An Enterprise Control Support System for Economic Growth

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Abstract: - The successful leadership of any enterprise or organization which is in constant interaction with a multitude of external heterogeneous agents requires an increasing amount of knowledge. Thus, the management of distributed knowledge has become a critical factor for enterprise management, because: management structures are based on decisions taken at every organizational level, carrying out the production demands knowledge integrated into the different departments of the enterprise and the rapid and continual changes of the market impose accurate modifications (adaptations) in real time on clients and strategies. The purpose of this paper is to present the main results of our project PR356 to integrate multiple sources of knowledge based on an Enterprise Control Support System (ECSS) for Economic Growth.

Key-Words: Distributed Knowledge Management System (DKMS), Artificial Intelligence (AI), Enterprise Control Support System, Economic Growth

1. Introduction

DKMSs are real-time interdisciplinary decision making systems. Decision making becomes more complicated and difficult in today’s rapid changed decision environment than ever before [2,9]. Decision makers often require increasing technical support to high quality decisions in a timely manner. Decision support systems (DSS), as a kind of interactive computer-based information systems, help decision makers utilize data and models to solve mostly semi-structured or un-structured decision problems in practice. Intelligent DSS, along with knowledge-based decision analysis models and methods, incorporate well databases, model bases and intellectual resources of individuals or groups to improve the quality of complex decisions [3,5,8,10]. In the recent years, multi-criteria DSS, group DSS, and Web-based customer recommender systems have had unimaginable developments and improvements in dealing with complex, uncertain, and un-structured decision problems under the support of computational intelligent technologies. DKMS implies human resources management, ICT methods and AI techniques for which representing and processing of knowledge are ends all onto themselves. The correct management of knowledge, organized in the distributed knowledge models and exploited by an Enterprise Control Support System (ECSS), can raise the competition strength of the enterprise only through the complete integration of the technological aspects within the human and organizational ones. A well defined knowledge structure, which is based on the inclusion of heterogeneous and distributed information which may be used by any member of the enterprise at any moment, represents the basis for a knowledge ontology [1,4,7]. The ontologies are just the first step in the knowledge structuring and managing of distributed knowledge, implemented at the level of the different agents with which the enterprise may necessarily interact. The ECSS purpose proposed for development within the project PR356 is to integrate the multiple sources of knowledge regarding products, services, financial resources, firms and associations in order to offer a rigid, unique, interactive resource process for enterprise leadership as well as other components such as distributed agents, which may integrate different knowledge ontologies [6]. The management structures of enterprises, companies or governmental agencies elaborate different sequences of plans with a purpose to fulfill their objectives. At the level of the whole organization, the managers analyze the internal as well as external information of the organization; they refine the different management plans and take certain decisions. Afterwards, the managers continue to supervise should the results of the decisions have been achieved and to what extent. Seeing as organizations work on certain hierarchical structures, the decisions of the managers (as acting leadership) are based on their implication in productive activities. Thus, the leadership attribute at the level of managers is fundamentally based on rational activities of planning the internal and external resources of the organization, having as a direct significance for ECSS, the following types of
Artificial Intelligence: resource planning (human, soft, materials), classification and prediction, control (low level operative leadership). With a view towards the development of this ECSS, we will specify the effective execution of the leadership function of the proposed system, in the context of a type of organization. The characteristics of the current leadership of enterprises are visibly oriented towards the correct management of large quantities of knowledge and complex operations with a high rate of change. Therefore, the prediction given by the data accumulated in the past becomes difficult towards the accomplishing of activities distributed on a large scale. The papers is organized as follows: section 2 presents the conceptual framework for ECSS, based on Project 386 [6], and section 3 includes conclusions and further research directions for the development of semantic web and grid technologies, Virtual Organizations, and other agent technologies for economic growth.

