MakerNet: Distributed manufacturing

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Abstract:
"Release early, release often!" This well-known saying in the computer world comes from *The Cathedral and the Bazaar* (RAYMOND 1997), a basic book on the open-source movement that sheds light on the competitive advantages gained from this new vision of digitization. This philosophy, when applied to material objects, leads to designing a new model — distributed manufacturing — that blockchain technology will make secure. France has offshored its cutting-edge industries and lost much of its know-how in microelectronics. In contrast, electronics has become a craft in Shenzhen. As a result, dozens of new smartphones, called *shanzai*, are created day after day: a sort of open standardized hardware, which exists only in China. MakerNet proposes generalizing this model to other cultures through distributed manufacturing, a possibility opened by blockchains.

From open source to open hardware

The history of open source started at midnight, 1 January 1970, the nul second of Unix time.[1] This date signals a new epoch. While the Unix operating system (created by AT&T) could not be marketed owing to a noncompete clause, its sources were being distributed for free. Hundreds of programers contributed to the Unix source code, which would inspire Richard Stallman to create, in 1984, the GNU project, the first software suite totally free of copyrights. In 1991, this project combined with the Linux kernel to offer the first operating system completely free of copyrights. There now exist hundreds of GNU/Linux distributions for uses more varied than those of the two well-known proprietary operating systems, Windows and MacOS.

Since open-source products are seldom marketable, it is very hard to generalize about the business models of open-source industries! Nonetheless, "open hardware" now seems loaded with promises. The blueprints of open hardware products are freely available, of course; but there is always a physical object to sell. It is, therefore, easier to make a formal description of this market. True, it can be argued that a designer's free blueprint for mass producing an object can be stolen; but the thief would then miss out on the powerful advantages of updates by the open-source community. The members of this community of interests take part in improving the product (to make it measure up to their expectations) at a pace that mass production plants cannot hope to keep up with.

Centralized manufacturers, such as Foxconn with its 1.6 million employees, can produce masses of identical objects. However making a change on the assembly line is very expensive. By contrast, a production line based on 3D printing is very cheap. As happened for Unix, the availability of self-service 3D printers is now making this technology a success. Invented in 1984 by three Frenchmen for Alcatel, 3D printing fell into the public domain in 2004; and RepRap (replicating rapid prototyper), an open-hardware project, started designing hundreds of models.

[1] This article has been finalized with the valuable help of Vivien Roussel and Laura Bui. It has been translated from French by Noal Mellott (Omaha Beach, France).

From building prototypes to rolling products out on an industrial scale

Frequently used to rapidly make prototypes, 3D printers are not suited to mass production. Maintenance is complicated, and they still run too slowly. If placed on a network however, the printers would form a cluster with a considerable production capacity. If one printer stopped working, the repercussions on the production line would be slight. Like a node in a blockchain network, another 3D printer would pick up the slack. This is a far cry from what happens when an injection mold costing thousands of euros is no longer operational on a conventional assembly line.

Closely associated with open hardware, additive manufacturing has run into unprecedented legal problems. What if an amateur reproduces a spare part covered by a patent and then freely diffuses it over the Internet? Till now, such cases have been few in number and of limited scope. Nevertheless, patent offices must obviously address this question (as is now the case in the culture and entertainment industry owing to the formation of new consumption patterns). Smart contracts are part of the answer to this question. Since they are immutable, honest and international, they could serve as a new type of digital patent.

Distributed manufacturing

The Internet opens a universe of experimentation to manufacturing. Why transport products a thousand kilometers and uselessly consume gasoline, when it suffices to send only the information and specifications about the products? The formation of an international network of designers whose products are manufactured locally, close to buyers, is a utopia becoming reality.

FabCity, an urban planning program set up in 2014 by Tomas Diez, signals a turning point in policy-making for urban areas worldwide.[2] It intends to make big cities 50% self-sufficient in energy, the food supply and industrial products within a period of forty years. By exchanging information about production and consumption, these areas become nodes in a worldwide network that learns from its uses and differences.

