs more and more knowledge. This explains why appeared competent users or new disciplines specialized in knowledge processing. One of them is called knowledge engineering and aims to disseminate the analysis and development methodology of knowledge-based systems, intelligent information systems, and to train such systems' developers or cognitions. In organizations with intelligent behavior, the role of personnel, of knowledge pieces, learning and innovation, and internal operations of the departments are conducted in accordance with a specific logic. Knowledge engineering is one of the newest and most fascinating disciplines of information society. This discipline evolved from the art of developing expert systems, knowledge-based systems and information systems that integrate expert systems. In its work, it is known that the organization relies on a fundamental resource - knowledge, for which all its defining elements such as learning, innovation, creation and efficient updating of the knowledge pieces, etc. fall under the auspices of knowledge management. Whole staff knows that based on this foundation has permissiveness, motivation, opportunities and capacities to act intelligently.

Currently, in information technology the focus is especially on data storage, at the expense of means of transforming data into useful information for decision-makers. Under these conditions, managers are often forced to spend time browsing thousands of data sources of enterprises looking for the information they need, rather than analyze them. Often, efforts are directed to IT departments which are forced to reduce the time spent maintaining and improving systems. Difficulties in accessing information are: (1) obtaining data takes too long and is generally late; (2) the analysis adversely affect the performance of transactions;

(3) necessary information appears in an inadequate format; (4) information is rarely consistent and constantly subject to change; (5) ad-hoc queries are difficult. AI tools have been subject to major changes in recent years, from their original meaning, becoming the new core technology for customers analysis based on e-commerce, information portals and other. These instruments have an increasing number of users.

This paper has as scientific objective to analyze the impact of our temporal framework on the synthesis of intelligent systems in economy. To this end, an intelligent system in economy was considered any system that incorporates operational knowledge, often inaccurate, which can be formalized, represented and used rationally within KMS, which includes FKBS. An intelligent organization is defined by its strategy. If an organization is focused clearly on its objectives, then there is no need for centralized planning and control systems. Organization will be able to advance through continuous interactions between its members which, through trial and error, will find the best organization for their environment and will be able to adjust it according to environmental changes. An intelligent organization cannot lose its goal, because the organization itself is re-creating continually through intellectual cooperation. The goal guides the organization, not vice versa. The use of knowledge and communication is the central objective of section 2, because already exists a long debate about the transformation of fuzzy temporal knowledge into technical and standardised working procedures or operational knowledge. Section 3 presents some contributions from logical perspective, characterizing an Extended Fuzzy Logic System with Temporal Attributes for Distributed Knowledge Based Systems, and in section 4 are presented concluding remarks.

2. The use of Knowledge and Communication

The intention of this section is to show that the influence of knowledge on new forms of work organisation can be described as a mutual relationship. It is not only the case that the content and structure of knowledge change the organisational patterns of working activities; conversely, different changes in work organisation also have a strong influence on the increasing importance of knowledge within the production processes as well as on the social and cultural expectations of different individual and collective actors in working situations [1,2]. One of the central advantages of modern ICTs is that they bridge both time and space, which traditionally have been key barriers to information and knowledge exchange. ICTs enable rapid communication across geographical space and organisational boundaries [3]. It is no longer necessary to combine all competences and resources in the same place. Because of the networked character of these technologies, people from all over the world with different expertise can work together to resolve specific problems. This ability to overcome geographical limitations together with the rapidity of transmission can be seen as the major ways in which modern ICTs can facilitate further acceleration of the innovation process. The communication and storage capacity of network technologies enables the creation of innovation as well as the production of knowledge. In this respect, it seems very important that modern ICTs support the exchange of both codified and tacit knowledge. The codification of knowledge on the one hand reduces transaction costs and on the other hand makes it possible to establish information bases and electronic networks for enterprises. Modern ICTs are the first global technology with the potential for international codification and transferability of intercultural communication. Knowledge is from this perspective a non-rival good. It can be shared by many people without diminishing in any way the amount available to one of them. Without taking this important issue into account, the new possibilities of worldwide communication, the models of networking and the creation of new social and cultural perspectives through ICTs cannot be considered seriously. At the firm level, ICTs contribute to the creation of new knowledge which can accelerate different learning and innovation processes. They radically transform both intra- and inter-firm communication which is of particular importance in the daily operation of intensively co-operating company networks [4,5]. ICTs can also radically transform communication between firms and their clients. The possibility of direct communication with clients (who are becoming one of the most important sources of knowledge) opens up new paths to company level learning. As well as technical access to modern ICTs, specific skills and routines are needed to use the technologies, which are also strongly connected with the capability to generate non-formalised communication. From this perspective, the emphasis is on their potential to reinforce human interaction and interactive learning and ways that companies can support and mobilise tacit knowledge [6,7,8].

