Chapter XXV
Multi-Agent Systems for Distributed Geospatial Modeling, Simulation and Computing

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ABSTRACT

Multi-agent system is specialized in studying the collective effects of multiple intelligent agents. An intelligent agent is a computer system with autonomous action in an environment. This technology is especially suitable for studying geospatial phenomena since they are complex in nature and call for intertwined actions from different forces. This chapter describes multi-agent systems and their application in geospatial modeling, simulation and computing. Geospatial data integration and mining are discussed.

INTRODUCTION

This section reviews applications of **multi-agent** systems in **geospatial data integration**, modeling, simulation, and computing. Agent is a computer system with autonomous action in some environment (Weiss, 2000). This is by no means a comprehensive or concise definition for an agent. As pointed out by many scientists, no consensus has been reached on the definition of an agent (Franklin & Graesser, 1997; Russell & Norvig, 2002; Weiss, 2000). Readers who are interested in the different interpretations and typologies of agents in different contexts may refer to Weiss (2000) and Nwana (Nwana, 1996) for an in-depth discussion. In this context, the definition focuses on the most commonly agreed-upon property of agents - namely, their autonomous ability. This is the backbone in forming **multi-agent** systems. **Multi-agent** systems are formed by many agents that interact with each other. These systems emphasize the interaction between agents and the emergent effects from relatively simple individual behaviors of agents. One of the key promises of **multi-agent** systems is its capability to decompose complex geospatial problems into manageable pieces. Agents communicate and interact with each other through an understanding of common **ontology** (or domain-specific vocabulary) and communication languages. Agents can be managed and discovered through a centralized directory, peer-to-peer discovery, or hybrid mechanism. Agent mobility provides a mechanism to extend stabilities and sustainability of geospatial services in a heterogeneous distributed environment. Table 1 summarizes some of the most popular properties of agents that are important for interactions in a distributed **multi-agent** system. Table 2 lists some popular platforms for developing **multi-agent** systems.

Standards are emerging to enable agent to communicate in ubiquitous environment. FIPA (Foundation for Intelligent Physical Agents) is one of the major efforts in evolving standards and specifications for agent architecture, agent **ontology**, and agent communication languages. Through a well-defined **ontology**, **geospatial data integration** and geospatial service chains can be completed with reasoning support. Applications of **multi-agent** systems in geospatial fields are quickly expanding as these systems promise simpler programming, robustness, parallelism, scalability, cost-effectiveness, and geographic distribution (Stone & Veloso, 2000). This section focuses on exploring potentials of **multi-agent** technology in a distributed geospatial computing environment. First, a comparison between the **multi-agent** approach and **web service** approach – the most popular distributed technology - is given. Next, several application aspects are discussed, i.e., **geospatial data integration**, **geospatial modeling**/simulation, and geospatial data mining. These applications are just the tip of the iceberg. Many are beyond the scope of this

Table 1. Properties of an agent(Franklin & Graesser, 1997; Russell & Norvig, 2002; Weiss, 2000)

Property	Description
Reactive	reaction based on its sense
Autonomous	responses based on its own experiences
Rational	maximize its own interest
goal-oriented	pursue an goal
temporally continuous	deals with continuous process
Mobile	able to transport itself from platform to platform
Communication	interactions on another level of abstraction - language

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