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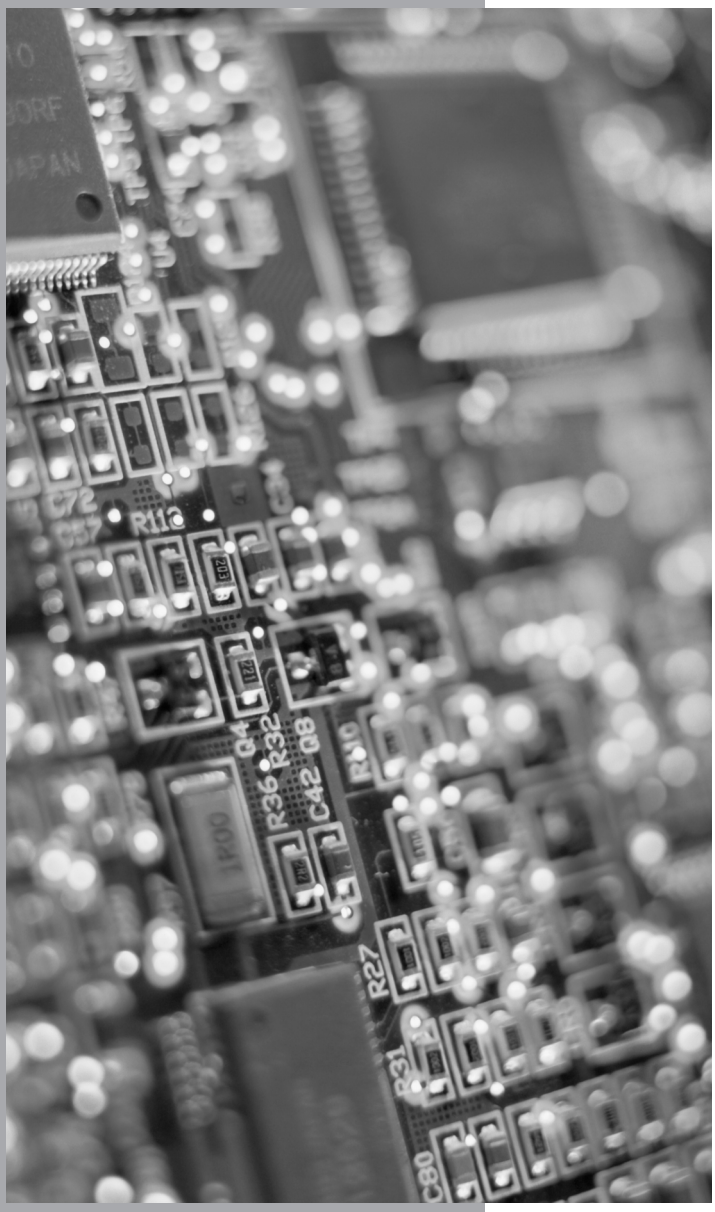

OPEN STANDARDS, OPEN SOURCE, AND OPEN INNOVATION:

Harnessing the Benefits of Openness

A REPORT BY THE DIGITAL CONNECTIONS COUNCIL OF THE COMMITTEE FOR ECONOMIC DEVELOPMENT

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RESPONSIBILITY FOR CED STATEMENTS ON NATIONAL POLICY

The Committee for Economic Development is an independent research and policy organization of over 200 business leaders and educators. CED is non-profit, non-partisan, and non-political. Its purpose is to propose policies that bring about steady economic growth at high employment and reasonably stable prices, increased productivity and living standards, greater and more equal opportunity for every citizen, and an improved quality of life for all.

All CED policy recommendations must have the approval of trustees on the Research and Policy Committee. This committee is directed under the bylaws, which emphasize that "all research is to be thoroughly objective in character, and the approach in each instance is to be from the standpoint of the general welfare and not from that of any special political or economic group." The committee is aided by a Research Advisory Board of leading social scientists and by a small permanent professional staff.

The Research and Policy Committee does not attempt to pass judgment on any pending specific legislative proposals; its purpose is to urge careful consideration of the objectives set forth in this statement and of the best means of accomplishing those objectives.

Each statement is preceded by extensive discussions, meetings, and exchange of memoranda. The research is undertaken by a subcommittee, assisted by advisors chosen for their competence in the field under study.

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PREFACE
BY THE CED RESEARCH AND POLICY COMMITTEE

CED's Digital Connections Council (DCC), a group of information technology experts from CED trustee-affiliated companies, was established to advise CED on the policy issues associated with cutting-edge technologies. This report, concerning "openness" in the digital economy, is the second of its products. CED appreciates greatly the efforts of the members of the Council, and in particular, the work of Paul Horn, Senior Vice President for Research of IBM Corporation and Chair of the DCC, for his leadership in bringing this report to completion. Special thanks are also due to Elliot Maxwell, CED's project director and consultant, and to Carolyn Cadei for assistance with research, editing, and publication.

This report is the work of the DCC and is endorsed by CED's Research and Policy Committee. We welcome this report and recommend it to readers as an excellent analysis of how the U.S. economy can benefit from greater openness in technological standards, software development, and innovation.

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EXECUTIVE SUMMARY

In its most recent report, the Digital Connections Council examined the digital economy and the special case of digital intellectual property. That report highlighted the benefits of making information widely available through the Internet for the encouragement of innovation and the stimulation of economic growth. The Council recognized the importance of protecting the interests of initial creators—authors, songwriters, inventors—but also saw a critical role in the historically balanced intellectual property scheme for the vast number of potential "follow-on innovators," who build upon earlier innovation by standing on the "shoulders of giants."

In this report, the Council further explores this theme by examining the phenomenon of "openness," which the Organisation for Economic Co-operation and Development (OECD) calls "an underlying technical and philosophical tenet of the expansion of electronic commerce" that will "cause transformations, for better (e.g. increased transparency, competition) or worse (e.g. potential invasion of privacy), in the economy and society."

But what is "openness" in the context of today's digital economy? There are many potential definitions. Works and processes are usually neither open nor closed but somewhere on a spectrum between the two. One key attribute of openness is accessibility. The more accessible a work is to anyone, the more open it is. Another attribute of openness involves responsiveness—as the degree to which a work can be modified by anyone increases, so too does the work's level of openness.

Intellectual property law in the United States has provided a means by which the holder of intellectual property rights may "close" off an information product, controlling access to it and charging for the rights to copy, distribute, or modify it. This right to "exclude" fit neatly into an economic framework where it was difficult and costly to create and distribute a physical good, such as a book or a recording on a physical medium, such as vinyl, tape, or compact disc, and where allowing one person to have access and control of that good precluded others from having the same rights at the same time. Just as with a physical space, only one person could use it at any given point in time. The legal regime was also consistent with the centralized economic processes that had emerged from the Industrial Revolution.

But this model is under considerable pressure. Digital works require no less creativity than non-digital works but are dramatically easier to copy, modify, and distribute. At the same time, these works can be shared by millions of users without any other potential user being prevented access; they are, as economists say, non-rivalrous. These characteristics are creating opportunities for different models of production and distribution that are decentralized, collaborative, and global. Digitization of information and the Internet have profoundly expanded the capacity for openness, and the Council sought to understand the consequences of these changes.

The Council examined three areas—open standards, open-source software, and open innovation—to study the impact of openness in specific circumstances, to gauge its importance, and to determine whether public policy should encourage it, restrict it, or be neutral.

OPEN STANDARDS

The very best example of open standards is the Internet itself. Built on a set of standards available to anyone, that were created in a process that allowed participation by anyone, the Internet's open standards enable any network to interconnect and any applica-

tion to be made available to everyone. At the same time, the very connectivity that the Internet provides has become the vehicle for the expansion of "open innovation"—the collaboration of parties separated in time and distance but united through their contributions to projects as diverse as mapping the human genome and building new on-line encyclopedias.

Proprietary standards—those controlled by a particular party—can provide substantial benefits, as anyone knows who has ever been prevented from sharing an electronic document with an individual using different software. Moreover, such standards have the advantage of being validated by the marketplace. But open standards prevent a single, self-interested party from controlling a standard, facilitate competition by lowering the cost of entry, and stimulate innovation beyond the standard by companies that seek to differentiate themselves. Customers value the interoperability that open standards provide and generally benefit from not being locked into a particular supplier. ***Because of the advantages of open standards, the Council recommends that governments encourage the development and use of open standards through processes as open to participation and contribution as possible. The Council believes that the participation of civil society would be beneficial in the formation of standards with important social consequences. The Council also recommends that the results of government-supported research be readily available for inclusion in open standards, as they have been in areas such as grid computing.***

Support for open standards has grown dramatically in recent years. But as the National Innovation Initiative has pointed out, issues surrounding intellectual property claims threaten the development of open standards. Companies involved in standards development that believe their technology to be essential for the implementation of an open standard may insist on licensing terms that inhibit broad adoption. Even providing for "reasonable and non-discriminatory licensing" (RAND) may, according to groups such as the World Wide Web Consortium (W3C), inhibit the process of developing standards.

Providing technology essential for the implementation of a standard under a royalty-free (RF) license may prevent a company from maximizing its royalty revenues, but it does not eliminate the benefits the company may obtain. The more the standard draws on a company's technology, the more likely it is the standard will validate the technology, expand the market for it, and provide advantages to the firm that created the technology and, thus, knows it best.

However, RF licensing by firms involved in the development of an open standard does not preclude a firm that has not participated in the process from asserting an intellectual property claim after the standard has been adopted and implemented. Perversely, there is even an incentive for such a firm to wait until the standard is widely utilized before challenging it, so as to maximize revenues from licensing or from damages. ***The Council, therefore, recommends that incentives be created to induce the early disclosure of intellectual property claims and that consideration be given to progressively limiting recovery by a firm asserting infringement, as time elapses from the adoption of a standard.***

OPEN-SOURCE SOFTWARE

The second form of openness examined was open-source software. In proprietary software, the "source code" comprehensible by a programmer is not "open" and available for study, modification, and redistribution; the software is licensed for use under conditions set by the rights holder. In contrast, open-source software is governed by a license under which anyone can access, modify, and further distribute the source code. It is the mirror image of the manner in which intellectual property law has operated in the physical world; rather than excluding others and seeking compensation for creative activity through licensing access, open source uses intellectual property law to guarantee the widest possible distribution of the source

code in order to stimulate its improvement and to add value.

As Steven Weber points out in *The Success of Open Source*, unrestricted distribution and modification are central to the open-source software system, as development requires a programming task be separated into small modules. These modules encourage contributions by interested parties but, at the same time, do not overwhelm the individual participants with the enormity of the entire project. Among the many who can access the code because of the broad distribution, there is a smaller group who self-select to take part in any given open-source project; within this group, there is likely to be at least one individual with the skill, experience, insight, and interest to improve the software.

This model of sharing is not new. It is key to the practice of science and is rooted in the academic system of creating and sharing.

Although the open software model is vastly different from the dominant model of proprietary software based on controlling access, it is becoming increasingly important in today's environment. The Internet itself runs on open-source software, and a growing number of large commercial firms are supporting open-source software as part of their commercial strategies. Just as the Internet has facilitated the development of global open standards, it has also made global collaboration on open software development possible.

Some proprietary software firms have criticized open-source software by suggesting that it undercuts, or even destroys, the economic incentives necessary for the software industry to continue to create quality products by making them compete with "free" software. Supporters of open software point to its role in competitive markets such as Web-server technology (Apache) or database systems (MySQL), and its growing strength in markets with dominant players such as Web browsers (Mozilla's Firefox) and operating systems (Linux).

Critics of open software also argue that the open-source model is unsustainable, as it does not provide the economic incentives necessary for someone to choose to devote his or her time and effort to solving a particular problem. But there are many reasons why programmers contribute to open-source efforts—the culture of sharing, the desire to contribute to a communal effort, the sheer joy of creation, the feeling of accomplishment for solving a difficult problem, the reputational gains from a highly regarded piece of work, and the expectation of reciprocity from helping those who might later help you. Complementing these incentives, major players in the information technology industry are paying for software development that is, at least in part, contributed to the open-software "commons."

There have been initiatives in a number of countries, particularly in the developing world, to mandate that governments purchase only open-source software. Proponents of such a requirement argue that it would save much-needed governmental funds, encourage the development of local programming resources, and reduce dependence on foreign software firms.

The Council believes that, rather than replacing one another, proprietary software and open-source software will co-exist, with each playing an appropriate role in the information and communication technologies (ICT) environment. The Council opposes any requirement forcing governments to make purchasing decisions based on the licensing system used. It recommends that the U.S. government not advocate purchases based on any particular licensing scheme—proprietary or open.

But the debate over such mandates has highlighted the importance of interoperability and the negative impacts that result when it is not achieved. In a striking example, survivors of Hurricane Katrina could only apply to the Federal Emergency Management Agency (FEMA) using a particular vendor's proprietary browser—another burden on those already battered by the storm. In its 2004 report calling for an interoperable system of health care records, the Bush Administration recognized the power of interoperability and made it a centerpiece of

the Administration's efforts to reduce the cost and improve the provision of medical care in the United States. ***The Council believes there are certain critical functions of government that should be conducted solely with interoperable technology; in these critical areas, no citizen should be required to use the hardware or software of any particular vendor.*** This does not mean that only open-source software would be available. Proprietary software vendors choosing to sell in these markets, however, would be required to provide sufficiently open interfaces, so as to allow others to interoperate with their product. The use of open standards and royalty-free licensing are particularly important in these areas. ***The Council recommends that the United States support such interoperability requirements in international procurement as well. The Council also recommends that international agreements entered into by the United States regarding intellectual property should reflect the nation's historically balanced intellectual property regime reflecting the interests of both first and follow on innovators.***

OPEN INNOVATION

The combination of the Internet and the growing importance of digital information products is changing even the organization of creative enterprises and enabling new processes of innovation. The firm, as an economic unit, was, in part, a response to the problems of organizing work by dispersed parties. Information was difficult and expensive to gather and share, and coordination of diverse efforts was hard to achieve. But the Internet is changing these conditions, as it has changed so many other areas. Communication is cheaper, and coordination far easier than in the past. Rather than seeing the firm as the only model for organizing innovation and production, we are seeing new collaborative models of open innovation. The emerging result is what Tim O'Reilly has called an "architecture of participation."

Open-source software is only one example of the open innovation model. It is open because the source code is broadly available and subject to successive modification, but it is not completely open, as there are evaluative mechanisms in place to ensure the stability and quality of the product (mechanisms that have also been adopted in many other forms of open innovation).

It is relatively easy to see how software could be developed collaboratively, and why more and more producers of physical goods are seeking improvements through collaborative efforts. Open innovation can be seen in the growing use of digital software tools tied to computer-controlled fabrication devices that allow users to design an object and then produce it physically. As the costs of these digital design tools decrease, users are able to innovate, breaking the model of manufacturers being the source of innovation and customers simply consuming them. The openness model, the antithesis of a "not invented here" attitude, encompasses not only manufacturers and users, but suppliers whose innovations should be welcomed by the companies they supply.

Perhaps most striking is the extraordinary increase in "peer production" of digital information products. Many, if not most, of the pages accessible on the World Wide Web are posted by individuals with no expectation of monetary gain. Similarly, the on-line encyclopedia Wikipedia is the result of contributions from thousands of individuals, as are the buyer's recommendations on Amazon.com, and the buyer and seller reviews on eBay.

Just as major information technology (IT) companies see benefits in seeding the open-source commons, sophisticated commercial firms are harvesting the benefits of openness. The podcasting capability of Apple's iPod was developed by users, who function as an external research and development unit; Eli Lilly's e-research subsidiary turns to a network of thousands of independent researchers for assistance in solving pharmaceutical problems.

"Open science" is making scientific information available well beyond the subscribers of traditional scientific journals. The National Institutes of Health (NIH) are encouraging widespread publication within

12 months of the results of the research that they fund. Open courseware is providing self-directed students around the world with the syllabi and course readings of great university teachers. All of these efforts rest on the assumption that society benefits by increasing access to information and allowing more people to contribute their special skills and experiences. Advocates for more openness contend that openness will result in greater innovation than would be achieved by restricting access to information or allowing first creators to exert greater control over it. Such a belief in the value of tapping the collective wisdom is profoundly democratic.

In order to foster open innovation, the Council recommends not only that the NIH should continue their efforts to expand the dissemination of the research they support, but also that other federally funded, unclassified research should be made broadly available. Consistent with the position it has taken in its earlier reports, the Council recommends that any legislation or regulation regarding intellectual property rights be weighed with a presumption against the granting of new rights. The burden of proof should be on proponents of new rights to demonstrate with rigorous analysis the necessity of such an extension, because of the benefits to society of further innovation through greater access to technology. Finally, the Council suggests that the National Science Foundation (NSF) fund research into alternative compensation methods, similar to those created to facilitate the growth of radio, to reward creators of digital information products and accommodate the changes brought about by the digitization and growth of the Internet.

INTRODUCTION

Fostering economic growth has long been at the heart of the mission of the Committee for Economic Development (CED). As the "digital economy" became a reality, CED established the Digital Connections Council to help it better understand the implications of this new economic frontier.

In 2004, the Digital Connections Council issued a report addressing the "special problem" of digital intellectual property and its impact on innovation and economic growth. The report noted three important trends: the increasing digitization of all forms of information; the growing importance of intangible property; and the replacement of the sale of digital information in its many forms by various licensing agreements made between the rights holder and the consumer. The three trends, coupled with the dramatic rise of the Internet, led to what the National Academy of Sciences labeled the "digital dilemma:" While a digital information product can be created, modified, perfectly duplicated in innumerable quantities, and distributed to millions of people around the world at little or no cost, it can also be locked down, made inaccessible, or controlled completely, at least temporarily.

This paradox is visible in two different and contradictory phenomena. The rise of Napster led to the creation of the world's largest file sharing network, with millions of participants downloading billions of files, many of which were being shared without the authorization of the rights holders. At the same time, rights holders were using licenses and digital rights management systems to dictate the conditions under which consumers could use and manipulate digital information products. This led to conflict, as many consumers believed that they were being prevented from engaging in activities that they had long undertaken and that they considered to be well within their rights.

In its earlier report, the Council's attention was focused on the many proposals for laws and regulations that were introduced to deal with the unauthorized access and use of digital information products. The proposals shared a common aim: to make it easier for rights holders to enforce their rights through the courts in order to prevent or punish misappropriation, and to provide rights holders greater control of digital information products. Some of the proposals sought to protect the rights of creators by providing them with control over the design and operation of technologies for recording, modifying, displaying, or distributing digital information products.

The Council recognizes the critical importance of creative activity. The nation's founders did as well. The founders generally opposed monopolies, but they offered creators what amounted to limited-term, government-sanctioned monopolies of control over their creations, subject to certain conditions. The founders knew that these monopolies, like any monopolies, had a cost to society—but in the case of patents and copyrights, the cost was thought to be justified because the incentives they provided would increase creative activity. They recognized that society benefited if all these creations eventually became part of an ever-expanding "commons" available for anyone to use as the basis for their own follow-on innovation.

Because the most recent proposals for changes in intellectual property law focused on protecting the rights of first creators (or those who now controlled those rights), they tended to ignore the creative contributions of follow-on innovators. The Council, on the other hand, recognizes that innovation is almost always a cumulative and unending process, with every creator, in Newton's words, "standing on the shoulders of giants." In order for intellectual property law to

achieve its aim—the stimulation of the greatest possible innovation for the benefit of society—it must balance the interests of "first" creators and against those of creators who follow them. To provide too great an incentive to either first creators or follow-on creators would unbalance the system.

