

February, 2014

# Frictions Collaborative Creation of Knowledge vs. Practices in Trade and Commerce: The Example of Open Hardware

Peter Troxler  
Dannie Jost



# Frictions

## Collaborative Creation of Knowledge vs. Practices in Trade and Commerce: The Example of Open Hardware<sup>1</sup>

Peter Troxler (Rotterdam University of Applied Sciences)

Dannie Jost (World Trade Institute, University of Bern)

Knowledge creation in the twenty-first century is a collaborative and ubiquitous enterprise. It takes place in environments that are markedly shifting from traditional, hierarchical structures towards new, lateral and networked structures. This shift produces a variety of frictions and tensions between established ways of knowledge creation and new emergent knowledge creation modes. These frictions can be thought of as the indicators of an imminent industrial revolution catalysed by digital technologies, and favouring services over goods.

Today's technologies are complex and require the collaboration of many to produce machines that include both digital and physical components where both software and hardware are integral parts of sophisticated systems. The development of these systems takes place in institutional contexts which were not necessarily designed for collaboration. In particular, intellectual property rights were not conceived to handle collaborative intellectual assets. While open source methodology has long been established in software, for hardware it is new.

Most of today's legacy of intellectual property treaties and laws come from an era before digital technologies were invented and which did not envisage a broader class of intellectual assets that can accommodate the integration of digital and physical components. This proprietary legacy regime is glaringly ill-suited to the task of transmitting information about the knowledge pertaining to systems developed in collaboration, and it is not very helpful as legal titles for the commercialization of such integrated systems. In the future, as a result of the shift to more integration and a heavier reliance on tacit elements, competitiveness could rely less on proprietary systems or trade secrets, and more on collaborative and cooperative strategies.

In the first part of this article – frictions – we elaborate on the shift from hierarchical to lateral, networked structures in various fields. Specifically, we address the fields of software, content, design, electronics, manufacturing, and services. In all these fields we find various types of frictions between new structures and approaches and traditional ways of working with intellectual assets. Such frictions are valuable aids to understanding the shifts that are happening in society and they pinpoint areas where new practices are needed or are already under development.

In the second part – open hardware at CERN – we focus on one field in particular, the field of hardware. We introduce a specific example of how integrated electronics hardware is developed collaboratively at CERN and how CERN established a new practice to deal with intellectual assets in an open source way. CERN's open hardware licence, the reasons behind it, its implementation and how the licence benefits knowledge creation in science and research are also discussed.

In the third part – creativity and commerce – we consider the causes and consequences of this convergence in technologies and shifts in the modes of production that result in integrated systems comprising various types of software and a variety of hardware technologies produced cooperatively. In particular, we reflect upon the collaborative nature of knowledge creation and the emergence of open source strategies in the management of intellectual assets. These strategies have to mature in such a way as to sustainably nourish the public domain which is required to fuel future

---

<sup>1</sup> To be published in: A. Von Gunten (ed.). The 2013 Open Reader. Stories and articles inspired by OKCon2013: Open Data, Broad, Deep, Connected. Zürich: buch & netz, OKF Switzerland in association with OKCon 2013.

knowledge creation.

## 1. Frictions

Digital tools, and particularly the Internet, are generally seen as drivers behind a societal shift from a centralized and hierarchical paradigm to a new paradigm of networks and lateral relations. According to Jeremy Rifkin's analysis, new opportunities emerge from the coincidence of transformations affecting communication media and dominant energy sources. These coincidences trigger industrial revolutions. The first industrial revolution was made possible by coal as an energy source and newspapers printed on the rotary press; the second industrial revolution depended on electrical energy from a grid of fossil-fuel power plants and on telephone and radio. The third industrial revolution is now being triggered by the Internet and by renewable energy sources, which share an important characteristic: they do not require heavy central investments and central management, but rather allow for decentralized, lateral structures. Therefore, Rifkin argues, the third industrial revolution will promote lateral power – in energy, the economy, and the world [1].

## Software

In software, the shift from purely hierarchical to more lateral forms of development took place a long time ago: free and open source software (FOSS) –symbolized for many by the 1985 GNU Manifesto [2] – (re)installed lateral collaboration in software development. This required dealing creatively with copyright protection of code. The four freedoms of the GNU Manifesto were translated into standard licences allowing anybody to use, study, distribute, and fork software, activities which otherwise were all restricted by copyright.

Richard Stallman found it appropriate to address a few questions in the GNU Manifesto, questions that have been repeatedly asked in other domains that went open source: “Don't programmers deserve a reward for their creativity?”, “Shouldn't a programmer be able to ask for a reward for his creativity?”, “Won't programmers starve?”, and “Don't people have a right to control how their creativity is used?” Stallman used these questions to demonstrate the frictions between the incumbent paradigm of proprietary (non-free, copyright-enforced) software and the new paradigm of FOSS.

FOSS has become the basis of a thriving industry – in parallel to the old-school software businesses – and has overcome those frictions. Programmers are rewarded for contributing to FOSS as e.g. roughly 40 percent of software development companies are spending development time on FOSS projects. Two thirds of web servers run on Linux, three quarters of web servers use open-source Apache to respond to browser requests. 70 percent of web browsers are either completely open-source (Firefox) or share large parts of their codebase with open-source products (Google Chrome), and use an open-source layout engine for rendering HTML – Gecko in the case of Firefox, WebKit in the case of Google Chrome and Apple's Safari. Other notable examples include server-side programming languages (such as PHP) and content management systems (Drupal, Joomla, WordPress) [3, 4, 5]. Publishers and service providers have established their businesses around FOSS by providing extra value such as immediacy, personalization, interpretation, authenticity, accessibility, embodiment, patronage, and findability [6].

