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Designing CBR-BDI Agent for implementing Supply Chain system

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ABSTRACT

The intelligent agent becomes supplementary the budding technology of Artificial Intelligence that is being used for scheming the enterprise applications. AI is concerned in studying the mechanism of intelligence (e.g., the ability to learn, plan) while the study of agents deals with integrating these same components. The reasoning capability & autonomous features of intelligent agents makes the programmers to resolve the complex problem. But the inability of learning from the environment is the main problem faced with intelligent agent. The case-based reasoning is the major approach that enables to learn from the existing environment. Hence the CBR-BDI agent are the variety of intelligent agents that utilize the features of case-based reasoning to enable the intelligent agents to learn from the environment & make the decisions by using the existing solutions.

In global market competitions, more companies know that without handling supply chain management they can survive for long time period. Supply chain system consists of various entities, flows and relationships. In this paper, the CBR-BDI agents are applied to imitate the entities of supply chain system. These agents maintain the flows of material, products and information. This system helps managers to analyze the business policies with respect to different situations arising in the supply chain.

Keywords - Intelligent Agent, Case-based Reasoning, Supply chain, CBR-BDI agent

I. INTRODUCTION

Over the last two decades, various “intelligent technologies” analyses have significantly impacted on the design and development of new decision support systems and expert systems in diverse disciplines such as engineering, science, medicine, economics, social sciences and management. So far, however, barring a few noteworthy retailing applications reported in the academic literature, the use of intelligent technologies in retailing management practice is still quite limited.

An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors. A human agent has eyes, ears, and other organs for sensors, and hands, legs, mouth, and other body parts for effectors. A software agent has encoded bit strings as its percepts and actions. A generic agent is diagrammed in Figure 1.

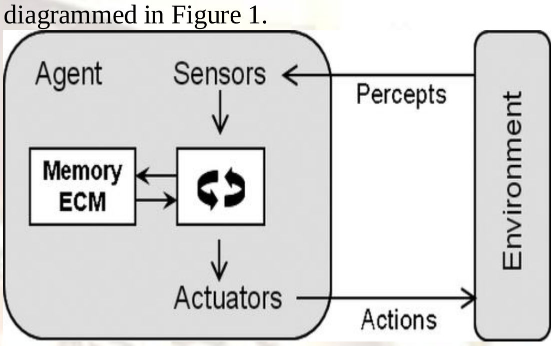

Figure 1: Intelligent Agent

Wooldridge and Jennings (1995) define an intelligent agent as one that is capable of flexible autonomous action to meet its design objectives. Flexible means:

- *Reactivity*: intelligent agents perceive and respond in a timely fashion to changes that occur in their environment in order to satisfy their design objectives. The agent’s goals and/or assumptions that form the basis for a procedure that is currently executing may be affected by a changed environment and a different set of actions may be need to be performed.
- *Pro-activeness*: reacting to an environment by mapping a stimulus into a set of responses is not enough. As we want intelligent agents to do things for us, goal directed behavior is needed. In a changed environment, intelligent agents have to recognize opportunities and take the initiative if they are to produce meaningful results. The challenge to the agent designer is to integrate effectively goal-directed and reactive behavior.
- *Social ability*: intelligent agents are capable of interacting with other agents (and possibly humans), through negotiation and/or cooperation, to satisfy their design objectives.

Other properties sometimes mentioned in the context of intelligent agents include:

- *Mobility:* the ability to move around an electronic environment

- *Veracity:* an agent will not knowingly communicate false information
- *Benevolence:* agents do not have conflicting goals and every agent will therefore always try to do what is asked of it
- *Rationality:* an agent will act in order to achieve its goals insofar as its beliefs permit
- *Learning/adaptation:* the intelligent agents improve performance over time [1].

The architecture might be a plain computer, or it might include special-purpose hardware for certain tasks, such as processing camera images or filtering audio input. It might also include software that provides a degree of insulation between the raw computer and the agent program, so that we can program at a higher level. In general, the architecture makes the percepts from the sensors available to the program, runs the program, and feeds the program's action choices to the effectors as they are generated. The relationship among agents, architectures, and programs can be summed up as follows:

agent = architecture + program

Before we design an agent program, we must have a pretty good idea of the possible percepts and actions, what goals or performance measure the agent is supposed to achieve, and what sort of environment it will operate in. There exists a variety of basic agent program designs, depending on the kind of information made explicit and used in the decision process. The designs vary in efficiency, compactness, and flexibility. The appropriate design of the agent program depends on the percepts, actions, goals, and environment [2]

II. CBR-BDI AGENTS

Agents must be able to reply to events, which occur in their environment, take the initiative according to their goals, interact with other agents (even human), and to use past experiences to achieve current goals. Several architectures have been proposed for building deliberative agents, most of them being based on the BDI model. In this model, agents have mental attitudes of Beliefs, Desires and Intentions. In addition, they have the capacity to decide what to do and how to get it according to their attitudes. In BDI architecture, agent behavior is composed of beliefs, desires, and intentions. The beliefs represent its information state, what the agent knows about itself and its environment. The desires are its motivation state, what the agent is trying to achieve. And the intentions represent the agent's deliberative states. Intentions are sequences of actions; they can be identified as plans.

These mental attitudes determine the agent's behaviour and are critical in attaining proper performance when the information about the problem is scarce. A BDI architecture has the advantage that it is intuitive and relatively simple to identify the process of decision-making and how to perform it. Furthermore, the notions of belief, desire and intention are easy to understand. On the other hand, its ma in drawback lies in finding a mechanism that permits its efficient implementation. Rao and Georgeff (1995) stated that the problem lies in the great distance between the powerful logic for BDI systems and practical systems. Another problem is that this type of agent is not able to learn, a necessary requirement for them since they have to be constantly adding, modifying or eliminating beliefs, desires and intentions. It would be convenient to have a reasoning mechanism that would enable the agent to learn and adapt in real time, while the computer program is executing, avoiding the need to recompile such an agent whenever the environment changes.

In order to overcome these issues, we propose the use of a case-based reasoning (CBR) system for the development of deliberative agents. The proposed method facilitates the automation of their construction. Implementing agents in the form of CBR systems also facilitates learning and adaptation, and therefore a greater degree of autonomy than with a pure BDI architecture. If the proper correspondence between the three mental attitudes of BDI agents and the information manipulated by a CBR system is established, an agent with beliefs, desires, intentions and a learning capacity will be obtained. Our approach to establish the relationship between agents and CBR systems differs from other proposals, as we propose a direct mapping between the agent conceptualization and its implementation, in the form of a CBR system [3].

The intentions are plans of actions that the agent has to carry out in order to achieve its objectives, so an intention is an ordered set of actions; each change from state to state is made after carrying out an action (the agent remembers the action carried out in the past, when it was in a specified state, and the subsequent result). A desire will be any of the final states reached in the past (if the agent has to deal with a situation, which is similar to a past one, it will try to achieve a similar result to the previously obtained one).

Case: <Problem, Solution, Result>
Problem: initial_state
Solution: sequence of <action, [intermediate_state]>
Result: final_state

BDI agent
Belief: state
Desire: set of <final_state>
Intention: sequence of <action>

Based on this relationship, agents (conceptual level) can be implemented using CBR systems (implementation level). This means, a mapping of agents into CBR systems. The advantage of this approach is that a problem can be easily conceptualized in terms of agents and then implemented in the form of a CBR system. So once the beliefs, desires and intentions of an agent are identified, they can be mapped into a CBR system.

III. RELATED WORK

Cindy Olivia et al. (1999) described a framework at integrates case-based reasoning capabilities in a BDI agent architecture as well as its application to the design of Web information retrieval agents. Their search proposed in this paper generates two key insights. First, it shows that the integration of case-based reasoning in BDI agent architecture is a non-trivial exercise that suggests interesting ways of building BDI agents with learning capabilities. Second it demonstrates the efficacy of the resulting framework by presenting the design of intelligent Web information retrieval agents that are effective in well-demarcated domain [4]. Cindy Olivia et al. (2003) introduces a robust mathematical formalism for the definition of deliberative agents implemented using a case-based reasoning system. The concept behind deliberative agents is introduced and the case-based reasoning model is described using this analytical formalism. Variational calculus is introduced in this chapter to facilitate to the agents the planning and preplanning of their intentions in execution time, so they can react to environmental changes in real time [5]. J. M. Corchado et al. (2003) shows how autonomous agents may be constructed with the help of case-based reasoning systems. The advantages and disadvantages of deliberative agents are discussed, and it is shown how to solve some of their inconvenient, especially those related to their implementation and adaptation. It shows how autonomous agents may be constructed with the help of case-based reasoning systems. The advantages and disadvantages of deliberative agents are discussed, and it is shown how to solve some of their inconvenient, especially those related to their implementation and adaptation [6]. Rosalia Laza et al. (2003) showed how deliberative agents can be built by means of a case-based reasoning (CBR) system. This system is used for providing advice to the user and its functioning is guided by a human expert. The most important features described are related with the implementation of retrieve and retain phases of the CBR cycle [7].

Juan M. Corchado-Rodríguez et al. (2004) presented a practical application of an agent-based architecture which has been developed using the methodological framework defined by case-based reasoning systems. The deliberative agents developed within the framework of this research have been used to construct a multi-agent architecture used in an industrial application. The developed architecture is presented together with the results obtained [8]. Juan M. Corchado-Rodríguez et al. (2005) presented a model of an agent that combines both BDI and CBR techniques. We discuss the development of this kind of agent and present a case study. We use a real application of a wireless tourist guide system to illustrate the proposal. The Beliefs-Desires-Intentions (BDI) approach to design deliberative agents can be improved with the learning capabilities of Case Base Reasoning (CBR) techniques [9].

Javier Bajo et al. (2006) presented a deliberative agent that incorporates a hybrid system as a reasoning motor in the frame of CBR systems. To solve this problem the agent incorporates neural networks to implement the stages of the CBR system. Our agent can acquire knowledge and adapt itself to environmental changes. The hybrid system has been applied for evaluating the interaction between the atmosphere and the ocean. The system has been tested successfully, and the results obtained are presented in this paper [10]. Mart´ Navarro et al. (2009) stated that In real-time Multi-Agent Systems, Real-Time Agents merge intelligent deliberative techniques with real-time reactive actions in a distributed environment. CBR has been successfully applied in Multi-Agent Systems as deliberative mechanism for agents. However, in the case of Real-Time Multi-Agent Systems the temporal restrictions of their Real-Time Agents make their deliberation process to be temporally bounded. Therefore, this paper presents a guide to temporally bound the CBR to adapt it to be used as deliberative mechanism for Real-Time Agents [11].

Costin Bădică et al. (2011) provided an overview of the rapidly developing area of software agents serving as a reference point to a large body of literature and to present the key concepts of software agent technology, especially agent languages, tools and platforms. Special attention is paid to significant languages designed and developed in order to support implementation of agent-based systems and their applications in different domains. Afterwards, a number of useful and practically used tools and platforms available are presented, as well as support activities or phases of the process of agent-oriented software development [12].

IV. ARCHITECTURE OF SUPPLY CHAIN SYSTEM

The object of SCM obviously is the *supply chain* which represents a "network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumer". In a broad sense a supply chain consists of two or more legally separated organizations, being linked by material, information and financial flows. These organizations may be firms producing parts, components and end products, logistic service providers and even the (ultimate) customer himself. So, the above definition of a supply chain also incorporates the target group – the ultimate customer.

In a narrow sense the term supply chain is also applied to a large company with several sites often located in different countries. Coordinating material, information and financial flows for such a multinational company in an efficient manner is still a formidable task. Decision-making, however, should be easier, since these sites are part of one large organization with a single top management level. A supply chain in the broad sense is also called an *inter-organizational* supply chain, while the term *intra-organizational* relates to a supply chain in the narrow sense. Irrespective of this distinction, a close cooperation between the different functional units like marketing, production, procurement, logistics and finance is mandatory – a prerequisite being no matter of course in today's firms.

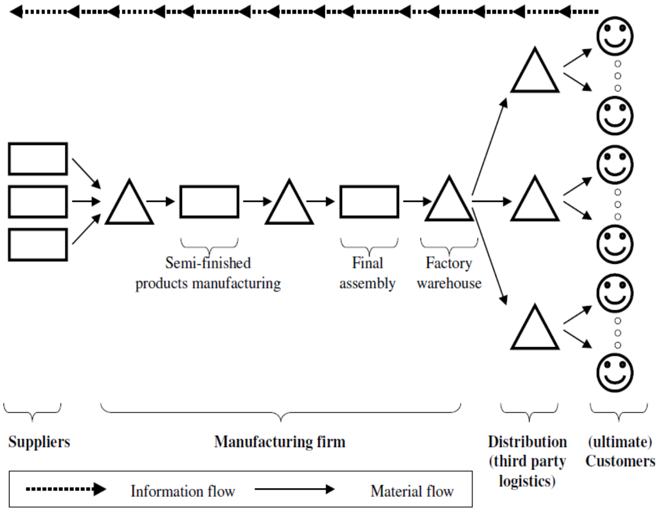

Figure 2: Supply chain system

The coordination of flows along the supply chain can be executed efficiently by utilizing the latest developments in *information and communication technology*. These allow processes formerly executed manually to be automated. Above all, activities at the interface of two entities can be scrutinized, while duplicate activities (like keying in the data of a consignment) can be reduced to a single activity. *Process orientation* thus often incorporates a redesign followed by a standardization of the new process.