Incentives are necessary for those creations that would not have been made without them. But if the incentives are too strong—giving the first creator too much control or control for too long—there would be little opportunity for follow-on creators. The result, in economic terms, would be "under-production" of follow-on innovation. On the other hand, if follow-on innovators were aided by eliminating incentives that were necessary to generate first creations, the result would be the "under-production" of first creations. The policymaker's aim should be the most innovation, not the enrichment of any particular group of creators. As the Federal Trade Commission wrote in its recent report on the patent system, "[P]atent policy is for the benefit of the public, not patent holders. The ultimate point of granting a patent is not to reward inventors, but rather to create incentives for actions—invention, disclosure and commercial development—that will further the public interest and thus benefit consumers over time."[1]

The Council made several recommendations in its earlier report. The first was that lawmakers and regulators should remember the Hippocratic injunction and seek to do no harm. Hurriedly passing new laws or regulations before the impact of the new digital technology is better understood and the full range of solutions examined is highly likely to result in unforeseen consequences. As the Council pointed out, some of the proposals for change had clearly foreseeable negative implications for the high technology industries that have been critical to recent economic growth in the United States. Some proposed laws or regulations seemed designed to protect existing distribution systems or business models rather than to foster increased innovation; these could prevent the emergence of new business models based on the specific characteristics of digital information products that are distinctly different than those of physical goods. They could also dampen the positive benefits of expanded access to digital information. A better way to protect the works of creators and stimulate greater innovation, the Council concluded, was to encourage the development of new business models and to continue the search for solutions within an intellectual property regime that balances the interests of first creators and follow-on innovators. Such a regime has proved capable of adapting to other profound technological changes in the past and can accommodate the recent changes in digital works.

The Council's interest in maximizing innovation has led to this second report, focusing on the phenomenon of "openness." This openness is challenging the conventional view of intellectual property and providing a springboard for unprecedented global collaboration. As it does, it is leading to dramatic changes in the very process of innovation.

I. THE MEANING OF OPENNESS

Even after the collapse of the Internet bubble, the Internet continues to change the way we live and work. It is ushering in a new age of "collaborative" or "participatory" or "democratized" or "globalized" innovation, different in fundamental ways from the centralized processes that emerged from the Industrial Revolution. "Openness" is what marks these new processes. "Openness" is what distinguishes the Internet from other networks. At the same time, it is the Internet that enables openness.

In a 1999 study, the Organisation for Economic Co-operation and Development (OECD) noted the phenomenon of openness in the growth of electronic commerce. "Openness is an underlying technical and philosophical tenet of the expansion of electronic commerce. The widespread adoption of the Internet as a platform for business is due to its non-proprietary standards and open nature as well as the huge industry that has evolved to support it…More importantly, openness has emerged as a strategy…An expectation of openness is building…which will cause transformations, for better (e.g. increased transparency, competition) or worse (e.g. potential invasion of privacy), in the economy and society."[2]

But what is this technical and philosophical tenet of "openness?" There are many potential definitions. Moreover, works and processes are not simply open or closed. They need to be placed on a continuum that ranges from closed to open and encompasses varying degrees of openness.†

One key attribute that determines the degree of openness of a work is its availability and accessibility. The creator of a work protected by intellectual property laws has the right to "exclude" others from its use—potentially to exclude all others and preclude virtually all uses until the "limited" term of protection ends. Such a work would be considered largely closed, although some limited access to the work may be permitted under exceptions to intellectual property protection. Eventually, after many years, the work would become open as it passes into the public domain. In the latter case, the work is almost entirely open, available to anyone interested in it. Due to the increasing penetration of information and communications technologies (ICT), including the Internet, being open now means that a digital information product is potentially available to a billion Internet users without its availability to any single person being diminished.

Such openness is of great societal value. Economists tell us that the widespread availability of information provides significant economic benefit. If information can be shared without cost, any withholding of access results in a loss to society. Given this loss, restricting access to information, via the limited-term monopolies of patent and copyright, can be justified only if the incentives they are designed to produce are necessary to spur creative acts that would not occur without them.[3]

The degree of openness of a work depends on more than its accessibility and availability. It also depends on its responsiveness, in other words on the potential for modifying it based on contributions from others, potentially from an almost unlimited number of interested people around the world.[4]

That digital goods can be copied and distributed virtually without cost increases their

† The spectrum of openness is very broad. If a person creates a work but does not share it with anyone, the work is completely closed. Less closed is a work that is made public, even if the rights holder for the work does not allow access, as some access might be possible under exceptions to intellectual property protections. On the other end of the spectrum are works made available to and modifiable by all. Linux, an open-source computer operating system, falls short of this extreme version of openness (see pages 20 and 27). It is open to all, but modifications to the software must undergo an evaluation process prior to inclusion in the next official release.

openness. That they can be similarly manipulated and modified increases their openness yet further. Among the billion people who now have access to a digital work, one or more should be able to manipulate it, making a notable improvement, or use it as the basis for a singularly new creation. Without minimizing the potentially enormous impact of inventive geniuses—think Edison or Gutenberg—society can benefit substantially from the cumulative, often small, contributions by the millions of people who now have access to digital works, upon which they can exercise their own creativity. Openness, thus, becomes the measure of the ability to benefit from the "collective intelligence" of our world.

There is a conflict between openness and the right to exclude. There is a tension between the claim that incentives, which can be used to restrict information availability and prevent modification, are necessary to spur innovation and the emerging potential for innovation from allowing millions of people with differing experiences, skills, and interests to access and manipulate a work.

With this in mind, the Council decided to examine three manifestations of openness—open standards, open-source software, and open innovation—and to focus on their effects and the policy questions they raise. The Council was not seeking to choose between closed, proprietary models or open models; it is convinced that they will continue to co-exist and that both provide important opportunities for innovation. Each is likely to be more appropriate than the other in particular circumstances.

But openness needs to be better understood. It seems to run counter to the traditional view of intellectual property and the incentives that lead to innovation. It has only recently become more prominent due to technological advances such as the Internet and the digitization of information. The Council, therefore, decided that a closer examination of the phenomenon of openness might help to determine where encouraging openness could produce the greatest societal value.

II. OPEN STANDARDS

The growth of the Internet and the World Wide Web are perhaps the most obvious examples of the attractiveness of open and unrestricted standards. Cheap and easy communication across this network of interconnected networks would have been impossible without universal access to, and use of, the TCP/IP protocols that enable users to transmit and receive any form of content regardless of the network, device, or software used. While network operators could have maintained their own unique standards, the value of compatibility for everyone outweighed the advantages to each of maintaining their own "walled network."[5] Similarly, the growth of the World Wide Web was based, in part, on the universal availability and use of Hypertext Markup Language (HTML), which allowed disparate devices to recognize a Web page's display characteristics. The millions of Web contributors who have voluntarily created this extraordinary repository of billions of pages of information by posting their own contributions (many, but not all, without any expectation of monetary reward) have validated the utility of this open standard; the richness of the Web is proof that, as *The Economist* noted, "open standards allow and promote unexpected forms of innovation."[6]

The Internet Engineering Task Force (IETF), which establishes standards for the Internet infrastructure, mirrors the openness of the Internet. Its processes for creating standards are open to all. Among the IETF's requirements for adoption of a new standard is that it be accessible and available to all; it must also be capable of implementation on disparate hardware and software.[7] Though theoretically it would have been possible for the Internet and the World Wide Web to have developed as they have using only proprietary standards, or those developed by individuals or small groups without an open process for receiving comments, the fierce competition among information technology firms makes it very likely that progress, if it had occurred at all, would have been much slower.

The degree of openness of an "open" standard can be determined by examining several key questions:

- How open is the process of choosing to develop, and ultimately developing, the standard? Who can participate and under what terms?
- Does the process ensure the ability of all participants to affect the standard? Is the process well documented?
- Is the standard publicly disclosed in its entirety? Is it readily available? What terms and conditions govern its implementation?
- Does the standard contain proprietary technology that must be licensed? Will royalties be charged and on what basis will they be determined?
- How will the standard be maintained and by whom? What rules apply after adoption?[8]

The more open the process and the greater the participation by firms, the more likely it is that the standard will not reflect the interests of any single firm or group of firms. This is important because companies might seek to disadvantage competitors by excluding them or denying them information needed to apply the standard. The greater the participation, particularly by purchasers of technology, the more likely it is that the standard will spur competition. The greater the participation by representatives of civil society, particularly where policy questions such as privacy and security are involved, the more likely it is that the standards will reflect the needs of consumers.[9] The greater the requirements for procedural

"due process" (such as the need to document and respond to objections or require consensus), the more likely it is that the standard will meet the needs of a broader group. It is noteworthy that all of these attributes can be facilitated by the Internet. The development of global open standards is now much easier because global distribution of proposed standards and global participation in their development is cheaper and easier.

All of the characteristics that reflect greater openness, however, greatly increase the possibilities of delay in reaching agreement. This tradeoff between openness of process and the time required to reach agreement is particularly troublesome in periods of rapid technological change, where standards "set by consensus may be obsolete before they are implemented."[10] Many of the leading innovations in the information technology (IT) area, such as Sun's Java or Microsoft's C#, were not brought to the formal U.S. standards processes because of the "arcane and potentially obstructionist processes that the formal process insists are its strength."[11]

Open standards facilitate competition among a multitude of suppliers by reducing barriers to entry. They are often favored by customers who want to avoid being locked into obtaining goods and services from a particular firm that controls a proprietary technology; such a firm may eventually choose not to support the technology or may even go out of business. Competition among technology suppliers encourages the spread of the technology and stimulates further innovation by suppliers anxious to differentiate themselves. On the other hand, technology vendors have traditionally been attracted to standards based on proprietary technology, especially if they believe that a standard based on their own proprietary technology will be adopted in the marketplace and allow them to garner significant economic returns.

De facto standards based on proprietary technology provide substantial benefits and have the attractive characteristic of having been validated by market processes. For example, the emergence of Microsoft Word as a de facto standard facilitated the easy exchange of digital documents—something that users found to be very valuable. The de facto standard reflected Word's success in the consumer word-processing market; moreover, competition in adjacent markets that could build upon the de facto standard was stimulated. Participants in these markets, however, had to remain wary of the possibility that the de facto standard could be exploited to favor Microsoft if it entered those same markets.†

Even where standards are putatively open, there are temptations for firms to "extend" them if they believe that doing so would allow their company to establish a more profitable proprietary version of the standard.[12] At other times, a firm's corporate strategy may be to resist creating an open standard that would allow interoperability if the firm believes that doing so would threaten its market leadership or reduce its "customer control." For example, while the IETF has been working for several years on an open standard for instant messaging that would allow interoperability of all instant messaging systems, it appears that some of the delay in reaching agreement reflects the strategic interests of individual firms rather than disagreement about technical issues.

A key benefit of open standards is that they foster interoperability, allowing disparate devices, applications and networks to communicate. Such interoperability is critical to the development of network effects and the operation of Metcalfe's law.[13] Metcalfe's law demonstrates that the value of a network increases as users are added to it; interoper-

† The arguments about whether to prefer open standards to defacto standards based on proprietary technology are closer in the area of software applications than in the area of infrastructural technologies. The present debates in Massachusetts over the proposed mandate requiring the use of open standards for electronic documents (see endnote 94) illuminate the complexity of a situation where a defacto standard for electronic documents exists, but where a new, more open standard tied to the Web is emerging, supported by a number of major players. Questions also have been raised about the openness of various standards bodies. We discuss the interoperability issues surrounding critical governmental applications later in this paper (see pages 30-32).

ability allows the full benefits of each addition to be realized. In some cases, the benefits can be enormous. The National Institute of Standards and Technology (NIST) has estimated that the lack of interoperability in information systems costs the construction industry more than $15 billion dollars each year; the lack of interoperability in the supply chains of the automobile and electronics industries costs an additional, combined $8.9 billion annually.[14]

There are those who argue that open standards reduce the efficiencies that may be gained by using proprietary technology to bind together complex systems.† Others have argued that innovation may be reduced because of open standards. What is lost, they argue, is the innovation that results from having to "design around" a standard based on proprietary technology—having to develop a truly different mousetrap (if it is even called a mousetrap). But, supporters of open standards argue that they don't reduce innovation but "focus" it "on where the real value lies, which is usually everything you can add above and around the standard."[15] Reaching agreement on the standard provides a base; firms can compete via innovation above and beyond that standard. And, those innovations may later form the basis for new open standards on which to build even further innovation.

The success of the Internet has reinforced the contention that open standards are desirable to foster competition and interoperability. But, as the National Innovation Initiative noted, issues surrounding intellectual property claims are threatening the development of open standards.[16] These issues include whether patented technology should be included in open standards, and if so, how these elements will be treated. In standards groups ranging from the World Wide Web Consortium (W3C), based at Massachusetts Institute of Technology (MIT) and led by Tim Berners-Lee, to the IETF and others, debates over these issues have been intense.

Many open standards include material that has been patented but has either been "donated" or is made available on a royalty-free (RF) basis. Microsoft, for example, agreed to forgo royalties on its style sheets so that the W3C could reach agreement on Web standards. The fear that firms owning the patents might try to skew standards for their own benefit has led some to argue against including any patented technology in an open standard because it "can imbue the technology with market power that it previously lacked. Thus there is a potential for monopolization…through the conjunction of an adopted standard and a proprietary technology."[17] Others argue that any standards containing patented technology would be resisted by competitors and users fearful of abuse by the rights holder and, therefore, the value of the standard itself would be reduced. But, the most strenuous disagreements have been about the terms and conditions for access to proprietary technology included in an open standard and the rights retained by the proprietary technology's owner.

The recent debate within W3C on its patent policy examined the full range of issues.[18] W3C standards had, in the past, included patented technology, but there was a de facto RF regime for the core technical standards that defined the Web architecture. Even though there had been no serious issues involving patents in Web standards in its early years, W3C set up a Patent Policy Working Group to review its patent policy due to 1) the development of convergence

† This argument was made forcefully by Microsoft in its defense in recent anti-trust cases, when it argued for the integration of new functionality into the Windows Operating System. It argued that tight integration, available using proprietary technology, provides a performance advantage in comparison to what results from the cobbling-together of technologies based upon open public standards. In another example, Apple's continued use of its proprietary technology, as opposed to technology based on open standards, is considered to be one reason for the seamless integration of its various components and its ease of use. Opponents have conceded the potential value of such integration but have pointed to the pro competitive arguments in favor of open standards—more players, lower costs, lack of customer lock-in, and greater potential innovation from a multitude of players. They have also noted that the rapid improvement in the basic components of information technology systems—computing power, memory etc.—allow competing vendors using open standards to compensate for any efficiency losses resulting from a lack of integration by a single vendor utilizing proprietary technology.

and, thus, a whole range of patent policies in the telecommunications, broadcast media and consumer electronics industries with which W3C was becoming involved; 2) the rise of patent issuance, including European consideration of software patentability, and the popularity in the United States of business-method patents; and 3) the experience of Internet-related standards bodies that had "encountered potential barriers to acceptance of standards because of licensing requirements perceived as onerous."[19]

The W3C Patent Policy Working Group first recommended a two-track approach, with patents being licensed RF or under reasonable and non-discriminatory (RAND) licenses, which require a payment be made to the rights holder. There was a mixed reaction to the proposal, particularly the suggestion that a royalty could be charged for those who implemented a W3C recommendation.

Not surprisingly, the strongest opposition was from open-source software developers. Since they distribute their products for free, they have no way of recovering any royalties that they might have to pay under a RAND license. They argued that "a RAND approach would cause open-source developers to stop using W3C standards [and] impel some to form alternate Web standards, thus Balkanizing the Web."[20]

After considerable debate, W3C adopted a policy requiring that:

- All parties that participate in the development of a W3C recommendation must agree to license essential claims (that is, patents that block interoperability) on a RF basis;
- Any patents specifically identified to be excluded from the RF licensing requirement must be identified by the patent holder shortly after publication of the first public working draft so as to minimize any uncertainty about licensing requirements;
- Patents essential to the implementation of a standard held by W3C members must be disclosed.[21]

To maintain flexibility, the policy provides a mechanism for exceptions to the RF licensing policy. It also makes clear that the RF licensing policy does not require a participant to give up its entire patent portfolio but only to commit to RF licensing of "essential" claims—patents that would block interoperability—for the implementation of the specific standard. (The patents could be licensed under other regimes for other purposes by the patent holder.) Moreover, the policy allows the licensor to: "require a royalty fee grant back" or reciprocal licenses "either to the original patent holder or to all other implementers;" or to suspend the license "if the licensee sues the licensor." In addition, the policy prohibits the licensor from imposing "any other material conditions, such as requirements to use other technologies."[22]

The policy was adopted by W3C, although there were still substantial objections. Some argued that RAND licensing had been successful in other settings (such as in compact disc and telecommunications standards) and that some business models were based on royalty income; others argued that companies would forgo participation in the W3C standards processes, or not bring new technologies to it, if they were not allowed to require payments for licenses (the exact opposite of the open-source developers' objections).

In his decision, as head of W3C, to adopt the proposed patent policy, Tim Berners-Lee wrote:

> The Policy affirms and strengthens the basic business model that had driven innovation on the Web from its inception. The availability of an interoperable, unencumbered Web infrastructure provides an expanding foundation for innovative applications, profitable commerce, and the free flow of information and ideas on a commercial and non-commercial basis.
>
> This decision on the W3C Patent Policy coincides almost exactly with

> the tenth anniversary of CERN's decision to provide unencumbered access to the basic Web protocols and software developed there even before the creation of the W3C. In fact the success of technical work at the World Wide Web Consortium depended significantly on that decision by CERN. The decision to base the Web on royalty-free standards from the beginning has been vital to its success until now. The open platform enabled software companies to profit by selling new products with powerful features, enabled e-commerce companies to profit from services that built on this foundation, and brought social benefits in the non-commercial realm beyond simple economic valuation. By adopting the Patent Policy with its commitment to royalty-free standards for the future, we are laying the foundation for another decade of technical innovation, economic growth, and social advancement.[23]

Two other important standard-setting organizations have recently addressed the same questions. The IETF was asked to begin a process that would re-examine its policy of allowing proprietary technology in IETF standards and RAND licensing. The Task Force decided not to do so, based on a lack of consensus on the need for such a reconsideration and because IETF had not had major difficulties in dealing with patents in forming Internet standards.[24] (The IETF may face this question again, as recent efforts to establish an IETF standard to reduce spam foundered on the issue of use of proprietary technology.[25])

The Organization for the Advancement of Structured Information Standards (OASIS), another Web-oriented software standards body, has also recently reconsidered its patent policy. It adjusted the requirements to make them more hospitable for open-source developers by allowing RF licensing, although inclusion of proprietary technology under RAND licensing is still allowed.[26]

Overall, open standards with RF licensing of any proprietary technology seem more likely to stimulate innovation, particularly where infrastructural technologies are involved and where the benefits of interoperability are greatest.[27] RF licensing should reduce contentions over intellectual property claims and encourage the greatest possible use of the standard. This is particularly important when standards are being created to develop a new market, such as that for grid computing. Without standards, the new market would be slow to develop; an open standard under RF rules should lead to the participation of the largest number of relevant players and stimulate the market's growth.