The most important impact of ICTs is that they move the border between tacit and codified knowledge. The attention to increasing skill requirements and the growing knowledge-intensity of jobs related to ICT and to the structural transformations they bring about in the economy, also results from the incompleteness of the codification of knowledge and the growing relative importance of the remaining tacit knowledge components. Other researchers also agree on the growing importance of generic skills because of the limits of codification and automation [9,10]. In particular in knowledge work it is now assumed that precisely the remaining tacit knowledge part will embody the main value of the activity and that work relies to an important extent on tacit knowledge (creativity, talent, experience), that by definition requires more autonomy and discretion in the job.

With respect to the tacit *versus* codified skills debate it is important to note that the interaction between both kinds of knowledge (tacit and codified) should be acknowledged. Knowledge creation or learning is 'an accumulative process whereby tacit knowledge is transformed into codified knowledge and new kinds of tacit knowledge are then developed from close interaction with the new piece of codified knowledge. Such spiral movement is at the every core of individual as well as organisational learning. Huws describes this dynamic relationship between tacit and codified knowledge and the concurrence of upgrading and deskilling in the processes of innovation and technical division of labour. Codification and deskilling are counterbalanced by tasks that require different kinds of (new) skills related to new emerging tasks, such as creative tasks, but also relational, communication or commercial tasks (Perret, 1995). The implications of a - proportionally - growing knowledge-intensity of jobs, can be considerable. If knowledge-intensive jobs can be defined as those jobs where the active and independent acquisition, processing and development of knowledge and information plays a dominant role, this implies that these jobs are by nature complex and non-routine, because of the importance of non-codified knowledge in this process. The assumption is that a so-called 'knowledge worker' can easily access complex knowledge, is continuously learning and is qualified to use formal, abstract and complex information. The work organisation of such work will have specific characteristics, notably these workplaces will be characterised by non-routine, non-standardised jobs, requiring autonomy and opportunities for learning and intensive interaction and collaboration with others (inside and beyond the firm) in view of problem-solving requirements. The question remains what is the spread of such knowledge-intensive jobs in firms and organisations and to what extent and under what conditions knowledge work, is becoming a more dominant type of work in Europe to the detriment of routine work.

Related to the debate on knowledge work and increasing knowledge-intensity, in recent years a growing body of research has emerged from studies in computer science and organisational studies focused on knowledge management systems within organisations and beyond. In order to manage knowledge, knowledge and information is codified and standardised. Some approaches to knowledge management prioritise structural models and IT systems whereas others focus on processes, communities of practice and dialogue. The main problems knowledge management aims to solve, *i.e.* the generation, representation, storage, distribution and application of knowledge, are of particular importance in networked organisations and with distributed work [11]. While advanced databases greatly support co-operation over distance, recent trends in the debate on knowledge management emphasise implicit knowledge and the role of communities of practice [12,13]. Research on various forms of work indicates that neither higher levels of codification of knowledge, increased planning, nor a more intensive use of technology can fully replace tacit forms of knowledge in the light of increasing complexity and critical situations. Likewise, the more information is codified and stored in ICT, and retrievable from it, the more important tacit knowledge becomes in selecting, combining and applying knowledge [14]. With respect to distributive teams, it is however worth making a distinction between the uses of ICT in 'task-orientated' *versus* 'space-time dependent' forms of distributive virtual teams. In task-oriented teams, the ICT support is more useful for efficient co-ordination (management of workgroup inter-dependencies) in comparison with space-time dependent teams. This distinction is especially important in the case of use, transfer and sharing of so-called diffused knowledge (tacit skills) in comparison with codified knowledge. It is anyway crucial to understand the impact of new forms of work organisation on the opportunities for the acquisition, mobilisation and utilisation not only of explicit, but also of implicit knowledge [15].

The restructuring of value chains is, next to ICT, a second important 'driver of change' which is of interest in relation to the introduction structural changes in the skills structure of organisations. In this respect the emergence of the so-called networked organisation is especially relevant [16]. The impact of ICTs on knowledge and communication is a crucial factor in globalised corporate restructuring, implying an increased externalisation of activities through outsourcing and subcontracting, a considerable change in transaction costs and - thus - a growing importance of market-led forms of control and management of businesses functions. A number of authors describe this transformation from the traditional bureaucratic organisation to a networked organisation. It is argued that organisations are disintegrating and networked forms of co-ordination of economic transactions are emerging. Several recent studies focus on the different forms these networked organisations can take and what implications this can have on different aspects of the employment relationship and on the social dialogue. Without describing in detail the different forms of 'multi-employer' environments networked or boundaryless organisations, it is obvious that such new organisational models will have huge implications for the way skills acquisition and development are organised in firms [17].

