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CHAPTER FIVE

Things in Themselves: Redefining Intellectual Property in the Nano-age¹

We have been confronted in the last 100 years with a rapidly changing technological environment. This environment has brought with it great wealth and prosperity, and there is no doubt that emerging concepts and applications of intellectual property (IP) have aided to some degree our scientific, technological, and economic expansion. Copyrights and patents offer monopolistic rights to authors and inventors over their creations, ensuring profits for fixed terms, and providing fortune as well as fame for the most successful inventors and authors. Monopoly rights are strong incentives to create both utilitarian and aesthetic works.

Recently, emerging technologies have challenged traditional IP theory and practice. Consider the rise of computerized phenomena, and the proliferation of software and instantaneous communications through the internet. Software has been considered a kind of hybrid, treated both as a patentable invention and as copyrightable expressions. In my first book, *The Ontology of Cyberspace*, I considered how software has revealed that our distinctions between copyrightable and patentable objects are artificial and illogical. I argued that all intentionally produced, man-made objects are expressions, and that computerization has merely revealed how one expression is very much like another. More recently, I have considered the question of patenting unmodified genes. In the course of that discussion, I further criticized the application of existing IP to genomics and genetics, at least where patents have been issued for unmodified genes or life-forms. In all of my work, I have sought to uncover the ontologies (descriptions of the objects and relations involved) of the underlying objects. I have done this believing that once we reveal the nature of things (like expressions, machines, software, and genes, as well as relations and social objects like property, ownership, and intentions) we could then sensibly sort out logical errors and inefficiencies in public policies.

We are now on the cusp of a new engineering breakthrough that will once again challenge our relation to our technological world, and likely pose new challenges to the application of traditional IP. Nanotechnology involves the

construction of materials and objects at the ‘nano-scale’, beginning at the molecular level. Theoretically, this will mean cheap and abundant objects of any size and shape, more or less instantly created, with little to no waste, and constructed anywhere and at any time. The science-fiction notion of simply dialing up an object and having it constructed on the spot, molecule by molecule, may well be decades away or further, but it is the ultimate goal of many who pursue nanotechnology research. Even so, we will begin facing unique challenges about the nature of IP as the dividing lines between ideas and expressions further blur, and matter itself becomes programmable.

IP has become a major force economically and culturally, impelling in part our hyperbolic economic and technological growth in the past century, and influencing both cultures and economies worldwide. Historically, the emergence of IP as a class of objects is relatively new. This class of objects, which includes things that are patentable, copyrightable, and trademarkable, has evolved since its inception both significantly and rapidly. Let’s look briefly at the evolution, form, and purposes of IP law, and then consider how and to what extent new material technologies will finally destroy current notions of IP.

The Emergence of Intellectual Property

IP is often mistakenly thought to protect ideas in much the same way that ordinary property law protects things. In fact, there never has been any legally recognized protection for ideas themselves, but only for various forms of expressions. Beginning around the time of the Renaissance, in Britain and Italy, the first legally sanctioned monopolies over inventions and works of authorship were created. Some of these monopolies took the forms of ‘letters patent’ entitling inventors to a limited monopoly for the sales of their inventions. Others were in the form of copyrights, entitling first publishers to monopolies over printed works, and much later, moving that monopoly right to authors and artists. Over time, IP protection became formalized throughout the western world, and embedded, among other places, in the grant of powers to Congress in the United States under Article 1 Section 8 of the US Constitution.²

This emergence was not without its periods of reticence, and particularly during the nineteenth century, major economies in western Europe drew back from their recent embrace of IP, and went through periods where they completely rejected the notion of IP. While France and the United Kingdom

had been among the first and most eager adopters of IP regimes, following the example set in the United States following the revolution, the United Kingdom had a long-lasting intellectual debate about the wisdom and necessity of IP in general. France, among the European nations, had most fully succumbed to their particular arguments about the *moral* rights of authors and inventors, establishing their patent and copyright system early after their revolution, and never backing down. But in the United Kingdom, propelled by modern economic theory, and given prominent voice by the journal *The Economist* and others, anti-patent sentiment grew. The anti-patent movement, which will be more thoroughly detailed later, culminated in lengthy periods in the mid- to late nineteenth century when the Swiss, Germans, Dutch, and British did away with IP laws entirely, even as their economies apparently continued to grow.³