Companies that provide proprietary technology for the implementation of standards under RF licenses still retain important advantages with respect to their technology. They are not barred from exercising their intellectual property rights regarding their technology except for use in implementing the standard. Moreover, their familiarity with the technology can be employed in developing other applications; as Carl Cargill, Director of Standards at Sun Microsystems, explained, they don't have to change their architecture or engineering, "while others have to grow extra teeth and learn how to use it."[28] In fact, the more proprietary technology that they contribute, the more likely it is that the standard will serve their interests. In addition, adoption of the technology for a standard provides validation of the technology's utility, making customers more likely to be comfortable in using it.[29]

Support for greater openness in standards and RF licensing may become the preferred strategic choice for firms as it facilitates the speedier development of new markets and the expansion of existing markets. Companies with major intellectual property holdings may decide that the revenues from more rapidly growing markets and the increased participation of firms with

complementary products outweigh whatever royalties they might have obtained from RAND licensing.† And, the old saying would again prove true: "Nobody makes money off standards but everyone makes money because of standards."[30]

But, while the use of RF licensing should minimize the costly process of discovery and disclosure for participants in the standards development process, and eliminate the need to determine what would be a "reasonable" royalty under a RAND licensing scheme, there remains the problem of outsiders and "hold up." Participants in the W3C process may agree to the rules regarding RF licensing, but companies outside the process are not bound to follow the same practices. If a company that has not participated in the process claims to control intellectual property essential to the implementation of the standard, and is prepared to assert its claims and seek licensing revenue or injunctive relief, it can "hold up" those companies implementing the standard. The entire standards development process might have to begin again, in order to work around the claims. The longer the outside firm delays the disclosure of its intellectual property claims, the more likely it is that companies would have already implemented the standard based on a belief that all relevant intellectual property claims had been considered during the development process. And, the longer the delay, the greater the potential costs that they will face.[31]

The problem is now complicated by the increasing number of well-funded firms engaged in acquiring intellectual property without plans to use that intellectual property for the production of goods or services. These firms may provide a useful service in identifying valuable intellectual property, but they may also hinder the development and implementation of standards. Because they are not producing goods or services, they have less incentive to facilitate production by cross licensing their intellectual property. If their object is to maximize their licensing revenue or the damages they may obtain from firms that they sue, they may have a perverse incentive to delay disclosure of their intellectual property claims until firms implement the standard. They can then seek injunctive relief and increased damages.

Thus, disclosure of such claims regarding standards, and the timing of such disclosures, are important issues. It would be desirable to create incentives for firms that are not part of a particular standards development process to disclose any relevant intellectual property claims at the earliest possible moment. Reducing the economic returns that they can achieve or diminishing the damages that they can claim based on the length of the delay in asserting their claims might work to encourage earlier disclosure of claims. This would decrease the possibility of hold up, provide greater certainty to those who would implement a standard, and generally strengthen the standards development process.

As a general proposition, effective disclosure of intellectual property claims seems more likely to aid innovation, particularly follow-on innovation. But the law can work in mysterious ways. Companies may actually discourage researchers from trying to identify existing intellectual property claims in an area of interest. A search may lead to discovery of existing intellectual property, and such knowledge could dramatically increase potential liability. A company could be accused of willful infringement if it proceeds into, or already has been working, in an area where it is cognizant of existing intellectual property. It seems ironic that the legal system should provide benefits for such a lack of effort. Ignorance becomes bliss.

The problems relating to proprietary technology in open standards are particularly difficult for small and medium-sized firms. Large firms often have constructed patent portfolios that generate income from licensing, but which also are useful for obtaining cross-licensing agreements and responding to

† This strategic choice may be attractive to manufacturers. Firms providing services or those that have built their business models on royalty income would be unlikely to make the same choice.

infringement claims. (Some observers have argued that the drive to accumulate patents for these purposes may even reduce research and development spending, although others have challenged this view.[32]) The sheer volume of patents from the incremental innovations common in software development can easily lead to the creation of patent thickets, where it is hard to discover and expensive to license all of the necessary rights for a particular development path. Large firms are more likely to have the capacity for dealing with these problems; because of their limited revenues and patent portfolios, smaller firms may find it more difficult to emerge from these thickets unharmed. They are, therefore, more vulnerable to hold up and more likely to cease research and development in the face of uncertainty.

Governments have important interests in standards development. As major customers for information and communications technologies, they have a large stake in fostering competitive markets in this area. Governments are inherently involved in social issues such as protecting privacy and strengthening information security and, thus, have an interest in the social implications of standards. Governments also are major supporters of research that underlies standards; the emerging field of grid computing, for example, has greatly benefited from work at the Argonne National Laboratory.

Governments are not well suited to setting technology standards by themselves. They are not organized for this purpose, have relatively limited technical resources, and are subject to conflicting political pressures. They can, however, foster the development of open standards for information technology upon which software and hardware can be built.[33] They can use the specialized resources of government, such as The National Institute of Standards and Technology, to help other government agencies determine which standards processes are sufficiently open to merit support and to devise test procedures for standards compliance.[34] NIST can also analyze the effect of interoperability (or its absence) on particular sectors of the economy and "develop (or at least evaluate) technology that may facilitate interoperability."[35]

III. POLICY RECOMMENDATIONS REGARDING OPEN STANDARDS

Governments should not dictate standards, particularly in fast-developing areas of technology. But, governments should strongly encourage the development of open standards, especially with regard to infrastructural technologies, because of the substantial benefits of open standards in fostering competition and promoting economic development.

The results of government-funded research should be readily accessible and freely available to be used in standards development.

Governments should advocate for the greatest possible openness in standards-making processes.

Government should encourage the effective disclosure of intellectual property claims in order to facilitate follow-on innovation. Incentives for the earliest possible disclosure of relevant intellectual property claims involving standards should be part of reforms of the patent system. Incentives might include reducing access to economic returns or limiting damages by claimants and increasing protections for unwitting implementers with the reductions, limits, and protections increasing as delays in disclosure of claims mount.

The National Institute of Standards and Technology has played, and is continuing to play, a valuable role in representing U.S. government interests in standards development. This role is increasingly important and should be funded accordingly.

The National Science Foundation (NSF) has, in the past, funded participation by civil society groups with both technological and policy expertise in certain standards-making processes for standards with critical social policy dimensions. Funding for such groups that otherwise would be unable to participate would likely improve the standards and increase the probability of their adoption. As the Council's earlier report on digital intellectual property pointed out, there are many efforts to develop standards in the area of digital-rights management where a voice for consumers of digital information products would usefully supplement the voices of content providers and technology vendors.

Private-sector parties involved in standards development with important policy aspects should consider providing support for the participation of competent civil-society interests in relevant proceedings in order to obtain their perspectives and encourage the adoption of the standards.

NSF should provide seed funding for new open-standards efforts, such as occurred with the World Wide Web Consortium, particularly those related to critical governmental activities such as standards regarding file formats for communications with the citizenry.

IV. THE MAINSTREAMING OF OPEN-SOURCE SOFTWARE (OR THE MARCH OF THE PENGUIN)

THE GROWTH OF OPEN-SOURCE SOFTWARE

Other than the Internet, the example of openness likely to be most familiar to the general public is the open-source software movement. Relying on the basic attributes of openness—making information widely available and receiving comments and modifications from the broadest possible range of people—the open-source software movement has migrated from a technically sophisticated corner of the software business into the mainstream of the information and communications industries. A study by Forrester Research analyzing the corporate market indicates that 60 percent of major businesses plan some implementation of open-source software in the coming years.[36] International Data Corporation (IDC) projects that the open-source Linux operating system will grow 26 percent annually between 2005 and 2008.[37] Today's fastest growing Internet browser is Mozilla's highly rated open-source Firefox which has garnered more than 10 percent of the browser market.[38]

Major information technology companies such as IBM, Hewlett Packard, Sun Microsystems, Novell, Computer Associates and others have now integrated open-source software into their core strategies. Google uses open-source software for its core business of searches; Yahoo! employs open-source software in its core business of directories.

Just as the growth of open source depends on the Internet to facilitate the worldwide collaboration of thousands of programmers, the Internet itself depends on open-source software. Roughly 70 percent of the servers that seek out Web pages use open-source Apache software. Open-source Sendmail is used in 80 percent of e-mail servers. Open-source BIND software under girds the domain name system. The open-source PERL programming language has been called the "duct tape" of the Internet.[39]

Not only has the open-source community grown—from 200,000 registered participants on SourceForge in 2001 to 1,200,000 registrants in 2006 working on over 110,000 projects—but well-accepted open-source products have extended beyond the operating system (Linux) into databases (My SQL), applications servers (J-Boss), customer relations management (Sugar CRM), and even TiVo.[40] And the prospects for open-source software are bright, with its incorporation in leading-edge research activities such as those of Internet2.[41]

OPEN-SOURCE SOFTWARE IS NOT A NEW PHENOMENON

While the phrase "open-source software" is relatively new, open-source software's roots in information technology are deep. They reach back to the 1950s and 1960s, when the number of people engaged in software development was a tiny fraction of those participating in today's global software industry. Many of those who did produce software were in academic settings, where the sharing of software was part of the free exchange of information that has traditionally marked scientific and academic pursuits. The norm was sharing, and anyone was free to modify the code. Software was neither patented, nor considered patentable, but it was the community's norms that controlled how it was treated, not legal requirements.

In the relatively early days of computing, there was, as Steven Levy has pointed out, a "hacker ethic."† [42] The hacker ethic rein-

† Then, as now, the computing community used the term "hacker" as a sign of respect and competence; MIT Professor Joseph Weizenbaum characterized a hacker as a "compulsive programmer."

forced the sense of community and the ethos of sharing among the relatively small and close-knit group of programmers. It was, in its own way, anti-establishment, but its enemy was the limited amount of computer cycles, memory, and bandwidth available to programmers.

The ethic supported not only the sharing of one's programming, but access to computing resources for everyone. Information would be free. (As Stewart Brand noted, information wants to be free while at the same time information wants to be expensive—thereby defining the two poles of intellectual property debates to this day.[43]) Control of information technology would be decentralized and brought closer to the user—or, to paraphrase a more modern description of the Internet, intelligence and control would move to the edges of the network to be controlled by the end user, not be placed at the network's center to be controlled by the network operator as in telecommunications.

This culture of sharing, founded in academic computing, was also present in corporate research labs like AT&T's Bell Laboratories, and was the norm for the software development community in the 1950s, 1960s and 1970s. Steven Weber's *The Success of Open Source* brilliantly details the history and operation of open source, beginning with the development of Unix at Bell Labs, the University of California at Berkeley and elsewhere; he also describes the transition, as the ethos of sharing was slowly replaced by attempts to control and "own" the software.[44]

At the same time that the culture of ownership and control was becoming stronger in the software field and the proprietary software universe was growing, computational power was following Moore's Law and becoming more broadly available. During this era, those who supported openness and sharing found a powerful voice in Richard Stallman, a gifted programmer at MIT. In the early 1980s, Stallman argued the case for "free software," taking a strong stand that it was morally and politically wrong to control access to software and to profit from selling access to it.[45] Stallman believed that because of its very nature, software, and specifically its source code, should be accessible to anyone.[46] Anyone should be able to study it, modify it, use it in any way they choose, and further redistribute it with or without modifications, without permission from the original author; doing so did not reduce its availability to anyone else. Software was a form of expression, and expression was meant to be free and uncontrolled. Free software was the motto: "'free' as in 'free speech,' not as in 'free beer.'"[47]

The Free Software Foundation was established under Stallman's leadership, and the General Public License (GPL) was created, in the words of Tim O'Reilly, to "*preserve* a culture of sharing" (emphasis added).[48] The GPL provided a licensing scheme based on intellectual property law for "free software," utilizing what was coyly called "copyleft" (as opposed to copyright). Any software that incorporated any code licensed under the GPL would, as if infected by a virus, automatically become subject to the GPL, which would allow others to have unlimited access to, and the absolute right to modify and further redistribute, the entire program. Stallman and the Free Software Foundation remain strong advocates of the political and moral arguments in favor of absolute openness in software.

By the 1990s, the free-software movement had found other voices to articulate a rationale and process that would encourage the growth of shared software production and unencumbered distribution. Eric S. Raymond, author of *The Cathedral and the Bazaar,* Bruce Perens, John "maddog" Hall, Larry Augustin and others founded the Open Software Initiative and gave "open-source" software its now more common name. The supporters of the Open Software Initiative, like those of the Free Software Foundation, believed in the importance of having full access to source code and being able to modify and redistribute it without restrictions; but they tended to be, in the

view of most observers, more pragmatic and flexible and less ideological and confrontational than "free software" advocates. In particular, supporters of the Open Software Initiative were willing to acknowledge a role for proprietary software and unwilling to ban any link between open-source software and proprietary software. Richard Stallman aptly characterized the differences—"We disagree on the basic principles but agree more or less on the practical recommendations."[49]

The early 1990s also marked the beginnings of what is now Linux.† Linus Torvalds began to program an open-source operating system based on UNIX in 1991 and, by 1994, released it to the public.[50] During that same period, Tim Berners-Lee created the architecture for the World Wide Web and published the first browser; the first graphical Web browser was built at the University of Illinois; and more and more personal computers were being purchased for use in the office and the home. The Internet, the World Wide Web, and the open-source software movement were coming of age together.

INTELLECTUAL PROPERTY—THE TRADITIONAL VIEW AND THE VIEW UNDERLYING OPEN-SOURCE SOFTWARE

The basic method employed by today's intellectual property regime to provide incentives for innovation is to give a creator a limited period of time during which he or she can exercise control over who has access to the creation and how it is used. With this right to exclude, the rights holder is able to sell or lease the various rights of access to and use of the creation, and therefore, be rewarded for his or her creative efforts and investment. Whether or not incentives are needed, and if they are, how strong they need to be to generate innovations that would otherwise not take place, are hotly debated questions. Undisputed is that intellectual property rules have traditionally focused on the first creator and the rights holder's control of the creation for some period of time before the work becomes part of the public domain and available for all to use.

This view reflects an earlier time when there were substantial costs involved in the production and distribution of most, if not all, creative works. It seemed obvious that few people would expend the effort and make the investment necessary to create, produce and distribute a work if someone else could simply copy and distribute it at a much lower cost, thereby profiting from its sale without making any of the substantial investment required for its creation and production.

In a proprietary software model, the control over access and use is exercised through control over the source code—the form of instructions for the computing device that programmers can most easily understand and alter. The code that is broadly available—the machine-readable code—is virtually unintelligible to humans (and even, apparently, sometimes to machines).[51] Control over access to the source code is, thus, synonymous with control over access to the software itself.

Open-source software turns the idea of control on its head, or rather provides a mirror image of the control traditionally exercised by rights holders. Rather than focusing on the rights of creators, it focuses on the rights of users—the right to have access to the software, the right to study and modify it, and the right to share it and redistribute it further without any authorization. Rather than closing it, all the various open-source software licenses, of which there are dozens, require that the source code be open.[52]

In order to recoup their investments in creating, producing, and distributing works, traditional intellectual property rules allow rights holders to limit access and to charge for access to the work; the open-source model aims at ensuring the widest possible

† Linux is a computer operating system and its kernel. It is one of the most prominent examples of free software and open-source development. Unlike proprietary operating systems, such as Windows and Mac OS, all of Linux's underlying source code is available to the public and anyone can freely use, modify, improve, and redistribute it. Initially, Linux was primarily developed and used by individual enthusiasts. Since then, Linux has gained the support of major corporations such as IBM, Sun Microsystems, Hewlett-Packard, and Novell for use in servers and is gaining popularity in the desktop market.

distribution of the software by prohibiting restrictions on its distribution. The traditional intellectual property model matched the economic characteristics of the Industrial Age and physical goods, where use by one individual precluded use by others. The open-source model, on the other hand, matches the defining characteristics of the Internet and digital information goods. Digital information products can be created, modified, and widely distributed at virtually no cost without diminishing their availability to others.

Traditional intellectual property systems emphasize the rights of the first creator and are based on creating incentives for the first creator to innovate. Follow-on innovation is achieved primarily by limiting the term and scope of control and providing for eventual placement of the work in the public domain. Open-source software, in comparison, is oriented toward follow-on innovation. Encouraging the widest possible distribution aims to provide the largest number of people with the opportunity to study, test, improve and extend the original creation, thereby generating the greatest number of improvements at the lowest possible cost.

This is not to say that the traditional intellectual property model or proprietary software is inappropriate or out of place with today's economy or that the incentive system it relies upon is mistaken or misguided. It is not to say that society has to choose between proprietary or open models. It is instead to say that there is nothing inherently inconsistent with intellectual property law in a software development system that seeks to maximize distribution as opposed to controlling access. Both systems can and will coexist. Both can and will produce excellent products. But, open-source licensing systems have different aims and make different assumptions about the nature and process of innovation and the incentives that encourage it from those traditionally associated with proprietary software. The latter focuses on the first creator, while the former sees the potential for creation in everyone.

A CRITIQUE OF OPEN-SOURCE SOFTWARE BASED ON TRADITIONAL INTELLECTUAL PROPERTY CONCEPTS

Advocates of proprietary software argue that open-source software reduces the incentives for creation essential for new software development; the most fervent opponents have described the open-software movement as a "cancer" on the entire intellectual property system and an "intellectual property destroyer."[53] The core of the argument is that by making software available without charge in competition with proprietary software, the open-source movement will ultimately drive out proprietary software producers. These producers will not make the necessary investments to create proprietary software because they know they will not be able to compete with a similar product that is available for free.†

This argument against open-source software closely resembles one of the arguments against file sharing that the Council examined in its earlier report on digital intellectual property.[54] Rights holders of music and movies and videos argued that the incentives to create will be destroyed because "you can't compete with free." No one would write a song or a poem if they could not recapture their investment in time and effort by selling the work—something not possible if pirated copies are readily available for free.

But as the Council noted, the choice is not simply between proprietary and free. In many cases, it may be between "cheap and great" as opposed to "free and crummy." While it is wrong for someone to appropriate another's work without permission, rights holders may give permission in order to build audiences for performances or to whet the appetite of fans for other works. Society,

† Some free software advocates are ideologically opposed to anyone profiting from proprietary software development. But that hardly describes the open-source software movement in its entirety, ranging as it does from independent programmers who contribute code intermittently to the full-time employees of some of high tech's biggest names who are developing open-source software full time for their firms.

in specific circumstances such as with fair use, has recognized the value in allowing limited access as part of the government's grant of exclusive rights.

Perhaps most important, it is likely that new models of compensation for creators will be developed, consistent with the characteristics of the digital environment, as occurred in response to earlier technological challenges such as those posed by the arrival of radio. It may be that the business models of those who create proprietary software will evolve as a result of the rise of the Internet and the special characteristics of digital information products, just as the business models for distribution of music, video and movies are evolving. But, these changes are not the result of an inherent conflict between intellectual property rights and open-source software.

The charge that open-source software undercuts the incentive system that drives the creation of proprietary software may be, at its core, a different statement—or rather a different question. Proprietary software depends on investments of time and energy in the creation of a digital information product, which is licensed to provide a return on that investment. Talented software producers and the companies that employ them or that distribute their work can be rewarded handsomely under this model. So, why would someone invest the time and effort required to develop software, or alternatively why would they incur the opportunity cost of not doing something else, without being able to obtain a return on their investment? Why would anyone give away their work to a system where it will be broadly available for free without any restrictions on its modification or redistribution? Why would they join a system that prevents them from receiving any direct monetary reward for their work? In other words, why do they create and share?

