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Open Standards, Open Source, and Open Innovation

Harnessing the Benefits of Openness

In many many ways, the Internet has changed our lives. For those concerned with public policy, one of the most important of those changes has been in the treatment of intellectual property, and the ways we view both the process of innovation and the process of deriving value from creative acts.

As the Internet grew, and as all forms of information increasingly became digitized, the sale of digital information in its many forms has been replaced by various licensing agreements between the rights holder and the consumer. These changes have led to what the National Academy of Sciences labels the “digital dilemma”: A digital information product, unlike a physical good, can be created, modified, perfectly duplicated in innumerable quantities, and distributed to millions of people around the world at little or no cost. But its creator, or those who owned the rights to it, could control it completely, lock it down or make it inaccessible, at least temporarily.

This paradox is visible in two different and contradictory phenomena. The rise of Napster, and other file-sharing networks using the Internet, allowed millions of users to download billions of digital audio and video files, many of which they were sharing without the authorization of the rights holders. At the same time, rights holders were using licenses and digital rights management systems to

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dictate the conditions under which consumers could use and manipulate digital information products. The views of many rights holders—defending their right to control their works—were increasingly coming into conflict with the views of many users who saw themselves as prevented from undertaking activities that they had long considered well within their rights.

As rights holders increasingly complained about the impact of rampant “piracy,” many proposals to change laws and regulations to deal with the unauthorized access and use of digital information products were introduced in Congress, state legislatures, and regulatory commissions. The proposals shared common aims: 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 over digital information products. Some of the proposals even sought to give rights holders increased control over the design and operation of technologies for recording, modifying, displaying, or distributing digital information products.

These proposals to increase the power of rights holders served as the stimulus that eventually led to this paper. As I studied them to see how they related to the goals of intellectual property law, I developed the ideas about openness that I set out later in this paper.

Proposals to increase the control given to rights holders are based on two assumptions: (1) creative acts will not take place unless creators see a promise of some economic returns; (2) the best way to provide those economic returns is to allow the creator to control, for some period of time, access to and use of the creation, and to sell or lease different rights of access and use. For purposes of analysis, I will call this a closed model, as the creative work is “closed” to others until they provide some form of benefit to the rights holder under terms that the rights holder sets. The Internet and digitization are often seen as fundamental threats to this model, given how easy and cheap it is to modify, copy, and distribute digital information products.

I do not reject the closed model. I do argue that a closed model is not the only possible way to create value. Indeed, an alternative model—the mirror image of the closed model—often encourages even greater creative activity and innovation. This open model rests on several assumptions: (1) creative acts take place for a variety of reasons; (2) the value of a creative work can be increased by sharing the work and allowing, even encouraging, more potential innovators to contribute to its development; and (3) economic value can be enhanced by such sharing.

The founders of the United States believed in the importance of creative activity. They generally opposed monopolies—closed models—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 they thought the cost was justified because the incentives they were providing would increase creative activity. They recognized that society benefited if all these creations eventually became part of an ever-expanding “commons,” an open model available for anyone to use as the basis for their own “fol-

low-on innovation.”

To understand the difference between the closed and open models, it is useful to first look at the process of innovation. Innovation can be characterized (all too simply) as a process with a first creator and many follow-on creators. But innovation is almost always a cumulative and unending process, with every “first” creator, in Newton’s words, “standing on the shoulders of giants.” In other words, almost every first creator is a follow-on innovator to someone else.

In order for intellectual property law to achieve its aim—stimulating the greatest possible innovation for the benefit of society—it must balance the interests of first creators and those who follow them. Providing too great an incentive to either group would unbalance the system. If, for example, the incentives for first creators are too strong—they are given too much control or control for too long—little opportunity would be left for follow-on creators. The result, in economic terms, would be “under-production” of follow-on innovation. On the other hand, if the system helped follow-on innovators by eliminating the incentives that were needed to generate first creations, we would see “under-production” by first creators. The policymaker should aim to encourage the most innovation, not to favor either first creators or follow-on innovators. 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

In determining the appropriate balance between the rights of “first” creators and those of “follow on innovators,” we should remember that, by definition, far more creators fall into the second category. The first creator may well know more about his or her creation than anyone else. Based on this, some have argued that he or she should be given absolute control over its subsequent development. But this argument rests on the assumption that one person or a small group of people can anticipate the many ways that millions of other people—all potential follow-on innovators—will use and improve a creation. Would it be wise to base public policy on such an assumption? For example, would we be prepared to grant control over all future uses of the wheel to its inventor? Are we prepared to believe that he or she would have been able to anticipate all of the uses that follow-on innovators made of it without the permission of its creator? Would we be prepared to believe that the creator would give up control to allow others to profit from the discovery? Perhaps. But in answering these questions, we begin to see why a careful balancing of interests is the goal of policy in this arena.

The most recent proposals for changes in intellectual property law were based on the threats of “piracy” and sought to enhance the rights of first creators (or those who now controlled those rights)—by closing the more balanced intellectual property model that had evolved in the U.S. over the years. Thus they tended to minimize or even ignore the contributions of follow-on innovators. But the contributions of these innovators require us to look not only at more closed models,

but also more open ones.

Openness, facilitated by the Internet, is challenging the conventional closed model of intellectual property and providing a springboard for unprecedented global collaboration. As it does so, it is leading to dramatic changes in the very process of innovation. It is this phenomenon that this paper seeks to illuminate.

I. THE MEANING OF OPENNESS

Although the Internet bubble collapsed, the Internet itself 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, and distinguishes the Internet from other networks. At the same time, the Internet itself facilitates openness.

In a 1999 study, the Organization for Economic Cooperation and Development (OECD) noted how the phenomenon of openness had spurred the growth of electronic commerce. “Openness is an underlying technical and philosophical tenet of the expansion of electronic commerce.” The Internet has been adopted “as a platform for business” because of “its non-proprietary standards and open nature as well as the huge industry that has evolved to support it.” The report continues, “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?” Many definitions are possible. 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

The spectrum of openness is very broad. If a person creates a work but does not share it with anyone, the work is closed. On the other end of the spectrum are works made available to, and modifiable, by all. Most works fall between the two extremes. Thus characterizing a work as open or closed is rarely a binary decision; it is generally a question of “how open.”

Two key attributes determine a work’s degree of openness: 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 almost 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. Then, the work is almost entirely open, available to anyone interested in it. Due to the increasing penetration of information and communications technology, 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 sin-

gle 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, including any loss incurred by restricting access to information via the limited-term monopolies of patent and copyright. To the economist, such loss can be justified only if the incentives these restrictions are designed to produce are necessary to spur creative acts that would not occur without them.³

But a work's degree of openness 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. Given the reach of the Internet, these "others" who might modify a work are an almost unlimited number of people around the world.⁴

That digital goods can be copied and distributed virtually without cost increases their openness. That they can be similarly manipulated and modified further increases their openness. 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 should be able to benefit substantially from the cumulative, often small, contributions by those billion people. Openness, then, becomes the measure of the ability to benefit from the "collective intelligence" of our world.

Obviously, this openness conflicts with the right to exclude that characterizes more closed systems. In this conflict, two key claims are in tension. Are incentives, like those that allow rights holders to restrict information availability and prevent modifications of a work, necessary to spur innovation? Or, will society benefit more from the Internet-enabled innovation that results from allowing millions of people with differing experiences, skills, and interests to access and manipulate a work? I do not believe we have to choose one or the other but we must try to find a way to use this tension creatively.

In this paper I will examine three manifestations of openness: open standards, open-source software, and open innovation. My goal is to better understand several exemplars of more open systems as well as the policy issues that they raise. While openness has existed in the past, its emergence as a global phenomenon is relatively new, tied to technological developments such as digitization and the growth of the Internet. It is far less familiar than more closed systems that served innovation well in the realm of tangible objects. While it appears that works and processes of varying degrees of openness will coexist, depending on the nature of the goal and the tasks required, we need to better understand the phenomenon of openness and attempt to determine where encouraging openness would produce the greatest societal value. I end this paper by considering the implications of openness, especially for public policy, and offering recommendations that should help harness the benefits of openness.

