Multi-Agents Model for Web-based Collaborative Decision Support Systems

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Abstract. In this paper, we propose a Multi-agent model for web-based collaborative decision support system in which a facilitator and group decision makers are supported by agents. The integrated agents into web-based collaborative decision support system constitute a collection of autonomous collaborative problem solving intelligent agents, goal-directed, proactive and self-starting behaviour; interact with other agents and humans in order to solve problems. Specifically, agents were used to collect information and generate alternatives that would allow the user to focus on solutions that were found to be significant. The decision making process, applied to the boilers defects in an oil plant, relies on a cycle that includes recognition of the causes of a defect (diagnosis), plan actions to solve the incidences and, execution of the selected actions.

Keywords: Collaborative decision making, Web-based decision support systems, Multi-agent systems, Decision support

1 Introduction

As organizations seek to adapt in a world of rapid change, decision making becomes increasingly dynamic and complex. Collaborative decision support systems provide a means by which a larger number of organizational stakeholders can efficiently and effectively participate in the decision making process. A greater number of organizational members participating in the decision making process logically leads to a better decision. The resulting decision should benefit by the richness of knowledge provided by the greater representation of organizational members. A success factor critical to this involvement is the successful organization of massive amounts of information generated by such a group.

On the other hand, the Distributed Artificial Intelligence (DAI), which is commonly implemented in the form of intelligent agents, offers considerable potential for the development of information systems and in particular Decision Support Systems (DSS). Widely range applications domains, in which agent solution is suggested, are being applied or investigated [Cheung, 2005].This is because of the reason that intelligent agents have a high degree of self-determination capabilities, and they can decide for themselves when, where, and under what condition their action should be performed. Intelligent agents have the promise to provide timely assistance in various areas of such environments as information gathering, information dissemination, monitoring of team progress and alerting the team to various unexpected events.

This article takes a multi-agent view of the web-based collaborative decision making process and examines the potential integration of agent technology into a distributed group decision support systems. It considers group participants as multiple agents concerned with the quality of the collaborative decision. We define a facilitator agent as that agent responsible for the overall decision making process. This includes managing the complex negotiation processes that are required among those participants collaborating on decision making.

We take first a literature survey of some related work in section 2 and 3. Then we propose a multi-agent architecture for web-based collaborative decision support systems in section 4. We also present some implementations issues in section 5. Finally, we conclude with future research direction in section 6.

2 Collaborative Decision Support Systems

Decision aid and decision making have greatly changed with the emergence of information and communication technology (ICT). Decision makers are now far less statically located; on the contrary they play the role in a distributed way. This fundamental methodological change creates a new set of requirements: web-based collaborative decisions are necessarily based on incomplete data. “web-based collaborative decision” means that several entities (humans and machines) cooperate to reach an acceptable decision, and that these entities are distributed and possibly mobile along networks. Distributed decision making must be possible at any moment. It might be necessary to interrupt a decision process and to provide another, more viable decision.

Collaborative or Group Decision Support Systems (GDSS), which are closely related to DSS, facilitate the solution of unstructured and semi-structured problems by a group of decision makers working together as a team [Ribeiro, 2006; DeSanctis, and Gallup, 1997; Nunamaker, 1997]. Group Decision Support Systems (GDSS) are interactive computer-based environments which support concerted and coordinated team effort towards completion of joint tasks. DeSanctis and Gallup [1997] defined GDSS as a combination of computers, communications and decision technologies working in tandem to provide support for problem identification, formulation and solution generation during group meetings.

Research that studied group decision support systems in the existing literature used mainly face-to-face facilitated collaborative decision support systems. Some of its results may not apply to distributed teams that, it is difficult for distributed teams to arrange face-to-face meetings or to meet at the same time virtually.

3 Multi-Agent Systems

In recent years, there has been considerable growth of interest in the design of a distributed, intelligent society of agents capable of dealing with complex problems and vast amounts of information collaboratively. Various researches have been conducted into applying intelligent agent-based technology toward real-world problems. Furthermore, there has been a rapid growth in developing and deploying intelligent agent-based systems to deal with real-world problems by taking advantage of the intelligent, autonomous, and active nature of this technology. The main benefits of an agent-based approach come from its flexibility, adaptability, and decentralization.

The definition of multi-agent systems (MAS) is well known and accepted as a loosely coupled network of agents that work together to find answers to problems that are beyond the individual capabilities or knowledge of each agent and there is no global control system.