SHARING AND THE OPEN-SOURCE MOVEMENT

Richard Stallman, Eric Raymond, Josh Lerner and Jean Tirole, Steven Weber, Eric von Hippel and Yochai Benkler, among others, have addressed in great depth the questions of why people develop and share software they create.[55] All have suggested answers, mixing pro-social arguments with those based on more narrow conceptions of individual benefits. The reasons are complex and obviously vary from person to person, but based on both theoretical and empirical work, it is clear that there are multiple reasons for individuals to participate in these efforts that do not directly reward them monetarily.

ALTRUISM

Some have argued that the open-source process is unsustainable because it depends on voluntary action. And many open-source participants acknowledge that they are motivated by altruism.

Eric Raymond's writings on open-source software noted the existence of a "gift economy" in which contributors were rewarded primarily via the personal satisfaction they experienced due to their sharing.[56] Certainly among the factors animating voluntary contributions is the desire to be helpful to a broader community of which they are a part, in this case the open-source community with its norm of sharing.

The rewards for altruism are substantial and deep-seated. As David Bollinger and John Clippinger have pointed out, some comparative anthropologists and evolutionary psychologists are suggesting that "as a species we are neurologically hard-wired to be empathetic and cooperative."[57] Richard Stallman has invoked the golden rule as a guiding principle for free software: "If I like a program I must share it with other people who like it."[58]

We are all taught early that "it is better to give than to receive." (Some of that teaching may even take root.) As Yochai Benkler notes, "Anyone who sits in a New York City playground can only marvel at the paradoxical phenomenon of Wall Street traders admonishing their children to 'share nicely,' and will appreciate our deep cultural commitment to sharing."[59]

Everyone knows someone who relies less on financial rewards than on the positive feelings that they get from helping others. There is even a category of workers—the helping professions—many of whose members have chosen to accept fewer financial rewards in exchange for other, less tangible, rewards. But, although altruism is part of the motivation for many open-source participants, it provides only a partial answer as to why they act, just as monetary rewards provide only a partial answer as to why people create new works.

THE JOY OF CREATING, THE EXCITEMENT OF PROBLEM SOLVING

Many programmers get the same feeling of excitement and accomplishment from writing a program or solving a difficult problem that they choose to address as others get from similar acts of creativity, whether it be completing a sketch, writing a poem, or forming a tune on a musical instrument. Most artists never offer their work for sale; most poets go on writing poetry even though they never publish; most people who play an instrument never play for pay. Everyone experiences, at one time or another, the excitement and pleasure of creating.

That the joy and excitement of creation plays a part in the motivation of open-source participants is not surprising. What other reasons might contributors have for investing their time and energy to create and to share?

SOLVING A PROBLEM THAT YOU HAVE TO OVERCOME

A central reason given for working to produce a piece of shared software is that the programmer is attempting to solve his or her own technical problem. He or she is, as Eric Raymond put it, "scratching a…personal itch," such as a problem for which there is no available solution.[60] The personal benefit from solving a problem that is obstructing one's progress is immediate and tangible.

Jack Kilby, the much honored inventor of the integrated circuit, wrote of such feelings:

"I'm motivated by a need to solve problems, to make something work. For guys like me, the prize is seeing a successful solution…It's quite satisfying—hell, it's incredibly satisfying—to face some important problem and find a solution that works."[61]

The development of the open-source Apache Web-server software is a clear example of how an individual addressing a problem resulted in a widely used open-source software program.[62] In the early days of the Web, there was little industrial-strength software available to IT center managers for running servers that would retrieve Web pages. In response, an IT center manager wrote a program to address this problem and, following the norm of his community, shared it. Others responded with improvements and so on and so on until Apache became the dominant Web-server program—a position it retains today in the face of many proprietary software challenges. It began, however, with a problem faced by many people and one person motivated enough to attempt to solve it—and also willing to share the solution. As Eric Raymond noted, "Your program doesn't have to work particularly well. It can be crude, buggy, incomplete, and poorly documented. What it must not fail to do is (a) run and (b) convince potential co-developers that it can be evolved into something really neat in the foreseeable future."[63]

But why share the solution? In part, altruism. In part, community norms. And then there is the prospect for "reciprocity."

RECIPROCITY: GIVE A BRICK AND GET BACK A BUILDING[64]

If an individual shares code that provides benefits to others, that individual may receive code and benefits in return, both now and in the future. Perhaps others will share programs they have written that will help solve a current problem. If someone shares a problem or a solution with a large-enough group, he or she increases the number of people

who might be able to help solve a problem in the future.

INCREASING STATURE AND REPUTATION AND PROFESSIONAL OPPORTUNITIES

Another reason for people to participate in open-source development is increased reputation among one's peers. If someone finds an elegant solution to a difficult problem and does not share it, he or she may be gratified by the act of creation and satisfied by solving the problem. But, if someone finds an elegant solution to a difficult problem and shares it with peers, his or her reputation as a programmer will be enhanced. Competitive programmers may also enjoy beating other programmers to the solution.

As Lerner and Tirole have written, a gain in reputation may have additional private benefits. A programmer or project leader may get a promotion or better job offers based on their enhanced reputation, or have better access to venture capitalists for a new venture.[65]

IMPROVING PROGRAMMING SKILLS

Another reason for participating is simply to improve one's programming skills. One of the most attractive aspects of the open-source process is that it allows an individual to choose the problem or problems on which to work and the amount of time and effort to invest. He or she can then attempt to find a solution and be reasonably sure to receive feedback. The feedback will not necessarily be supportive—harsh criticism and "flaming" are common—but it will be forthcoming. As a result, the programmer has an opportunity to hone skills and potentially to gain in reputation and prestige, all while working on a problem that he or she finds worth pursuing.

THE COSTS OF, AND THE BARRIERS TO, SHARING HAVE BECOME SO LOW THAT THE BENEFITS OF PARTICIPATING NEED NOT BE VERY GREAT TO OUTWEIGH THE COSTS

On the most mundane level, the actual costs of sharing have been dramatically reduced by improvements in information technology. To share digital information products, whether by e-mail or peer-to-peer systems, requires increasingly less effort.[66]

Moreover, the effort required to make a contribution has been dramatically reduced due to the organization of most open-source development projects. The core design principle that allows widespread collaboration calls for modular solutions that can communicate easily with other modules through well-defined interfaces. A potential contributor self-selects a project (limited in size due to modularity) that is consistent with the contributor's self-identified skills and experience, and matches the resources that he or she is willing to expend.[67]

But, what of the monetary rewards forgone by sharing what is created? It is not clear whether the limited contributions described above would be worth much if offered directly in the marketplace or would be worth protecting via the intellectual property system. Although the contribution might well be of high quality, it is likely to be much more valuable as a part of the larger whole than in its own right.

THE FUNDAMENTAL PRINCIPLE OF OPEN-SOURCE SOFTWARE'S LICENSING SYSTEM—PREVENTING RESTRICTIONS ON FURTHER DISTRIBUTION—IS CRITICAL TO THE SUCCESS OF THE OPEN-SOURCE SOFTWARE DEVELOPMENT PROCESS

The central tenet of open-source software licenses—preventing further restrictions on distribution—buttresses the central process of open-source creation. It encourages the widest possible distribution of the software to the largest number of potential contributors.

There is an important characteristic of software that increases the potential benefits from sharing a problem or solution with the largest possible group. About one-half the cost of creating and maintaining software is in debugging and maintenance.[68] The larger the group of people engaged in debugging and maintenance, the more likely that there will be a match between the talents and interests in the group and the problems to be detected. Eric Raymond encapsulated this idea in the phrase, "given enough eyes, all bugs are shallow."[69] Open-source software, with its emphasis on expanding distribution, increases the chances that the group available to engage with the problem will be larger and more heterogeneous. The larger and more heterogeneous the group of programmers, the more likely that it will have the right "eyes," the right experiences, the right talents, and the right interests to find and fix the bugs.

Increasing the number of potential contributors has other benefits. It enhances potential reciprocal benefits for each contributor, provides a larger audience for those seeking reputational benefits, and allows problems to be broken into smaller and smaller packages, reducing even further the costs associated with participation.

It also helps to reduce the "free rider" problem associated with the open-source software movement. There is a temptation for individuals to take advantage of the benefits offered by access to open-source software without contributing anything meaningful in return. Increasing the number of potential contributors improves the odds that among the group will be individuals who find that their own personal cost/benefit calculations lead them to participate.

All of these private benefits support participation in the open-source software development process. And in pursuing these private benefits, the contributors add to the societal value of the collective product.[70]

THE INCREASING IMPORTANCE OF CORPORATE CONTRIBUTIONS TO OPEN-SOURCE SOFTWARE DEVELOPMENT

In an increasing number of cases, the production of open-source software is a job, not a volunteer activity.

More and more companies that plan to use open-source software in their businesses or that have made open-source software part of their strategy are directly supporting open-software development rather than relying completely on volunteer labor. They are paying open-source developers or are assigning their own programmers to open-source projects. This enables them to ensure that their particular problems are addressed and that they will benefit from the efforts of the broader open-source community. A recent survey indicated that as many as a third of the participants in open-source projects are being paid directly by their employers for their open-source work.[71]

Many software programmers are not employed by companies that produce and license proprietary software. They work for corporations developing, testing, installing

and maintaining in-house software or overseeing the functioning of software licensed from others. If a firm can increase the value of the work of its own employees by leveraging the efforts of others outside the firm, it is clearly in its economic interest to do so.

IBM, for example, has analyzed the potential benefits from using open-source software and from directing its own employees to work on open-source projects. It calculated that it costs approximately $500 million annually to maintain an industrial-strength operating system such as Linux. If IBM invests $100 million dollars in support of Linux, it stands to benefit (as do all other Linux supporters) from hundreds of millions of dollars worth of contributions from around the world. The calculation was clear to IBM; a growing number of other firms are coming to the same conclusion.

There are many different reasons why corporations are providing support for open-source development.[72] Major hardware companies are packaging open-source software on their hardware and offering support for it, reducing the licensing fees they pay to proprietary software companies and strengthening their own consulting offerings. Companies like Google are wooing open-source developers in order to improve their own products. New open-source-software-based companies are contributing to development efforts, while selling support, installation assistance, documentation, code management services, and customization, as well as branded versions of basic programs with increased functionality. Non-IT firms are supporting development, as they recognize the importance of customized, extensible, thoroughly debugged solutions to their own particular needs. They appreciate not being locked into a potentially crippling reliance on a proprietary software vendor for upgrades and support. They see the same benefit that motivates some individuals to contribute—the open-source process potentially marshals a much larger, more heterogeneous group of collaborators able to find the best solution to their particular problem.

This increasing corporate production of open-source software is helping to build the "commons" created by the totality of open-source software development efforts. Like the work on UNIX at AT&T's Bell Laboratories, which provided a foundation for Linux and which was indirectly supported by the fees paid to AT&T by local telephone companies, this growing commons will provide an increasingly rich legacy for future open-source developers.[73]

OPEN-SOURCE SOFTWARE DEVELOPMENT IS PROVIDING A TESTING GROUND FOR THE ORGANIZATION OF MASSIVE, DISTRIBUTED COLLABORATION BY VOLUNTEERS WHO ARE SUBJECT TO NEITHER AUTHORITY FROM WITHIN A HIERARCHICAL FIRM NOR TO THE MARKET'S PRICE SIGNALS

Proprietary software is produced by firms much like firms produce physical goods. How is it possible to organize collective action by volunteer collaborators separated by time and distance without the authority found within a firm or without using monetary rewards?

The Internet is the answer, reducing transaction costs by reducing the costs of communications and coordination enormously. The difficult job of assigning tasks in a project, which within the firm requires a division of labor, knowledge of the resources available, and the assignment of resources, is greatly reduced in the open-source environment. The potential labor pool has been greatly expanded via unrestricted distribution. Individuals in the pool self-select their tasks based on their own interests, skills and willingness to invest resources. The downside is that there may be substantial duplication of

effort, something that proprietary software firms seek to avoid, so the open-source software development process needs to carefully and efficiently evaluate proposed contributions.

Linux and Apache, like other successful open-source projects, have addressed this evaluation problem, the task of determining what contributions should be included in the next software release.[74] Linux has two production streams overseen by hierarchically organized, trusted veterans of the Linux development process. One group of experts evaluates code that has been well-tested and debugged to determine if it is sufficiently mature and stable to be included in the next regular Linux release. The other stream is more experimental, allowing for new ways of attacking problems or new areas of work. It is here that revolutionary rather than evolutionary progress might emerge. Although it has a slightly different structure, Apache too has organized itself using experienced Apache program managers to screen contributions and evaluate their readiness for "prime time."

By providing a process to evaluate contributions—and to reject many—these open-source development organizations have limited the "openness" of the software, although anyone can still submit a contribution. But while reducing the openness, they have improved the quality and reliability of the software. Thus, the level of openness of any product or process will likely reflect the underlying needs of the system. There is little likelihood of building a community to use and improve a software program that has a million different versions, with a new one appearing whenever anyone proposes any change. The pace of improvement, however, generally remains faster than in the proprietary world, with a model of "release early and release often."[75] Open-source software has, in fact, been described as being in a perpetual "beta" test, albeit with an unlimited number of testers/contributors.[76]

But, will volunteers accept this level of screening and control? Will they defer to the judgments of the veterans? As Weber points out, the open-source development process cannot succeed without well-respected leadership and a strong set of cultural norms.[77] What is particularly interesting is that the nature of the development process provides incentives for a leadership style that appears to be consistent with the norms of the open-source community.

Every open-source project has a leader. That leader does not have the authority over the volunteers that is possible in a hierarchical firm. At the same time, the leader requires a strong relationship with potential contributors, who can stop work at any time. Contributors can also choose to follow another path in the software (there are an infinite number of possible development paths in software) and establish a new project—what is known as "forking" the code. The leader has incentives to maintain or increase the number of volunteers working on the project in order to get the work done, and to increase reputational gains. The volunteers' ability to quit or to fork provides a strong incentive for the leader to work to obtain the trust of his or her followers by setting realistic goals and listening to and responding to criticism. The very absence of authority encourages the leader to lead.

The absence of traditional authority does provide challenges. There is no easy way to set and enforce priorities or to ensure that resources are directed toward unmet needs—a problem not inherent in proprietary software development.[78] One strength of the open-source development system is task self-selection, but self-selection may result in critical work being left undone. As Linus Torvalds has admitted, sometimes he may have to suggest areas that need attention or even start a project and lead it until it becomes self-sustaining.[79]

Similarly, it is not surprising that open-source software products have been criticized for a lack of quality documentation and support and consumer-oriented usability. It is hard to imagine that the "itch" that wants to be scratched, and that animates a talented programmer, would be to write documenta-

tion—taking on a cutting-edge problem would be more attractive. An analogous problem may exist in producing high-quality user interfaces for open-source software; the intrinsic rewards in this area may not animate the most gifted programmers. Open-source software has drawn particular criticism for this lack of "fit and finish," even compared with proprietary software that is not particularly admirable in this regard.[80] As commercial firms play an increasing role in open-source software development, these challenges are likely to be faced directly, while the advantages of open-source software development for customization, extensibility, and debugging are maintained.

V. PUBLIC POLICY ISSUES RELATING TO OPEN-SOURCE SOFTWARE

Currently, two subject areas—the structure of the current patent system and government procurement of both open-source and proprietary software—dominate public policy concerns and debates regarding open-source software.

THE PATENT WARS: THE ARMED VERSUS THE CONCIENTIOUS OBJECTORS

One sign of the success of open-source software has been the increasing threat of intellectual property challenges raised against Linux and other open-source offerings by proprietary software providers and others.

Patent infringement actions are certainly not rare in the IT arena. But, software patents have a fairly short history. Until relatively recently, the very idea of patenting software was hotly debated in the United States; it is being debated still in Europe, where open-source software advocates have been among the leaders opposing it.

In the United States, SCO has sued IBM for misappropriation and copyright infringement regarding certain Linux-related patents. IBM has countersued.[81] (Given the openness of open-source software, it is easier to scrutinize its source code for infringing code than it is to obtain and analyze proprietary source code.[82])

A successful infringement action by SCO against IBM could provide SCO with a strong basis for claims against Linux and other Linux-related projects. Because these programs are distributed without charge, the open-software developers have no revenue stream from which to draw royalties or pay damages. Even the filing of the infringement actions has a potentially powerful negative effect, as prospective users have to weigh their potential liability and the long-term availability of the Linux program that they might want to implement. Proprietary software providers have emphasized this in suggesting to customers that they consider "intellectual property risk" in making their software choices.[83]

Open-source supporters have attempted to counter this issue in several ways. A recently launched company is providing insurance against infringement claims.[84] Another is selling a product that will enable developers and users to screen open-source code for proprietary code that might inadvertently be included.[85] Some open-source developers are requiring contributors to certify that they have the right to provide the code, either because they wrote it, own the copyright, or have all the necessary licenses for its use.

Potentially even more important have been the actions of a number of leading IT firms in contributing their own patents to the open-source software development process. Novell, Computer Associates and IBM, among others, have helped to create a "patent commons" by contributing thousands of patents from their own large patent arsenals—arsenals that were created to generate revenues from licensing and provide either offensive or defensive weapons in intellectual property battles.[86] Some of the same large firms have pledged not to challenge open-source projects based on their own patents or to indemnify and defend against patent infringement claims that are based on open-source software that they provide.[87] It is yet to be seen whether open-source software developers can achieve a "mutually assured destruction" stalemate with proprietary software producers based on patents donated by open-source software's patent-rich corporate supporters.

No company, large or small, has been willing to generally indemnify Linux and, thus,

risk potentially enormous liability; some proprietary software companies are highlighting the absence of this indemnification, as well as the general lack of warranties in open-source software, as they compete with open-source products. In the absence of general indemnification, open-source advocates and potential users are likely to continue facing "fear, uncertainty, and doubt."[88]

Open-source software providers, proprietary software providers, indeed any innovator that faces intellectual property challenges has to rely on the ability of the U. S. Patent and Trademark Office (PTO) to issue quality patents based on a thorough scrutiny of prior art and an informed view of non-obviousness, and on the wisdom and speediness of the U.S. judicial system in reviewing them. Recent studies by the National Academy of Sciences and the Federal Trade Commission and the Department of Justice make clear the need for a thorough review of the system.[89] Problems with patents in the information processing and communications technologies sectors, in particular, suggest that a system that works reasonably well in regard to pharmaceuticals may need substantial adjustment to reflect a process of innovation in digital information products that is marked by numerous incremental improvements and extensive cross-licensing arrangements.

GOVERNMENT PROCUREMENT: SHOULD GOVERNMENTAL USE OF OPEN-SOURCE SOFTWARE BE MANDATED?

Patent infringement challenges may stall the growth of the open-source movement. But, a strong source of support is coming from the developing world, where proposals calling for governments to utilize only open-source software have proliferated. From the Peruvian legislature to the Indian Ministry of Defense, governmental bodies have been deliberating whether to impose such mandates based on claims that they would lower overall IT expenditures, improve security, reduce dependence upon foreign proprietary software providers, help to stimulate indigenous software development capabilities and foster economic development.[90]

This push to require governments to procure open-source software is particularly threatening to proprietary software companies because of its strength in the developing markets in Asia and Latin America that are likely to have the highest growth rates in the future. Lower costs are particularly important to governments in these markets because of their lower income; moreover, arguments for economic independence resonate in many of these countries based on their colonial histories.† To counter this trend, proprietary software companies have actively sought U.S. government support in opposing open-source purchasing mandates in countries where they have been raised.

