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From Products to Services: The Software Industry in the Internet Era

The computer-services and software industry used to be conveniently divided into three main sectors: mass-market software vendors, enterprise software vendors, and computer services. The three sectors were distinct, because personal computers, corporate mainframes, and online computer networks operated in relative isolation. The arrival of the Internet effectively connected everything, facilitating the entry of mass-market vendors into enterprise software and of both mass-market and enterprise software vendors into computer services. As the turbulence of the first decade of the Internet era subsides, a gradual transition from traditional software products to "Web services" is taking place.

The rise of the Internet had a profound effect on the computer-software and services industry (CSSI). Before the advent of the commercial Internet, beginning in 1994, the industry comprised three distinct sectors.[1]

In the first, mass-market software products, prominent vendors like Microsoft, Adobe Systems, and Intuit supplied software packages—such as word-processing programs and spreadsheets—for use on personal computers (PCs). In the second, enterprise software products, companies sold software packages for business administration and corporate-

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[1] Martin Campbell-Kelly, *From Airline Reservations to Sonic the Hedgehog: A History of the Software Industry* (Cambridge, Mass., 2003), 3–5. Detlev J. Hoch, Cyriac R. Roeding, Gert Purkert, and Sandro K. Lindner, *Secrets of Software Success* (Boston, Mass., 2000), 259–71.

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computing infrastructure. Prominent firms included Computer Associates, Oracle Systems, and SAP. In the third sector, computer-services, firms provided processing services remotely by means of a connection to the company's private network. Prominent players included ADP (the leading payroll processor) and EDS (the leader in healthcare administration). The three divisions of the CSSI were historically, culturally, and technologically determined.

Historically, the computer-services industry was established in the mid-1950s, when computers were expensive to buy and costly to operate, a situation that created a market opportunity for data-processing services to supply firms that did not want to buy their own computers. The enterprise software industry was established in the mid-1960s. At that time, the cost of a mainframe computer had fallen rapidly, and the economics of information processing had swung in favor of owning a computer and purchasing software products to run diverse applications. The mass-market software industry was established in the late 1970s, supplying products for the newly invented PC.

Because the three sectors evolved as distinct corporate cultures with their own business practices, movement between sectors was difficult. Thus, computer-services firms grew into a classic service industry, establishing permanent relations with their customers, who purchased services based on demand. Enterprise-software vendors evolved as a capital-goods industry, using a direct-sales force to sell expensive technical artifacts and then provide after-sales service. By contrast, the mass-market software industry followed an information-goods model (rather like the record or book-publishing industries), selling programs in high volumes at low prices to both consumers and corporate users.

Technology was another factor that kept the three sectors apart. For example, computer-services firms invested in extensive private networks that constituted a high barrier to other entrants. Enterprise and mass-market software vendors made products for distinct computing environments: enterprise software ran on powerful centralized mainframes and minicomputers, whereas mass-market software ran on low-powered PCs. These companies required different software-development skills. For example, in enterprise software, reliability was paramount, while, in mass-market software, user friendliness was at a premium. At a time when these two computing environments were largely independent, neither type of firm had a strong incentive to develop competencies in the other sector.

The arrival of the Internet connected all the parts of the computing environment that had previously been separate and dramatically reduced the entry costs of establishing a network presence. In the complex restructuring of the industry that ensued, the most conspicuous

change was a form of horizontal integration that has been described by Alfred D. Chandler Jr. First, mass-market vendors integrated into enterprise software. Second, both mass-market and enterprise-software vendors entered computer services. Interestingly, we observe little evidence either of computer-services firms becoming involved with software products or of enterprise-software vendors moving into mass markets. Our findings are consistent with the trend by firms to move from products into services that has been observed by Michael Cusumano and others.[2]

Our focus is on the changes in the software industry that have occurred in the post-Internet era. The Internet also created opportunities for new firms. For example, it facilitated collaborative software development to an unprecedented degree, which led to the "open-source" software movement. Open-source firms gave their software away, making their money from associated services. The Internet, by circumventing the traditional software-distribution mechanisms, internationalized the software industry and diminished U.S. dominance. In this article we concentrate on the changes that have taken place in the preexisting software industry.[3]

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The modern computing environment can be viewed as a technological system with three main components: the appliance, the infrastructure, and services.[4] Historically, these have been supplied, respectively, by the mass-market software, enterprise software, and service sectors of the industry.

First, we describe the impact of the Internet on the "appliance"—typically a PC, but increasingly other devices too, such as personal digital assistants (PDAs), also called handheld computers, videogame consoles, cell phones, and digital music players. In part, this is the well-known story of the "browser wars," but we show that the story is deeper than

[2] Michael Cusumano, *The Business of Software* (New York, 2004), 86–127.

[3] This article concerns the recent development of an entire industrial sector. It is broader in scope than the typical *Business History Review* article, though not unprecedented (see, for example, Richard Langlois's 1992 study of the development of the microcomputer industry, "External Economies and Economic Progress: The Case of the Microcomputer Industry," *Business History Review* 66: 1–50). Consequently, the range of sources we have consulted is also not typical. Because the events described are recent, we are more than usually reliant on the contemporary business and technical press. Few academic studies have yet been made, and primary sources, such as industry-analyst reports and corporate records, are not generally in the public domain. These, in any case, would likely be subject to a twenty- or thirty-year embargo on disclosure.

[4] In justifying this choice of model, we note that broadcasting and telecommunications are similar technological systems with an appliance-infrastructure-services industrial structure.

the simplistic David-versus-Goliath struggle between Netscape and Microsoft. Next, we describe the effect of the Internet on the software infrastructure. It is in this context that open-source software has flourished and a new subindustry of information security has developed. We then describe the renaissance of computer services—the oldest and staidest sector of the industry. Whereas software was once sold as bits-in-a-box, increasingly it is being delivered as a service over the Internet—blurring the once sharp boundaries between software products and services.

Finally, we review the transformation of the preexisting software industry in the Internet era. We show that firms have engaged in classic Schumpeterian creative destruction in order to redeploy corporate strengths in new markets with better prospects. We also show that firms, most often, have obtained new technologies by firm acquisition, rather than by internal development.

Appliance Software: Web Browsers and Complements

The Internet existed as an academic-research network some years before it became synonymous with the World Wide Web. Technically, the Internet is a network infrastructure that can support numerous "application layers," such as e-mail and file transfers. The World Wide Web was, at first, just another such application layer developed by computer scientist Tim Berners-Lee at the CERN nuclear-particle physics laboratory in Geneva, Switzerland.[5] However, the Web browser provided a radically new look and feel to the Internet, making it more accessible, user friendly, and visually compelling.

Berners-Lee's original Web browser was a rather ungainly and fragile program, and it was quickly polished and reengineered by the Internet community. The most popular browser was Mosaic, which was developed at the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign. Remarkably, the project was led by a second-year undergraduate computer-science student, Marc Andreesen, who later cofounded the Netscape Corporation.[6] The Mosaic browser was made available for downloading from the Internet in November 1993, resulting in thousands, and eventually hundreds of thousands, of copies being downloaded.

Web Browsers and Servers. The extensive coverage of the rivalry between Netscape and Microsoft has obscured the fact that the story

[5] Tim Berners-Lee, *Weaving the Web: The Past, Present, and Future of the World Wide Web* (London, 1999).

[6] Michael A. Cusumano and David B. Yoffie, *Competing on Internet Time: Lessons from Netscape and its Battle with Microsoft* (New York, 1998).

featured more than two players. From 1994 to 1995, there were about two dozen entrants producing browsers to run on the desktop PC.[7]

Although these browsers provided a means of accessing the Web, the majority of firms did not add materially to the content or infrastructure of the Web itself. In contrast, Netscape, and later Microsoft, created browser complements that offered a more comprehensive technological system.

The Netscape Communications Corporation (originally named Mosaic Communications) was established in April 1994 by the entrepreneur Jim Clark, the wealthy founder of SGI, a workstation manufacturer, and Marc Andreesen, who had become the poster boy of the Web after leading the development of the Mosaic browser at the University of Illinois. Netscape's Navigator browser was released as a "beta" program for early adopters and was made available for free downloads in October 1994. Some ten million copies were downloaded during the next two months. In December 1994, Netscape released a commercial browser, Navigator 1.0, which was offered free to educational institutions and for a nominal fee of $39 to corporations after a ninety-day trial period (a requirement more often overlooked than observed). At the same time, Netscape introduced complementary server software: Communications Server and Commercial Server, costing $1,500 and $5,000, respectively.[8] Netscape's browser complements were critical to the transformation of the Web from an academic information space to a place for electronic commerce. Netscape did more than just create a window on the Web: its server software enabled corporations to establish their own Internet presences. In March 1995, Netscape launched a number of specialized applications—Merchant System, Community System, Publishing System, and IStore—that simplified the creation of Web sites in particular domains.[9] Netscape was thus something of a hybrid company, supplying both mass-market and infrastructure products.