## Content

A similar shift from hierarchical to lateral ways of production happened in the content industries. Creative Commons-licensed Wikipedia has outgrown printed encyclopedias in volume, depth, up-to-dateness and use [7]. Printed newspapers have lost many of their readers who now follow much of the attention they were used to get to blogs and social media [8]. User-generated YouTube videos are displacing corporate news teams [9].

The Creative Commons licences provided a similar facility for content to that which the FOSS licences provided for software. Yet the authors of the Creative Commons licences decided to deal differently with some of the frictions cited above. In particular, they addressed the “reward” issue and the “control” issue by providing options in the licensing system that prohibit commercial use and creating derivative content, respectively. This in turn created new frictions between those authors who prefer the “non-commercial” or “no derivatives” option and the proponents of free culture who regard content under these licence conditions as non-free [10, 11, 12].

In the content arena, other frictions arise. Whereas blogs are sometimes full of fractious narcissism, a collaborative project like Wikipedia is supposed to balance openness (“the free encyclopedia that anyone can edit”) with maintaining encyclopedic standards, the latter requiring blocking users and protecting content from editing from time to time [13]. Wikipedia, so far, has successfully achieved this balance between the conditions that both “require and threaten openness” [14].

## Design

Open design purports to be to design what open source is to software. As design in many legislations is protected by copyright, the open-sourcing strategies discussed above under content apply – and hence the related frictions. However, there are areas in design that are not protected by copyright (such as food recipes) or which actually thrive on copying mechanisms, namely, fashion [15].

Open design can be seen in line with other artistic traditions such as Dada, Situationism, Punk Rock and the artistic Internet experiments of the mid-1990s. The Situationists included the “copyright” statement: “All texts published in Situationist International may be freely reproduced, translated and edited, even without crediting the original source” [16]. In this respect, open design is part of a “culture without commodity” that challenges the prevailing utilitarian “commodity culture” in design [17].

However, and perhaps even more than in other areas, labelling designs as “open” could mainly be used as a marketing instrument. The widespread preference for Creative Commons licences which include the non-commercial restrictions might be read as supporting that hypothesis. This leads to an interesting friction between the anti-utilitarian potential of open design and the use of the label for purely utilitarian purposes.

## Electronics and Hardware

In electronics and general hardware there have been a number of initiatives defining and certifying open source hardware, starting as early as 2007 (TAPR radio amateur community). The Open Source Hardware and Design Association is one of the more active initiatives today, collating and consolidating earlier work in this arena [18]. Open-source hardware has developed a strong foothold in niche markets, for example the educational Arduino micro-controller board, which is also widely used for art projects, or the development of highly specialized hardware for particle accelerators at the CERN laboratories and elsewhere (see below).

The challenge to collaboration in hardware is in general different, as there is typically no copyright protection for “useful articles” (i.e. hardware) in the first place – although this is arguable. Rather, a patent needs to be applied for, and granted to afford protection. Therefore it is not the existing protection that stands in the way of sharing legally. One potential threat (or friction) however is that one or a few members of a collaborative development team could register the combined result of the collaboration under their own names, which is illegal under patent law but requires litigation to enforce. This threat can partially be countered by publishing contributions and declaring them as intended for “open source” (e.g. using an open hardware “licence”). Such a declaration would equally assure third parties that the designers

or inventors had no intent to patent their contribution.

Open hardware licences can therefore be an important signalling device – as long as they are not overly restrictive and do not try to discourage completely lawful uses. The question remains as to whether such licences would be legally enforceable, or if (legally) they just “don't matter” [19]. On the other hand, the use of “open” as a signalling device for mainly marketing purposes (and the readiness to drop the term when no longer useful, as in the case of Makerbot Industries) poses serious credibility issues with that term and instrument – another interesting friction.

## Fabrication

It might seem odd to add fabrication after having discussed design, electronics and hardware. However, in the context of physical objects – be they objects of design, electronics or general hardware – the arenas of describing artefacts and fabricating artefacts are not as seamlessly integrated as in software or (digital) content. Manufacturing equipment, however, has equally been subject to the digital revolution. Many steps in manufacturing are computer-controlled today; and computer-controlled manufacturing equipment is currently undergoing a similar development to the mainframe-personal computer-transition: it is becoming affordable for everybody.

Affordable fabrication equipment will have an impact on the manufacturing equipment industry, as PCs had on the use of computers in industry. A striking example is the graphics industry, which already has undergone the transition from traditional to digitally driven ways of working [20]. Equally, spreadsheets, text processing and presentation software have had a major impact on the way we do and manage business – it would be no surprise if affordable fabricators were to have a comparable effect, e.g. on how products are designed and developed. Moreover, as investment is considerably lower, the per-piece cost of equipment also falls considerably. This potentially creates the preconditions for distributed, small-batch manufacturing that could even use raw material that is locally available: instead of “atoms” being shipped around the globe, “bits” could be shipped, and fabrication could be mainly local or regional. Such a scenario exhibits a number of interesting frictions which call into question the need for global logistics at their current extent, substitution of local materials for general ones and the possible consequences for product design, differences in manufacturing processes across various locations possibly without agreed standards and centralized quality control, among others.

