INFRASTRUCTURE FOR ELECTRONIC COMMERCE

Content
A.1 A Network of Networks
A.2 Internet Protocols
A.3 Web-Based Client/Server Applications
A.4 Multimedia Delivery
A.5 P2P Applications
A.6 Web 2.0: Blogs, Wikis, RSS, and Podcasts

Virtually all e-commerce sites rest on the same network structures, communication protocols, and Web standards that originated over 30 years ago. In this appendix, we briefly review the structures, protocols, and standards underlying the millions of sites used to sell to, service, and communicate with customers and business partners. We also examine the infrastructure of some newer network applications, including streaming media and peer-to-peer (P2P) networks.

A.1 A NETWORK OF NETWORKS

Despite the introduction of new applications such as blogs, wikis, and podcasting, the physical infrastructure of the Web and the underlying Internet have remained basically the same over the past 30 years. The Internet is a network of thousands of interconnected networks. Included among the interconnected networks are (1) the interconnected backbones, which have international reach; (2) a multitude of access/delivery subnetworks; and (3) thousands of private and institutional networks connecting various organizational servers that contain much of the available information.

The Internet backbones are maintained and serviced by network service providers (NSPs), which are the major telecommunications companies, such as MCI and Sprint. Each backbone handles hundreds of terabytes of information per month. The subnetworks are provided by local and regional Internet service providers (ISPs). ISPs exchange data with the NSPs at network access points (NAPs). Pacific Bell NAP (San Francisco) and Ameritech NAP (Chicago) are examples of such exchange points.

When a consumer requests a Web page from a B2C site, the request will likely traverse an ISP network, move over one or more of the backbones, and then travel across another ISP network to the computer containing the information of interest. The contents of the requested page will follow a similar path. For any given request and associated response, there is no preset route. In fact, the request and response are each broken into smaller segments called packets, and the packets can follow different paths. Special computers called routers determine the paths traversed by the packets. Routers have updatable maps of the networks on the Internet that enable them to determine the paths for the packets. Cisco (cisco.com) is one of the premier providers of high-speed routers.

One factor that distinguishes the various networks and subnetworks is their speed, or bandwidth. The bandwidths of digital networks and communication devices are rated in bits per second (bps). For example, more than 75 percent of the U.S. households that are connected to the Internet connect through higher speed digital subscriber lines (DSL) running at 1 to 1.5 Mbps (megabits per second) or cable connections offering speeds of up to 10 Mbps (i.e., broadband connections) (Burns 2006). A megabit equals 1 million bits. Many businesses are connected to their ISPs via a T-1 digital circuit. Students at many universities enjoy this sort of connection (or something faster). The speed of a T-1 line is 1.544 Mbps. However, the vast majority of the Internet’s 1 billion worldwide users connect to the Internet via telephone lines through digital modems at 56 Kbps (kilobits per second). The speeds of various types of Internet connections are summarized in Exhibit A.1.

Bandwidth is especially important for B2C sites because slow response times can cause online consumers to abandon a site and go elsewhere. At 56 Kbps, downloading anything but a standard Web page is a torturous exercise. A standard Web page with text and graphics is around 400 kilobits. With a 56K modem, it takes about 7 seconds to retrieve the page. A cable modem takes about 0.04 seconds. Fortunately for online merchants, the percentage of residences in the world with broadband connections (e.g., cable or DSL) is rising steadily, especially in Europe and North America.

network service providers (NSPs)
Major telecommunications companies, such as MCI and Sprint, that maintain and service the Internet’s high-speed backbones.

Internet service providers (ISPs)
Companies that provide Internet delivery subnetworks at the local and regional level.

network access point (NAP)
An intermediate network exchange point that connects ISPs to NSPs.

packets
Small segments of messages sent over the Internet; each packet contains both data from and the addresses of the sending and receiving computers.

routers
Special computers that determine the paths traversed by data packets across the Internet.

bandwidth
The speed at which content can be delivered across a network; it is rated in bits per second (bps).
A.2 INTERNET PROTOCOLS

One thing that amazes people about the Internet is that no one is officially in charge. It is not like the international telephone system, which is operated by a small set of very large companies and regulated by national governments. This is one of the reasons that enterprises were initially reluctant to use the Internet for business purposes.

The closest thing the Internet has to a ruling body is the Internet Corporation for Assigned Names and Numbers (ICANN). ICANN (icann.org) is a nonprofit organization that was formed in 1998. Prior to ICANN, the coordination of the Internet was handled on an ad hoc and volunteer basis. This informality was the result of the culture of the research community that originally developed the Internet. The growing business and international use of the Internet necessitated a more formal and accountable structure that reflected the diversity of the user community. ICANN has no regulatory or statutory power. Instead, it oversees the management of various technical and policy issues that require central coordination. Cooperation with those policies is voluntary. Over time, ICANN has assumed responsibility for four key areas: the Domain Name System (DNS); the allocation of IP addresses; the management of the root server system; and the coordination of protocol number assignment. These four areas form the base upon which the Internet is built.

A recent survey published in January 2007 by the Internet System Consortium (isc.org) revealed that there are over 318 million host computers on the Internet in 239 countries (ISC 2007). Not all of these computers are the same. They are produced by different hardware manufacturers and run different operating systems. The genius of the Internet is that it provides a set of protocols that enables the inter-networking of the various computers without centralized control or without any one computer having knowledge of the others.

A protocol is a set of rules that determine how two computers communicate with one another over a network. The protocols around which the Internet was and still is designed embody a series of design principles (Treese and Stewart 1998):

- **Interoperability.** The system supports computers and software from different vendors. For e-commerce, this means that customers or businesses do not require specific systems to conduct business.
- **Layered.** The Internet protocols work in layers, with each layer building on the layers at lower levels. This layered architecture is shown in Exhibit A.2.
- **Simple.** Each of the layers in the architecture provides only a few functions or operations. This means that application programmers are hidden from the complexities of the underlying hardware.
- **End-to-end.** Interpretation of the data happens at the application layer (i.e., the sending and receiving side), not at the network layers. It is much like the post office. The job of the post office is to deliver mail; only the sender and receiver are concerned about the envelope’s contents.