The theoretical underpinnings of IP law were thoroughly debated during this anti-patent period, and four major arguments promoted the use of patents: (a) there is a natural right to the products of one's inventiveness, for example, ideas; (b) society should reward inventors for their service by grant of some limited monopoly; (c) economic and technological progress is good and will not be encouraged without some grant of a limited monopoly; (d) government-granted IP rights require disclosure, which benefits society and which would not exist without IP laws. Inherent in these arguments, and generally adopted by proponents and opponents of IP laws alike, is the understanding that the *nature* of the subject matter of IP *differs in kind* from other forms of property. Ideas tend to spread without control, and it is difficult or impossible to naturally defend them absent secret-keeping. Even secret-keeping does not prevent independent discovery. Nevertheless, in ordinary marketplaces, it is possible to see and track the movement of goods, and generally also the use of various processes. If governments create IP systems, patent holders can seek redress if they see their techniques or technologies reproduced without license, just as authors can note substantial similarities between their works and the works of copiers, and sue them in court for violating their IP rights.

The creation of government-sponsored monopolies over types of expressions is intended to balance two competing goals: encouraging innovation and moving knowledge into the public domain. Historically, secret-keeping was one of the first means by which inventors and, to some extent, authors profited from their creations. Trade secrets are

still an effective means of preventing others from profiting for one's unique inventions, but only where those inventions are somehow impenetrable to 'reverse-engineering'. As technology and science make the process of 'reverse-engineering' cheaper, easier, and more widely available, secret-keeping has diminished as an effective means of protecting the fruits of one's inventions. In order to ensure that authors and inventors would continue to contribute to society, governments have established IP regimes to ensure guaranteed profits for the fruits of authorship and invention for certain time periods. Currently in the United States and elsewhere, authors are granted a monopoly while they are alive, and their estates still profit for seventy years after the author dies. Inventors only get a twenty-year monopoly following the filing of a patent.⁴

Among the justifications for granting such exclusive monopolies is the assumption that without guaranteed returns on investment (of time or money) neither inventors nor authors would take the risk of innovating or creating. Behind this pragmatic goal are some notable theoretical underpinnings, some of which have been challenged of late by new technologies. A central theory of IP is that ideas and expressions are distinct from one another, and no monopolies should ever limit the dissemination of ideas. The idea/expression dichotomy, as it is called, recognizes that the ultimate goal of IP law is to benefit the public, even while benefiting inventors and authors for their unique contributions to society. The idea/expression dichotomy is grounded in sound metaphysics. Not only are there practical distinctions among things and ideas, but there are also uncontroversial ontological distinctions between, for instance, a chair and the *idea* of a chair. If you don't believe me, just try sitting on the *idea* of a chair.

Ideas versus Expressions

The idea/expression dichotomy may also be behind some prominent, recent confusion in the treatment of emerging technologies under IP law. As we have touched upon briefly above, there have been historical prohibitions against granting *too much* protection to certain objects, notably, 'laws of nature' and ideas. Laws of nature and 'abstract ideas' cannot be monopolized for two reasons: (a) they are not the products of human authorship and (b) granting monopolies over them curtails useful arts derived from them, which contravenes the general purposes of IP law.⁵ Ideas cannot be

monopolized for fully pragmatic reasons as well. If ideas were amenable to IP protection it would pose a similar problem of stifling innovation, as well as one of enforcement. If a monopoly existed over an idea, rather than only its expression, how could one prevent others from expressing that idea in all potential media, or from just being uttered? Protecting bare ideas would be unenforceable. Instead, given that IP protection only extends to expressions in *fixed* media, rather than the bare ideas, enforcement is limited only to instances where an unauthorized expression appears in the market. But there are certain expressions that appear at first to be much like ideas, if not ideas themselves. It has been objects like these that have resulted most recently in problematic treatment of new technologies where authors, inventors, and those who apply the laws of IP have treated some objects as erroneously protectable, and others as unprotectable. Historically, these distinctions were not so problematic, until modern technologies blurred these lines.⁶

