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## A METHOD TO PROVIDE PRINT CONTROL OVER HETEROGENEOUS 3D PRINT BUCKETS

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## A method to provide print control over heterogeneous 3D print buckets

### Abstract (Required)

How could a company make sure that their intellectual property is being used correctly and according to the agreements set with Print-Service-Providers (PSP) So far the copyright laws did not catch up to this new 3D print world and one of the challenges is to enable Content Providers to track the agreements set with PSPs, and allowing management of thousands of different PSPs printing a variety of models per bucket (3D bed filled with objects to be printed). Some of these models can have copyright and some not, creating a heterogeneous print bucket. The models in the bucket may have different providers (Company A and COMPANY B for example) and they may be printed together in order to save time and material. This work provides a way to control 3D prints in heterogeneous 3D print buckets allowing only the pre-defined people (or PSP) to print the correct amounts of models (with the correct properties) using an agreement base using the 3MF as standard input for the Terminus project that will be released later in 2018.

### Problems Solved (Required)

The 3D print market for prototypes and manufacturing is a reality for big companies that are using this technology to save money and time. However, the copyright laws have to keep up to constant changes of the 3D scenario and possibilities. The control that can be exercised by the Content provider depends on agreements and a very limited domain of applications that restrict the file itself rather than providing features and functionality. Thus, the problem can be stated as “how can a Content provider control the terms of the agreement set without any additional hardware and at the same time, allowing anyone to see the 3D models?”

### Prior Solutions (Required)

Usually when talking about 3D and IP, the problem solved is how to send 3D files directly to printers without having anyone in between have access to the files, thus preventing piracy. One plausible solution to that involves encrypting those files. Encryption however has its downsides, requiring certificates, passwords, special hardware and so on. Another characteristic of encrypted files it that it forbids combination of 3D files and even visualization, which is covered by the proposed solution. .Moreover, this article describes a process that tracks the digital files protected by copyrights allowing content owners to control how their content is being printed, which is not achieved with encryption.

Even though this solution differs from encryption- based systems, encryption can still be applied in addition to the proposed solution to further protect the files. The solution described in this disclosure can easily co-exist with encryption-based solutions as the printer must decrypt the file before processing and process the files without the need for visualization.

- <https://www.3ders.org/articles/20130903-fabsecure-secure-3d-streaming-for-3d-printers-goes-live.html> Their site seems to be down. It doesn't seem they're operating anymore. Plus this article is from 2013 and it seems they were using STLs back then (3MF is younger than that), while our approach uses 3MFs. Also, their solution works with additional hardware that has to be purchased by content providers and PSPs. Finally the file their solution works with is an encrypted file that only allows models to be viewed/printed with passwords and additional hardware.
- <http://secured3d.com/> this solution enables any content provider to work submitting models to a cloud environment. The customer does not have any contact or agreement with the content provider. The build must be generated in this cloud environment and then processed in the local printer. This does not allow heterogeneous buckets nor is flexible enough for allowing Content Providers and PSPs to establish their own rules.
- <https://www.createitreal.com/> uses encryption to send the files to directly printers, without anyone in between having access to the file's contents ( <https://3dprint.com/177784/create-it-real-copyright-3d-print/> )

- <https://polyport.io/landing/> it seems they're still beta. Their solution uses encryption and keeps file extension, so that the encrypted file can still be opened with regular software, but without special software and decryption key, users cannot visualize file contents
- <http://www.infratrac.com/> uses a different method, called "light-based authentication", which involves adding chemicals to the material. This is different from our approach, since they focus on the printed products, distinguishing real from counterfeits, while we are focusing on tracking the digital files representing products. Some other ideas along this line are using RFIDs and ID tags ( <https://3dprint.com/117613/combat-counterfeiting-am/> )

## Description (Required)

The proposed solution is composed by:

