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3D printing is revolutionizing innovation and may require adaptation of intellectual property protections.

Reevaluating Intellectual Property Law in a 3D Printing Era

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How will three-dimensional (3D) printing technology (also known as additive manufacturing) challenge presumptions in intellectual property law? The technology democratizes design, distribution, and manufacturing such that these activities are accessible to even moderately skilled individuals.

Millions of makers will thus, knowingly or not, interact with intellectual property law as they go about creating, tweaking, and sharing designs (Gibb 2014). For example, an open design heat exchanger may unwittingly infringe another's patent. Moreover, goods that have an aesthetic element to them may infringe another's copyright, trade dress (e.g., a product's packaging or design), or design patent. Importantly, individuals or companies can be guilty of infringement *regardless of whether* they intended to infringe or even knew about the intellectual property right involved.

Brief Introduction to Intellectual Property Rights

Intellectual property (IP) law includes copyrights, patents, trademarks, industrial designs (design patents), and trade secrets. In this article I review basics of the law that are most relevant.

Copyrights

While most laypeople may be familiar with copyrights, which protect creative expression such as literature, drawings, music, movies, and sculptures,

they often do not realize how easy it is to obtain copyright protection for a work. The work need only meet the following criteria:

1. not be copied from something else,
2. be fixed in some tangible medium (e.g., written on paper, stored on a disk), and
3. contain a modicum of creativity.

Copyright protection *automatically* attaches to work that meets these three criteria (although there are benefits to obtaining a federal copyright registration, which can often be done for about $100). Thus, a 3D-printed sculpture (which is creative), as well as the STL (stereolithography) file of it, receives automatic protection.[1]

Purely utilitarian objects, such as a basic shovel, are not copyrightable. But what about the STL file that will print the shovel? Intuition might suggest that if the shovel is not protected, the STL file ought not to be either. But the law is not that clear.

Of particular relevance to 3D printing, the copyright statute specifically identifies "technical drawings," like traditional blueprints, as copyrightable. Is an STL file sufficiently like a blueprint to also enjoy protection? This is unsettled, and depends in part on how courts will interpret copyright law's requirement for a "modicum of creativity."

Traditional blueprints have creative components that many STL files will not, such as the choice of perspectives to display and which parts to label (recall that only a "modicum" of creativity is required). Most STL files include only the information required to manufacture an item; if that item is purely utilitarian, then arguably there was no creativity (in the copyright sense) in making the file. Such questions are yet to be answered.

Importantly, a person does not need to be aware that something is protected by copyright to be liable as an infringer. Ignorance is not bliss. At the same time, for copyright infringement the accused must actually copy the protected work. This could be as simple as making a copy of the file on one's computer.

Patents

Patents protect utilitarian inventions such as new mechanical or electrical devices, processes, and chemicals. Compared to copyrights, obtaining a patent is much more difficult. The invention must be, among other things, (1) new, (2) not obvious, and (3) useful. Furthermore, rights attach only once a patent is issued, and patents take years to procure and cost thousands of dollars. If someone owns a patent, she can prevent others from making, using, selling, and offering to sell the invention.

But a patent only specifically protects "claims," a term of art that refers to the enumerated sentences at the end of a patent. For example, the background portion of a patent may discuss the history and state of the art of heat exchanger technology, but claim number 1 may specify a "shell and tube heat exchanger where the outer layer of the tube is lined with alloy X." Such a claim would generally only be infringed by a similar heat exchanger with a tube lined with alloy X.

Focusing on claim language is important for 3D printing. If someone owns a patent that claims a physical heat exchanger, for example, that patent will not directly protect against someone who merely makes and sells a 3D printable *file* of the heat exchanger. Someone with the file must physically print the heat exchanger (or otherwise sell, use, etc. the physical item) for there to be direct infringement.[2]

Purely utilitarian objects, like a shovel, are not copyrightable. But what about the STL file that prints the shovel? The law is not clear.

Liability in patent law is even stricter than in copyright. As with copyright, an infringer need not be aware of the patent. But unlike copyright, in patent law an infringer does not even need to copy someone else's work to be liable.

Trademarks and Other Protections

Other IP law will be highly relevant to the 3D printing industry. Trademarks, for example, protect product

[1] In this article I refer to any 3D printing file generically as an STL file.

[2] A patent owner may be able to stop someone from distributing the file based on an "indirect infringement" theory, but this article does not delve that deeply into patent doctrine.

brand names and logos. Trademark law also covers "trade dress" rights when, for example, a product's design is so distinctive that it indicates to consumers that the product comes from a particular source.

Design patent rights (generally referred to as "industrial design rights" outside the United States) protect ornamental or aesthetic aspects of a utilitarian article, such as the pleasantly shaped contours of a smart phone.

Finally, trade secrets protect virtually any information or technology that gains some value from not generally being known. They may be alloy compositions or complex manufacturing specifications. One of the most well known and most valuable trade secrets is the Coca-Cola recipe.