II. OPEN STANDARDS

The growth of the Internet and the World Wide Web may be the most obvious arguments for open 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 interoperability—what might be considered openness at the engineering level—for everyone outweighed the advantages to each of maintaining their own “walled network.”⁵ Similarly, the growth of the Web was based, in part, on the universal availability and use of Hypertext Markup Language (HTML), which allowed disparate devices to recognize a webpage’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.⁷ Its processes for creating standards are open to all. One of the IETF’s requirements for adopting a new standard is that it be accessible and available to all; it must also be possible to implement it on disparate hardware and software.⁸ Theoretically, the Internet and the Web could have developed as they have using only proprietary standards, or those developed by individuals or small groups without an open process for receiving comments, but the fierce competition among information technology firms makes it very likely that progress, if any, would have been much slower.

To determine the degree of openness of an “open” standard we have to consider 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 that all participants can 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?⁹

The more open the process and the more firms and individuals participating in forming the standard, the more likely it is that the standard will not reflect the interests of any single firm or group of firms. This is important: companies might seek to disadvantage competitors by excluding them or denying them the information they need to apply the standard. The greater the participation, particularly by

purchasers of technology, the more likely it is that the standard will spur competition that benefits consumers. 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 societal needs of consumers.¹⁰ 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 facilitated 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.”¹¹ Many leading innovations in the information technology (IT) area, such as Sun’s Java or Microsoft’s C#, were not brought into the formal standards processes because of the “arcane and potentially obstructionist processes that the formal process insists are its strength.”¹²

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 very valuable. The de facto standard reflected Word’s success in the consumer word-processing market; the existence of a de facto standard also stimulated competition in adjacent markets that could build upon the standard. Participants in these adjacent markets were, and continue to be, wary of the possibility that the de facto standard could be exploited to favor Microsoft if it entered those same markets.¹³

Even where standards are putatively open, firms can be tempted to “extend” them if they believe that doing so would let them to establish a more profitable proprietary version of the standard.¹⁴ 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 “cus-

tomers control” (a phrase that, as a customer, I despise.) For example, while the IETF has been working for several years on an open standard for instant messaging that would make all such systems interoperable, 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. This interoperability is critical to the development of network effects and the operation of Metcalfe’s law,¹⁵ which demonstrates that the value of a network increases as users are added to it. Interoperability, in turn, 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 US\$15 billion each year; in the supply chains of the automobile and electronics industries, it costs an additional, combined US\$8.9 billion annually.¹⁶

Some argue that open standards reduce the efficiencies that may be gained by using proprietary technology to bind together complex systems.¹⁷ 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; instead, open standards focus innovation “on where the real value lies, which is usually everything they can add above and around the standard.”¹⁸ Reaching agreement on the standard provides a base; firms will compete, innovating above the standard. And these 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.¹⁹ 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) 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 they see “potential for monopolization...through the conjunction of an adopted standard and a proprietary technology.”²⁰ Others argue that any standards containing patented technology would be resisted by competitors and users fearful of abuse by the rights holder;

that would reduce the value of the standard itself. 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.

We can better understand these issues by examining the recent vigorous debate within W3C on its patent policy.²¹ In the past, W3C standards had included patented technology, but a de facto royalty-free regime for the core technical standards defined the Web architecture. No serious issues involving patents in Web standards arose in the Web's early years, but W3C set up a Patent Policy Working Group to review its patent policy as new situations arose. One such situation was the development of convergence, which led to a whole range of patent policies in the telecommunications, broadcast media and consumer electronics industries with which W3C was becoming involved. Second, the rate of patent issuance increased, Europeans considered patenting software and business-method patents became popular in the United States. Finally, Internet-related standards bodies "encountered potential barriers to acceptance of standards because of licensing requirements perceived as onerous."²²

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 to the rights holder. Reactions to the proposal were mixed, particularly to 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 of the royalties 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."²³

After considerable debate W3C adopted a policy with three requirements:

- All parties that participate in developing a W3C recommendation must agree to license essential claims (that is, patents that block interoperability) on an 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 in order to minimize any uncertainty about licensing requirements.
- Patents essential to implementing a standard held by W3C members must be disclosed.²⁴

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; it must only commit to RF licensing of "essential" claims—patents that would block interoperability—for implementing the specific standard. (The patent holder could license the patents

under other regimes for other purposes.) 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.”²⁵

W3C adopted the policy, although substantial objections remained. Some argued that RAND licensing had been successful in other settings (such as standards for compact discs and telecommunications) and that some business models were based on royalty income. Others argued that companies would forego 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.

As head of W3C, Tim Berners-Lee decided to adopt the proposed patent policy. He wrote:²⁶

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.²⁷ 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.²⁸

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, because no consensus had been reached on the need to reconsider and because IETF had not had major difficulties in dealing with patents in forming Internet standards.²⁹ (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.³⁰)

The Organization for the Advancement of Structured Information Standards (OASIS), another Web-oriented software standards body, has also recently recon-

sidered its patent policy. It adjusted its 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.³¹

Overall, open standards with RF licensing of any proprietary technology seem more likely to stimulate innovation, particularly where infrastructural technologies are involved and where interoperability offers the greatest benefits.³² 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 develops slowly; with an open standard under RF rules a larger number of relevant players should participate, and thus stimulate the market's growth.

While they would lose licensing revenues, companies that provide proprietary technology for implementing standards under RF licenses still retain important advantages with respect to their technology. They can still exercise their intellectual property rights regarding their technology except when they are used in implementing the standard. Moreover, they can employ their familiarity with the technology 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 [them]."³³ In fact, the more proprietary technology they contribute, the more likely they are to see the standard serving their interests. In addition, as the technology is adopted for a standard, it validates the technology's utility, making customers more likely to be comfortable using it.³⁴

Firms may choose the strategy of supporting greater openness in standards and RF licensing, as doing so speeds the 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 licensing revenues they might have obtained from RAND licensing.³⁵ And, the old saying would again prove true: "Nobody makes money off standards but everyone makes money because of standards."³⁶

Thus, 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. But a problem remains: "hold up" by outsiders. Participants in a standards development process like the W3C process may agree to the rules regarding RF licensing, but outsiders, companies that did not take part in the process, are not similarly bound. If a company that has not participated in the process claims to control intellectual property essential to implementing 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 intellec-

tual property claims, the more likely it is that companies would have already implemented the standard, on the theory that all relevant intellectual property claims had been considered during the development process or since its adoption. And, the longer the delay, the greater the potential costs.³⁷

Complicating this problem, an increasing number of well-funded firms are acquiring intellectual property without plans to use it to produce 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 either their licensing revenue or the damages they could get from firms 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. With the right incentives, firms that are not part of a particular standards development process might be more willing to disclose any relevant intellectual property claims at the earliest possible moment. They might disclose their claims earlier if some mechanism could reduce their potential economic returns or diminish the damages they can claim based on the length of their delay in asserting their claims. Either strategy would lower 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 patent search may lead to discovery of existing, potentially relevant, patents; 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 aware of existing intellectual property. It seems ironic that the legal system should provide an incentive for a lack of effort. Is this a case where ignorance becomes bliss?

The problems caused by the use of 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 are also useful for obtaining cross-licensing agreements and responding to 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.³⁸) The sheer volume of patents from the incremental innovations commonly made while developing software can easily lead to the creation of so-called “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 often better able to deal with these problems; with fewer resources and smaller

patent portfolios, smaller firms may find it more difficult to emerge from these thickets unharmed. This makes them more vulnerable to hold up and more likely to stop doing research and development.

Governments too have important interests in developing standards. As major customers for information and communications technologies, they have a large stake in fostering competitive markets in this area. Inherently involved in social issues like protecting privacy and strengthening information security, governments have an interest in the social implications of standards. They 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.

But few governments are well suited to setting technology standards by themselves. They are not organized for this purpose, often 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.³⁹ In the U.S., for example, the federal government can use the National Institute of Standards and Technology (NIST) to help other government agencies determine which standards processes are sufficiently open to merit support and to devise test procedures for standards compliance.⁴⁰ NIST has, and should continue to 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.”⁴¹

The points above lead naturally to several recommendations:

- Governments should not dictate standards, particularly in fast-developing areas of technology. They should strongly encourage the development of open standards, especially with regard to infrastructural technologies, because such standards are so helpful in fostering competition.
- The results of government-funded research should be readily accessible and freely available to be used in standards development.
- Governments 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 now being considered. 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 should be funded sufficiently to continue its increasingly valuable role in representing U.S. government interests in standards development.
- 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 could not otherwise participate would likely improve the standards and increase the probability of their adoption. For example, in the

many efforts to develop standards for managing digital rights, 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 support 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, like those that occurred with the World Wide Web consortium, particularly those related to critical government activities like standards regarding file formats for communications with citizens.

