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Implementation and analysis of the BitTorrent protocol with a multi-agent model

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ABSTRACT

A peer to peer (P2P) computer network relies on direct connections between participants instead of conventional centralized resources. This kind of network is useful for many purposes, but its killer application nowadays is file sharing. BitTorrent is a very popular protocol for this matter.

In this paper, we model a BitTorrent network as a multi-agent system. In it, each BitTorrent client is an agent that interacts with other agents and reacts autonomously, following the same decision algorithms as a real client. The clients aim at downloading content files in the shortest time possible and they share them with other agents.

The model is programmed in JADE, a software framework in Java language for agent development. The model has been validated by initial tests, and it will be used to study the behavior of BitTorrent networks in diverse situations that are hard to emulate in a real network, or to simulate with other models, like modifications of the protocol or user behaviors.

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1. Introduction

Peer to Peer networks have become extremely popular in the last years. They are mainly used for file sharing (eMule Kulbak and Bickson, 2005; Kazaa, 2006; BitTorrent, 2009) and Internet telephony (VoIP). A pure P2P network does not follow the client-server model. Instead, the nodes are equal peers that simultaneously act as clients and servers for the rest of the network.

In P2P file sharing networks, the files are stored in the personal computers of the users and served from them. Most people who participate in Internet file sharing both serve (upload) and receive (download) files. Usually, these networks either provide uploading incentives, such as credits, or force the users to share the files they download. Some peers may not cooperate (by not uploading or sharing their information). This behavior is known as free-riding (Adar and Huberman, 2000).

One of the most popular file sharing networks is BitTorrent (2009), which has its own protocol, a method for distributing large amounts of data. Unlike in client-server free distribution networks, the original distributor does not incur the entire costs of hardware, hosting and bandwidth resources. Subsequent recipients supply pieces of data to newer ones, thus reducing costs as well as the burden on any individual source. This paradigm is redundant against system failures, since it does not depend on an original distributor, but on multiple ones.

On the other hand, multi-agent systems (MAS) are a powerful modeling paradigm for complex systems. A multi-agent system is composed of many software agents (Wooldridge and Jennings, 1995), collectively capable of reaching goals difficult for individual ones or for a monolithic system.

JADE (2007) is a software framework that is fully implemented in Java language. We have developed a multi-agent system in JADE that models a BitTorrent network, where each agent models a BitTorrent user that interacts with other agents to exchange information according to the BitTorrent protocol. This model allows to study the influence of protocol modifications on the network, or how user behaviors affect network performance, since each user is modeled as an agent and we can assign a different behavior to every single agent. Our model has been validated by comparing its results with the most relevant BitTorrent studies in the literature. This precise agent model of a BitTorrent client could allow us to generate a real BitTorrent client that can work in any real BitTorrent network, as JADE agents can run autonomously.

The rest of this paper is organized as follows: Section 2 discusses the background in BitTorrent modeling. Section 3 describes P2P architectures, specially that of the BitTorrent protocol, and it also introduces multi-agent systems and JADE. Section 4 presents the model of a BitTorrent network as a multi-agent system. Section 5 describes three different experiments and discusses their results. Finally, Section 6 concludes the paper.

2. Background in BitTorrent modeling

Since the release of BitTorrent (Cohen, 2003), there have been several studies on its modeling. We describe the most relevant to our research.

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