Incentives for cooperative behavior in peer-to-peer systems

Jonathan Shapiro
Department of Computer Science & Engineering
Michigan State University
3115 Engineering Building
East Lansing, MI 48824-1226, USA

Abstract

Peer-to-peer design has emerged as an important paradigm both for providing network services in the absence of a fixed service infrastructure. Examples include ad hoc networks, application-level multicast, anonymous communication protocols, and numerous peer-to-peer applications. Even in more traditional network settings where a fixed infrastructure exists, network-network interfaces can be viewed as peer-to-peer applications. In an inter-domain routing protocol, for example, each peer might represent a different autonomous system. A distinguishing characteristic of peer-to-peer systems is that each peer simultaneously presents demand to the system and controls a subset of system resources. Although such systems rely on their users to behave cooperatively by allocating resources to each other, natural incentives exist to withhold resources from the system while still consuming service—a behavior known as free-riding. It is doubtful that peer-to-peer systems can function at large scales in the face of widespread free-riding, leading many researchers to explore the possibility of building incentive mechanisms into systems to encourage user cooperation.

This talk will present an overview of recent work (by the presenter and by others) on several classes of incentive mechanisms. One class of mechanisms, known as reputation systems, record peer interactions allowing peers either individually or collaboratively to reward good

behavior or isolate free-riders. An alternate class of mechanisms are based on a notion of currency that must be exchanged for service. Since currency is necessary to acquire service, peers are motivated to cooperate in order to obtain the necessary currency. Reputation and currency-based mechanisms are general-purpose in nature and have been adapted to a range of applications including ad hoc networks, anonymous communication and distributed storage. In addition to such generic mechanisms, there are a few examples of application-specific incentive mechanisms.

The study of incentive mechanisms poses many interesting challenges and opportunities for analytical modeling in the search for mechanisms that provide effective incentives with minimal overhead. We will discuss several examples from the recent literature including: how to assess the cooperativeness of other peers, how to incorporate reputation information from untrusted parties, the use of currency-based mechanisms to promote stable group membership, and the impact of anonymity on cooperative behavior.