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### EXHIBIT A.1 Bandwidth Specifications

<table>
<thead>
<tr>
<th>Technology</th>
<th>Speed</th>
<th>Description</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital modem</td>
<td>56 Kbps</td>
<td>Data over public telephone networks</td>
<td>Dial-up connections</td>
</tr>
<tr>
<td>ADSL (asynchronous digital subscriber line)</td>
<td>1.5 to 8.2 Mbps</td>
<td>Data over public telephone networks</td>
<td>Residential and commercial hookups</td>
</tr>
<tr>
<td>Cable modem</td>
<td>1 to 10 Mbps</td>
<td>Data over the cable network</td>
<td>Residential hookups</td>
</tr>
<tr>
<td>T-1</td>
<td>1.544 Mbps</td>
<td>Dedicated digital circuit</td>
<td>Company backbone to ISP</td>
</tr>
<tr>
<td>T-3</td>
<td>44.736 Mbps</td>
<td>Dedicated digital circuit</td>
<td>ISP to Internet infrastructure; smaller links in Internet infrastructure</td>
</tr>
<tr>
<td>OC-3</td>
<td>155.52 Mbps</td>
<td>Optical fiber carrier</td>
<td>Large company backbone to Internet backbone</td>
</tr>
<tr>
<td>OC-12</td>
<td>622.08 Mbps</td>
<td>Optical fiber carrier</td>
<td>Internet backbone</td>
</tr>
<tr>
<td>OC-48</td>
<td>2.488 Gbps</td>
<td>Optical fiber carrier</td>
<td>Internet backbone; this is the speed of the leading edge networks (e.g., Internet2)</td>
</tr>
<tr>
<td>OC-96</td>
<td>4.976 Gbps</td>
<td>Optical fiber carrier</td>
<td>Internet backbone</td>
</tr>
</tbody>
</table>

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TCP/IP

The protocol that solves the global internetworking problem is the Transmission Control Protocol/Internet Protocol (TCP/IP). Any computer or system connected to the Internet runs TCP/IP. This is the only thing that all of the computers and systems on the Internet share in common.

Actually, TCP/IP is two protocols—TCP and IP. TCP ensures that two computers can communicate with one another in a reliable fashion. Each TCP communication must be acknowledged as having been received. If the communication is not acknowledged in a reasonable time, then the sending computer must retransmit the data. In order for one computer to send a request or a response to another computer on the Internet, the request or response must be divided into packets that are labeled with the addresses of the sending and receiving computers. This is where IP comes into play. IP formats the packets and assigns addresses.

The current version of IP is IP version 4 (IPv4). Under this version, Internet addresses are 32 bits long and written as four sets of numbers separated by periods (e.g., 130.211.100.5). This format is also called dotted-quad addressing. You are probably familiar with addresses in the format of “www.google.com.” Behind every one of these English-like addresses is a 32-bit numerical address.

With IPv4, the maximum number of available addresses is slightly over 4 billion ($2^{32}$). This sounds like a large number. However, with the popularity of smartphones and other gadgets with Internet connectivity, the growing number of Internet users in developing countries, and the increasing use of peer-to-peer applications, IP addresses will eventually be in short supply. Although stop-gap measures such as interdomain routing have been used, the market research firm Frost and Sullivan estimates that within the next 4 to 7 years the world will run out of IP addresses (Patrizio 2006).

For this and other reasons, various Internet policy and standards boards have been working since the early 1990s on the next-generation IP protocol that goes by the name of IP version 6 (IPv6). IPv6 is designed to improve upon IPv4’s scalability, security, ease of configuration, and network management. IPv6 uses 128-bit addresses. This will allow 1 quadrillion computers ($10^{15}$) to be connected to the Internet. Under this scheme, one can imagine individual homes having their own networks. These home networks could be used to interconnect and access not only PCs within the home but also a wide range of appliances, each with its own unique address. To date, there has been minimal deployment of the protocol. The U.S. government has specified that the network backbones of all federal agencies must deploy IPv6 by 2008. However, native IPv6 connectivity for consumers is a few years off.

DOMAIN NAMES

Names such as “www.amazon.com” that reference particular computers on the Internet are called domain names. Domain names are divided into segments separated by periods. The part on the very left is the name of the specific computer, the part on the very right is the top-level domain to which the computer belongs, and the parts in between are the subdomains. In the case of “www.amazon.com,” the specific computer is “www,” the top-level domain is “com,” and the subdomain is “amazon.” Domain

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**EXHIBIT A.2 TCP/IP Architecture**

<table>
<thead>
<tr>
<th>Application Layer</th>
<th>User Datagram Protocol (UDP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FTP, HTTP, Telnet, NNTP</td>
<td>Internet Protocol (IP)</td>
</tr>
<tr>
<td>Transmission Control Protocol (TCP)</td>
<td></td>
</tr>
<tr>
<td>Network Interface Layer</td>
<td>Physical Layer</td>
</tr>
</tbody>
</table>

**Transmission Control Protocol/Internet Protocol (TCP/IP)**

Two combined protocols that together solve the problem of global internetworking by ensuring that two computers can communicate with each other reliably; each TCP communication must be acknowledged as received or the sending computer will retransmit the message.

**IP version 4 (IPv4)**

The current version of Internet Protocol, under which Internet addresses are 32 bits long and written as four sets of numbers separated by periods.

**dotted-quad addressing**

The format in which Internet addresses are written as four sets of numbers separated by periods.

**IP version 6 (IPv6)**

Version of the Internet Protocol, still in the planning stage, that will replace IPv4 and improve network management.