As patent and copyright law developed, it was clear that machines and processes were patentable, whereas works of authorship were copyrightable. Each was an expression of an idea in some medium, the primary roles of each differed socially. Works of authorship were not primarily ‘utilitarian’ whereas an invention was. Books seemed very different from the printing presses that made them, and even more clearly distinct from the ideas that conceived each. Ideas, and expressions, either as machines or as works of authorship, were most clearly distinct when media were less complicated. As media have evolved, those distinctions have blurred. A painting expresses an aesthetic idea in a traditionally artistic medium, but what about computer art? When digitized, a painting resides in computer chips, as the logic of electronic gates as part of a machine. In theory, the same painting could reside in mechanical computers as well, as parts and processes of obvious machines. All of which requires us to ask the question: In what way does the medium matter when an idea is expressed? We could logically conceive of a machine whose sole purpose is to store and express a particular painting, let’s say, the Mona Lisa, just as an optical disk can store and express the Mona Lisa. How does the medium alter the nature of the painting, if at all? What makes paint different from computer chips, mechanical or electronic logic gates, or bits on an optical disk?

As media have become more flexible, and the ability to express the same ideas in various disparate media has become possible, laypersons, lawyers, and jurists have had difficulties distinguishing among ideas and expressions.

The blurring has actually been of the historical distinctions between machines and other, 'non-utilitarian' expressions, but has bled over into the idea/expression dichotomy. Transmissions over airwaves or internet, at the speed of light, *seem* to many to be like ideas themselves. This is but a convenient delusion for many, and for others it is an actual ontological error. I have detailed the delusion of Michael Heim, in his *Metaphysics of Virtual Reality*, in which he continually conflates cyberspatial entities and ideas themselves.⁷ 'Virtual' artifacts are not, however, ideas. They *seem* like ideas only in their evanescence. Turn off the computer and the expression stops. Turn off the monitor and the painting disappears. Wipe the memory clean and the virtual artifact cannot reappear.

Conflating ideas and expressions in new media serves a number of ideological interests as well, interests with which I am not wholly unsympathetic. But ideology is not a sound basis on which to make decisions about ontology. Ideas differ from their expressions in one very important manner. Ideas can be held in the mind of one individual without becoming expressed. Once an idea leaves a mind, it is either expressed or forgotten. If forgotten, then the idea itself no longer exists as a thought. If expressed, then other minds may come to possess the same or similar idea, depending on the success of the expression. There is no sense in which any object that exists in a computerized medium is an idea because, so far, artifacts are not yet able to conceive things. All computerized artifacts are (also, *so far*) the intentional results of humans. This does not rule out the eventual possibility that minds will come to exist in artificial media, but until then we have no right to conflate ideas with virtual artifacts. This conflation, while popular, must be seen for what it is: ideologically motivated.

Marshall McLuhan's oft-misquoted 'the medium is the message' (it was originally the 'massage') adopted by proponents of the 'new' media and a certain anti-intellectual bent are partially responsible for spreading a sort of new-age metaphysics about cyberspace.⁸ This metaphysics, adopted without much scrutiny by Michael Heim, and spread among those who would leave cyberspace an ungovernable medium, immune to standard IP regime, assumes that virtual objects *are* idea-like, if not actual ideas. Heim goes as far as to call virtual objects 'pure thought' or Platonic ideals. But ideas are unique. So far, they can only subsist as thoughts in the medium of a mind, which for now is a biological brain. Of course, mind need not necessarily be limited to biological brains, but until there is better evidence of true, thinking

artificial intelligence, capable of forming new ideas and expressing them, we cannot logically confuse ideas and expressions in artificial media. Nothing justifies it.⁹

