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Case Study of HP to Learn About IP

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Case Study of HP to Learn About IP

by

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Table of Contents

Introduction	1
Why We Have a Patent System: Theory	1
1. Natural Rights	2
2. “Reward for Services Rendered”	2
3. Monopoly Profits Incentive	2
4. Exchange for Secrets	3
The Practical Side of Patents	4
The Value of Patents	5
Case study: Hewlett-Packard, Inc.	6
Patents and Litigation.....	7
Alternate Measure of a Patent’s Usefulness	8
References in a Patent.....	9
Patent Maps	10
Does the Way That Patents Are Used Match the Intent of the Patent System?	16
Summary: Evaluation of the US Patent Law System	16
Bibliography	18
Appendix A: The Patent Maps Developed in This Project	21
Appendix B: Considerations for Future Work.....	22
Appendix C: Reflections	23
Appendix D: Integration of Faith	24
Appendix E: Spreadsheet Built As Part Of This Project.....	25
Appendix F: Matlab Program Written As Part Of This Project	26
Main code: pat_map.m	26
Secondary level function: pre_findandplot.m.....	30
Secondary level function: suc_findandplot.m.....	31
Secondary level function: markers.m	32
Tertiary level function: id_coords.m.....	35
Tertiary level function: suc_id_coords.m	36
Tertiary level function: sortandplot.m	37

Introduction

The term “patent” conjures up images of inventors dreaming up the next market-revolutionizing innovation, or tinkering with Rube Goldberg machines. The term can also prompt thoughts of companies grappling with lawsuits over one company’s use of another company’s patent in a product, with millions of dollars at stake. Patents themselves are in fact legal assets that are categorized as intellectual property, which like physical property can be owned by individuals and businesses. Patents can be quite valuable, because for a limited time a patent grants its owners the right to exclude others from using the idea that the patent claims. This enables whoever owns a patent to profit from their development of novel innovations by allowing them to control whether their patented innovation can be used in potentially competing products; in other words, the owner gets to use their patented innovation without fear that competitors will steal the idea and potentially take the market share the owner is aiming to capture. This system incentivizes sharing new ideas, ultimately benefitting society as well as the inventor—society enjoys the use of products incorporating the new ideas, and the patent system provides a means to publish the ideas and inspire more new ideas. This paper examines the philosophic justification of the patent system, the process of obtaining a patent, and the value of a patent asset to both its holder and to society through various metrics.

Why We Have a Patent System: Theory

The US government grants patents with the intent to promote innovation, by providing an avenue for novel processes and things, commonly called widgets, to be published and later allowing any patented ideas behind those processes and widgets to be used freely by the public (as the time limit of each patent expires). The publishing of patents also has potential to spark new ideas before the patent expires, and thus fuel further innovations. However, patents do grant an exclusive right over the use of an idea for a twenty-year period, which may be decried as an excessive time period during which newly developed products can be marketed above the price range of many possible consumers. Avenues besides patents also serve to protect intellectual achievements, including copyright, trademarks, and trade secrets. Likewise other methods exist to promote innovation, including offering prizes for solving a particular challenge; in industries like electronics, often the primary incentive to innovate is being the first to get a product to market. Thus, some consider the temporary monopoly provided by patents unjustified. The following theory provides a counterargument to that position.

There are several philosophical rationalizations that justify the granting of patents. These include the concept of original ideas being personal property (and thus owning them being a natural right), the concept of patents being a “reward for services rendered,” the concept of “monopoly profits incentive,” and the concept of granting the patent being in exchange for secrets (innovations). Each of these concepts is fleshed out below.

1. *Natural Rights*

John Locke proposed a framework justifying private property based on an original assumption that self-ownership is a natural right. From this premise, a person's labor is his or her own. Locke proposed that mixing one's labor with materials held in common with the rest of humanity gave one a right to claim the product of this combination as one's own property, subject to the qualification that "as much and as good" of the original materials was left available for the rest of humanity, and that one did not take more than one could use. [1, p. 26] While the 'as much and as good' qualification can present issues when applied to finite resources, no such issue exists when applied to ideas, "For the number of good ideas is indenumerable." [2, p. 95] This notion is supported by the sheer number of patent applications filed: over 8 million patents have been issued in the US since the US patent office was instituted, with over one million patent applications pending at the end of 2011. [3, p.15] While an elegant system, this natural rights argument for intellectual property does present challenges in terms of when these ideas may be used by the public: does the inventor own the idea or only "the concrete, physical *tokens* of their innovation" [4, p. 118], and is that ownership perpetual [1, p. 26]? The argument also fails to address how property rights should be allocated when multiple innovators have contributed to the final product. [1, p. 27]

2. *"Reward for Services Rendered"*

Under the assumption that innovation is beneficial to society, the idea that society is "morally obligated" to provide compensation for generating innovation constitutes one of the rationalizations for granting patents. However, this rationalization assumes that the invention was developed with "conscious effort and hard work" by the inventor; it does not provide guidance when attempting to award the development of innovations by accident. This rationalization is also challenging because it assumes that the immediate market value the inventor can obtain is an adequate reward for the invention. But current market value is not always an appropriate way to measure an invention's usefulness to society: some patents do not become economical to implement until well after they expire, while others net far above their intrinsic value to society by incorporation into fad products. [1, p. 27]

3. *Monopoly Profits Incentive*

An alternative way of rationalizing the granting of patents is that offering a temporary monopoly on the use of a particular new idea spurs a "societally optimal level of innovation." [1, p. 28] Adjusting the time period of this temporary monopoly is assumed to likewise adjust the level of innovation. This approach yields part of the justification of US patent law, though the uniform 20-year term for utility patents affects the dynamics of different fields differently. These differing effects are reflected in the tendencies of some fields to use patents to block competitors' development completely, as where the fields are comprised of "discrete products" protected by relatively few patents. [5, p. 31]

Pharmaceutical applications often fall into this category, in part because adjusting small aspects of a compound can mean that the compound stays in the body too long and so is deemed toxic, or that the compound does not stay in the body long enough to effectively medicate. [6] In contrast, fields like electronics generate products with complex combinations of discrete components, and so specific products are covered by a multitude of patents held by different companies, promoting the practice of cross-licensing. [5, p. 29-30] Other factors also affect the applicability of the monopoly profits incentive for patents: in some fields simply being the first to market yields competitive advantages that are comparable, if not greater, in magnitude to holding patents on the pertinent technology, even though not obtaining patents on the methods and technology allows competitors to mimic those methods and technology without penalty.

4. *Exchange for Secrets*

Still another model justifying the granting of patents holds that most innovations would remain secret without the incentive of a patent system. [1, p. 28] This is a legitimate concern according to Larry Kahaner, who coaches businesses to mine all available information sources to gain a competitive edge: “More than 75 percent of the information contained in U.S. patents is never released anywhere else.” [7, p. 112] By offering a patent, it is posited that developments that otherwise would not have been published, even if developed in parallel by independent parties, will be published in the form of the patent for the whole public to learn from. This model is another that undergirds the US patent system. Today the difference between publishing and not publishing an idea is still important, but when that idea is incorporated into a product the difference is slightly less than it has been over the past decades. This is because “the technological resources available for reverse engineering... [have] increased, thereby also increasing the ability and reducing the cost of extracting a good idea from its physical realization.” [2, p. 99] This means both that keeping trade secrets can be more difficult and that enforcing IP rights is increasingly arduous, especially on an international level.

The US relies primarily on the third and fourth principles for its justification of granting patents. [1, p. 29-30] This impacts how US laws regarding patents are constructed. Promoting profit or protecting inventors’ rights are not the end goals of US patent law—patents are offered as the incentive in exchange for the benefit of encouraging, documenting, and sparking more innovation.¹ With these theoretical justifications for the patent system in mind, let us examine how this system operates on the practical level.

¹ “The patent law is directed to the public purposes of fostering technological progress, investment in research and development, capital formation, entrepreneurship, innovation, natural strength, and international competitiveness.” (Hilton Davis v. Warner-Jenkinson) [8]

² HP also experimented with sub-\$80 printers in 1999, but this is not mentioned in

The Practical Side of Patents

The process of securing a patent in the United States is resource intensive. You must first invent something that is novel and ‘non-obvious’—not an obvious extension of prior art (processes and widgets either currently patented or in the public domain). Then, you must decide whether it is worthwhile obtaining a patent on the invention. The process of obtaining a patent is a costly one, generally taking approximately twenty-four months. This requires many hours spent scouring the US Patent Trademark Office’s (USPTO) patent database for similar ideas in order to determine the novelty of the given innovation, followed by filing complex forms and carefully drafting claims on strict deadlines by highly paid patent attorneys or agents in consultation, initially with the engineer/s who did the inventing, and then with an examiner from the USPTO, which itself first requires a licensing fee. During the process you can claim that your innovation is ‘patent pending.’ All said and done you might emerge from this lengthy, expensive process with a shiny new patent, or you might not. Even if your filing is successful, the patent may not ultimately be worth anything. On the other hand, it could net a substantial profit, either directly or indirectly. This range of value arises from the nature of the rights that patents convey.

A patent is a license from the federal government granting inventors a temporary right to exclude others from using their invention. This ‘negative’ right is intended to incentivize and compensate innovators for the investment of time and funds required to create new inventions that will eventually enter the public domain. This license allows inventors to profit through the use of their patent or through the licensing of its use to others, and to claim damages from those who infringe upon the patent by using the invention without permission. [9] This means that a patent’s worth is directly tied to how useful the idea(s) claimed in the patent are to furthering the field and products in which they might be used. A patent is very valuable if it enables the holder to produce and sell products that are in some way superior to those already on the market, potentially capturing a greater market share. The patent holder can also license the patent’s use to others that they do not view as direct competitors, retaining their own market potential while generating further income from the licensing fees. Patent holders may also exchange licenses with each other—this is cross-licensing, and it enables the inventors to combine the usefulness of their own patents with the developments of others. This may generate some competition from the other innovators’ products, but allows each inventor to market a superior product than they could before. Obtaining licenses to others’ patents may in fact be necessary to use the patent at hand, because the prior patents can exclude the use of our inventor’s patent. The more integral a patented invention is to the improvement of a given product line, the more valuable the exclusivity provided by the patent to its holder is.