The arguments over mandating governmental purchases of open-source software recently reached into the heart of Silicon Valley. A proposal was made by the California Performance Review Commission to require the California state government to acquire only open-source software where it was available.[91] With advocates for and against the proposals actively lobbying, Bruce Perens, one of the founders of the Open Software Initiative, proposed a requirement focused on interoperability.[92]

He argued that the issue was not whether to require government to acquire open-source software but rather whether a government should require that any software it acquired for a critical governmental function be interoperable across various platforms. In other words, should a citizen be required to

† One factor seen as legitimating the purchase of open-source software by governments is its acceptance by a growing number of governmental agencies in the developed world—including in the United States, where open-source software is used by the Department of Defense, the Federal Aviation Administration, the National Oceanic and Atmospheric Administration, the Department of Energy and the Federal Emergency Management Agency, among others.

purchase a particular vendor's hardware or software to engage in a critical interaction with his or her own government?

Perens suggested that governments should not be required to purchase open-source software but should identify critical governmental functions and the capabilities required to provide interoperability across various platforms such as open file or data formats. Any software that the government acquired for a critical governmental function would have to include these capabilities. Proprietary software vendors could meet the conditions without disclosure of source code if there were sufficiently open interfaces that could be used to provide interoperability.[93] (De facto proprietary standards have provided a more limited interoperability in the past.)

The State of Massachusetts has recently attempted to address the issue of interoperability in critical communications with its citizens by requiring the use of Open Data Standards by vendors with which it deals. The proposal has generated considerable controversy.[94]

The importance of interoperability with respect to critical governmental functions is even clearer than the general benefits of interoperability provided by open standards. The competition enabled by interoperability lowers costs, increases the number of vendors, reduces lock-in, and encourages innovation by broadening the potential market for new applications. In particular areas such as health care, interoperability can provide the basis for improved care for the chronically ill, fewer medical errors, and dramatically reduced administrative costs. According to one study, fully standardized and integrated health care information system could save the nation $77.8 billion annually.[96]

The Bush Administration recognized the attraction of interoperability in its 2004 report "The Decade of Health Information Technology," which seeks to create an interoperable system for electronic health care records within 10 years.[96] The system would allow the storage and sharing of electronic health records while maintaining security and patient confidentiality. Under this proposal, the government would provide funding for test beds and pilot programs to develop and evaluate interoperable solutions.

The consequences of a lack of interoperability in telecommunications were evident during the 9/11 rescue events and during the recent hurricanes in the Gulf Coast. Hurricane Katrina provided a particularly dramatic example of the lack of interoperability for citizens involved in critical interactions with their government. People seeking to obtain assistance from the Federal Emergency Management Agency (FEMA) were unable to fill out the required forms unless they used one specific proprietary Web browser.[97] While this may simply be due to a lack of resources at FEMA, a drawn-out Web implementation process, or a lack of recognition of the problem, it created yet another obstacle for those in desperate need.[†]

At the same time that the virtues of interoperability in health care information systems are being stressed by the Administration, the United States is on record as questioning interoperability requirements proposed as part of the European Commission's intellectual property policies. During consultations between the U.S. government and the European Union, the United States raised objections to governmental interoperability requirements on the basis that they might violate governmental procurement requirements under the World Trade Organization agreements as well as the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement regarding intellectual property.[98] In a related area, U.S. proposals regarding intellectual property in several bilateral trade negotiations with other countries include intellectual property protections based on the Digital Millennium Copyright Act (DMCA) but do not include protections for consumers contained in that Act, including provisions that promote interoperability.[99]

[†] Internet users needed Microsoft Internet Explorer 6 in order to apply on-line for aid from FEMA. Although Internet Explorer is now available for download free of charge, this was not always the case. More importantly, citizens and government agencies should not depend on a company's independent business decisions to ensure interoperability in critical interactions.

VI. PUBLIC POLICY RECOMMENDATIONS REGARDING OPEN-SOURCE SOFTWARE

The Council recognizes that serious issues have been raised over the last several years about the operation of the present patent system in the area of software and business methods patents. (In a report released in 2001, CED recommended that automated business methods should not be patentable; rather, copyright should be used to protect software that implements a business process.[100]) The Council is encouraged that Congress is engaging in such a review with the goal of fulfilling the Constitution's aim to provide the highest possible level of innovation within the United States, recognizing the importance of both initial and follow-on creators. Such a review should reexamine the premise that today's unitary system continues to serve all industrial sectors well, especially given the proliferation of problems regarding software patents.

The Council opposes any mandate that would require any governmental agency to utilize only a particular form of software license or development process, be it proprietary or open source. Procurement decisions should be based on identifying and obtaining the software that best meets the needs of the particular governmental activity involved.

The Council recommends that governments at all levels should identify critical governmental functions, particularly as they involve citizen-government interactions, and place a high priority on requiring interoperability across various platforms for any software that is acquired related to performing these critical functions.

The government should advocate open standards and interoperability in critical areas of governmental function and should support royalty-free licensing of any intellectual property required to implement such standards

The government should consider additional areas in which interoperability would provide significant improvements in governmental performance, such as in the area of homeland security, where the lack of interoperability of first responder data and communications systems on September 11th provided a lesson in what not to do. The National Institute of Standards and Technology has an exemplary record in such studies and should continue to expand the areas under review.

The U.S. government should not be an advocate in the international arena for any particular type of software licensing or development and should oppose mandates for the utilization of any particular type of software licensing or development.

The U.S. government should review its policies regarding interoperability mandates to determine whether such mandates, particularly regarding interoperability in the IT arena with respect to critical governmental functions, can be accomplished in a manner consistent with treaty obligations.

The Digital Millennium Copyright Act's provisions regarding interoperability are an important check on the control that can be exercised by rights holders and should be included in any international agreements made by the United States in the area. Such agreements should reflect the balanced nature of U.S. intellectual property law.

The Patent and Trademark Office should make increased use of the Internet in seeking to document "prior art," particularly in the area of information technology, where the Internet provides new capabilities to reach the most knowledgeable commentators. A "Slashdot for prior art" should be the goal.[†101]

Given the proliferation of patent applications, the Congress should consider additional funding for the PTO.

[†] Slashdot is a popular website that features short summaries of technology-related news articles from a wide variety of other websites. Readers are provided with a link to the original website, should they wish to read the article in its entirety, and can also post their comments regarding the article on the Slashdot website. The editors of Slashdot are responsible for accepting or rejecting news articles, which are generally submitted by Slashdot readers.

VII. OPEN INNOVATION

The open-source software movement is an exemplar of a broader movement, that of "open innovation."

While the dramatic growth of open-source software is recent, tracking the growth of the Internet, today's open-source movement is directly related to the sharing practices of academic computer scientists dating back fifty years and more.

In a profound way, open-source software reflects practices that have produced much of the innovation in America. These innovations took place in factories and offices, farms and hospitals, homes and laboratories but often lay outside the formal system of innovation marked by patents, copyrights, and trade secrets.

These innovations have, over time, been labeled "reactive" or "collective" or "distributed" or "cumulative" innovation. Eric von Hippel of MIT has recently written an important book, *Democratizing Innovation*, which focuses on user-led innovations.[102] This form of innovation can be seen as part of a broader phenomenon that might be called "open innovation."

Open innovation involves the collaboration of manufacturers, suppliers, customers, or the simply inventive, which leads to the creation or modification of both tangible and intangible goods and services. The defining characteristics of open innovation are collaboration and sharing, often without economic reward. Open innovation should not be equated with the absence of intellectual property or the absence of compensation. But, much open innovation has not been protected under our intellectual property laws, and much has been done without any prospect of payment.

OPEN INNOVATION HAS A BROAD AND RICH HISTORY

Open innovation is hardly a new phenomenon. Adam Smith wrote about innovations by working men in the *Wealth of Nations*.[103] Lawrence Lessig has pointed out that the Oxford English Dictionary began with a call for volunteers to send in examples of vernacular word usage.[104] "Yankee tinkerers" went from village to village mending tools while passing along what today might be called "upgrades" shared with them by earlier customers. Competitively valuable innovations were passed around among the early iron makers in America directly, through shared contractors or via workers switching employers.[105]

Nor has open innovation slowed as technology has become more complex. As von Hippel points out, the mountain bike industry came into being based on the knobby-tired, shock-absorber-enabled bicycles cobbled together by enthusiasts before there was any such thing as a "mountain bike."[106] The legendary Homebrew Computing Club was a forum for sharing that led to the first successful personal computer.[107]

OPEN INNOVATION IS LIKELY TO BECOME MORE IMPORTANT GIVEN DEVELOPMENTS IN INFORMATION AND COMMUNICATIONS TECHNOLOGIES

Software, potentially infinitely malleable by programmers—if open or "openable"—is playing an ever growing role in economic activity in general. More specifically, it is becoming increasingly important in the

performance of hardware devices, from traditional computers to portable entertainment devices to scientific instruments and machine tools to toys. The history of information and communications technologies is filled with examples of capabilities originally manifest in hardware—the crystals in radios for example—eventually being transformed into software—the software of software-defined radios.[108]

Given its characteristics, software is particularly hospitable to the workings of open innovation, as can be seen from the open-source software movement. But, all digital information products can benefit as can be seen in recent developments based on the "repurposing of data," such as the Google Maps that are "mashed" together with housing lists, or incidents of avian flu, or whatever data set someone believes will provides a useful source of information when combined with a map.[109]

The ever increasing availability of computing power, combined with cheaper memory, has decreased the costs of digital tools, further lowering the barriers to the "democratization of innovation." The greater availability of these tools permits a larger number of users to create designs and even prototypes for new physical products; open innovation, thus, is being extended further and further into the physical world. New companies are offering design tools linked to fabricators that can produce a physical copy of almost anything that can be represented digitally.[110] Neil Gershenfeld of MIT's Center for Bits and Atoms calls this the "fab revolution;" as the Internet and personal computers made bits flexible, digitally driven fabrication will do the same things for atoms.[112] Some fab enthusiasts are even applying open-source principles to the new arena, creating an open database of interesting fabrication projects and fab techniques "like a Wikipedia for making stuff."[†] [112]

At the same time the cost of communicating to collaborate—whether to produce something new or to share an innovation—has plummeted. The Internet, improved and more available digital tools, and new applications such as social software and wikis[††] have produced what Timothy O'Reilly called a new "architecture for participation."[113]

THE CONVENTIONAL WISDOM PORTRAYS MANUFACTURERS, AND HEROIC INVENTORS, AS THE SOURCE OF INNOVATIONS THAT ARE PASSIVELY CONSUMED BY THEIR CUSTOMERS

Americans are in love with the idea of the lone inventor.[114] Edison is revered as a genius, responsible for the light bulb, the phonograph and countless other inventions. He could, however, be as well remembered as a master of collaboration who collected talented associates, instructed them to test whatever they thought best to solve a particular problem (such as the optimal material for a light bulb filament), and created a virtual "invention factory" at Menlo Park.[115] Americans argue about who was (or laugh over who claims to be) the father of the Internet, rather than appreciating the many acts of inventiveness that cumulatively led to its creation and development.

Discussions about innovation often reflect a view that producers of goods and services are the sources of innovation and customers passively consume the innovations embodied in the goods and services they acquire. But as von Hippel demonstrates, there are more useful ways of thinking about the process than manufacturers innovating and customers consuming.[116]

Customers usually know more than anyone else about their own needs and, in many cases, are capable of identifying actions that

[†] Wikipedia is a free, online encyclopedia with entries created entirely by Internet users (see page 36).

[††] A wiki is a type of website that allows users to easily modify content. The term is also used to identify the collaborative software that makes possible the operation of these websites.

can be taken to meet them. While they know their needs, that knowledge can be "sticky," tacit, and hard to communicate precisely. Customer needs, moreover, can be quite heterogeneous, varying by locality, gender, age cohort, etc. A subset of customers—von Hippel calls them "lead-users"—experience significant needs before other customers in the marketplace, have the resources and incentives to create their own solutions, and are, therefore, a particularly important source of innovation.[117]

Customers, by and large, don't care how their needs are met. They simply want the "optimal" solution. As a general rule, they prefer solutions that increase competition to serve them, provide them with greater choice, and reduce their costs. Increasingly, they have access to tools, particularly digital tools, that enable them to create their own solutions.

Manufacturers might be thought of as being in the business of providing solutions to customer needs. They are most knowledgeable about the subset of solutions (in the universe of solutions) in their area of specialization. Steel manufacturers are most knowledgeable about the range of available steel solutions, chemical manufacturers about chemical solutions that might work, and so forth. To sell solutions, they need to understand customer needs, and they try hard to do so. To be most profitable, they prefer to provide "acceptable" solutions that meet the needs of the largest number of customers in order to have the largest possible market over which to spread development and marketing costs. They seek to minimize development costs by relying on solutions that they have already created and understand. They are further motivated to utilize proprietary solutions to maximize profits.

Customers are specialists in their own needs with a growing ability to create solutions. Manufacturers are specialists in the solution sets with which they have experience. The relationship between the two groups is changing in an increasingly digital networked world.

OPEN INNOVATION EXTENDS WELL BEYOND LEAD USERS

Von Hippel makes a strong case for the importance of lead-users in the "democratization" of innovation, particularly customers with substantial expertise, resources and incentives, who have made substantial contributions in areas such as scientific instruments. In the field of kite sailing, users have employed digital tools to evaluate kite designs and either make their own kites or turn the designs over to a manufacturer.[118] But, there is a broader set of potential innovators that need to be considered to understand open innovation.

Several years ago Henry Chesbrough, now at the University of California at Berkeley, used the term "open innovation" in calling for companies to look beyond their own research and development organizations for ideas and practices that they could profitably employ. Firms, he noted, needed to be "open" to innovations from elsewhere.[119] In the last few years, new institutions and practices have emerged that provide firms with a much wider choice of innovations from a much broader set of innovators.

For example, Procter and Gamble now obtains 35 percent of its new products from outside the company, compared to 20 percent in 2002, and aims to increase this number to over 50 percent. It uses outside experts, such as the 80,000 online independent self-selected experts who address research problems for many different firms under the auspices of InnoCentive Inc., and connects with other sources of innovation through its "Connect and Develop" strategy.[120]

As the vice president of Eli Lilly's e.Lilly research unit stated, in words that could have come from the mouth of any open-source software advocate, "If I can tap into a million minds simultaneously, I may run into one that's uniquely prepared."[121] The same strategy of supporting the broadest possible distribution of problems utilized by the open-source software movement and underpinned by open-source licenses is being profitably

employed in the industry sector that has benefited most from today's patent system.

John Seely Brown and John Hagel III have recently made the case for the importance of suppliers as sources of innovation.[122] "Productive friction" with their suppliers helps firms to continually upgrade their own capabilities, enabling them to succeed in rapidly changing markets. Brown and Hagel point to Toyota and contrast its relationship with its suppliers with those of its American competitors. Toyota seeks long-term relationships with its suppliers and works with them to upgrade *their* capabilities. It engages them in a "deep dialogue" about what functionality Toyota needs, but does not rigidly define the means to achieve the enhancements, leaving ample room for supplier creativity. In contrast, according to Brown and Hagel, American car makers more often choose suppliers on the basis of the lowest price to produce a design that the car makers specify, with little room for supplier input and less attention to improving a supplier's performance over the long term.[123] (Ford's recent announcement of its plans to revamp its supplier relationships seems aimed squarely at emulating the Toyota model.[124])

Brown and Hagel's choice of Toyota suggests yet another category of participants beyond customers and suppliers. The well-known implementation of quality control principles and continuous improvement technologies by Japanese firms such as Toyota depends on contributions from everyone in the workforce, from the executive suite to the factory floor. Business school classes since the 1980's have taught that any worker can shut down the Toyota production line upon detecting a defect. While Brown and Hagel make the point that stopping the production line when a problem is encountered has the virtue of freezing the context and, thus, facilitating problem identification, the very nature of so empowering the workforce is built on a fundamental respect for *everyone's* potential to contribute. There is even a Japanese phrase that captures this belief in the value of every worker: "If you gather together three people, you have a genius."

OPEN INNOVATION AND MASS COLLABORATION

As Yochai Benkler wrote, the Internet has facilitated the rise of "peer production," which extends open innovation beyond traditional commercial or academic settings and allows *everyone* to contribute. This form of open innovation, where anyone can participate electronically in creative activities, has also been called mass collaboration. Among the best known examples is Wikipedia.

Wikipedia is an online encyclopedia created over the last five years. As its founder Jimmy Wales explained, "The goal is to give a free encyclopedia to every person in the world in their own language…Not just in a 'free beer' kind of way, but also in a free speech kind of way."[125] Wikipedia now boasts over 900,000 English language entries, more than seven times as many as that of the Encyclopedia Britannica. These entries were generated using a process even more open than that of Linux or Apache, with every proposed entry being logged and without an elaborate review processes. Earlier versions of an entry are available and can be restored should there be a breakdown in the "culture of neutrality" that Wikipedia seeks to foster. [126] As a result of its openness, Wikipedia must depend on a group of people who care to an unusual degree about its success and who have enough leverage that they can roll back graffiti or inflammatory entries.[127]

Overall, the quality of Wikipedia entries is high. A recent study in the publication *Nature* of Wikipedia's scientific entries found that they rivaled those of Britannica.[128†]

The book reviews at Amazon.com are also the results of voluntary actions by thousands of interested readers.[129] The World Wide Web is, in effect, the product of millions of individuals and institutions that posted pages.

† In March 2006, Encyclopedia Britannica issued a twenty page report challenging the methodolgy and the findings of the study conducted by *Nature*.

Every one who uploaded files to KaZaa or who rated a buyer or seller for eBAY or who commented on one of the millions of blogs that now exist was engaged in peer production and has helped create value with neither conventional corporate oversight nor payment. And supplementing these voluntary contributions are business processes designed to generate new data that become more and more valuable as they are automatically collected—such as purchase data at Amazon.com that help create Amazon's recommendations about books or music that may be of interest to a customer.

The photo site Flickr.com provides a different example of peer production or mass collaboration—what *The Economist* has called a "website of mass description."[130] Flickr does not assume that existing hierarchical organizational structures (such as the Dewey Decimal System) necessarily provide the best way of organizing data. Flickr allows anyone to "tag" an image, creating a wealth of different categories and paths through the photo archive; others can then search using whatever tags they choose and serendipitously benefit from the organization that others have created.[131]

In *The Wisdom of Crowds*, James Surowiecki describes the seemingly perplexing results that demonstrate that large numbers of independent people are better at solving certain problems than even the brightest individuals or the best-known experts.[132] This same insight, that "everybody knows more than anybody," guides Google's Page Rank system, which ranks Web pages to be retrieved based on links established by previous users. This is yet another example of utilizing what Business Week has called "the power of us."[133]

WHY ARE THESE INNOVATIONS SHARED?

If these innovations are so valuable, why are they shared? It is the same question raised about software programmers in the open-source movement.

In cases of a small but useful cumulative innovation, the creator might conclude that it is not worth the time and effort to obtain a patent—perhaps thousands of dollars and years of waiting. Or, the creator might conclude that intellectual property mechanisms might not effectively protect the innovation, for example where many others have similar information, where it would be difficult to keep the development a secret, and where the development can be easily replicated.[134]

The private interests that animated sharing in the open-source movement might also apply here, such as the potential gains in reputation and prestige. This is certainly true in academic settings, where sharing is the norm and the rewards—tenure, other employment prospects—depend on disclosure. Or, it might simply be the desire to create that inspires poets and songwriters.