2 The conceptual framework for ECSS
Within ECSS we conceived and designed a specific Distributed Knowledge Model for ECSS (DKMECSS) through the integration into its structure of electronic and multimedia documents, specific knowledge bases, ontologies, case bases. DKMECSS is used by ECSS which will be able to exploit variable knowledge in time. The actors of ECSS are human factors, placed, in their own right, on different levels: document authors, knowledge and specific ontologies engineers, final users (with common or individual tasks), IT managers and specialists, electronic commerce (intelligent), etc. From the analysis undertook by us, three dominant characteristics of distributed information burden the implementation of decision assistance support systems and in particular of leadership systems specific to certain organizations: information available through the Internet is often weakly organized, has different interpretations and is disseminated through different structures of computers distributed throughout the world; the number and variety of services and data sources rise dramatically (almost daily); furthermore, the availability and type of services regarding data and knowledge processing are in a state of constant change and adaptation; information is most of the time ambiguous or (possibly) erroneous due to the dynamic nature of information sources and their updating. Consequently, the acquisition of data and knowledge, filtering, evaluating and using them in an enterprise control system becomes a difficult problem, whose solution is possible by using intelligent software agents. Agent-specific tasks include the localization and access of online information from different sources, solving a series of inconsistencies in finding the information again, filtering irrelevant or unwanted information, integrating of information coming from different heterogeneous sources, etc. We consider, thus, that the development of enterprise leadership systems based on multi-agent structures is very important. Agents can cooperate between them and ECSS implemented in such a concept must allow for the coordination of their behavior. As a structure, ECSS may appear in a simplified form. The different models of knowledge within the structure of DKMECSS and at the level of the enterprise as a whole include: technological intelligence aspects; competitive intelligence, used for identifying activities, products, services or other competitors on the enterprise market with a view to integrate the firm in the economic environment; commercial intelligence, necessary for understating distributors, clients, etc.; strategic intelligence, used directly by the managers of the enterprise.

An ontology may be defined as a specification of conceptualization [7]. From one point of view, an ontology refers to the way in which an agent structures its perceptions on the world. From a different perspective it refers to the significance of the vocabulary used by an agent to communicate its messages. Two agents may share the same conceptualization simultaneously, using different vocabularies. Two terms may refer to ontologies which are different in time but which may share the same conceptualization. In order to discuss properties referring to common ontologies, there must be an analysis of ontology fusion and translation (which implies different languages and different world views). It is also necessary to differentiate between ontology and conceptualization. A conceptualization does not also include the allocation of significance, but only the formal structure of reality as it is perceived and organized by the agents, independent of the language used to describe it and the actual existence of a specific situation. One of the major problems in ECSS synthesis at the level of ontologies is constituted by the integration of information. Even if two agents adopt the same vocabulary, there is no guarantee that they will reach the same understanding of the information, if they do not engage in the same conceptualization. A necessary condition to make understanding possible is the overlapping of both conceptualizations of internals models. This means that the bottom-up approach to the integration of
systems, which is based on the multiple integration of a local ontology, may not be operational, especially when the local ontologies are concentrated on conceptual relations relevant to a specific context. As a consequence, the accord of one top level ontology seems more convenient than basing everything on understandings at the crossroads of different ontologies.

The distributed structure of ECSS assumes the existence of a multitude of agents (local or not) which can and must cooperate, in order to fulfill the leadership purpose. Such a multi-agent structure implies the study and synthesis of certain mechanisms of agent behavior coordination for an efficient execution, subordinated to the process of supervision of the enterprise control. Agents will be represented as actors which encapsulate strands of execution, states, methods and interfaces (which contain public methods operating on the basis of states). They communicate in a non-synchronized manner through different types of messages. Seeing as an agent is integrated into an open system, it may initiate the partial solving of certain sub-problems specific for the enterprise leadership. ECSS is used in a distribution chain of digital information, supplying the communication and control infra-structure for production processes specific to the enterprise, goods distribution (physical objects or services).