Inventors do not always own the patent rights of their inventions, or rather, the right to wield the patent is not always held by the inventors. There is an option for inventors to assign their right of exclusion to another entity, called the assignee. This is how companies develop their patent portfolios. For example Hewlett-Packard boasts a portfolio of 36,000

patents worldwide as of 2012. [10, p. 10] Universities, individuals, and patent holding companies can also be assignees. Having an assignee means that the inventors are not responsible for identifying and tracking down infringements on their patents—the assignee is. On the other hand, the inventors are also not in charge of licensing, and do not necessarily gain any monetary returns from their patent. This is how research and development programs tend to work. The researchers develop new technologies, and are paid to do so. Their employer (or research sponsor in the case of university research grants) receives ownership of the work, and reaps the benefits of any patentable technologies developed.

Company assignees weigh the economic benefit of obtaining and defending patents very carefully. While the benefits of owning the patent on a given invention may be substantial, the invention might also not be useful in developing a new or better product, or might be easily developmentally circumvented, and thus be little more than a sinkhole for application labor and processing fees. Furthermore, while a company may decide to invest in obtaining various patents, not all of those patents will necessarily end up in products or be licensed or cross-licensed to others. Far fewer patents are defended in court—the resources required to file litigation usually dwarf the benefits of maintaining an exclusive right to the given innovation, and submitting to the decision of the court risks owing significant compensation to the other party. Thus, except when a significant amount of money is at stake and the potential licensee is uncooperative, companies often opt to grant either an express license to use their patent or an implied license (assumed when a relatively long period of time passes without allegations of infringement). [1, p. 330] The innovations a company views as its most valuable can thus be readily deduced by identifying the patents that it has chosen to defend in court.

The Value of Patents

The pace of many developing technologies is such that keeping the competition out of a particular portion of the market (represented by the patent) is enough to outpace competitors in terms of progressing to the next product revolution. Thus, patent disputes, or the threat of them, can be wielded rather ruthlessly as a strategic business tool.

Patents are assets, much like a piece of equipment. The entity with rights of ownership may use the equipment or rent it to another party, but these benefits are the exclusive right of the owner of the equipment. Applied to patents, this exclusivity means that ownership of patents is rigorously questioned and tested because the financial implications of rights of ownership are substantial. In exploring the business usages of patents, this project focused on patent disputes taken to court, because these disputes are over the patents that the companies involved are implicitly identifying as most important to them—patent litigation is a notoriously expensive and lengthy ordeal. To narrow the search for this type of dispute, domestic cases were identified which involved Hewlett-Packard, a large electronics hardware and software corporation that boasts the development of

thousands of patents over the past several decades. [10, p. 10] This paper focuses on one of the cases HP chose to litigate rigorously.

Case study: Hewlett-Packard, Inc.

Reviewing HP’s annual stockholder reports, HP clearly places significant emphasis on the importance of intellectual property (IP) to its ability to do business. HP’s reports from 1994, 1995 and 1996 attribute the maintenance of HP’s technical leadership to its researchers’ “technical competence and creative ability.” [11, p.5] [12, p.6] [13, p.6] Within a few years, this wording shifted to emphasize the fact that “there can be no assurance that any of the Company’s proprietary rights will not be challenged, invalidated or circumvented, or that any such rights will provide significant competitive advantages.” [14, p.6] [15, p.7] [16, p.7] In 2012, the report included significant emphasis on IP to remain competitive. Emphasis on remaining competitive in a technical, electronics-based field means that HP does substantial research and development, which contributes heavily to its large IP portfolio. As noted above, to narrow the scope of this research, this paper considers only patents that had been involved in litigation. The scope of research was further refined to focus only on patents specifically pertaining to HP’s printer products.

HP has developed printers based on many types of technology over the years: thermal jet, laser jet, and inkjet are among those technologies. Inkjet technology is the most relevant to the court case and patents discussed below. HP rolled out its first inkjet printer in 1984, with the DeskJet printer being the “‘breakthrough’ product” in 1987. [17] According to the (non-affiliated) HP museum website, inkjet printer sales experienced dramatic growth through the 90s. [17] This is paralleled by the grouping of Imaging and Printing Systems into a named subsection of the company starting in 1999 [16, p.47], and regrouped as the Imaging and Printing Group in subsequent years. This means, in part, that printing (and imaging) systems brought in enough money to warrant discrete reporting in HP’s annual stockholders report. Prior to this, HP’s printing product groups had been listed with Computer products, service and support, and referred to as personal peripherals. [11, p.3] [12, p.3] [13, p.3] [14, p.40] From 1994 to 1998, HP reported steady increases in profits from printing hardware and supplies. Starting in 1999, however, HP started reporting gross margin decreases on hardware. This was primarily attributed to competitive pricing: HP noted reaching out to the sub-\$150 printer market starting in 2001 [18, p.18-24], and to the sub-\$100 printer market starting in 2002.² [19, p.28] HP also noted a ‘softening’ of the business and then the home printer markets starting in 2000 [20, p.14]— in other words, nearing market saturation. This does not mean that HP was selling fewer printers, but rather that the number of printers sold year to year was not increasing as quickly. Additionally, printers by themselves are “low-margin” products—they are not

² HP also experimented with sub-\$80 printers in 1999, but this is not mentioned in subsequent reports. [16, p.4]

products that could quickly cover the costs of their development through the profit they generate.

In order to turn a profit, HP's Printing Systems segment relies on more than selling printing hardware. As a whole, the segment reported gross margin increases in the same period that profit generated on hardware was plateauing. Printer supplies, specifically ink cartridges, were the primary profit-generating products. Supplies like ink cartridges need to be continually replenished by printer owners, and so provide steady sale volumes. Described as "high-margin" products, the average price of these supplies was also increased, something specifically noted in 2001. [18, p.24] In sum, ink was and is important to HP's printing systems' business model.

Beginning in 2001, HP started including a note in their annual reports about "refill and remanufactured alternatives for our supplies [which] are available from independent suppliers and, although generally offering lower print quality, may be offered at lower prices and put pressure on our supplies business." [18, p.11]³ This happens to also be the year that HP started listing litigation that it was involved in by name—prior to this stockholders saw only some variation of "HP is involved in lawsuits, claims, investigations and proceedings, including patent... matters, which arise in the ordinary course of business," followed by the assurance that "There are no such matters pending that HP expects to be material in relation to its business, financial condition or results of operations." [16, p.47] Before these changes, HP had been involved in litigation with one of those independent suppliers: Repeat-O-Type Stencil Manufacturing Corporation (hereafter referred to as RoT). This case involved HP's ink cartridges for its inkjet printers, and specifically the HP patents used in those cartridges. These patents are examined together as a case study in the rest of this report.

Patents and Litigation

Hewlett-Packard uses profits from selling its single-use ink cartridges to support the development and manufacture not only of the ink cartridges, but also of the associated printers. Repeat-O-Type developed a method to render HP ink cartridges refillable, and sold these ink cartridges, effectively reducing HP's profits to the first set of its single-use cartridges bought by a printer customer. Since the cartridges were built using technology covered by multiple HP patents, HP filed against RoT for patent infringement in a case that reached the Federal Court of Appeals in 1997 (the Supreme Court denied certiorari in 1998 [21][22]). The goal was to keep HP's single-use ink cartridges as the only available option

³ The 2012 report tells that "independent suppliers offer refill and remanufactured alternatives for HP original inkjet and toner supplies, which are often available for lower prices and generally offer lower print quality and reliability. Other companies also have developed and marketed new compatible cartridges for HP's laser and inkjet products, particularly outside of the United States where intellectual property protection is inadequate or ineffective." [10, p. 11]

for customers buying HP's printers, and thereby retain monopoly power in the marketplace for this product line.

At least twelve HP patents were used in the two types of HP ink cartridges involved in the case. HP filed suit against RoT for infringement of all twelve patents, varying from patents on parts of the cartridges themselves to the ink formulated for them. The court determined that only the patents for the two cartridge components RoT was actively modifying were pertinent in deciding whether RoT was producing a new product. [23, §C. The Remaining Patents in Suit] Producing a new product would constitute infringement upon all twelve patents, as opposed to the lawful reselling of an existing product, since that new product would read onto, or infringe, all of the patented ideas that remained in use in the modified cartridges. This meant that all of the patents would be pertinent in determining the amount RoT would be liable for if found guilty of infringement.

In this case, the question was whether RoT's activity constituted 'permissible repair' or 'impermissible reconstruction.' This technical legal distinction involves the right of a buyer to perform repairs to their property. However, this right does not include completely rebuilding the patented product. The court found RoT's activity to constitute permissible repair (albeit premature) because RoT was modifying *new* HP ink cartridges purchased from "a legitimate source" and because the modification that RoT made was not a reconstruction (new construction) of the original patented combination. [23, §A. The '294 and '811 Patents] RoT was therefore found not guilty of infringing on any of HP's patents.

HP makes a point in each of its annual reports about how "in general no single patent is in itself essential to us as a whole or any of our principal business segments."⁴ [20, p.9] This case was built on not just one patent, but twelve; cases like this prompt another phrase in HP's annual reports: "any of our intellectual property rights could be challenged, invalidated or *circumvented*, or our intellectual property rights may not provide competitive advantages" (emphasis added). [18, p.33] In the context of a stockholders report, these disclaimers speak to the relative unpredictability of investing in the development or litigation of patent rights.