III. MAINSTREAMING OPEN-SOURCE SOFTWARE, OR, THE MARCH OF THE PENGUIN

Other than the Internet, the example of openness 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 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 found that 60 percent of major businesses plan to implement some open-source software in the coming years.⁴² International Data Corporation (IDC) projects that the open-source Linux operating system will grow 26 percent annually between 2005 and 2008.⁴³ 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.⁴⁴

Major information technology companies, including IBM, Hewlett Packard, Sun Microsystems, Novell, and Computer Associates, have now integrated open-source software into their core strategies. Google uses open-source software for its core business of searches; Yahoo uses it in its core business of directories. Many companies are utilizing open-source software and customizing it for their own use without making their customized products generally available.

Just as the growth of open source depends on the Internet to facilitate the world-wide 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 undergirds the domain name system. The PERL programming language has been called the "duct tape" of the Internet.⁴⁵

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.⁴⁶ And the prospects for open-source software are bright, with its incorporation into leading-edge research activities such as those of Internet2.⁴⁷

In this section, I describe the growth of open-source software and various perspectives about open source from supporters, skeptics, and opponents. In addition, I attempt to set it in the context of traditional concepts of intellectual property and newly emerging views about how value can be created.

Open-Source Software: Not a New Phenomenon

While the phrase “open-source software” is relatively new, the phenomenon has deep roots in information technology. 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 they shared software as 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, as Steven Levy has pointed out, programmers adhered to a “hacker ethic.”⁴⁸ This ethic reinforced 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 the regime it rejected was the then-current state of computing, with its limited amount of computer cycles, memory, and bandwidth.

The hacker ethic supported not only the sharing of one’s own programming, but access to computing resources for everyone. Information would be free. (As Stewart Brand noted, information wants to be both free and expensive—thereby defining the two end points of the openness continuum.⁴⁹) Control of information technology would be distributed and decentralized, 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 is true in traditional telecommunications networks.

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. In *The Success of Open Source*, Steven Weber brilliantly details its history and operation, 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.⁵⁰

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 growing at the rate described by Moore’s Law and at the

same time was becoming more broadly available.⁵¹ 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.⁵² Stallman believed that because of its very nature, software, and specifically its source code, should be accessible to anyone.⁵³ 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 would 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.’”⁵⁴

The Free Software Foundation (FSF) 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).⁵⁵ 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 the entire program—along with the right to modify and further redistribute it. Stallman and the FSF remain strong advocates of the political and moral arguments in favor of absolute openness in software.

By the 1990s other voices began to articulate a rationale and process that would encourage the growth of shared software production and unencumbered distribution of its results. Eric S. Raymond, author of *The Cathedral and the Bazaar*, along with 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 most observers saw them as 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. So we can and do work together on many specific projects.”⁵⁶

The early 1990s also marked the beginnings of what is now Linux.⁵⁷ Linus Torvalds began to program an open-source operating system based on UNIX in 1991 and, by 1994, released it to the public.⁵⁸ During that same period, Tim Berners-Lee created the architecture for the World Wide Web and published the first browser. Meanwhile, the first graphical Web browser was built at the University of Illinois, and more and more people were buying personal computers to use in the office and at home. The Internet, the World Wide Web, and the open-

source software movement were coming of age together

Intellectual Property: Opposing Views

Today's intellectual property regime uses one basic strategy to provide incentives for innovation: it gives 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 can sell or lease the various rights of access to, and for use of, the creation, and therefore be rewarded for his or her creative efforts and investment. Are such incentives needed? If they are, how strong must they be to generate innovations that would otherwise not take place? These questions are hotly disputed among economists. Undisputed is that intellectual property rules have traditionally focused on the first creator and have sought to protect 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 of what is necessary to provide incentives for innovation reflects an earlier era when substantial costs were involved in producing and distributing 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 to create and produce it.

In the 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 sometimes even seems confusing to machines.)⁵⁹ Thus, control over access to the source code is 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 that rights holders traditionally exercised. 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 distribute 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.”⁶⁰

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, on the other hand, aims to ensure the widest possible distribution of the software by prohibiting restrictions on its distribution. The traditional intellectual property model matched the economic characteristics of tangible, physical goods, where anyone's use of the good 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 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 beyond that authorized by the first creator is achieved primarily by limiting the term and scope of control and providing for the work to eventually be placed in the public domain. Open-source software, in comparison, is geared 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 model of intellectual property or proprietary software is inappropriate or out of place with today's economy or that the incentive systems they rely upon are mistaken or misguided. It is not to say that society has to choose between proprietary or open models. Instead, I believe, there is nothing inherently inconsistent with intellectual property law in a software development system that leans toward follow-on innovation as opposed to first creation or that seeks to maximize distribution as opposed to controlling access. Both systems can and will coexist. Both can and will produce excellent works. But open-source licensing systems are based on 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 inventor, the lone creator, while the former sees the potential for creation in everyone.

A Critique of Open-Source Software

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.”⁶¹ 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. That is, 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.⁶²

A similar argument has been raised in the recent debates about music and video file sharing systems and piracy.⁶³ 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.

It is clearly wrong for someone to appropriate another's work without permission. But the debate is not so simple. It is not simply a choice between allowing rights holders to restrict access and forcing them to give up all their rights. In some

cases, it has been between forcing users to accept a creative work in an existing physical medium such as a CD or a DVD rather than providing a more functional digital file. When a song is available only as part of a larger collection on a physical object such as a CD, the choice may be between “more than I want for much more money than I’m willing to spend” and free from a file-sharing service. In many cases, as Apple’s i-Tunes digital delivery service successfully demonstrated, music providers can indeed compete with free. Customers have chosen “cheap and great,” as offered by Apple, as opposed to “free and crummy”—and they have purchased over a billion downloads while avoiding viruses and incomplete versions of songs that they may get from file-sharing services. (MySpace, the most visited Internet address among Web users in the U.S., has just announced that it will be offering its own music service where musicians will be able to set their own prices and sell from their own MySpace pages.)⁶⁴

In other cases rights holders have released their music for free in order to build audiences for performances, to whet the appetite of fans for other works, or to share in advertising revenue. In specific circumstances, such as fair use, existing intellectual property law has recognized the value in allowing limited access to a work as part of the government’s grant of exclusive rights even if the rights holder objects.

As rights holders experiment more and more with Internet distribution of their works, it is likely that new models of compensation for creators will be developed; this has already occurred in response to earlier technological challenges to existing distribution systems such as those posed by the arrival of radio. The business models of those who create proprietary software are evolving; consider the rise of software “as a service,” in response to the capabilities of the Internet and the characteristics of digital works, just as the business models for distribution of music, video and movies are evolving. But these changes are not the result of any inherent conflict between the concept of intellectual property rights and the value model based upon sharing.

While both proprietary and open-source software rely on intellectual property licensing systems, they rest on radically different assumptions about how creative acts lead to value creation. The more traditional closed model assumes that the rights holder needs tight control in order to charge for access and use; the open model assumes that the original work becomes far more valuable as many add their own contributions.

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—or any creative act such as writing a song, making a video, or composing a poem—depends on investments of time and energy. The closed model assumes that the rights holder charges for access to or the right to use that work in order to provide a return on that investment. Talented software producers and the companies that employ them or that distribute their work can gain handsome rewards under this model.

So, if all this is true, why would someone invest the time and effort required to

develop software (or write a song, etc.)? Or, alternatively, why would they incur the opportunity cost of not doing something else, if they could not get 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?

The Open-Source Movement: Motivations for Sharing

Among others, Richard Stallman, Eric Raymond, Josh Lerner and Jean Tirole, Steven Weber, Eric von Hippel and Yochai Benkler have addressed in great depth the questions of why people develop and share software.⁶⁵ All their answers mix pro-social arguments with those based on more narrow conceptions of individual benefits. Obviously, the reasons behind any individual's actions are complex and vary from person to person. But both theoretical and empirical research shows that individuals have many reasons for participating in these efforts that do not provide direct monetary rewards.