Microsoft woke up to the Internet in early 1994, around the time that Netscape was being incorporated.[10] However, it took about a year for Microsoft to change direction. One of the most celebrated events in the history of the Internet occurred on May 26, 1995, when Bill Gates circulated a memorandum entitled "The Internet Tidal Wave," in which he signaled a strategic realignment from proprietary networks to the universal Internet. Although Microsoft's response to the Internet has sometimes been portrayed as lagging, in reality it was one of the first of the major software firms to take advantage of the phenomenon.

[7] Ibid., 96.
[8] Ibid., 98.
[9] Ibid., 330.
[10] Kathy Rebello, "Inside Microsoft," *Business Week*, 15 July 1996, 56–67.

The Internet Explorer browser was released in August 1995, simultaneously with the introduction of the new Windows 95 desktop-operating system. Like Netscape, Microsoft recognized the need to supply both a browser and infrastructure complements. In February 1996, Microsoft introduced the Internet Information Server (IIS), its Web server, bundling it at no additional cost with the NT server-operating system.

Microsoft's early browsers were lackluster, achieving barely a 10 percent market share throughout 1996.[11] However, the company gradually caught up with Netscape in successive releases.[12] By release 4.0 in September 1997—the result of a team effort by "100 people with an estimated annual budget of $100 million"—it achieved technical parity with its competitor.[13] By mid-1998, each company controlled close to half of the browser market.

Microsoft's Web software was either given away free or bundled with its operating system at no additional cost, a tactic that reduced the opportunity for Netscape to derive revenues from software sales. Instead, Netscape refocused on Web services and exploited its Web portal: "Netscape would cease to consider itself a pure software company altogether. Instead, it would embrace a new mission that was based on the convergence between software and services."[14] Most Netscape browser users visited the company's "home page" every time their browsers were opened, generating 100 million hits a day. By 1997, the company was deriving annual revenues of $108 million in fees from advertising and search-engine referrals.[15] In November 1998, Netscape was acquired by AOL for $4.2 billion, principally for its portal operation, and the browser market was effectively ceded to Microsoft.

Web Publishing. One reason for the rapid acceptance of the Web was the informality with which documents could be published and the ease with which they could be created.[16] The language of Web pages,

[11] Stan J. Liebowitz and Stephen E. Margolis, *Winners, Losers, and Microsoft: Competition and Antitrust in High Technology* (Oakland, Calif., 1999), 217–23.

[12] Netscape released the Navigator browsers as follows: version 1.0 in Dec. 1994; 2.0 in Feb. 1996; 3.0 in Aug. 1996; 4.0. in Aug. 1997. Microsoft released Internet Explorer as follows: 1.0 in Aug. 1995; 2.0 in Nov. 1995; 3.0 in Aug. 1996; 4.0 in Sept. 1997. Cusumano and Yoffie, *Competing on Internet Time*, 329–34. David S. Evans, Albert L. Nichols, and Richard Schmalensee, "An Analysis of the Government's Economic Case in U.S. v. Microsoft Corp," in David S. Evans, ed., *Microsoft, Antitrust, and the New Economy: Selected Essays* (Boston, 2002), 23–92.

[13] Paul Windrum, "Leveraging Technological Externalities in Complex Technologies: Microsoft's Exploitation of Standards in the Browser Wars," *Research Policy* 33 (2004): 385–94.

[14] Cusumano and Yoffie, *Competing on Internet Time*, 38.

[15] Ibid., 326.

[16] Craig Cline and Matt McKenzie, "Authoring the Web," *Seybold Report on Internet Publishing* 1 (Oct. 1996): 9–14.

HTML, employed a simple mark-up system that could be written directly by anyone who had a passing familiarity with computer programming or with a page mark-up notation.

In order to extend the reach of the Web, however, publishing tools were needed to create Web pages and Web sites. This was a broad, inventive space.[17] The product spectrum ranged from relatively primitive tools for experts to systems for consumers and professional Web designers that were much like word processors for Web pages. Prices ranged from about $50 for the simple consumer products up to $1,000 per user for enterprise systems. By the fall of 1996, more than fifty products were reported to be on the market.[18]

The most authoritative account of the Web publishing scene during 1994 and 1995 is Charles Ferguson's book about the creation of Vermeer Technologies, subsequently acquired by Microsoft in January 1996.[19] Ferguson originally founded Vermeer in April 1994 to develop tools for electronic publishing.[20] As he describes it, in May 1994 he glimpsed the possibilities in the Web phenomenon some months ahead of the incumbent mass-market producers. Vermeer, and a few companies like it, thus had a brief window of opportunity to develop a product and secure a foothold before the incumbents moved in.

Vermeer's Web-publishing product, FrontPage, was scheduled for release in October 1995. While the development was underway, Ferguson engaged in extensive industry networking, negotiating with Netscape and Microsoft, both of which needed a powerful Web publishing tool to complement their browsers and servers. Although FrontPage was a highly competitive product, its position as the market leader among the many competitors was not assured, so Ferguson made the rational decision to sell the company to Microsoft for $130 million.[21]

FrontPage was a major strategic acquisition for Microsoft. In late 1996, armed with FrontPage, the NT operating system, the IIS Web server, and its own database software, Microsoft was able to offer a complete system for establishing a company intranet or an e-commerce operation. Apart from Netscape, no other vendor had such a complete one-stop solution.

Web publishing was a natural development for the leading mass-market desktop-publishing and multimedia companies, such as Adobe

[17] "Tools for Creating Web Pages," *Seybold Report on Publishing Systems* 24 (May 1995).

[18] Sharon Terdeman, "Web Authoring," *PC Magazine*, 10 Sept. 1996, 115.

[19] Charles H. Ferguson, *High St@kes, No Prisoners: A Winner's Tale of Greed and Glory in the Internet Wars* (New York, 1999). Prior to founding Vermeer, Ferguson was a technology analyst and policy expert, and his book is full of insights.

[20] Ibid., 31.

[21] Ibid., 253.

Systems and Macromedia. Adobe introduced a consumer product, PageMill, in September 1995, followed by a professional system, GoLive, in 1999 (like FrontPage, these were both acquisitions); Macromedia developed its own professional product, DreamWeaver, which was launched in December 1997.[22]

Compared with the word-processing market (where one product, Microsoft Word, has dominated for many years), Web publishing remained relatively diffuse. The leading word-processing products had benefited from "network effects," which made it advantageous for users to adopt a common package so they could exchange files.[23] Such network effects had little impact on Web publishing. Web-publishing standards were open, and they were negotiated through the nonprofit World Wide Web Consortium. By and large, any Web-publishing system could work with any Web page. Although FrontPage, DreamWeaver, PageMill, and GoLive became the most popular systems, there were numerous niche products.[24]

Helper Applications and Plug-Ins. As originally implemented, the Web browser was a rudimentary multimedia system primarily intended for the display of text and images. However, within months of the appearance of Netscape's commercial-grade browser in December 1994, innovators began to transform the Web, enabling it to deliver the kinds of service already available on consumer networks like AOL and CompuServe—audiovisual entertainment, chat rooms and tools for collaboration, and e-commerce applications ranging from retailing to auctioneering.[25]

To achieve these diverse uses, additional applications software was needed. These programs could either be run as applications in their own right or integrated into the Web browser as "helper" applications or "plug-ins." The integrated mode of use provided a single interface for the ordinary user and had the potential for turning the Web browser into a new platform that would transcend the underlying operating system.

Hundreds of browser complements were developed, and in the more popular categories (such as media players) there were many competing

[22] Pam Pfiffner, *Inside the Publishing Revolution: The Adobe Story* (Berkeley, 2002), 170, 213–14; "DreamWeaver Wakes Up the Web Authoring Market," *Seybold Report on Internet Publishing* 2 (Nov. 1997): 33–36.