Alternate Measure of a Patent's Usefulness

As mentioned above, companies weigh the costs of obtaining patents carefully, and there are various ways that investing in obtaining a patent may not be profitable. In HP's words, "any of our ... intellectual property rights may not be sufficient to permit us to take advantage of current market trends or to otherwise provide competitive advantages." [10, p.24] The lack of finding infringement in the Repeat-O-Type case seems to fall under the 'may not be sufficient' category in that it essentially circumvented HP's intent that

⁴ The "in general" qualifier does not appear in the 2012 report, though it does appear in every report from 1994 to 2003.

customers buy new ink cartridges each time they emptied a given set.⁵ Focusing on this information would suggest that the value of these patents was not as great as HP had hoped.

Patents provide exclusive rights to a specific piece of intellectual property. That property might correspond to a relatively large or small ‘space,’ but nothing prevents others from exploring and claiming the idea space ‘neighboring’ that of a given patent. This means that the economic return of obtaining a patent may not be very great, because others could potentially circumvent the innovation as protected by the patent. Furthermore, prior patents may block access to the property claimed by the patent in question (we might have expected the use of RoT’s patent, US patent no. 5408256, “Refillable Color Ink Jet Cartridge And Method For Making Said Cartridge” to be blocked by HP’s patents in this way). This does not mean that the given patent does not have value as an innovation—rather that the inventors or assignees themselves might not reap that value. A patent’s value can be in marking a novel concept in a technological field, drawing other people to explore and optimize the potential uses of that idea. One way of quantifying this is by examining the number of patents that reference a given patent.

References in a Patent

An important component of a patent document is the section listing references. Patents include references to other patents and sometimes papers as a means to point out the differences between the invention being claimed and what has previously been invented. Aspects that are referenced are considered outside what the patent is actually claiming. Including multiple references thus serves to clarify what a patent is *not* claiming.

The goal of the patent filer is to claim as large a piece of intellectual real estate as possible, thus maximizing the likelihood that their patent will be valuable when negotiating for licenses. In this light, it seems that including many references would encroach on the borders of the intellectual property being claimed. This is not always the case. Some of the patents reviewed in this research included around 100 references; all of the patents included at least one reference. Specifically with regard to the number of references included, there are different tactics employed in filing for patents.

There are several reasons why references are used. First, while patents do not try to educate the reader about what the patented idea actually is, they must convince the patent examiner that the idea is or can readily be implemented in real life. This means that a patent needs to provide enough information, including an accurate description of the widget or process, such that a “person having ordinary skill in the art,” that is, someone who’s already working in the field the patent deals with, would be able to figure out how the patented process or widget works. [24] Including references in the patent application can help

⁵ “HP contends that it has clearly manifested its intent that the ink jet cartridges be non-refillable. The package insert accompanying...the cartridges suggests that the cartridges be discarded once they are empty; HP does not sell refillable cartridges, and HP does not sell ink refills.” [23, §A. The ‘294 and ‘811 Patents]

streamline the documents and information required to ensure this. A second reason for including references is that the patent examiner is ensuring that the claimed invention is not ‘more invented’ than the actual invention—that is, that the inventor is not claiming more intellectual property than their invention actually represents. The examiner must check existing patents to ensure that the claimed invention has not previously been invented (and thus is “novel”); therefore, including most of the possible references to other inventions and distinguishing the innovation in the patent application from those previous inventions can eliminate some of the initial exchanges between the filer and the examiner. This can also be helpful to the examiner in determining whether the claimed invention is actually innovative. Including more references can thus make the prosecution process faster.

Regardless of how few or how many references are included in a given patent, there is usually some connection between the patents in a given field. This can be exploited in studying key breakthroughs in that field, the direction of development, and/or identifying the field’s primary players. Identifying key breakthroughs might be achieved by comparing volumes of succeeding patents that reference the ‘key’ patents, as in Table 1 above. These patents are all unique in the number of succeeding patents that reference them: “Seventy to 80 percent of patents are never cited by another inventor in his patent.” [7, p.113] It is little wonder then that they were involved in litigation: “when one particular patent is cited continually, it shows that the assignee owns some leading-edge technology.” [7, p.113] In studying these and other patents, however, a more comprehensive tool is a graphic representation in the form of a patent map.

Patent Maps

A patent map works essentially like a family tree for patents. All of the patents that examined in this research cited at least one reference. Additionally, and unusually, all of the patents involved in the studied case were cited by later patents. Both of these facts signal that the patents were well related to other work in the electronics/printing hardware field. This is immediately apparent when the patents are shown with their references and referencing patents in a patent map. Figure 1 (page 12) is a map for patent number 4347524, the oldest of the patents involved in the studied case. While this patent has one of the smallest lists of patents that reference back to it according to Table 1, it is clear that this patent represents a valuable contribution to its field: many companies reference it in their

Patent no. of patents involved in HP v. RoT	Number referencing patents
4347524	24
4635073	52
4683481	160
4771295	354
4794410	54
4794411	33
4812859	116
4827294	119
4862197	70
4872027	128
4931811	77
5108503	34
5408256* (RoT’s patent)	15

Table 1. Patents involved in HP vs. Repeat-O-Type

own patents, including several companies that HP lists as direct competitors (in this map that includes Xerox Corporation, Lexmark International Group Inc., and Canon USA, Inc.).⁶ [18, p.11] Besides aiding in the identification of important breakthroughs for the industry, patent maps thus also help identify major players in the fields—companies with multiple patents appearing in a patent map, especially one that spans multiple ‘generations’ of patents, are most likely actively pursuing innovations for their products. Comparing the maps in this report, companies like Canon and IBM are likely candidates, alongside HP. Identifying companies doing research and development in a given area is facilitated by the qualities of the maps generated for this report—they incorporate different line styles and colors as outlined by Table 2, with patents linked by a blue line being developed by the same company.

Table 2. Map line key

Map quality	Meaning
Blue line	Patent is referencing a patent developed by the same company
Black line	Patent is referencing a patent developed by someone else
Dotted line	Referenced patent expired before being referenced
Solid line	Referenced patent was still in effect when referenced

Interconnection between patents, in this case patents predominately assigned to HP, is especially apparent when multiple patents are plotted together. All of the HP patents that HP accused RoT of infringing, excepting the 4347534 patent (shown separately in Figure 1), are shown together in Figure 2. The patents involved in litigation are marked with yellow triangles (when marking litigation the legend lists the company with whom HP was involved in litigation over the given patent). Unlike Figure 1, Figure 2 does not explicitly show patents coming after the patents the map is based on. Rather, it focuses on references that the HP patents held in common. This map actually does not show all of the patents referenced; this is explained in depth in Appendix A, and also affects the number of patents shown in Figure 1. However, the map still effectively demonstrates that the patents are substantially interconnected. This is consistent with the analogy of the map working like a family tree for patents; furthermore, in this case the maps show that the patents represent a very inbred family!

⁶ The same companies, in a different order, appear in HP 2002 report [19, p.9]; competitors were not listed prior to 2001. The companies listed above are named specifically as competitors with HP’s Imaging and Printing Systems segment.

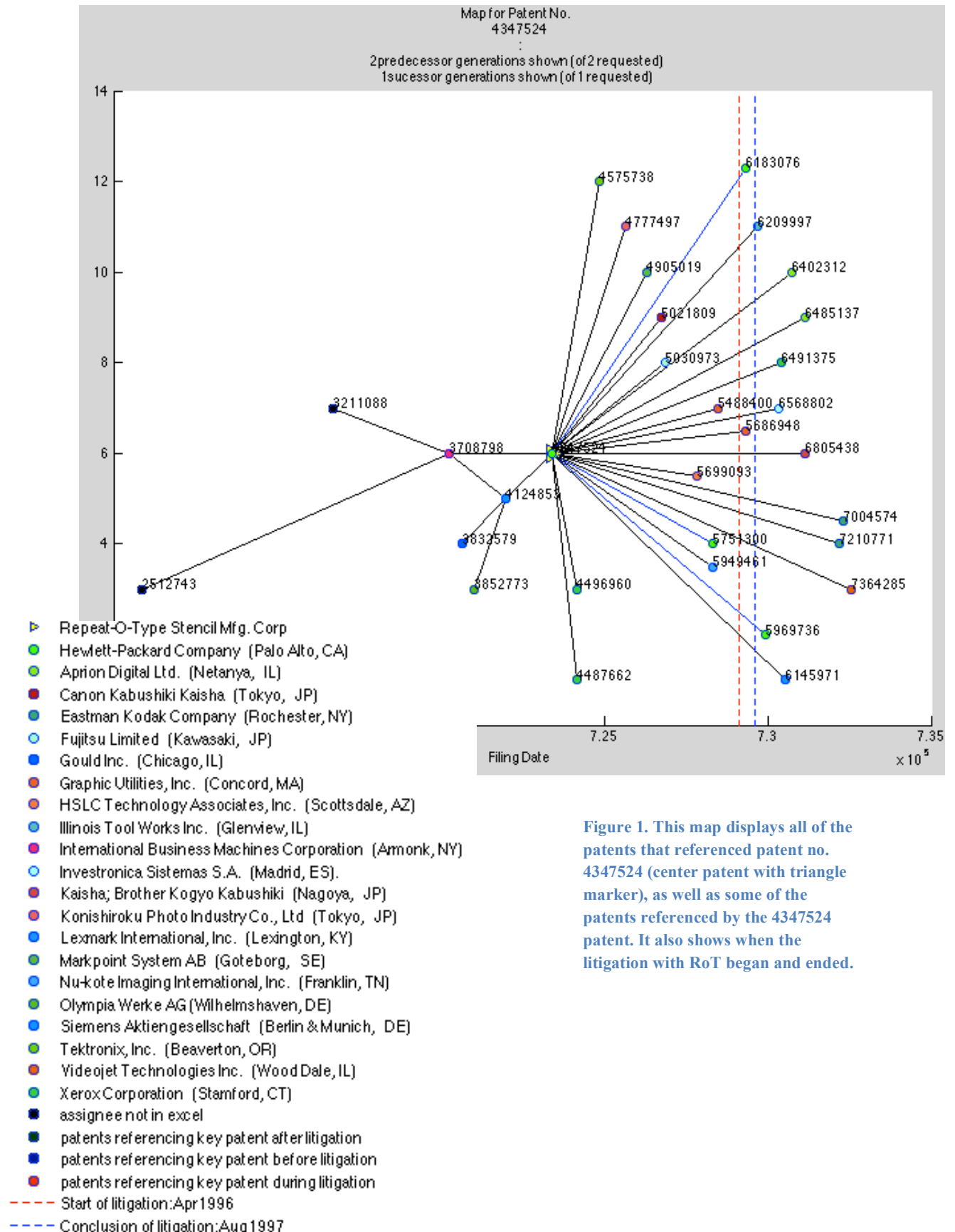


Figure 1. This map displays all of the patents that referenced patent no. 4347524 (center patent with triangle marker), as well as some of the patents referenced by the 4347524 patent. It also shows when the litigation with RoT began and ended.