The evolution towards distributed organizations seems to be inevitable once everyone has access to collaboration systems that allow horizontal, crisscross interactions. Organizations that remain too hierarchical may soon crumble under the pressure created by these systems. This trend started with phone, fax, and now with the Internet which has exploded. Central coordinating items appear and disappear when making successive adjustments in response to environmental change. Companies wishing to increase their collective intelligence, must therefore make a priority from implementing collaborative intranets. We do not refer here to an intranet for information or communication, but one that provides real cooperation. A collaborative intranet allows information to flow through individual horizontal interaction, rather than a top-down central coordinated communications company. Information finds its way to right individuals, on appropriate levels. They do not need the same information level at the same time to produce collective intelligence. What matters is that information must be distributed. This information may reach to someone in the organization who really needs it, without requesting it. Note that there is no absolute ideal organization, only for a specific culture, a specific environment and specific context. Therefore, an organizational structure will always be relative and contextual. Schematically, the company consists of four elements: strategy (which provides the vision, concept, direction), an organization (that structures the power, the relations), systems (e.g. Information, management, control, allowing operation of the organization) and operations (all objectives, activities, tasks). A sale is a transaction between two brains, and the sale instruments are: the commercial thinking matrix, cognitive brain, info-exchange, mental maps (very close to neuro-genetic models), compass of the sale. This approach supports the use of the brain in an increasingly large proportion, namely its extraordinary creative ability.

During the last decade, there was a transfer from data-based information systems to information systems based on processes. Business Process Management includes methods, techniques and tools to support design, use, management and analysis of operational business processes involving people, organizations, applications, documents and other sources of information. Business Process Management can be considered an extension of classical systems based on workflow management. A *business process* is a set of activities that follows a logical flow, resulting an output. A business process is to specify the tasks to be fulfilled to achieve a business objective. Inputs and outputs may be facts and / or information, and the transformation can be performed by human actors, machines, or both. Although an organization's business processes can be tracked separately, by integrating them is obtain value-added which, long term, leads to positive results, a good control over the resources involved and over the environment in which it operates. Petri networks are tools of business process modeling. One of the advantages of using Petri networks for modeling workflows is access to many analysis techniques based on Petri networks. Accuracy, applicability and efficiency of business processes supported by systems based on workflow management are vital to any organization. It is important to review the definition of a process through network flows before applying it in practice. In theory, there are three types of analysis: (1) *validation*, testing whether a workflow behaves as expected; (2) *verification,* determining the accuracy of the network flow; (3) *performance analysis*, evaluating the ability to meet the requirements, taking into account the time, levels of work and resources. Validation can be done through interactive simulation: are analyzed a number of cases to see if the system behaves properly. For verification and performance analysis, are used advanced analysis techniques specific to Petri networks, such as invariants, reachability trees, coverage graphs analysis, etc. The multitude of available analysis techniques shows that Petri networks can be seen as an independent environment (solution) between the design of a process' definition through workflows and the analysis of the resulted workflow.

Another important direction in the synthesis of intelligent KMS systems in economy is the development of heterogeneous computing environments, in which one can develop adaptive algorithms for planning and resource allocation using genetic algorithms and evolutionary computation technology [18]. Heterogeneous computing environment is a suite of processing units, high-speed interconnections, interfaces, operating systems, communication protocols, and programming environments. It provides a variety of architectural options and skills that can be adapted to perform an application in accordance with different execution requirements.

Different parts of an application task often require different types of calculation. It is generally impossible for a single architecture along with the compiler, operating system and associated programming tools to equally meet the computational requirements in such an application. In the heterogeneous computing environment considered, an application task can be decomposed into subtasks, each subtask being computationally homogeneous (appropriate, indicated for a single processing unit) and different subtasks may have different architectural requirements. These subtasks may have data dependencies between them. If the application task is decomposed into subtasks, the following decisions must be taken: subtasks' distribution on different processing units and scheduling, ordering subtasks' execution for each processing unit, as well as planning data transfer between processing units. In this context, the aim of heterogeneous compilation is to obtain a minimum duration of execution, i.e. the minimum total execution time of the application task in the suite of processing units. It is well known that such an allocation and planning problem is generally NP-complete. It was proposed a large number of approaches to different aspects of this problem. This chapter proposes an approach based on genetic algorithms to solve the problem of concurrent allocation and planning in heterogeneous systems from the computational point of view. It decides the subtasks' allocation to processing units, orders the execution of the subtasks allocated to a processing unit and coordinate the data transfer between subtasks. The characteristics of this approach include: separation of allocation and planning representation, the independence of chromosomes' structure from communication subsystem's details and an assessment of the coverage degree and overlap between all communications and calculations that meet the precedence constraints of subtasks.