Our standard idea/expression dichotomy can hold for now. Ideas differ from expressions, which are always the instantiation or depiction of an idea by way of artifact or intentional performance. Ideas cannot be pragmatically protected by IP laws because there is simply no way to restrict an idea to a thought in just one mind. Once it has become expressed, other minds may then hold the idea. Moreover, nothing prevents independent ‘discovery’ of an idea by any other mind. So IP law protects only expressions. It gives a limited, exclusionary right to the holder of the IP, preventing others from expressing the protected IP until a certain time. This has worked historically, largely because of the enforceability of IP regimes over old media. Pages were harder to copy than files, and widgets more difficult to reproduce than digits. But the new media are attractive because of their portability, speed, flexibility, and ease of use. Now, IP laws are violated, and unauthorized copying abounds in cyberspace. This raises now some vital questions, which I have set forth before, but which deserve exploring as the new media continue to alter the means of production. Can standard IP regimes adapt to the new media in sensible ways that encourage innovation, but do not make criminals of ordinary people?

The answer in cyberspace has been yes, but it has occurred at the grassroots. Governments have not even sought to change the fundamental modes of IP protection, choosing instead only to increase the length of terms of protection, and stiffen the penalties for violations. Rather, innovators, sensing the losing battle involved in strong IP, which is often a tool of the already wealthy, and seeing it as a hindrance to consumer acceptance and robust product development, have chosen another path. Alternatives to standard, government-sponsored monopolies have emerged, and have been successful, employing private contract and licenses. Creative-commons, open source, shareware, GNU/GPL, and other innovative licenses have evolved to cope with the inherent strengths and weaknesses of new media, to encourage their economic exploitation, and to not treat users as potential enemies.¹⁰

The new media have revealed flaws in our old distinctions between patentable and copyrightable objects. The distinction is rooted in pragmatic concerns, and a certain preference, it seems, for utilitarian objects (inventions) over aesthetics. But the distinction ultimately is

among objects without any ontological difference. Inventions and works of authorship are all expressions, the uses of which differ socially. Works of authorship are expressions (the extensions of ideas outside minds) with primarily aesthetic uses, and inventions are expressions with other types of utility. New modes of IP protection should be agnostic, ultimately, about the medium, recognizing that what matters in order to encourage innovation, and to retain consumer good will, is access to good, flexible, open goods at reasonable prices rather than governmentally supported monopolies. Artifacts can be conceived, designed, produced, and delivered utilizing the new media in cheaper, often distributed modes. Individual innovators can reap rewards from consumers not just in the margins they realize with each individual copy delivered, but also through an ongoing, open design phase so that consumers become co-producers, sharing in the profits by better products, and at reduced prices. New media have not only revealed flaws in the original conception of IP, but also encouraged the creation of new modes of distribution, and grassroots responses to IP laws that seemed to hinder entrepreneurial activities.

But is this new wave of innovation, which has seen success with products like Open Office, Mozilla Firefox, Apache server software, and others, limited to the domain of bits? What happens when atoms become like software, programmable, instantly distributable, and abundant? This is the future envisioned after all by a growing number of those working to fully realize nanowares. Will IP laws as they have existed so far suffice for such a future?

Atoms for Bits: Pragmatic and Theoretical Challenges

For the rest of this chapter and the next, I will concentrate on the applicability of current theories of IP to nanowares. Adapting or altering current IP schemes to fit emerging modes of manufacturing and distribution requires us first to have a coherent theory of artifacts and ideas, and then a useful mode of organizing our behaviors so as to promote the goals of IP laws. This first part is largely accomplished, though not necessarily explicitly. Implicit in the law of IP is a sound ontology of artifacts, expressions, and ideas. Although the current regime complicates matters somewhat by artificially dividing the domain of expressions into ‘utilitarian’ and ‘aesthetic’, as mentioned above, this distinction only truly became problematic when the new media emerged. Nevertheless, underlying IP law has always been

a recognition of the critical ontological distinction between ideas and expressions. Expressions are ontologically dependent upon ideas, but not vice versa. Ideas can be held and never expressed. Ideas are ontologically primary and predicate to an expression. Expressions of ideas are intentional manifestations of those ideas beyond a mind.