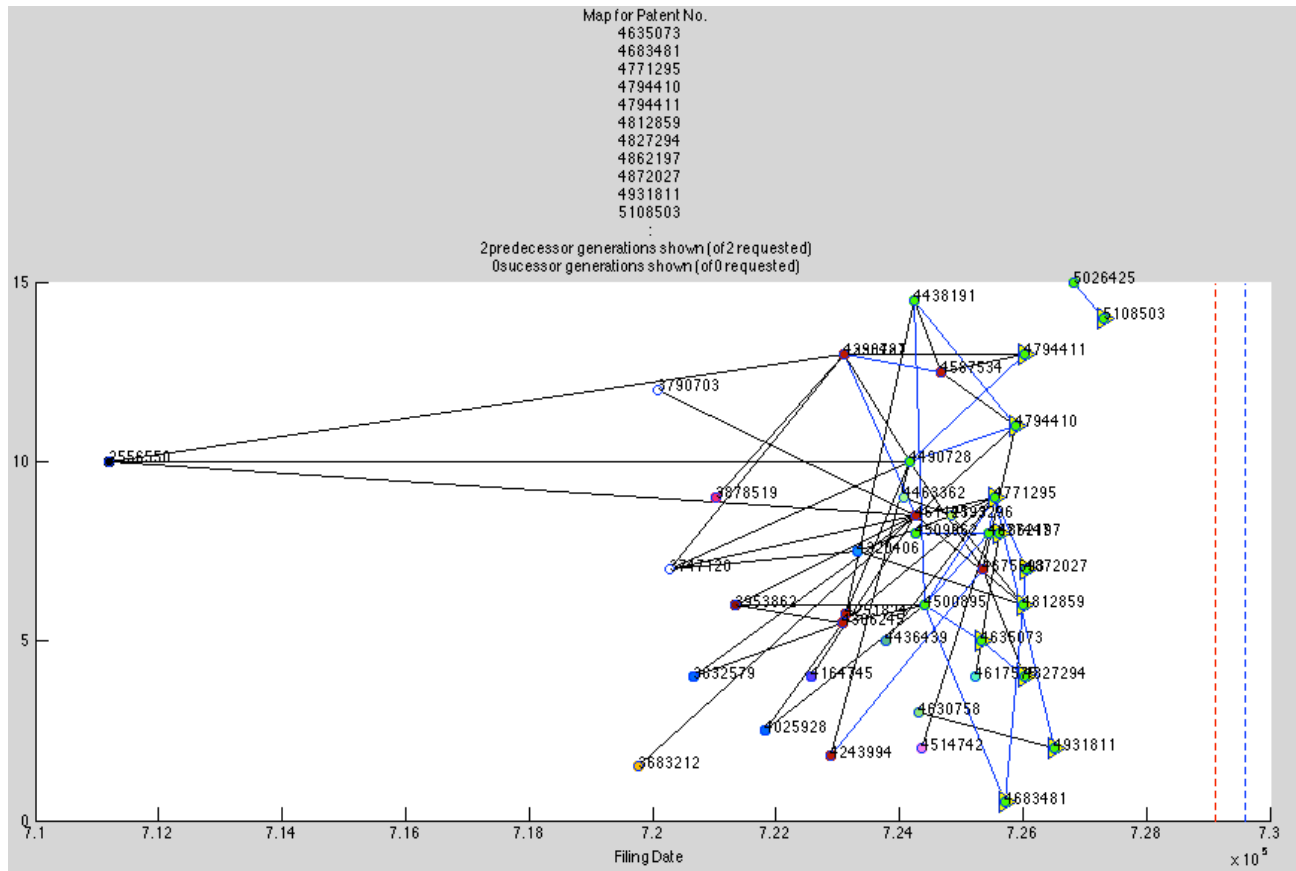


Figure 2. This map shows all but one of the patents HP accused Repeat-O-Type of infringing. The other patent, no. 4347534, is shown in Figure 1. This map demonstrates how interconnected the patents in a given field can be.

While, as noted above, the typical volume of references cited in a company's patents varies some depending on strategy, a patent with many references of its own is notable in that it often represents a piece of intellectual property that the filing company views as integral to further developments. [25] Besides ensuring that the company is able to use the patented idea (which could alternately be accomplished by allowing the innovation to directly enter the public domain), this type of filing is partly influenced by the practice of developing and patenting technologies that competitors are expected to need, in order to increase leveraging power when negotiating for cross-licensing agreements. Specifically in electronics, this contributes to companies' dependence on technologies developed by others: HP notes that "much of our business and many of our products rely on key technologies developed by third parties." [18, p.33] This is true despite the fact that HP's IP portfolio is very large. This is explained, at least in part, by "the rapid pace of technological change in the information technology industry." [18, p.33] This emphasizes that companies are developing their printing products while the technology is current. It also highlights the absence of one of the map qualities listed in Table 2 among the maps included in this report: dotted lines linking patents. The program built and used for this project displays references to expired patents with this different formatting relative to those patents referenced before they expired. However, almost none of this formatting is apparent in the included maps. Therefore, it is reasonable to assume that it would not make business sense to wait until the original patents expired to improve products. The maps thus further illustrate the importance of being able to obtain licenses from other companies.

When it comes to patents, obtaining a license is the safest way to avoid litigation. However, with so many patents on sometimes narrow and nebulous ideas, it is often impractical for a company to seek licenses to use every patent that might possibly appear in their product. If accused of infringement, there seems to be neither a guarantee of winning or losing in court. This makes going to court an expensive gamble, but Figure 3 seems to suggest that the information technology market is lucrative enough that many are willing to make that bet. Figure 3 shows a patent map that includes patent 4931811 (lower left corner) from the HP v. RoT case, along with patents that were involved in other larger court cases (marked with yellow triangles with different colored outlines, per the legend). It is especially interesting to find that three different cases involved patents that dealt with technology very related to each other.

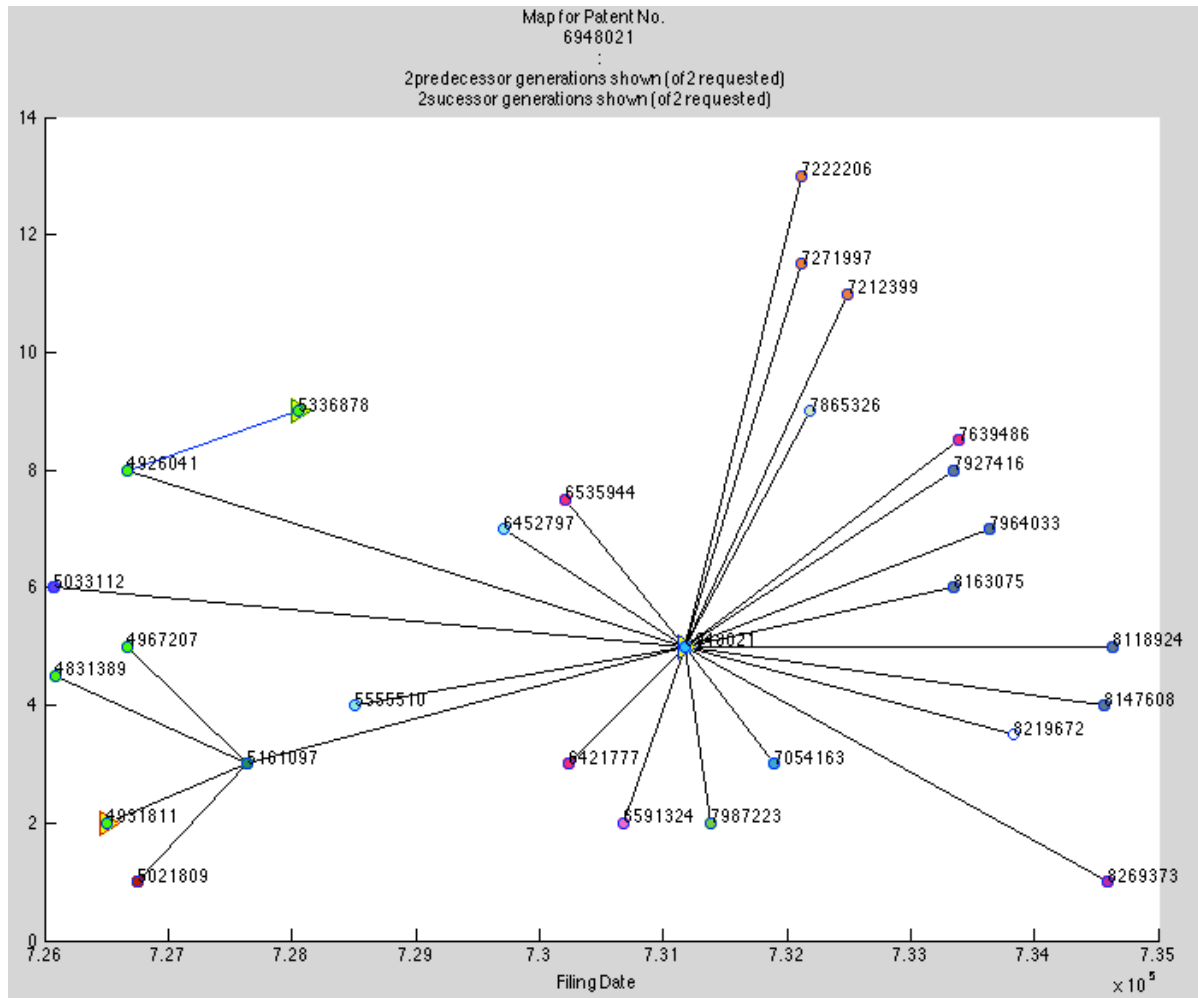


Figure 3. This map shows all of the patents that referenced patent no. 6948021, as well as several patents that were referenced by 6948021. Patent no. 4931811 (lower left) was implicated in the HP v. RoT case examined in this report.