3. Characterizing an Extended Fuzzy Logic System with Temporal Attributes

The approximate reasoning refers to creating new rules of inference and translation. It is a mathematical instrument used for modeling the human reasoning based on imprecise knowledge. The theory suggested by Zadeh is based on intuitive rules and leads to operations with fuzzy relations, obtaining thus very useful applications [19]. This perspective has the advantage of demonstrating that the fuzzy logic is a generalization of bivalent logic, replacing the discrete feature of the latter with a continuous one. If in the case of bivalent logic there are used methods that clear up every possibility of evaluation according to the interpretation function, when we refer to fuzzy logic this are no longer possible. The formalism of the first-degree fuzzy logic represents the mathematical basis for the general theory of approximate reasoning. A special feature of the human thinking is the effective use of natural language even within the process of logic reasoning. According to this observation, we can conclude that the mathematical model of the way in which man thinks (acts) in a management position and at a certain level of synthesizing decisions, could be based on the fuzzy logic, combined with modal temporal features. I will tackle next the formalism of first-degree fuzzy logic, highlighting the structure of truth values, the extended syntax and the semantics of this formal logic system. I will underline in this way the connections between fuzzy logic and approximate reasoning, which is further analyzed through the possibility reasoning, which is considered useful by the inference engine of the expert management system SECOMBCF [19].

The structure of truth values is a residual lattice written $L = (L, \vee, \wedge, \otimes, \rightarrow, 0, 1)$ where the 0 and 1 values are the smallest respectively the biggest elements, $\vee$ and $\wedge$ are the supremum, respectively infimum operators, $\otimes$ is the isotone product operator for both variables, $(L,\otimes,1)$ is a commutative monoid, and $\rightarrow$ is the residuation operator. Furthermore, $a \otimes b < c$ only if $a < b \rightarrow c$ $(\forall)$ $a,b,c \in L$. For $L = [0,1]$ the logical connectives are $\vee = \mathbf{max}$, $\wedge = \mathbf{min}$, $a\otimes b = 0\vee (a+b-1)$ and $a \rightarrow b = 1 \wedge (1-a+b)$. If we consider, for instance, $a\otimes b=\mathbf{min}(a,b)$, then the only corresponding residuation operator is the Gödel implication operator. *The syntax* of the basic language of the extended first-degree fuzzy logic with modal temporal operators consists of: (x,y,...) *variables* and (c,d,r,...) *constants* seen as elements that describe the set of states of an expert management system $X^{SEC} = X^{SE} \cup X$, (f, g,...) *functional symbols* of n arity, a set of *symbols for the truth values* $\{a: a \in L\}$, *predicate symbols* of n arity, *a binary connective* $\Rightarrow$, a $\{o_i: i\in J\}$ set of *connectives of m arity*, a *symbol for the* $(\forall)$ *quantifier*, the o modal temporal operators (the following moment in time), (for all present or following moments in time), $\lozenge$ (for a present or following moment in time) and punctuation marks. The terms are classically introduced. *The formulas* are defined as follows: **i**) an *a* symbol for a $(a\in L)$ truth value is an atomic formula; **ii**) if $t_1,...,t_n$ are terms and p a predicate symbol of n arrity, then $p(t_1,...,t_n)$ is an atomic formula; **iii**) if A, B, $A_1,...,A_m$ are formulas and o_1 is a connective of m arity, then $A \Rightarrow B$, $o_1(A_1,...,A_m)$, $(\forall x)A$ are formulas. The $\rceil A$ formula is an abbreviation for $A \Rightarrow 0$. There are similarly defined the $(\vee)$ disjunction, the $(\wedge)$ conjunction, the $(\Leftrightarrow)$ equivalence, A&B, $(\exists x)$ A, $A^k = (A \,\&\, A \,\&\, ... \,\&\, A)\ /_{k\ times}$; **iv**) The $x^{SE} \in X^{SE}$, $x\in X$ variables are formulas, and if g is a formula, then og, g, $\lozenge g$ are formulas, too; **v**) Any application of the above-mentioned rules for a certain number of times, determines a formula. Given a J_1 language of the extended first-degree fuzzy logic with modal temporal operators, the set of all terms will be noted M_{J1}, and the set of all formulas will be noted F_{J1}. If t is a term and A is a formula, then $A_x[t]$ is the formula obtained by substituting of the t term whenever the x variable appears freely in A. $g_s = (x_1\vee x_2 \vee...\vee x_n)$ and $g_0=(x_{01}\vee x_{02}\vee...\vee x_{0n})$ are given fuzzy formulas. The $g_0 \rightarrow \lozenge g_s$, $g_0 \rightarrow \lozenge\ g_s$, $g_0 \rightarrow \lozenge g_s$ relations are formulas too, and they allow expressing certain qualitative management conditions.