- **Content Provider and PSP agreement:** the proposed solution will work based on the existent agreements already set and it will require the following information from both parts:
  - The knowledge that the PSP should not change the original 3MF model
  - Content Provider and PSP will set the transformation (if any) can be applied to the model (PSP can scale the model up to 2x the original size, for example) as well as any changes in color or texture.
  - Content Provider and PSP will set the number of copies to be printed.
  - Content Provider and PSP will decide if the model(s) has to be exclusive (meaning that the print buckets must have only the specific model and PSP will be not authorized to mix products from other Content Providers).
  - Content Provider and PSP may set minimum and maximum dates for printing, allowing printing only while the agreement lasts or any date constraint
- **Firmware support:** This will add new functionality to the printer allowing it to:
  - Check the checksum of the 3MF file if it is present, if this is not present the printer will calculate the checksum.
  - Generate a QR code containing the printer information, Checksum of the models, number of copies, transformations applied (scale, rotation, translation), color and texture for all the models present in the print bucket requested. This QR code must be valid for a few seconds or a minute. After that the QR code must be re-generated.
  - Receive the notification from the Cloud server about the authorization to print (all, part or none) the requested bucket.
  - Send information about the print status after the print execution (in order to update the limits in the Cloud Server).
- **Cloud Server:** The brand- new environment where the Content Provider will enter the agreement set with the PSPs. It will provide the ability to:
  - Allow PSPs to login using a web- based account as well as using a smartphone application in order to take a snapshot from the QR code provided by the printer.
  - Allow Content Providers to setup the agreements with PSPs, in terms of models, number of copies, allowed properties (textures, colors, transformations. etc...), initial date and expiration date.
  - Allow the printer to send the information about the printed bucket, in terms of models printed (checksum) and number of copies printed.
  - Send to the printer the information about the authorization (allowing all, part or none of the models requested).
  - Allow Content Providers and PSPs to generate usage reports by demand.
- **Smart Phone Application:** That will allow PSPs to log in the cloud environment and scan QR Codes.

The Content Provider and the PSP create an agreement allowing the PSP to use the copyright from the Content Provider to 3D print one (or more) model(s) with certain characteristics as illustrated in figure 1.

The PSP will receive one (or more) 3MF file(s) from the Content Provider (the same PSP may have different agreements with several Content Providers).

The Content Provider will enter the terms of the agreement into the Cloud Server (the Content provider may have several agreements with different PSPs).

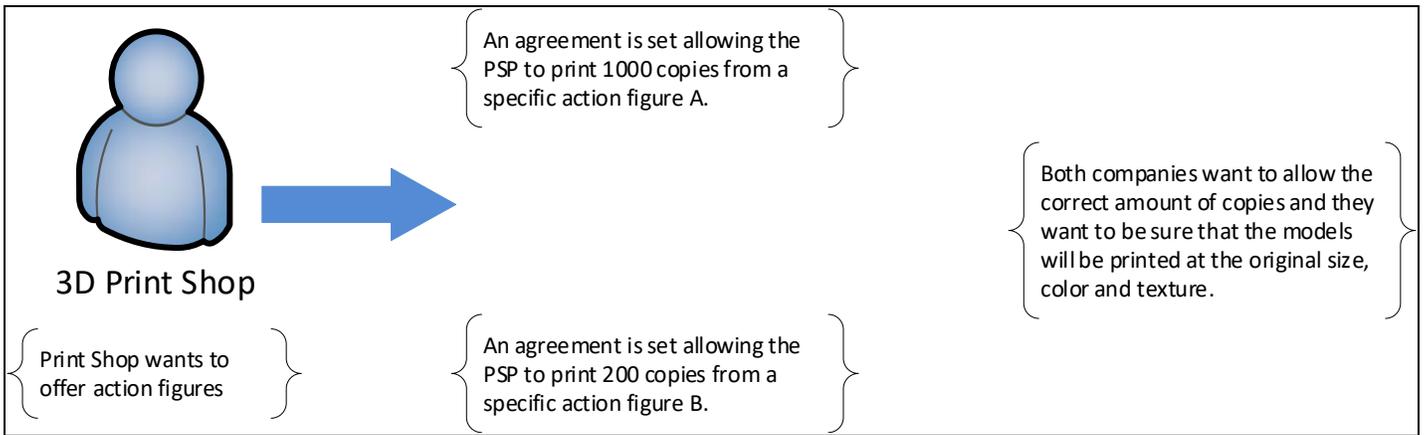


Figure 1: An example of how the relationship may start

Once the Content Provider enters the agreement, the models will be monitored by the Cloud Server, figure 2.