MakerNet, a stakeholder in FabCity, is committed to self-sufficiency in industrial production.[3] As a marketplace for local, distributed manufacturing, it connects makers (designers and manufacturers) with consumers via a platform that proposes a toolkit for protecting and remunerating shared intellectual property. This platform assembles stakeholders in communities of interest around specific uses. The objective is to create a joint database on materials (similar to Github for software).[4]

[2] The following have joined FabCity (http://fab.city/): Barcelona, Boston, Somerville, Cambridge, Ekurhuleni (South Africa), Kerala (India), Georgia, Shenzhen, Amsterdam, Toulouse, the Occitania Region, Paris, Bhutan, Sacramento, Santiago (Chile), Detroit.

[3] https://makernet.org/

[4] GitHub (https://github.com/) is a software development Web service that uses the free, decentralized software Git as a version control system.

Designers, makers and consumers

On MakerNet, the word “designers” is to be understood in the broadest sense, like “inventors”. The designer identifies a need for a product and draws up the plans for manufacturing it through a blueprint. Intellectual property rights are protected and remunerated via a blockchain. This system induces designers to make plans that are modular so that other projects can incorporate the modules. The more a designer’s work is incorporated in the work done by other designers, the larger the base used to calculate the “royalties” to be collected when products are made.

“Makers” and “maker spaces” are listed on MakerNet. As a hub for accessing local producers and creative capacities, this platform gives a boost to craftwork and the “pro-amateurs” (MILLER & LEADBEATER 2004) who propose making a product on demand at the lowest cost. A maker’s qualifications are certified with tokens[5] that, awarded on the blockchain, let him receive requests for making all or a part of a product. The maker replies with a manufacturing price and date of delivery to the next unit on the manufacturing line. His reputation is very important to maintaining visibility on the market.

The final user (buyer) places an order on MakerNet for a product to be manufactured locally. He chooses a design file, which generates a call for bids from nearby certified makers in the user’s vicinity. The user then receives a roadmap of the possibilities for having the product physically made. The user’s choice will depend on the total prix, the expected quality, the materials proposed and the transportation of each of the product’s components.

These three stakeholders are permeable. During the “prototyping” of a product prior to marketing, the consumer might be successively a designer, (partial) maker and consumer of his own product. The ease of prototyping strongly accelerates the finished product’s arrival on the market. A startup can “get the feel” of its market before raising and spending funds to make products.

Remunerating creative common goods

On MakerNet, modified versions of a product can be made. As on Github, this is called a fork. This possibility is regulated by the rules set by the creator of the initial product, by the license that he has granted and the business model he has chosen (for-free, donation for free or for a price, fixed price, percentage of the production price, etc.). As a result, the product’s new version will include all pre-existing intellectual property rights and their beneficiaries. When this new product is made, the price of the intellectual property will be calculated for each party as a function of his/her contribution to the new product.

The MakerNet platform associates every product with a market, if only of a single person. When a product is “forked”, its use is modified. It might then appeal to a broader public. In this case, the original product’s designer will receive remuneration from a larger market. Niche markets thus become dynamic; they grow as the product improves.

When a designer updates his production plans, a new blueprint is created for the product. This new version is selected by default for manufacturing, while earlier versions remain accessible. Updates thus become instantaneously available for manufacturing around the world. The consumers are notified who bought the product before the update. They can have the updated spare part manufactured to replace the obsolete component.

[5] A token is a virtual unit on a blockchain. What it represents depends on the network where it is used. It might represent, for example, a diploma or permission for access.

Peer-to-peer certification

To build confidence within the community, a peer-to-peer system for certifying skills and qualifications has been developed in addition to the tokens for building a reputation. Let us take as example the head of a plant with a laser cutting machine. His factory lists the laser cutter on MakerNet, and he attests to the skills of the persons who frequently use it by rewarding them with tokens for their laser-cutting skills. This lets them receive local orders for laser cutting. Owing to this token, the certified person may teach this skill to other persons and certify them. When these newly certified persons take laser cutting jobs on MakerNet, a percentage of their earnings will be paid to their teacher. If the maker does a poor job, two reputations are sullied: his own and that of the person who taught him the skill.