The semantics of the first-degree fuzzy logic is defined as follows. A *structure* of the language of the fuzzy logic J_1, is characterised by $\overline{D} = (D, p_D, ..., f_D, ..., u, v,...)$ where D is a set, $p_D\ D^n$ are relations of n arity assigned to each p n-ar predicate symbol and, f_D are n-are functions in D assigned to each functional symbol of n arity, whereas $u,v,... \in D$ are elements assigned to each u,v,... constant of the J_1 language. Take $\overline{D}$ a structure for the J_1 basic language. The interpretation function of the formulas in $\overline{D}$ is a $\widetilde{D}: F_{J1}\rightarrow L$ function, which assigns a truth value for any formula from F_{J1}, as it follows: **i**) $\widetilde{D}(a) = a$, $a\in L$; **ii**) Take $t_1,...,t_n$ terms without variables and p an n-ar predicate symbol. Then $\widetilde{D}(p(t_1,...,t_n))=p_D(\widetilde{D}(t_1),..., \widetilde{D}(t_n))$, where $\widetilde{D}(t_i)\in D$ is an interpretation of the $t_i\in M_{J1}$, i=1,...,n term; **iii**) $\widetilde{D}(A\Rightarrow B) = \widetilde{D}(A) \rightarrow \widetilde{D}(B)$, highlights the fact that A and B are closed formulas; **iv**) $\widetilde{D}(o_1(A_1, ..., A_n)) = o_1(\widetilde{D}(A_1), ..., \widetilde{D}(A_n))$; **v**) $\widetilde{D}((\square x)\ A(x)) = \wedge_{d\square D}\widetilde{D}(A_x[\mathbf{d}])$, where **d** is the

name of the $d\in D$ element; **vi**) $\widetilde{D}(A(x_1,...,x_n)) = \wedge_{d1,...,dn} \widetilde{D}(A_{x1,...,xn}[d_1,...,d_n])$. Take $Y \underset{\sim}{\subset} F_{J1}$ a fuzzy set of formulas. The fuzzy set of semantic consequences of the Y fuzzy set (where $Y(B) \in L$ represents the truth degree of B in Y) is: $(C^{sem}Y)A = \wedge\{\widetilde{D}(A)$: $\overline{D}$ is a structure for J_1 and (for each $A\in F_{J1}$), $(Y(B)\leq \widetilde{D}(B))\}$.
If $(C^{sem}Y)A=1$, then for any fuzzy set of Y formulas the following relation occurs $\models$A and A is a tautology, and C^{sem} is the closing operator in *L.*

Lemma 1. A) $\models A\Rightarrow B$ only if $\widetilde{D}(A) \leq \widetilde{D}(B)$; **b**) $\models A\Leftrightarrow B$ only if $\widetilde{D}(A) = \widetilde{D}(B)$, for any $\overline{D}$ structure. This result is used in the derivation of tautologies. It is allowed the introduction of a set of fuzzy axioms to support the derivation of new formulas.

A *logical inference* is a $B_1,...,B_m$ sequence of formulas, each of them being either a logical and special axiom, or a formula derived from other formulas, using a rule of inference. The rules of logical inference can be schematically written under the form $A_1,...,A_n$ / B where $A_1,...,A_n$ are known formulas, and B is a derived fact ($A_1,...,A_n$, $B\in F_{J1}$). The rules of inference preserve the truth values after the inferential process.
The theory of approximate reasoning, as a methodology of exploitation of imprecise knowledge with respect to the state of the expert management system (noted with $\mathbf{x}^{SEC}\in X^{SEC}$ and represented as distributions of possibility), allows that, given certain logical inferences, strict characterizations of the values of linguistic variables to be obtained from the structure of the $\mathbf{x}^{SEC}$ state, compliant to the management purpose. The X^{SEC} set can be defined as a Cartesian product X^b **x** X^{int} **x** X, in which $\mathbf{x}^b = [x_1^b \ x_2^b \ ... \ x_{k_1}^b]^t \in X^b$. For instance, the x_1^b component marks, through its values, possible command events for the process, $x_i^b \in U^{(i)}$, $i=2,...,k_1$ where $U^{(i)}$ are the universes of discourse attached to the linguistic variables $X^{(i)}$ (chosen in order to characterise the $\mathbf{x}^{SE}\in X^b\mathbf{x}X^{int}$ state), X^{int} represents the set of internal states of the engine of inference, and X refers to the set of the states of the process.