The general structure of a control system specific to an enterprise is based mainly on three elements: the breaking down of the purpose into tasks, the intelligent processing of knowledge (coming from different sources) and a series of associated elements. Such a system may be conceived as a multi-agent system (MA), built on the basis of elements specific to intelligent applications of distributed control, with a view to managing complexity. In the ideal case, the separation of the control structures with regards to the ECSS execution structure is imposed, in order to obtain a clearer and easier to maintain the control structure. Each agent within the ECSS structure has its own control part (the decentralization of the control function). Agents may be conceived as dedicated intelligence systems, which may interact in order to solve complex situations, but not every agent must be intelligent. A real-time, multi-agent, heterogeneous system structure is distinguished, with some agents possibly being classic systems. The transformation of the representation of knowledge is necessary, depending on the type and purpose of the agent. This may be accomplished through a global modeling formalism of knowledge, accompanied by a knowledge exchange protocol. This structure does not demand that the agents have identical or similar local purposes and allows each agent to detect the moments and conditions of cooperation which are most fitting; in other words, detecting the necessity of cooperation, choosing the type of cooperation, choosing the policy of cooperation and executing the cooperation.

The importance of the theme refers to the strengthening of the ties between knowledge management (a relatively new field on the national and international level), Internet and intranet respectively, through the elaboration of an ECSS, conforming to a multi-agent system structure. ECSS will also encompass e-business and e-commerce problems, seeing as electronic commerce represents one of the junctions where economic models and information technology can and must go together. Current decision makers are convinced of the fact that information technology, under its many forms, represents a key strategic factor in the development of any company or enterprise. The inclusion of electronic business techniques in those of artificial intelligence distributed through heterogeneous agents is possible due to certain proprieties of electronic commerce, such as: connectivity, interactivity, contextual knowledge. At a formal level, through artificial intelligence knowledge models, it is possible to model basic functions of electronic commerce as well as multi-agent systems, such as: communication, coordination, negotiation. The global connectivity of business and clients may create a network of enterprises (each with specific DKM) which may work together towards the same economic goal. Interactivity and communication may lead to new business models.

The generic definition of an agent architecture, which would represent the agents of the scripts through with practical application are described, represent an essential attribute of ECSS proposed for elaboration. Another fundamental aspect is tied to the fact that interactions between the participants to a script impose the existence of a common perspective on the concepts which are being manipulated. The explicit specification of the concepts will be done through ontologies, their elaboration being a new mandatory step in the development of ECSS, as a system based on a community of interactive agents.

The case base will be exploited by an agent which will allow ECSS to learn from the control experience. The integration of such an agent is considered important due to the advantages that Case-Based AI Systems have (Case Based Reasoning – CBR). The acquisition of knowledge may be simplified if the leadership solutions are
memorized (of the human decider at a manager’s decision level) for a series of leadership situations. Therefore, meta-rules may be extracted starting from the examples solved by the expert. Furthermore, the interface engine associated to the CBR subsystem will generalize a series of rules which it will later apply to new leadership situations. The CBR subsystem sections a common knowledge structure, and for a new situation it will: existent identify all the similar cases from the existent Case Database; modify the identified case afterwards in order to apply it to the current situation; apply the modified variant of this case; save the solution from point c), recording the degree of satisfaction of the application of this solution (success or failure).

The structure of the ECSS as a control support system is justified for those organizations (enterprises) for which there are production (technological) processes such as assembly lines (automobile factories), processes described as systems with discrete events (the automatic loading of ships placed on loading ramps). Also, ECSS is useful for problems of resource allocation (human, technological, the allocation of tasks in a power plant), with the fulfillment of economic objectives and in the presence of some restrictions. These problem fields are suited for the conceiving of an ECSS which conforms with the proposed structure, for the following reasons: i) the fact that different actors (physical-machines equipped with sensors and execution elements, economic agents, human agents or resources which are modified) exists in a distributed environment (local or not) creates a high degree of dynamics. These actors (randomly modifying in real time) will be modeled under the shape of agents which must react to all changes taking place in time. ii) agents must fulfill their own objectives efficiently (transport, individual production tasks), after which to interact with other agents. iii) the lack of an ECSS (essentially, the lack of a global control) at the level of the whole organization, imposes a variety of mechanisms which are to solve different types of interactions between agents; iv) The problem fields are sufficiently complex and dynamic as to make modeling the leadership decisions of agents using optimal methods based on a sole Knowledge Based System unreasonable. Furthermore, agents have limited resources.