The chain of ontological dependence and priority begins with minds, which conceive of ideas. Ideas, so far, subsist only in minds as thoughts. Thoughts are material components of mind, and while they are evanescent, they exist in certain locations at certain times. It is their evanescence and their privacy, as well as a potential preference for freedom of thought, that prevent us from allowing monopolies over ideas. Moreover, the similarity of bare, unexpressed ideas to other ideas in other minds cannot be determined without some expression, so not only is enforcement of trespass on ideas difficult, but isolating those trespasses without some further act seems practically impossible. As touched upon above, nothing about the nature of minds or ideas requires that ideas be located *only* in human brains; it's just that so far we only have evidence for their existence in human brains. It is possible that other animals, or eventually machines, could conceive ideas, and even express them. Meanwhile, the IP regimes under which we work only apply to expressions that originate in human minds, and only human authors or inventors get the benefits of protection. It is only human ideas in human minds that we have evidence of through every single human artifact that has ever been created.

All expressions are *products* of human intention. Some expressions are artifactual, others are less clearly so. A dance is an expression, as is an utterance. But these sorts of expressions, because they are fleeting, are ordinarily never accorded any sort of monopolistic protection in IP regimes. Representations of these sorts of expressions in some medium which lasts over time are often afforded IP protection. There are both theoretical and pragmatic justifications for this. Non-fixed expressions exist over spans of time. They are occurrents. Their representations are continuants. No two occurrents can ever be identical. Occurrents are ontologically dependent upon continuants, and the social/legal preference for fixed expressions in IP regimes tracks the simple dichotomy between continuants and occurrents, by which continuants are ontologically primary. There are also some highly pragmatic reasons to prefer fixed, continuant expressions over non-fixed, occurrents, at least when according expressions legal protections. Not least

among these reasons is enforceability. If someone reproduces an expression as a continuant, it is much easier to discover the reproduction than if one reproduces an occurrent expression. Infringements are thus easier to locate, and legal action is easier to pursue. Moreover, there is a likely social preference for allowing freedom of actions that makes attempts to stifle occurrent expressions unpalatable.

Would protecting occurrent expressions ever be justified either theoretically or practically, and if so, would it uphold the purposes of IP regimes? One could certainly envision a social/legal system that prohibited reproducing occurrent expressions (inasmuch as they can be *duplicated*) and that required some royalty, license, or acknowledgement for every reproduction. It would require a great deal of mutual trust to work given that these sorts of expressions are necessarily fleeting and difficult to prove in case of some infringement. Moreover, it is unclear whether this would bolster or hinder the purposes of IP regimes, given that such protections might unduly stifle experimentation in expression. It would likely limit forms of expression we feel generally unwilling to hinder, such as free speech and movements. If one faces the risk of unknowing infringement of another's expressions whenever one engages in dialogue, or dances, improvises, or brainstorming out loud, then values that we favor even over those embodied in IP will be threatened. While it is logically possible, devising institutions that would protect occurrent expressions is both pragmatically difficult to conceive and potentially threatening to both the purposes of IP law and other more basic values.

IP Challenges in Present and Future Nanowares

The resulting products from both present and future nanoware technologies will be continuant expressions. The distinction lies in the manner of delivery, because until recently, the author, inventor, or some intermediary has either printed or assembled the final product that gets sold. Enforcement of the first sale right to royalties has been more or less straightforward. Infringing products could be spotted by tracing their point of origin. Counterfeits could be tracked by unique IDs, trademarks, or other materials. Of course, counterfeit products still abound, but the chain of custody of each authentic item, whether a film, book, or handbag, leads to some author, inventor, or authorized intermediary who constructed the authentic product and placed it into the stream of commerce. But all of this becomes complicated if

consumers become the producers, assembling the final product themselves. This scenario poses theoretical and practical problems relating the theory of artifacts discussed above.