There are also incentives for commercial firms to share broadly. Sharing might help get a new product to market more quickly, gaining a first-mover advantage. Sharing may lead to the establishment of a de facto standard or the generation of network effects. Sharing might help build a community of users that will support a new product or process; it might stimulate the sales of related products.[135] McAfee security software was initially given away in order to build a market for the product; Netscape released its browser on the Net for free, triggering the browser wars.

Sharing as a strategy may be particularly useful to a platform producer. If, as Eric Raymond has written, users are treated as co-developers, they can create new features, such as videogame "mods," that make platforms more valuable.[136] This expanded role of active and inventive consumers may lead to new systems of compensation for user-created innovations.

One of the characteristics of hackers is that they have traditionally pushed platforms to their limits, for the pleasure of the accom-

plishment, for the benefit of other users, and for bragging rights among their peers. These hacker/customers have, in some cases, served as unofficial research and development associates for new machines and applications.[137] New capabilities in the iPod such as the ability to podcast were the results of hacking and have led to a new form of commercial broadcasting.[138] The ability to control a TiVo over the Internet was created by a hacker/customer.[139]

Platform producers do not always welcome such assistance. They may conclude that opening a platform might negatively affect its functionality or threaten their relationship with a broader base of customers. SONY, whose robot dancing dog AIBO was a hit with hackers, did not want to lose control over the software that dictated the dog's dances, even though hackers had created and shared dozens of new dances that arguably made the AIBO more functional and valuable. SONY threatened to void the warranties for hacked AIBOs and continuously issued new software releases to frustrate potential hackers.[140] While TiVo embraced the capacity for remote control over the Internet, it refused, not surprisingly, to support a hacker/customer development that allowed TiVo customers to avoid its subscription fee.[141]

Rather than speeding up releases of new software that create barriers to hackers or voiding the warranties of devices with hacker-modified software, it might be better for platform providers to welcome the potentially larger co-development community. They could learn from, and appropriate mechanisms developed in, the open-source world to evaluate proposed modifications and to decide whether to include them.

SOME IMPLICATIONS OF OPENNESS

Openness clearly has its downsides. The openness of the Internet, which so powerfully facilitates communication and collaboration, has also opened the way for spam, phishing, and malware.[†] The information superhighway, as one commentator put it, goes through some very bad neighborhoods.

Controversy has erupted recently over the reliability of several Wikipedia entries, with individuals accused of posting false information to further personal and political interests. One intern in Washington, D.C. was given the task of removing old campaign promises from a senator's profile on Wikipedia that the senator since had violated. Another senator's profile erroneously listed him as having been voted "most annoying senator by his peers in Congress."[142]

These problems stretch well beyond the political sphere. A Wikipedia entry falsely suggested that John Seigenthaler, a former assistant to Robert Kennedy, may have been involved in the assassination of Robert F. Kennedy. Other Wikipedia users have complained that podcasting pioneer Adam Curry anonymously deleted references to other individuals' seminal podcasting work. These claims have led to changes in Wikipedia procedures, including preventing anonymous, unregistered users from posting new articles, thus moving Wikipedia closer to its open-source software relatives.[143] Questions of reviews and evaluation are likely to continue to be central to determining where a particular activity falls on the range of openness.

The mass collaboration in peer-to-peer networks that created the world's largest repository of music also resulted in the massive appropriation of copyrighted creative works. Sharing music on KaZaa was possible not only with friends and family, but with 60 million strangers. Attempts to create open editorial blogs have triggered hostile and hate-filled submissions.[144] SONY may have a justified concern that it customers

[†] Posing as a legitimate, and often well-known, person or business, individuals engaged in phishing use seemingly official electronic communications in an attempt to fraudulently obtain sensitive information, including passwords, and credit card, bank account and social security numbers, from unsuspecting Internet users. The term malware is a fusion of two words—malicious and software—and describes software that is designed to infiltrate or damage a computer system, without the owner's consent. Malware is commonly taken to include computer viruses, Trojan horses, and spyware.

would react badly to an AIBO programmed to attack them.

Part of the answer may lie in using the same digital technologies to facilitate evaluation of proposed contributions. Similarly, these technologies may facilitate new systems for compensating creators/co-developers for their works. William Fisher III and others have suggested various means to provide for compensation in the peer-to-peer world, but more rigorous analytic studies and broad dialogue will be necessary if new incentive-based compensation systems are to replace today's expensive litigation and high-priced lobbying.[145]

Developing new compensation systems, analogous to the payment mechanisms created in the past to accommodate radio broadcasts of music or cable television companies' use of broadcaster's transmissions, may prove more efficient and valuable economically than legislation or regulation aimed at controlling the development of information and communications technologies.[146] They would provide a means to ensure that creators will still have the incentive of being rewarded for their work, and ease the transition from systems that distribute physical products to potentially more capable and robust on-line marketplaces for digital information products. And, they should be able to accomplish this without imposing legal restrictions on technological development.

The centralized systems that produced and distributed music, video, movies and other cultural products are being challenged not only by peer-to-peer networks, but by new creators equipped with personal computers and broadband Internet connections, who can create podcasts, blogs or vlogs, or can make the music or videos or movies that they create available to global audiences.[†] New licensing mechanisms such as the Creative Commons are providing these creators with different choices about how they want their creations treated under intellectual property law.[147] New businesses are being born that attempt to provide order in this explosion of creation by evaluating and aggregating digital information products or by arranging for their delivery based on the individual preferences of a consumer. And as Chris Anderson described in "The Long Tail," the unlimited capacity of the Internet is allowing cultural products with relatively small audiences to compete economically with the "blockbusters" that have dominated more centralized "mass markets."[148]

The Internet is even leading to a re-evaluation of the idea of "the firm." The economist Ronald Coase saw the vertically integrated firm as an institution created to respond to the complex and expensive problems of transaction costs incurred in coordination among economic entities.[149] Now that the Internet has brought communications and coordination costs close to zero, the process of rethinking the relationships among firms and their partners, suppliers, and customers in the digital economy is just beginning.

Openness seems to touch every corner of our world. The means of doing science are changing as "open science" seeks to broaden the channels of distribution of knowledge beyond the traditional publisher-controlled journals. The Public Library of Science is creating a collection of scientific journals that will be available under an open-content license, while the National Library of Medicine (NLM) is providing health care information to those previously unable to access or afford relevant journals.[150] The National Institutes of Health (NIH) are asking grant recipients to make their work available voluntarily to the general public within twelve months of publication.[151] The astounding collaborative success in mapping the human genome has spawned dozens of efforts that are accelerating the development of genomics.[152] "Open courseware" is changing the academy by allowing millions of teachers and self-directed learners around

[†] Vlogs, or video blogs, are similar to regular blogs in which Internet users post entries on a regular basis. However, instead of simply typing their thoughts, video bloggers use video as the primary medium of expression. The advent of video blogging has been made possible by rapid technological advances, which have increased the available bandwidth and decreased the cost of high-speed Internet connections. Vlogs are now being produced and made available on the Internet by everyone from reputable news organizations such as MSNBC to lone teenagers with a Web camera and Internet access.

the world to see, compare, and potentially improve the syllabi offered by leading universities.[153] Publishing is facing challenges from self-appointed journalist/bloggers and what *The Wall Street Journal* calls "do it yourself media."[154] Google's proposal to scan entire libraries has triggered a profound debate about the relative importance of access versus control.[†][155] Advertisers and marketers are trying to adjust to an environment where TiVo viewers fast forward through advertisements and Web sites discuss the merits and demerits of countless products.[156] Just as a string of Federal Communications Commission (FCC) decisions allowing the attachment of non-AT&T telephones and accessories to the AT&T network triggered a wave of innovation in the customer telephone market, advocates of "open spectrum" are pointing to the remarkable degree of creative activity in the unlicensed "junk bands" of the radio frequency spectrum and the rise of Wi-Fi.[††][157] Proponents of "open access and network neutrality" in broadband telecommunications seek to ensure customer access to the broadest possible sources of information and applications, and oppose a "gatekeeper" role for cable television or telephone companies.[158] The creators of "mesh networks" have overturned traditional ideas of congestion in telecommunications by demonstrating communications systems in which each additional communicator enhances the capability of the network rather than burdening it. From the prize offering that led to Lindburgh's historic flight to the Department of Defense "Grand Challenge" aimed at the creators of autonomous vehicles, institutions are seeing the benefits of allowing a much broader range of participants to contribute their talents and efforts to benefit society.[159]

Each of these "open" works or processes differs in its degree of openness. Each has characteristics dependent on the particular domain. But, each rests on the joint ideas that providing more access to information and allowing more people to contribute their special skills and experiences will result in greater innovation than is achieved by restricting access to information or extending greater control over it. Such attempts to "harness the collective wisdom" are profoundly democratic.

[†] Google is developing two different services: Google Book Search Partner Program and Google Book Search Library Program. The Partner Program, which is currently up and running, features works only from copyright holders who have opted into the service and is not controversial. However, in the Library Program, copyright holders must opt out, meaning they must contact Google if they do not wish their works to be included. Internet users will then be able to search Google's database of copyrighted materials and will receive several sentences from copyrighted works that correspond to their query.

[††] These unlicensed bands represent a significant change from licensed bands, which historically have been allocated for particular services with stringent rules and a limited number of licenses assigned to specific users.

VIII. PUBLIC POLICY ISSUES REGARDING OPEN INNOVATION

Because much of open innovation takes place outside of the formal system of innovation, we have little information about how much there is, how important it is, how it takes place, and what can be done to foster it. Even though empirical studies have demonstrated its value in a number of different industries and its dominance in others, it is not counted in any governmental measures of innovation.[160]

Because we have overlooked or underappreciated open innovation by equating innovation with those actions covered by the formal systems of innovation, we should consider whether there is a governmental role in encouraging it. Under the tax system, the government provides a tax credit for research and development. Should the "development" that takes place in other settings be eligible for such subsidies?[161] Are there ways in which manufacturers, particularly small- and medium-sized manufacturers, can be shown how to profit from open innovation? Are there governmental incentives that would foster open innovation, such as decreased patent fees for intellectual property made available via royalty-free licensing?

One of the ironies of today's intellectual property system is that companies are motivated to ignore suggestions for new products or product improvements due to fear of later litigation. Many just destroy incoming communications to protect themselves or route them to their legal departments for polite rejections.[162] Should public policy suggest that a company's response to the potential for increased innovation based on the contributions of outsiders be larger recycling bins in the mailroom?

The Council's earlier report on digital intellectual property raised a number of questions about the effect of the Digital Millennium Copyright Act on innovation. In addition to the concerns the Council expressed about the DMCA's impact on access to digital information under the traditional Fair Use doctrine, and the way it is upsetting the traditional balance of intellectual property rules, the DMCA may well discourage customers from improving products that they thought they had bought (but which they might have, according to the manufacturers, merely licensed for a limited number of permitted uses). For example, customers who modified digital printer cartridges to allow them to be used for decorating cakes have been subject to litigation under the DMCA.[163] To the list of DMCA complaints, therefore, should be added the fact that it may be inhibiting creative users from adding value to products, particularly platform and other software-controlled products.

Finally, the impact on open innovation of legislative or judicial decisions aimed at problems regarding digital information products needs to be considered. For example, legislative or regulatory actions that would restrict peer-to-peer technology would eliminate the most efficient means of distributing new releases of open-source software and remove one of the key mechanisms for collaboration to achieve open innovation and for distribution of its results. Similarly, the Supreme Court's recent decision in the Grokster case is likely to add uncertainty for creators and investors, who may hesitate to bring products to the market for fear of litigation based on their potential uses to infringe intellectual property rights.[164] While the Court sought to provide some assurances that only products aimed specifically at fostering infringement would be liable for infringement, the decision may make it much more difficult for innovators to obtain summary judgments

against plaintiffs who accuse them of fostering infringement and who seek extensive and expensive discovery.

A recent policy statement, entitled the Adelphi Charter, by a group of artists, scientists, lawyers, business executive, and other experts from around the world provides a useful starting point in considering changes in intellectual property rules.[165] The charter suggests a test to be employed by lawmakers before new laws or regulations regarding intellectual property are passed. The test would establish a presumption against expanding intellectual property rights, placing the burden for justifying expansion on those who would advocate change, and would require a rigorous analysis of the impact of the change on people's basic rights and economic well-being.

There are a wide range of effects of openness that this report does not address—perhaps most prominent among them the impact on personal privacy (increasingly large amounts of personal information widely distributed or available to groups such as businesses or the government and potentially maintained in perpetuity) and security (while the majority of people use their increased access to information to benefit society, a small group will use this same information for destructive purposes, including terrorism). Other effects are far from clear, but may have profound effects in the longer term. While the Internet connects more and more people, it is not the direct connection of meeting physically that shaped our social practices—how will new forms of social interaction develop and change everything from greetings to geopolitics? Will our wider connections increase understanding and tolerance or exaggerate differences? How will the decentralization of creative activity affect the role of cultural products that have helped shape the ideas and images of every society? Will there be a cultural "Balkanization" of society with individuals retreating to their "information warrens?"[166]

There are dozens of questions such as these, which are beyond the scope of this report. However, public policy can address some issues that are already clear and can help promote openness and the innovation that it supports.

IX. PUBLIC POLICY RECOMMENDATIONS REGARDING OPEN INNOVATION

The statistical agencies of the government should consider definitions for open innovation and methods for gathering relevant data.

The Digital Millennium Copyright Act should be reviewed with the aim of guaranteeing access under the Fair Use doctrine to digital information that has been the subject of some form of access control and of fostering open innovation and interoperability involving products subject to the Act's protection.

Proposed legislation or regulations regarding intellectual property rights should be subject to the Adelphi Charter test, which establishes a presumption against the grant of any new rights, requires that proponents of new rights bear the burden of proof, and calls for rigorous analysis of the impact of the proposed changes.

The National Science Foundation should support research into alternative compensation systems for creators of digital information products.

The National Institutes of Health program for open publication of research results should be reviewed within twenty-four months and should be made mandatory if researchers are not publishing results voluntarily. All unclassified government research support should be governed by similar requirements.

The Telecommunications Act of 1996 should be amended to prevent unreasonable discrimination by cable and telephone companies in providing access to information sources or applications via the Internet. A similar ban on unreasonable discrimination against the attachment of devices that do not harm the network, imposed via terms of service, should also be enacted.

The Patent and Trademark Office should consider whether there are workable systems that would reward intellectual property rights holders for increasing access to the intellectual property they control.

X. CONCLUSION

The benefits of openness are becoming more apparent and are likely to grow as we learn to utilize the new capabilities enabled by information and communications technologies. These benefits are challenging our conventional wisdom about innovation and the incentives needed to stimulate it. And, they are suggesting new ways of acting based on the special characteristics of the digital world, which are far different than those that developed based on what we knew of the physical world.

Years ago, the theory of the tragedy of the commons was developed in economic literature. It argued that users of a commons (such as a grazing field shared by an entire community), who had no particular or individual stake in the success of the commons, might act in such a way as to maximize their own short-term interests at the long-term expense of the commons and the community that used it. Thus, the actions of a few could harm the interests of many, and of society as a whole.

The digital world provides an opportunity to think of the commons differently. The use of the digital commons by everyone does not necessarily exclude its use by anyone. To the extent that new information and communications technologies allow more and more people to contribute their own genius, the digital world offers new opportunities from the commons and for the commons.

Openness is not an overriding moral value that must prevail in every circumstance. But, its extraordinary capability to harness the collective intelligence of our world requires us to consider its implications carefully, nurture it where possible, and avoid efforts to foreclose it without compelling reason. We should not miss the opportunity to harvest the benefits openness might bring.

ENDNOTES

1. Federal Trade Commission, *To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy* (October 2003), chapter 6, p. 4.

2. Andrew Wyckoff and Alessandra Colecchia, *The Economic and Social Impact of Electronic Commerce* (Organisation for Economic Co-Operation and Development (OECD), 1999), p. 11.

3. Herbert Hovenkamp, Mark D. Janis, and Mark A. Lemley, *IP and Antitrust: An Analysis of Antitrust Principles Applied to Intellectual Property Law* (New York: Aspen Law & Business, 2002), section 1.3a. The book notes, "Because intellectual property rights impose costs on the public, the intellectual property laws can be justified by the public goods argument only to the extent that the laws on balance encourage enough creation and dissemination of new works to offset those costs."

4. "Public Sector Modernisation: Open Government," OECD Policy Brief (February 2005), p. 2.

5. Thomas L. Friedman, *The World is Flat: A Brief History of the Twenty-First Century* (New York: Farrar, Straus and Giroux, 2005), p. 62.

6. "Mashing the Web," *Economist,* Technology Quarterly, September 17, 2005.

7. Wikipedia, "Internet Engineering Task Force," available at <en.wikipedia.org/wiki/IETF>; Wikipedia, "Request for Comments," available at <en.wikipedia.org/wiki/Request_for_Comments>; Tim O'Reilly, "Open Source Paradigm Shift," June 2004, available at <www.oreillynet.com/pub/a/oreilly/tim/articles/paradigmshift_0504.html>. The Internet Engineering Task Force (IETF) develops and promotes Internet standards; in particular those of the TCP/IP protocol suite. It is an open, all-volunteer standards organization, with no formal membership or membership requirements.

8. Andrew Updegrove, "The Many Faces of 'Open'," *Consortium Standards Bulletin*, vol. IV, no. 3 (March 2005), available at <www.consortiuminfo.org/bulletins/mar05.php#feature>.

9. Wikipedia, "P3P," available at <en.wikipedia.org/wiki/Platform_for_Privacy_Preferences>. The Platform for Privacy Preferences, or P3P, was designed to give users more control of their personal information when browsing.

10. David Balto, "Standard Setting in a Network Economy" (address given at Cutting Edge Antitrust Law Seminars International, New York, February 17, 2000), available at <www.ftc.gov/speeches/other/standardsetting.htm>.

11. Statement of Carl Cargill, Director of Standards, Sun Microsystems, before the Subcommittee on Technology of the House Committee on Science, September 13, 2001.

12. David Bollier, *The Power of Openness: Why Citizens, Education, Government and Business Should Care About the Coming Revolution in Open Source Code Software*, research publication no. 1999-02 (Berkman Center for Internet & Society at Harvard Law School, 1999) p. 9.

13. Wikipedia, "Network Effect," available at <en.wikipedia.org/wiki/Network_effect>. A network effect causes a good or service to have a value to potential customers dependent on the number of customers already possessing or using that good or service. Metcalfe's law states that the total value of a good or service that possesses a network effect is roughly proportional to the square of the number of customers already owning that good or using that service.

14. Michael P. Gallaher, Alan C. O'Connor, John L. Dettbarn, Jr., and Linda T. Gilday, *Cost Analysis of Inadequate Interoperability in the U.S. Capital Facilities Industry*, NIST GCR 04-867 (U.S. Department of Commerce, Technology Administration, National Institute of Standards and Technology, August 2004), p. iv; William J. White, Alan C. O'Connor, and Brent R. Rowe, *Economic Impact of Inadequate Infrastructure for Supply Chain Integration*, Planning Report 04-2 (RTI International, June 2004), p. 8.

15. Friedman, *The World is Flat*, p. 76.

16. The Council on Competitiveness, *Innovate America: Thriving in a World of Challenge and Change*, The National Innovation Initiative Interim Report (July 23, 2004), p. 10.

17. David Balto, "Standard Setting in a Network Economy." For more information, see: Sherrie Bolin, ed., *The Standards Edge* (Ann Arbor, MI: Sheridan Books).