One reason is altruism. Some critics of the open-source movement have argued that the open-source development process is unsustainable because it depends on voluntary action—that is, it rests entirely upon altruism. And many open-source participants acknowledge that altruism motivates them. Eric Raymond noted the existence of a “gift economy” in which contributors find their primary rewards in the personal satisfaction of sharing.⁶⁶ Certainly one factor 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. As John Clippinger and David Bollier have pointed out, some comparative anthropologists and evolutionary psychologists suggest that “as a species we are neurologically hard-wired to be empathetic and cooperative.”⁶⁷ Richard Stallman has invoked the golden rule—variants of which can be found in almost all of the world's major religions—as a guiding principle for free software: “If I like a program I must share it with other people who like it.”⁶⁸

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.”⁶⁹

Everyone knows someone who relies less on financial rewards than on the positive feelings they get from helping others. And consider the entire category of workers—the helping professions—many of whom have chosen to accept fewer financial rewards in exchange for other, less tangible, rewards. Although altruism is part of the motivation for many open-source participants, it is usually only a

part, just as monetary rewards provide only a partial answer as why people create new works.

Many programmers get the same feeling of excitement and accomplishment from writing a program or solving a difficult problem that others get from similar acts of creativity, whether from completing a sketch, to 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 helps motivate open-source participants is not surprising. What other reasons might they have for investing their time and energy to create and to share?

A key reason many programmers give for working to produce a piece of shared software is that they are attempting to solve a technical problem of their own. They are, as Eric Raymond put it, “scratching a...personal itch,” such as a problem for which no solution is already available.⁷⁰ We get an immediate and tangible personal benefit from solving a problem that is obstructing our progress. 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 works⁷¹

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.⁷² In the early days of the Web, little industrial-strength software was 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; following the norm of his community, he shared it. Others responded with improvements and the process continued until Apache became the dominant Web-server program—a position it retains today in the face of many proprietary software challenges.

So we see that Apache’s success began 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 regarding open-source development, “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.”⁷³

But why share the solution? In part, altruism. In part, the community norm of sharing. And then there is the prospect of “reciprocity.” If an individual shares code that provides benefits to others, that individual may benefit, both now and in the future, as others share code that they have written. As the number of people with whom we are sharing increases, so does the number of people who might

reciprocate and the value of the potential benefits.

Another reason people participate in open-source development is increased reputation among their 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 that same someone finds an elegant solution to a difficult problem and shares it with peers, it will enhance his or her reputation as a programmer. Geeks have egos too; would we be surprised to learn that there are competitive programmers who enjoy solving a hard programming problem before anyone else, or creating more elegant solutions? And, as Lerner and Tirole have written, a gain in reputation may have benefits beyond personal gratification. 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.⁷⁴

Another reason to participate in an open-source development process is simply to improve one's programming skills. One very attractive aspect of the open-source process is that it allows an individual to choose which problem to address and how much time and effort to invest. The individual 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. This gives the programmer 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.

Overall, then, why not participate? On the most mundane level, the actual costs of sharing digital information products, whether by e-mail or by peer-to-peer systems, have been dramatically reduced by improvements in information technology. Sharing requires less and less effort and the potential barriers are continually being lowered.⁷⁵

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.⁷⁶

But don't the contributors forego monetary rewards by sharing what they create? The rewards may not be that great. And it is not clear that the limited contributions that a programmer chooses to make in an open-source project would be worth much if offered directly in the marketplace or would be worth protecting through 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 central tenet of open-source software licenses—preventing further restrictions on distribution—buttresses the central process of open-source creation. This practice encourages the software's distribution to the largest number of

potential contributors.

An important characteristic of open source software is that it increases in value as it is improved by contributions from the largest possible group. About half of the cost of creating and maintaining software is invested in debugging and maintenance.⁷⁷ The more people engaged in debugging and maintenance, the more chance of a match between the talents and interests in the group and the problems to be detected. Eric Raymond encapsulated this idea: “given enough eyes, all bugs are shallow.”⁷⁸ Open-source’s emphasis on expanding distribution increases the chances that more, and more different, people will be available to engage with the problem. The larger and more varied 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 creates greater 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 participating.

It also helps to reduce the “free rider” problem associated with the open-source software movement. As economists have noted, individuals may be tempted to take advantage of the benefits offered by access to open-source software without contributing anything meaningful in return. The larger the group of potential contributors, the better the odds that some individuals’ own personal cost/benefit calculations will lead them to participate and thus contribute.

All of these “private” (as opposed to altruistic) benefits support participation in the open-source software development process. And in pursuing private benefits, the contributors add to the societal value of the collective product.⁷⁹

Corporate Contributions to Open-Source Software Development

In an increasing number of cases, however, the production of open-source software is a job, not a volunteer activity. More and more of the companies that plan to use open-source software in their businesses, or that have made it part of their strategy, are directly supporting its 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 lets them ensure that their corporate problems are addressed by open-source projects 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 that work.⁸⁰

Many programmers do not work for companies that produce and license proprietary software. They do work for corporations that develop, test, install, and maintain in-house software or oversee the functioning of software licensed from others. If a firm can increase the value of its own employees’ work by leveraging the efforts of others outside the firm, that is clearly in its economic interest.

For example, IBM 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 US\$500 million annually to maintain an industrial-strength operating system like Linux. If IBM invests US\$100 million 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.

Many different situations are leading corporations to support open-source development.⁸¹ 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 companies, based on open-source software 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 who can help find the best solution to their particular problem.

Companies customizing open-source products do a considerable amount of in-house work that they do not then share with others, but companies also support considerable shared work in open-source development. It would benefit the open-source community if incentives could be created to encourage the sharing of more in-house work, but the increasing corporate production of shared open-source software is helping to build a “commons”: the totality of shared open-source software development efforts. Just as the work on UNIX at AT&T’s Bell Laboratories provided a foundation for Linux and was indirectly supported by the fees that local telephone companies paid to AT&T, this growing commons will provide an increasingly rich legacy for future open-source developers.⁸²

Who Develops Open-Source Software

Firms produce proprietary software much as they produce physical goods. Just as some critics say that the open-source development process cannot be sustained because it is based on altruism, others say it is impossible to produce first-rate software through collective action by volunteer collaborators separated by time and distance without the authority found within a firm or without using monetary rewards. Is this necessarily true?

The answer is that the Internet makes voluntary collective action increasingly

easy to conduct. Advances in information and communications technologies have slashed transaction costs by greatly reducing the costs of communications and coordination. Assigning tasks in any project is difficult; within a firm it requires a division of labor, knowledge of the available resources, and finally the assignment of resources. But this work 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. Of course, they may substantially duplicate the effort of others, something that proprietary software firms seek to avoid. This is an important challenge; the open-source development process does need to evaluate proposed contributions efficiently.

Linux and Apache, like other successful open-source projects, have addressed the evaluation problem, which is essentially the task of determining what contributions among many should be included in the next software release.⁸³ Linux has two production streams that are 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, working to incorporate new ways of attacking problems or new areas of work. It is here that revolutionary rather than evolutionary progress might emerge. Although Apache has a slightly different structure, it too has organized itself using experienced Apache program managers to screen contributions and evaluate their readiness for distribution.

By providing a process to evaluate contributions—and to reject many—these open-source development organizations have limited the “openness” of the software. Anyone can still submit a contribution but the contribution may not be included in the software that is ultimately distributed. While this process has reduced the “openness,” it has 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 a change.

Even with the problem of duplicative contributions and the need for evaluation, open-source software generally improves more quickly than proprietary software. In part, this happens because open-source software uses a model of “release early and release often.”⁸⁴ It has, in fact, been described as being in a perpetual “beta” test, albeit with an unlimited number of testers/contributors.⁸⁵

The need for evaluation raises more questions. Will those who volunteer accept this level of screening and control, especially if they might see their contributions rejected? 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.⁸⁶ Interestingly, the very 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 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 stay with a project but they can also choose to follow another path in developing the software—and an infinite number of such paths are possible. If they choose another path and establish a new project they are considered to be “forking” the code. A project 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 his or her reputational gains. The volunteers’ ability to quit or to fork provides a strong incentive for the leader 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. Leaders have 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.⁸⁷ 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.⁸⁸

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 documentation: a cutting-edge programming problem is usually much 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.⁸⁹ As commercial firms play an increasing role in developing open-source software, these challenges are likely to be faced directly, while open-source development maintains its advantages for customization, extensibility, and debugging.

IV. OPEN-SOURCE SOFTWARE AND PUBLIC POLICY ISSUES

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

The Patent Wars: Those Who Arm Themselves versus the Conscientious Objectors

As if to prove that open-source software is succeeding, proprietary software providers and others have raised increasingly threatening intellectual property challenges against Linux and other open-source offerings. 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 still being debated in Europe, where open-source software advocates have been among the leaders opposing it.