Types of Knowledge Specific to a Real-Time Expert Fuzzy System

Creating certain efficient reasoning algorithms, within expert management systems, demands for a corresponding analysis of the type and signification of knowledge from the structure of the involved models. The elements presented in the next section of the paper refer mostly to the logical aspects regarding fuzzy inference, without paying too much attention to the semantics of the fuzzy rules. From this point of view, the implication and the multi-evaluated extensions can correctly express the problem of the semantics of the fuzzy rules, hardly investigated in literature. There are put forth three types of fuzzy rules „if..., then..." according to the paper [19] and these will be further presented in this paper: **i**) *Rules to qualify certainty*. These rules are expressed like "the more $u\in A$, the more sure $v\in B$", which are translated by the relation $(\forall)$ u, $\mu_A(u) \leq g_t(B)$, where $g_t(B)$ evaluates the degree of reliability of the statement $v\in B$ when x=u. The g_t function can be any occurrence of the kind necessity, possibility, and probability; **ii**) *Gradual rules* (or rules to qualify truth) expressed by: "the more u⍰A, the more $v = f(u)\in B$", i.e. there is a f : Supp(A) Supp(B) function so as $f(A) \subseteq B$. This condition can be written down again as $(\forall)u\in A$, $\mu_A(u) \leq \mu_B(f(u))$, a relation as a definition of the fuzzy function in the paper [8]. This last relation can be relaxed by replacing the f function with the R fuzzy relation, and thus resulting the inequality: $(\forall)u,v$, $T(\mu_A(u), \mu_R(u,v)) \leq \mu_B(v)$, where T is a triangular norm. We can create this type of statements of the kind "the more $u\in A$ and the more u is in relation with v, the more $v\in B$". In this situation, the degree of truth of the antecedent restricts the degree of truth of the consequent; **iii**) *Rules to qualify possibility* expressed by: "the more $u \in A$ the more possible $v\in B$", which represents a partial description of the R relation between u and v. In this case, the inclusion $AxB \subseteq R$ takes place, and this further implies that $\mu_R(u,v) \geq \mathbf{min}(\mu_A(u),\mu_B(v))$. This type of rules is used in the fuzzy decision/control process.

The interpretation of the semantics of fuzzy rules is important, since it allows the selection of certain ϕ- operators to match with the significance of the rule. In the case of gradual rules, Yager's principle of minimum specificity is satisfying in order to obtain the distributions of possibility implied by these rules. For instance, the R relation from the gradual rules definition is a relational fuzzy equation with unknown μ_R. Applying the minimum specificity principle leads us to the definition of the distribution of possibility $\pi_{x|y}(u,v)$, which expresses the semantics of the rule as a maximum solution in the $\mu_A(u) \leq \mu_B(f(u))$ relation, i.e. $\pi_{x|y}(u,v) = \mathbf{sup}\{\alpha \mid T(\mu_A(u,\alpha) \leq \mu_B(v), (\forall)\ u,v\}$. This result offers to the R – implications semantics of representation of gradual rules. The minimum specificity principle is not sufficient in order to solve the above-mentioned inequality, especially when B is fuzzy. This last problem demands the use of a qualification of α-certainty applied to B. The above-mentioned aspects entail possible domains of application of the various types of fuzzy rules, compared to their semantics for different kinds of reasoning: uncertain, interpolative, by analogy. In the case of the expert management system REFK2 prototype, the inferential subsystem based on fuzzy logic uses the scheme of inference generalized modus ponens. The knowledge-based reasoning represented as certain distributions of possibility, uses the notion of similarity defined as complement of distance.

The DKMSs can entail also the temporal reasoning. In this situation, we attach temporal descriptors like $\mathbf{DT}_{\alpha}$, to rules which can be punctual (α=p) or interval(α=i). These temporal descriptors can be modeled with the help of certain distributions of possibility, so as to attach the fuzzy statements of temporal features. The attachment of the temporal fuzzy descriptors is specific to artificial intelligence techniques, but from the point of view of automation, this idea is equal to the fuzzyfication of the moments of time within the discrete events systems theory, a class of systems which the expert management system developed in this paper is part of. So as to elaborate an actual model for an expert system, in which to make possible the development of the temporal possibilistic inference, we will refer to the structure of the expert system based on the fuzzy inference. The temporal descriptors are operators that characterize the temporal properties of a P fuzzy statement and these can be:

i) *punctual* $\mathbf{DT}_p\left(P,\int_T \frac{\mu(t)}{t},u\right)$; **ii**) *of interval type* $\mathbf{DT}_i\left(P,\int_T \frac{\mu_1(t)}{t},\int_T \frac{\mu_2(t)}{t},u\right)$, in which P is a fuzzy sentence, $\int_T \frac{\mu(t)}{t}$ is a T-number that describes the point on the axis of time at which statement P takes place, and μ represents the membership function of the moment of time associated to P.