Affordable fabrication equipment is also an enabler for personal fabrication. As was the case in the early days of the PC, nobody really knows yet what people would do with personal fabrication. A good guess, however, would be that people would do other things with personal fabrication tools than what manufacturers do. We do not normally use PCs for payroll or inventory management at home, but for digital creation, individual content consumption and social interaction across time and distance. It is quite likely that people would use personal fabrication not for producing machines or standard components, but for creation, individual consumption and social interaction – as this is what people do.

There are a number of interesting frictions in personal fabrication. One is its antithesis to mass manufacturing. Another is the antagonism between the traditional position of manufacturing as part of work and personal fabrication as a more hedonistic, playful activity. A third is the contradiction between what is called the ceteris paribus imperative of the 21st century – consume less, create more – and the apparent trend towards commodifying creation by corporations such as Techshop and Makemedia (their names alone are telling).

But the biggest friction is probably that although personal fabrication is currently seen as a personal thing its main impact will be a social one. So, in essence, we should be talking about social fabrication. Only then will the relation between open source movements in software, content, design, electronics and hardware on the one hand and fabrication

on the other hand become relevant. The constituents of openness are participation, collaboration and sharing [21], the future of fabrication is more than just “technology for a market of one, personal expression in technology” [22]. Social fabrication is much more closely related to the notions of “deep play” [23] which in turn is related to sustainable development, quality of life, and interdependence, preserving one's cultural identity and living in a multicultural world, more cosmopolitan and less territorial – in essence the characteristics of a “third wave” or post-industrial society [24].

## Services

Also in the field of services there is a growing number of peer-to-peer initiatives and experiments ranging from accommodation (Air BnB, Couchsurfing) and car sharing to the financing of projects (Kickstarter, Indiegogo). As these services are operating through the Internet, it is obvious that there is one apparent arena of friction between the peer-to-peer nature of service provision and the centralized operation of the Internet platforms enabling the service. Frictions include service fees and the business model of the platforms and the juxtaposition of a not-for-profit model for taking part in the platform and a for-profit model for operating the platform, the terms of service and the distribution of business risks between platform operators and platform clients, and, more importantly, the questions of how data generated by users on the platform is kept secure and private and who gets to use or sell the data.

## Frictions

The frictions encountered in the transition from traditional, hierarchical systems to emerging lateral, networked systems stem from traditional ways of working with intellectual assets – creative works, technical inventions, data – that were established at a time when such assets were scarce. These ways of working are alien in a networked society, even dysfunctional. Incumbent organizations (and many individuals, too) are unable to grasp that fact and are unwilling to develop new ways of working. Rather, they try to re-label old practices with new terminology that includes words such as “sharing” or “open” – a practice Mayo Fuster Morell calls “wikiwashing” [25]. Yet there are also real experiments in applying the new paradigm and developing practices that are true to the principles of the network and of laterality. One example is open hardware at CERN.

## 2. Open Hardware at CERN

Open Source Hardware (OSHW) efforts at CERN's Beam Controls Hardware and Timing section (BE-CO-HT) started in earnest in 2009, in the context of the White Rabbit (WR) project [26]. This project aimed at achieving very precise synchronization of nodes in an Ethernet network, and started off as a collaboration between several institutes and companies. The hardware developers dreamed of having the same freedom to collaborate remotely as their software counterparts, many of whom were developing device drivers for the Linux kernel. It soon became apparent that the developers needed to do some foundation work before starting to enjoy these freedoms.

## Forge

The Open Hardware Repository (OHR) [27] is a web-based collaborative work space which is made of Free and Open Source Software (FOSS) only. It allows hardware developers to easily share design files, track versions, document using wikis and communicate via mailing lists or forums. It is based on Chiliproject, a fork of Redmine, and the various plugins which have been added to it have also been released as FOSS. The site is maintained by CERN, but developers can have any affiliation. For scalability and maintainability reasons, the scope is limited to designs that are of interest to the community of people working in physics laboratories. At the time of writing (September 2013) the OHR hosts more than 100 designs involving more than 150 active designers from many laboratories and companies.

The OHR is also a very efficient tool for dissemination of knowledge, one of CERN's key missions. Since designs are published and open for external review, designers strive to increase the level of quality, both of the design and the documentation. In addition, because the end goal is to have many of the designs commercialized by companies, special care is devoted to quality aspects such as manufacturability and automated production testing.

## Legal Framework

Companies are an essential ingredient in OSHW, but they are understandably reluctant to adopt this paradigm unless the rules of the game are clear. This is why CERN decided to develop the CERN Open Hardware Licence (CERN OHL) [28]. The licence specifies the conditions under which licensees can modify and distribute design documents, and also deals with distribution of products built based on that documentation. It is a weak copyleft licence in the sense that everybody should be able to profit from modifications to a licensed design, but the terms do not extend to proprietary blocks which interface with the licensed design from outside. The licence complies with the standard definition of Open Source Hardware [29].

