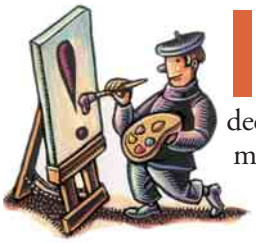
Detlef Schoder and Kai Fischbach

Peer-to-Peer Prospects

The P2P design philosophy needs far more detail before we can appreciate a clear picture of its potential.



Is peer-to-peer (P2P) a set of protocols, an IT architecture, a design philosophy stressing decentralization, a business model, or merely a fad? In its current form it encompasses all of these attributes. Reduced to a common denominator, P2P refers to technology that enables two or more peers to collaborate spontaneously in a network of equals (peers) by using appropriate information and communication systems without the necessity for central coordination.

The most frequently discussed applications include popular file-sharing systems, such as early Napster or BearShare and its numerous successors. Napster possessed a central directory service that, in fact, disqualifies it as a pure form of P2P. BearShare takes advantage of Gnutella technology, an open approach genuinely independent of a central server, rendering it a typical P2P implementation. In addition to file-sharing collaborative P2P spaces, Grid computing and instant messaging are key applications of P2P. We are reluctant, however, to add Web services to this list. Web services can be regarded as a complementary concept that will enrich the Internet infrastructure and its utilizing applications, including any P2P application.

The technologies on which P2P applications are based as well as the challenges they pose are not new. Depending on the way the term is defined, P2P can even be seen as one of the oldest architectures in the world of telecommunication. The telephone system, the discussion forums of Usenet, or the early form of the Internet can be classified as P2P systems [2]. Consequently, it has been noted that "peer-to-peer technologies return the Internet to its original version, in which everyone creates as well as consumes" [3].

IT practitioners are confronted with the question whether, and if so, to what extent, P2P offers advantages in contrast to other architectural concepts, such as the client/server model. While comparisons on the basis of technical and economic criteria, such as persistence, performance, or costs, can be made, they miss the point. Operating largely independent of central coordination, P2P opens up new dimensions of information management. It has the potential for accelerating communication processes, exploiting idle resources, and facilitating the exchange of the most recently created and highly distributed information. It can reduce collaboration costs through lean and ad hoc administration of working groups, even if groups extend beyond the boundaries of a company. They permit a greater degree of freedom and independence on the part of users by making resources available in a more customized manner. These benefits are strengthened by the increasing availability of powerful communication networks, a growing number of agreed technical standards for interfaces and protocols, as well as more user-friendly clients that make P2P architectures transparent for the user.

It appears profitable to build information systems based on P2P architectures. However, the extent to which companies can take advantage of P2P is subject to debate. Practitioners at the forefront of corporate information management, especially those working in settings that extend beyond the boundaries of their own company, have raised a number of concerns and challenges to be met. Will decentralized control be able to cope with challenges such as network control, security, interoperability, metadata, and cost sharing? (see [3] for more interrelated problems).

Network control. Unlike traditional technologies, which favor a top-down design and planning approach, P2P facilitates a bottom-up approach in

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the sense of emerging, self-organized networks or the communities using them. As a result, the development, the size and the connections, as well as throughput and stability of P2P networks (in particular those that extend beyond an individual company) can hardly be planned or predicted. The upside is that this facilitation of emergent coordination makes new application scenarios feasible.

Security. Due to the widely acknowledged threats to networked systems, effective security mechanisms constitute one of the most important and most complex requirements for a modern IT infrastructure. The implementation of P2P technologies creates additional challenges with respect to security as their use frequently requires that third parties be allowed to access the resources of an internal system, for example, to share files or CPU running time. Use of an information system to communicate with or grant access to third parties can be accompanied by critical side effects. During communication in P2P networks conventional security mechanisms, such as firewall software, are frequently circumvented. An example is instant messaging software, where communication often happens without encryption creating yet another risk of company data being compromised. If P2P is to become interesting for business use, techniques and methods for authentication, authorization, availability, data integrity, and trust have to be integrated.

Interoperability. Today's world of P2P does not even begin to fulfill this requirement. Virtually all applications utilize specific protocols and interfaces. As a result, interoperability that extends beyond a single application or network is rare in current P2P networks. Although there are serious doubts of the feasibility and desirability of an "Übernetwork" [5] that would satisfy the needs of everyone, work aimed at creating a common infrastructure (middleware) with standardized interfaces for P2P applications is in progress. The goal is to shorten development time and to enable applications to be implemented easily in existing systems. A platform for discussing suitable architectures and protocols for achieving this goal is the Global Grid Forum (www.gridforum.org).

Metadata. The implementation of P2P technology is accompanied by the problem of locating resources that may be significantly more difficult to identify than MP3 files within context-specific file-sharing systems. In order to convert raw data into usable information and make this available for efficient searches, suitable metadata concepts are required, such as those being discussed in connection with Tim Berners-Lee's vision of the Semantic Web and emerging XML standards [1].

Cost sharing. Free riders or freeloaders, that is, peers who take advantage of the available resources but do not contribute any in return, can present a considerable problem for P2P networks. This type of behavior undermines the characteristics of P2P, since bottlenecks are created that restrict the availability of information and reduce network performance. It also has a particularly negative effect on the willingness of people to make resources available. A possible solution is accountability, for example, keeping records on participants and introducing negative or positive incentives, such as charges or credits in the form of remuneration or user rights. Due to the absence of central authorities, however, this raises difficult questions with respect to the acceptability, enforcement, privacy of the usage data, and so on, and therefore doubts remain about the practicality of such methods.

The extent to which P2P is implemented for (internal and external) business purposes will depend on the technological, economic, and legal challenges posed by the technology and how these are resolved [4]. More specifically, we expect instant messaging, which currently focuses on person-to-person communication, to be expanded with application scenarios of person-to-machine and machine-to-machine communication. As it matures, Grid computing will

benefit from P2P characteristics as the peers will be part of a ubiquitous infrastructure, transparently integrated, both providing and consuming resources. Regarding the IT architecture level, there is no reason to assume that P2P networks will replace client/server systems. Instead, we can expect a synthesis combining the advantages of both approaches in hybrid systems. An example is central servers that will manage security functions or provide directory and transaction services.

Moreover, it is very likely the design philosophy underlying P2P networks will gain importance in the development of mobile business and ubiquitous computing, particularly when the aim is to establish communication between mobile, spontaneously networked peers or entities (PDAs, mobile telephones, computers) in the absence of central coordinating instances. C

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Detlef Schoder (schoder@whu.edu) holds the DaimlerChrysler Chair for E-Business and is a professor at the Otto Beisheim Graduate School of Management (WHU), Vallandar, Germany.

Kai Fischbach (Kai.Fischbach@whu.edu) is a research associate in e-business at the Otto Beisheim Graduate School of Management (WHU), Vallandar, Germany.