[23] Carl Shapiro and Hal R. Varian, *Information Rules: A Strategic Guide to the Networked Economy* (Boston, 1999), 44–46.

[24] There are no public-domain sources for market shares of Web publishing tools. A proxy for their current popularity is, perhaps, the number of textbooks listed on Amazon.com: FrontPage, 529; DreamWeaver, 638; GoLive, 71; PageMill, 24, NetObjects Fusion, 21; HoTMetal, 4. (Search conducted by author, 19 Jan. 2007.)

[25] For example, Amazon.com was founded in July 1995; AuctionWeb (later eBay), in late 1995. Robert Spector, *Amazon.com: Get Big Fast* (New York, 2000); Adam Cohen, *The Perfect Store: Inside eBay* (New York, 2002).

Table 1
Leading Browser Plug-ins

Plug-in	*Maker*	*Diffusion in 2006 (%)*[a]	*Revenue-Generating Products*
Flash	Adobe Systems	98	Authoring tools and servers
Java	Sun Microsystems	87	Technology licensing; development tools
Media player	Microsoft	83	Server operating system
QuickTime	Apple Computer	67	Premium reader
RealPlayer	RealNetworks	55	Premium reader; authoring tools; server software; and media services
Shockwave	Adobe	52	Authoring tools and servers
PDF	Adobe Systems	n/a	Authoring and publishing tools; servers

[a] Data for the diffusion statistics are from the Millward Brown Survey, Adobe Systems, December 2006.

developments. By mid-1995, when the first helper applications started to appear, the pricing strategies for Internet software had become firmly established: the "client software" (which ran on a user's PC) was free, and the supplier generated revenues from the sale of developer tools and server software. This pricing environment set a high barrier for new entrants. In order to generate a revenue stream, it was necessary to offer a portfolio of software: the client program, development tools, and server software. Relatively few start-up firms had the necessary resources. Hence, most of the leading browser complements were produced by large, successful firms with deep pockets and sophisticated marketing operations. (See Table 1.) Every successful plug-in has its own unique history. Their trajectories, however, were broadly similar. For example, most of the browser complements listed in Table 1 predated the commercialization of the Internet and were subsequently retrofitted for the Web. Adobe Systems' PDF product is typical.

Adobe's PDF viewer is probably the best-known browser plug-in in the scholarly and business communities. In 1991, John Warnock, the cofounder of Adobe, conceived the idea of a portable document format that would enable electronic documents to be accessed on any computer platform.[26] The product was launched under the name Carousel in November 1992. The initial market for the product was the "paperless office," and the sales pitch for electronic-publication technology was that it would reduce costs by replacing paper.[27] Carousel was not

[26] Pam Pfiffner, *Inside the Publishing Revolution*, 137.
[27] Richard Brandt, "Does Adobe Have a Paper Cutter?" *Business Week*, 16 Nov. 1992, 98–99.

particularly successful, but, in the wake of media hype about the "information superhighway," the product was improved and relaunched as Acrobat in June 1993.[28] Again, the product did not succeed until Adobe made the reader free in September 1994. Adobe encouraged PC assemblers to bundle the reader with new computers, and it was distributed through cover disks on PC magazines. PDF became a popular document dissemination format before the commercial Web took off.

Of the firms listed in Table 1, only RealNetworks was not a preexisting successful firm. RealNetworks (originally Progressive Networks) was founded in November 1993. Although a start-up, it was a sophisticated operation, backed by several million dollars of venture capital and able to draw on the experience of its founder, Robert Glaser, a fifteen-year Microsoft multimedia veteran.[29] Its first product, RealAudio, was launched in July 1995. The RealAudio client software enabled a Web user to listen to "streaming" audio—that is, sound played in real time—rather than having to download a file before being able to play it. The RealAudio player was made available for free download and was also bundled with the Netscape and Microsoft browsers and with Windows 95.[30] RealNetworks gained revenues primarily from the sales of complements (the RealAudio Studio development tool and RealAudio Server software), but the firm did not make a profit until 1999. Once bandwidth improved with the introduction of cable and broadband Internet connections around 1997, streaming video was introduced.

RealNetworks' principal competitor was Microsoft. Although Apple Computer offered its QuickTime media player, the hardware-dominated company did not pursue browser plug-in sales aggressively. Microsoft introduced a successful streaming product in May 1998.[31] Like RealNetworks, Microsoft gave the client software away, but the server software, too, was bundled with Microsoft's NT operating system at no additional cost. Thus, like Netscape, RealNetworks found it difficult to generate software revenues.[32] Instead, the company refocused on services—subscription music, music downloads, and computer games. RealNetworks emerged from the rivalry a different company: whereas

[28] Amy Cortese, "This Acrobat Has Really Limbered Up," *Business Week*, 26 Sept. 1994, 73–74; Pfiffer, *Inside the Publishing Revolution*, 141.

[29] For the early history of RealNetworks, see Robert H. Reid, *Architects of the Web* (New York, 1997), 69–101.

[30] "Progressive Networks Announces RealAudio Personal Server," *BusinessWire*, 9 Oct. 1995.

[31] Steve Hamm, "The 800-Pound Gorilla's New Toy," *Business Week*, 11 May 1998, 60–64.

[32] In December 2003, RealNetworks filed an antitrust suit against Microsoft, alleging that it had used its monopoly power to restrict competition. The action was settled in October 2005 when Microsoft agreed to pay RealNetworks $761 million. RealNetworks, *Annual Report*, 2005, p. 4.

in 1998 software licensing had constituted 73 percent and services 22 percent of its annual revenues, by 2005 these shares were effectively reversed, to 25 percent and 75 percent, respectively.[33] Today, RealNetworks is still classified as a software company, although software is no longer its primary product. The question of what constitutes a software firm in the Internet era will be taken up in our conclusion.

Infrastructure Software

The Internet accelerated three major trends in infrastructure software. First, the industry encountered more competition from the open-source software community. By giving software away and charging for services, the open-source business model was a challenge to traditional enterprise software firms that sold code, not services. Second, the server-operating system became more important. Although "client-server" systems had been gaining in importance since the mid-1980s, their suitability for Internet-based applications (when compared with older mainframe systems) established them as the dominant computing environment of the 1990s. The server-operating system became as fundamental to the Internet infrastructure as the Web browser was to the desktop computer. The third trend was the rise of the security-software sector. Probably no existing software category benefited more from the Internet than security software, which developed into one of the major software categories, ranking in importance with traditional sectors, such as database systems and enterprise resource-planning (ERP) software.

Open-Source Software and Linux. Although the term "open source" dates from 1998, the concept of free source-code-disclosed software is far from new. In the 1950s, it was a common form of software development.[34] Beginning in the mid-1960s, this form was displaced by closed-source, proprietary software products, enabling costly custom-written programs to be replaced by standardized packages.

The revival of open-source software (OSS) in the early 1980s is often attributed to Richard Stallman, an MIT-based computer programmer, who was its most vocal and passionate advocate.[35] To ensure that open-source software stayed in the public domain, he devised, with legal advice, the GNU General Public License (GPL) scheme. In short,

[33] Real Networks, *Annual Reports*, 1998, 2005.

[34] See, for example, Atsushi Akera, "Voluntarism and the Fruits of Collaboration: The IBM User's Group Share," *Technology and Culture* 42, no. 4 (2001): 710–36.

[35] Richard Stallman, "The GNU Operating System and the Free Software Movement," in Chris DiBona, Sam Ockman, and Mark Stone, *Open Sources: Voices from the Open Source Revolution* (Sebastopol, Calif., 1999), 53–70.

this license ensures that any derivative work of a GPL program remains in the public domain. Hence, in practice, those who would seek to profit from open-source software can only do so by selling complementary services, not the software itself.[36]

The rise of OSS was aided by another, unrelated, factor: a number of software artifacts developed for the Internet.[37] These programs were created as free and open source, not for ideological reasons but because they were developed in a public, academic-research context and because the emerging technology of the Internet encouraged collaborative development and consensual design.

Linux has become the centerpiece of the open-source project. The history of Linux is extraordinary.[38] The founder of the project was Linus Torvalds, who in 1990 was a second-year computer-science undergraduate at the University of Helsinki. His electives included a course on operating systems, which drew him into an Internet community of operating-system enthusiasts. Torvalds proposed the development of a free version of the Unix operating system to run on PCs, which would be written by himself and any other collaborators who wished to participate. Torvalds's operating system was first released in September 1991. From 1992 on, the code was issued under the GPL license, which facilitated its diffusion and ensured that software innovations were returned to the community.