Distribution of hardware can in fact be a complex process involving many intermediate actors. These actors do not infringe intellectual property rights by redistributing hardware, so the CERN OHL cannot impose obligations on them. However, a designer can ensure that documentation remains accessible to any downstream recipients of hardware by appropriately using Documentation Location notices. These notices cannot be removed from the design documentation without infringing copyright, and if they are placed in a way such that they will appear in a visible part of the final product, then the recipient of the hardware will just need to look at the product to find a pointer to the documentation. This is easily achievable in the case of printed circuit boards (PCBs) if one places the notice on a visible layer such as top copper. It is also very easy to achieve this traceability of design documents in 3D-printed hardware.

The CERN OHL is itself hosted as a project in the OHR, and is run much like open source software or hardware projects. The project's mailing list counts among its members many competent lawyers and enthusiasts, and all key decisions are peer-reviewed and discussed. The mailing list archive is public, so anyone can read the history of a given thread before deciding to contribute to the discussion.

The CERN OHL community is very dynamic, and the licence itself evolves as new ideas emerge. One example is the use of documentation location notices as explained above. The next big challenge for the CERN OHL will be to provide a solution to the problem of licensing cores described in a hardware description language (HDL). Many HDL designers with a weak copyleft mindset use the GNU Lesser General Public (LGPL) licence for HDL designs. This licence was not written with hardware in mind, and a better suited alternative is needed. The difficulty comes from the fact that one single HDL description can be destined to become software running e.g. in a simulator, but it can also become a configuration bitstream for a field programmable gate array (FPGA) or provide the basis for building an application specific integrated circuit (ASIC). An appropriate licensing scheme needs to cover all these possible uses and, in the case of the CERN OHL, decide what weak copyleft should mean in each context.

## Business Model

The role of commercial companies is very important in OSHW. They ensure that unpaid labour does not become a risk for a project. Open *and* commercial is a winning combination. By introducing the notion that users should pay for support, developers do not become overwhelmed by requests for help and can continue designing hardware. This is very important, and without it, it would be difficult to imagine how the whole scheme can be self-sustaining.

OSHW is a change in mindset not only for many companies, but also for users. The freedom one gains by using open

instead of proprietary solutions has value and it should therefore not surprise anyone if it has a price. Consumers can vote for openness with their wallets, deciding to pay companies to do open design, modifications, testing, distribution and support. The experience at CERN shows that this scheme works well. Not all companies are well suited for this kind of collaboration, but that is not a problem considering the number of companies which can work this way.

Companies benefit particularly from OSHW because the barriers to entry into a new technology are vastly reduced, as are the risks. This is beneficial for small and medium-sized companies which have the required resources to understand and review a design but may not be able to afford the extensive R&D needed to produce it in the first place.

For large international organizations, such as CERN, it is also very important to be able to decide where money should be spent in order to guarantee a fair return to member states. OSHW gives them that flexibility, while ensuring that there is no risk of vendor lock-in.

## Development Tools

Having addressed the forge, legal and business model parts of the problem, we are now confronted to what we believe is the last important hurdle to efficient sharing of hardware designs: the lack of high-quality FOSS tools for designing hardware. The availability of such tools would allow us to collaborate with many more designers remotely. CERN has started contributing to two FOSS projects, with the aim of taking their features and quality to a level that would not adversely affect its developers' productivity when using them. These two tools are the Icarus HDL simulator and the KiCad PCB design application.

In the realm of HDL simulators, there is a need for a tool which will simulate mixed-language designs, covering at least the three most common HDLs: Verilog, SystemVerilog (SV) and VHDL. CERN has teamed up with the developers of Icarus to start adding VHDL and SV support to the existing Verilog infrastructure.

Regarding PCB design, the current situation, with a fragmented market and incompatible formats among the most important tools, makes efficient sharing complicated. The advent of a professional quality PCB design tool entirely made of FOSS will change things for the better. CERN is currently contributing to KiCad through a number of work packages [30], initially focusing on the PCB layout part. As more functionality is added, CERN expects more users and developers to join the project, including educational and research institutions and companies. For both Icarus and KiCad there needs to be a self-sustainable scheme whereby these tools will rest on solid enough foundations to make them reliable enough for large institutions to depend on them. Here again, the involvement of commercial companies which would sell support and development contracts is the most obvious way of meeting that need. And here too users can vote with their wallets and support FOSS tools by paying these companies for support contracts.

## Lessons Learned

Four years of intensive practice with OSHW in CERN BE-CO-HT show that this paradigm is very well suited to help CERN's developers fulfil their mission efficiently. OSHW allows them to share designs seamlessly, to involve industry to boost their design team and to disseminate information to society in a very natural and effective way. CERN's developers have a forge, a legal framework and they have worked out a viable business model with commercial companies. They are now contributing towards the development of two FOSS tools for hardware design, and they see all these developments, not just the hardware, as being very useful contributions to the public. CERN is a major generator of new knowledge, not just in physics, and OSHW is one more method in its tool kit to help it to make a positive impact on society.

### 3. Creativity and Commerce

As demonstrated above, in sophisticated integrated technological environments, knowledge creation is an evolving collaborative enterprise. Legacy intellectual property concepts originate from an era before digital technologies were invented and are glaringly ill-suited to the task of transmitting information about the knowledge regarding the invention, or as legal titles for commercialization. One preoccupation that we share is about the kind of intellectual asset titles that need to be invented to facilitate commerce and trade and that are commensurate with this new level of integration, convergence, and collaboration.