The Incentive Theory of Patents and Copyrights

Although each area of IP law will be important to 3D printing technology, this article focuses on patent rights and their relevance to open source hardware designers.

Proponents of the patent system justify it in large part as an incentive to invent. The idea is that only the first innovator must sink large amounts of capital into researching and developing an innovation. Follow-on competitors can charge a lower price for the product while the first innovator loses in the marketplace because it cannot charge a price high enough to recoup its R&D costs.

Patents can discourage follow-on research by preventing others from using and improving on a patented technology.

The patent system purports to provide innovators with the incentive to invent (and to disclose and commercialize those inventions) by granting a 20-year exclusive right to "make, use, sell, and offer to sell" the innovation. The copyright system is organized around a similar rationale: People won't write as many books or make as many movies if these works can be copied with impunity and sold at a cheaper price.

Unfortunately, the patent system imposes certain costs on society. First, by giving an exclusive right to its owner to make, use, sell, and offer to sell the invention, a patent allows the owner to sell the invention at an inflated price, assuming there are no reasonable substitutes. The higher price creates a deadweight loss because some purchasers, who would have bought the product at a lower price, are priced out of the market for the item (Merges and Nelson 1990).

Second, the patent system imposes a societal cost by impeding follow-on technology. Inventions are cumulative: inventors build on them to create new ones (Scotchmer 1991). Patents can discourage follow-on research by preventing others from using and improving on a patented technology. In this way, longer patent terms can slow the rate of cumulative research advances.

The *theory* of the benefits and costs of the patent system is well known. Ideally, a patent system appropriately balances the costs and benefits of patents to maximize the benefits to society. But the *actual* costs and benefits of the patent system are not well known. Because the system is so complex, scholars have noted for decades that it is not possible to know for certain whether the current patent system is a net benefit or not (Merges 2011).

How IP Law Can Help 3D Printing Technology

Even without fully knowing the costs and benefits of IP law, one can catalogue some ways the law might help 3D printing technology and open source design.

Advantages

Patent law might provide the incentive needed to research and develop a new 3D printer or printing material. In addition, if IP rights protect certain computer-aided design (CAD) or STL files, such rights incentivize creation of those files and the objects they will manufacture.

Beyond the traditional "incentive" benefits, however, IP law is key to open source initiatives. Open source software, for example, relies on copyright law to prevent downstream users from "enclosing" a software product (i.e., selling it as a non–open source proprietary product): if downstream users violate the terms of the free open source license by enclosing a product, they become copyright infringers.

Without copyright law, an original open source provider would have little control over downstream users. Although the original provider would have a breach of contract claim if someone to whom he *directly* licensed breached the license agreement, the claim would not

necessarily reach users further down the chain if there is no privity (i.e., contractual connection) between them and the original licensor (Osborn 2017). Copyright infringement claims, however, do not require privity. The ability to control multiple generations of downstream users is a key distinction between open source software and public domain software.

As with software, open source hardware designers who want to control multiple generations of downstream users (e.g., to prevent them from enclosing aspects of the design) need help from IP law. Designers can rely on patent law, or in some cases copyright law, to prevent downstream users from enclosing certain designs.

Challenges

One drawback to using patent law is that patents are difficult to obtain. An inexpensive patent may cost $8,000 and take three years to procure. By then, the open source community may have moved on from a given design.

Patents are expensive and time consuming to obtain in part because patent law is complex. Not only must the inventor create something that meets the criteria enumerated above, in the patent application she must describe how to make and use the invention and draft "claims" that specify what she wants to protect. Claim drafting is a highly nuanced undertaking that professional patent attorneys or patent agents typically perform (with accompanying costs).

Copyrights, on the other hand, are comparatively cheaper and easier. As indicated above, copyright protection automatically conveys for creations in a "tangible medium of expression," such as writing. Federal registration for a copyright can cost less than $100, and laypeople can generally file for the registration without attorney assistance.

Copyrights may be of limited value to makers of hardware, however, because they do not protect utilitarian objects, only creative expression. As mentioned in the introduction, hardware designers may still benefit from copyright protection for an STL file because the threshold for what counts as "creative" expression is extremely low: simple prose, simple pictures, and simple software code can suffice.

The copyright statute's applicability to technical drawings has particular salience to open source design. If an STL file of a useful object can constitute a "technical drawing," it may receive copyright protection, but only if the technical drawing contains a modicum of creativity (Osborn 2014). But this is an unsettled question in the law: Does a CAD or STL file of a heat exchanger contain copyrightable creativity (Osborn 2017)? Even if copyright law protected a file, it would prevent only slavish copying of the file. It would not prevent someone from independently creating her own design file of a heat exchanger.

The ability to control multiple generations of downstream users is a key distinction between open source and public domain software.

Given the importance of IP law to open source licensing, open hardware designers should become familiar with it.

How IP Law Can Hinder 3D Printing Technology

Intellectual property law can slow 3D printing technology development if it overprotects rights holders. Overprotection implies that the costs (deadweight loss from higher prices and slower follow-on innovation) outweigh the benefits (incentives to create, invent, and commercialize).