**domain name**

The name used to reference particular computers on the Internet; the name is divided into segments separated by periods.
names are organized in a hierarchical fashion. At the top of the hierarchy is a root domain. Below the root are the top-level domains, which originally included .com, .edu, .gov, .mil, .net, .org, and .int. Of these, the .net, .com, and .edu domains represent the vast majority (343 million out of 433 million) of the names currently in use (ISC 2007). Below each top-level domain is the next layer of subdomains, below that is another layer of subdomains, and so on. The leaf nodes of the hierarchy are the actual computers.

When users wish to access a particular computer, they usually do so either explicitly or implicitly through the domain name, not the numerical address. Behind the scenes, a special server called the domain name server converts the name to its associated numerical address. Each organization provides at least two domain servers, a primary server and a secondary server to handle overflow. If the primary or secondary server cannot resolve the name, the name is passed to the root server and then on to the appropriate top-level server (e.g., if the address is “www.microsoft.com,” then it goes to the .com domain name server). The top-level server has a list of servers for the subdomains. It refers the name to the appropriate subdomain and so on down the hierarchy until the name is resolved. Although several domain name servers might be involved in the process, the whole process usually takes microseconds.

As noted earlier, ICANN coordinates the policies that govern the DNS. Originally, Network Solutions, Inc. was the only organization with the right to issue and administer domain names for most of the top-level domains. A great deal of controversy surrounded its government-granted monopoly of the registration system. As a result, ICANN signed a memorandum of understanding with the U.S. Department of Commerce that resolved the issue and allowed ICANN to grant registration rights to other private companies. A number of other companies are now accredited registrars (e.g., America Online, CORE, France Telecom, Melbourne IT, and Register.com).

Anyone can apply for a domain name. Obviously, the names that are assigned must be unique. The difficulty is that across the world several companies and organizations have the same name. Think how many companies in the United States have the name “ABC.” In addition to the television broadcasting company, stores such as ABC Appliances also use “ABC.” However, there can only be one “www.abc.com.” Names are issued on a first-come, first-served basis. Applicants must affirm that they have the legal right to use the name. If disputes arise, the disputes are settled by ICANN’s Uniform Domain Name Dispute Resolution Policy or settled in court.

**NEXT-GENERATION INTERNET: INTERNET2**

It is difficult to determine, or even comprehend, the vast size of the Web. Some sources estimate that the deep Web—the reservoir of Internet content that is unreachable by the traditional search engines—contains 600 billion individual documents (Zillman 2003). Whether this figure is exactly right is unimportant. What is important is that Web content continues to increase at a very rapid pace. Unfortunately, the current data infrastructures and protocols were not designed to handle this amount of data traffic for the current number of Web users.

For the past 10 years, the Internet2 consortium (internet2.org) has been investigating the next-generation Internet—both its application possibilities and infrastructure needs. Internet2 consists of 208 universities working in partnership with 70 companies and 40 government agencies to develop and deploy advanced network applications and technologies. The primary goals of Internet2 are to:

- Create a leading-edge network capability for the national research community
- Enable revolutionary Internet applications
- Ensure the rapid transfer of new network services and applications to the broader Internet community

Thus far, the consortium has succeeded in deploying a high-speed (40 to 100 Gbps) fiber-optic network among the university members.

Just as the original Internet came from efforts sponsored by NSF and DARPA, it is believed that the research being done by Internet2 will ultimately benefit the public. Although the efforts of the consortium will certainly impact the bandwidth among the major nodes of the Internet, it still will have not addressed the transmission barriers across the last mile to most homes and businesses.

**INTERNET CLIENT/SERVER APPLICATIONS**

To end users, the lower-level protocols, such as TCP/IP, are obscured. Users do not “see” these protocols as they go about their business on the Internet. Instead, end users interact with the Internet through one of several client/server applications. As the name suggests, a client/server application has two major classes of software:

- **Client software** usually resides on an end user's desktop and provides navigation and display.
- **Server software** usually resides on a workstation or server class machine and provides back-end data access services (where the data can be something as simple as a file or as complex as a relational database).
The most widely used client/server applications on the Internet are listed in Exhibit A.3. As noted in Exhibit A.3, each of these applications rests on one or more protocols that define how the clients and servers communicate with one another.

### A.3 WEB-BASED CLIENT/SERVER APPLICATIONS

The vast majority of e-commerce applications are Web based. In a Web-based application, the clients are called Web browsers, and the servers are simply called Web servers. Like other client/server applications, Web browsers and servers need (1) an addressing scheme so they can locate one another and send requests and responses back and forth and (2) a communication protocol so they can communicate with one another.

The addressing scheme used on the Web is the **Uniform Resource Locator (URL)**. We are all familiar with addresses such as “www.anywhere.com/web_page.htm.” For example, “www.microsoft.com/ms.htm” is the homepage for Microsoft Corporation. The page is actually designated by “ms.htm,” and the Web server on which the page resides is denoted by “www.microsoft.com.” This is the default syntax for a URL. It actually points to a default Web page stored on a Web server with that Web address.

When the user clicks on a hypertext link, a series of actions takes place behind the scenes. These actions are guided by the **Hypertext Transport Protocol (HTTP)**. HTTP is a lightweight communication protocol that enables Web browsers and Web servers to converse with one another. The protocol has only seven commands. Two of these—GET and POST—make up the majority of requests issued by browsers. The GET command retrieves a resource (e.g., a Web page) specified by a URL. The POST command sends data (usually from a form) from the browser to the Web server.

### WEB BROWSERS

The earliest Web browsers—Mosaic, Netscape 1.0, and Internet Explorer 1.0—were truly “thin” clients. Their primary function was to display Web documents containing text and simple graphics. For quite some time, Microsoft’s Internet Explorer (v.7.0) has had the lion’s share (over 80 percent) of the browser market, although a small but increasing percentage of users are relying on Mozilla’s Firefox browser (mozilla.com). Internet Explorer 6.0 is anything but thin, offering a suite of functions and features that, which are summarized in Exhibit A.4.