#### One Fact

What we observe from CERN's four-year experience is that open source methodology for hardware works. This phenomenon is not seen only in electronics, but also in synthetic biology. The emergence of open source methodology, a dedicated repository (forge), and the creation of a specific licence (CERN OHL) are a starting point. Of significance is that the CERN open hardware repository now houses more than 100 projects, 70 of which come from groups inside CERN and 53 from other institutes. Furthermore, several technology firms are actively placing products on the market using the CERN OHL. There are two development process elements that make open source methodology for hardware an imperative: collaboration and speed.

The kind of instrumentation that has inspired the engineers and scientists at CERN to make the development of sophisticated *integrated instrumentation* systems available to all through an open hardware licence is a previously uncategorized type. It is sophisticated in that it integrates state of the art mechanical, electronic, software, and digital techniques performing to demanding high standards dictated by the requirements of the experimentation.

The convergence of technology types (software, electronics, optics, mechanical) and the collaboration dictum required in a science and technology information rich age poses the question of what the consequences might be for the commercial aspects.

#### Six Centuries

Simplicity reigned when technological inventions included ideas such as an improvement in wire-fences (barbed wire) (US 157124, 1874, Joseph F Glidden), or a new and useful improvement in the manufacture or production of acetyl salicylic acid (US 644 077, 1900, Felix Hoffmann, Farben Fabriken Elberfeld, NY (now Bayer AG)). Today's products can encapsulate many inventions, each of which may be complex. Science and technology have joined hands, although they were never apart while the great philosophical minds from Immanuel Kant to the Vienna Circle were of the opinion that there was something like *pure* theoretical knowledge and *impure* social utility.

In today's (2013) pervasive quantified-self vogue, open data and transparency activism, instead of a lone James Clerk Maxwell (1831–1879) pondering Saturn's rings, we have large teams of scientists and engineers at CERN peering into the smallest quanta of matter. These teams test phantasmagorical theories with colourful stringy names that, in their rich abstractions, can be grasped by an ever smaller fraction of the world's population. For the task of peering into the most intimate processes of quantum particles, instrumentation built to meet stringent measurement requirements and integrating state of the art mechanical, electronic and digital technologies is required. To develop these instruments one must assemble teams that work together to integrate their knowledge.

The amount of scientific and technical information available makes collaboration a necessity when developing integrated instrumentation of the type we are considering. This is a very different situation from that encountered by

Galileo. One single individual can still excel in specialized areas of science or technology, but her knowledge and expertise realize their full social welfare benefit only when integrated with cooperation from others who have adjacent and complementary knowledge.

Patents are the intellectual property title of choice as a legal title for commercialization and information dissemination. Patent statutes have not changed much since 1474 when the Venetian general patent statute was enacted: All modern patent laws are closely related to the 1474 statute including the English 1624 Statute of Monopolies which also served as a model for the US's First Congress Patent Act of 1790. From this perspective, it should not surprise us to observe the emergence of new methods to share technical information and to create competitive advantage. While the advantages of open source are obvious when sharing technical information, the argument that it also creates a competitive advantage needs more elaboration.

The last legal paradigm shift that brought innovation to the very system from which we expect innovation – technology – took place six centuries ago! In these six hundred years, from Galileo through Einstein and von Karman to Mandelbrot, science and technology have moved on by leaps and bounds. The economy has also been reshaped several times. Manufacture has moved to industrial production through at least two industrial revolutions, and some would have it that we are in the middle of a third industrial revolution. Economic production did not stop evolving with the assembly line, and today General Motors and US Steel have taken a back seat to Google, Apple, and Microsoft as economic engines.

## Human Nature

Among the increased information that we have about our world and ourselves is that humans are cooperative. While Adam Smith's *Wealth of Nations* still makes for good reading, self-interest is not all that motivates us, nor does the invisible hand regulate all. Yochai Benkler in *The Penguin and the Leviathan* suggests that in the twenty-first century, we are poised to apply the lessons learned about cooperation to improve the systems in which we live, work, and play. That is, while not all of us, not all the time will cooperate, the fact is that evolution favours cooperation.

Benkler suggests seven building blocks for designing for cooperation: communication; framing, fit and authenticity; looking beyond ourselves: empathy and solidarity; constructing moral systems: fairness, morality and social norms; reward and punishment; reputation, transparency and reciprocity; and building for diversity [31].

## Mercantilism and Free Trade

Since the conclusion of the Uruguay Round and the signature of the Marrakesh Agreement establishing the World Trade Organization in 1994, almost 20 years ago, a tension has been mounting between the interests of the public domain and those of unabashed mercantilism.