In summary, designers find on MakerNet profiles sorted by certified skills. Makers are listed by the tokens they have, whereas designers are listed by the software they use to make the blueprints published on MakerNet.

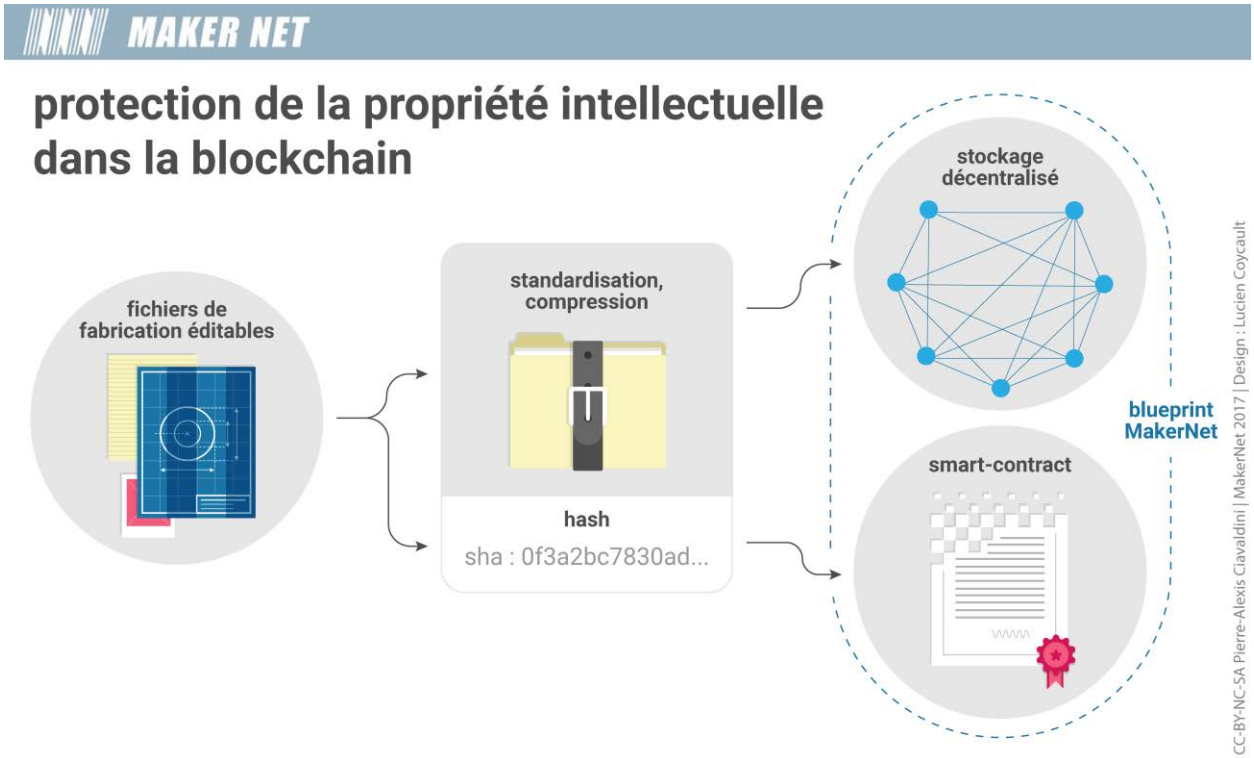

Figure 1: Protecting intellectual property rights on a blockchain

To offer a product on MakerNet, the designer has to make a blueprint, which is a virtual representation of the product and its manufacturing process. This information is secure on the blockchain. The blueprint's files are in the editable format of the software used by the designer. They are standardized, compressed and "hashed" to form a complete archive about how to make the product. The storage of the compressed file is decentralized (as on BitTorrent) to make sure it is available. Its hash is stored in a time-stamped smart contract, which contains the payment addresses of all participants holding intellectual property rights. Once stored, the blueprint's contents cannot be altered. However revoking a blueprint is possible in case of litigation.

The consumer (or user) on MakerNet chooses a product from the list of proposed designs and calls for bids from the local makers listed by their certifying token. These makers have a given period of time to respond to the call. MakerNet then calculates the manufacturing phases as a function of the offers made, and proposes the offers, as soon as they are available, to the consumer.