Similarly, the T-numbers $\int_T \frac{\mu_1(t)}{t}$, $\int_T \frac{\mu_2(t)}{t}$, that represent the moments of emergence and extinction of the event described by the P statement are also interpreted. The available information about a certain moment in time will be represented within the model by a possibility distribution.

Due to the change of values of the variables in a dynamic way within the problem domain, the evolution of the $x^{(i)}(t)$ specimens can engender dynamic corresponding symptoms in the fact base. Moreover, the basic rules describe the dependences between the numerical values of the symptoms by means of fuzzy sentences P_j, $j\in M_k$, $M_k\in M_0$, and the temporal relations between these symptoms by using the $\mathbf{DT}_j$ associated temporal descriptors.

In the case of the REFK2 system, this kind of knowledge does not interfere, since the temporal aspect appears only as real time, and not as the reasoning concerning time also. In fact, this last aspect of time is adequate in the artificial intelligence systems with applications in diagnosis. An important feature of time in expert systems in order to manage processes is represented by their real-time behavior, capable to guarantee a satisfying response time. By introducing certain real-time restrictions inside an expert system, we provide the system with features like: **i**) reasoning is evolutionary and non-monotonous because of the dynamic aspect of the application; **ii**) unexpected events can change the state of the expert management system. There is a series of additional problems if we take into account the temporal characteristics, associated both to the model and to the evidence system that reflect the state of the process at a certain moment in time. These problems can be summarized as it follows: **i**) The filtering of a temporal fuzzy rule demands that, beside the numerical filtering, to adequately solve the temporal filtering also, i.e. the temporal attributes attached to the motives within the structure of the fuzzy temporal rules R_i, i=1,...,n, must filter the temporal attributes formed by the corresponding dynamic symptoms from the fact base in a fuzzy sense. It is also necessary to determine a method of numerical temporal filtration, so as to evaluate the degree of filtration between R and X^b; **ii**) the way in which the conclusion can be inferred (i.e. the result of the inference and the corresponding degree of reliability) and which is the domain of time associated to it. The model associated to the filtering stage from the structure of a temporal fuzzy reasoning system based on intervals, must satisfy a series of conditions presented in above example. From the filtering point of view, we can obtain various situations, by choosing a corresponding window of filtration in the $U^{(i)}$ **x** T bi-dimensional space. Figure 1 presents a similar type of filtration. The filtering window can be a point or a rectangle, depending on how the temporal attribute attached to the P_i sentence is: punctual or interval. In the fact base, the evolution of values afferent to the $X^{(1)}$ and $X^{(2)}$variables, generates certain manifestations or specific situations, which are determined for the $\mathbf{x}^b$ state of the expert system. Meanwhile, the rules in which the $X^{(1)}$ and $X^{(2)}$ variables appear (implicitly attached to the P_1 and P_2 sentences), highlights the presence of some temporal descriptors that define the temporal relation between P_1 and P_2.