### WEB SERVERS

In the computer world, the term `server` is often used to refer to a piece of hardware. However, a Web server is not a computer; it is a software program that runs on a computer. Although the primary function of a Web server is to service HTTP requests, Web servers also perform the following functions:

- Provide access control, determining who can access particular directories or files on the Web server.
- Run scripts and external programs to either add functionality to the Web documents or provide real-time access to database and other dynamic data. This is done through various application programming interfaces, such as PHP or ASP.NET.

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**EXHIBIT A.3  Internet Client/Server Applications**

<table>
<thead>
<tr>
<th>Application</th>
<th>Protocol(s)</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-mail</td>
<td>Simple Mail Transport Protocol (SMTP)</td>
<td>Allows the transmission of text messages and binary attachments across the Internet.</td>
</tr>
<tr>
<td></td>
<td>Post Office Protocol version 3 (POP3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Multipurpose Internet Mail Extensions (MIME)</td>
<td></td>
</tr>
<tr>
<td>File transfer</td>
<td>File Transfer Protocol (FTP)</td>
<td>Enables files to be uploaded and downloaded across the Internet.</td>
</tr>
<tr>
<td>Chat</td>
<td>Internet Relay Chat (IRC)</td>
<td>Provides a way for users to talk to one another in real-time over the Internet. The real-time chat groups are called channels.</td>
</tr>
<tr>
<td>Usenet newsgroups</td>
<td>Network News Transfer Protocol (NNTP)</td>
<td>Discussion forums where users can asynchronously post messages and read messages posted by others.</td>
</tr>
<tr>
<td>World Wide Web (Web)</td>
<td>Hypertext Transport Protocol (HTTP)</td>
<td>Offers access to hypertext documents, executable programs, and other Internet resources.</td>
</tr>
</tbody>
</table>

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**Uniform Resource Locator (URL)**

The addressing scheme used to locate documents on the Web.

**Hypertext Transport Protocol (HTTP)**

A lightweight communication protocol that enables Web browsers and Web servers to converse with one another; of its seven commands, GET and POST make up the majority of requests issued by browsers.
Enable management and administration of both the server functions and the contents of the Web site (e.g., list all the links for a particular page at the site).

Log user transactions provide data that can be statistically analyzed to determine the general character of the users (e.g., what browsers they are using) and the types of content that are of interest to them.

Although there are dozens of Web servers on the market, two servers predominate—Apache and Microsoft’s Internet Information Server. The Apache server is free from Apache Software Foundation (apache.org). This server runs on a variety of hardware, including low-end PCs running the Linux and Windows operating systems. It has a number of functions and features usually found with more expensive servers. A commercial version of the server is provided with RedHat’s (redhat.com) Enterprise Linux server solution. Microsoft Internet Information Server (IIS) is included (free of charge) with Windows 2000 or Windows XP. Like other Windows products, IIS is easy to install and administer.

Since 1995, a company called Netcraft (netcraft.com) has been surveying Web servers connected to the “public” Internet in order to determine market share by vendor. This is done by physically polling all of the known Web sites with an HTTP request for the name of the server software. Since 1999, Apache has had between 50 to 75 percent market share, and Microsoft IIS has had between 20 and 35 percent. In January 2007, their respective shares were 59 percent and 31 percent (Netcraft 2007).

**A.4 MULTIMEDIA DELIVERY**

In addition to delivering Web pages with text and images, Web servers can also be used to download audio and video files of various formats (e.g., .mov, .avi, and .mpeg files) to hard disk. These files require a stand-alone player or browser add-in to hear and/or view them. Among the most popular multimedia players are RealNetwork’s RealMedia Player, Microsoft’s Windows Media Player, Apple’s QuickTime, and Macromedia’s Flash Player. Web servers can also be used to deliver audio and/or video in real time, assuming that the content is relatively small, that the quality of the transmission is not an issue, or that the content is not being broadcast live.

**Streaming** is a term used to refer to the delivery of content in real time. It is distinguished by three characteristics (Miller 2006):

- Streaming provides live or on-demand access to audio, video, and multimedia content via the Internet or an intranet.
- Streaming content is transmitted by a special media server and is processed and played back by a client player as it is received.
- A residual copy of the streaming content does not remain on the receiving device after the content has been processed and played.

Obviously, if the content is delivered on demand, then the content must exist ahead of time in a file. On-demand streaming is also called **progressive streaming**. With on-demand streaming, if an end user clicks a Web page link to an audio and/or video file, the file is progressively downloaded to the end user’s desktop. When enough of the file has been downloaded, the associated media player will begin playing the downloaded segment. If the media player finishes the downloaded segment before the next segment arrives, playback will pause until the next segment arrives.

The streaming of live broadcasts is called **true streaming**. True streaming is being used with online training, distance learning, live corporate broadcasts, videoconferencing, sports shows, radio programs, TV programs, and other forms of live education and entertainment. The quality of the audio that is delivered with true streaming can range from voice quality to AM/FM radio quality to near-CD quality. In the same vein,
the quality of true video streaming can range from a talking-head video delivered as a 160 × 120 pixel image at a rate of 1 to 10 frames per second to quarter-screen animation delivered as a 300 × 200 pixel image at 10 frames per second to full-screen, full-motion video delivered in a 640 × 480 pixel window at 20 to 30 frames per second. You can think of a pixel as a small dot on the screen.