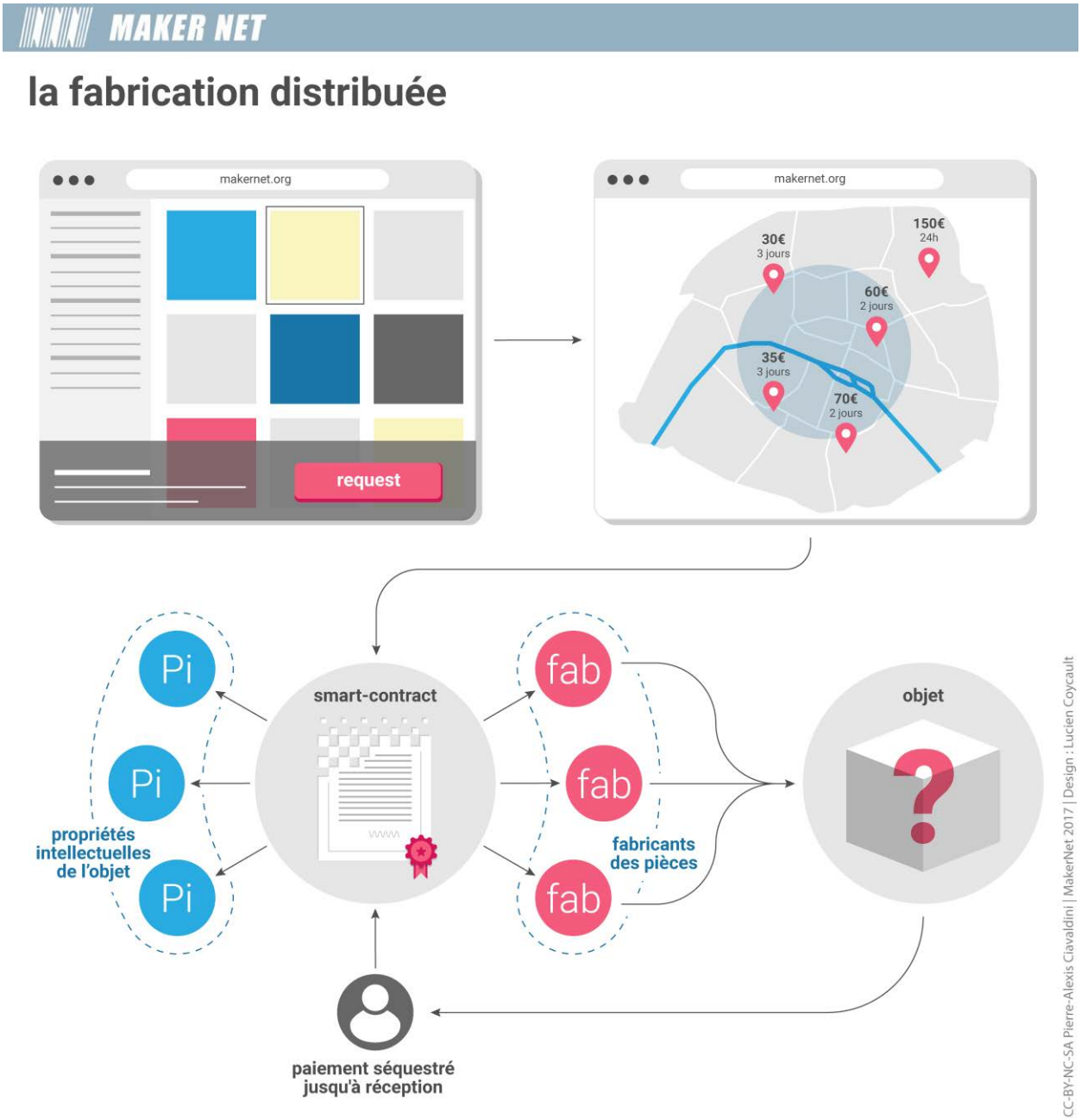

Figure 2: Distributed manufacturing

Each path for making the product includes the prices of materials, transportation, manufacturing and intellectual property rights. It might contain options for insurance and standardization. When a satisfying manufacturing path is proposed, the consumer can choose it and pay for the product to be made. His payment is held in escrow[6] on the smart contract for making the product; only the part of the payment corresponding to raw materials is sent to suppliers. The consumer is sure to receive his product, since the remainder of his payment will not be turned over to the maker as long as the product has not been delivered in compliance with plans. The maker is, in turn, sure that the consumer has already paid and that this payment is being held in escrow.