IP protection has centered around granting monopoly rights to authors and inventors for each first sale of the objects of their authorship or invention. Both present and future nano/microfab products will be assembled more or less by the consumer or at least at the consumer end of the supply chain. So what will constitute the first sale? It will be something very much like, but not exactly, a 'type' rather than a token which will be sold in the scenarios envisioned, or the token sold will at least differ significantly in kind from the token that is ultimately used. While the software that will actually be exchanged, that drives the local fabrication of the eventual object constructed, will be purchased, its purpose will be the fabrication of something else. There is a problem with this that confounds ordinary IP laws and their reach. Namely, instructions, directions, recipes, and other *utilitarian* works of authorship (rather than aesthetic) have typically been *excluded* from most IP protection. The justification has been that protection should only issue for original works of creativity or inventiveness, and recipes, instructions, and directions constitute facts or descriptions of states of affairs, even if listed in a particular order. Software seems to get around this by being both the process and the product. The instructions bound up with software inform the computer to direct the software's own functioning. But this is cheating. It really points to the erroneous original distinction between utilitarian and aesthetic expressions. Software consists of instructions that are performed by a machine. But software also consists of the instructions immanent in the machine while the software is running. All of which is what seems to complicate the application of traditional IP law to software, and eventually nanowares. We have resolved the confusion in software by simply stating by fiat that copyright (and, strangely, patent, which used to be mutually exclusive with copyright) shall apply to software in all its forms. This more or less gets it right, treating the object as it is, an expression, plain and simple. But software is distributed on disks, on memory cards, or in files, the reproductions of which are all identical to one another in the arrangement of their bits. It is that string of bits that gets the protection. Each first sale of that string of bits deserves a royalty because it is that string that is the end product of the sale. What of manufactured items whose manufacture occurs not before but after the purchase, and at the site of the consumer, not by the author or inventor?

Traditional IP will not be able to be applied to the nanowares. It will utterly fail to mesh with IP's aims or methods, or to protect and incentivize in converging technologies. This is partly because traditional IP prohibits reproduction of the object purchased. This has been a sticking point with software which has been resolved by specific exceptions noted explicitly in software licenses (such as the necessary copying and reproduction associated with moving software into the hardware). But in the case of present and future nanowares, the item that will ultimately be constructed is the primary reproduction consumed. The package of software that is used to construct the final object will not be the primary object to be consumed. Rather, it is the chair, RepRap machine, or other widget assembled either by hand, by robot, or by molecular assembly that must ultimately receive protection, even though it is *transferred* to the consumer in some other form, and assembled or otherwise reproduced by the consumer. Both patent and copyright prohibit the sort of reproduction that will actually be necessary for the full use of the widget sold, and to make the promise of present and future nanowares complete. So what will be sold, what sorts of protections can be used to both encourage innovation and make full use of the technology envisioned, and how will we have to adapt our institutions to accommodate new modes of innovation, distribution, and assembly?

There is no natural basis by which we can exert control over ideas. The types are abstract, they are reproduced in minds, and until they are expressed in some way, there is neither any way to determine who holds an idea nor to prevent that conception. There is also only one known way to exert any natural control over expressions, and that is secrecy. If you wish to prevent others from expressing 'your' ideas, you can only keep secret those ideas and hope that others don't conceive of them as well. Once expressed, ideas can become easily reproduced in other minds and then other media. The problem with secret-keeping is that it discourages rather than encourages innovation, so IP regimes seek to promote disclosure and grant limited monopoly rights to ensure profits. IP regimes are entirely the creatures of positive lawmaking, and we are free to create them as we wish, consistent with other important values and rights. Can we conceive of a better way to encourage innovation, help ensure profits, and benefit consumers? Can we develop new institutions that will fit new modes of manufacture and distribution? We can. Some of these new institutions are already developing at the grassroots, and could likely be adapted to fit the world of atoms in the nanowares future envisioned.

