Chapter 11
Agent Negotiation in Water Policy Planning

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ABSTRACT

With the growing demand for water, and many challenges related to water availability, food security, pollution, and environmental degradation, it becomes imperative to establish good water policy planning for a sufficient supply of water consumption. This paper presents a general problem-solving framework for modeling multi-issue agent negotiation in water policy planning via fuzzy constraint processing. All participants involved in water policy planning are modeled as agents. Agent negotiation is formulated as a distributed fuzzy constraint satisfaction problem. Fuzzy constraints are used to define each participant's professional views and demands. The agent negotiation simulates the interactive process of all participants' water policy planning. This approach provides a systematic method to reach an agreement that benefits all participants' water policy planning with a high satisfaction degree of fuzzy constraints, and move towards the deal more quickly since their search focuses only on the feasible solution space. An example application to Negotiation for Water Policy Planning is considered to demonstrate the usefulness and effectiveness of the proposed approach.

1. INTRODUCTION

With the boosting demand for water, and many challenges related to water availability, food security, pollution, and environmental degradation, it becomes imperative and necessity to establish good water policy planning for sufficient supply of water consumption. Many studies have been presented to address such problems. Adams and Simon (1996) proposed game theory-based negotiation model for California water policy planning. Randall et al. (1997) proposed water supply planning simulation model using mixed-integer linear programming. Watkins et al. (1998) presented

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decomposition methods for water resources optimization models with fixed costs. Blackstock and Richards (2007) proposed an approach to evaluate stakeholder involvement in river basin planning. Larson (2009) investigated the new water planning processes from the perspective of the design principles for the robust institutions.

An agent (Bradshaw, 1997; Huhns & Munindar, 1998) with autonomy, self-learning, and coordination can serve as an efficient approach for water policy planning in view of its following features. Firstly, an agent can stand for different institutes or groups related to water resource and fulfill autonomously its duty that is assigned to itself. Secondly, an agent can self-learn and anticipate the oncoming water demand and trend in water resource development, in a changeable and unpredictable environment of water resource. Thirdly, an agent can coordinate and solve a problem in water policy planning from perspectives of its self- and overall-interest. In Addition, agent negotiation (Pruitt, 1981) is an iterative process through which a joint decision is made by two or more agents in order to reach a mutually acceptable agreement. Many approaches to such negotiation have been proposed, including negotiation support systems (NSSs) (Kersten & Lo, 2001), a game theory-based model (Rosenschein & Zlotkin, 1994), a Bayesian model (Ren, Anumba, & Ugwu, 2002), evolutionary computation (Oliver, 1996), and distributed artificial intelligence (Eaton, Freuder, & Wallace, 1998).

NSSs emphasize support, rather than automation. In the game theory-based model, the agent's utility for each possible outcome of an interaction is used to construct into a pay-off matrix. The aim of the game theory-based model is to formalize agent negotiation in a context in which each agent tries to maximize its own utility with respect to other agents. However, the pay-off matrices are generally based on some unrealistic assumption that all agents have common knowledge of the pay-off matrix. Even if the pay-off matrix is known, it may quickly become intractable for large games that involve multiple issues and agents. As a result, the use of negotiation strategies based on game theory should generally be treated with skepticism. In the Bayesian model, a Bayesian network is used to update an agent's knowledge and beliefs about other agents, and Bayesian probabilities are employed to generate offers. Based on this model, Zeng and Sycara (1998) modeled multi-issue negotiation as a sequential decision making model, but their system could not easily capture users' demands on attributes of a product. Evolutionary computation shows how a rational agent can learn to mimic human negotiation. Oliver (1996) and Choi et al. (2001) presented a genetic agent-based automated negotiation system for application in electronic business. However, evolutionary approach requires many trials to acquire good strategies. Another cluster of work on agent negotiation draws on the field of distributed artificial intelligence (DAI). Sycara (1989) presented a negotiation model based on the integration of case-based reasoning and multi-attribute utility theory (MAUT). Sathi and Fox (1989) argued that negotiations can be viewed as constraint-directed problems.

As declared in Luo et al. (2003), fuzzy constraints can serve as a natural means of modeling a buyer's requirements over products' single issues and the combination of the products' multiple issues. They are also appropriate for modeling trade-offs between different issues of a product, and capturing the process by which a buyer relaxes his constraints to reach a partially satisfactory deal. Hence, this paper presents a general problem-solving framework for modeling multi-issue agent negotiation in e-marketplace via fuzzy constraint processing. In this framework, all participants involved in water policy planning are modeled as agents. Agent negotiation is formulated as a distributed fuzzy constraint satisfaction problem (DFCSP). Fuzzy constraints are used to define each participant's professional views and demands. The agent negotiation can simulate the interactive process of all participants' water