An agent's architecture is a particular design or methodology for constructing an agent. Wooldridge and Jennings refer to an agent's architecture as a software engineering model of an agent [Jennings, 1996]. Using these guidelines, agent architecture is a collection of software modules that implement the desired features of an agent in accordance with a theory of agency. This collection of software modules enable the agent to reason about or select actions and react to changes in its environment.

MAS are software systems composed of several autonomous software agents running in a distributed environment. Beside the local goals of each agent, global objectives are established committing all or some group of agents to their completion. Some advantages of this approach are: 1) it is a natural way for controlling the complexity of large and highly distributed systems; 2) it allows the construction of scalable systems since the addition of more agents become an easy task; 3) MAS are potentially more robust and fault-tolerant than centralised systems.

As is typical with an emerging technology, there has been much experimentation with the use of agents in DSS, but to date, there has been little discussion of a framework or methodological approach for using agents in DSS, and while DSS researchers are discussing agents as a means for integrating various capabilities in DSS and for coordinating the effective use of information [Whinston, 1997], there has been little discussion about why these entities are fit for such tasks.

4 A Multi-Agent Architecture for Web-based Collaborative Decision Support Systems

We started our framework with the following fundamentals:

1. The first fundamental, in keeping with [Adla et al., 2007], was to segment web-based collaborative decision support systems into two components: Facilitator and participants (decision-makers)
2. The second fundamental we adopted was to include in each collaborative decision support system component an agent to oversee or manage the other agents within the component;

4.1 The Web-based Collaborative Decision Making Framework

In [Adla et al., 2007] we consider the paradigm of web-based collaborative decision-support systems, in which several decision-makers geographically dispersed who must reach a common decision. The networked decision-makers can evaluate and rank alternatives, determine the implications of offers, maintain negotiation records, and concentrate on issues instead of personalities.

In our proposed framework [Adla et al., 2007], the group is constituted of two or several decision-makers (participants) and a facilitator. Each participant interacts with individual DSS integrating local expertise and allowing him to generate one or several alternatives of the problem submitted by the facilitator. The group (facilitator and participants) use the

group toolkit for alternative generation, organization, and evaluation as well as for alternative choice which constitutes the collective decision. Therefore, we view the individual DSS as a set of computer based tools integrating expert knowledge and using collaboration technologies that provide decision-maker with interactive capabilities to enhance his understanding and information base about options through use of models and data processing, and collaborate with him.

Agents were integrated into the DSS for the purpose of automating more tasks for the user, enabling more indirect management, and requiring less direct manipulation of the collaborative decision support system. Specifically, agents were used to collect information outside of the organisation and to generate decision-making alternatives that would allow the user to focus on solutions that were found to be significant. A set of agents is integrated to the system and placed in the collaborative decision support system components, according to our framework [Adla et al. 2007].

4.2 The Multi-Agent Architecture

The goal of Distributed Group Decision making is to create a group of coarse-grained cooperating agents that act together to come to a collective decision. Participants in a collaborative decision making meeting are considered as a set of agents involved in creating a collective decision. These participant agents are involved with the content knowledge of the particular group problem at hand. The responsibility of managing any decision making process is typically put upon a supervisory agent. We call this agent the facilitator. We view the participants as multiple agents responsible for creating the *content* of the decision, and the facilitator as an outside agent responsible for managing the decision process that the participant agents use to come to common decision

For each participant (decision's maker), the following agents are defined:

• DA (Decision-maker Assistant): it's the interface between the participant and the system. During idea (solution) generation stage, a decision maker can use its proper DSS (Decision Support System) through the DA.

• CA (Collaborator Assistant): The role of this agent is devoted exclusively to the collaboration of the decision maker in the process of decision making support. The only interaction it manages is with CRA of the facilitator and does not communicate directly with agents of other decision makers.

For the facilitator side, the following agents are defined:

• FA (Facilitator Assistant): it manages the interface between the system and the facilitator. It provides a private workspace for the facilitator and a public space for the group. It also allows the facilitator to communicate at any time with group members outside the decision making process, helps to establish communications with other system users through their assistants (DA).

• CRA (CooRdinator Agent for the decision making process): It's the central agent of the decision making process. It is supervised by the facilitator via the FA. Its role is to ensure the rules checking and application during the various phases of the decision making process. FA starts the decision making session. The CRA takes in charge the following tasks of this activity. It guides the group through the activity phases.

