Chapter XLVII
Efficient Searching in Peer-to-Peer Networks Using Agent-Enabled Ant Algorithms

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ABSTRACT

In this chapter we describe a mechanism to search for resources in unstructured peer-to- peer (P2P) networks using ant algorithms implemented through software agents. Traditional resource search algorithms in P2P networks use an uninformed or blind search among the various nodes of the network. In contrast, the resource search algorithm described in this chapter performs an informed search using the ant-based heuristic. In our algorithm, ants, implemented as software agents, are created in response to a user's resource search query. An ant reinforces the route that yields a successful search for directing ants in the future towards nodes with higher probability of locating resources. We describe and compare different reinforcement strategies used by ants to perform efficient resource search in P2P networks.

INTRODUCTION

The advent of the Internet over the past decade has enabled humans to interact and exchange information with each other in various formats including text-based communication, audio, and video. Recently, file-sharing networks such as Napster, Kazaa, and BitTorrent have become an attractive paradigm for online users to exchange resources such as data, information, and services with one another. Most of these file-sharing networks are based on a peer-to-peer (P2P) network architecture. Besides file sharing, P2P systems are currently being used in applications including data sharing and information management for digital libraries (Walkerdine & Rayson, 2004), future combat systems, and large-scale computing for searching for extra-terrestrial life (Anderson, Cobb, Korpela, Lebofsky, & Werthimer, 2002). With

the recent research and commercial interest in P2P networks, it is clear that P2P networks are becoming an important technology for managing large-scale information systems. Therefore, it makes sense to develop mechanisms that make management of P2P networks more efficient. In this chapter, we focus on techniques to improve an essential feature of P2P networks—searching for resources within P2P networks. We envisage that understanding and addressing the issues related to P2P search algorithms will enable us to improve information management in P2P networks.

A P2P network consists of users located on nodes that are interconnected with each other. In the client-server paradigm used commonly over the Internet, a client computer requests access to information or services that are available with a server computer, giving rise to a master/slave-like hierarchy between the server and the client. In contrast, in a P2P network, all nodes behave as peers with similar or comparable capabilities. Every peer node can provide as well as access information and services from other peer nodes. The peer-based model makes P2P networks decentralized and distributed. Consequently, in contrast to a centralized server-based architecture, P2P networks can grow in size without worrying about problems such as congestion at the central server node and scalability of the network. However, the decentralized nature of P2P networks also introduces several challenges such as rapid searching of resources in the network, issues related to security and trust of nodes in network, and enforcing fair sharing of resources among nodes in the P2P network. Several mechanisms including structured overlays (Ratnaswamy et al., 2001), reputation and referral-based mechanisms (Yu, 2003), and game-theoretic approaches (Marti & Garcia-Molina, 2004) have been proposed to address these challenges. In contrast to these approaches, in this chapter we discuss nature-inspired computing techniques to address the problem of rapidly searching for resources in a P2P network.

P2P NETWORK CLASSIFICATIONS

In a P2P network, a user at a node makes different resources such as text, audio, and video files, and even computational resources such as CPU time and networked storage, available to other users. A user on another node can access and acquire these resources, and in return is expected to share resources that it possesses. Consequently, one of the major operations performed by users in a P2P network is to search for resources on other nodes of the network. Searching for resources rapidly and efficiently is a challenging problem in P2P networks because of the absence of a central server node that would maintain information about the contents shared by all nodes in the network. The decentralized nature of P2P networks also introduces challenges such as load balancing, authenticating the identity of nodes, and monitoring the actions performed by different nodes.

Various types of P2P networks that modify some of the features of the peer-based model have been proposed to address some of these challenges. One class of P2P networks is the structured P2P networks where nodes are arranged on a pre-determined topology such as a hypercube or a ring. Distributed hash table (DHT)-based techniques are used to facilitate rapid searching of resources in the network. Several structured P2P networks such as Chord (Stoica, Morris, Karger, Kaashoek, & Balakrishnan, 2001), Pastry (Rowstron & Druschel, 2001), Tapestry (Zhao, Kubiatowicz, & Joseph, 2001), Content Addressable Net-