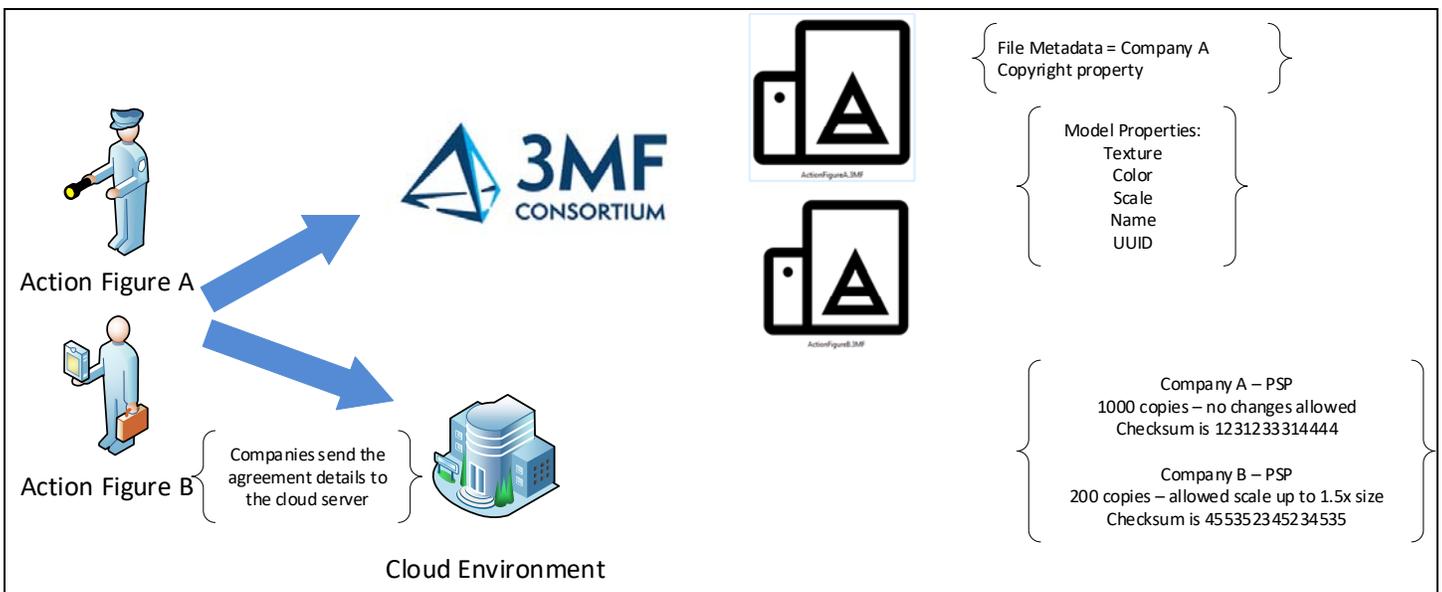


Figure 2: Action figures will relate to copyrighted 3MF files with all their properties, the same will be uploaded to Cloud Environment with the agreement set.

When the PSP wants to print a bucket, figure 3, the employee may use several different 3MF files to compose a print bucket in the printer that can be automatically put to be printed or require an authentication from the PSP.