• MA (Mediator Agent): is requested by the CRA during the alternatives organisation phase. Its role is to refine the alternatives (deletes or merges synonymous, redundant or inconsistent alternatives) and to classify the alternatives as well.

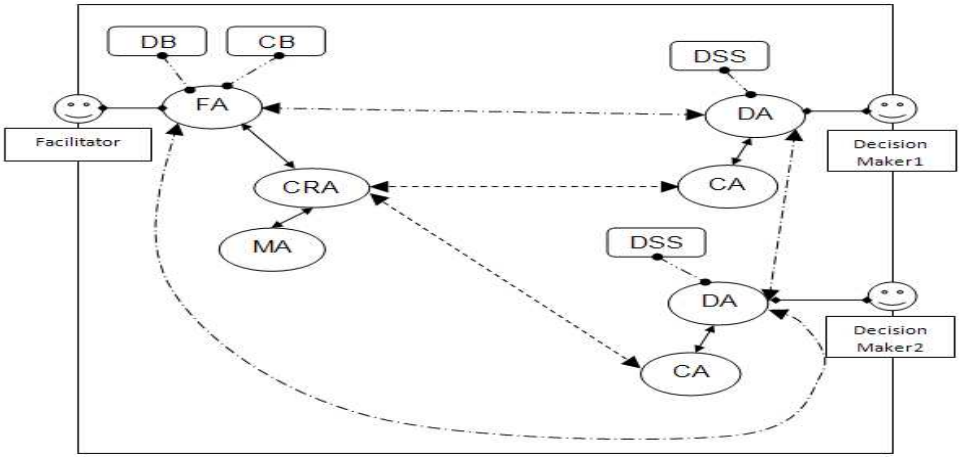

Figure 2: Distributed DSS-MAS logical Architecture

5 Implementation Issues

A prototype of the multi-agent architecture for distributed group decision support system is being implemented in order to generate results that can be analyzed and validate our work. To this end, we have used the FIPA compliant JADE platform to implement our system. Some implementation details are given in the next section.

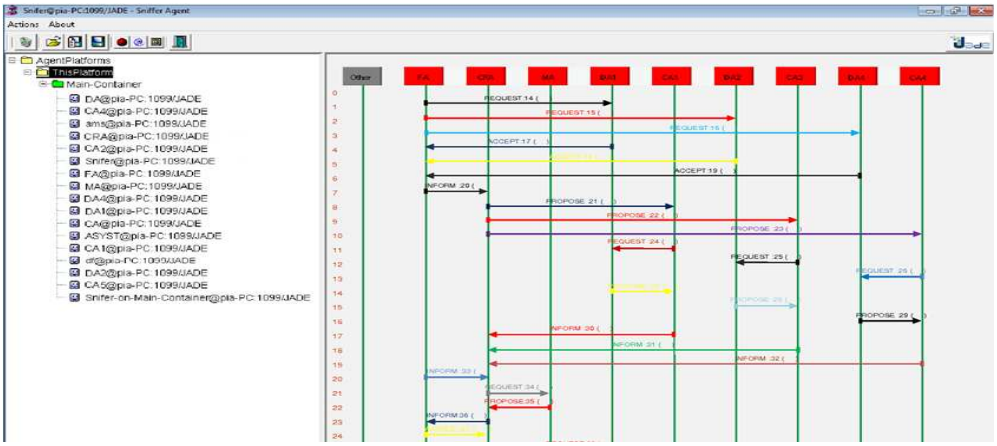

Figure 4: Partial result (sniffer screen)

As depicted in figure 4, a decision group composed of a facilitator and four decision makers collaborate and interact to solve a problem; the decision maker number three doesn't appear on the figure as it's disconnected and does not participate to the decision making session. A partial result of the interactions between agents (JADE's sniffer screen) is given Figure 4.

6 Conclusion

In this paper we presented a web-based collaborative decision support system based on a multi-agent architecture. We have integrated agents into a cooperative intelligent decision system for the purpose of automating more tasks for the decision maker, enabling more indirect management, and requiring less direct manipulation of the DSS. In particular, agents were used to collect information and generate alternatives that would allow the user to focus on solutions found to be significant. Agents are normally used to observe the current situation and knowledge base, and then make a decision on an action consistent with the domain they are in, an finally perform that action on the environment.

The use and the integration of software agents in the decision support systems provide an automated, cost-effective means for making decisions. The agents in the system autonomously plan and pursue their actions and sub-goals to cooperate, coordinate, and negotiate with others, and to respond flexibly and intelligently to dynamic and unpredictable situations.

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