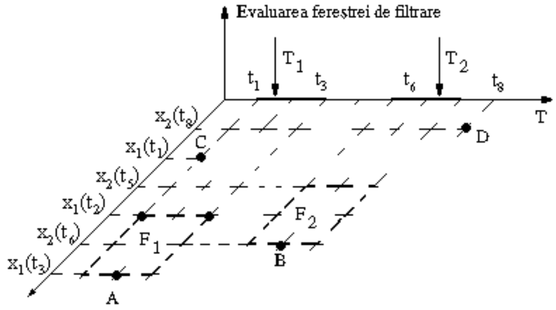

Figure 1. The bi-dimensional filtering space

This way, we can give top *priority to numerical filtering* by choosing $x_1(t_3)$ and $x_2(t_6)$ to be filtered with P_1 and, respectively P_2. We obtain a good result of the numerical filtering, but the temporal filtering offers weak results instead. We can give *priority to the temporal filtering* as compared to the numerical filtering. The results may favorably change for the temporal filtering compared to the first case (for example, we choose $x_1(t_3)$ and $x_2(t_8)$ or $x_1(t_1)$ and $x_2(t_6)$ in order to filter with P_1, respectively P_2). It is obvious the fact that there are other choice possibilities also in the $U^{(i)}$ x T space of the window filtering position. The unsolved problems from a practical point of view represent the means by which the width of the filtering windows is determined (F_1, F_2), their best possible positioning within the $U^{(i)}xT$ (i=1,2) space, the summary inside the filtering windows of the evolutions afferent to the $X^{(1)}$ and $X^{(2)}$ variables in values that can be further undergo a numerical filtering with P_1 and P_2, by assessing the consistency of the filtering phase on the whole. The advanced stages in order to obtain the reasoning strategy are: determining the time domain, temporal and numerical filtering. Once these properties have been mentioned, we may continue the development of the advanced model for the effective DKMS.

4. Conclusions

In the present paper we also analyzed the formal aspects of the reasoning corresponding to an expert management system as a decision making system that includes imprecise knowledge and time variables. With this aim, I extended a first-degree logic fuzzy system with temporal modal operators that allow the justification of the synthesis of certain linguistic process management models. The process of modeling the approximate reasoning assumes the definition of certain fuzzy sets of evaluated closed formulas, which are actually fuzzy subsets of certain sets of special axioms. The description of some models that include also attributes like temporal descriptors, we highlight the fact that the specification and synthesis of fuzzy management models is marked, from a logical point of view first of all, by the presence of the possible and the necessary. The temporal precedence relations can appear especially in diagnosis applications, where the introduction of time is made from the exterior and these types of applications allow symptoms classification. The formulas from the extended first-degree fuzzy logic domain with temporal modal operators can be used in order to model various management strategies. For instance, take $g_s = (x_1 \vee x_2 \vee \ldots \vee x_n)$, where $x_i \in X_s \subseteq X$ and take $g_0 = (x_{01} \vee x_{02} \vee \ldots \vee x_{0n})$ in which x_{0i} are initial states for the state variables of the ($1 \leq i \leq n$) process. Take $X^b \subset X^{SE}$ and $g_b = (x_{b1} \vee x_{b2} \vee \ldots \vee x_{bn})$ in which $x_{bi} \in X^b$. The $g_0 \rightarrow \Diamond g_s$ formula can be seen as an admission condition. The formulas: **i)** $g_0 \rightarrow \Diamond \; g_s$ (if the process starts from one of its initial states, then, after a certain number of moments of time its state will always be found in X_s); **ii)** $g_0 \rightarrow \; \Diamond g_s$ (if the process starts from one of its initial states, then it will be in X_s for an infinity of times); **iii)** $g_b \rightarrow \; g_s$ (if the inputs of the process are always in a X^b set, then the states of the process will always remain in X_s set), characterizes properties which can be thought of as the equal of the stability demands. The temporal logic is a particular type of modal logic and provides a formal framework which allows the description of the way in which certain systemic properties can be specified, and it is useful in a more profound understanding of the state of the systems. It is very important to know these facts when we refer to the expert management systems of technological processes, in order to analyze the time evolution of the states and events sequences, to implement and verify the system itself. We can more adequately specify the behavior of the management system within the temporal logic formalism, since this kind of specifications have a greater expressivity in comparison to the classical logic specifications. The temporal logic properties cover many of the dynamic behavior aspects of the knowledge-based management systems. That is why we consider that the logic formalism presented above is important for the creation of the REFK2 system, since it is an attempt of including both fuzzy and temporal attributes.

Performance of an organization should not be measured by the number of restrictions placed upon its data, but by the number of high quality connections created between people, and how fast and fluid are these connections. Risk of information to be stolen is real. But precautions taken to protect information against fraudulent people must not destroy the organization as a whole, slows down intellectual collaboration for the sake of protecting against a potential risk that may never happen. This endangers the long-term success of the company rather than opening the door to the unscrupulous. Only rarely individuals outside a company are trying to spy and steal information from there. In 80% of cases, people who steal information are people from the inside! Truly confidential information (strategic, sensitive) should not even be included in information systems, but to be specially handled. All of the information protection systems have a crack: overthrow. An employee leaving the company to work for its competitors damages the company more than any pirate in the computers would ever do, because he leaves with a lot of information, some of which are not capitalized and thus lost forever. The best way to protect our information is to gain employees' loyalty and to encourage knowledge capitalization and sharing. Recently implemented in organizations, KM essentially has three functions: (1) decision support by increasing the quality and quantity of knowledge, by facilitating the emergence of new ideas; (2) their identification, validation and conversion in projects; (3) production optimization (recurring processes), by implementing best practices, reducing errors and re-using knowledge and skills.

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