Selecting a multi-agent structure for the ECSS is considered opportune for the following reasons: i) the structure of the ECSS as an MA system is capable of boosting its compatibility with structures of knowledge distribution with which this system interacts and the robustness of the leadership support system is reinforced overall; ii) the flexibility of ECSS is raised by the possibility of its reconfiguration; iii) DKMELLS will be constructed by symbolic representations associated with different knowledge ontologies attached to the agents (logically of physically distributed) which will communicate in-between them. Therefore, a global view of leadership plans will exist, based on the behavior of agents. Within the ECSS structure, agents must be: i) reactive (to react in due time to different discrete events coming from inside the agent community or from other heterogeneous agents); ii) deliberative (to fulfill their tasks being guided by specific goals); iii) efficient (correct from an algorithmic standpoint); iv) adaptable to the environment modifications. From this perspective of general properties of agents, an important problem which the current project must solve through the synthesis of an ECSS prototype is the conceiving of a control architecture for the MA system structure.

The measure in which this project prepares professionals in a different specialization in new fields demanded by the job market is relevant. Theoretical and practical knowledge implicated within the project are important for every participant, since it is desired that some of the most debated problems in the economic, information technology and real time systems fields be tackled, such as: architectures dedicated to electronic business (client stations, transaction servers, WEB servers, database and knowledge serves, routers); types of transactions (EDI – Electronic Data Interchange), EFT (Electronic Funds Transfer), payments, marketing; application of distributed artificial intelligence methods (acquisition of knowledge, the synthesis of distributed semantic ontologies, the synthesis of a multi-agent system, fuzzy planning, hierarchical control, qualitative modeling) in knowledge management and conceiving ECSS based on DKMECSS; integration of attributes related to time in the knowledge stricter, which will complicate their semantics and processing; communication between processes, described as agents.

From this perspective, we consider the theme justified as well as the approach proposed in this research project. The planners based on AI techniques are made of the following important components: the plan generator, the plan simulator (uses plans under the shape of heuristic decision rules) the mode of execution of the selected plan, the situation evaluator (optional). The AI techniques used in the elaboration of planning or expert systems are diverse. They refer especially to representation problems (great care must be taken in selecting the
degree of detail of the mathematic structure to be employed or to the allowed modeling power, seeing as too great a modeling power may hinder the development of certain components of the planner, verification and validation of the system), the type of approach (dependent or independent of the field), the type of planner (hierarchical or not, linear or non-linear, reactive, distributed, including a meta-planner, etc.), the type of interactions which may appear in the synthesis of decisions, the search and re-planning means. Systems based on knowledge running in real-time possess characteristics that the majority of classical systems do not: the dating of knowledge, time reasoning, response time guarantee, etc. Thus, we conceived and elaborated ECSS, the characteristics of which we synthesize as follows, using the G2 system of the American company Gensym. The specifics of the G2 system comes from its capacity to control a process in constant evolution, a reaction to the emergence of events, application of production rules and procedural knowledge, the representation of the transitional aspects of an application, the representation and use of relations between objects, the acquisition of a large amount of data from exterior sources (local or at a distance), as well as supplying of information and communicating with other G2 systems. Characteristics of development for G2: a programming environment in a natural language; dynamic modeling and simulation; fast and strong prototyping ability; rapid and incremental development of the application using the lifecycle. Applications elaborated using the G2 basic environment and other products (GDA, NeurOn-Line, GSPC, ReThink, Fault Expert), compatible with G2, may be used for: i) Monitoring, diagnosis and treatment of alarms (G2 Diagnostic Assistant- GDA) offers a programming environment for intelligent applications of leadership and process diagnosis, help on-line, prediction and identification, solving of certain problems which may appear in the process, with or without the support of a human operator; ii) Dynamic planning and logistics; iii) Process optimization (G2 is used along with ReThink, applicable in problems of re-engineering, analysis, optimization and leadership of complex businesses, production processes); iv) Advanced supervision and control (NeuroOn-Line is used as an extra, ideal for external data validity, form recognizing, defect classification, for quality control applications); v) Process design and simulation (GSPC); vi) Intelligent network management (Fault Expert). Fuzzy models are suited to the synthesis of planner or meta-planner types integrated in multi-agent structures of leadership such as the proposed ECSS.

