**Impact of 3D Printing Technology to Patent Law**

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I. An overview of 3D printing technology

 The modern patent law system originates from incentives for encouraging innovation and distribution of technologies. Technologies are complex and ever changing, while the laws and statutes are relatively definite and rigid. Constantly there are conflicts, impacts, and responses between the technology areas and the patent law system. The two systems are evolving interactively. Particularly, the three-dimensional (“3D”) printing technology, as a rapid prototyping or manufacturing technology, is increasing its technological availability to various industries and expanding its areas of functionalities and applications. The advance of 3D printing may eventually triggers patent wars between parties, e.g., patent wars between manufacturers and end users. (Placeholder1)

 On technological level, 3D printing technology compliments the traditional subtractive manufacturing processes, and is a fusion and a further development of digital technology, material technology and manufacturing technology. The new manufacturing technology for making products and components from scratch is an important and revolutionary invention of 20th century manufacturing industry. Emerging of consumer level 3D printers further accelerates the transition of 3D printing from the laboratories to consumer sides, and from industry context to individual context. Nowadays, 3D printing technology companies are selling various types of 3D printers, from million dollar 3D printers for printing components of supersonic jets, to sub-$1000 desktop 3D printers for 3D printing hobbyists.

 Such transitions fundamentally change the commercial processes, including configurations of manufacturing infrastructures, raw material supply chains and product sales. The 3D printing technology has such a deep impact to industrial manufacturing and commercial practice modes that it imposes a challenge to the current patent law system. Some scholars even believes that the 3D printing technology will shake the foundation of the patent system, because arguably there is no “use” in patent law sense when parties use 3D printing to avoid infringement. (Placeholder2) Companies in countries like the United States and the United Kingdom consider 3D printing technology as a major target for achieving further innovation in near future in the manufacturing industry. It is urgent to sort out and analyze, from patent law perspective, the legal problems derived from the socialization process of the application and distribution of 3D printing technology.

II. The impact of 3D printing development to the patent law system

 Comparing with traditional subtractive manufacturing technologies, the manufacturing mode using 3D printing is drastically different. The cost of replicating actual products decreases, and the manufacturing process is easier to be implemented. To make products, business owners and individuals may not need to purchase complex machines and equipment or to possess special skills. They can print the actual products using 3D printers based on 3D digital model files (as referred to as 3D blueprints). The only materials they need are the raw materials needed by the 3D printers.

 Research institutes and organizations around the world are promoting an open source movement for the 3D printing technology, such as the open source hardware and software of RepRap (replicating rapid prototyper) under the GNU General Public License developed by a group of British researchers. (Placeholder3) The open source movements further promote the research and development of 3D printing technology. (Placeholder4) The application areas of 3D printing also expand from originally industrial prototyping to other markets such as food and toys. Around year of 2014, some key patents in the 3D printing area, particularly the patents about laser sintering process, expired or will expire soon. Once the key laser sintering technology moves into the public domain, the development of 3D printing will explode. (Placeholder5)

 3D printing technology gradually moves into consumer world. Hardware and software cost for implementing 3D printing decrease over time. The prices of 3D printers, computer aided design (“CAD”) software, and 3D scanner become more affordable to business owners and individuals. However, a large-scale marketization of 3D printing still takes time and will not form in a very short period of time. Before the global market of 3D printing matures, the parties involving in the 3D printing concern the tension between capital investment return and the openness of software, hardware and 3D digital model files in 3D printing area. (Placeholder6) The parties also need a clarification on how to handle relevant legal issues, particularly issues in patent law area.

 The patent law system is designed to protect the legitimate interests of the patent owners, to encourage innovations and promote applications of the innovations, and therefore to promote scientific and technological development and economic growth of the society. The low cost and replicability of the patented products may harm the incentive for corporations to invest on development and design. (Placeholder7) Nowadays it is easier to provide source of 3D printing data, partially due to the development and perfection of 3D scanners and CAD software. There are also dedicated 3D printing online platforms enabling corporations and individuals to update, share and download 3D digital model files. The open structure of the Internet makes it hard to control or limit the online transferring and sharing of 3D digital model files. (Placeholder8) The traditional efforts to deter copycats by obtaining patenting protection face a significant challenge in the digital age.