In the United States one software company, the SCO Group, has sued IBM for misappropriation and copyright infringement regarding certain Linux-related patents. IBM has countersued.⁹⁰ (Ironically, 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.)⁹¹ If the SCO Group succeeds in its infringement against IBM, that could give it 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 must weigh their potential liability and the long-term availability of the Linux program that they might want to implement. Proprietary software providers emphasize this as they suggest that customers consider “intellectual property risk” in making their software choices.⁹²

Open-source supporters have attempted to counter this issue in several ways. One recently-launched company is providing insurance against infringement claims.⁹³ Another is selling a product that will enable developers and users to screen open-source code for proprietary code that might inadvertently be included.⁹⁴ 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, several leading IT firms have contributed 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.⁹⁵ 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.⁹⁶ It is not yet clear 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 open source users are likely to continue facing “fear, uncertainty, and doubt.”⁹⁷

Providers of either open-source or proprietary software, indeed any innovator that faces intellectual property challenges, must rely on the ability of the U.S.

Patent and Trademark Office to issue quality patents. This process relies on a thorough scrutiny of prior art, on an informed view of non-obviousness⁹⁸, and on the wisdom and speed of the U.S. judicial system in reviewing them. Recent studies by the National Academy of Sciences, the Federal Trade Commission, and the Department of Justice reveal the need for a thorough review of the system.⁹⁹ Problems with patents, especially in the information processing and communications technology sectors, suggest that a system that works reasonably well with pharmaceuticals may need substantial adjustment to reflect a different process of innovation in digital information products, one marked by many incremental improvements and extensive cross-licensing arrangements.

In its most recent five-year plan, the U.S. Patent and Trademark Office said it was willing to use IT tools to improve its decisions; it would commit to developing a new “peer review mechanism” that would allow volunteers to comment on patent applications. Responding to this “call for collaboration,” a patent attorney and accountant designed and launched WikiPatents.com to allow anyone to evaluate already-issued patents; eventually the site will allow evaluation of pending applications. The site complements “community patent review,” a proposed venture scheduled for rollout in 2007. Initiated by Professor Beth Noveck of New York Law School, and backed by IBM, Microsoft, Red Hat, and Hewlett-Packard, this project will subject pending applications to the judgments of anyone interested.¹⁰⁰

Government Procurement: Should We Mandate Government Use of Open-Source Software?

Patent infringement challenges may stall the growth of the open-source movement. But the developing world is a strong source of support; there, increasing numbers of proposals call for governments to use only open-source software. From the Peruvian legislature to the Indian Ministry of Defense, government bodies have been deliberating whether to impose such mandates based on claims that they would lower overall IT expenditures, improve security, reduce dependence on foreign proprietary software providers, help stimulate indigenous software development capabilities, and foster economic development.¹⁰¹

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 with their future higher growth rates. Lower costs are particularly important to governments in these countries because of their lower income; moreover, arguments for economic independence resonate in many of these countries based on their colonial histories.¹⁰² 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 government 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 gov-

ernment to acquire only open-source software where it was available.¹⁰³ With advocates actively lobbying for and against the proposals, Bruce Perens, a founder of the Open Software Initiative, proposed a requirement focused on interoperability.¹⁰⁴ He argued that the issue was not whether to require government to acquire open-source software; rather, should a government require that any software it acquired for a critical government function be interoperable across various platforms? In other words, should a citizen be required to purchase a particular vendor's hardware or software in order 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 they should identify critical government 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 such a function would have to be interoperable. Proprietary software vendors could meet the conditions without disclosing source code if sufficiently open interfaces could be used to provide interoperability.¹⁰⁵ (De facto proprietary standards have provided a more limited interoperability in the past.)

The importance of interoperability with respect to critical government functions is even clearer than the general benefits of interoperability that open standards provide. Interoperability facilitates competition, which in turn 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 electronic health care records, interoperability can provide the basis for improved care for the chronically ill, fewer medical errors, and dramatically reduced administrative costs. According to one study, a fully standardized and integrated health care information system could save the nation US\$77.8 billion annually.¹⁰⁶

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.¹⁰⁷ The system would facilitate 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.

Interoperability in telecommunications is also crucial; we saw the consequences of its absence during the 9/11 rescue events and during last year's hurricanes on the Gulf Coast. Hurricane Katrina provided a particularly dramatic example of what happens when citizens are involved in critical interactions with their government, and government systems are not interoperable. People trying to get help from the Federal Emergency Management Systems (FEMA) could not fill out the required forms unless they used one specific proprietary Web browser.¹⁰⁸ While the cause may have been a simple lack of resources at FEMA, a drawn-out Web implementation process, or the failure to recognize the problem, it created yet another obstacle for those in desperate need.

Recently, the Commonwealth of Massachusetts tried to address the issue of

interoperability in critical communications with its citizens. It sought to require vendors providing record systems and storage to use Open Data Standards. The proposal has generated considerable controversy but the debates should help policymakers better evaluate the costs and benefits.¹⁰⁹

While the administration has acted to gain the benefits of interoperability in health care information systems, the U.S. government has questioned the 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 government interoperability requirements, arguing that they might violate government procurement requirements under the World Trade Organization agreements as well as the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement regarding intellectual property.¹¹⁰ Moreover, in a series of bilateral trade negotiations with other countries, the U.S. has pushed for intellectual property protections based on the Digital Millennium Copyright Act (DMCA) without including provisions in the Act that promote interoperability. (These proposals also failed to include many of the protections for consumers contained in that same act.)¹¹¹

V. PUBLIC POLICY RECOMMENDATIONS REGARDING OPEN-SOURCE SOFTWARE

Based on the discussion of open-source software, several recommendations for public policy emerge:

- Over the last several years, serious issues have arisen about the operation of the present patent system, particularly in the area of software and business methods patents. Congress is currently reviewing the patent system and should 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 specifically reexamine the premise that today's unitary system continues to serve all sectors equally well, especially given the proliferation of problems regarding patents in the information technology arena. While the patent system has strong support from the pharmaceutical sector, issues in the IT sector continue to fester.
- No mandate should require any government agency to use only one particular form of software license or development process, be it proprietary or open source. Government procurement decisions should be based on identifying and obtaining the software that best meets the needs of the particular government activity involved. However, governments at all levels should identify critical government functions, particularly as they involve citizen-government interactions, and place a high priority on requiring interoperability across various platforms for any software they acquire to perform these critical functions.
- To support interoperability in critical areas, governments should advocate open standards and interoperability in standards-setting processes and royalty-free licensing of any intellectual property required to implement such standards.
- The government should consider additional areas where interoperability

would provide significant improvements in performance, such as homeland security, where the lack of interoperability of first responder data and communications systems on September 11th provided a lesson in how governments should not behave. The National Institute of Standards and Technology has an exemplary record in conducting interoperability studies and should continue to search for areas with the greatest potential to benefit.

- 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 using any particular type of software licensing or development.

- The U.S. government should review its policies and international treaty interpretations regarding interoperability. It should support the rights of governments to require interoperability in IT purchases impacting critical government functions.

- The Digital Millennium Copyright Act (DMCA) contains provisions on interoperability that are an important check on the control that can be exercised by rights holders. These should be included in any international agreements the United States makes in the area. Such agreements should reflect the balanced nature of U.S. intellectual property law.

- Because the Internet provides new opportunities to reach knowledgeable commentators, the Patent and Trade Organization (PTO) should act quickly on a proposal included in its most recent draft 5-year plan: to employ peer review and the Internet in seeking to document “prior art.” It should also intensively evaluate proposed and granted patents, particularly in the area of information technology. A “Slashdot for prior art” could provide the model.¹¹² Recent proposals including the Community Patent Review and WikiPatents.com are useful complements to government action.

VI. OPEN INNOVATION

The open-source movement is important in its own right for its impact on the software market, its demonstration of an alternative model for creating value under an intellectual property regime, and as a laboratory for production through mass collaboration in a non market regime. But it is also an exemplar of a broader movement which I will call “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 they 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*, that focuses on user-led

innovations.¹¹³ This form of innovation can also be seen as part of the broader phenomenon of open innovation.

