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Copyright Protection in Additive Manufacturing with Blockchain Approach

Martin HOLLAND[a], Christopher NIGISCHER[b] and Josip STJEPANDIĆ[a,1]
[a] *PROSTEP AG, Darmsadt, Germany*
[b] *NXP Semiconductors Germany GmbH, Hamburg, Germany*

Abstract. Within "Industrie 4.0" approach 3D printing technology is characterized as one of the disruptive innovations. Conventional supply chains are replaced by value-added networks. The spatially distributed development of printed components, e.g. for the rapid delivery of spare parts, creates a new challenge when differentiating between "original part", "copy" or "counterfeit" becomes necessary. This is especially true for safety-critical products. Based on these changes classic branded products adopt the characteristics of licensing models as we know them in the areas of software and digital media. This paper describes the use of digital rights management as a key technology for the successful transition to Additive Manufacturing methods and a key for its commercial implementation and the prevention of intellectual property theft. Risks will be identified along the process chain and solution concepts are presented. These are currently being developed by an 8-partner project named SAMPL (Secure Additive Manufacturing Platform).

Keywords. Additive Manufacturing, Urheberrecht, License Management, Blockchain Technology, Plagiarism, RFID

Introduction

Within „Industry 4.0“, 3D printing technology emerges as one of the disruptive innovations. Conventional supply chains are replaced by value-added networks [1]. The spatially distributed development of printed components, e.g. for the rapid delivery of spare parts, creates a new challenge when differentiating between "original part", "copy" or "counterfeit" becomes necessary [2]. Based on these changes classic branded products adopt the characteristics of licensing models as we know them in the areas of software and digital media [3]. Further, 3D printers for synthetic materials have already become very cheap, so that plagiarism and the protection against it have naturally gained the relevant importance [4].

The entry of Microsoft into that issue even strengthens this trend. Thereby, one comes to the conclusion that this process has already become commodity [5][6][7]. Hence, it is important that counterfeiting and protection against it will be granted the required attention, as product and trademark counterfeiting cause billions of losses to German companies [2][8].

At present, the theme of plagiarism is strongly related to 3D printing. Thus, the trade association Spectaris is warning that „3D printing considerably increases the

[1] Corresponding Author: josip.stjepandic@opendesc.com

danger of plagiarism in the sector of medical technology". Even technology lawyers warn of counterfeiting risks through 3D printers [9]. And in case the prices of copy technologies will be constantly falling, plagiarism risk will significantly increase [10].

This also means transfer of design data for 3D printing and decentralized creation of objects by 3D printing only being economically reasonable in case there are the according security mechanisms and an according digital license management that ensures the copyright holder being fairly paid and able to control who is creating samples of the according 3D object [2][3]. This is particularly important as through local manufacturing of an additively produced component, customs control becomes increasingly more difficult.

Thus, to the integration of Additive Manufacturing procedures in the production process and the whole product life cycle, significant challenges are tied in the authorized access to product data, assured supply of the agreed quantity, distinction of original parts from counterfeits as well as prevention of intellectual property, product liability and warranty [2][3].

In the consumer area, according to §53 Copyright Law, (as well copyrighted parts additively manufactured by the enduser may be copied for private use without agreement of the author) it also applies to parts additively manufactured by the enduser that copies for private use are as well allowed without the agreement of the author. Originals of other authors - such as templates from the internet - may as well be printed. For this, a few conditions have to be taken into account: The number of copies has to be kept small. So far, with quantities of maximum 7 copies, courts have assumed private use. These copies are as well allowed to be passed on to friends and relatives free of charge. However, the printer may not receive a return service for the work pieces, as the parts otherwise serve for profit-making measures. This would be plagiarism. Furthermore, the copy may not derive from an obviously illegal source [11].

What may be right for private use in the Consumers' sphere, may quickly become a risk factor in the B2B field. It is important to answer the questions of the IP- and counterfeit protection and take corresponding protective measures [2]. Although there will not be a 100% protection, the obstacles have to be set as high as it might be economically justifiable for the copyright holder on the one side and, on the other side, it may not be financially profitable for the pirate to produce counterfeits [12]. The subject of counterfeit protection is to be bound into a company-wide concept for the product and know how protection [13]. Measures for counterfeit protection can be divided in four categories (internal security, external security, product labelling and legal safeguards) [14]. The last two categories will be specified in sections 1 and 2. In section 3 we will introduce a new concept.