 In turn, there is legitimate concern on whether the patent law system hinders the further development of the 3D printing technology. The industrial circle and academic circle are concerning the impact of 3D printing to the patent law system, as well as the responses to the 3D printing growth from the patent law system. Particularly, the further growth of 3D printing at least partially relies on the clarification of several important issues in the patent law areas. Can the patent law system continue to protect innovation and to prevent potential unfair or illegal replication in 3D printing area? How does the patent law balance between the rights of patent owners and the interests of the general public. How to determine whether a conduct of printing products using 3D printing technology constitutes patent infringement? Particularly, does 3D-printing a patented product or a component of a patented product constitutes “manufacturing” under patent law? Does distributing 3D model files of patented products constitute patent infringement? Is it economically viable for a patent owner to obtain appropriate monetary relief by asserting patent infringement against others who practice 3D printing? (Placeholder9)

III. Whether 3D-printing a patented product or a component of a patented product can constitute “manufacturing” under patent law

 Patent rights are exclusive rights. Entities and individuals cannot practice the patented invention without authorization of the patent owner. For example, the exclusive patent rights in the United States includes exclusive rights to make, use, offer to sell, sell patented invention within the United States and exclusive rights to import the patented invention into the United States.

 Upon the growth of the 3D printing technology, there is technological transferring from factories to desktop in some areas. Such technological transferring achieves breakthroughs over the economical limits and design obstacles of traditional manufacturing technology. (Placeholder10) Considering that the 3D printers print patented products or components of patented products, it is a question whether the technological process of “printing” constitutes “manufacturing” under patent law.

 The “manufacturing” under patent law means a processing of making a patented product to perform properly and to achieve technological functionalities as designed. Such a manufacturing process includes making a new copy of a patented product, as well as a full refurbishment or a substantial reconstruction of a patented product. (Placeholder12) The process of making a patented product itself is an independent conduct of practicing a patented invention, even though the process is usually accompanied by other conducts such as sales or importation.

 It is a misconception to only consider 3D printers peripheral devices of computers. 3D printing lays a technological foundation for the so called “Maker Movement” (for transferring ideas into reality not for profit). (Placeholder11) 3D printers enable corporations or individuals to make specific products in factories or even at home. When a 3D printer prints a product, the machine actually makes the product by a way of layered manufacturing. If the 3D-printed product is covered by a patent, an unauthorized conduct of printing can potentially constitute patent infringement.

 It is a harder question whether 3D-printing a component of a patented product constitutes “manufacturing” under patent law. The U.S. patent law system recognizes a doctrine of repair and reconstruction. After the sale of a patented product authorized or manufactured by the patent owner, or the patent expires, a user can freely use the patented product. If the any component of the patented product breaks or fails, the user may need to repair or replace the broken or failed component.

 Based on the doctrine of repair and reconstruction, the user or a repair can maintain the normal functionalities of the patented product by repairing or replacing the component. The conduct is a legal repair, as far as the repaired or replaced component itself is not covered by any claim of the patent or covered by another patent directed to that component. If the repair or replacement is out of certain extent and effectively makes a new product, the conduct can constitute an illegal reconstruction.

 The doctrine of repair and reconstruction has positive contribution to the balance between the rights of patent owners and the interests of the general public. However, it is not clear as to the test and standard for differentiating between repair and reconstruction. In Wilson v. Simpson, the Court emphasized that the durability of the replaced component and the intent of the patentee are important factors for determining a legal repair. (Placeholder13) In Afro Mfg. v. Convertible Top Replacement Co., the U.S. Supreme Court did not adopt the practice of considering factors including product life, cost, importance of the component, when deciding the issue under the doctrine of repair and reconstruction. (Placeholder14) The Supreme Court ruled in Afro Mfg. that a replacement of failed component of a patented product is maintenance of the functionality of the patented product instead of reconstructing the product, as far as the replaced component alone is not protected by any patent.

 Similarly in Universal Elec., Inc. v. Zenith Elec. Corp., the Court ruled that a remote control is part of a transmitting/receiving system, and that consumers can legally repair their broken remote controls to revert the system back to its normal working condition. (Placeholder15) In Everpure v. Cuno, Inc., the patent owner provided a manual to a user disclosing how to replace the filter cartridge and the filter, but did not specifically require the user to purchase the filter cartridge exclusively from the patent owner. (Placeholder16) The Court ruled that the user can legally replace the filter cartridge when the filter needs to be changed. All these cases differentiate between repair and reconstruction based on various factors. But the cases did not clarify the basis of considering these factors and the weights of the factors. Thus, these U.S. cases provides little practical guidance to future courts on the issue under the doctrine of repair and reconstruction. (Placeholder17)