In early 1992 Linux took off, and the number of users "grew from five, ten, twenty . . . to hundreds of unidentifiable people."[39] Over the next two years, contributors identified bugs and submitted numerous software enhancements. In March 1994, Torvalds released Linux 1.0, a version number connoting that the operating system was now functional, rather than experimental. Coincidentally, Linux arrived on the scene just as the commercial Internet was expanding, creating an unprecedented demand for server operating systems.

Server Operating Systems. Traditionally, from the 1960s to the mid-1980s, the dominant form of computer network was a centralized mainframe with "dumb" terminals attached. The system's intelligence resided in the mainframe; the terminals were just used to enter and dis-

[36] Steven Weber, *The Success of Open Source* (Cambridge, Mass., 2004), 52.

[37] Three prominent examples were the Apache Web-server software, the Sendmail program, and the Bind DNS software. These programs were fundamental components of the Internet infrastructure, and all of them captured more than half of their "markets." See Weber, *Success of Open Source*, 6. It is somewhat paradoxical to speak of markets for free software, because open-source products are not directly purchased. The market is usually measured by units, rather than in revenues.

[38] Linus Torvalds and David Diamond, *Just For Fun: The Story of an Accidental Revolutionary* (New York, 2001).

[39] Ibid., 92–93.

play data. The development of the PC and more powerful workstations in the early 1980s made it possible to have much more complex network topologies. The client-server network had emerged by the mid-1980s and would become the dominant mode in the 1990s. In this scheme, "clients" (desktop PCs or workstations) were attached to a server computer. The server provided services for the clients, such as file storage, database access, and running enterprise applications. Several physical server computers could coexist in the network, depending on the load that had to be serviced. The first client-server networks used the Unix operating system and were based on high-performance RISC-based computers.[40] Toward the end of the 1980s, simple PC-based client-server systems came into existence. Usually known as "workgroups," they consisted of a cluster of standard IBM-compatible PCs and one or more low-cost servers that enabled files to be centrally stored and resources, such as printers, to be shared. The most common software arrangement used the Microsoft desktop-operating system (MS-DOS or Windows) on the client's PCs and a Novell Netware network-operating system on the servers. Novell introduced its innovative Netware product as a complement to Microsoft's desktop-operating systems in 1985. It was so successful that, by 1992, Novell had become the number two vendor (after Microsoft) in the mass-market software industry.[41]

Two factors enhanced the popularity of client-server systems in the second half of the 1990s. First, the rise of the Internet created a huge demand for dedicated servers for applications such as e-mail and Web serving. Second, the rapid improvement of Intel microprocessors (those used in IBM-compatible PCs) made them competitive with the more expensive RISC technology.[42]

By about 1994, Linux was sufficiently stable that it could be used for Intel-based servers. At first, Linux could only be deployed by members of the development community or by technicians familiar with the technology. This created an opportunity for entrepreneurial firms to package and market Linux. These products, known as "distributions," consisted of an integrated set of software components that could be installed by means of a relatively user-friendly procedure. The firms also

[40] Paul Ceruzzi, *A History of Modern Computing* (Cambridge, Mass. 1998), 282–87; Ed Dunphy, *The Unix Industry and Open Systems in Transition* (New York, 1994). RISC (Reduced Instruction Set Computer) technology gave a superior price performance to that of traditional mainframe computers. See Ceruzzi, *History of Modern Computing*, 287–90.

[41] Kathy Rebello, Robert D. Hof, and Russell Mitchell, "Novell: End of an Era?" *Business Week*, 22 Nov. 1993, 43–45.

[42] Throughout the 1990s, microprocessor improvements followed "Moore's Law," according to which transistor density in microchips improved by a factor of two every year. See "Computer Laws," in Anthony Ralston, Edwin D. Reilly, and David Hemmendinger, eds., *Encyclopedia of Computer Science* (London, 2000), 960–64.

provided telephone support and software upgrades for users. Dozens of firms from several countries rushed into this market. Red Hat (U.S.) and Suse (Germany) quickly became market leaders; other prominent players were Turbolinux (Japan), Conectiva (Brazil), MandrakeSoft (France), and Red Flag (China).[43] These firms pioneered the open-source-software pricing model, whereby firms gave the software away but charged for support services. Users who did not need support could download the software for free, and millions did.

Linux's credibility was given a massive boost in 2001, when IBM stated that it would adopt Linux and would also donate the time of several hundred of its developers to open-source projects, including Linux.[44] In 2003, aggregate Linux revenues for all distributions were just $91 million, a sum that does not begin to reflect the impact of Linux.[45] That figure corresponded to approximately one million paid-up Linux licenses but did not account for an incalculable number of servers running free Linux. Several of the largest commercial Web sites, such as Google and Amazon.com, used Linux for their "server farms." For example, in 2006 Google was reported to be using Linux exclusively on its 450,000 servers installed worldwide.[46]

The firm that benefited most from the rise of Intel-based servers was Microsoft. Microsoft had begun the development of a server-operating system in 1988, hiring an operating-system architect who had once worked for Digital Equipment Corp. to lead the development.[47] This product was released as Windows NT in 1993. After Microsoft recognized the significance of the Internet in 1994, it scrambled to develop and incorporate facilities for Web serving and other Internet technologies.[48] The system was relatively inexpensive and easy to install (using familiar Windows nomenclature and configuration processes) compared with that of its principal competitor, Novell Netware. Microsoft also headed off a potential human-resource bottleneck by setting up instructional courses, accredited with its MSCE (Microsoft Certified Engineer) imprimatur, for the installation and maintenance of networks.

[43] Martin Fink, *The Business and Economics of Linux and Open Source* (Upper Saddle River, N.J., 2003), 87–91.

[44] Spencer E. Ante, "Big Blue's Big Bet on Free Software," *Business Week*, 13 Aug. 2001, 57–58; P. G. Capek et al., "A History of IBM's Open-Source Involvement and Strategy," *IBM Systems Journal* 44, no. 2 (2005): 249–57.

[45] IDC, *Worldwide Client and Server Operating Environments, 2004–2008 Forecast* (Framingham, Mass., 2004), 2–4.

[46] John Markoff and Saul Hansell, "Hiding in Plain Sight, Google Seeks an Expansion of Power," *New York Times*, 14 June 2006, A1.

[47] G. Pascal Zachary, *Showstopper: The Breakneck Race to Create Windows NT and the Next Generation at Microsoft* (New York, 2004).

[48] Paul Andrews, *How the Web Was Won: How Bill Gates and His Internet Idealists Transformed the Microsoft Empire* (New York, 2000), 203–7.

This aspect of Microsoft is rarely mentioned in the popular literature. By the 1990s, Microsoft had become a sophisticated organization, not just learning from its own experience but emulating as well the best practices of traditional business-system firms like IBM, which had offered training programs since the early years of the twentieth century.[49]

From this point on, Microsoft's server-operating system (later branded as Windows Server) continued to mature and to incorporate new technologies as they arrived on the scene. Intel-based networks evolved beyond simple workgroups and Web serving to become a scalable infrastructure for global organizations' wide-area networks and robust enough for demanding business-processing tasks. Windows Server has dominated server sales for Intel-based corporate networks, selling some 3.4 million licenses in 2003.[50]

Security Software. The lack of built-in security is the most fundamental weakness of the Internet. The Internet was designed in the 1980s as a network for cooperating academics and research scientists, for whom security was not a major issue. As a consequence, security technology has had to be retrofitted onto the Internet, and security has become a major concern of corporations. In 2005, the annual economic losses due to security flaws were estimated at well in excess of $10 billion.[51] Security breaches are caused by viruses (computerized vandalism with no financial benefit to the perpetrators); small-scale scams, such as spam e-mail and "phishing"; and major illegal activities that include hacking into computer systems to obtain potentially valuable data, such as customers' credit-card details. By 2002, some 60 percent of U.S. companies employed at least one full-time information security officer who was responsible for integrating the various components of a computer security solution.[52] In 2005, Gartner estimated that the worldwide security software market totaled $7.4 billion.[53]

In 2005, *Software Magazine*'s "Software 500" identified twenty-nine software-product firms whose primary activity was computer security.[54]

[49] James W. Cortada, *Before the Computer: IBM, NCR, Burroughs, and Remington Rand and the Industry They Created, 1865–1956* (Princeton, 1993), 269–70.