In case of litigation about the product's quality after delivery, the consumer and the maker responsible for the defective component have to find an out-of-court settlement since the smart contract has provided for a deposit from the consumer. The clause about this deposit requires the consumer to pay an additional amount (above the order price) that will not be refunded if a dispute is not settled — in line with the ultimatum game principle, an economic experiment developed in 1982 by Güth, Schmittberger and Schwarze.

Blockchain, leverage for confidence

While creating jobs in R&D, robotization tends to eliminate many tasks and jobs, in particular for manual workers. To revitalize the current system of production and consumption, we propose placing participatory innovation and custom-made production (electronics included) at the center of the paradigm for production, thanks to distributed manufacturing.

This conception of industrial production brings along complicated problems. Such an ecosystem can probably not be realized without security, the "dematerialization" of monetary transactions, and the decentralization inherent in blockchain technology.

Through educational efforts, citizens can take power back from technology. They can propose products adapted to their uses instead of having to adapt themselves to the uses proposed for products.

[6] An escrow is the procedure whereby a tribunal safeguards a sum of money or a good. The latter is temporarily unavailable to its owner… until the decision is made to lift this restriction.

The Matrices at École 42*

No courses, no teachers: at École d'Informatique 42, the students themselves are in charge of their success and of the success of fellow-students. To make progress on the projects proposed to them, they have to rely on the group's strength, give and take information, alternate between teaching and learning. This peer-to-peer education abolishes subordination in the learning relationship. Each party is responsible for a part of the success of the projects that are conducted by everyone together.

"We are switching from the industrial to the digital era."

Creating, innovating, building are the magic words of our times. Current forms of technology are making these activities ever more accessible. École 42 teaches its students to learn technology by themselves. However self-learning of the information sciences does not naturally lead to a mastery of the institutional environment. Between the two, a fruitful dialog is yet to be organized.

The Matrice program has come out of the meeting between École 42 and Creative Valley (an incubator for startups). It brings institutions or firms in contact with students from different degree courses for a 10-month period in the effort to develop economically viable digital solutions. By associating the agility of start-ups with students' power of reflection, Matrice covers the whole chain of innovation, from basic research to production. This program reaches farther than education by integrating real data from markets, firms and users. Attracted by this unconventional approach, several firms are joining the Matrice program, in particular to study blockchain technology.

École 42 allows interested students to study unconventional topics. This intellectual curiosity is the driving force of education, of a custom-made quality education.

"Digital technology should not be shunted toward advertising or data predation."

Given the place it now occupies in contemporary society, digital technology has a power that should force it to constantly raise ethical questions about itself. A primary responsibility is to assist students in computer science with their ethical development by bringing them to face the reality of institutions and the world of work.

At École 42, nothing is imposed. There is no one who forces students to attend. The school allows students to combine their educational needs with their desire to do things. This is the real driving force behind an education and commitments. Students spontaneously take an interest in technology, present new educational projects and create groups around centers of interest, such as the association Blockchain 42.

Lectures and events can be organized, like BlockFest, the educational festival of blockchains, in June 2016. Organized by a team motivated by sharing, BlockFest had the objective of being a collective, friendly and fruitful event. Lectures, workshops on high tech prototyping, courses in programing and business analysis come together to form a topic with several entry points for both the neophytes of the Internet and experts in cryptography. Two other BlockFests have taken place; and several firms, now acquainted with the feasability of blockchains, are developing prototypes.

* By Pierre-Alexis Ciavaldini with the help of François-Xavier Petit, director of the Matrice program at École 42.

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