Open innovation involves the collaboration of various parties, sometimes numbering in the millions—manufacturers, suppliers, customers, or the simply inventive—which leads them to create or modify 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 an intellectual property regime: remember that the open-source movement uses intellectual property licenses. Nor should it be equated with the absence of compensation, because new forms of compensation are emerging to reward those who participate in open innovation. But much open innovation has not been protected under our intellectual property laws, and much has been done without any prospect of payment. In this section I review some of its history, key characteristics, and future prospects.

Open innovation is hardly a new phenomenon. Adam Smith wrote about innovations by working men in the *Wealth of Nations*.¹¹⁴ Lawrence Lessig has pointed out that the *Oxford English Dictionary* began with a call for volunteers to send in examples of vernacular word usage.¹¹⁵ “Yankee tinkers” went from village to village mending tools while passing along what today might be called “upgrades” that their earlier customers had shared with them. Competitively valuable innovations were passed around directly among the early iron makers in America, as employers shared contractors and workers switched employers.¹¹⁶

Nor has open innovation slowed as technology has become more complex. As Kathleen Franz points out in her book *Tinkering*, many of the most important innovations in the early days of the automobile were made by auto enthusiasts who shared them with others of a similar mind until the automobile companies began to exert more control over their products.¹¹⁷ Eric von Hippel notes that the mountain bike industry came into being based on the knobby-tired, shock-absorber-enabled bicycles that bicycling enthusiasts cobbled together before there was any such thing as a “mountain bike.”¹¹⁸ The legendary Homebrew Computing Club was a forum for sharing that led to the first successful personal computer.¹¹⁹

Open innovation is likely to become more and more important. Software 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 technology is filled with examples of capabilities originally manifest in hardware, like the crystals in radios, eventually being transformed into software—the software of software-defined radios.¹²⁰ This happens in part because software is infinitely malleable, can be improved and customized far more readily than hardware, and, once improved, can be duplicated at little or no cost.

Given its characteristics, software is particularly hospitable to the workings of open innovation, as can be seen from the open-source software movement. In fact, all digital information products readily benefit from open innovation. We see this

phenomenon in the “repurposing of data,” for example, as Google Maps are “mashed” together with housing lists, or incidents of avian flu, or whatever data set someone believes will provide a useful source of information when combined with a map.¹²¹ We hear it in the mixes and remixes that play such an important part in today’s music. We watch it in the 100 million videos on YouTube.

Open innovation benefits from more than the rise of software. 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.” As these tools become more available, more users can create designs and even prototypes for new physical products; thus open innovation 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.¹²² 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.¹²³ 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.”¹²⁴

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 wikis¹²⁵ have produced what Timothy O’Reilly called a new “architecture for participation.”¹²⁶

Who is producing all this innovation? The conventional wisdom portrays manufacturers, and heroic inventors, as the principal sources of innovations that are then passively consumed by their customers. But open innovation runs counter to this conventional wisdom. Americans are in love with the idea of the lone inventor.¹²⁷ Edison is revered as a genius, responsible for the light bulb, the phonograph and countless other inventions. But he could just as well be remembered as a master of collaboration; he 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.¹²⁸ Americans would rather 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.¹²⁹

Customers usually know more than anyone else about their own needs and can often identify actions that 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, gen-

der, age cohort, etc.

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. In fact, 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.¹³⁰

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 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 so they can develop the largest possible market over which to spread their 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.

I would argue that open innovation extends well beyond lead users. Von Hippel does make a strong case for the importance of lead-users in the "democratization" of innovation, particularly customers with substantial expertise, resources and incentives. As an example, he describes the development of kite sailing. Its enthusiasts (the lead-users) have employed digital tools to evaluate their own kite designs and either make their own kites or turn the designs over to manufacturers.¹³¹ To von Hippel, kite sailing is a demonstration of how lead-users can control the entire process of innovation, from design to production. But we should consider a broader set of potential innovators to understand how deeply open innovation has democratized innovation.

Several years ago Henry Chesbrough, now at the University of California at Berkeley, used the term "open innovation" in calling on 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.¹³² 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. Procter and Gamble connects with other sources of innovation through its “Connect and Develop” strategy and has even coined a new slogan for its researchers —from “not invented here” to “proudly discovered elsewhere.”¹³³

As Alpheus Bingham, the vice president of Eli Lilly’s e.Lilly research unit, said, “If I can tap into a million minds simultaneously, I may run into one that’s uniquely prepared.”¹³⁴ These words could have come from the mouth of any open-source software advocate. The strategy of the open-source movement, underpinned by open-source licenses, is to support the broadest possible distribution of problems to the largest number of potential contributors. Now the same strategy is being effectively employed in the pharmaceutical sector, arguably the sector that has benefited most from today’s patent system and the closed model of value production.

John Seely Brown and John Hagel III recently made the case that suppliers are key sources of innovation.¹³⁵ “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 functionality, 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.¹³⁶ (Ford’s recent announcement that it plans to revamp its supplier relationships seems to be aimed squarely at emulating the Toyota model.¹³⁷)

That Brown and Hagel chose to focus on 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. Brown and Hagel point out the value of this practice: by freezing the context, it facilitates problem identification. But empowering the workforce in this way is not just a way of identifying and solving operational problems. It reflects a fundamental respect for *everyone’s* potential to contribute. A Japanese phrase captures this belief in the value of every worker: “If you gather together three people, you have a genius.”

Open innovation is reflected in today’s almost countless examples of 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 have access to shared information as well as to contribute. This form of open innovation, where anyone can participate elec-

tronically 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.”¹³⁸ 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: as a general rule every proposed entry is accepted 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 in the entries.¹³⁹ As a result of its openness, Wikipedia depends on a group of people who care to an unusual degree about its success and who have enough leverage to roll back graffiti or inflammatory entries;¹⁴⁰ unlike the evaluators in Linux or Apache, they are not necessarily recognized as subject-matter experts.

Overall, Wikipedia entries are of high quality, although they vary considerably and reflect both the interests of the Wikipedia community of volunteers, its own short history and the natural evolution of a new model. Recently, the much-respected *Nature* published a study of Wikipedia’s scientific entries, which it said rivaled those of *Britannica*.¹⁴¹ That a five-year-old volunteer venture can even be mentioned in the same breath as the *Britannica* demonstrates the power of mass collaboration; as Wikipedia becomes more and more popular with both contributors and users, it will, like Linux and Apache before it, have to struggle with issues of reviews and evaluations. How these issues are addressed will continue to be central to determining where a particular activity falls on the continuum of openness.

Like Wikipedia entries, the World Wide Web is, in effect, the product of millions of individuals and institutions that posted pages. Similarly, the book reviews at Amazon.com are the results of voluntary actions by thousands of interested readers;¹⁴² they are one factor that allows Amazon to sell a commodity product like a book at prices higher than others in the online book market. Everyone who uploaded files to KaZaa or who rated a buyer or seller for eBAY was engaged in peer production and has helped create value with neither conventional corporate oversight nor payment. Supplementing these voluntary contributions, various business processes now gather information based on customer behavior that becomes more and more valuable as it is aggregated and analyzed: purchase data at Amazon.com helps create Amazon’s recommendations about books or music that may interest a customer; Yahoo’s click stream library allows for “evidence-based” design decisions.

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.”¹⁴³ 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 cat-

egories and paths through the photo archive; others can then search using whatever tags they choose and serendipitously benefit from the different information schemas that others have created.¹⁴⁴

In *The Wisdom of Crowds*, James Surowiecki describes his seemingly perplexing finding, that large numbers of independent people are better at solving certain problems than even the brightest individuals or the best known experts.¹⁴⁵ 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.”¹⁴⁶

But why are these innovations shared, if they are so valuable? Remember that this same question was raised about the voluntary work of software programmers in the open-source movement.

In many cases, the contributions are valuable only as they are aggregated. In cases of 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, what if many others have similar information, or it would be difficult to keep the development a secret, or the development can be easily replicated?¹⁴⁷

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 making the results open to review by others. And as the power of mass collaboration becomes more widely understood, new non-monetary reward systems are being devised. Examples are the points Yahoo! provides to those who contribute the best answers to questions and the progress a Slashdot contributor can make up the hierarchy of Slashdot moderators. Or the reason for sharing might simply reflect the same desire that inspires poets and songwriters.