The real challenge in delivering streaming media is the bandwidth problem. For example, 5 minutes of CD-quality audio requires about 50 megabytes of data. Given that 1 byte equals 8 bits, it would take hours to download the file with a 56K modem. Several techniques can be used to overcome the bandwidth problem:

- Compared to television shows, which are displayed in a 640 × 480 pixels image at 30 frames per second, streaming videos are usually displayed in small areas at lower frame rates.
- With video streams, sophisticated compression algorithms are used to analyze the data in each video frame and across many video frames to mathematically represent the video in the smallest amount of data possible.
- With audio streams, sampling rates are reduced, compression algorithms are applied, and sounds outside the range of human hearing are discarded.

The compression algorithms that are used to encode audio and video streams are called codecs (short for compression and decompression). Special tools are used to perform the compression. With on-demand streaming, the audio and video files are stored in compressed form. With true streaming, the content is compressed on the fly. In both cases, the media player decompresses the content. Unfortunately, different media players work with different compressed formats. For instance, the RealMedia player requires the RealMedia (.rm) or RealMedia variable bit rate (RMVB) format, whereas Microsoft’s Windows Media Player uses the Advanced Streaming Format (.asf). Both of these are proprietary formats. MPEG-4, an audio/video compression format that has been adopted by the International Standards Organization (ISO), is being promoted as an open streaming standard. Apple’s QuickTime player supports MPEG-4. Apple, Cisco, Philips, Intel, Hitachi and others have joined together to form the Internet Streaming Media Alliance (isma.tv) to ensure that MPEG-4 is implemented in different products in a standardized fashion.

True streaming requires specialized streaming servers, such as RealNetworks’ RealServer or Microsoft’s Windows Media Server, to deliver the live content. Streaming servers use different communication protocols than regular Web servers. More specifically, they employ a transport protocol called User Datagram Protocol (UDP) rather than TCP, along with two streaming protocols—Real-Time Protocol (RTP) and Real-Time Streaming Protocol. Real-Time Protocol (RTP) adds header information to the UDP packets. This information is used to enable the synchronized timing, sequencing, and decoding of the packets at the destination. Real-Time Streaming Protocol (RTSP) is an application protocol that adds controls for stopping, pausing, rewinding, and fast-forwarding the media stream. It also provides security and enables usage measurement and rights management so that content providers can control and charge for the usage of their media streams.

Because of the complexities surrounding the production and delivery of streaming media, a number of companies offer media hosting services for both on-demand and live streaming. The following are some of the providers offering these services (Lorance 2003):

- AudioVideoweb.com (audiovideoweb.com) provides streaming services for QuickTime, Windows Media, and RealMedia.
- DVLABS Inc. (dvlabs.com) provides streaming services for QuickTime, Windows Media, and RealMedia formats using advanced networking technology.
- Online Video Service (onlinevideo.com) provides streaming services for QuickTime, Windows Media, and RealMedia.
- VitalStream (vitalstream.com), formerly Playstream, provides streaming services for Adobe’s Shockwave/Flash, Apple’s QuickTime, RealNetworks’ RealMedia, and Windows Media.

### A.5 P2P APPLICATIONS

Most Internet and Web applications are built on a client/server model, with the server housing the data and hosting the application. A few years back, a new set of distributed applications appeared. These applications use direct communications between computers to share resources—storage, computing cycles, content, and human presence—rather than relying on a centralized server as the conduit between client devices. In other words, the computers on the “edge” of the Internet are peers, hence the name peer-to-peer (P2P) applications.

For years, the entire Internet had one model of connectivity. Computers were assumed to be on and connected at all times and, thus, were given permanent IP addresses. The DNS was established to track...
those addresses. The assumption was that addresses were stable, with few additions, deletions, or modifications. Then, around 1994, the Web appeared. To access the Web with a browser, a PC needed its own IP address to connect to the Internet. In this environment, computers entered and left the Internet at will.

To handle the dynamic nature of the Web and the sudden demand for connectivity, ISPs began assigning IP addresses dynamically, giving client PCs a new address each time they connected to the Web. Because there was no way to determine which computer had a particular address, these PCs were not given DNS entries and, as a consequence, could not host applications or data.

P2P changed all of this. Just like the Web, computers on a P2P network come and go in an unpredictable fashion and do not have fixed IP addresses. Unlike the Web, the computers in a P2P network operate outside the DNS. This enables the computers in a P2P network to act as a collection of equals with the power to host applications and data. This is what makes P2P different from other Internet applications.

If you want to know whether an application is P2P, you need to determine (1) whether connectivity is variable and temporary network addresses are the norm and (2) if the nodes at the edge of the network are autonomous. ICQ, an instant messaging application, was one of the first P2P applications. ICQ relies on its own protocol-specific addresses that have nothing to do with the DNS. In ICQ, all of the (chat) clients are autonomous. eDonkey2000 and Gnutella, both well-known file distribution applications, also are P2P because the addresses of its nodes bypass the DNS and the nodes control file transfers.

A wide variety of P2P applications exist. These applications can be divided into five categories (Berg 2001; Taylor 2003): access to information, instant messaging, collaboration, distributed computation, and (4) access to information.

ACCESS TO INFORMATION

P2P applications make it possible for one computer to share files with another computer located somewhere on the Internet. Essentially, the Internet or intranet becomes one big disk drive whose files can be located and transported with the P2P application. In the business world, P2P is used to create “affinity communities” where interested parties can share a collection of files on key business matters (e.g., strategic documents, white papers, etc.). The files can not only be viewed but also moved from one computer to another.

The earliest of the file-sharing applications was Napster. After a long series of lawsuits by the Recording Industry Association of America (RIAA) and various media companies against Napster and Bertelsmann (the German media company that attempted to purchase Napster), Napster finally declared bankruptcy and shut down its operations for good at the end of 2002. In its place, a whole host of file-sharing programs and services, such as Kazaa’s Media Desktop (kazaa.com) and Gnutella (gnutella.com) emerged. These programs and services are still in widespread use today.