 A British court differentiated between repair and reconstruction based on a theory of silent permission. (Placeholder18) The Court ruled that a purchaser has the right to repair the patented product including repairing component that is important to the working condition of the product, but the purchaser cannot make new copies of the patented product. In another case, the center of the dispute is whether the defendant’s conduct constitutes manufacture in the patent context. (Placeholder19) The patent covers a system including a filter and a filter frame. The defendant provided service to repair older filter frame and to install new filter. The defendant considered that he was repairing the system. After the sale of the system, anyone can extend if the life of the system by repairing it without considering whether the patent owner game silent permission. The Court ruled the defendant’s conduct to be manufacturing and found patent infringement. The Court reasoned that product no longer existed after removing the filter and the filter frame. In 2013, the Supreme Court of the United Kingdom used a multifactor analysis based on factors including the lives of the product and the component, the expectance of replacing the component, and inventive step. (Placeholder20)

 Although the courts considered some common factors in the above U.S. and U.K. cases, the emphasis was different in the cases. There is no relatively clear and consistent principle or standard formed yet for the doctrine. The unclear distinction between repair and reconstruction leads to uncertainty to consumers and business operators. It is hard to determine whether they infringe when the consumer or business operators use or resell products sold by or authorized by the patent owner.

 The 3D printing technology provides a new impact to the doctrine of repair and reconstruction. Upon emerging of the 3D printing, the industry of product components undergoes a deep change. In certain areas such as toys, the possibility of socialized manufacturing presents new challenges to the doctrine of repair and reconstruction. The 3D printing technology provides a possibility that the manufacturer and repairer of a component of a patented product is no longer has to be the business operator.

 When the patented product breaks or fails, the user no longer relies merely on the component manufacturer, the component seller, or the repair service provider. The user can just download or create (e.g., by 3D scanning) 3D digital model files, and then print a copy of the component that needs replacement. The user can even select the material of the component among plastics, metals or other materials based on the needs of the product or the user.

 The 3D-printed item is not a complete patented product, but a component of the patented product. It is a question whether the printing constitutes a manufacturing under the patent law. Furthermore, it is also a question whether a user legally repairs or illegally reconstructs a product, when the user simultaneously replaces multiple components of the patented product, or when the user repairs the product multiple times to maintain the product functionality. (Placeholder21)

 The above discussion shows that the differentiation between repair and reconstruction is important to the determination whether 3D-printing a component of patented product constitutes manufacturing under the patent law. It is necessary to have a clearer borderline between the concepts of repair and reconstruction.

 According to the patent exhaustion doctrine (also referred to as the first sale doctrine), for the patented product or product directly obtained by the patented process, made by the patent holder or authorized manufacturer, the patent holder exclusive rights on the patented product exhausts when the product is sold in the market. The patentee no longer has control over the sold patented product in a geographical area associated with the patent. The buyer of the patented product can freely use, offer to sell and resell the product.

 The distinction between repair and reconstruction is in fact a way of balancing of benefits between the patent owner’s exclusive rights and the rights of the product purchaser/user. The usage rights of the purchaser/user reflect on the right that the purchaser or user can repair the patented product to a certain extent. However, when the continuous usage of the patented product exceeds the extent of the usage right, the conduct may constitute illegal manufacturing.

 A multifactor analysis should be adopted to determine whether 3D-printing and replacing a component of a patented product constitutes repair or reconstruction. A balancing test should be used after weighing multiple factors including the life of the component, the relationship between the component life and product life, prevailing market opinion on whether the component is replaceable, and value percentage of the component proportionate to the product value.

IV. Whether distributing 3D model files of patented products can constitute patent infringement.

 3D digital model file is a key in the process of 3D printing. 3D digital model files can be created using 3D scanner or 3D CAD software. 3D printers transform the 3D blueprints into actual products by process of layered manufacturing.

 If 3D digital model files of a patented product is updated to the Internet for unrestricted downloading, it is highly possible that the patented product will be manufactured, as well as sold, offered for sale and imported. However under the current patent law, patentee likely would not be able to assert that creation or sale of the 3D digital model files of the patented product constitutes direct patent infringement. Creation of the 3D digital model files does not equal manufacturing of the patented product. Sale of the 3D digital model files does not equal sale of the patented product.

 Now it is a question whether creation or sale of the 3D digital model files of the patented product can constitute indirect patent infringement. Indirect patent infringement refers to the act that the actor does not directly infringe a patent, but objectively provides the necessary conditions for the occurrence of others’ direct infringement and subjectively induces the others to infringe or contributes to the infringement. (Placeholder22) The key issue in determining indirectly patent infringement is whether the actor supplies or offers to supply any “means relating to an essential element to put the invention into effect.” For the means relating to an essential element to put the invention into effect, courts in various countries start to apply it to a broader range beyond mere tangible tools. For instance, the appellate court of England ruled that providing CDs containing a game software or uploading a game software to a download website can constitute means relating to an essential element to put the invention into effect. (Placeholder23)

 Regarding the determination of indirect patent infringement based on creation or sale of the 3D digital model files, the dispute mainly focus on whether the 3D digital model files constitute means relating to an essential element to put the invention into effect, and whether creation or sale of the 3D digital model files provide necessary conditions for the occurrence of direct infringement. In other words, the question is whether the 3D digital model files are necessary means for users of 3D printers to manufacture the patented product, or just a digital form of product manufacturing instructions instead of a component of the patented product.