[50] IDC, *Worldwide Client and Server Operating Environments*, 2–4. The success of the Windows Server operating system led to antitrust concerns over its interoperability with other systems, particularly Linux. In March 2004 the European Commission brought an antitrust suit against Microsoft, which compelled it to publish detailed specifications for interoperability.

[51] Mark Egan, *The Executive Guide to Information Security: Threats, Challenges, and Solutions* (Indianapolis, 2005), 9.

[52] Ibid., 15.

[53] Gartner, "Gartner Says Worldwide Security Software Revenue Totaled $7.4 Billion in 2005," press release, 12 Sept. 2006.

[54] "The 2005 Software 500," *Software Magazine*, Sept. 2006. In addition, the larger infrastructure software firms, such as Computer Associates (CA) and IBM, also supplied security software. In 2005 the reported revenues for CA's and IBM's security products were $438 million and $299 million, respectively. See Gartner, "Worldwide Security Software Revenue."

Of these twenty-nine firms, approximately one-quarter, including two of the largest, were non-U.S. companies. The internationalization of the industry is a noteworthy phenomenon, since, in the 1980s, of the top fifty software-product firms worldwide, only one or two were non-U.S. firms.[55]

The leading security-software firm by far was Symantec, which built up a one-third market share. In 2005 Symantec was ranked the fourth-largest-independent software vendor, with annual revenues of $2.5 billion. A decade earlier, in 1995, Symantec had been a modestly successful vendor of miscellaneous desktop-software packages, with annual revenues of $438 million.[56] Around 1996, after bringing in a new chief executive officer, Symantec altered its strategy and set out to become a leading Internet security vendor.[57] To become an industry leader, Symantec perceived the need to offer a complete security solution. Throughout the 1990s, security professionals had to integrate products from multiple vendors, each specializing in a single product, such as intrusion detection, firewalls, antivirus software, identity management, or encryption products.[58] Symantec made numerous acquisitions to fill out its security-software portfolio.

Security software is still an immature industry, and Symantec comes the closest of all the firms to being a one-stop supplier. Most of the others, especially the smaller ones, provide specialized "point solutions," typically addressing just one security concern. These smaller firms are primary candidates for acquisition, or oblivion, as the industry consolidates.

Israel established the highest concentration of security-software vendors outside the United States. In addition to three firms in the Software 500—Check Point, Aladdin, and SecureLogic—Israeli sources list another two dozen firms in the sector.[59] Israel's national advantage in security software is attributed to the historic isolation of its defense industry, which drove the country to develop its own security technologies, such as intrusion detection and encryption.[60] The preponderance of security firms in Israel is illustrative of what may be an emerging trend in indigenous software specialization.[61]

[55] See, for example, "Software's Big 50," *Datamation*, 1 Dec. 1990, 67–71.

[56] Richard A. Shaffer, "Symantec's Little Hits," *Forbes*, 25 Nov. 1991, 196.

[57] Brian Grow, "Symantec: Leading the Charge Against Hackers," *Business Week*, 21 Jun. 2004, 85.

[58] Egan, *Executive Guide to Information Security*, 12–14.

[59] "Software Companies in Israel—Security," at the Israel Science and Technology home page, "Software Companies in Israel," www. science.co.il/SoftwareCo.asp, accessed 5 Dec. 2007.

[60] Jana Sanchez-Klein, "Israel: Land of High-Tech Promise?" *Computer Business Review*, July 1998, 33–40.

[61] For example, Britain has an important videogame software industry. See Department of Trade and Industry, *From Exuberant Youth to Sustainable Maturity: Competitiveness Analysis of the UK Games Software Industry* (London, 2002). Russia is reported to be particularly

Open-source entities also contributed significantly to security software. However, trying to evaluate or quantify their impact reveals the general difficulty of analyzing open-source software. Although there are numerous firms, they barely register in industry analysts' reports, and none appears in the Software 500.

Software-as-a-Service and Web Services

The Internet has enabled the emergence of two distinct but related forms of software consumption: software-as-a-service and Web services. In both, software is no longer bought as "code" in a real or metaphorical shrink-wrapped box. Instead, customers pay to use the software, and associated services, on a subscription basis. Broadly, the distinction between software-as-a-service and Web services is determined by whether the software or the service element dominates the provision.

Subscription-based software is a recent development for the software-products industry, although it is less new for computer-services firms, as we will describe below. A subscription model has, in fact, been an aspiration of the software industry for many years. Software has traditionally been sold for a one-time, up-front fee for a perpetual license. This sales model has made it very difficult for software vendors to maintain a steady, year-to-year income stream.[62] For example, customers typically defer purchases during an economic downturn, causing revenue dips for software vendors. Further, all software-product markets eventually saturate, leaving vendors with much lower incomes, consisting of what enterprise software vendors call "maintenance" fees and mass-market vendors term "upgrades."

Although subscription-based pricing is a beneficial long-term development for the industry, change is disruptive. What has been unfolding for a decade, and is still ongoing, is a transition from the old product-based software to software services. This change provided an opportunity for newcomers, while incumbent firms entered a turbulent period as they evolved new production, delivery, and pricing models.

Utility Computing and Computer Services. The provision of online computer services is far from new. The industry developed in the 1960s when, for the first time, it became technically and economically feasible to access mainframe computers remotely over data-communications lines.

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successful in algorithmic and mathematical software. See Andrey A. Terekhov, "The Russian Software Industry," *IEEE Software*, Nov./Dec. 2001, 98–101. See also Ashish Arora and Alphonso Gambardella, *From Underdogs to Tigers: The Rise and Growth of the Software Industry in Brazil, China, India, Ireland, and Israel* (Oxford, 2005).

[62] Cusumano, *Business of Software*, 25–29.

One of the drivers of online services was the "computer utility" rhetoric of the 1960s.[63] The utility concept arose from the observation that electricity consumers did not possess their own generating plant, because it was cheaper and more reliable to use a centralized power utility. In the same way, went the argument, it would be cheaper and more reliable for organizations to buy information processing from a service provider, rather than owning a mainframe computer. The concept was both rational and economically compelling; thus, by 1978, online services accounted for about 15 percent of American data-processing purchases.[64]

Processing-services firms operated a standardized computing service (using the vendor's software and mainframe computers) for client firms. One of the first firms to enter the industry (and one of the largest today) was ADP Inc. ADP was established in Clifton, New Jersey, as Automatic Payrolls Inc. in 1949, when it provided a payroll service for firms in northern New Jersey and New York City, using traditional accounting machines.[65] The firm computerized in 1961 and changed its name to Automatic Data Processing Inc. Using computers and the embryonic data communications of the period, ADP was soon able to roll out its service nationwide. By 1970, it was processing the payrolls of seven thousand firms, and it later diversified into brokerage services, auto-dealer services, and insurance-claims processing. Some of ADP's contemporaries also grew into major firms in the 1960s. For example, the Computer Sciences Corporation (later CSC) developed a major private network, Infonet, in the 1970s, at a cost of $100 million, that supported activities like brokerage services and online hotel reservations.[66] EDS—founded in 1962 by Ross Perot, who later became a presidential hopeful—specialized in health-care data processing.[67]

The arrival of the Internet was not particularly disruptive for computer-services firms. A degree of change came about during the transition from private networks to the public Internet, but a constantly evolving infrastructure had always been a characteristic of the business. Although by the 1990s online services had been—infelicitously—renamed "business process outsourcing," the fundamentals of the computer-services business had not changed. For example, in 2005, ADP still gained 61 percent of its revenues from payroll processing, which accounted for 25 percent of U.S. pay packets and fifty million workers

[63] Martin Campbell-Kelly and William Aspray, *Computer: A History of the Information Machine*, 2nd. ed (Boulder, Colo., 2004), 193–96.

[64] Montgomery Phister Jr., *Data Processing: Technology and Economics*, 2nd. ed. (Santa Monica, Calif., 1979), table II.1.26a, p. 610.

[65] Edward J. Kanarkowski, *ADP 50th Anniversary, 1949–1999* (Roseland, N.J., 1999), 6.

[66] Computer Sciences Corp., *The CSC Story* (El Segundo, Calif., 2003), 7–8.