1. Product Labelling

Within the scope of additive manufacturing processes, visible and invisible labelling systems may apply. They may be used during the manufacturing process or within the scope of rework. In product labelling, 2 basic principles can be distinguished: labelling information about, e.g., the product origin or the manufacturer and secondly measures for a biunique identifiability and, thus, traceability of an individual product [2].

When selecting the right procedure for individual application, it is to be paid special attention to the usability in court. Usability in court means recognition and

admission of a procedure by the Court. This may be a crucial factor in case of defence against a product liability claim or against unjustified warranty claims [13].

The labelling of products during 3D printing may be done visible or invisible. Visible product labelling can be reached by application of a security tag or by means of holograms. Here, when removing the seal for the first time, there may as well be exposed an irreversible message.

If applicable, in compliance with RFID (Radio Frequency Identification), these procedures may provide additional information about origin, supply chain or manufacturing parameters. To avoid signature fraud of Radio Frequency Identification tags, the attached label can as well be combined with a highly resolved, cloud-like printed image, the subtleties of which are not visible to the naked eye. In case a counterfeiter tries to imitate it, the picture looses precision and optical details and, thus, can be exposed as a forgery with appropriate reading devices. These images may as well be attached to additively manufactured components as direct markings and are then inseparably attached to the product. Inseparability is reached, for example, through direct application of a serial number to the surface of the component by stamping, through lasers or similar procedures. Here, it is as well possible to apply an according code or a picture not verifiable for counterfeiters.

Next to these „visible“ tagging systems, there are quasi invisible or only machine-readable labels. By adding special security pigments, optical fingerprints are introduced in the products. They are displayed as special spectral profiles in the reading device. Thereby, a bijective identification of an individual product and, thus, traceability is as well enabled.

Another method is scanning determined surface areas combined with a Barcode or RFID: An individual surface structure is to be scanned and, thus, serves as a fingerprint of this special product.

Selective introduction of foreign particles during the manufacturing process is as well possible. Owing to the foreign particles being placed inside the component, the labelling is invisible from outside and cannot be manipulated later. Further, for the defined arrangement of foreign particles, a precise process knowledge is required [15]. This method, coming from sintering, can be transferred to additive manufacturing procedures. Whereby, next to the „arranged“ installation of foreign particles, only a disordered installation may be practicable. However, this installation will result in another bijective fingerprint of the product, which can be accordingly selected and saved after production to then serve as proof of authenticity.

As displayed, next to the labelling, a product’s traceability is of vital importance. The importance of this issue is as well evidenced by the establishment of the standards committee “Measures against Product Piracy”. The according measures for counterfeit protection, authentication controls, management standards and specific protection concepts are viewed to then, in cooperation with international committees, develop the corresponding norms.

Among others, the purpose of these measures is to establish interoperatibility between identification systems.

2. Legal Aspects

Within the process chain of Additive Manufacturing, the preparation of geometry, the determination of the process parameters or the manufacturing of components is often

done by external partners, whereby copyright questions have to be answered. In case a service provider prepares the geometry model for printing and subsequently creates the print template via Slicing Software, he may eventually have created a work according to copyright law, §3 section 1 No. 1 or No. 7. The author is granted the protection by preparing the file. Thus, to protect the work, it does not have to be registered. The conditions required to classify it as a work is, on the one hand,that it has to be created by a human and, on the other hand, requires an "intellectual creation" [11].

In this case, the resulting work must not be copied and distributed without approval of the copyright holder. Public availability needs as well the approval of the author. Furthermore, the original product manufacturer might not be allowed an amendment of the prepared geometrical model. Thus, the rules for the legal boundary conditions must be defined clearly when charging service providers with the creation of a print template. On the other hand, printing a template means copying it. The reproduction rights are based on §16 copyright law. Printing means copying, because the work – the template – is made perceptible as a physical object. The work itself is not changed thereby, but merely the form of expression. Thus, the number of printed works does not matter, already the first workpiece is a copy of the template. The reproduction right according to §16 Copyright Law is the main standard for the manufacturing of the workpieces. In case the printing file is passed on to a service provider for production, he has no property rights with regard to the protected work. In case of the mere process of the printing order, the intellectual creation is missing [11][2].