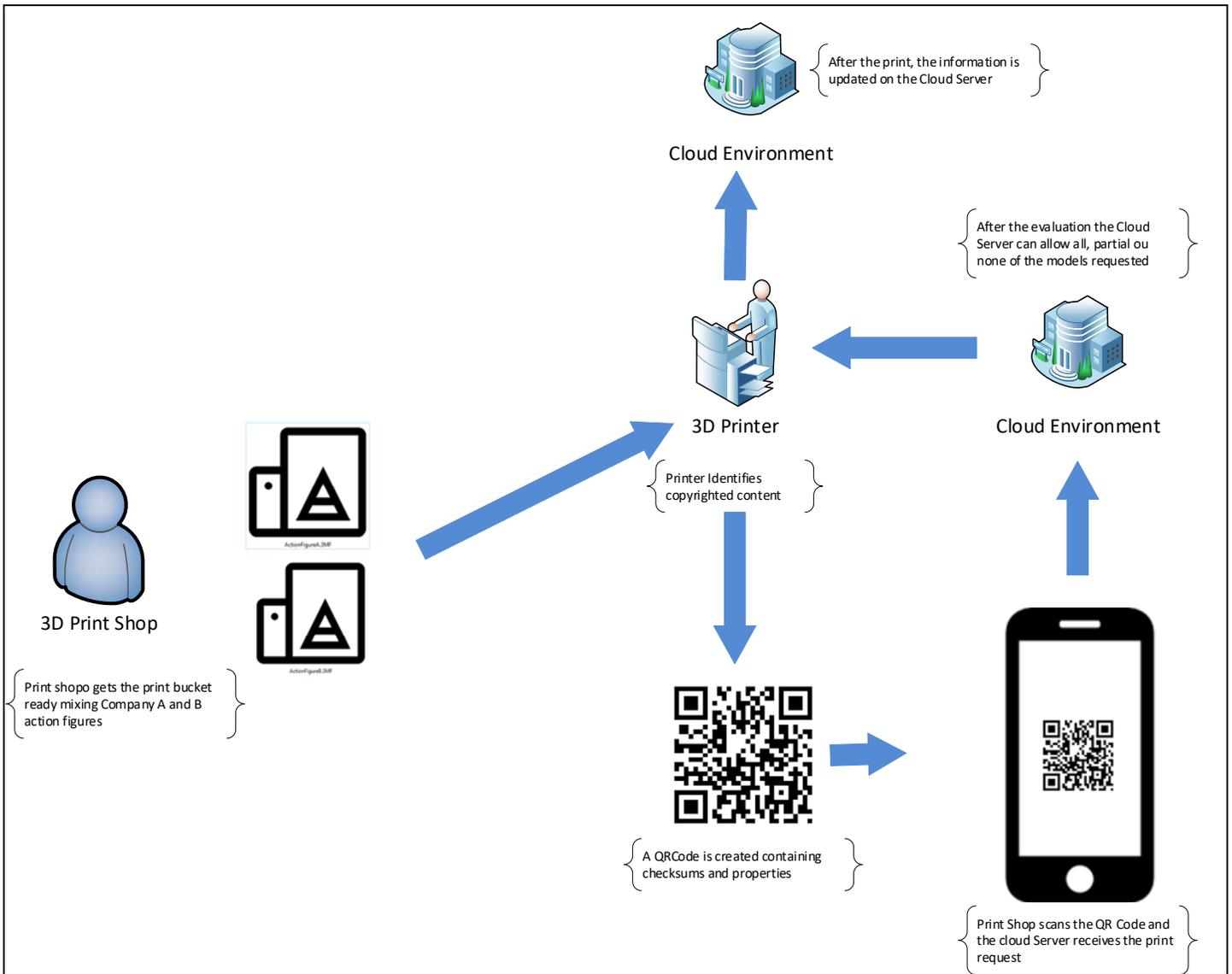


Figure 3 : The PSP will request the print job, which will be approved by the Cloud Environment

The figure 4 shows another way to accomplish the task without using the QR code, when the print bucket is created by the PSP the printer will connect to the Cloud Server and request the agreement, it will reject or accept the print job.