The dictionary definition of 'mercantilism' hints at where some of this tension may be. First, mercantilism refers to the benefits of profitable trading, and secondly it refers to commercialism. In any case, mercantilism is closely associated with a theory of economics that purports that a nation's wealth is increased by a favourable balance of trade, and that exports should be promoted and imports restricted (protectionism). Free trade has as much to do with a globalized economy as it has to do with the removal of import restrictions. Most obvious is that mercantilism and free trade are opposites. Mercantilism favours both individual and state self-interest, and has no notion of cooperation or the common good. Unfortunately, many of the intellectual property clauses in recently negotiated (bilateral) free trade agreements (FTAs), or the controversial ACTA, qualify as mercantilist albeit concealed under the label of free trade. On the other hand, the objectives and principles of the WTO's Agreement on Trade-Related Aspects of Intellectual Property Rights

(TRIPS) aim at creating mutual advantage of producers and users of technological knowledge in a manner conducive to social and economic welfare, and to a balance of rights and obligations. That is, there are many of flexibilities in TRIPS and emerging evidence suggests a more efficient global division of production [32].

## Individuals, Institutions, and States

The picture that emerges so far is not a simple one; it is a classic path dependence scenario. The intellectual property system has been on its rails for six centuries, but science and technology have left their corresponding rails within the last hundred years. What we observe is that at the individual level and to a lesser degree at the institutional level, cooperative behaviour is starting to emerge as an adaptation to the increase in information and the complexity of the desired technological solutions. Is an established order starting to be overturned? I would like to think so. Here I would borrow from Michael Foucault who asks how desire can be introduced into thought, into discourse and into action [33]. The suggestion made is that one introduces desire into thought, then theory, and then into political action.

At the individual and institutional level, CERN's open hardware initiative has turned desire into action. Theory and political action still need attention. At the state (nation) level, TRIPS may not offer the solution in spite of its flexibilities, but the Development Agenda at WIPO has contributed significantly to opening up the range of issues being considered that are of interest to emerging economies that in the past have not benefited from intellectual property.

## Intellectual Assets and Knowledge Transfer

There is a fundamental distinction missing in the discourse on intellectual property and open-source methodology. Intellectual property is based on information. Information has traits of a public good: it is *nonrivalrous*, and it is *nonexcludable*. Patent law provides two services: it provides an incentive in the form of a time-limited monopoly to allow the inventor to recover his investment in time and capital, and it prevents (in theory) the inventor from keeping her innovation secret and hidden in a black box, by making the publication of information about the invention compulsory. That is the theory. The practice is messier. Since inventions are not complete products, only a solution to one specific technical problem, it is still possible for a product (instrument) to be de facto a black box built using a mix of disclosed information and trade secrets. Patents make up a large repository of technical information: it is useful, it is in the public domain, but the more complex and more integrated the devices, the less useful that information is. Invariably, there are some pieces missing from the puzzle, and learning from patent documentation becomes difficult.

The term intellectual property can be misleading. For example, a (letter) patent is a title to an immaterial good. The ownership of the title gives you a right to industrially (patent) and/or commercially (trademark) exploit the information. To acquire the knowledge necessary to work with the information, additional investments in knowledge transfer are usually needed. Knowledge is not information. Knowledge is excludable. One cannot copy knowledge, but one can copy information. Knowledge is created by each individual through cognitive assimilation of information (learning). The information does not get consumed, and anybody may learn from the same information.

As Keith Maskus points out, "innovation has always been an heterogeneous process, it is becoming more so because of complex interactions between goods and standards and efficiencies from distributed research networks" thus traditional concepts of patent protection may not necessarily be sustained. The economic narrative of intellectual property, nonexcludable and nonrival, does not quite map into reality [34]. There are four observations that highlight the reality. First creative motivation is not necessarily driven by market mechanisms. Second, technologies that make copying cheap, may lower distribution costs thus eliminating costly distribution channels. Third, to be the first to market brings competitive advantages all on its own. Fourth, not all aspects of innovation are nonrival, i.e. service and authenticity. In

the case of software, like in the case of integrated instrumentation, copying is easy, but service cannot be copied or downloaded.

## Public Domain and Knowledge Creation

The public domain is to knowledge creation what the air that we breathe is to life: an absolute necessity. Concerns about intellectual assets are many. We can name a few: appropriation of research results generated by public funds, public access to research results, implementation of knowledge transfer between intellectual property exporters and least developed countries, and the care and feeding of the public domain. One suggestion for the issue of feeding the public domain is to instate a provision that allows products to be placed on the market with a 'patent waived' notice [35]. This would permit buyers or users to be informed of the public domain status of the item. This is however a very different legal status from that aspired to by the CERN OHL, which aims to foster collaboration and sharing among hardware designers. The documentation on the technology is published, and potentially the licence provides a new mechanism with which to care for and feed the public domain, and a tool for knowledge transfer.

## Conclusion

The abundance of scientific and technical information has resulted in the dispersion of knowledge and fragmentation of specialization. To produce sophisticated complex instrumentation such as exemplified by the various open hardware projects carried out at CERN, open source methodology is the chosen method as it affords speed of development and full transparency, and reciprocity for the documentation. The issue of an open hardware licence that codifies the rules of the game points to another element in Benkler's recipe for cooperation: fairness, morality and social norms – the construction of moral systems.

The view that patents are ill-suited for the task that they claim to do is also emerging [32]. While networked groups practising new modes of production and work on integrated and mixed technologies need new intellectual asset tools, some of which are already existent (open hardware licence), this does not mean that all intellectual property title types are in sore need of revision. It also does not mean that the existing regime has nothing to offer for the open hardware movement. Possible avenues are: to consider the layering of titles (i.e. licence, trademark, design); to further enquire into the role of the public domain; and to explore what new intellectual asset title or legal instrument could accommodate the needs of these emerging collaborative modes of production.