Contract versus Monopoly

Because neither copyright nor patent has satisfied a number of consumers and producers of new media (such as software), alternate forms of protection have developed as viable methods of distributing products without government-sponsored monopolies. Beginning with the free software movement that launched the GNU/GPL (GNU General Public License), numerous new, grassroots innovations in contractual agreements have arisen to protect and encourage authors and inventors while enabling greater flexibility and fair use of new works. These innovations recognize the vital role that agreements and incentives play in encouraging innovation, as well as the moral choice involved when inventors and authors seek some compensation for their works. But they also recognize that these goals and choices are not constrained by the models employed historically in the rather recent inventions of copyright and patent laws. Sometimes, new forms of products or services deserve new forms of incentives. In the case of software, a number of the new forms of protection that have emerged have become favored by developers and consumers alike, and have enabled profits to be reaped outside of the traditional, government-sponsored monopolies of copyright and patent.

In general, alternate forms of protection involve various licenses, including shareware, creative commons, open source, copyleft, and others. Underlying all of these various devices is their flexibility and their openness. They are created to encourage dissemination, while retaining either some information flow back to the author/inventor, or some payment, or both. In each case, alternate forms of recognition of authorship or inventor status confer some limited possessory and use rights to the consumer, and retain some rights to the author or inventor. Defining the nature of those rights is the providence of a private contract. So far, most of these alternate forms of licensing have concerned software, and they are entered into through various mechanisms. 'Shrink-wrap' agreements make the license binding when the software is either unpackaged or installed. More commonly, downloading software under one of these schemes involves agreeing to some form of End User License Agreement. There are important issues involved with the propriety of contract in many of these cases due to the fact that many end users enter into license agreements rather casually, and without any of the requisite 'meeting of the minds' generally necessary in contract law for a contract to be legal and binding. We might well ask, however, if a valid and enforceable alternative licensing scheme could be applied to present or future nanowares?

There is no doubt that any form of licensing of products distributed with this technology will differ in important ways from software that is currently licensed through alternate schemes. There are critical distinctions between what is actually going to be exchanged under the sorts of present and future nanowares infrastructures that are conceivable. Unlike an ordinary purchase from, let's say, a furniture store, no material good (of the ordinary kind) will be exchanged. The only material exchanged will be the design templates, CAD drawings, or similar artifacts. The final construction of the ultimate product will be made by the consumer, mediated through some set of machines. So what will be sold? What will be the responsibilities of the vendor and what liabilities will the consumer assume? To illustrate graphically why all of this is so vitally important, consider what might happen should an inventor distribute his or her design, marketed as a new and improved safety helmet for biking, which when constructed by the consumer turns out to cause more injuries than it prevents? Ordinarily, product liability is strict, and flows from the manufacturer to every good manufactured, put into the stream of commerce, and used as it is intended to be used. But in the scenario envisioned, who is the manufacturer? Is the 'publishing' of the design specifications, no matter how detailed, enough to make the inventor potentially liable? To whom will the inventor be liable? Will *anyone* manufacturing the item, no matter how they came into possession of the design (e.g. even if they pirated the specs), be in some sort of liability/contractual relationship with the inventor?

If licensing schemes for physical products are to achieve the promise and potential they are achieving for certain software goods, they will need to be different, perhaps radically different, from alternative licensing for software. In the case of software, the good delivered is the final good, and the range of liabilities is necessarily limited by the medium. So far, software failures are generally incapable of causing physical harms. In the case of physical goods, delivered *via* software, the range of liabilities is greater, and mechanisms for maintaining information and control over each copy are made more complicated. There is no theoretical reason, however, why a license could not be developed that could accommodate physical products. Perhaps the seeds of such a license lie in currently used and successful alternative licenses. Can we adapt any of these to serve the various goals typically associated with IP regimes so that products can begin to be marketed, adapted, and adopted by paying consumers as open source software or shareware currently is?