There are two P2P file-sharing models. One model is based on a central server system that directs traffic among the nodes. This was the model used by Napster. The central server maintains a directory of shared files that exist on the PCs of registered users. The directory is updated when the PC connects to the server network. When a user requests a particular file, the server creates a list of matching files on the PCs that are currently connected. The user selects the file from the list, at which point a direct HTTP connection is made between the user’s PC and the PC possessing the file. The file is transferred directly between the PCs. The main advantage of this model is that the index maintained by the central server is both comprehensive and efficient.

The second model is completely decentralized. With this model, each client contacts one or more other clients to link into the network. Each client serves as a search engine for its neighbors, passing search requests throughout the network one node at a time. This is the model used by Gnutella. With Gnutella, each computer on the network has a Gnutella “servant”—a program that combines server and client functionality. An end user employs the servant to connect his or her computer to another computer on the Gnutella network. In turn, that computer announces to all the computers to which it is connected that another computer has joined the network. In turn, those computers announce the presence of the newly connected computer to the computers to which they are connected, and so on. When an end user wants to search for a file, the request is sent to the computers to which the user’s computer is directly connected. In turn, the request is passed on to the computers to which they are connected, and so on until a match is found. At that point, the computer with the matching file will send the file information back through the connected computers to the computer making the request. The user can then employ the servant to download the file directly from the computer with the matching file. This is done through HTTP. Although not as efficient as the first model, this model is very robust because it does not depend on a central point of contact.

INSTANT MESSAGING

In the United States, instant messaging (IM) programs such as ICQ, AOL’s Instant Messenger (AIM), MSN Messenger, and Yahoo! Messenger are almost as ubiquitous as e-mail, especially among teens and young adults (Christ 2005). These programs enable IM users to send notes back and forth
with other IM users, create chat rooms where they can converse with other interested parties, share Web links, look at images on other people’s computers, and play sounds for other people. When you think of instant messaging, you might think of chatting with family and friends. However, IM has also established a presence in the corporate world.

Like Napster, most IM products are based on a central server model and work in essentially the same way. The products consist of two parts—IM clients and an IM server. The communication protocol that the clients use to converse with one another and with the server varies from one vendor to the next. For instance, AOL’s IM uses a different protocol than MSN Messenger. This is why most IM products are unable to converse with one another.

When a user opens an IM client, the client connects to the IM server. Once connected, the user logs into the server. After the server has verified the user’s ID and password, the client sends the server its connection information, including its IP address and the port that client is using for messaging. Next, the server creates a temporary file that has the connection information, along with a list of the user’s contacts (in AOL terminology this is the “buddy list”). The server checks to see if any of these contacts are logged in. If any of the contacts are logged in, the server sends the connection information for those contacts to the user’s client. At the same time, it sends the client’s connection information to the contacts’ PCs.

When a user clicks on an online contact, a messaging window opens. The user then enters a message and clicks “Send.” Because the IM client has the IP address and port number for the contact’s computer, the message is sent directly to the contact’s machine, bypassing the central server. The message that is sent appears in the contact’s messaging window. The contact can then respond in a like manner. The conversation proceeds in this way until one of the participants closes the messaging window.

Eventually, when the user goes offline and exits the IM client, the client sends a message to the server to terminate the session. At this point, the server will inform the PCs on the end user’s contact list that the user is no longer online. The temporary file containing the client connection information will be deleted.

COLLABORATION

Collaboration applications are the P2P version of a class of software applications that used to be called groupware. As the name implies, groupware was designed to support workgroup activities, such as the joint creation of a project document. In the same vein, these P2P applications are designed to support the collaborative activities of groups of individuals.

In reality, the applications within this category actually combine the features of the file-sharing applications with the functions of the instant messaging applications and provide support for various joint activities (e.g., conferencing). More specifically, these applications use a central server P2P model to provide the following types of capabilities: communications (instant messaging, chat, threaded discussions, content sharing); shared files, images, contacts, and virtually any other sort of data and information; and joint activities (real-time conferencing, white boarding, simultaneous browsing of documents or other files, and co-editing of documents). One example of a P2P collaborative application is Microsoft’s Groove Virtual Office. Groove Virtual Office is based on the Groove Network that was designed by Ray Ozzie (the original designer of a well-known groupware application, Lotus Notes). In April 2005, Microsoft bought Groove Network and subsequently integrated it with its Office applications.

DISTRIBUTED COMPUTATION

By one very conservative estimate, the Internet has at least 10 billion MHz of PC processing power and 10 thousand terabytes of disk storage, assuming that each of the PCs only has a 100-MHz chip and a 100-MB hard drive, which is paltry by today’s standards (Cortese 2001). Much of this processing power and storage goes unused. Imagine if you could harness these unused resources to solve complex computational problems. This is what P2P distributed computation does. It uses P2P resource sharing to combine the idle processing cycles of computers on the network to form a virtual computer across which large computational jobs can be distributed.

One well-known distributed computation application was SETI@Home (seticlassic.ssl.berkeley.edu), now referred to as the Classic version. This application, which ran until December 2005, used more than 5 million computers on the Internet to analyze radio signals gathered from the Arecibo Observatory in Puerto Rico to search for extraterrestrial life. The Classic version has now been replaced by a new version which is also called SETI@Home (setiathome.berkeley.edu). Like its predecessor, the current version is focused on the search for extraterrestrial life and relies on the Berkeley Open Infrastructure for Network Computing (BOINC).
IMPEDIMENTS TO P2P

Although P2P applications such as IM enjoy widespread use, some major impediments to the continued growth of P2P exist. The first problem is performance. In a client/server application, the bottleneck is the processing speed of the server. In P2P, the performance of the application depends on the speed of the various network connections and the individual computers on the network. If any of these connections or machines is slow, then the performance of the application can degrade. It is one thing to deal with a single server whose performance is slow. It is a much more difficult task to deal with network links and peer computers over which you have little control.

