

# Peer-to-Peer Network Architecture

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## INTRODUCTION

The emergence of file-sharing systems such as Napster and Gnutella make the term *peer-to-peer* (P2P) popular. The benefits and challenges of such network architectures are realized by network operators and users. Their cost-effective resource aggregation capability, together with many other benefits, has motivated many new developments and products. Today, file sharing, content distribution, distributed computing, instant messaging, Internet telephony, and video conferencing, and ad hoc networking are all taking advantage of P2P network architectures. This chapter summarizes the network architectures that use the P2P concept.

We start with a discussion of what a P2P network is in the section on Definitions. Collections of the existing definitions of a P2P network are listed. Although there is no single concise definition of a P2P network, these definitions give us an informal description of a P2P network. Such an open mind is favorable, since new technologies can be accommodated as they are introduced.

An analysis of the benefits and limitations of P2P networks is given in the section on Benefits and Limitations of P2P Networks. Compared to centralized networks, P2P networks benefit from cost sharing and reduction, scalability, resource aggregation and interoperability, robustness improvement, increased autonomy, anonymity and privacy, enhanced dynamics, ad hoc communication, and collaboration. However, P2P networks are limited by their manageability, security, and service guarantee capability. It has been observed that P2P networks have limited methods to prevent cheating and selfish behaviors.

To present a general framework, we use a conceptual layered architecture to illustrate key building blocks in a P2P network in the section on PSP Network Architecture. The abstract reference P2P network architecture consists of three layers: the base overlay layer, the middleware layer, and the application layer. The base overlay layer provides peer discovery, overlay network construction, and application-level multicast. The middleware layer offers distributed search, publish and subscribe, security, distributed indexing, distributed directory, metadata, and scheduling. The application layer includes distributed communication and collaboration, file sharing, content

distribution, distributed storage, and massively parallel computing. P2P network implementations use very diversified architectures. Some P2P networks are developed as single applications, possibly using proprietary implementations. Some P2P networks provide software modules that can be used to compose other applications. The three-layer reference P2P network architecture captures the major functional characteristics of P2P networks. However, it does not imply that a P2P network has to strictly follow the reference architecture.

This chapter focuses on the architectural aspects; Chapter 145 is about P2P network applications. Although ad hoc networking extensively uses P2P network architecture, we do not cover ad hoc networking in this chapter, since other chapters discuss this concept.

## DEFINITIONS

The term *client* refers to a process using a service. In the context of networks, a client refers to a communication process receiving information from others or getting connected to others by the means of transit services. A client process initiates service requests to others. But a pure client process is not able to serve requests from others, unless each participating device supports linked client and server processes. In contrast to a client process, a *server* refers to a process offering services. In networks, a server process hosts information for client processes to search, download, and so on.

The term *peer* means “equal,” which can be informally interpreted as a process with capability similar to the other processes with which process communicates. In the context of P2P networks, a peer process acts as a client process and at the same time as a server process for the same function. For example, a process that downloads files from others and meanwhile the process hosts shared files for others to download is a peer process in file downloading/uploading. There is no distinction between these processes in terms of which is providing or using services. Peer processes communicate with each other in a symmetric pattern. Note that the function that a peer process requests and offers must be the same within the context of a given application. A peer process can be