 3D digital model files are necessary where a patented product is manufactured only using 3D printing technology. There are reports that right after product designers update digital files of certain product, the products are offer for sale on other websites. (Placeholder24) In certain areas, online users can just implement the manufacturing process for a product using 3D printers, 3D digital model files and 3D printing materials. In these case, the 3D digital model files should constitute “means relating to an essential element to put the invention into effect”.

 In contrast, when a product is manufactured using traditional manufacturing process, 3D digital model files are not necessity for manufacturing the product. Since 3D scanner can create digital model files by scanning, in some areas manufacturers can freely select between traditional manufacturing process and 3D printing. In these scenario, there is a dispute on whether 3D digital model files constitute “means relating to an essential element to put the invention into effect”. (Placeholder25)

 In practice, some corporations start to use technological means to protect their 3D digital model files. These technology restrict downloading and printing of the 3D digital model files and limit transferring the 3D digital model files in networks. For instance, 3D Burrito is developing a trading platform website for 3D blueprints and offering data protection of the 3D blueprints. The website will enable trading 3D blueprints by adopting strategies to facilitate licensing negotiations.

 The current patent and copyright law systems cannot yet solve the entire problem of unauthorized distribution of 3D digital model files. Some scholars suggest that including claims directed to process of creating digital files for providing plan of manufacturing product when drafting patent claims. (Placeholder26)

 Although the patent law system has not directly responded to the issue of 3D digital model files, it can be a good response to adopt a relatively independent rule of indirect infringement associated with 3D digital model files. If the patent law or statute can provide an indirect infringement mechanism specifically for 3D printing, it will be much easier to identify indirect patent infringement in terms of the objective behavior, subjective intentions and behavioral consequences.

V. The patent law system’s possible responses to 3D printing revolution

 Whether and how the patent law system plays its institutional function appropriately in the future development of 3D printing technology depends largely on its responses to patent law issues derived from the 3D printing technology.

 The patent law system should create a counterpart of the Digital Millennium Copyright Act (“DMCA”), namely Digital Millennium Patent Law (“DMPA"). The growth of 3D printing technology has the potential to trigger a second file-sharing revolution. Adopting the DMCA approach, the patent law system can create a similar “notice and takedown” rule to prevent unauthorized distribution of 3D digital model files of patented products on the Internet.

 However, the rationality and feasibility of the protection mechanism similar to copyright protection have been questioned. Under the promotion of 3D printing technology, digitization of innovation and creation has a positive effect on forming an innovation open sharing system on the Internet. Enforcement of patent right protection by limiting distribution of 3D digital model files may slow down the development of 3D printing technology. The enforcement does not solve the fundamental problem of democratization of manufacturing and rise of end-user production. (Placeholder27)

 Moreover, when the patentee seeks cross-protection of 3D digital model files of patented products based on both patent and copyright laws, it can leads to problems of backdoor patent (Placeholder28) and mutant copyrights (Placeholder29).

 The patent law system should also revisit the foundation of the doctrine of repair and reconstruction. The patent law system should differentiate between legal repair and illegal reconstruction, by deicing the boundary or standard for the doctrine. As previously mentioned, 3D printing technology is a new impact to the patent law doctrine of repair and reconstruction. The level of legal clarity in the boundary between the concepts of repair and reconstruction allows consumers to better foresee the legal boundary of 3D printing activities, and allows patent owners to better plan the strategy for technological development and patent right protection.

 To some extent, 3D printing technology provides a chance to reconstruct the relationships among patent owners, product manufacturers, and consumers/end users from patent law perspective. In order to balance between patentee rights and interests of the general public prior to the existence of socialized manufacturing, some countries (China) treat the practice of other’s patented invention for non-commercial uses, as an exception to patent infringement.

 It may be helpful to adopt such a treatment by clarifying the non-commercial uses by statutes or case laws. For instance, the patent owner may get no monetary relief, if the 3D printing activity is for non-commercial use and the activity has little impact on the benefits of the patent owner. (Placeholder30). The case laws may set up certain boundary to the non-commercial use in 3D printing context, such as a threshold monetary upper limit for the value of a patented product, or a threshold quantity of replaced or repaired components.