Commercial firms also have incentives 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.¹⁴⁸ Sharing might help build a community of users that will support a new product or process; it might stimulate the sales of related products.¹⁴⁹ McAfee initially gave away its security software in order to build a market for a new consumer product; in order to challenge Microsoft, 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 the videogame platform more valuable.¹⁵⁰ This expanded role of active and inventive consumers may also lead to new systems of compensation for user-created innovations.

Hackers have traditionally pushed platforms to their limits, for several reasons:

the pleasure of the accomplishment, the benefits that they can provide to other users—and bragging rights among their peers. These hacker/customers have, in some cases, served as unofficial research and development associates for new machines and applications.¹⁵¹ New capabilities in the iPod, such as the ability to podcast, resulted from hacking; in podcasting they created a new form of broadcasting that commercial broadcasters entered quickly.¹⁵² Similarly, a hacker/customer created the ability to control a TiVo over the Internet.¹⁵³

Some platform producers embrace contributions by their users. For example, the on-line community in Second Life is an extraordinarily powerful creative force that continually adds value to this artificial world.¹⁵⁴ Lego's management invited hackers to contribute capabilities for the company's new robot. Others, such as Apple with podcasting, accept some innovations while generally exercising greater control over their platforms, be it the Mac or the iPod. 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.¹⁵⁵

Other platform producers are even more resistant. They may have concluded 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 controlled the dog's dances, even though hackers had cracked the software and 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,¹⁵⁶ before finally terminating the entire product line.

Perhaps Sony made the right decision regarding the AIBO: its customers would probably have reacted badly to an AIBO that was programmed to attack. The optimal amount of openness obviously varies under different circumstances. But what is important is that any choice about the degree of openness should be made with an understanding of the benefits of openness. 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 might, for example, learn from, and appropriate, mechanisms developed in the open-source software world to evaluate proposed modifications and decide whether to include them. They might provide incentives for positive and valuable contributions. And in doing so, they might create a more productive relationship with some of their very best customers.

VII. SOME IMPLICATIONS OF OPENNESS FOR PUBLIC POLICY

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.¹⁵⁷ MySpace, the Website most often visited by U.S.

users, is not only the creation of its users but a venue for user/stalkers who have taken advantage of its very openness. To borrow a phrase from the early days of the Internet, the information superhighway goes through some very bad neighborhoods.

Wikipedia's openness has led to controversy over its entries, with individuals accused of posting false information to further personal and political interests. One summer intern in Washington was given the task of removing old campaign promises from a senator's profile on Wikipedia that the senator had failed to fulfill. Another senator's profile erroneously listed him as having been voted "most annoying senator by his peers in Congress."¹⁵⁸

These problems stretch well beyond the political sphere. A Wikipedia entry falsely suggested that John Seigenthaler, a former assistant to Robert Kennedy, might have been involved in the assassination of Robert F. Kennedy. Other Wikipedia users have complained that one podcasting pioneer anonymously deleted references to seminal podcasting work by others. In response to these and other examples, Wikipedia is changing its procedures such as preventing anonymous, unregistered users from posting new articles. As it continues to develop Wikipedia is moving away from its earlier openness and toward its slightly more closed open-source software relatives.¹⁵⁹ These events have also led Wikipedia's founder to urge that contributors "turn our attention away from growth and towards quality."¹⁶⁰

Virtual reality pioneer Jaron Lanier has taken the criticism further. In a posting entitled "Digital Maoism" at Edge.org, Lanier argues that collaborative efforts like Wikipedia, and Digg, which ranks news items based on user responses, will stifle individual creativity and reflect the lowest common denominator of the culture, creating a "stupid and boring" hive mind.¹⁶¹ Lanier's criticisms were answered by a bevy of individuals reminding him that the Internet not only allowed us to benefit from collaboration but that it empowers us to assert ourselves individually, providing the most powerful tool for individuals to distribute content they have created or admired.¹⁶²

The mass collaboration in peer-to-peer networks like Napster created the world's largest repository of music for downloading, built at a fraction of the cost in time and money that would have been incurred to build a centralized offering. At the same time it resulted in the massive appropriation of copyrighted creative works. It became possible to share music with friends and family, but also with 60 million strangers. Attempts to create open editorial blogs have triggered hostile and hate-filled submissions.¹⁶³

An optimist might say these are the birth pangs of mass collaboration; a pessimist might say that the apparent benefits of mass collaboration will disappear as smaller communities with shared norms are replaced by larger, more anonymous communities with little history of self-policing. Part of the answer to the question of how to harness the benefits of openness may lie in using the same digital technologies and organizational structures to scrutinize proposed contributions that have been developed in the open-source software world.

Similarly, these technologies may facilitate new systems for compensating cre-

ators/co-developers for their works. In *Promises to Keep*, William Fisher III suggests some means to accomplish this in the peer-to-peer world; others have suggested differing systems to deal with intellectual property issues.¹⁶⁴ But such systems require rigorous analytic studies, a genuine dialogue over rights and compensation, and eventually the support of rights holders who believe that the long-term benefits from developing these systems are greater than those that can be obtained from litigation and lobbying. It is my strong belief that 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, are more likely to be economically efficient and societally beneficial than legislation or regulation, such as the Broadcast Flag, that aim to control, and more importantly limit, the development of information and communications technologies.¹⁶⁵ They would provide a means to ensure that creators will still have the incentive of being rewarded for their work. They would 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 adding legal restrictions to the already demanding task of 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 that they create available to global audiences through sites such as MySpace and YouTube.¹⁶⁶ 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.¹⁶⁷ But, as Larry Lessig points out, these new licenses that allow users to redistribute content and use derivative works must be made "interoperable."¹⁶⁸ Newborn businesses are attempting 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 has described in "The Long Tail," the Internet's unlimited capacity to store digital information products is allowing cultural products with relatively small audiences to compete economically with the "blockbusters" that have dominated more centralized "mass markets".¹⁶⁹

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.¹⁷⁰ 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. In the past, loose conglomerations of individuals were only occasionally brought together for a specific purpose—think of those involved in making a movie or the independent truckers assembled to deliver products. Now, the Internet reduces the cost and effort required for like-

minded groups to form, dissolve, and reconstitute themselves optimally for the next task.¹⁷¹

Openness seems to touch every corner of our world. The means of doing scientific research are changing as the astounding collaborative success in mapping the human genome spawns dozens of efforts that are accelerating the development of genomics and other fields.¹⁷² The fundamental structures of scientific and technical publishing that bring the results of research to practitioners and the public are changing as “open science” seeks to broaden the channels that distribute knowledge beyond the traditional publisher-controlled journals and to increase access beyond those able to pay high subscription costs. 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 expanding the distribution of health care information to new audiences globally.¹⁷³ The National Institutes of Health (NIH) is asking its grant recipients to make their work available voluntarily to the general public within twelve months of publication,¹⁷⁴ and legislation has been proposed to require the recipients of federal research grants in all non-classified subject areas to make their results publicly available within some fixed period of time.¹⁷⁵

Given these extraordinary changes in research it is not surprising that universities—among the largest producers, and consumers, of research—are feeling the winds of openness. “Open courseware” is changing the world of higher education by allowing millions of teachers and self-directed learners around the world to see, compare, and potentially improve the syllabi offered by leading universities.¹⁷⁶ Institutions of higher education are collaborating to find open educational resources that they can share to take advantage of their skilled resources and to lessen their dependence on proprietary offerings.

Beyond the narrow niche of scientific and technical publishing, traditional publishers are facing challenges from self-appointed journalist/bloggers and what *The Wall Street Journal* calls “do it yourself media.”¹⁷⁷ Google’s proposal to scan entire libraries has triggered a wide debate in the publishing world about the relative importance of openness—in other words access—versus control—in other words the exercise of intellectual property rights.¹⁷⁸ Advertisers and marketers are trying to adjust to an environment where Websites discuss the merits and demerits of countless products.¹⁷⁹ Unlike the famous Peter Steiner cartoon where dogs sit around a computer enjoying the fact that “On the Internet no one knows you’re a dog,” in today’s connected world, everyone on the Internet can know if you or your product is a dog.¹⁸⁰ Amateurs are demonstrating their video skills by posting their own ads or responding to on-line contests while creative marketers are embracing Web-based viral marketing,¹⁸¹ advertising on popular social networking sites, and placing their products in the artificial world of Second Life.