In additon, product liability plays a crucial role. Process Parameters and especially layering may have a significant impact on the product features. If the suppliers produce according to the manufacturer's instructions or are these instructions not clearly defined, the manufacturer holds responsible for any defects. The requirements are to be clearly defined and the process parameters have to be agreed upon by contract. What influence have the parameters on the product features and how can they be controlled and recorded?

The best protection against plagiarism offer patents and registered trademarks. In Additive Manufacturing, 3D Trademark and registered product designs may play an essential role in future. Three-dimensional Trademarks are representational brands. They are composed of a design, e.g. the shape of the product and its package [16].

When registering a 3D brand name it has to be considered that the form distinguishes by special aesthetic features from others and, secondly, that it is not only required to reach a technical effect but as well an aesthetical. Lego, for example, did not succeed by arguing that the clamping effect of toy bricks could as well be reached by a different construction and design of the coupling elements (nubs) without qualitative, technical, functional or economical benefit against those having been built differently [17]. In contrast, the classical Cola bottle or Toblerone chocolat are registered 3D Trademarks.

Next to patent and trademark regulations, in the run-up to a cooperation with external partners, certified elements and legal aspects should be considered: How reliable is a partner, wich certification has he and which legal system does he come under. With a partner certified according to ISO 9001 and 27001, one can expect an according compliance of certain basic rules. Furthermore, the above mentioned aspects should always be agreed upon by contract. Here, one should consider: The content of a bilaterally written contract is of little use if a company has no chance to enforce it. Then, the contract isn't worth the paper it has been written on.

3. Our Approach: Secure Process Chains for Additive Manufacturing

Owing to the special features in additive manufacturing, in particular 3D Printing, currently a „Chain of Trust“ is in discussion widely. The idea is to reduce risks to a minimum by using the according technologies. At present, there are different, primarily cryptografic approaches to secure the authenticity of printing data and prevent unauthorized use of it [4].

Encoding and licensing of data by using Blockchain Technology provides an opportunity. The relevant data are encoded and the identification of the print template and the licensing of the printing process is done by means of Blockchain Technology. So far, this is mainly known from the finance world. It is a chryptografic procedure to proof the authenticity of financial transactions at digital payment. A specific Blockchain Application, for example, is the cryptocurrency Bitcoin. Blockchain Technology, however, may basically be used as well for the application of transactions in terms of franchising. Instead of Bitcoins, the license allows to print a certain number of a component.

Figure 1 displays how to represent the transaction „Alice authorizes Bob to print four copies of a certain product“ in a Blockchain. A so called Smart Contract files the license information in the Blockchain and secures that only Alice and Bob are able to read it. Later, Bob‘s printer verifies the license before starting to print. Additionally, the serial numbers of the separately printed components can be displayed in the Blockchain to proof type and quantity having been printed in accordance with the license terms [4].

To completely close the Chain of Trust, the machine and automation suppliers have to be taken into account. Similar concepts as those of manufacturing copiers can be realized. Like copying money is being prevented, by the installation of so called Secure Elements into machines for Additive Manufacturing, trusted printers communicating with the Blockchain are realized. Thereon, you can build up a complete Chain of Trust from copyright holder to service provider [18][19]. Other ways to lay Trademark Protection one level up are certified partners and the use of trusted printers (“Block-Chain Ready”) [4].

Figure 1. Licence Information pictured by means of Blockchain-Technology.

The project Secure Additive Manufacturing Platform (SAMPL) aims at developing consistent Chains of Trust for Additive Manufacturing Procedures for a commercial purpose. The entire process is seen – from development of digital 3D Printing Data via the exchange with a service provider of 3D Printers trusted by specific Secure Elements up to labelling of printed components by means of RFID-Chips. In addition to the available encoding mechanisms, a digital license management based on Blockchain Technology will be integrated into the data exchange solution OpenDXM GlobalX of PROSTEP AG. The interface for the exchange of certification and license data between copyright holder and receiver is Industry 4.0 Standard OPC-UA. Figure 2 illustrates the System Architecture [4].

