14 Intelligent Agents in Portfolio Management

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14.1 Introduction

Due to advances in technology, diverse and voluminous information is becoming available to decision makers. This presents the potential for improved decision support, but poses challenges in terms of building tools to support users in accessing, filtering, evaluating, and fusing information from heterogeneous information sources. Most reported research on intelligent information agents to date has dealt with a user interacting with a single agent that has general knowledge and is capable of performing a variety of user delegated information finding tasks (e.g., Etzioni and Weld, 1994). For each information query, the agent is responsible for accessing different information sources and integrating the results. We believe that, given the current computational state of the art, a centralized agent approach has many limitations: (1) a single general agent would need an enormous amount of knowledge to be able to deal effectively with user information requests that cover a variety of tasks, (2) a centralized information agent constitutes a processing bottleneck and a ‘single point of failure,’ (3) unless the agent has beyond the state of the art learning capabilities, it would need considerable reprogramming to deal with the appearance of new agents and information sources in the environment, (4) because of the complexity of the information finding and filtering task, and the large amount of information, the required processing would overwhelm a single agent. For these reasons and because of the characteristics of the Internet environment, we employ a distributed collaborative collection of agents for information gathering.

We are currently working on a system where each user is associated with a set of agents which have access to the task and situation models and keep track of the current state of the task, situation, environment, and user information needs. Based on this knowledge, the agents decide what information is needed and initiate collaborative searches with other agents to get the information. During search, the agents communicate with each other to request or provide information, find information sources, filter or integrate information, and negotiate to resolve conflicts in information and task models. The returned information is com-
municated to display agents or agents that possibly combine it with information from other sources (e.g., the user) and/or filter it for appropriate display to the user.

This chapter focuses on the design of such a system of agents for the task environment of financial portfolio management, and on the key issues that we will be addressing. These issues include:

- **Gathering and integrating diverse information sources with collaborating software agents.** Because of the volume, complexity, and dynamic nature of the information available to support a user’s goals, it is impossible for a single computational agent to find, access, and integrate all that information in a timely manner.

- **Case-based user, task, and situation models.** The utility of information depends on the user, task, and situational context. We propose to model user, task, and situations in cases. Cases organize information gathering plan fragments under currently valid user, task, and situation features; focus distributed agent information searches; and guide information filtering and integration. Case up-dates resulting from agent information gathering activities refine these models and reflect the current situation.

- **Adaptive integration of planning, co-ordination, scheduling, and execution.** We will explore the construction of individual agents that have the ability to be highly autonomous, quickly adapt to changes in the current environmental situation, and yet still be socially situated, balancing predictability and responsiveness.

In our system, case-based reasoning provides meta-level control and activation of agents. Depending on the task, user, and situation, case-based retrieval selects current planning goals, information needs, and information gathering goals. Based on the plans and information gathering goals, agent teams are activated ‘on demand’ to access, integrate, and filter information to fulfill these goals. New information can be incorporated in the case base and may give rise to new plans and information gathering goals (and as a result activation of potentially different agent teams). The system has two types of agents, task agents and information agents. Task agents have information about tasks and associated information gathering goals. Information agents have models of information sources, information access strategies, and associated task agents to whom the information should be returned. The reported work is a continuation of our previous work on multi-agent information access, filtering, and integration of everyday organizational tasks (Sycara and Zeng, 1995).

### 14.2 The Portfolio Management Domain

To evaluate our domain-independent agent control, organization, co-ordination, and architectural schemes, we have chosen financial portfolio management as a task domain. This is the task of providing an integrated financial picture for