[67] For the early history of EDS, see Doron P. Levin, *Irreconcilable Differences: Ross Perot versus General Motors* (Boston, 1989), 27–64.

worldwide. In that same year, ADP had annual revenues of $8.5 billion and forty-five thousand employees worldwide.[68]

Subscription-Based Software. The current incarnation of subscription-based software grew out of the development of portal-based Web services for consumers in the early years of the commercial Internet. For example, Yahoo! quickly expanded its original directory service to include Web-based e-mail and personal calendars.[69] In both of these applications, software was executed on the portal's servers, and the "state" persisted between a consumer's interactive sessions. These early services attracted tens of millions of consumers and were funded by advertising.

The development of Web services established tools and infrastructure-management techniques that enabled a software-as-a-service industry to develop.[70] The new vendors prospered, especially where on-demand software offered new benefits, such as mobile and collaborative working.

Salesforce.com, a producer of customer-relationship-management (CRM) software, was the most successful. CRM was an established software genre whose major vendors included Siebel and BEA Systems. Typically, in these older systems, a mobile salesperson would use a laptop loaded with CRM software, book orders on the move, and periodically synchronize with the master database in the home office. Salesforce.com reconfigured this arrangement so that the CRM software and associated databases resided on its servers, and both mobile and office-based users accessed the service through a Web browser. Access could be gained through an ordinary desktop PC, a laptop, or even a public terminal or kiosk at an airport. The subscribing firm was thus relieved from maintaining an infrastructure to support the CRM application. In 2004, Salesforce.com was the leader among some half-dozen on-demand CRM players, including RightNow, WebSideStory, and Siebel's CRM OnDemand. In 2004 Salesforce.com reported that it was serving over 300,000 users in 16,900 organizations.[71] Even so, with just $176 million annual revenues, Salesforce.com was a minnow in the software ocean, ranking only 162 in the Software 500.

At the time of writing, on-demand software has only begun to have an impact on productivity applications, such as word-processing and spreadsheet programs. In 2005, several start-up firms, including Upstartle, developed basic office applications that ran in a Web browser.

[68] ADR, *Annual Report*, 2005.

[69] Karen Angel, *Inside Yahoo* (New York, 2000), 126–30.

[70] Jeffrey Kaplan, "Software-as-a-Service Myths," *Business Week Online*, 17 Apr. 2006.

[71] IDC, *Worldwide On-Demand Customer Relationship Management Applications 2004 Vendor Analysis* (Framingham, Mass., 2005), 21.

These applications, primarily word processors and spreadsheets, were very simple compared with professional office software, but their capabilities were similar to those of "Works"-type packages. The services also provided online storage and some collaboration features, making them potentially useful for mobile workers. In the fall of 2005, Google acquired Upstartle and attracted considerable publicity as a potential rival to Microsoft Office when it launched Google Spreadsheets in June 2006.[72]

Achieving acceptable interactivity on remote applications has been a formidable technical challenge that is not yet fully solved. Whether traditional desktop applications, such as office suites, photo-editing programs, and computer-aided-design (CAD) packages, will someday give way to software-on-demand services is still an open question. The outcome will depend on both technical feasibility and a complex trade-off between the benefits and costs, for both users and vendors.

Web Services and Open-Source Software. Traditional computer-services firms were, and are, vertically integrated enterprises. That is, they write software and supply it as a service over a computer network. The same degree of vertical integration is typically present in Web service and software-as-a-service firms like Yahoo! and Salesforce.com. These firms develop their own proprietary software, "host" it on their own servers, and supply a service via the Internet. Thus, computer-services firms compete on both the quality of their software and their hosting services.

Open-source software represents a challenge to both old and new computer-services firms. Whereas, in the 1990s, the principal OSS products were for operating systems and infrastructure software, OSS versions of several important enterprise-software categories emerged in the next decade. Among them were ERP, human resources, and CRM software.[73]

For example, SugarCRM, the leading open-source competitor of Salesforce.com, began offering Web services in November 2004.[74] SugarCRM is the "owner" of the eponymous open-source project, and although it employs a number of full-time developers, the software is (one presumes) less costly to support than a proprietary package because many individuals freely give their time to improve the program and fix bugs. As a result, SugarCRM's service is about two-thirds the

[72] John Markoff, "Google Takes Aim at Excel," *New York Times* (6 Jun. 2006), A1.

[73] Christopher Koch, "Open-Source ERP Gains Users," *CIO Magazine*, 3 Feb. 2004; Ed Frauenheim, "Open-Source Software Opening HR Doors," *Workforce Management Online*, Jan. 2007; Colin Beasty, "Low-Cost, Open Source CRM," *destinationCRM.com*, 15 Apr. 2005.

[74] Tony Kontzer, "SugarCRM Offers Online Service," *Information Week*, 8 Nov. 2004.

price of Salesforce.com. This is considerably more than free-software advocates might expect; however, the price reflects the fact that Web services are more than just software. Of course, SugarCRM is itself vulnerable to competition, because anyone can download the software and deploy it as a competing Web service.

The development of open-source Web services is another example of the complex economics of OSS. Program code is just one aspect of providing a Web service. Among other important attributes are network speed and resilience, customer support, and assurance of continuity of supply. Open-source software may alter the cost structure of supplying computer services, but it is unlikely to cause incumbent firms to fail. Further, there is no evidence that computer-services firms have an ideological objection to open-source software. They can (and will) use open-source and proprietary software pragmatically, adopting whichever one is more cost effective.

The Impact of the Internet on the Software Industry

The Internet arrived on the scene as a new environment that significantly reshaped the incumbent software industry. This reshaping took place in two ways. First, firms had to engage in creative destruction, abandoning old competencies for new ones. Second, new technologies had to be brought into firms; these technologies were often developed by start-up companies close to the technology that were then acquired by larger firms.

The Internet extended the boundaries of software products from the confines of an isolated computer system, whether a desktop PC or a mainframe installation, to a global network. This greater interconnectedness had two effects. First, the boundaries were dissolved between mass-market and enterprise software, creating the opportunity for mass-market vendors to develop enterprise software products. Second, both mass-market and enterprise-software vendors extended the reach of their products into services delivered over the network.

Boulders and Pebbles. When the Internet tidal wave broke in 1994, there were thousands of firms in the software-products industry, mostly in the United States. The industry had low concentration. Even the mighty Microsoft, with sales of over $5 billion, had less than 10 percent of the market.[75] The industry has been characterized as "boulders,

[75] The size of the global software-products industry is notoriously difficult to estimate. However, we estimate that the four-firm concentration ratio of the industry in 1995 (based on IBM, Microsoft, Computer Associates, and Oracle Systems) was probably no more than 15 percent. (Based on data and observations in Campbell-Kelly, *From Airline Reservations to Sonic the Hedgehog*, esp. ch. 1.)

Table 2
Leading Software Product Vendors, 1995 and 2005

Vendor[a]	*Date Founded*	*1995*[b] *Revenues*	*Rank*	*2005*[c] *Revenues*	*Rank*
Microsoft	1975	7,271.0	1	36,546.0	2
Computer Associates	1976	3,196.0	2	3,426.0	23
Oracle Systems	1977	2,558.0	3	11,799.0	7
Novell	1983	1,900.0	4	1,197.7	47
SAP	1972	1,350.0	5	9,994.4	8
Adobe	1982	762.3	7	1,966.3	33
Intuit	1983	502.6	10	1,966.7	32
Symantec	1982	437.8	11	2,582.8	25

[a] Mass-market vendors are in italic; enterprise vendors are in roman type.
[b] Revenues (in millions) and rank for 1995 are based on "Software 100," in *Software Magazine*, July 1996, which excluded computer-services firms.
[c] Revenues (in millions) and rank for 2005 are based on "Software 500," *Software Magazine*, Sept. 2006, which included computer-services firms.

pebbles, and sand." That is to say, it comprised a few very large firms with annual sales roughly exceeding $1 billion, a few score of firms with sales exceeding $10 million, and thousands of firms with revenues below $10 million. In order to examine the strategic behaviors of firms, we focus on most of the boulders and some of the pebbles. (See Table 2.) Besides being the firms on which a viable amount of public-domain data are available, they were also the firms with sufficient breadth and resources to engage in creative destruction and firm acquisition, though, in fact, not all firms did so.

For example, Computer Associates had created an extremely successful business that sold infrastructure software for the mainframe systems of the pre-Internet era. In 1995 Computer Associates was the second-largest independent software vendor and was initially dismissive of the Internet, seeing it as "just another system for the company's software to manage."[76] Its slow reaction, coupled with a software catalogue that was exceptionally difficult to redeploy, resulted in the firm's being left behind and doing little more than treading water during the Internet decade.