3 Conclusions

Through its structure and objectives, the present project contributes to the development of specific knowledge under the following aspects: 1) the elaboration of suitable instruments of analysis of organization, oriented with a view to synthesize certain ontologies, for the purpose of a unitary management, on the basis of which distributed knowledge models may be structured, which may cooperate; 2) the conceiving and validating of synthesis methods regarding the design of a multi-agent system dedicated to the leadership of an enterprise; 3) ECSS the elaboration of hierarchical control structures included in ECSS; 4) the development of a CBD type subsystem to assist decision making on the basis of past leadership experience and new scenarios deduced from the existing ones (this subsystem may also fulfill instruction functions); 5) obtaining an experience of knowledge management and applying important distribute AI concepts in the context of modeling the enterprise as a control process, using G2; 6) approaching economic modeling techniques to current information technology techniques.

The objectives of the project PR386 are quantitative and qualitative, and the material support obtained is destined mainly to developing the management capabilities of an enterprise by implementing an ECSS capable of integrating the obtained results. Enterprise management includes a series of traditional functions (task planning, organization, agent motivation, decision control), which are to be remodeled and extended in the context of elaboration of this ECSS. Also, the acquisition of documentary, didactic and research material is desirable – books, magazines, multimedia products, software. From a research point of view, the project has as a goal the study and reinforcing of the fundamental links between knowledge models compatible with verified AI techniques and those from the enterprise control field, of knowledge management and their inclusion into a control support system, capable of communicating with a series of heterogeneous agents. The specific objectives to be followed are: conceiving and designing an ECSS model in a prototype variant, based on a distributed multi-agent system structure in G2; the elaboration of a DKM based on the development of heterogeneous ontologies, capable of representing knowledge models of different types and at different levels; the common use of knowledge by ECSS through the synthesis of an ontology translation model; elaboration of agent models; the synthesis of agent communication models; designing the agent coordination model; the
testing of the respective ECSS prototype by using object-oriented technologies; the elaboration of the case base within the DKM structure, useful for the assistance of the human decider by the ECSS within the leadership process; designing a fuzzy-type meta-planner; the synthesis of an ECSS qualitative analysis method; the elaboration of a case study for resource allocation (the analysis of a real organization and the identification of applicability and economic efficiency of ECSS).

Recent years have seen a lot of work on task and resource allocation methods, which can potentially be applied to many real-world applications. However, some interesting applications where relations between agents play a role require a slightly more general model. Such situations appear very frequently in real-world scenarios, and recent technological developments are bringing more of them within the Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, to republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Especially in business applications, preferential partner selection and interaction is very common, and this aspect becomes more important for task allocation research, to the extent that technological developments need to be able to support it. For example, the development of semantic web and grid technologies leads to increased and renewed attention for the potential of the web to support business processes. As an example, Virtual Organizations (VOs) are being re-invented in the context of the grid, where they are composed of a number of autonomous entities (representing different individuals, departments and organizations), each of which has a range of problem-solving capabilities and resources at its disposal. The question is how VOs are to be dynamically composed and re-composed from individual agents, when different tasks and subtasks need to be performed. This would be done by allocating them to different agents who may each be capable of performing different subsets of those tasks. Similarly, supply chain formation (SCF) is concerned with the, possibly ad-hoc, allocation of services to providers in the supply chain, in such a way that overall profit is optimized. Traditionally, such allocation decisions have been analyzed using transaction cost economics, which takes the transaction between consecutive stages of development as its basic unit of analysis, and considers the firm and the market as alternative structural forms for organizing transactions.

References: