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MANAGING CLIMATE CHANGE IN SUPPLY CHAIN SYSTEM THROUGH MULTI-AGENT SYSTEM APPROACH

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Abstract - Climate change has become one of the major challenges for the international community, the business world and individual citizens. The growing release of carbon dioxide (CO2) into the atmosphere and its recognized effect on the climate is one important reason for this change. Carbon footprint quantification, analysis and reduction are keys to preventing the growing volume of CO2. There are many reasons why companies are mapping the carbon impacts throughout their supply chain. Businesses are beginning to realize that good environmental performance can have positive effects on their profits, reputation and society as a whole. Green supply chains can lower costs and be more efficient and agile. The reduced contribution to global climate change is an extra bonus. Knowing the company's total carbon footprint allows management to make effective steps towards reducing the climate change impact of the business and supply chain activities. In this paper it is presented a preliminary research work that involves the development of the Supply chain management system through Multi-agent system for managing Climate change. We focus on the architecture of the multi-agent systems for resolving this major concern.

Keywords— Multi-agent system, Supply chain system, Climate change, Supply chain strategy, Supply chain risk, multi-agent simulation.

INTRODUCTION

While climate change is considered important in purchasing according to a majority of responding high-tech and other manufacturing executives - 54% and 56% respectively - the same group of executives were no more likely than average to say it was considered in practice. Translating high-level, conceptual concerns about climate change and the environment into feasible, real world practice is going to require collaboration with a diverse set of often autonomous supply chain partners, according to the authors. The first step should be to conduct comprehensive studies that enable them to understand the emissions associated with products. That should be followed by a systematic analysis of abatement options.

"Surprisingly perhaps, we find that many of the opportunities to reduce emissions carry no net life-cycle costs - the upfront investment more than pays for itself through lower energy or material usage. Others, however, will require tradeoffs between emissions and profitability, in areas such as logistics and product design (including product specification and functionality). "Forward-looking companies are using such discussions as opportunities for supplier development, for example by transferring best practices in manufacturing, purchasing, and R&D - as well as energy efficiency - to key suppliers. This opens the possibility of still lower costs and improved operational performance, in addition to helping suppliers remove more carbon from their supply chains," Brickman and Unger wrote.

Clearly some industrial sectors, like agricultural and tourism, have greater exposure to climate- related risks than other sectors. But even sectors that aren't directly affected by climate change, like electronics, could find themselves impacted when severe weather events disrupt supply chains. As climate change rises rapidly up the business agenda, companies are beginning to realize that if they are to adequately understand their carbon footprint or the risks that they face from climate change, they must extend their focus into their supply chain. In fact, up to 80% of a retailer's carbon footprint and between 40-60% for consumer goods makers, high-tech players and other manufacturers is found upstream in the supply chain through activities such as processing, packaging and transportation (McKinsey Quarterly, July 2008). PepsiCo UK and Ireland has discovered that only 30% of the carbon footprint of its Walkers products come from their own manufacturing processes.

Manufacturing systems are totally dependent on the ecological environment in which they are operating. Changes in this environment; such as global warming, climate change, decline of the natural resources would then definitely affect the manufacturing systems. Hence it is required to be aware of the environmental changes when trying to be compliant with the change as whole. In order to continue manufacturing operations, they must comply with Laws, which are assumed to be revised due to the changes in the environment. Suppliers are increasingly being asked to share information about their vulnerability to climate change and their strategies to reduce greenhouse gas emissions. They vary widely in their responses. We theorize and empirically identify several factors associated with suppliers being especially willing to share this information with buyers, focusing on attributes of the buyers seeking this information and of the suppliers being asked to provide it.

ROLE OF SUPPLY CHAIN SYSTEM

There are significant business risks and opportunities associated with climate change which, if left unmanaged, could ripple down to their customers. The following are just a few:

Increased Costs: The price of oil reached a staggering $150 then plummeted to below $40 during 2008. This unforeseen volatility has a dramatic effect on operating costs for businesses. For many, the opportunity to address energy efficiency can also result in cost savings. International negotiations to progress a successor to the Kyoto Protocol which expires in 2012 are likely to result in increased taxation and regulation for GHG emissions globally. The United States is one country that could increase regulation for business in order to meet country- level reduction targets.

Disruption to supply: Changes in weather patterns may affect growing seasons for crops that form the key ingredients for some products. Increased flooding could affect location choices and one only has to look at Australia to understand the implications of droughts on global supply chains.

New markets: The consumer is becoming increasingly informed on climate-change issues, which is resulting in a shift in attitude and demand. Businesses need to anticipate these shifts which will require a collaborative approach to Research and Development to ensure that products have less embedded carbon and consume less energy.

The need to keep score: You can't manage what you don't measure. This has been the premise for the Carbon Disclosure Project since it began. By going through the process of measuring their greenhouse gas emissions and the risks and opportunities from climate change, organizations frequently find that their operations are not as streamlined or free of waste as previously thought. From Wal-Mart to the smallest SME, significant efficiencies are often the result of taking this step. In 2008, 634 suppliers responded to the CDP Supply Chain questionnaire, 71% of these were disclosing information to CDP for the first time. Surprisingly and potentially a cause for concern, a large number of suppliers do not identify risk to their business operations as a result of climate change. As few businesses will escape any impact from climate change, this demonstrates a potential lack of understanding on the issue of climate change.

Conversely a large proportion of suppliers did identify opportunities from addressing climate change, with 71% identifying regulatory opportunities, 53% identifying opportunities from the physical effects of climate change and 71% identifying general opportunities. 2008 was the first year for CDP Supply Chain and for our member companies one of the key reasons for participation was to raise awareness amongst their suppliers of the importance of carbon and climate change issues. Raising awareness is the critical first step for suppliers to better understand and take steps towards managing this issue; it is equally critical to CDP"s member organizations to begin to understand the impact of climate change in their supply chain so that they can begin to see progress going forward.

A number of key actions have been identified for companies wishing to begin to take action in managing carbon and climate change in their supply chain.

Understand the market: many businesses believe that they are behind the curve on managing climate change with their suppliers. This is not the case and it is important for companies to realize that the most effective way to increase their understanding is to get started and to ask their suppliers to consider these issues. Companies need to understand what regulation both they and their suppliers are exposed to and the financial and business implications these may pose. They should also investigate the long-term risks posed to their sources of supply by climate change.

Priorities categories of spend: a key initial step for any business seeking to manage its climate change risks is to determine the priority impacts they need to manage. The greatest sources of carbon in the supply chain are frequently in unexpected areas. A company needs to understand the impacts of each of the main procurement categories so that a plan can be established. It is also important to identify suppliers to approach for possible collaboration on joint emissions reduction projects. It prefers a two-way street with suppliers in sharing ideas to reduce waste, reduce emissions and reduce costs through process / product improvements. This approach helps suppliers to reduce the risk of incidents that can interrupt supply and allows Heinz to improve its holistic sustainability performance.

Prepare internally: board level ownership and management buy-in are vital if a company is to make real progress. Objectives should be adjusted across the supply chain (not merely focused on short-term costs) with sustainability and procurement teams working together, sharing information and addressing challenges.

Engage suppliers: in order to build trust and encourage transparent responses from suppliers, companies need to clearly communicate what level of data is required, why they want it and how they plan to use it in both the short-term and long-term.

A key area of focus for PepsiCo UK and Ireland's supplier engagement has been the Walkers supply chain. At the end of 2007 and 2008, Walkers brought together key suppliers of raw materials and packaging at Supply Chain Summits. The first summit was to raise awareness and ask suppliers for help in collecting data. The second summit

The second summit was designed as a workshop where suppliers had the opportunity to report back on data collected, setting the stage for future ideas on how to reduce the overall carbon footprint of the product. Plan practically for projects: providing training, information or support to suppliers to educate them on GHG emissions measurement and reporting is valuable groundwork. Mapping and evaluating risk and building suppliers" risk awareness enables companies to determine what to prioritize. Developing Key Performance Indicators and data metrics means that progress can be monitored and reported both internally and externally.

MULTI-AGENT SYSTEM

The Multi-Agent system is a system in which more than one (software) agent operates. With an 'agent' we do not refer to a physical agent, but to a piece of software that operates on behalf of its „owner". The concept is derived from the traditional agent-principal relationship we can find at for instance a insurance-agent and an insurance company. In such a relationship the agent is expected to act on behalf of its principal and along the principal's lines. De

Deprincipal is the person or organization that is represented by the agent. The agent has a mandate to make a contract and decisions on behalf of the principal. The relationship between an agent and a physical person or company in a Multi-Agent system is analogous to this traditional agent- principal relationship. Research in MASs is concerned with the study, behavior, and construction of a collection of possibly pre-existing autonomous agents that interact with each other and their environments. Study of such systems goes beyond the study of individual intelligence to consider, in addition, problem solving that has social

The MAS can be defined as a loosely coupled network of problem solvers that interact to solve problems that are beyond the individual capabilities or knowledge of each problem solver. These problem solvers, often ailed agent, are autonomous and can be heterogeneous in nature. The characteristic of MASs are that (1) each agent has incomplete information or capabilities for solving the problem and, thus, has a limited viewpoint; (2) there is no system global control; (3) data are decentralized; and (4) computation is asynchronous.

The motivation for the increasing interest in MAS research includes the ability of MASs to do the following:

- To solve problems that are too large for a centralized agent to solve because of resource limitations or the sheer risk of having one centralized system that could be a performance bottleneck or could fail at critical times.

- To allow for the interconnection and interoperation of multiple existing legacy systems. To keep pace with changing business needs, legacy systems must periodically be updated. Completely rewriting such software tends to be prohibitively expensive and is oft en simply impossible.

- To provide solutions to problems that can naturally be regarded as a society of autonomous interacting components agents.

For the barge example the Multi-Agent system looks conceptually as follows:

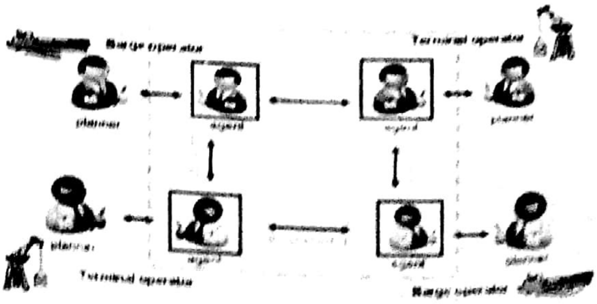

Figure 1. Multi-agent system

Every planner has its own agent. This agent runs on the local server of the company it works for. The agent gets all the relevant information from its planner to make the right decisions. The agent in turn communicates with agents of other companies to make appointments. The agents only exchange only limited information between each other, but enough to make the best decision for their planners. For instance: based on the information the barge operator agent gets from all the terminal operators a barge has to visit, it searches for the best rotation possible and makes agreements with terminal operator agents. The way this is done is similar to the way the planner would have decided otherwise. Terminal operator agents in turn process the information they get such that they make decisions as their planner would have done otherwise. In case of an exception the planner can be consulted to indicate the decision (s)he thinks is the best.

Although MASs provide many potential advantages, they also present many difficult challenges.

- To formulate, describe, decompose, and allocate problems and synthesize results among a group of intelligent agents.
- To enable agents to communicate and interact.
- To ensure that agents act coherently in making decisions or taking action, accommodating the non-local effects of local decisions and avoiding harmful interactions
- To enable individual agents to represent and reason about the actions, plans, and knowledge of other agents to coordinate with them

The Multi-agent System Engineering (MaSE) methodology, takes an initial system specification, and produces a set of formal design documents in a graphically based style. The primary focus of MaSE is to guide a designer through the software lifecycle from a prose specification to an implemented agent system. MaSE is independent of a particular multi-agent system architecture, agent architecture, programming language, or message-passing system. The need of software tools for designing and testing complex distributed multi-agent systems is considerable. Over the past few years a number of theoretical and practical methodologies for designing, implementing and testing multi-agent systems are being developed. As part of this effort an agent-oriented CASE tool, which aims at simplifying the multi-agent system designer's work, and a testing framework, which provides a uniform and automated approach to the testing of multi-agent systems, have been designed and implemented.

POLICY MODELING BY MULTI-AGENT SIMULATION

Major application area for agents in social simulation is that of policy modeling and development. Regulatory and other similar bodies put forward policies, which are designed or at least intended - to have some desired effect. An example might be related to the issue of potential climate change caused by the release of greenhouse gases (cf. Downing et al, 2001). A national government, or an international body such as the EU, might desire to reduce the potentially damaging effects of climate change, and put forward a policy designed to limit it. A typical first-cut at such a policy might be to increase fuel taxes, the idea being that this reduces overall fuel consumption, in turn reducing the release of greenhouse gases.

But policy makers must generally form their policies in ignorance of what the actual effect of their policies will be, and, in particular, the actual effect may be something quite different to that intended. In the greenhouse gas example, the effect of increasing fuel taxes might be to cause consumers to switch to cheaper - dirtier -

fuel types, at best causing no overall reduction in the release of greenhouse gases, and potentially even leading to an increase. So, it is proposed, multi-agent simulation models might fruitfully be used to gain an understanding of the effect of their nascent policies.

An example of such a system is the Freshwater Integrated Resource Management with Agents (FIRMA) project (Downing et al, 2001). This project is specifically intended to understand the impact of governments exhorting water consumers to exercise care and caution in water use during times of drought (Downing et al, 2001, p. 206). (In case you were wondering, yes, droughts do happen in the UK!) Downing et al (2001) developed a multiagent simulation model in which water consumers were represented by agents, and a 'policy' agent issued exhortations to consume less at times of drought. The authors were able to develop a simulation model that fairly closely resembled the observed behaviour in human societies in similar circumstances; developing this model was an iterative process of model reformulation followed by a review of the observed results of the model with water utilities.

The advantage of MAS is the possibility to solve partial problems without having to consider the general problem. Intelligent agents know about their specific domain and try to obtain the necessary information or resources to solve the actual problem. The agents have to cooperate with other agents, which can be organized in terms of negotiation, bidding or opportunistic behavior.

CONCLUSION

Moreover, simply choosing to participate in the CDP Supply Chain program might send a sufficiently strong signal to suppliers that the buyer is very interested in this information. This would imply that our results generalize to all other buyers who might participate. It also would also suggest that our results might underestimate the true effect on supplier responsiveness from buyers using scorecards or RFPs to convey their commitment to using this climate change information in future procurement decisions. That is, if merely participating in the CDP Supply Chain already communicates some level of commitment, then the effects of scorecards or RFPs might be attenuated in our context, and using these tools outside of the CDP Supply Chain Program would to be even more effective in prompting supplier responses.

Buyers requesting climate change information from a subset of their suppliers might evoke a concern about whether our results accurately generalize to all of their suppliers. Generalizing to other suppliers might not actually be an important concern in practice because, as noted earlier, most buyers in the CDP Supply Chain program request climate change information from all suppliers that constituted 80-90% of the buyer's total spend on suppliers. Analyzing the relationships pertaining to these suppliers is not only the feasible set due to data availability, but also the relevant set of suppliers because this prioritization approach is widely acknowledged and endorsed by the Greenhouse Gas Protocol standard governing Scope 3 GHG emissions.30 For those nonetheless interested in the extent to which our results might generalize to buyers" other suppliers, logical arguments support the notion that our results might either underestimate or overestimate an average effect across all suppliers to our buyers.

In several research projects the usefulness of MAS in realistic commercial application scenarios has been investigated. Production is one important domain for MAS. Several MAS-based solutions have been developed for complex problems in manufacturing. MAS are analyzed for controlling machines and manufacturing lines to reach a more fault tolerant and more flexible control. This approach allows a conceptual integration of MAS into the production system by considering agents as actors that act on behalf of other actors. The actor approach permits the adoption of the theoretical benefits of MAS into the mass customizing manufacturing system. The application of Internet based production concepts provide the necessary decentralized organization structure, as well as technical prerequisites

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