Some Initial Requirements

Before we successfully apply flexible forms of licensing to physical products, a minimal set of requirements must be established. Among these are the purposes of IP law, namely, encouraging innovation and ensuring that useful information eventually flows into the public domain and to the public benefit. A further, more complicated set of requirements revolves around potential liabilities, including for economic and personal harms. Software so far hasn't had a significant potential to physically harm people (War Games scenarios aside), but physical products distributed first as software and then constructed by the consumer pose real dangers. If a licensing scheme is to be successful in the realm of physical goods, the potential liabilities, and means to address them realistically, meaningfully, and efficiently, must all be worked out before the first big harm occurs.

Alternative schemes work best when they are flexible, and contracts work best when they are plain and easily understood by all parties. In the spirit of do it yourself (DIY) culture, a part of which drives the current trends in nanowares, it is worth trying to devise licensing schemes that can easily be adapted to the particular good sold, and that are based on plain, easy to understand terms, concepts, and interchangeable parts. Legalese will not do. Underlying the success of alternate forms of software licensing is the basic value of trust between consumer and vendor. Openness and free exchange of information between the parties have helped improve the products produced and distributed under these schemes, so that names like Firefox, Apache, and Linux are trusted as reliable purveyors of well-built goods. Alternative forms of licensing should help ensure that this spirit remains alive in present and future nanowares, and trust must remain a cornerstone of transactions. Freedom and openness should be preserved.

There are alternatives. Future nanotech and even present schemes of microfabrication could be modeled after patent and copyright. However, it is hard to *fully* envision. Problems of enforceability, and realizing the full potential of these technologies are two of the largest impediments to fitting nanowares into the straightjackets of patent and copyright. A new form of legal protection might be devised, granting some other form of monopoly right, utilizing a top-down approach. Authors and inventors might prefer the reliability and safeguards seemingly afforded by government-sponsored monopolies to those that might be constructed from the grassroots in a free market. If so, then so be it, but a free market demands that experimentation

and alternatives exist, and battle it out for market share, before settling on a particular form of protection over any other. Copyright and patent already exist, and some software authors use one or the other or both depending upon their preferences. Others use copyleft, creative commons, open source, or shareware to enter the marketplace, and some have achieved significant success.

There is already good reason to believe that physical goods and software can theoretically be treated as a kind. Each is an expression – the manifestation of an intentional idea from a mind into the world outside that mind. But because transactions of goods under the sorts of technological infrastructures envisioned and ultimately demanded by present and future nanowares will differ from sales of physical goods with which we have become accustomed, new models for a future supply chain, and delivering nanotech goods, might be better devised and employed. It is worth beginning the task of creating these new models, and testing them on existing, nascent forms of microfabrication such as RepRap Darwin, Fab@Home, and Fab Lab.

Empirical Work to be Done

A proof of concept can easily be devised. It is being devised by some who have been developing versions of the Creative Commons license that will apply to physical goods. The requirements described above can be fleshed out, and existing licensing schemes can be adapted to tangible goods. Early adopters are already tinkering with the technology, improving it steadily, and waiting for the killer app that will help it move from garages to the mainstream. Economic downturns like that of 2008–10 provide a good excuse to move the technology, and the social–legal infrastructure forward. Downturns are only made worse by the backlog of goods that ordinary manufacturing supply chains require. The system clogs up with old, warehoused products, requiring manufacturing slowdowns and sending prices into deflationary spirals. If products were delivered at the point of sale, in a ‘just-in-time’ manner, then it seems likely that downturns would not be so deep. Moreover, surpluses, waste materials, and recent concerns about environmental consequences of large-scale industrialization also suggest that our old modes of manufacturing need reevaluating. Now is a good time to invest time and energy not only in the technology and infrastructure, but also the institutions that will be required for the full promise of these new technologies to be realized. Those who are tinkering with the technology and

seeking funding to perfect it would also do well to work with those of us who are interested in ensuring that nanowares fulfill their ultimate promise, profit those who have invested time, money, and energy into realizing the technology's full potential, and provide the backbone for a new technological and commercial infrastructure that will help turn human creativity loose in the world of physical goods as it has done so in the world of software.

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