Recall how a string of Federal Communications Commission decisions “opened” the AT&T network to non-AT&T telephones and accessories, triggering a wave of innovation by other manufacturers who discovered non-black handsets. In much the same way, the more open and minimally regulated unlicensed bands

of the radio frequency spectrum have hosted a remarkable degree of creative activity including the rise of Wi-Fi.¹⁸² The creators of “mesh networks” have demonstrated the technical value of openness for the efficiency of communications networks. They show the benefits of having more, rather than fewer users (thereby overturning traditional ideas of congestion) by creating communications systems in which each additional communicator enhances the capability of the network rather than burdening it.

Proponents of “open access” in telecommunications who earlier had successfully fought to ensure that cable companies like Time Warner opened their networks to competitive Internet Service Providers now crusade for “net neutrality” to ensure customer access to the most open set of sources of information and applications, and oppose a “gatekeeper” role for cable television or telephone companies that might allow them to reduce the openness that has marked the Internet.¹⁸³

The Defense Department too is harvesting the benefits of openness. Drawing from a long tradition of prize offerings like the one that led to Lindburgh’s historic flight, the Department’s “Grand Challenge” sought the assistance of a wide range of creators of autonomous vehicles by offering a prize to the entrant who could most quickly navigate a rugged desert course. Other institutions, like NASA, are also seeing the benefits of allowing a much broader range of participants to contribute their talents and efforts to accomplish the NASA mission.¹⁸⁴

Each of these “open” works or processes differs in its degree of openness. Each has characteristics that depend on the particular domain. But each rests on a key pair of ideas: that providing more access to information and allowing more people to contribute their special skills and experiences will lead to more innovation than would occur if access to information were restricted or if manipulation of the information were prevented.. Such attempts to “harness the collective wisdom” are profoundly democratic.

Given the history and impact of open innovation, it is worth considering how public policy issues affect it. Because much of open innovation takes place outside of the formal system of innovation, we tend to overlook or underappreciate it. 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 now counted in any government measures of innovation.¹⁸⁵

Thus it makes sense to consider whether government can play a role in encouraging it. Under the tax system, for example, the government provides a tax credit for research and development. Should the “development” that takes place in other settings be eligible for such subsidies?¹⁸⁶ The government has certainly helped small and medium-sized manufacturers to compete successfully. Could some government programs help similarly sized businesses to consider the benefits of greater openness? Could government incentives foster open innovation? How about decreased patent fees for intellectual property made available via royalty-free (RF) licensing?

Open Standards, Open Source, and Open Innovation

One irony of today's intellectual property system is that companies are motivated to close themselves off, to ignore suggestions for new products or product improvements from outside their four walls, fearing that they will later be charged with stealing an idea. Some even destroy incoming communications to protect themselves or route them to their legal departments for polite rejections.¹⁸⁷ How enlightened is a public policy that implies that a company should respond to innovative suggestions from outsiders by purchasing larger recycling bins for the mail-room?

The Digital Millennium Copyright Act serves as another barrier to more open innovation by increasing the controls offered to rights holders. 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.¹⁸⁸ To the list of DMCA complaints, therefore, we should add the fact that it is inhibiting creative users from adding value to products, particularly software-controlled products.

Finally, we should consider the impact on open innovation of legislative or judicial decisions aimed at problems such as the misappropriation of digital information products. 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 would also remove one of the key mechanisms that lets people collaborate to achieve open innovation and to distribute its results. 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 use to infringe intellectual property rights.¹⁸⁹ The Court did seek to provide some assurances that only products aimed specifically at fostering infringement would be liable for infringement, but 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, developed by an international group of artists, scientists, lawyers, business executives, and other experts, provides a useful starting point in considering changes in intellectual property rules.¹⁹⁰ The charter suggests a test that lawmakers can use before they pass new laws or regulations regarding intellectual property. The test would establish a presumption against expanding intellectual property rights. It would place the burden of justifying expansion on those who would advocate change, and it would require a rigorous analysis of the impact of the change on people's basic rights and economic well-being.

Currently, the U.S. Congress is debating a new copyright treaty for the "Protection of the Rights of Broadcasting Organizations." Opponents say it could expand broadcasters' rights and "shrink existing protections in the U.S. for public domain works and other instances of fair use." This debate offers a timely oppor-

tunity to apply the Adelpia principles in order to make a better policy choice.¹⁹¹

Openness has a wide range of effects I have not addressed here. Perhaps most prominent among them is its impact on personal privacy and security. Privacy, for example, is threatened as increasingly large amounts of personal information are widely distributed and available. Security, for example, may be threatened by the access that violent groups have to information that would allow them to more easily attack vulnerable targets. Other effects are far from clear, but may be profound in the longer term.

While the Internet connects more and more people, it is not the same direct connection, through physical interaction, that traditionally shaped our social practices. Will new forms of social interaction develop and change everything from greetings to geopolitics? Will our wider connections increase understanding and tolerance or will they 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 we see a cultural “balkanization” of society as individuals retreat to their “information warrens?”¹⁹²

Dozens of other, similar questions are beyond the scope of this paper. But increased openness, based on clear technological trends, will continue, and will be a fruitful ground for scientists, economists, anthropologists, sociologists, lawyers, and others to study.

Several public policy recommendations have evolved from these thoughts on open innovation:

- The government’s statistical agencies should consider definitions for open innovation and methods for gathering relevant data.
- The Digital Millennium Copyright Act should be amended with two aims: to guarantee access under the Fair Use doctrine to digital information that has been the subject of some form of access control, and to foster open innovation and interoperability involving products subject to the Act’s protection.¹⁹³
- Proposed legislation or regulations regarding intellectual property rights should be subject to the Adelpi Charter test. It 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 suggestion for the open publication of research results within a fixed period of time should be made mandatory. This requirement should apply to all federal agencies that award more than US\$100 million in research grants to support unclassified research.
- 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. Congress should also enact a similar ban on unreasonable discrimination against the attachment of devices that do not harm the network, imposed via terms of service.

- The Patent and Trade Organization (PTO) should work to develop systems that would reward intellectual property rights holders for increasing access to the intellectual property they control.

CONCLUSION

Openness provides many benefits. They are becoming more apparent and are likely to grow as we learn to utilize the new capabilities offered by information and communications technology. 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 from those developed based on what we knew of the physical world.

Years ago, Garrett Hardin described the tragedy of the commons.¹⁹⁴ The theory held 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 that commons, might act to maximize their own short-term interests at the long-term expense of the commons and the community that used it. The actions of a few could harm the interests of many, and of the society as a whole.

The digital world provides an opportunity to think of the commons differently. The use of¹⁹⁵ 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 absolute 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 that openness might bring.

We invite reader comments. Email <editors@innovationsjournal.net>.

Acknowledgments

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12. Statement of Carl Cargill, Director of Corporate Standards, Sun Microsystems Inc., in U.S. House of Representatives, *The Role of Standards in Today's Society and in the Future*, hearings before the Subcommittee on Technology of the House Committee on Science (September 13, 2000), available at <www.house.gov/science/cargill_091300.htm>.
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19. The Council on Competitiveness, *Innovate America: Thriving in a World of Challenge and Change*, The National Innovation Initiative Interim Report (Washington, DC, July 23, 2004), p. 10, available at <www.compete.org/pdf/NII_Interim_Report.pdf>.
20. David Balto, "Standard Setting in a Network Economy." See also, Sherrie Bolin, ed., *The Standards Edge*, annual series (Ann Arbor, MI: Sheridan Books).
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25. Ibid.
26. Wikipedia, "Tim Berners-Lee," available at <en.wikipedia.org/wiki/Tim_bernens-lee>. Sir Timothy "Tim" John Berners-Lee is the inventor of the World Wide Web and director of the World Wide Web Consortium, which oversees its continued development.
27. Wikipedia, "CERN," available at <en.wikipedia.org/wiki/CERN>. Officially known as the Organisation Européenne pour la Recherche Nucléaire, CERN boasts the world's largest particle physics laboratory and is credited with creating the World Wide Web through a project originally titled ENQUIRE.
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29. Paul Festa, "Standards Group Beats Back Patent Foes," CNET News.com, April 10, 2003, available at <news.com.com/2100-1013-996351.html>.
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31. Paul Festa, "Warming Up to Open Source," CNET News.com, February 9, 2005, available at <news.zdnet.com/2100-3513_22-5569610.html>. 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.
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35. This strategic choice may attract manufacturers. Firms providing services or those that have built their business models on royalty income would not necessarily make the same choice.
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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: Inventing the Future at MIT* (New York, NY: Viking, 1987).

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