18. Daniel J. Weitzner, *Standards, Patents and the Dynamics of Innovation on the World Wide Web* (draft, Boston, MA, November 1, 2004).

19. Weitzner, *Standards, Patents and the Dynamics of Innovation*, Section II.

20. Weitzner, *Standards, Patents and the Dynamics of Innovation*, Section IIIA.

21. Weitzner, *Standards, Patents and the Dynamics of Innovation*, Section IIIB.

22. Weitzner, *Standards, Patents and the Dynamics of Innovation*, Section IIIB.

23. Weitzner, *Standards, Patents and the Dynamics of Innovation*, Section IIID.

24. Paul Festa, "Standards Group Beats Back Patent Foes," CNET News.com, April 10, 2003, available at <news.com.com/2100-1013-996351.html>.

25. Bill Thompson, "Keeping How the Net Works Open to All," BBC News, September 3, 2004, available at <news.bbc.co.uk/1/hi/technology/3624798.stm>.

26. Paul Festa, "Warming Up to Open Source," CNET News.com, February 9, 2005, available at <news.zdnet.com/2100-3513_22-5569610.html>. The Organization for Advancement of Structured Information Standards (OASIS) released its updated intellectual property policy, which was revised "to enhance support for open standards development." The revised policy accommodates, but does not require, royalty-free licenses.

27. Gordon Bell, "A Time and Place for Standards," *VoIP*, vol. 2, no. 6 (September 2004), p. 2, available at <acmqueue.com/modules.php?name=Content&pa=printer_friendly&pid=210&page=1>. Bell contends "that a standard has a far better chance of making a real impact if no royalty is charged to those who employ it. You'd think this would go without saying, but sadly, it doesn't. For example, the fact that Xerox was willing to provide a royalty-free license for its Ethernet technology proved to be a significant factor contributing to the general adoption of 802.11. In contrast, IBM paid an inventor for the Token Ring patent, and ultimately that royalty worked to erode support for the ring's adoption."

28. Paul Festa, "Patent Holders on the Ropes," CNET News.com, December 2, 2002, available at <news.com.com/Patent+holders+on+the+ropes/2100-1023_3-975587.html>.

29. David Balto, "Standard Setting in a Network Economy."

30. Alex Soojung-Kim Pang, "The Economist on the Digital Home," The Institute for the Future, September 2, 2005, available at <future.iftf.org/2005/09/the_economist_o.html>.

31. W3C, *W3C Patent Policy* (working draft, February 5, 2004), available at <www.w3.org/Consortium/Patent-Policy-20040205/>; Festa, "Patent Holders on the Ropes."

32. James Bessen and Eric Maskin, *Sequential Innovation, Patents, and Imitation*, Working Paper 00-01 (Massachusetts Institute of Technology (MIT), January 2001).

33. *Roadmap for Open ICT Ecosystems* (Berkman Center for Internet & Society at Harvard Law School, September 9, 2005), available at <cyber.law.harvard.edu/epolicy/roadmap.pdf>.

34. Statement of Carl Cargill, Director of Standards, Sun Microsystem, in U.S. House of Representatives, *Standards-Setting and United States Competitiveness*, hearings before the Subcommittee on Environment, Technology and Standards of the House Committee on Science (June 28, 2001).

35. Martin C. Libicki, James Schneider, Dave Frelinger, and Anna Slomovic, *Scaffolding the New Web: Standards and Standards Policy for the Digital Economy* (Santa Monica, CA: Rand, 2000), pp. 24-25.

36. Martin LaMonica, "Open Source Reshaping Services Market," CNET News.com, January 10, 2005, available at <news.com.com/Open+source+reshaping+services+market/2100-7344_3-5504851.html?tag=st.num>.

37. "Open Invention Network Formed to Promote Linux and Spur Innovation Globally Through Access to Key Patents; Investors Include IBM, Novell, Philips, Red Hat, and Sony," Business Wire, Inc., November 10, 2005.

38. OneStat.com, "Mozilla's Browsers Global Usage Share Remains Stable According to OneStat.com" (press release, Amsterdam, Netherlands, January 31, 2006), available at <www.onestat.com/html/aboutus_pressbox41_mozilla_firefox_usage_share.html>.

39. Jon Udell, "Strategic Developer: Automation is like Riding a Bike," *InfoWorld*, vol. 27, no. 6 (February 4, 2005); Linda Seebach, "Open Source Evolved after Tinkering with its 'Memes'," *Rocky Mountain News*, September 20, 2003, p. 13C; "ActiveState Releases ActivePerl 5.6 to the Community; Now Available for Linux and Solaris," Business Wire, Inc., March 28, 2000.

40. "SourceForge.net," available at <sourceforge.net/>, accessed February 16, 2006.

41. Wikipedia, "Internet2," available at <en.wikipedia.org/wiki/Internet_2>. Internet2 or UCAID (University Corporation for Advanced Internet Development) is a non-profit consortium that develops and deploys advanced network technologies and applications, primarily for high-speed data transfer. Its members include more than 200 U.S. universities and partners from the networking (Cisco Systems), publishing (Prous Science) and technology industries (such as Comcast, Intel, Sun Microsystems).

42. Steven Levy, *Hackers: Heroes of the Computer Revolution* (Garden City, NY: Anchor Press/Doubleday, 1984); Simson Garfinkel, "Hack License: Recent Books Struggle to Define Hacking and its Economic and Social Legitimacy," *Technology Review* (March 2005), p. 75; Joseph Weizenbaum, "Science and the Compulsive Programmer," in Weizenbaum, *Computer Power and Human Reason* (San Francisco, CA: W. H. Freeman, 1976).

43. Stewart Brand and Matt Herron, "1984 Ad," *Whole Earth Review* (May 1985), p. 49. At the first Hacker's Conference in 1984, Stewart Brand famously said, "On the one hand information wants to be expensive, because it's so valuable. The right information in the right place changes your life. On the other hand, information wants to be free, because the cost of getting it out is getting lower and lower all the time. So you have these two fighting against each other." A slightly amended version of this statement can be found in Brand's book, *The Media Lab*.

44. Steven Weber, *The Success of Open Source* (Cambridge, MA: Harvard University Press, 2004).

45. Andrew Leonard, "Code Free or Die," Salon.com, April 2, 2002, available at <www.salon.com/tech/books/2002/04/02/stallman/print.html>.

46. Wikipedia, "Source Code," available at <http://en.wikipedia.org/wiki/Source_code>; Lawrence Lessig, "The Limits in Open Code: Regulatory Standards and the Future of the Net," *Berkeley Technology Law Journal*, vol. 14 (1999), pp. 759, 764-765. Source code is any series of statements written in a human-readable computer programming language. A computer program's *source code* is the collection of files that can be converted from human-readable form to an equivalent computer-executable form. As Lessig writes, "It is this code that allows a programmer to open an open-source software project and see what makes it tick. By being able to see what makes it tick, open-source software makes transparent any control that the code may carry…Closed code functions differently…hidden under a hood that won't open."

47. Free Software Foundation (FSF), "The Free Software Definition," available at <www.fsf.org/philosophy/free-sw.html>.

48. O'Reilly, "Open Source Paradigm Shift," June 2004.

49. Wikipedia, "Open Source Movement," available at <en.wikipedia.org/wiki/Open_Source_movement>; Garfinkel, "Hack License," p. 77. Since its inception, the open-source movement has been a matter of controversy within the hacker community. Richard Stallman, speaking on behalf of the Free Software Foundation, has attacked the motivation of the open-source movement. He asserts that the pragmatic focus of the movement diverts users from the central moral issues and freedoms offered by free software. Stallman characterizes the free software and the open-source movements as separate "political camps" within the same free-software community, however, and says: "We disagree on the basic principles, but agree more or less on the practical recommendations. So we can and do work together on many specific projects."

50. Steve Hamm, "Linus Torvalds' Benevolent Dictatorship; The Creator of Linux Says 'I Can't Be Nasty' When Leading the Open-Source Movement," Business Week Online, August 18, 2004.

51. Wikipedia, "Machine Code," available at <en.wikipedia.org/wiki/Machine_language>. The "words" of a machine language or code are called instructions, each of which cause an elementary action by the central processing unit (CPU), such as reading from a memory location. Unlike source code, machine code is virtually unreadable by human programmers. Every CPU model has its own machine code, or instruction set, although there is considerable overlap between some.

52. Martin Fink, *The Business and Economics of Linux and Open Source* (Upper Saddle River, NJ: Prentice Hall PTR, 2003); Ingrid Marson, "Defender of the Linux Faith," CNET News.com, March 18, 2005, available at <news.com.com/Defender+of+the+Linux+faith/2100-7344_3-5625667.html>. For more information on the various licenses of open-source software versus free software, please see the following websites: <www.opensource.org/docs/definition.php> and <www.fsf.org/licensing/essays/free-sw.html>.

53. Stephen Shankland, "Microsoft, Red Hat Argue Open Source," CNET News.com, July 26, 2001, available at <news.com.com/Microsoft%2C+Red+Hat+argue+open+source/2100-1001_3-270684.html>.

54. Digital Connections Council (DCC), Committee for Economic Development (CED), *Promoting Innovation and Economic Growth: The Special Problem of Digital Intellectual Property* (Washington, D.C.: CED, March 2004).

55. Josh Lerner and Jean Tirole, *The Simple Economics of Open Source*, Working Paper No. 7600 (Cambridge, MA: National Bureau of Economic Research, March 2000); Eric von Hippel, "Innovation by User Communities: Learning From Open-Source Software," *MIT Sloan Management Review*, vol. 42, no. 4 (Summer 2001), pp. 82-86; Yochai Benkler, "'Sharing Nicely': On Shareable Goods and the Emergence of Sharing as a Modality of Economic Production," *Yale Law Journal*, vol. 114 (2004), pp. 273-358; Yochai Benkler, "Coase's Penguin, or Linux and the Nature of the Firm," *Yale Law Journal*, vol. 112 (2002), pp. 369-446.

56. Eric Steven Raymond, "The Many Faces of Reputation," in *Homesteading the Noosphere*, last modified August 24, 2000, available at <www.catb.org/~esr/writings/cathedral-bazaar/>.

57. John Clippinger and David Bollier, *A Renaissance of the Commons: How the New Sciences and Internet are Framing a New Global Identity and Order* (2003), p. 12. See also: Ernst Fehr and Urs Fischbacher, "The Nature of Human Altruism," *Nature*, vol. 425 (October 23, 2003), pp. 785-791.

58. Garfinkel, "Hack License," p. 76.

59. Benkler, "'Sharing Nicely'," p. 305.

60. Eric Steven Raymond, "The Mail Must Get Through," in *The Cathedral and the Bazaar*, last modified September 11, 2000, available at <www.catb.org/~esr/writings/cathedral-bazaar/>.

61. T.R. Reid, "Jack Kilby, Touching Lives on Micro and Macro Scales," *Washington Post*, June 22, 2005, p. C1.

62. Friedman, *The World is Flat*, pp. 82-92.

63. Raymond, "Necessary Preconditions for the Bazaar Style," in *The Cathedral and the Bazaar*.

64. Ganesh Prasad, "Open Source-onomics: Examining Some Pseudo-Economic Arguments About Open Source," Linux Today, p. 4, available at <http://linuxtoday.com/infrastructure/2001041200620OPBZCY—>.

65. Lerner and Tirole, *The Simple Economics of Open Source*. Some of the most important open-source projects do not acknowledge the contributions of particular programmers and, thus, this benefit is not available; however, this is not the case with all projects and does not affect the benefits to one's reputation that word of mouth can bring.

66. Wikipedia, "BitTorrent," available at <en.wikipedia.org/wiki/Bit_torrent>; Tim O'Reilly, "What is Web 2.0: Design Patterns and Business Models for the Next Generation of Software," September 30, 2005, p. 2, available at <www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-web-20.html?page=1>. BitTorrent is the name of a client application for the torrent peer-to-peer (P2P) file distribution protocol created by programmer Bram Cohen. In discussing BitTorrent, Tim O'Reilly stated, "the service automatically gets better the more people use it."

67. Weber, *The Success of Open Source*, pp. 172-173.

68. Weber, *The Success of Open Source*, p. 154.

69. Raymond, "Release Early, Release Often," in *The Cathedral and the Bazaar*.

70. Tim O'Reilly, *Tim O'Reilly in a Nutshell* (O'Reilly Media, Inc., 2004), p. 38, available at <www.oreilly.de/oreilly/oreilly_inanutshell.pdf>.

71. Berlecon Research, *Free/Libre Open Source Software: Survey and Study—Firms' Open Source Activities: Motivations and Policy Implications*, FLOSS Final Report—Part 2 (prepared for the Information Society Technologies of the European Commission, Berlin, Germany, July 2002), p. 7.

72. Open letter from Joel Spolsky, "Strategy Letter V," June 12, 2002, available at <www.joelonsoftware.com/articles/StrategyLetterV.html>.

73. O'Reilly, "Open Source Paradigm Shift."

74. Weber, *The Success of Open Source*, pp. 91-93.

75. O'Reilly, "What is Web 2.0," p. 4.

76. O'Reilly, "What is Web 2.0," p. 4; Raymond, "Release Early, Release Often," in *The Cathedral and the Bazaar*.

77. Weber, *The Success of Open Source*, pp. 166-171.

78. Weber, *The Success of Open Source*, pp. 126-127.

79. Hamm, "Linus Torvalds' Benevolent Dictatorship."

80. Dan Gillmor, "Still Some Way to Go on Usability," *Financial Times*, September 21, 2005, p. 2; Alorie Gilbert, "Tech Firms to Tackle Linux Desktop Standards," CNET News.com, October 17, 2005, available at <news.com.com/Tech+firms+to+tackle+Linux+desktop+standards/2100-1016_3-5898069.html>; David S. Evans, "Is Free Software the Wave of the Future?," *Milken Institute Review*, 4th quarter (2001); Tim O'Reilly, "Why Open Source *Doesn't* Suck for the Consumer," available at <www.oreilly.com/ask_tim/ossucks_0800.html>.

81. Stephen Shankland, "SCO Sues Big Blue Over Unix, Linux," CNET News.com, March 6, 2003, available at <news.com.com/SCO+sues+Big+Blue+over+Unix%2C+Linux/2100-1016_3-991464.html>; Stephen Shankland, "Big Blue Files Counterclaims Against SCO," CNET News.com, August 7, 2003, available at <news.com.com/Big+Blue+files+counter-claims+against+SCO/2100-1016_3-5060965.html>.

82. Weber, *The Success of Open Source*, p. 215.

83. Randall Stross, "Why Bill Gates Wants 3,000 New Patents," *New York Times*, July 31, 2005, section 3, p. 3.

84. Stephen Shankland, "Group: Linux Potentially Infringes 283 Patents," CNET News.com, August 1, 2004, available at <news.com.com/Group+Linux+potentially+infringes+283+patents/2100-7344_3-5291403.html>.

85. Robert A. Guth, "Start-Up Hires Open-Source Ally," *Wall Street Journal*, June 8, 2005, p. B4. See also, Black Duck Software's website at <www.blackducksoftware.com>.

86. Steve Lohr, "I.B.M. to Give Free Access to 500 Patents," *New York Times*, January 11, 2005, p. C1; Steve Lohr, "Sharing the Wealth at I.B.M.," *New York Times*, April 11, 2005, p. C1.

87. Ed Scannell, "IBM Says it Won't Assert Patents Against Linux Kernel," InfoWorld Daily News, August 4, 2004.

88. Robert A. Guth, "Microsoft Extends Legal Protections," *Wall Street Journal*, June 23, 2005, p. B4; Stacey Higginbotham, "How Open? That's the Big Patent Question," CNET News.com, September 25, 2005, available at <news.com.com/How+open+Thats+the+big+patent+question/2100-1014_3-5877028.html>.

89. Stephen A. Merrill, Richard C. Levin, and Mark B. Myers, eds., Committee on Intellectual Property Rights in the Knowledge-Based Economy, Board on Science, Technology, and Economic Policy, Policy and Global Affairs Division, National Research Council, *A Patent System for the 21st Century* (Washington, D.C.: National Academies Press, 2004); Federal Trade Commission, *To Promote Innovation: The Proper Balance of Competition and Patent Law and Policy* (October 2003).

90. Henry Chu, Mark Magnier, and Joseph Menn, "Developing Nations See Linux as a Savior From Microsoft's Grip," *Los Angeles Times*, August 9, 2004, p. A4; Ina Fried, "Microsoft Struggles in Emerging Markets," CNET News.com, May 7, 2004, available at <news.com.com/2100-1001-5208422.html>; Steve Lohr, "An Alternative to Microsoft Gains Support in High Places," *New York Times*, September 5, 2002, p. C1; Todd Benson, "Brazil: Free Software's Biggest and Best Friend," *New York Times*, March 29, 2005, p. C1; Renata De Freitas and Alberto Alerigi Jr., "Microsoft Brazil Decries Government Use of Linux," Reuters, June 4, 2004; Janet Paterson and Pamela Weaver, "South Africa: Open-Source Software and Speech Technology Could Help This Multicultural Country Pull Itself Into the Information Technology Big Leagues," *Technology Review* (April 2005), p. 50.

91. David Becker, "California Considers Open-Source Shift," CNET News.com, August 27, 2004, available at <news.com.com/2100-7344-5327581.html>.

92. Bruce Perens, "MS 'Software Choice' Scheme a Clever Fraud," *Register*, August 9, 2002, available at <www.theregister.co.uk/2002/08/09/ms_software_choice_scheme/>. For more information, please visit the website <www.sincerechoice.org/>.

93. Jerry Fishenden, Oliver Bell, and Alan Grose, *Government Interoperability: Enabling the Delivery of E-Services*, version 1.1 RTM, a white paper (Microsoft, April 2005); K.D. Simon, "The Value of Open Standards and Open-Source Software in Government Environments," *IBM Systems Journal*, vol. 44, no. 2 (July 2005), pp. 227-238.

94. Commonwealth of Massachusetts, Executive Office for Administration and Finance, Information Technology Division, "Enterprise Open Standards Policy," ITD-APP-01 (January 13, 2004), available at <www.mass.gov/Aitd/docs/policies_standards/openstandards.pdf>; Eric Kriss, Secretary, Executive Office for Administration and Finance, Commonwealth of Massachusetts, "Informal Comments on Open Formats" (edited and condensed from transcription of original oral comments at the Massachusetts Software Council annual meeting, January 15, 2005), available at <www.mass.gov/eoaf/open_formats_comments.html>; Martin LaMonica, "Microsoft Commits to XML Docs for Long Term," CNET News.com, November 5, 2004, available at <news.com.com/Microsoft+commits+to+XML+docs+for+long+term/2100-1007_3-5440380.html>.

95. Jan Walker, Eric Pan, Douglas Johnston, Julia Adler-Milstein, David W. Bates, and Blackford Middleton, "The Value of Health Care Information Exchange and Interoperability," *Health Affairs*, Web exclusive (January 19, 2005), p. 10.

96. David J. Brailer, *The Decade of Health Information Technology: Delivering Consumer-centric and Information-Rich Health Care* (U.S. Department of Health & Human Services, July 21, 2004).

97. Linda Rosencrance, "To Apply For FEMA Aid Online, Katrina Survivors Will Need IE 6: Mac and Linux Users Will Have to Seek FEMA Help By Phone," Computer World, September 7, 2005, available at <www.computerworld.com/securitytopics/security/recovery/story/0,10801,104440,00.html>; Jeffrey H. Birnbaum, "Lobbyists Tangled in a Paperless Pursuit," *Washington Post*, October 31, 2005, p. D1.