- ▶ Acceleron LLC
- ▶ Repeat-O-Type Stencil Mfg. Corp
- ▶ Mustek Sys., Inc
- Hewlett-Packard Company (Palo Alto, CA)
- ADC Telecommunications, Inc. (Eden Prairie, MN)
- Canon Kabushiki Kaisha (Tokyo, JP)
- Dia. Semicon Systems Incorporated (Tokyo, JP)
- Intel Corporation (Santa Clara, CA)
- International Business Machines Corporation (Armonk, NY)
- Juniper Networks, Inc. (Sunnyvale, CA)
- National Instruments Corporation (Austin, TX)
- Nexcom International Co. Ltd. (Chung-Ho, TW)
- Northern Telecom Limited (Montreal, CA)
- Oracle America, Inc. (Redwood City, CA)
- Racemi Systems (Duluth, GA)
- Sensient Colors LLC (St. Louis, MO)
- Vulcan Portals, Inc. (Seattle, WA)
- no company assignee

Does the Way That Patents Are Used Match the Intent of the Patent System?

This research demonstrates that identifying trends in patented technologies is challenging. There is not a time-dependency in the generation of new ideas, and even filtering to only patents involved in litigation does not guarantee that the patent was referenced often. However, there are characteristic traits of patents that are attributable to the way the United States patent law is structured. Patents are filed in order to obtain an exclusive right to a new idea, a right which can generate profits through constructing a superior product or licensing. That incentive is offered because US patent law recognizes that publicizing innovative ideas feeds into the generation of both more ideas and improved products all around both before and after the patent expires.

This project does not focus on a technological field that invites criticism based on the ethics of keeping the right to use an invention in the field exclusive. Innovations with respect to printers and computers may make the end consumer's life easier, but being required to pay a little more for these products is not something that can legitimately be challenged as unfair or unethical, something pharmaceutical innovations which could improve public health are sometimes accused of. However, this project does focus on the way that patents are used in business.

Patents are tools that are used in business, and themselves are amoral. Sometimes businesses wield patents in seemingly cutthroat ways, as in the case between HP and RoT. However, while the US patent system does not prioritize protecting inventors' rights over promoting innovation, the system does serve to protect inventors and companies from having their ideas stolen, helping to level the playing field between start-ups and large corporations. With large numbers of small entity inventors,⁷ providing some sort of protection from exploitation of ideas fosters an inviting environment for further innovation.

We can look at the success of the intent to promote innovation through the window of the patent maps shown in this paper and that are otherwise available, whether through the program built for this project or some other means. We can furthermore see through this case study how companies might value their patents, and also see how customers' benefit from the innovations (in this paper: needing fewer ink cartridges) may well differ from the benefit primarily sought by companies (selling maximum volumes of ink cartridges).

Summary: Evaluation of the US Patent Law System

By examining the ways in which patents are used in fields not subject to ethical or moral criticism, it becomes easier to more effectively evaluate the extent to which accusations of unjust business practices are actually warranted. This in turn can aid in the evaluation of the effectiveness of current patent law and thus suggest necessary updates to US patent law. The US has recently changed over to a first inventor to file system from a

⁷ "Between the years 2007 and 2011 about 20% of utility patents were issued to small entities." [3, p.22]

first to invent system,⁸ in part to help streamline the prosecution process and keep up with the volume of patent applications (the new system also better matches international practices). [3, p.163] With today's rate of technological advancement, previous expectations of how patent law affects inventors and the public should be revisited and include a comparison between the old and new systems. Additional changes may be advisable, but great care should be taken in determining further steps: changes could easily have unintended effects well beyond the specific issues targeted, including killing or suppressing the environment that currently promotes research and development and innovation. It is hoped that this project may contribute to a better understanding of that environment.

⁸ A first to invent system grants the right to patent to the first person who invented a given process or widget, even in the case where a later, independent inventor files for a patent first. A first inventor to file system simply grants the right to patent to the first inventor who files for the patent.

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Appendix A: The Patent Maps Developed in This Project

I built up my patent maps beginning with the patents involved in the case described above and then looked up the patents they referenced. I then worked back, adding patents that were referenced by at least one of those patents. I did not completely add all of the patents referenced, simply because of the volume of references made—several of the patents I came across made over fifty references, with a couple nearing 100 references. Therefore, some patents that were listed as references by up to two patents were not included in the database I built, though the program I wrote to generate maps does include a list of the referenced patents that were not listed. If a patent was referenced at least three times, it is in the database I compiled. After gathering a list of ‘referenced’ patents, I then looked up patents that referenced the patents involved in the cases above. This yielded a list for each key patent of between 15 and 360 patents. Though this feature does not appear in the maps shown in this paper, larger lists are consolidated into markers showing the number of referencing patents before, during, and after the litigation—they are the only numbers that do not have seven digits on the maps. Those markers are based on the earliest and latest instances of filing and court opinions that I could find between the parties involved in each case. I combined this information with the USPTO-provided list of the first patent issued each year to approximate which patents were filed before litigation started and which were filed after it ended. [26] While this information did not ultimately appear in my paper, I did examine it as briefly addressed in Appendix C.

My map shows each patent at its filing in a serial date number format. In this format, 7.1×10^5 on the x-axis corresponds to November 30, 1943, 7.3×10^5 corresponds to September 2, 1998, and so on, with an increment of 7306 representing approximately one year. The patents are shown at their filing date because this is when the USPTO starts counting the twenty years for the limited-time monopoly that the patent grants—the twenty years does *not* start when the patent is granted. [1, p.19] This is because the inventor is allowed to commercialize the use of their invention for up to one year before filing for a patent, and to continue using their invention on the market during the patenting process. The goal here to ensure that inventors cannot effectively extend the time of their exclusive right to the use of their invention past the allotted twenty years the government grants the patent for. Note that if the inventor uses their invention for more than one year before filing for a patent, or if they at all publish any information about it before that one year, that they forfeit the right to patent. [27]

Other features to note about my patent map are the markers and colors. In the map that I built, references are shown by lines connecting a patent to the patent referenced. To identify trends, if a patent references a patent filed by the same company, the line is blue; if the reference is to a patent filed by a different company the line is black. Also, if the referenced patent expired before the referencing patent was filed, the line is dotted; otherwise it is solid. This is laid out in Table 2. As a further help to identifying which companies filed which patents, the patents are color-coded. This color code is consistent

between the different maps, with Hewlett-Packard being bright green. The company colors are included in the legend for each map. As a note, if the company color is black, it means that the company is not identified in my database; this corresponds to the patents that the USPTO provides in .pdf format (those filed roughly before 1970). These patents are typically several ‘generations’ before the patents involved in the cases I am studying. Another color of special note is white, which represents patents filed by the inventor with no assignee. Patents that are known to have been involved in litigation are marked with a yellow triangle. If multiple patents have been involved in the same litigation, the outline of the triangles will be the same color. The map for patent no. 6948021 is interesting in that three cases are shown, and the patents they involved are not far removed from each other. In each map, the case names involved are listed in the legend along with the company color code.

Appendix B: Considerations for Future Work

In evaluating the maps I developed for future use, a couple things should be noted. First, my maps only include domestic utility patents. In reality there is much cross-referencing between US and foreign patents, but to narrow the scope of my project I limited myself to US patents. This is partly because the patents are required to be in English, and because the larger, more important patents are likely to be filed in the US in addition to in foreign countries. This means that there are several non-US based companies that appear in the patent maps and the database I compiled. Second, there are two major types of patents issued in the US: utility and design. I was only interested in patents that are actually useful, so I focused on utility patents. My code is written for the format of the utility patents; different formats are used for design patents, patents on plants, and reissued patents, respectively. Reissued patents and design patents are *not* included in my counts for patents issued before, during, and after litigation. However, there are a number of these patents that could be included in the counts. The third thing to consider about my maps is that the time period covered was operated under the ‘first to invent’ requirement, which changed in the United States to the ‘first to file’ system in 2013. [3, p.163] This change therefore does not affect my data, but it may have bearing on future studies of the effect of litigation on patenting trends.

Appendix C: Reflections

In embarking on this project of studying patents, I expected that there would be some trend eventually identifiable in my data. This expectation went wholly unfulfilled. I looked for trends in patents citing expired patents, trends indicating a lull in citing a particular patent while it was involved in litigation, and trends in numbers of referencing patents. I originally started with five instances of litigation; attempting to differentiate between the cases was unsuccessful, with one major attempt being to seek differences between the cases grouped by competitor/non-competitor relations. I ended up with plenty of practice coding in Matlab, an enormous Excel workbook of patent numbers and names as shown in the example in Appendix E (around two thousand entries total, with just over two hundred of those fully formatted), and a healthy appreciation for the fact that generating novel ideas is unpredictable.