That the patent has come to the end of its serviceable life-time as a 'one size fits all' title should come as no surprise. A patent was an invention – while being a legal title, one can consider it a service provided by the state, but an invention nonetheless – that met a specific need of the Venetian guilds (silk weaving industry) for the protection of their innovations from imitation by their competitors [36]. Old habits, however, die hard. The *Scenarios for the Future* considered in 2007 by the European Patent Office include a "blue skies" option in which technological change is the primary factor. In that scenario, cumulative innovation would favour the use of licences. The major consequences for industry and commerce could be the emergence a more differentiated approach towards intellectual assets, and that competitiveness will rely less and less on proprietary systems or trade secrets.

## So What?

Above we highlighted some of the changes that are happening today and how these changes conflict with traditional ways of working with intellectual assets. We demonstrated how CERN has started to work differently with intellectual assets in its Beam Controls Hardware and Timing section. And we have discussed the role of current legislation to

protect an inventor's interest in intellectual assets as codified in patent legislation.

Conclusions, at this stage of the debate, are bound to remain preliminary. It appears that a doctrine of protecting intellectual assets by default can be at odds with contemporary practices and relationships. The need for and use of open licences that get around by-default copyright protection is sufficient proof for this. In the arena of patenting, corresponding tools are not yet readily available.

Beyond working within the limitations of the current legal system it is worthwhile to investigate how one would formulate legislation today that would fulfil the purpose "to promote the progress of science and useful arts" as e.g. stated in article I, section 8, clause 8 of the United States Constitution. For a networked society this would probably have to take into account that distribution of knowledge is wide, access to knowledge is open, and willingness to collaborate is substantial.

Yet "hacking" the current legal system is equally as important as developing the legal basis and needs to be progressed in parallel: it allows growing a new practice and forming shared experiences that in turn can inform the development of the legal basis. And the development of the practice of collaborative creation of knowledge simply cannot wait until such a basis is ready. To this end, it is imperative that forums that discuss "open" principles do not limit their remit to the obvious, content-related fields, but include the field of open hardware, too.

## Acknowledgements

We are indebted to Javier Serrano of CERN, Geneva, who has provided valuable insight into the development and application of the CERN Open Hardware License in the preparation of and during the workshop held at the Open Knowledge Conference in Geneva in September 2013. We also would like to acknowledge the about forty participants of the workshop and their valuable contributions to our discussions. Thanks also go to Susan Kaplan for revising the final manuscript.

## Endnotes and References

- [1] Rifkin, Jeremy (2011). *The third industrial revolution: How lateral power is transforming energy, the economy, and the world*. Palgrave Macmillan, 2011.
- [2] Stallman, Richard (1985). *The GNU Manifesto*. *Dr. Dobb's Journal* Vol. 10, No. 3, pp.30–35.
- [3] Usage of operating systems for websites, W3Techs, August 2011, <[http://w3techs.com/technologies/overview/operating\\_system/all](http://w3techs.com/technologies/overview/operating_system/all)> (accessed October 29, 2012). Benkler, Practical Anarchism: Peer Mutualism, Market Power, and the Fallible State, in: *Politics & Society*, Vol. 41, No. 2, pp. 213–251, 2013, p. 221.
- [4] Charles M. Schweik & Robert C. English, *Internet Success: A Study of Open-Source Software Commons*, MIT Press, 2012.
- [5] Josh Lerner and Mark Schankerman, *The Comingled Code: Open Source and Economic Development*, MIT Press, 2010.
- [6] Kelly, Kevin (2008). *Better than Free*. Available online: [http://www.kk.org/thetechnium/archives/2008/01/better\\_than\\_fre.php](http://www.kk.org/thetechnium/archives/2008/01/better_than_fre.php) (accessed 12 December 2008).
- [7] Okoli, Chitu, Mehdi, Mohamad, Mesgari, Mostafa, Nielsen, Finn Årup and Lanamäki, Arto, *The People's Encyclopedia Under the Gaze of the Sages: A Systematic Review of Scholarly Research on Wikipedia* (March 13,