98. U.S. Mission to the European Union, "U.S. Comments on the Draft European Parliament Amendments Regarding the Proposed European Union Directive on the Patentability of Computer-Implemented Inventions" (submitted following a meeting between U.S. officials and Mr. Wim van Velzen, member of the European Parliament, on August 21, 2003), available at <www.aplf.org/mailer/USCommentsPatentCompImplInv.pdf>.

99. Michael Geist, Canada Research Chair in Internet & E-commerce Law, University of Ottawa, Faculty of Law, "Michael Geist," available at <www.michaelgeist.ca/resc/html_bkup/may92005.html>. According to Geist, at least a dozen countries have signed trade agreements that include intellectual property provisions. However, there are substantial questions about requirements that extend beyond the World Intellectual Property Organization (WIPO) treaties and even U.S. intellectual property protections. For example U.S. negotiators have pushed for provisions that do not reflect U.S. law and that eliminate safety valves built into U.S. law such as the ability to have access to intellectual property in order to ensure interoperability.

100. CED, *The Digital Economy: Promoting Competition, Innovation, and Opportunity* (Washington, D.C.: CED, 2001).

101. Anne Marie Squeo, "In Patent Disputes, a Scramble to Prove Ideas are Old Hat," *Wall Street Journal*, January 25, 2006, p. A1.

102. Eric von Hippel, *Democratizing Innovation* (Cambridge, MA: MIT Press, 2005).

103. Adam Smith, *An Inquiry Into the Nature and Causes of the Wealth of Nations* (Dublin, Ireland: Whiteston, 1776).

104. Lawrence Lessig, "The March of the Web-Enabled Amateurs," *Financial Times*, September 21, 2005, p. 2.

105. Robert C. Allen, "Collective Invention," *Journal of Economic Behavior and Organization*, vol. 4, no. 1 (1983), pp. 1-24.

106. von Hippel, *Democratizing Innovation*, pp. 72-76.

107. Roger Lowenstein, "Off the Shelf; Turn on, Tune In, Drop Out, Start the Computer Revolution," *New York Times*, late ed., May 22, 2005, section 3, p. 7.

108. Bell, "A Time and Place for Standards." Bell notes, "Once a technology has been proven in a hardware implementation, it proceeds to be implemented in software running on high-performance processors, which in turn continues to evolve at an even faster rate until it can be finally be implemented as a zero-cost option on small areas of silicon and iron oxide….Once a capability has been implemented as software, it essentially slips" from the patent holder's grasp.

109. "Mashing the Web," *Economist*, September 17, 2005.

110. Simon Hooper, "The Machine That Can Copy Anything," CNN Online, June 2, 2005, available online at <www.cnn.com/2005/TECH/06/02/tech.reprap/index.html>.

111. Clive Thompson, "The Dream Factory," *Wired Magazine*, September 2005, pp. 128, 130. For a more detailed discussion, see: Neil A. Gershenfeld, *Fab: The Coming Revolution on Your Desktop—From Personal Computers to Personal Fabrication* (New York: Basic Books, 2005).

112. Thompson, "The Dream Factory," p. 132. Thompson interviews Saul Griffith of Squid Labs.

113. O'Reilly, "What is Web 2.0," p. 3. O'Reilly notes, "This architectural insight may also be more central to the success of open-source software than the more frequently cited appeal to volunteerism. The architecture of the Internet, and the World Wide Web, as well as of open-source software projects like Linux, Apache, and Perl, is such that users pursuing their own 'selfish' interests build collective value as an automatic byproduct…In other words, these technologies demonstrate network effects, simply through the way that they have been designed…But as Amazon demonstrates, by consistent effort (as well as economic incentives such as the Associates program), it is possible to overlay such an architecture on a system that would not normally seem to possess it."

114. "How Companies Turn Customers' Big Ideas into Innovations," *strategy+business and Knowledge@Wharton*, January 15, 2005, available at <www.strategy-business.com/press/sbkw2/sbkwarticle/sbkw050112>.

115. Paul Israel, *Edison: A Life of Invention* (New York: John Wiley & Sons, 1998), p. 191; Michael Kanellos, "Building a New-Idea Factory," CNET News.com, April 28, 2005, available at <news.com.com/Building+a+new-idea+factory/2008-1008_3-5687180.html>; Henry William Chesbrough, "Reinventing R&D Through Open Innovation," *strategy+business and Knowledge@Wharton*, April 30, 2003, available at <www.strategy-business.com/press/enewsarticle/22190?pg=0>.

116. von Hippel, *Democratizing Innovation*, pp. 3, 45-61; Weber, *The Success of Open Source*, pp. 72-73.

117. von Hippel, *Democratizing Innovation*, p. 4.

118. von Hippel, *Democratizing Innovation*, pp. 22, 103-104, 125-126.

119. Henry William Chesbrough, *Open Innovation: The New Imperative for Creating and Profiting From Technology* (Boston, MA: Harvard Business School Press, 2003).

120. Robert D. Hof, "The Power of Us; Mass Collaboration on the Internet is Shaking Up Business," *Business Week*, June 20, 2005, pp. 77-79; NineSigma, Inc., "Procter & Gamble and NineSigma, Inc. Announce Strategic Relationship" (press release, Cincinnati and Cleveland, OH, March 19, 2003), available at <www.ninesigma.net/pressreleases/pressrelease.2004-08-19.9640766001>.

121. Hof, "The Power of Us," p. 77.

122. John Hagel III and John Seely Brown, *The Only Sustainable Edge: Why Business Strategy Depends on Productive Friction and Dynamic Specialization* (Boston, MA: Harvard Business School Press, 2005).

123. Interview of John Hagel III and John Seely Brown by Kevin Werbach, June 15, 2005, available at <knowledge.wharton.upenn.edu/index.cfm?fa=viewfeature&id=1220>. During the interview, Brown noted, "For example, we looked at how Toyota has worked with its supplier networks, and how the company has been able to turn these networks into sites of innovation. If you look at how any Detroit car company operates relative to Toyota, Detroit views suppliers as people who perform 'to spec' rather than as major sources of innovation in their own right."

124. Jeffrey McCracken, "Ford Seeks Big Savings By Overhauling Supply System," *Wall Street Journal*, September 29, 2005, p. A1. According to McCracken, Ford Motor's plan to reform its supply system "makes Ford's purchasing system more like that of Japanese auto maker Toyota Motor Corp., which has emphasized longer-term contracts with its suppliers in return for receiving the best technology."

125. Yuki Noguchi, "On Capitol Hill, Playing WikiPolitics; Partisanship Tests Web Site's Policies," *Washington Post*, February 4, 2006, p. A1.

126. Wikipedia, "Wikipedia," available at <en.wikipedia.org/wiki/Wikipedia>. Wikipedia is a multilingual, Web-based, free-content encyclopedia. Wikipedia is written collaboratively by volunteers, allowing articles to be changed by anyone with access to a Web browser. Established in January 2001 as a complement to the expert-written Nupedia, it is now operated by the non-profit Wikimedia Foundation. Since its inception, Wikipedia has steadily risen in popularity, and its success has spawned several sister projects.

127. Clay Shirky, "A Group is its Own Worst Enemy" (address given at the O'Reilly Emerging Technology Conference, Santa Clara, CA, April 24, 2003), available at <www.shirky.com/writings/group_enemy.html>.

128. Jim Giles, "Internet Encyclopaedias Go Head to Head," *Nature*, December 15, 2005, available at <www.nature.com/nature/journal/v438/n7070/full/438900a.html>.

129. Laurie J. Flynn, "Like This? You'll Hate That. (Not All Web Recommendations are Welcome.)," *New York Times*, January 23, 2006, p. C1; Ethan Todras-Whitehill, "Spreading the Word on What's Best to Their 13,000 Closet Friends," *New York Times*, late ed., November 2, 2005, p. G3.

130. "Websites of Mass Description," *Economist*, Technology Quarterly, September 17, 2005.

131. Bruce Sterling, "Order Out of Chaos: What's the Best Way to Tag, Bag, and Sort Data? Give it to the Unorganized Masses," *Wired Magazine*, April 2005, p. 83; Stefanie Olsen, "Yahoo's Game of Photo Tag," CNET News.com, March 22, 2005, available at <news.com.com/Yahoos+game+of+photo+tag/2100-1032_3-5630403.html>. As Peter Merholz, a founder at Adaptive Path, noted, "The future of folksnomies involves meshing these user-generated categorizations with more standardized categorizations, such as the Library of Congress or the Getty Thesaurus of place names, so you could start to connect data to allow more of these associations to be made."

132. James Surowiecki, *The Wisdom of Crowds: Why the Many are Smarter Than the Few and How Collective Wisdom Shapes Business, Economies, Societies, and Nations* (New York: Doubleday, 2004).

133. Hof, "The Power of Us," p. 75.

134. von Hippel, *Democratizing innovation*, p. 10.

135. Martin LaMonica, "Software: No Longer Business as Usual," CNET News.com, November 17, 2005, available at <news.com.com/Software+No+longer+business+as+usual/2100-1012_3-5958760.html?tag=nl>; Martin LaMonica, "Microsoft Learns to Live With Open Source," CNET News.com, July 11, 2005, available at <news.com.com/Microsoft+learns+to+live+with+open+source/2100-7344_3-5780030.html>.

136. Eric Raymond, "The Importance of Having Users," in *The Cathedral and the Bazaar* ; von Hippel, *Democratizing Innovation*, p. 111.

137. Victoria Murphy Barret, "It's a Mod, Mod Underworld," *Forbes*, December 12, 2005, p. 64; Leslie Walker, "Evolving in the Virtual World," *Washington Post*, February 4, 2006, p. D1.

138. Oxford University Press, "'Podcast' is the Word of the Year" (press release, New York, January 11, 2006); Diane Brady, ed., "Radio Dreams Come Alive in the Podcast," *Business Week*, December 19, 2005, p. 82. A podcast is a "digital recording of a radio broadcast or similar program, made available on the Internet for downloading to a personal audio player." As Business Week noted, "in July 2004 so-called podcasting software…democratized radio and let loose a wave of dormant creativity. There are now more than 20,000 podcasts online." Although Apple modified the iPod to include podcasting capabilities, its general strategy has been to try to retain tight control over its carefully integrated software and hardware.

139. Mike Musgrove, "Tapping Into Tinkering; Some Makers of Electronics Benefit From Users' Modification," *Washington Post*, July 12, 2005, p. D1. The article notes that "tinkerers become a consumer electronics maker's unofficial research-and-development team, with innovations winding up as built-in features down the line."

140. Musgrove, "Tapping Into Tinkering," p. D1; Ginny Parker Woods, "Sony Sets Its Sights on Digital Books," *Wall Street Journal*, February 16, 2006, p. B3; Joris Evers, "Sony Cracks Down on PSP Hacks," CNET News.com, September 29, 2005, available at <news.com.com/Sony+cracks+down+on+PSP+hacks/2100-1002_3-5885945.html>. Sony has stopped making the AIBO and, in releasing its new electronic book reader, is trying to be more flexible with regards to digital-rights management.

141. Musgrove, "Tapping Into Tinkering," p. D1.

142. Noguchi, "On Capitol Hill, Playing WikiPolitics," p. A1; Daniel Terdiman, "Growing Pains for Wikipedia," CNET News.com, December 5, 2005, available at <news.com.com/Growing+pains+for+Wikipedia/2100-1025_3-5981119.html>.

143. Terdiman, "Growing Pains for Wikipedia"; Daniel Terdiman, "Wikipedia Alternative Aims to be 'PBS of the Web'," CNET News.com, December 19, 2005, available at <news.com.com/Wikipedia+alternative+aims+to+be+PBS+of+the+Web/2100-1038_3-5999200.html>; Leslie Walker, "A Universe of Good Intentions, a World of Practical Hurdles," *Washington Post*, January 19, 2006, p. D1.

144. Katharine Q. Seelye, "Paper Decides to Close Blog, Citing Vitriol," *New York Times*, late ed., January 20, 2006, p. C2.

145. William W. Fisher III, *Promises to Keep: Technology, Law, and the Future of Entertainment* (Stanford, CA: Stanford University Press, 2004); Jessica Litman, *Sharing and Stealing* (Wayne State University Law School, September 2004); Daniel Gervais, *Application of an Extended Collective Licensing Regime in Canada: Principles and Issues Related to Implementation* (prepared for the Department of Canadian Heritage, June 2003); Neil W. Netanel, *Market Hierarchy and Copyright in Our System of Free Expression*, Public Law and Legal Theory Working Paper No. 013 (University of Texas Law School, October 2000); Glynn S. Lunney, Jr., "The Death of Copyright: Digital Technology, Private Copying, and the DMCA," *Virginia Law Review*, vol. 87 (September 2001); Raymond Shih Ray Ku, "The Creative Destruction of Copyright: Napster and the New Economics of Digital Technology," *University of Chicago Law Review* (forthcoming).

146. Jonathan Krim and Frank Ahrens, "FCC Approves First Digital Anti-Piracy Measure; Computers, Other Consumer Electronic Devices to Comply With 'Broadcast Flags' by 2005," *Washington Post*, November 5, 2003, p. E1; Jonathan Krim, "Court Tosses FCC Rules on Copying, Sharing TV; Commission Wanted to Encourage Digital Programs on Networks," *Washington Post*, May 7, 2005, p. E1.

147. PC Magazine, "Definition of: Creative Commons," available at <www.pcmag.com/encyclopedia_term/0,2542,t=Creative+Commons&i=40468,00.asp>. Creative commons is an organization that has defined an alternative to copyrights by filling in the gap between full copyright, in which no use is permitted without permission, and public domain, where permission is not required at all. Creative Commons' licenses let people copy and distribute the work under specific conditions, and general descriptions, legal clauses and HTML tags for search engines are provided for several license options.

148. Chris Anderson, "The Long Tail," *Wired Magazine*, October 2004, available at <www.wired.com/wired/archive/12.10/tail.html?pg=1&topic=tail&topic_set=>.

149. Ronald H. Coase, "The Nature of the Firm," *Economica*, vol. 4, no. 16 (November 1937), pp. 386–405.

150. Public Library of Science, "Announcing the Debut of a New Open Access Journal from the Public Library of Science" (press release, San Francisco, CA, June 23, 2005), available at <www.plos.org/news/announce_compbiol.html>; Bernard Wysocki Jr., "Scholarly Journals' Premier Status is Diluted by the Web," *Wall Street Journal*, May 23, 2005, p. A1; "What Good Are Ideas if We Lock Them Up?," *Toronto Star*, November 7, 2005, p. D3; National Library of Medicine, National Institutes of Health, "PubMed Reaches a Major Milestone" (press release, Bethesda, MD, September 14, 2004).

151. Robert Steinbrook, M.D., "Public Access to NIH-Funded Research," *New England Journal of Medicine*, vol. 352:1739-1741, no. 17 (April 28, 2005).

152. Nathanael Johnson, "Steal This Genome!," *East Bay Express*, March 30, 2005; University of Maryland, Center for Bioinformatics and Computation Biology, The Institute for Genomic Research, Karolinska Institutet, and Marine Biological Laboratory—Woods Hole, "AMOS: A Modular Open-Source Assembler," available at <amos.sourceforge.net/>.

153. MIT, "MIT's OpenCourseWare," available at <ocw.mit.edu/index.html>; MIT News Office, "MIT to Make Nearly All Course Materials Available Free on the World Wide Web" (press release, Cambridge, MA, April 4, 2001).

154. Christopher Lawton, "Made-By-Viewers TV," *Wall Street Journal*, December 13, 2005, p. B1.

155. Yuki Noguchi, "Google Delays Book Scanning; Copyright Concerns Slow Project," *Washington Post*, August 13, 2005, p. D1. For more information on the changing dynamics of publishing, see: Leonor Ciarlone, ed., *The Reality of Web 2.0: O'Reilly Media's SafariU Leads by Example* (Bluebill Advisors, Inc., 2006).

156. Bob Garfield, "Inside the New World of Listenomics: How the Open Source Revolution Impacts Your Brands," AdAge.com, Online Edition, October 11, 2005, available at <www.antharia.com/library/detail.php?id=214>.

157. Mark Landler, "Investing It; A Plodding Ma Bell and Her Precocious Child," *New York Times*, late ed., April 13, 1997, section 3, p. 1.

158. Statement written ex parte of Professor Mark A. Lemley and Professor Lawrence Lessig, before the Federal Communications Commission (FCC), in the matter of Application for Consent to the Transfer of Control of Licenses MediaOne Group, Inc. to AT&T Corp., CS Docket No. 99-251 (December 15, 1999).

159. For more information about the Department of Defense Grand Challenge, please visit its website at <www.darpa.mil/GRANDCHALLENGE/overview.html>.

160. von Hippel, *Democratizing Innovation*, pp. 111-112.

161. von Hippel, *Democratizing Innovation*, pp. 118-119.

162. Steven Pearlstein, "Lawyers Scare Firms Away From Good Ideas," *Washington Post*, February 23, 2005, p. E1.

163. von Hippel, *Democratizing Innovation*, p. 117.

164. For more information about the case, MGM Studios, Inc. v. Grokster, Ltd., please see the website <a257.g.akamaitech.net/7/257/2422/27jun20051200/www.supremecourtus.gov/opinions/04pdf/04-480.pdf>.

165. For more information on the Adelphi Charter, adopted October 31, 2005, please see the commission's website at <www.adelphicharter.org/>. The Geneva Declaration on the Future of World Intellectual Property Organization adopted in late 2004 states, "At the same time, there are astoundingly promising innovations in information, medical and other essential technologies, as well as in social movements and business models. We are witnessing highly successful campaigns for access to drugs for AIDS, scientific journals, genomic information and other databases, and hundreds of innovative collaborative efforts to create public goods, including the Internet, the World Wide Web, Wikipedia, the Creative Commons, GNU Linux and other free and open software projects, as well as distance education tools and medical research tools."

166. Lee Rainie, Project Director, Pew Internet & American Life Project, "Who Uses the Internet, What They Do, and What It Means" (address given at Freedom to Connect Conference, March 30, 2005); John Horrigan, Kelly Garrett, and Paul Resnick, *The Internet and Democratic Debate* (Pew Internet & American Life Project, University of Michigan School of Information, October 27, 2004), pp. 2-3.

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Close relations exist between the Committee for Economic Development and independent, nonpolitical research organizations in other countries. Such counterpart groups are composed of business executives and scholars and have objectives similar to those of CED, which they pursue by similarly objective methods. CED cooperates with these organizations on research and study projects of common interest to the various countries concerned. This program has resulted in a number of joint policy statements involving such international matters as energy, assistance to developing countries, and the reduction of nontariff barriers to trade.

CE	Circulo de Empresarios Madrid, Spain
CEAL	Consejo Empresario de America Latina Buenos Aires, Argentina
CEDA	Committee for Economic Development of Australia Sydney, Australia
CIRD	China Institute for Reform and Development Hainan, People's Republic of China
EVA	Centre for Finnish Business and Policy Studies Helsinki, Finland
FAE	Forum de Administradores de Empresas Lisbon, Portugal
IDEP	Institut de l'Entreprise Paris, France
IW	Institut der deutschen Wirtschaft Koeln Cologne, Germany
経済同友会	Keizai Doyukai Tokyo, Japan
SMO	Stichting Maatschappij en Onderneming The Netherlands
SNS	Studieförbundet Naringsliv och Samhälle Stockholm, Sweden