In seeking trends in patenting, with the hindsight I have now, examining design patents may have been more fruitful than utility patents. I started this project in part curious if products were changed to incorporate current patents as older patents expired. While I found no evidence for this with utility patents, it is still possible with design patents. This is because design patents are not required to be “useful” like utility patents and have a shorter term—this makes them potentially easier to incorporate into products and update products on a regular basis. In either case, locating which patents applied to which products is difficult, as that information is rarely published. I found the product names incorporating the patents mentioned in this paper in the court documents; I did not find any similar litigation over design patents, and so know of no similar sources for design patents.

Appendix D: Integration of Faith

I focused my project on patents as a subject where the engineering and legal fields overlap. Patents themselves are amoral. How patents are used, however, demands consideration of ethics. Patents are used as tools in business, and can be argued to either prevent or promote exploitation of people, whether inventors, end-consumers, or taxpayers funding the legal system. This interests me, because I am interested in the American legal system and how legal rights (such as those conferred by patents) are construed in seeking to reach fair judgments. Specifically as a US citizen, my concern centers on what types of behaviors are incentivized by various systems in our law. My hope is that patent law in practice minimizes exploitation while actually delivering on its promise of promoting innovation. I think periodic evaluation of patent law is warranted to ensure this. I also think that, since God is a God of justice, Christians should actively engage in evaluation of both this area of the law and the law in general, seeking to uphold it and where necessary update it so that our legal system does in fact mete out justice.

Part of engaging the culture and working to make the world a better place involves credibility. The legal system is a human system, and by being human is by definition imperfect, but God uses it nonetheless. Christians' respecting the rules of the system shows their acknowledgement of God's using it; it also shows that Christians don't count themselves as above the law applied to other humans. That in itself helps prevent others from immediately dismissing Christians as pompous. When Christians maintain a positive presence in the legal field, especially when they fairly represent clients who aren't necessarily Christian, they provide a witness to God's valuing justice.

In my view, being a Christian means striving for the pinnacle of excellence in whatever I do. "Love the Lord your God with all your heart, soul, mind and strength" means that my performance in every endeavor serves as a witness to God's glory; my degree of dedication and hard work reflects my commitment to offering my "best" to God. Whether it is my achievements or my efforts that attract attention, I want them to command people's respect. In this way, my actions provide a positive reason for people to ask why I'm living the way I do—then I can take the opportunity to obey 1 Peter 3:15, "Be ready to speak up and tell anyone who asks why you're living the way you are..." (MSG). Because I identify myself as a Christian, I bear a responsibility to ensure that my actions positively reflect on Christ and Christians in general. This means that I press to the leading edge of my chosen fields' scholarship, upholding excellence in those fields, while remaining wholly sensitive to ethical and moral issues that may arise. We can turn our successes and breakthroughs back to give God glory. Each instance provides a new platform to share about Christ, places us in positions to be asked about our lives.

Appendix E: Spreadsheet Built As Part Of This Project

The below figure is representative of the entries in the spreadsheet built for this project, and which is integral to the code written for the project.

Y	Patent #	name	assignee	inventors	filng date	filng date serial #	granted date	granted date serial #	litigation?	notes	references
0.5	2512743	jet sprayer actuated by supersonic waves	assignee not in excel	C.W.Hansell Hidenbrand; Walter W. Brewster, NY); Levine; Wilbur International Business J. (Poughkeepsie, NY), Manning; Stanley A. (Yorktown Heights, NY), Stroms; Karl F. (Wappinger Falls, NY)	4/1/46	16893	6/27/50	18441			
6	3708798	INK DISTRIBUTION FOR NON-IMPACT PRINTING RECORDER	International Business Machines Corporation (Armonk, NY)	Hara; Toshiami (Tokyo, JP), Sato; Yasushi (Kawasaki, JP), Takatori; Yasushi (Machida, JP), Shirato; Yoshiaki (Yokohama, JP)	12/23/71	26290	1/27/73	26666			2512743 3054109 3211088
4	4251824	Liquid jet recording method with variable thermal viscosity modulation	Canon Kabushiki Kaisha (Tokyo, JP) Epson Corporation (Nagano, JP) & Kabushiki Kaisha Suwa Seikosha (Tokyo, JP)	Koto; Haruhiko (Shiojiri, JP)	11/13/79	29172	2/17/81	29634			3308475 3480962 3553708
2	4436439	Small printer	Hewlett-Packard Company (Palo Alto, CA)	Johnson; Samuel A. (Eagle, ID)	8/26/81	29824	3/13/84	30754		Repeat-O-Type	3941230 4053040 4213714
17	4683481	Thermal ink jet common-color imager utilizing novel trichromatic beamsplitter	Hewlett-Packard Company (Palo Alto, CA)	Vincent; Kent D. (Cupertino, CA)	12/4/86	31750	7/28/87	31986		Repeat-O-Type	4188635 4271416 4376284
18	4709144	Ink delivery system	Hewlett-Packard Company (Palo Alto, CA)	Kapilinsky; George T. (San Diego, CA)	4/2/86	31504	11/24/87	32105			2392978 2749792 3498693
19	4714937	Process for manufacturing thermal ink jet printhead and integrated circuit (C)	Hewlett-Packard Company (Palo Alto, CA)	Stoffel; John L. (San Diego, CA)	10/2/86	31687	12/22/87	32133			4392147 4403233 4489335
12	4862197	Ink jet recording device with pressure-fluctuation absorption	Canon Kabushiki Kaisha (Tokyo, JP)	Abe; Tsutomu (Isehara, JP), Ebisawa; Isao (Tokyo, JP), Watanabe; Kenjiro (Tokyo, JP), Karita; Seichiro (Yokohama, JP)	8/28/86	31652	8/29/89	32749		Repeat-O-Type	4617575 Japan: 0259467
4	5021809	Ink jet recording device with pressure-fluctuation absorption	Canon Kabushiki Kaisha (Tokyo, JP)	Karita; Seichiro (Yokohama, JP)	10/10/89	32791	6/4/91	33393			3083689 4057807 4115789

The first column of the spreadsheet dictated where on the y-axis each patent was plotted. Values were assigned and adjusted by hand.

Columns for patent number, title, assignee, inventors, filing date and granted date, and references were all populated with information from the USPTO patent database. The date columns include two different formats, with the serial date format being used in the Matlab program.

The litigation column listed cases the given patent was known to be involved in. The notes column included notices on the USPTO website about corrections; notes also aided in keeping track of y-column values.

Patents listed as references in each patent were listed in the row corresponding to the patent; the rows extended as many columns as necessary to include all references, though not all references were listed for every patent in the spreadsheet.

Appendix F: Matlab Program Written As Part Of This Project

The following script and functions were coded in Matlab for this project. These scripts are not optimized for speed; however, they are designed to create patent maps like and including those shown in Figures 1, 2, and 3 for any of the patents included in the spreadsheets made for this project (see example of spreadsheet in Appendix E). The only feature in which the code is specific to a particular patent involves reassignments (in `pat_map.m` and `markers.m`, pointed out with comment `%Reassignments`); only one patent encountered in this project was known to have been reassigned multiple times, and the litigation it was involved in was not ultimately covered in the final paper.

Main code: pat_map.m

```
% FULL PATENT MAP: traces from a given patent to patents it references or
% from the given patent to patents that reference it (as specified)
% and so on back through the end of the database

close all
clc
clear all

[num,txt]=xlsread('beg.pat.info.xlsx');
B=num(:,:); % column1=arbitrary y-values, column2=patent#s,
            % column11=references
B(:,7)=B(:,7)+datenum('30-Dec-1899'); % filing date
B(:,9)=B(:,9)+datenum('30-Dec-1899'); % granted date
D=txt;

%asks user which patent to build map off of
prompt = {'Identify patent number to examine:',...
          'Number of generations to show: predecessor',...
          'Number of generations to show: successor',...
          'Litigation start date: month/day/year (type 0/0/0 to ignore
litigation)',...
          'Litigation end date: month/day/year (type 0/0/0 to ignore
litigation)',...
          'Reassignments?'}; %Reassignments currently specific to Acceleron
                             %case
dlg_title = 'Patent number and generations to examine';
default_dates = {'6948021','2','1','0/0/0','0/0/0','0'};
info = inputdlg(prompt,dlg_title,1,default_dates);

nums=strsplit(char(info(1)),';');
KP=str2double(nums');
generations_pre=str2double(info(2));
generations_suc=str2double(info(3));
start_lit=datenum(info(4)); % date conversion in Matlab,
                           % offset from Excel
end_lit=datenum(info(5)); % unnecessary; determination of whether
                           % to plot made in markers
reassignment_flag=str2double(info(6));

yesnopre=isempty(generations_pre); %for checking whether to run given map
```

```

if yesnopre==1 xor isnan(generations_pre)==1
    generations_pre=0;
end
yesnosuc=isempty(generations_suc);
if yesnosuc==1 xor isnan(generations_suc)==1 %filter not catching, may
                                                %not be necessary
    generations_suc=0;
end

[z,patrow]=ismember(KP,B(:,2));
if z==0
    display('The entered patent is not in the existing database.',...
            'Please check the patent number.') % formatted like this,
    break                                     % swaps rows displayed
end

if yesnopre==0 && generations_pre<0
    display('Please check the number of predecessor generations to
show.',...
            'A negative number of generations was requested.')
    break
end

if yesnosuc==0 && generations_suc<0
    display('Please check the number of successor generations to
show.',...
            'A negative number of generations was requested.')
    break
end

f = figure('Visible','on','Position',[900,150,850,400]); % need this to
                                                        % adjust location and size
% subplot(2,1,1) %for displaying stats below map
zero=zeros(length(KP),1);
M=[KP patrow B(patrow,7) B(patrow,1) zero zero]; % setting up chosen
                                                % patent's id
k=M; % so defined for building list of 'allincluded'
allincluded=M;
count_inter=zeros(0,1);
count_intra=zeros(0,1);
count_expired=zeros(0,1);
count_nonexpired=zeros(0,1);
showngenerations_pre=0;
showngenerations_suc=0;

if yesnopre==0 && generations_pre>0
    % because yesno checks if generations_pre is empty
    ns=zeros(1);
    m=M;
    for i_pre=1:generations_pre
        [allincluded, m, ns, count_inter, count_intra,...
count_expired, count_nonexpired] = ...
pre_findandplot( m, B, D, k, allincluded, ns,...
count_inter, count_intra, count_expired, count_nonexpired);
    if isempty(m)==1
        showngenerations_pre=i_pre; % in case generations required
                                    % are fewer than requested
    end
end