A second problem is security. For example, most IM applications send unencrypted text from one computer to another. This text can be easily captured and read by unauthorized parties. In the same vein, P2P file-sharing and distributed-processing applications usually bypass the firewall and let one machine control another. These applications are easy targets for hackers who can insert viruses or other rogue programs.

Third, in an enterprise environment, system administration can become a major hassle. It is very difficult to determine who has what version or who is authorized to use a particular application, because many of the applications come from the outside. Finally, the P2P world has few standards. All of these applications rely on proprietary protocols. Although various standards bodies are at work (e.g., the Internet Engineering Task Force has proposed the Instant Messaging Presence Protocol), none of the protocols they might release are likely to impact P2P in the near future.

A.6 WEB 2.0: BLOGS, WIKIs, RSS, AND PODCASTS

If you were to compare the major Web sites, applications, and Web traffic that existed before and after the dot-com era (around 2001), you would notice some substantial functional and technical differences. Many of today’s Web sites, applications, and technologies fall under the rubric of Web 2.0. The term Web 2.0 was coined back in 2004 by Tim O’Reilly, the founder of O’Reilly Media and a strong supporter of the free software and open source movements. The term has no clearcut definition; however, the poster children for Web 2.0—sites such as Wikipedia, Flickr, Del.icio.us, YouTube, and Technorati to name a few—give you a sense of its character. According to O’Reilly (2005a):

Web 2.0 is the network as platform, spanning all connected devices; Web 2.0 applications are those that make the most of the intrinsic advantages of that platform: delivering software as a continually-updated service that gets better the more people use it, consuming and remixing data from multiple sources, including individual users, while providing their own data and services in a form that allows remixing by others, creating network effects through an “architecture of participation,” and going beyond the page metaphor of Web 1.0 to deliver rich user experiences.

Based on O’Reilly’s definition, Web 2.0 is distinguished by its support of the following (O’Reilly 2005b):

- **Social collaboration.** In the past, content delivery was a one-way street. Users or consumers were unable to add or modify the content in any way. Today, the content of a number of sites, such as Wikipedia and Flickr, is created by end users.

- **Data as a key resource.** A number of well-known Web sites and applications rest on specialized databases. Amazon’s product database, YouTube’s videos, and MapQuest’s maps (which are the base of many mapping applications, such as Google Maps) are cases in point. Typically, these specialized databases provide a substantial competitive edge.

- **Web as a platform.** Many Web 2.0 sites provide a Web Services application programming interface (API) that enables other sites to utilize their application data and capabilities or to combine data and functionality from multiple sites (see Appendix B) to create new functionality. In the latter case, the combinations are often called mashups, a term taken from the music world. Housingmaps.com, which combines Google Maps with Craigslist, is an example of a mashup.

- **Lightweight interface.** During the dot-com era, sites with interactive user interfaces relied on Java Applets or Microsoft ActiveX objects to provide a rich experience. Today, highly interactive sites rely on “Ajax” (asynchronous JavaScript and XML), which produces “lightweight” user interfaces. These technologies are discussed in Appendix B.

As noted, one of the critical features of Web 2.0 is social collaboration—the ability for end users to add or modify content at a Web site. Because standard Web servers lack this functionality, specialized servers are required. Two servers that have become the building blocks of many Web 2.0 sites are Blog and Wiki servers. Among their capabilities is the ability to handle RSS syndication and news feeds.
BLOG SERVERS

A blog, short for Weblog, is a regularly updated personal Web site where entries are published in reverse chronological order. The concept evolved from earlier personal online journals or diaries. The term Weblog was coined by Jorn Barger in 1997; the shortened version was coined by Peter Merholz in 1999 (Silkstone 2007). Based on figures from Technorati, a Web site devoted to tracking blogs, there are over 57 million self-contained blogs and 80 million blogs in online communities such as MySpace and Live Journal (Walsh 2007). According to Pew Research, over 50 percent of all blogs are essentially private, either shared by a small group of friends and family or located behind a corporate firewall. Only a small number of blogs enjoy the same kind of readership as the largest daily newspapers. In general, blog readership is growing at an annual rate of approximately 60 percent (Pew Internet and Life Project 2006).

Blogs are distinguished from other forms of online communication—e-mail, IM, chatrooms, bulletin boards, etc.—in six ways (Scoble and Isreal 2006):

1. Publishable. It is simple and inexpensive for anyone to publish a blog that is immediately available worldwide.
2. Findable. The major search engines provide a straightforward means for finding blogs by subject, author, or both.
3. Linkable. Most blogs are linked with other blogs, providing access to other content and bloggers and potentially making each blog part of a larger global network, which has come to be known as the blogosphere.
4. Social. The blogosphere can be viewed as one big “conversation” in which “conversations” move from site to site, linking to each other.
5. Viral. Information moves through blogs faster than any other form of viral marketing.
6. Syndicatable. People can subscribe to RSS-enabled blogs with the click of a mouse so that they are notified when the blog’s content is updated.

Earlier blogs were built using standard Web components—Web pages and servers. Today, the vast majority of blogs are either hosted by services such as MSN Live Space or are maintained and delivered through specialized blog software and servers (or engines) such as Wordpress. In either case, a critical element of the system is the blog server. As Johnson (2006) notes, most blog servers provide support for:

- Editing content and administering the system through a Web-based user interface
- Categorizing blog entries
- Customizing page templates to create a unique look and feel for the blog
- Obtaining feedback from readers
- Notifying readers via e-mail and news feeds about new entries and comments
- A programming or Web Services interface (API) to the system, enabling access to application data and capabilities
- Uploading images, audio, and video files

Architecturally, these capabilities are provided by a three-tier system: (1) a specialized blog data tier containing blog content, as well as uploads and attachments; (2) a Web tier for transforming blog data into HTML and XML representations; and (3) a variety of client interfaces, such as Web browsers, newsfeed readers and customized clients for creating, reading, tracking, and responding to blog entries. A variety of open and commercial systems have this basic architecture and provide the capabilities listed by Johnston. Wordpress (wordpress.org) and Roller (rollerweblogger.org) are a couple of the more popular examples. A comparison of a number blog software systems is provided by asymptomatic.net/blogbreakdown.htm (accessed March 2007).