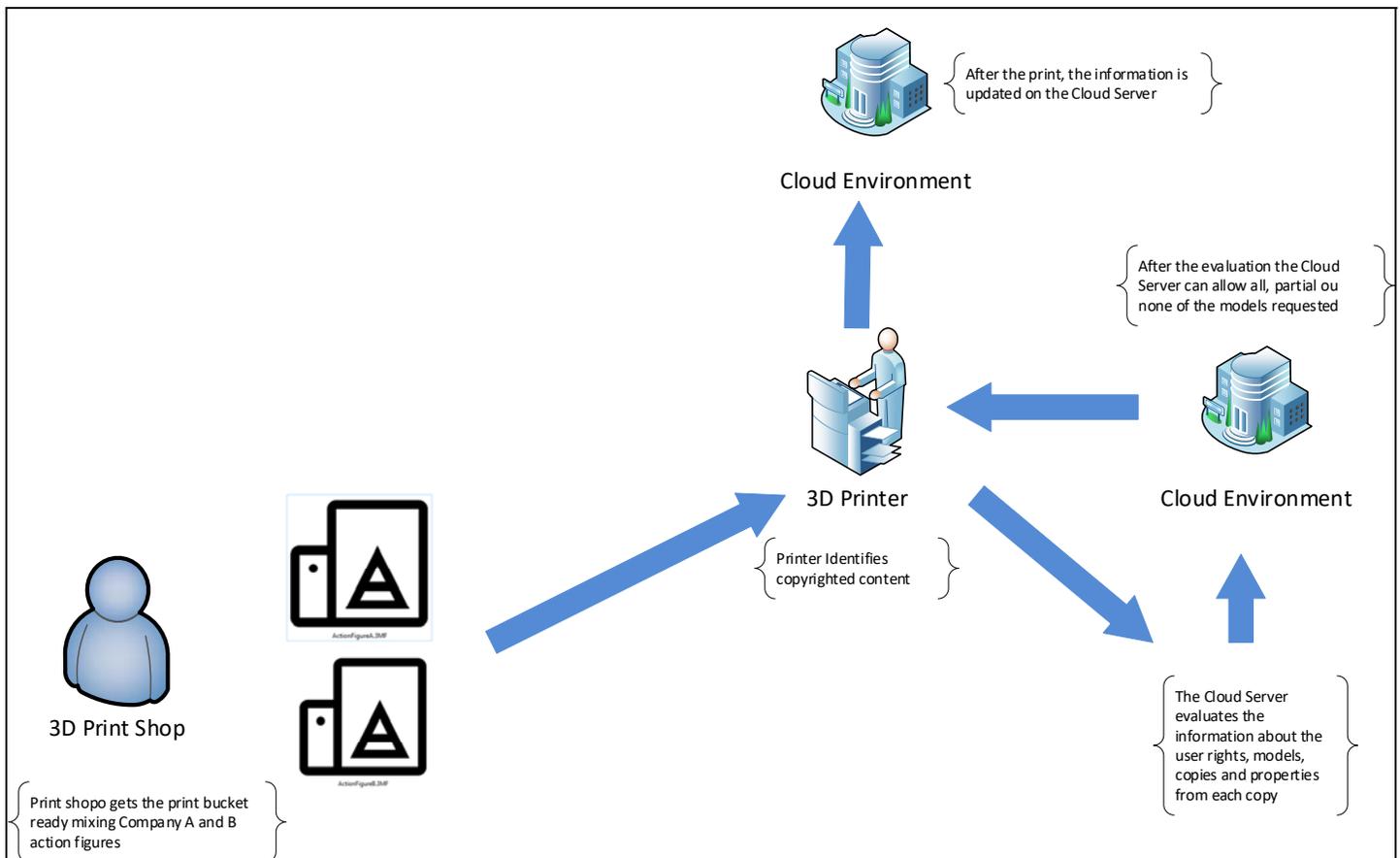


Figure 4: Scenario where the printer sends the information to the Cloud Server without the QR Code

The printer will recognize that some (or all, or none) of the models entered have Checksum, for those models that the Checksum is not present, the printer's firmware will calculate the Checksum. The QR code standard supports up to 4,296 characters that will allow the printer to add the checksum for each file in conjunction with the information about the transform matrix, current date, number of copies, texture, color and any additional information needed. Also, the QR code will allow the system to recognize the user requesting the print job.

The PSP employee will finish the print bucket, the printer will gather all the information needed and create a QR code. The QR Code will be displayed in the printer's panel allowing the employee to scan using the smartphone application. The Cloud server will receive the print request with the user logged in the smartphone, the PSP responsible for that user, the checksum of all models present in the print bucket. For those Checksums recognized as being part of an agreement the Cloud Server will match the rights of that particular PSP and the job request (number of copies, if the model has been scaled up, if this is an exclusive model, if the texture and color are correct and so on). The Cloud Server will respond to the printer passing a payload allowing or denying according to the rules created.

The printer will inform the user about any restrictions and changes that have to be made in the print bucket prior to print. Once printed, the printer will send a payload to the Cloud server allowing it to update the counters. If the payload is not sent, an alert will be created so that the Content Provider and PSP understand that there is a pending print request.

### Advantages (Required)

This solution has following advantages:

- Allows content providers to:
  - track how many copies of their products are being printed
  - specify what changes are allowed, if any at all, to their files prior to printing
  - specify dates such that PSPs may not print prior to these dates
  - specify expiry dates such PSPs may not print after these dates
  - no additional hardware required
- Allows PSPs to:

- combine several products from different Content Providers into a single bucket, with or without copyright restrictions (heterogeneous buckets), increasing print throughput and decreasing print cost, while still keeping track of copyright information.
- optimize files, while still maintaining quality expected from content providers.
- can see file contents before they're printed and check for errors, thus fixing or reporting these errors to content providers before printing, preventing material waste.
- no additional hardware required.
- the 3MF can be visualized in any device at any time.

*Disclosed by Ricardo da Silva Beck and Diogo Cravo, HP Inc.*