- 2012). Online at: <http://ssrn.com/abstract=2021326> or <http://dx.doi.org/10.2139/ssrn.2021326> (accessed 20 September 2012).
- [8] Alterman, Eric (2008). Out of print: The death and life of the American newspaper. *The New Yorker* 31.03.2008; Newman, Nic, William Dutton, and Grant Blank (2011). Social media in the changing ecology of news production and consumption: the case in Britain. Oxford Internet Institute Working Paper; Reuters Institute for the Study of Journalism Working Paper. Available at SSRN: <http://ssrn.com/abstract=1826647> or <http://dx.doi.org/10.2139/ssrn.1826647> (accessed 20 September 2012).
- [9] PEJ (2012). YouTube & the News: A New Kind of Visual Journalism. PEJ report, 16 July 2012. Pew Research Center, Project for Excellence in Journalism. Online at <http://www.journalism.org/node/30171> (accessed 20 September 2012).
- [10] Hill, Benjamin Mako (2005). Towards a Standard of Freedom: Creative Commons and the Free Software Movement. *Advogato*. Online at: <http://www.advogato.org/article/851.html> (accessed 15 September 2013)
- [11] Kleiner, Dmytri (2006). The Creative Anti-Commons and the Poverty of Networks. Presentation to the 4th Wizard of OS conference, Berlin, online at: <http://www.indymedia.org.uk/en/2006/09/350884.html> (accessed 15 September 2013)
- [12] Cramer, Florian (2008). The Creative Commons Misunderstanding. In: Mansoux, Aymeric and Marloes de Valk (eds.). *FLOSS + Art*. Poitiers: Goto10, pp. 128-137.
- [13] Reagle, Joseph Michael (2010). *Good Faith Collaboration. The Culture of Wikipedia*. Cambridge, MA: MIT Press.
- [14] Shirky, Clay (2006). News of Wikipedia's Death Greatly Exaggerated. *Many-to-Many*, 25 May 2006. Online at: [http://many.corante.com/archives/2006/05/25/news\\_of\\_wikipedias\\_death\\_greatly\\_exaggerated.php](http://many.corante.com/archives/2006/05/25/news_of_wikipedias_death_greatly_exaggerated.php) (accessed 15 Sept 2013).
- [15] Raustiala, Kal, Sprigman, Christopher (2006). The Piracy Paradox. *Innovation and Intellectual Property in Fashion Design*. *Virginia Law Review*, 92, 8, pp. 1687-1777. Available online at <http://www.virginialawreview.org/content/pdfs/92/1687.pdf> (accessed 29. Oct. 2012).
- [16] Cramer, Florian (2002). What Does Open Mean in Digital Arts? Online at: [http://cramer.pleintekst.nl/all/what\\_does\\_open\\_mean\\_in\\_digital\\_arts/what\\_does\\_open\\_mean\\_in\\_digital\\_arts.pdf](http://cramer.pleintekst.nl/all/what_does_open_mean_in_digital_arts/what_does_open_mean_in_digital_arts.pdf) (accessed 15 September 2013).
- [17] Felix Stalder, *Open Cultures and the Nature of Networks*, Futura publikacije, Novi Sad, 2005, pp. 24-29.
- [18] OSHWA (2013). Brief History of Open Source Hardware Organizations and Definitions. Online at: <http://www.oshwa.org/research/brief-history-of-open-source-hardware-organizations-and-definitions/> (accessed 15 Sept 2013).
- [19] See also Weinberg, Michael (2013). *What's the Deal with Copyright and 3D Printing?* Washington, DC: Public Knowledge. Online at <http://www.publicknowledge.org/Copyright-3DPrinting> (accessed 13 September 2013).
- [20] Dukker, René (2013). *Digitale revolutie; aanjager van de derde Industriële Revolutie!* In: *Printing The City*. Rotterdam Rijnmond Ontwikkelt, Rotterdam, AM+D.
- [21] Reagle, Joseph Michael (2006). *Notions of Openness*. Online at: <http://reagle.org/joseph/2006/02/fm10-openness> (accessed 15 September 2013).

- [22] Gershenfeld, Neil (2006). Unleash your creativity in a Fab Lab. TED talk. 16'2"-17'03". Available at [http://www.ted.com/talks/neil\\_gershenfeld\\_on\\_fab\\_labs.html](http://www.ted.com/talks/neil_gershenfeld_on_fab_labs.html) (accessed 15 September 2013).
- [23] Rikfin, Jeremy (2004). The European Dream. How Europe's vision of the future is quietly eclipsing the American dream. Los Angeles, CA: Jeremy Tarcher/Penguin. Excerpt in UNTE. September/October 2004. Available at: <http://www.utne.com/community/the-european-dream.aspx> (accessed 15 September 2013).
- [24] Toffler, Alvin (1970). *Future Shock*. New York: Amereon Ltd; Bell, Daniel (1973) *The Coming of Post-Industrial Society: A Venture in Social Forecasting*. New York: Basic Books; Toffler, Alvin (1980). *The Third Wave*. New York: Bantam Books (republished 2006 as *Revolutionary Wealth*).
- [25] Fuster Morell, Mayo (2011). The Unethics of Sharing: Wikiwashing. *International Review of Information Ethics*, 15, sept 2011, pp. 9-16.
- [26] <http://www.ohwr.org/projects/white-rabbit/wiki>
- [27] <http://www.ohwr.org/>
- [28] <http://ohwr.org/cernohl>
- [29] <http://www.oshwa.org/definition/>
- [30] <http://www.ohwr.org/projects/cern-kicad/wiki>
- [31] Benkler, Yochai. 2011. *The penguin and the Leviathan*. New York: Crown Business, pp. 238-247
- [32] Maskus, Keith. 2012. *Private Rights and Public Problems: The Global Economics of Intellectual Property in the 21st Century*. Peterson Institute for International Economics.
- [33] Deleuze, Gilles, and Félix Guattari. 1972. *Anti-Oedipus*. Translated by Robert Hurley, Mark Seem, and Helen R Lane. New York, NY: Continuum.
- [34] Boyle, James. 2008. *The Public Domain: Enclosing the Commons of the Mind*. Yale University Press.
- [35] Merges, Robert P. 2004. A New Dynamism in the Public Domain. *The University of Chicago Law Review* 71, 183-203.
- [36] Nard, Craig A, and Andrew P Morriss. 2006. Constitutionalizing Patents: From Venice to Philadelphia. *Review of Law & Economics* 2, no. 2: 223-321.