WIKI SERVERS

According to Wikipedia (2007), a wiki is a Web site that “allows visitors to add, remove, edit and change content without the need for registration.” The term comes from the Hawaiian word wiki, which means fast. Essentially, a wiki is a collection of Web (wiki) pages that are built collaboratively and linked to one another. You can also think of a wiki as a software system that enables contributors to simply and efficiently coauthor and link wiki pages using nothing more than a simple markup language and a Web interface. Although it’s difficult to pinpoint the first blog, the first wiki—WikiWikiWeb—was created by Ward Cunningham and installed on the Web in March 1995. Wikipedia, which is clearly the premier example of a Wiki, was started by Jim Wales and made its appearance in January 2001.
Although the function of a wiki is certainly different than that of a blog, the underlying software and architecture of a wiki system and a blog are essentially the same. Again, as Johnson (2006) indicates, most wiki servers provide support for:

- Editing wiki pages and administering the system through a Web-based user interface
- Partitioning wiki pages and user pages via namespaces (a portion of which is reserved for one topic or set of users)
- Obtaining feedback from readers, wiki page changes, and comments
- Notifying readers via e-mail and news feeds about new entries and comments
- A programming or Web Services interface (API) to the system, enabling access to application data and capabilities
- Uploading files for wiki page attachments

Similar to a blog, these wiki capabilities are provided by a three-tier system: (1) a specialized wiki data tier containing the wiki pages, as well as file uploads and page attachments; (2) a Web tier for transforming wiki pages into HTML and XHTML; and (3) a variety of client interfaces, such as Web browsers, newsfeed readers and customized clients, for creating, reading, tracking wiki pages. A variety of open and commercial systems have this basic architecture and provide the capabilities listed by Johnson. MediaWiki (mediawiki.org) and TikiWiki (tikiwiki.org) are a couple of examples. A comparison of wiki software can be found at en.wikipedia.org/wiki/Comparison_of_wiki_software.

### RSS AND PODCASTING

**RSS** is an XML format for syndicating news and other Web content, such as blogs and wikis. Through RSS, a user can subscribe to a site and be notified of or download new content. At a given site, the presence of an RSS feed is denoted by an orange subscription icon with waves or a small orange rectangle with the letters XML or RSS inside.

The initials RSS represent both a stand-alone name, referring generally to the concept of syndicated newsfeeds, as well as an acronym representing one of three newsfeed "formats." The first of these formats, RDF Site Summary, or RSS 0.9, was developed at Netscape by Dan Libby back in 1999. This particular specification used the Resource Description Framework (RDF) as its base. This was followed in 2000 by Dave Winer’s RSS 0.91, which eliminated the RDF component. Because of its deficiencies, RDF advocates released the RSS 1.0 format, also known as Rich Site Summary. Winer, who continued to oppose the reliance on RDF, released another version, RSS 0.92, which eventually became RSS 2.0. Winer called this last version Real Simple Syndication. Today, there is no agreed upon RSS standard. Instead, the various versions remain incompatible. This makes it difficult to develop standard components and tools to work with the incompatible RSS newsfeeds. Fortunately, in 2003 a well-known group of bloggers and XML experts joined together to produce a new format called Atom. In 2005, Atom became an Internet standard created by the Internet Engineering Task Force (IETF) and formally known as the Atom Syndication Format. Most of the major blog servers either support or plan to support Atom.

RSS and Atom are both XML formats. A simple example based on RSS 2.0 is displayed in Exhibit A.5. Without going into all the details underlying XML (see the discussion of XML in Appendix B), simply note that this example is based on a feed (designated as a <channel>) from JDA Corporation’s Articles and Reviews. This example has two <item> updates. Each item has a <title>, a <link> indicating the Web site location for the update, and a <description>. The feed can be found at the Web site designated by the channel <link>.

A key feature of both blog and wiki servers is their ability to generate syndicated newsfeeds using either RSS, Atom, or both. Additionally, various Web sites provide similar support. For this reason, there is much less demand for syndicated newsfeed server software. Instead, the focus has been on news aggregators, feed readers, or RSS readers. These are just different terms for the same type of software. Basically, an RSS Reader is client software that enables an end user to subscribe to various syndicated Web, blog, or wiki sites and to organize the presentation of the feeds coming from those sites.

**podcast**

A media file that is distributed over the Internet using RSS or Atom syndication feeds for playback on portable media players and personal computers.

**RSS Reader**

Client software that enables an end user to subscribe to various syndicated Web, blog, or wiki sites and to organize the presentation of the feeds coming from those sites.

**RSS** An XML format for syndicating news and other Web content, such as blogs and wikis.
subscribe to and track podcasts of interest using standard RSS readers. Special podcast readers or aggregators also are available for not only tracking podcast feeds but also automatically downloading the MP3 files when they are available. Doppler (dopplerradio.net) and Juice (juicereceiver.sourceforge.net) are both examples of free podcast readers.

**EXHIBIT A.5  RSS Example**

```xml
<?xml version="1.0" encoding="ISO-8859-1" ?>
<rss version="2.0">
  <channel>
    <title>JDA Corporation – Articles and Reviews</title>
    <link>http://www.jda.com/company/news-coverage.html?src=rss</link>
    <description>RSS feeds from JDA Corporation</description>
    <item>
      <title>Pumping Up Allocation Planning</title>
      <description>Famous Fashions reduces inventory with JDA</description>
    </item>
    <item>
      <title>Pilot Exceeds Expectations</title>
      <description>Pilot yields key savings for ABC Wholesaler</description>
    </item>
  </channel>
</rss>
```

**KEY TERMS**

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**REFERENCES**