For executing customer orders, the availability of materials, personnel, machinery and tools has to be planned. Although production and distribution planning as well as purchasing have been in use for several decades, these mostly have been isolated and limited in scope. Coordinating plans over several sites and several legally separated organizations represents a new challenge that is taken up by *Advanced Planning* (Systems). There are three major factors that have dramatically increased the stress on supply chains:

- Fragmenting customer needs, resulting in a broader selection of SKUs (stock keeping units) aimed at specific consumer segments, different price points, shorter product life-cycles, and less predictable demand patterns;
- Increased cost pressures based on global competition and shareholder demands to reduce working capital;
- A new level of complexity brought on by more complicated distribution models, increased outsourcing, and "new technologies that promise efficiency but can increase complexity."

While supply chains are getting more difficult to manage, the competitive environment means that most companies need to further reduce costs.

V. Implementing Supply Chain through CBR-BDI Agent

We propose a model of a learning agent whose interaction with the environment which allows the agent to project itself into future situations before it takes real action. A supply chain is a network of autonomous entities, or agents, engaged in procurement of raw materials, manufacturing and converting raw materials into finished Products and distribution of finished products. Distribution, manufacturing and purchasing organizations along the supply chain often operates independently and have their own objectives, which may be in conflict. The supply chain management (SCM) should ensure the objectives to deliver the right product, at the appropriate time, at the competitive cost, and with customer satisfaction in order to keep the competitive advantages. A perfect coordination among various functions always ensures success of SCM to achieve its main objective. We identify the elements in a supply chain, their features, and the challenges associated with SCM. We classify the elements in a supply chain as entities and flows. Entities include all manufacturers, logistics providers, electronic exchanges and all their internal departments that participate in the business process. These entities are essentially the operators in the supply chain. Flows are of three types: material, information and finance, and these are the operands in the supply chain. These entities have three common features:

1. **Dynamic**: The supply chains are more flexible now. In today's business environment, there are no obligations for companies to be part of a supply chain for a certain time period and they may join or leave based on their own interest. This changes the structure and flows in the supply chain. Information in the supply chain e.g. prices, demands, technologies, etc. is also changing continuously.
2. **Distributed**: The elements are distributed across various geographical locations. The planning and operating systems used by an entity may also be geographically distributed e.g. there may be a dedicated inventory database residing at each warehouse of a manufacturer.

The SCM related information might even reside as rules-of-thumb with the people responsible for performing the various tasks in the business process.

3. **Disparate**: The entities in a supply chain use different systems built on different platforms for planning and management of their business. Information pertaining to the various elements is also disparate in form.

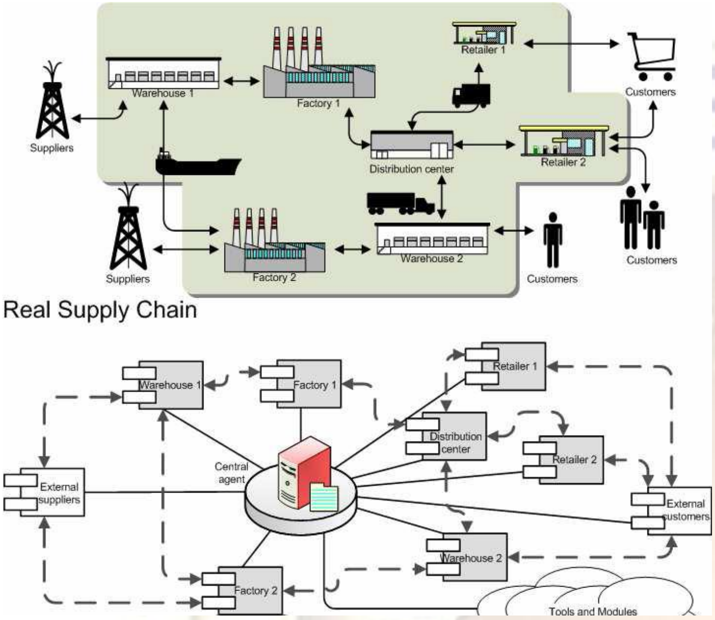

Figure 3: CBR-BDI Agent base SCM

The intelligent agents handle the flow of materials, product & information flow with mobility feature. The case-based reasoning provides the mechanism to take the decisions in sourcing, inventory, transport and demand forecasting. Hence CBR-BDI agents are more suitable for implementing the supply chain system.

VI. Conclusion

SCM has become the key strategic area that has direct impact over the success of any enterprise in today's highly competitive business environment. We have represented the supply chain and related problems through a unified, flexible, and scalable framework. The CBRR-BDI agent based SCM is capable of taking decision on basis of past experience. The system maintains the flow of information between the entities i.e. suppliers, manufacturers, distributors, retailers and the customers.

In future, the distributed database may be applied for storing the case-base for every agent. This factor will provide the access to case-base stored at different locations.

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