Too Much Incentive?

If patents are stronger than needed to incentivize innovation, society may needlessly endure some of patents' negative effects. Thus, policymakers must understand that 3D printing technology significantly reduces the cost of innovation (Osborn et al. 2016).

- Building and modifying prototypes is markedly easier and less expensive.
- The technology also allows multiple designers to collaborate remotely to improve a product iteratively.
- Once a product is finalized, 3D printing technology lowers the costs of distribution by allowing users to share the design files instantaneously over the Internet.
- The technology revolutionizes manufacturing by allowing users to "print" items remotely.

People therefore need less monetary incentive to engage in these activities. In these ways 3D printing challenges the fundamental cost-benefit analysis undergirding the current US intellectual property system. Moreover, people invent and create for nonmonetary reasons too—just consider the open source hardware movement. People may innovate because they love the innovation process, or for professional or community recognition, or to improve the world (Raustiala and Sprigman 2012).

As the need for monetary innovation incentives shrinks, nonmonetary incentives provide proportionally more of the incentive to create. If the cost to invent or create is near zero, then the standard incentive-based IP theory largely disappears; there are no "sunk costs" that need to be recouped, and nonmonetary incentives might supply sufficient fodder for creation (Lemley 2015).

Reevaluating Intellectual Property Law

In such a world, lawmakers will need to reevaluate IP law. Some will suggest abolishing patents and copyrights, at least in certain technology sectors (such as 3D-printable goods). But that might be overly hasty, because 3D printing technology also makes copying cheaper and easier. This has at least two effects.

Without IP protection, copiers will not need to attribute anything to the inventor.

First, even innovators who experience relatively modest costs to create are vulnerable to being undercut by copiers. With 3D printing technology, copying another's design files can be costless and instantaneous. Thus, IP law may remain salient simply from a cost perspective.

Second, copying can dampen even nonmonetary incentives. For example, someone who creates a new product may want some sort of recognition for the accomplishment and/or may want to control how it is used and distributed. But without IP law of some sort (or perhaps contractual protections), free riders will not need to attribute anything to the first creator. Person A may do all the work, but person B may get all the credit.

Thus, even with mature 3D printing technology, society will likely benefit from some form of IP or other legal protection, though perhaps the term of protection could be shorter. Even before 3D printing fully matures, however, policymakers should analyze IP laws and consider rebalancing them in the face of this technology.

Mechanisms for Rebalancing IP Rights

One way lawmakers can rebalance the strength of IP rights is by shortening the term of protection (Osborn et al. 2016). Today most copyrights last for the life of the author plus another 70 years, and patents last 20 years from the date they are filed. One can reasonably argue that lawmakers should shorten these periods given the decreased costs of innovation for 3D-printable products. Policymakers will debate how much to shorten them, and there is certainly no magic number. I suggest that lawmakers shorten the term enough to enable measurement of the change's impact; for example, taking at least 5 years off the 20-year patent term.

Changing the terms of patents and copyrights would, however, weaken those IP rights across all technology sectors, not only for 3D-printable products. Alternatively, lawmakers may want to weaken patents only in certain technology sectors. For example, commentators tend to agree that the software industry has much less need for patent protection than does the pharmaceutical industry (e.g., Kesan and Gallo 2009). Pharmaceutical companies might spend more than $1 billion to develop a single successful blockbuster drug (with many failed drugs along the way), whereas software companies (where technological failure rates are much lower) might spend several orders of magnitude less to develop a successful program. Moreover, software enjoys separate copyright protection against slavish copying.

Lawmakers thus might lower patent strength in specific industries where 3D printing (or other technological improvements) has lowered the costs of research and development. And rather than simply shortening the patent term for "sectors affected by 3D printing" (a vague and changing category), lawmakers could use patent law doctrine selectively for goods affected by 3D printing.

Although technical patent doctrine is beyond the scope of this article, a simple example can suffice. One way to infringe a patent is to "make" the patented thing without permission. Currently, patent law doctrine does not clearly state whether an STL file that will print a utilitarian device (1) is itself eligible for patenting (as opposed to patenting the physical device, which patent law clearly allows) or (2) will infringe a

patent directed to the physical device (Holbrook and Osborn 2015).

Lawmakers and courts could interpret these doctrinal questions in such a way as to weaken patents by declaring that STL files (1) are not patentable and (2) will not infringe a patent directed to a physical device. The net effect of these rules would be to weaken (dramatically) patent protection for items that can be 3D printed because a patent holder would only have a direct infringement claim against a person who physically printed the STL file (i.e., who "made" the physical object). But because discovering who prints an object in the privacy of their home or small business could be extremely difficult, the patent holder would effectively have a very weak patent.

Conclusion

Laws are formulated based on input from various interested constituencies. If parties with interests at stake do not fully participate in the political process, the law may not reflect their views and society might be worse off. It is thus incumbent on those scientists and engineers who truly understand 3D printing technology to consider what sort of IP rules would best incentivize innovation and to advocate for such rules.

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