SAP was also slow to adapt to the Web, although with a very different outcome. SAP's apparent lethargy was the subject of adverse media comment, much of which was made in the euphoric period that ended

[76] Amy Cortese, "Sexy? No. Profitable? You Bet," *Business Week*, 11 Nov. 1996, 70–72.

with the dot-com bust.[77] In fact SAP's ERP software—which runs the business processes of many of the world's largest corporations—operated on a different beat during the Internet frenzy. Full SAP installations typically took eighteen months to two years to implement, practically a decade in "Internet time." It was not until 2004 that SAP announced a comprehensive Web strategy, Netweaver, which took three years to deploy fully.[78] At that point, SAP had taken more than a decade to completely embrace the Web. Curiously, critics of SAP's Internet torpor did not comment on the fact that its revenues grew sevenfold during the Internet decade. It is a compelling illustration of the fact that the Internet is evolutionary as much as it is revolutionary.

Mass-Market Vendors' Integration into Enterprise Software. From 1984 to 2001, the industry newsletter *Soft-letter* tracked what it termed the "personal computer software category," publishing each spring the Soft-letter 100, a ranking by annual revenues of the leading vendors. In 1984, these firms sold "inexpensive, mass-market programs that ran on stand-alone machines like the IBM PC and the Apple II."[79] This categorization held good until the explosion of the Internet, which elicited the following comment in the newsletter:

> The retail channel has imploded; in its place, more companies now focus on "enterprise" sales and niche markets, often relying on the Web as a direct sales channel. Prices have simultaneously crashed for consumer titles and escalated to new highs for professional products. And many more PC software companies now earn a hefty percentage of their income from professional services.[80]

In 2001, the magazine published its last Soft-letter 100, arguing that attempts to categorize the PC software industry had become something of a "murky theological debate" as software products increasingly came to reside on servers as well as inside PCs, and the boundaries were blurring between the mass-market and enterprise software industries and computer services.

When the Soft-letter 100 was in its heyday, before the advent of the commercial Internet, the desktop computer was primarily an office machine (often utilizing a word-processing or spreadsheet program), perhaps connected to a local work-group system, but with little or no connectivity to any external network. For this reason, mass-market and enterprise-software vendors evolved independently, selling in different

[77] For example, see Stephen Baker, "The Sizzle is Out of SAP" *Business Week*, 12 Apr. 1999, 52; Stephen Baker, "Can SAP Swim with the Swiftest?" *Business Week*, 26 June 1999, 52; and Justin Fox, "Lumbering Toward B2B," *Fortune*, 12 June 2000.

[78] Baker, "Can SAP Swim with the Swiftest?"

[79] "The Soft-letter 100," *Soft-letter*, 30 Apr. 2001, 1.

[80] Ibid., 1–2.

markets. The most conspicuous differences were in product pricing and sales volume. A successful PC package usually cost considerably less than $1,000 and sold in a volume of millions. Typical enterprise-software products started at $50,000 and sold a few thousand copies at most. When the PC became an Internet-connected machine, mass-market products for the client computer increasingly required server-side elements, which blurred the sharp distinction between mass-market and enterprise products. This pattern is clearly seen in three of the leading vendors: Microsoft, Adobe, and Symantec.

Microsoft's principal enterprise-software foray was into server-operating systems. While Microsoft's entry into server software in 1993 was initially a response to the development of networked computing, the company benefited from the growth in the number of client-server systems that accompanied the explosion of the Internet. In 2005, Microsoft's "server and tools" segment generated revenues of almost ten billion dollars, approximately a quarter of its total sales and considerably more than the firm's total revenues ten years earlier.

Adobe's most conspicuous change in the Internet era was a shift from PC-based products for publishing on paper to products for electronic publishing and document management on the Web, primarily through the exploitation of its PDF technology. As described earlier, PDF was originally conceived for the production of electronic documents. With the rise of the Web, PDF technology offered opportunities that went beyond the informal exchange of documents between individuals. Adobe introduced new products that made it easier to engage in collaborative writing, facilitated the flow, security, and archiving of documents within an organization, and developed specialized servers for document delivery over the Web. These products now constitute the software infrastructure for many forms of electronic publishing.

The most aggressive entrant into infrastructure software was Symantec. In 1995, Symantec was a much smaller firm than it is today, and it sold only mass-market products that ran on a desktop computer. In the following year, it made the strategic decision to refocus on information security. Because many of these security issues reached well past the desktop computer and penetrated deep into the network infrastructure, Symantec was compelled to develop and acquire enterprise products in order to provide comprehensive security solutions. In 2005 the company "booked almost 1,350 enterprise deals greater than $100,000," including several million-dollar deals.[81] Individual sales of such magnitude would have been unthinkable a decade earlier, when Symantec was a mass-market firm. To achieve such sales, the firm had

[81] Symantec, *Annual Report*, 2005, p. 3.

to acquire not only new technologies but also organizational competencies, such as running a commission-based direct-sales force. Perhaps more than any other firm, Symantec illustrates the broad reach of today's leading software firms: along with million-dollar deals, consumers can still pick up Norton Internet Security for $50 at CompUSA.

Software-as-a-Service and Subscription-Based Software. The software-as-a-service (SaaS) business model matured rapidly in the Internet decade, replacing the traditional one-time software-product sale with a subscription-based, ongoing relationship between vendor and customer. From the vendors' viewpoint, this was a welcome development, because it had the potential to stabilize revenues and eliminate some of the peaks and troughs associated with one-time sales.

Of the top software firms, Oracle Systems led the way in developing an SaaS sales channel. Oracle On Demand opened for business in November 1998, offering Oracle's existing products and, subsequently, those of PeopleSoft, which it acquired in a hostile takeover.[82] Besides establishing its own hosting infrastructure, Oracle invested $100 million in third-party start-ups to resell Oracle products.

Of all the major software firms, the security vendor Symantec perhaps made the most natural transition to a subscription model. Because new security threats occurred on a daily basis, new virus definitions had to be communicated rapidly to users over the Internet. To protect against new viruses, which by the mid-1990s were emerging at the rate of three to six per day, the company established its Symantec AntiVirus Research Center (SARC) with a "dedicated team of 26 men and women whose sole mission [was] to provide swift global responses to computer virus threats."[83] As the virus threat increased—there were reportedly 4,500 new viruses in the first half of 2004—Symantec's antivirus team expanded to more than one hundred researchers.[84] Virus hunters were located in several globally distributed antivirus research centers, in Sydney, Tokyo, Leiden, Santa Monica, and elsewhere, to ensure round-the-clock coverage.[85] In order to fund the activity of virus detection and the substantial infrastructure of security centers and servers required to distribute software updates, Symantec devised a new consumer-pricing model that transformed the old one-time payment into a new subscription model. Thus, consumers bought a conventional retail box of software, which included a one-year subscription to updates. Thereafter, users had to subscribe to the update service.

[82] Paul Keegan, "Is This the Death of Packaged Software?" *Upside*, Oct. 1999.

[83] "Symantec Announces Norton AntiVirus 2.0 for Windows NT," press release, 16 Sept. 1996.

[84] Sarah Leah and Brian Grow, "Norton Gets a Bit Less Secure," *Business Week*, 12 Dec. 2005, 44.

[85] Symantec, *Annual Report*, 2001, p. 11.

Integration into Computer Services. Before the rise of the commercial Internet, the service component of software products had been small—typically limited to revenues from telephone help lines or training and maintenance fees. Most of a vendor's income was produced from licensing code deployed in a customer's computer. During the Internet decade, many vendors generated increasingly large fractions of their revenues from services.

For example, in 1995, Microsoft reported no significant computer-services revenues in its annual report. In 2005, it reported revenues of almost two billion dollars from the Microsoft Network (MSN), which then constituted one of the five main divisions of the business and 5 percent of its total revenues.