The approaches pursued by the demonstrated system architecture aim to develop concrete potential uses for a number of stakeholders based on recent regulation by law [20]:

- Printer manufacturers: Distinguishing Feature „trusted“ 3D Printer, Integration of a module for copyright protection enables hedge for service provider and user [21].
- Author: IP protection, prevention from pirate copies, make rights enforceable, traceability of use, pricing dependant on usability [2].
- Original Equipment Manufacturer (OEM): secure on-demand-production, reduction of storage and transport costs, lower capital binding, quality guarantee, optimized spare parts distribution [22].
- Printing Service Provider: reduced transaction costs by using trusted 3D Printers, support services on quality control, legal security and competitive advantage [2][23].
- Final Customer: verifiable authenticity, protection against design manipulation, precise and secure billing, confidence in the work, advantages with guarantee claims [2][23].

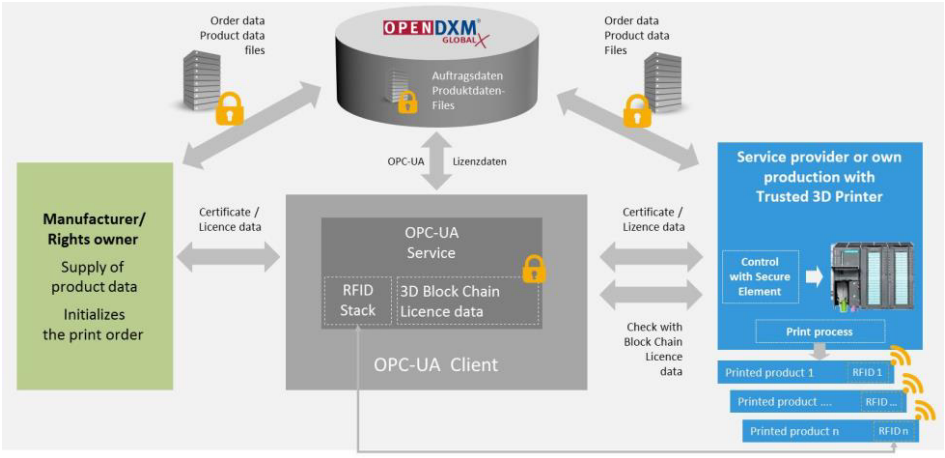

Figure 2. SAMPL System Architecture.

4. Conclusions and Outlook

In digital transformation, in the range of Additive Manufacturing, a lot of research is done on the topics of process management, technologies and methods [7]. Extensive research concepts on information security, license management, copyright protection and proof of authenticity, however, are still strongly underrepresented [18][24]. In digitalization and networking, products and production have to be granted a dominant role with regard to the security of the entire system and the risk management [25][26].

At present, there is no platform allowing to digitally and treaceably administrate data relevant for 3D printing taking into account digital licenses. In particular, digital product data have to be linked to license data. This lack is planned to be solved by an integration of the SAMPL Platform and a 3D Blockchain.

Saving and administrating digital licenses requires a database ensuring the stability of its entries. However, saving new license transactions such as updates of digital versions or changes in ownership are to be made possible. Having proven highest demands in terms of reliability and security with its first big implementation as a basis for the Cryptocurrency Bitcoin since having been started in the beginnings of 2009, Blockchain-Technology offers that kind of register.

The enlargement of the Chain-of-Trust via the 3D printer control into the printed product, e.g. via integration of RFID Chips, represents an interesting option for the organization of future business models culminating in the connection of any product with a digital product memory [27][28][29]. Thus, all 3D printed and RFID-tagged components could be smart products throughout the lifecycle. For example, the evaluation of product use, the analysis of typical damage patterns or repair requirements could lead to a targeted development and improvement. The control circuit, nowadays not closed at many products, could be closed across the product life cycle and, thus, allow new innovations [30][31].

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