```

```

        break
    end
    end
    n=ns(2:end); % because 1st ns entry = 0
    notincluded=length(n)
length(n)*100/(length(n)+length(allincluded))];
end

if yesnosuc==0 && generations_suc>0
    % because yesno checks if generations_suc empty
    m=M;
for i_suc=1:generations_suc
    [ allincluded, m, count_inter, count_intra,...
      count_expired, count_nonexpired ] = ...
      suc_findandplot( m, B, D, k, allincluded, ...
        count_inter, count_intra, count_expired, count_nonexpired);

    if isempty(m)==1
        showgenerations_suc=i_suc; % in case generations required
                                   % are fewer than requested
        break
    end
end
end

[litigation,num_pats_involved,CC]=markers(allincluded,D,B,comp_colors,...
    start_lit,end_lit,...
    reassignment_flag);
    % marks litigation and color codes the different companies

if showgenerations_pre>0
    gen_pre=showgenerations_pre;
else gen_pre=generations_pre;
end
if showgenerations_suc>0
    gen_suc=showgenerations_suc;
else gen_suc=generations_suc;
end

text((allincluded(:,3)+.1),allincluded(:,4)+.1,...
    char([char(num2str(allincluded(:,1))) char(D(allincluded(:,2),3))]))
    % plain num2str(allincluded(:,1) enough to just show numbers
title1=char(horzcat('Map for Patent No.',nums,': '));
title2=char(horzcat(num2str(gen_pre),...
    'predecessor generations shown (of', num2str(generations_pre),...
    ' requested)'));
title3=char(horzcat(num2str(gen_suc),'sucessor generations shown
(of',...
    num2str(generations_suc),' requested)'));
title([cellstr(title1);cellstr(title2);cellstr(title3)])

xlabel('Filing Date')

```

```

% xl=datevec(xlim);      % trying to put in terms of years instead of
                        % serial dates, doesn't seem to affect anything
% xlim=([xl(1,1) xl(2,1)+1]);

% subplot(2,1,2) %to show stats in figure under patent map
% text(0.5,0.1,num2str(unique(n)), 'VerticalAlignment', 'bottom')
%unique unlisted
% text(0.3,0.1,num2str(length(n)), 'VerticalAlignment', 'bottom')
%total # unlisted, with repeats
% text(0.1,0.1,num2str(allincluded(:,1)), 'VerticalAlignment', 'bottom')
%list of all included
hold off

lc_inter=length(count_inter);
lc_intra=length(count_intra);
lc_expired=length(count_expired);
lc_nonexpired=length(count_nonexpired);

inter=[lc_inter lc_inter*100/(lc_inter+lc_intra)];
intra=[lc_intra lc_intra*100/(lc_inter+lc_intra)];
expired=[lc_expired lc_expired*100/(lc_expired+lc_nonexpired)];
nonexpired=[lc_nonexpired lc_nonexpired*100/(lc_expired+lc_nonexpired)];

% printoutlabel=[char('inter-company') char('intra-company') ...
%               char('expired') char('non-expired') char('not in database')]
% printout=[inter intra expired nonexpired notincluded]
%           % only predecessor map generates included/not included lists

```


Secondary level function: pre_findandplot.m

```

function [ allincluded, m, ns, count_inter, count_intra,...
    count_expired, count_nonexpired ] = ...
    pre_findandplot( m, B, D, k, allincluded, ns,...
        count_inter, count_intra, count_expired, count_nonexpired)
%pre_findandplot
% Finds and plots patents that are referenced by the input patents in m;
% plot is labeled in other scripts. Also outputs a list of patents that
% are referenced but not included in database.

for j=1:length(m(:,1))
    patnum=m(j,1:4); % patnum=[pat#, excel_row, x-value(date), y-value]

    if j>1
        k=temp_m;
    end
    [n,mm]=id_coords(patnum,B); % predecessor version
                                % sorts into non-listed and listed,
                                % finds identifying info on referenced
                                % patents,including whether the referenced
                                % patent expired before being referenced

        ns=vertcat(ns,n);
    % inter- vs. intra-company
        mm(:,5)=strcmpi(D(mm(:,2)+1,4),D(patnum(2)+1,4));
                                % +1 because D includes headers
                                % yields logical if assignees same or not
                                % 1 means yes, 0 means not same

    % plotting and counts
        [m1,m2,m3,m4]=sortandplot(mm,patnum);
        count_inter=vertcat(count_inter,m3,m4);
        count_intra=vertcat(count_intra,m1,m2);
        count_expired=vertcat(count_expired,m2,m4);
        count_nonexpired=vertcat(count_nonexpired,m1,m3);

        if j==1 % so on first loop, before k is defined
            temp_m=mm;
        else
            temp_m=union(k,mm,'rows','stable');
        end
    end
    m=setdiff(temp_m,allincluded,'rows','stable');

    allincluded=vertcat(allincluded,temp_m);

end

```

Secondary level function: suc_findandplot.m

```

function [ allincluded, m, count_inter, count_intra,...
    count_expired, count_nonexpired ] = ...
    suc_findandplot( m, B, D, k, allincluded, ...
        count_inter, count_intra, count_expired, count_nonexpired)
%suc_findandplot
% Finds and plots patents that reference the input patents in m;
% plot is labeled in other scripts.

for j=1:length(m(:,1))
    patnum=m(j,1:4); % patnum=[pat#, excel_row, x-value(date), y-value]

    if j>1
        k=temp_m;
    end
    [~,mm]=suc_id_coords(patnum,B); % identifies referencing patents,
    % and shows whether the referenced
    % patent expired before being referenced

% inter- vs. intra-company
    mm(:,5)=strcmpi(D(mm(:,2)+1,4),D(patnum(2)+1,4));
    % +1 because D includes headers
    % yields logical if assignees same or not
    % 1 means yes, 0 means not same

% plotting and counts
    [m1,m2,m3,m4]=sortandplot(mm,patnum);
    count_inter=vertcat(count_inter,m3,m4);
    count_intra=vertcat(count_intra,m1,m2);
    count_expired=vertcat(count_expired,m2,m4);
    count_nonexpired=vertcat(count_nonexpired,m1,m3);

    if j==1 % so on first loop, before k is defined
        temp_m=mm;
    else
        temp_m=union(k,mm,'rows','stable');
    end
end
m=setdiff(temp_m,allincluded,'rows','stable'); % checks that new m only
    % looks at patents not already
    % checked

allincluded=vertcat(allincluded,temp_m);
    % above sees patents with multiple
    % references that don't have the same inter/intra
    % expired/non-expired tags as different, but not patents that
    % simply have multiple references

end

```

Secondary level function: markers.m

```

function [ litigation, num_pats_involved, CC ] = ...
    markers( allincluded, D , B, comp_colors,...
            start_lit,end_lit,reassignment_flag)
% markers plots markers for litigation and color codes different
% companies
% Besides plotting these markers, it outputs which patents are
% associated with specific cases (in the legend)

    excelrow=allincluded(:,2);
    X=allincluded(:,3);
    Y=allincluded(:,4);
    l=0;

% markers for litigation
    cases=char(D(allincluded(:,2)+1,10)); % +1 because D includes headers
    sizescases=size(cases);
    sumcases=sum(cases,2);
    none=ones(sizescases(1),1).*min(sumcases);
    lit_x=X(sumcases>none);
    lit_y=Y(sumcases>none);
    lit_c=sumcases(sumcases>none);
    totalcases=unique(lit_c,'stable');

        casecolors=[0 0 .8;
                    .8 0 0;
                    0 .5 0;
                    .8 0 .5;
                    .5 .5 .5;
                    .3 .8 0;
                    0 .8 .3];
        %the following is for checking colors
        %(for tonal distinction and whatnot):
        map=colormap; %or the list you're interested in
        hold on
        for i=1:length(map)
            scatter(1,i,'o','MarkerFaceColor',map(i,:))
        end
    for i=1:length(totalcases)
        l(i,:)=scatter(lit_x(lit_c==totalcases(i)),...
                    lit_y(lit_c==totalcases(i)),150,'>','filled','y',...
                    'MarkerEdgeColor', casecolors(i,:));
    end

% define matrix for output with pat# and case name
    pertinentrows=excelrow(sumcases>none);
    pertinentPatents=B(pertinentrows,2);
    casenames=D(pertinentrows+1,10);
    litigation=[num2str(pertinentPatents) char(casenames)]; %output,
        %smashes B&D stuff together
    stars=unique(casenames,'stable');

% # patents involved in cases
    [Cases,Ip]=unique(sort(casenames));
    if length(Ip)>1
        offset=[Ip(2:end,1); length(casenames)+1];
    elseif length(Ip)==1