In 2000 Symantec moved decisively into computer-security outsourcing, assuming continuous responsibility for all of a client's computer security. Security outsourcing was less connected to Symantec's particular software products than to the rapid-response capabilities it had developed in its antivirus research centers. To fulfill its security-management service, Symantec established two global-response centers in San Antonio, Texas, and Epsom, England. At these centers, security experts remotely managed Symantec's client networks and constantly monitored them for security vulnerabilities or signs of an intrusion. The *Economist* magazine featured this graphic description of the Epsom center:

> Beneath an innocuous green hillside in southern England, under 2.5 meters (eight feet) of steel-reinforced concrete, banks of hard drives buzz and hum. Operators, their eyes glued to computer screens, scan attentively for any sign of attack. Some miles away, tucked behind chain-link fences guarded by attack dogs and protected by airlocks, napalm-proof vents and steel blast doors, network servers collate and store encrypted data. You could be forgiven for thinking the cold war had never ended.[86]

In 2003, Symantec reported that it was providing security services for some six hundred firms, among them major corporations like Xerox, and its global reach had been extended with the creation of an additional four response centers, in Alexandria, Virginia, Sydney, Tokyo, and Berlin.[87] Computer-security outsourcing accounted for 15 percent of Symantec's annual revenues.

Intuit also made a major switch from software to computer services during the Internet decade. Intuit was established in 1983, offering a

[86] "Bunker Mentality," *Economist*, 17 Dec. 2005, 75.
[87] Christine Y. Chen, "A Trip to the Antivirus War Room," *Fortune*, 18 Oct. 2004, 272.

personal-finance management program, Quicken.[88] Quicken was extremely successful: in the mid-1990s, it was said to be the best-selling consumer software product of all time. In 1992–93, Intuit introduced QuickBooks, an accounting package for small businesses, and TurboTax, a program for personal tax filing. Intuit had an important services component, amounting to 15 percent of its sales, selling stationery supplies, such as payroll forms, invoice blanks, and checks, by mail order.

Around 1994, before the ill-defined Information Superhighway stabilized and became the Internet, electronic banking was imminent, and, like many other finance-based operations, Intuit positioned itself strategically for what was to come. For example, it took measures to gain an advantage in the financial sector by building relations with MasterCard and Visa, acquiring National Payments Clearinghouse Inc., an electronic payment processor, and creating an online banking subsidiary. While this was happening, however, Intuit agreed to a merger with Microsoft. The planned merger was referred to the Department of Justice, which objected on the grounds of potential monopoly issues in consumer electronic banking, and Microsoft tactically withdrew.[89]

During 1996–97, many of the market uncertainties around e-finance began to dissipate. For example, the banks had moved aggressively into consumer online banking, completely overwhelming Intuit's ambitions (and, incidentally, the concerns of the Department of Justice). Intuit abandoned its plans to become an online bank and payments hub and sold off its clearinghouse subsidiary.[90] Instead, it focused on computer services for its existing customer base of consumers and small businesses.[91] In 1997, through its Quicken.com portal, Intuit generated substantial revenues from advertising and services, such as mortgage and insurance broking. In 2000, Intuit reported that its Internet operations generated revenues of $294 million.[92]

Intuit's most radical break with its past, however, was the establishment of an online payroll service, which enabled it to compete head-on with payroll processors like ADP. Intuit's advantage was that QuickBooks users, all small- and medium-sized business, already used the package for their payrolls. Online processing enabled QuickBooks users to switch, according to their own schedule, to an online service

[88] For the history of Intuit, see Suzanne Taylor and Kathy Schroeder, *Inside Intuit* (Boston, Mass., 2003); Campbell-Kelly, *From Airline Reservations to Sonic the Hedgehog*, 294–300.

[89] Paul M. Horvitz, "Efficiency and Antitrust Considerations in Home Banking: The Proposed Microsoft-Intuit Merger," *Antitrust Bulletin* (Summer 1996): 427–46.

[90] Kathy Rebello and Keith H. Hammonds, "Gut Feel at Intuit," *Business Week*, 30 Sept. 1996, 46.

[91] Steve Hamm, "This Intuit Hunch May Pay Off," *Business Week*, 15 June 1998, 123–24.

[92] Intuit, *Annual Report*, 2000.

that eliminated the burdens of paying tax deductions and benefits to third parties. Intuit operated the service through a third-party payroll processor, CRI Inc. The service was launched in November 1998, and the company announced its goal of converting the one-time software buyer into a repeat user: "With the November 1998 launch of QuickBooks Online Payroll, that same customer can now sign up for our payroll service, representing more than $500 in additional potential revenue each year."[93] Intuit acquired CRI in May 1999 for $200 million.[94] By 2005, computer services accounted for 35 percent of Intuit's annual revenues.[95]

Conclusion

The Internet has enabled computer services to be delivered ubiquitously and at low cost. The result has been a gradual shift from software products to Web services. The phenomenon of products-to-services has recently been analyzed in depth by the industry observer Michael Cusumano.[96] He explains that because markets for software products ultimately become saturated, in order to maintain revenues, firms either have to invent new products (which is extremely difficult) or switch to services. We fully accept Cusumano's analysis. However, we also think that the Internet is accelerating this transition, acting as an invisible hand that is pushing software product vendors toward services.

We have observed that mass-market software-product vendors have combined their businesses with enterprise software, and that both mass-market and enterprise vendors are moving into the services. But we can find no significant examples of a reverse trend. We argue that the reason for the one-directional flow is that software represents a degree of indirection in fulfilling a customer's requirements. No rational business would choose to own software and the associated infrastructure if its needs could be met without them. Computer services increasingly allow these needs to be met without the intermediation of user-managed software. We think this fact also explains why the Internet decade has seen no major new software-product companies comparable to those that arose from the invention of the PC. The major new companies—such as RealNetworks and Salesforce.com—are service oriented. Indeed,

[93] Intuit, *Annual Report*, 1999, p. 7.

[94] "Intuit Completes Acquisition of Computing Resources, Inc.," press release, 3 May 1999.

[95] Intuit, *Annual Report*, 2005.

[96] Cusumano, *The Business of Software*, 86–127; Michael A. Cusumano, "Finding Your Balance in the Products and Services Debate," *Communications of the ACM* 46 (Mar. 2003): 15–17.

the greatest success of all is Google, a software-based enterprise that is fundamentally a service organization.

In order to provide computer services, a mass-market software firm has to develop competence in "server-side" software. This explains why there has been a transition from mass-market to enterprise software: it is a stop on the road toward services. But the reverse direction, an enterprise-software firm's developing mass-market products, would produce no new benefits that would help in delivery of services. Similarly, we know of no computer-services firms that have moved into software products. (In contrast, during the 1960s, when software products were more cost effective, computer services firms moved aggressively into products.)[97]

The move into services also helps to explain why open-source software has flourished in infrastructure software but has been less successful in desktop computers. The open-source business model makes it very difficult to generate revenues from supplying software products for desktop computers, because there is no significant service component to produce an income and hence to make the necessary investments in usability, packaging, and marketing. By contrast, computer services based on open-source software appears to be a viable business model, because it reduces the need for packaging while simultaneously generating a revenue stream.

The nature of the software company is in flux. There has never been a universally accepted definition of what constitutes a software company, although, before the Internet era, such a company was commonly described as one that generated half or more of its revenues from software-license sales.[98] In fact, there were few software firms that came close to the 50 percent threshold—80 percent of most companies' revenues were from products. Today, software firms still create software, but increasingly they make money by deploying it over the Internet as a service. This is precisely what computer-services businesses do, and it is therefore no longer possible to draw a sharp distinction between the two.

If a software company writes, hosts, and deploys software over the Internet, then what is an online bank? It too is software driven—users store financial data and make transactions in a way that is similar, for example, to Web-based CRM software. Or, alternatively, consider eBay. In a technical sense, eBay is a software platform: it publishes its "application program interfaces," and hundreds of firms exist by offering

[97] Campbell-Kelly, *From Airline Reservations to Sonic the Hedgehog*, 115.

[98] See, for example, "CBR Software Top 50," *Computer Business Review*, special report, 1996, p. 6.

software and Web-service complements.[99] As a business model, it is difficult to distinguish eBay from a post-Internet software company.

Possibly we are observing a change not only in the software industry but also in the nature of all information businesses. As software firms move into computer services, they will become increasingly indistinguishable from other information businesses that conduct their operations over the Internet. It is certainly too early to pronounce the death of the software-products industry, however. There is massive inertia in the product-based computing and software infrastructure, so it will be many years before the majority of software firms generate most of their revenues from services.

[99] David S. Evans, Andrei Hagiu, and Richard Schmalensee, *Invisible Engines: How Software Platforms Drive Innovation and Transform Industries* (Cambridge, Mass., 2006), 349–55. See, for example, John Paul Mueller, *Mining eBay Web Services: Building Applications with the eBay API* (San Francisco, 2004).