```

```

        offset=2;
    elseif length(Ip)<1
        offset=0;
    end
    occurrences=offset-Ip;
    num_pats_involved=[num2str(occurrences) char(Cases)];
        % another output

% color-coding companies
comp_names=D(allincluded(:,2)+1,4);
DD=sortrows(D(2:end,4));
AA=[num2str(unique(sum(char(DD),2),'stable')) ...
    char(unique(DD,'stable'))];
maxA=size(AA)-4; % minus 4 because AA includes # index for each comp
A=char(comp_names);
sizeA=size(A);
comp_index=sum(A,2)+(maxA(2)-sizeA(2))*32; %originally maxA(2)=63
    % spaces added in from master list
    % SO MATCHES color list
    % turns company names into numbers,
    % can index from there
[C,IA,IC] = unique(comp_names); % ends up with same info as
    % comp_index
NC=hist(IC,length(C)); % NC is the # times each company
    % is cited, in order listed in C
HP=4788; % 'Hewlett-Packard Company'(Palo Alto, CA)'
IHP=find(comp_index==HP,1);
if isempty(IHP)==0
x=find(IA==IHP);
IAA=[ IHP; IA(1:x-1); IA(x+1:end)];
CC=A(IAA,:);
else
    CC=C;
end

%the numbering for companies is for all the companies in the excel,
%and can be replicated with lines 69-71
% the currently used list is in the 'companies' sheet in the excel
% **careful when sorting the excel to put the HP companies on top and the
% 'no company assignee' and the 'assignee not in excel' labels on the
% bottom--excel doesn't pay attention to case when sorting**
    %and if that doesn't work, some entries have the same #s
    %for characters, so check
%
%         DD=sortrows(D(2:end,4));
%         CC=sum(char(DD),2);
%         [C,IA,IC] = unique(CC,'rows');
%         NC=hist(IC,length(C));
%         as=CC(NC>1);
%         unique(as) %checking for which sums are repeated in map
%         AA=[num2str(sum(char(DD),2)) char(DD)];
%         unique(AA,'rows');

hold on
dd=zeros(0,1);
for i=1:length(comp_colors)
    ind=find(comp_index==comp_colors(i,1));
    cc=plot(X(ind),Y(ind), 'o', 'MarkerFaceColor',comp_colors(i,2:4));
    dd=vertcat(dd,cc);
end

```

```

end

% start & end of litigation
if start_lit>0 & end_lit>0
    lit_flag=1;
    starting = graph2d.constantline(start_lit, 'LineStyle','--',
'Color','r');
    changedependvar(starting,'x');
    ending = graph2d.constantline(end_lit, 'LineStyle','--',
'Color','b');
    changedependvar(ending,'x');
    dates=[double(starting); double(ending)];
        % to convert into correct number format for legend
else lit_flag=0;
end

% Reassignments... currently only set up for Acceleron case
if reassignment_flag>0
    redates=datenum(char('11/15/2001', '2/16/2004', '11/17/2005',...
        '5/31/2007'),2);
    newassignee=char(', Racemi Systems (original assignee)',...
        ', Five Paces Ventures, L.P.; Pattillo, Robert A.',...
        ', Racemi, Inc.',',', Acceleron, LLC');

    assigning=graph2d.constantline(redates, 'LineStyle','--', 'Color','g');
    changedependvar(assigning,'x');
    reinfo=strcat(datestr(redates,22),cellstr(newassignee));
    all_assign=double(assigning)*ones(4,1);
end

% Legend
if l>0 & reassignment_flag>0 & lit_flag>0
    legend([l;dd;dates;all_assign],...
        [stars;cellstr(CC);'Start of
litigation:',datestr(start_lit,28);...
'Conclusion of litigation:',datestr(end_lit,28);
reinfo],...
        'Location','EastOutside') %'Reassignments:',
        % for if there's litigation & reassignment
        % & specific litigation date range
    elseif l>0 & lit_flag>0
    legend([l;dd;dates],...
        [stars;cellstr(CC);'Start of
litigation:',datestr(start_lit,28);...
'Conclusion of litigation:',datestr(end_lit,28)],...
        'Location','EastOutside')
        % for if there's litigation & specific
        % litigation date range
    elseif l>0
    legend([l;dd],...
        [stars;cellstr(CC)],...
        'Location','EastOutside')

    else legend(dd,deblank(CC),'Location','EastOutside');
end
end
end

```

Tertiary level function: id_coords.m

```

function [ n, mm ] = id_coords( patnum, B )
%PREDECESSOR VERSION; see suc_id_coords for successor version
%Divides references into a non-listed group (n) and a listed group (m)
% The listed group m also contains coordinate info about the referenced
% patents and info about the patents' timing relationships (expired)

referenced=B(patnum(2), 11:end);
    % patnum=[pat#, excel_row, x-value(date), y-value]
I1 = isnan(referenced);
argR = find(I1 == 0, 1, 'last');
ref = referenced(:, 1:argR); %just referenced patents, no extra entries

[yesno,where]=ismember(ref',B(:,2));

% non-listed matrix
ns= -1*(yesno-ones(length(ref),1)).*ref';
n=ns(ns>0);

% listed matrix
mms=where(where>0);
mm=zeros(length(mms),6);
mm(:,1)=B(mms,2); % pat#
mm(:,2)=mms; % excel_row
mm(:,3)=B(mms,7); % filing date
mm(:,4)=B(mms,1); % y-value

% sorting
% expiration dates
if patnum(3)-mm(:,3)>datenum(20,1,1) % corresponds to 20 years
    mm(:,6)=1;
end

end

```

Tertiary level function: suc_id_coords.m

```

function [ n, mm ] = suc_id_coords( patnum, B )
%Lists patents that reference the patnum in output mm
% The group mm also contains coordinate info about the referencing
% patents and info about the patents' timing relationships (expired)

n=zeros(0,1); % included for compatibility when combining pre&suc maps

[mms,~]=find(B(:,12:end)==patnum(1,1));

% listed matrix
mm=zeros(length(mms),6);
mm(:,1)=B(mms,2); % pat#
mm(:,2)=mms; % excel_row
mm(:,3)=B(mms,7); % filing date
mm(:,4)=B(mms,1); % y-value

% sorting
% expiration dates
if mm(:,3)-patnum(3)>datenum(20,1,1) % corresponds to 20 years
    mm(:,6)=1;
end

end

```

Tertiary level function: sortandplot.m

```

function [ m1,m2,m3,m4 ] = sortandplot( mm, patnum )
%Sorts, plots, and prints info about relationship between referenced and
%referencing patents
%Sorts given patents (already found in the excel database) into
% groups based on whether the connection between them and the
% referencing patent is inter- or intra-company and whether the given
% patents expired before or after the referencing patent was filed.
%Prints info about categories.
%Plots sorted patents with lines adjusted for the different categories.

mmcats=mm(:,5:6); % categories
lm=length(mm(:,1));
one=ones(lm,1);
zero=zeros(lm,1);

X=mm(:,3); % want just x&y coordinates
Y=mm(:,4);

hold on

if lm==1
    coord=[patnum(:,3:4); mm(:,3:4)];
    if mmcats(:,1)==one & mmcats(:,2)==zero
        m1=mm(:,1);
        m2=zeros(0,1);
        m3=zeros(0,1);
        m4=zeros(0,1);
        plot(coord(:,1),coord(:,2),'b-')
    elseif mmcats(:,1)==one & mmcats(:,2)==one
        m2=mm(:,1);
        m1=zeros(0,1);
        m3=zeros(0,1);
        m4=zeros(0,1);
        plot(coord(:,1),coord(:,2),'b:')
    elseif mmcats(:,1)==zero & mmcats(:,2)==zero
        m3=mm(:,1);
        m1=zeros(0,1);
        m2=zeros(0,1);
        m4=zeros(0,1);
        plot(coord(:,1),coord(:,2),'k-')
    elseif mmcats(:,1)==zero & mmcats(:,2)==one
        m4=mm(:,1);
        m1=zeros(0,1);
        m2=zeros(0,1);
        m3=zeros(0,1);
        plot(coord(:,1),coord(:,2),'k:')
    end
else
    m1(:,1)=X(mmcats(:,1)==one & mmcats(:,2)==zero); % seems to work fine
    m1(:,2)=Y(mmcats(:,1)==one & mmcats(:,2)==zero); % IF more than one
                                                    % patent to evaluate

    if isempty(m1)==1
    else
        sm=size(m1);
        n=zeros(sm(1)*2,sm(2));
        for j=2:2:sm(1)*2

```



```

        n(j-1,:)=m1(j/2,:);
        n(j,:)=patnum(:,3:4);
    end
    plot(n(:,1),n(:,2),'b-')
end
m1=mm(mmcats(:,1)==one & mmcats(:,2)==zero);
% rewriting m1 so can access patent numbers from outside script

m2(:,1)=X(mmcats(:,1)==one & mmcats(:,2)==one);
m2(:,2)=Y(mmcats(:,1)==one & mmcats(:,2)==one);

    if isempty(m2)==1
    else
        sm=size(m2);
        n=zeros(sm(1)*2,sm(2));
        for j=2:2:sm(1)*2
            n(j-1,:)=m2(j/2,:);
            n(j,:)=patnum(:,3:4);
        end
        plot(n(:,1),n(:,2),'b:')
    end
m2=mm(mmcats(:,1)==one & mmcats(:,2)==one);
% rewriting m2 so can access patent numbers from outside script

m3(:,1)=X(mmcats(:,1)==zero & mmcats(:,2)==zero);
m3(:,2)=Y(mmcats(:,1)==zero & mmcats(:,2)==zero);

    if isempty(m3)==1
    else
        sm=size(m3);
        n=zeros(sm(1)*2,sm(2));
        for j=2:2:sm(1)*2
            n(j-1,:)=m3(j/2,:);
            n(j,:)=patnum(:,3:4);
        end
        plot(n(:,1),n(:,2),'k-')
    end
m3=mm(mmcats(:,1)==zero & mmcats(:,2)==zero);
% rewriting m3 so can access patent numbers from outside script

m4(:,1)=X(mmcats(:,1)==zero & mmcats(:,2)==one);
m4(:,2)=Y(mmcats(:,1)==zero & mmcats(:,2)==one);

    if isempty(m4)==1
    else
        sm=size(m4);
        n=zeros(sm(1)*2,sm(2));
        for j=2:2:sm(1)*2
            n(j-1,:)=m4(j/2,:);
            n(j,:)=patnum(:,3:4);
        end
        plot(n(:,1),n(:,2),'k:')
    end
m4=mm(mmcats(:,1)==zero & mmcats(:,2)==one);
% rewriting m4 so can access patent numbers from outside script
end
end

```