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Information technology — 3D printing and scanning — Framework for an Additive Manufacturing Service Platform (AMSP)

Technologies de l'information — Impression et balayage 3D — Cadre conceptuel pour une Plateforme de services de fabrication additive (AMSP)

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Foreword

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Introduction

Additive manufacturing (AM) has been used for rapid prototyping for many years and is increasingly being applied to volume production, mass customization and spare parts production among other use cases. It is possible that low volume prototyping can tolerate simplified, ad hoc or informal interfaces between parts customers and AM service providers. As additive manufacturing capabilities have increased and as demand for additively manufactured parts has increased these informal interfaces are no longer sufficient. Additionally, AM workflows can require the contributions of several service providers in order to achieve the desired outcome. These workflows can need to nimbly adapt to needs specific to that outcome. To do so, a flexible and transparent interface structure is required.

Without interface standards, information exchanges between parts customers and AM service providers, and among collaborating AM service providers, often require ad hoc and expensive manual intervention. Inconsistent descriptions of the characteristics of the services provided can also create confusion, misunderstanding and rework.

The framework for an Additive Manufacturing Service Platform (AMSP) identifies interfaces and their key characteristics where standards can make a beneficial contribution to formalizing the interface for parts submission, design and creation. The Framework for an AMSP also identifies the qualities of an AM service provider that require a standard-consistent specification. The framework for an AMSP does not include these standards; they need to be developed separately. However, it does provide a landscape that clarifies how these standards relate to other elements of the AM ecosystem.

It is hoped that the adoption of this framework and the standards that it calls for will streamline and accelerate the adoption of AM technologies in the manufacturing ecosystem at large, enabling increasingly more complex use cases and richer collaboration between parts customers and a variety of AM service providers.

Information technology — 3D printing and scanning — Framework for an Additive Manufacturing Service Platform (AMSP)

1 Scope

This document specifies the framework for an Additive Manufacturing Service Platform (AMSP). The following elements are within the scope of this document:

— Overview introducing the stakeholders and workflow of an AMSP.

— Requirements specifying various prerequisite conditions from different aspects.

— Framework defining a general functional architecture based on the identified requirements.

— Use cases showing typical work modes of an AMSP.

This document is applicable when individuals or organizations (e.g. commercial enterprises, government agencies and non-profit organizations) build an AMSP or improve existing ones to provide 3D printing and other services specific to the submission, design and creation of AM parts.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/ASTM 52900, *Additive Manufacturing — General Principles — Fundamentals and vocabulary*

ISO/ASTM 52901, *Additive manufacturing — General principles — Requirements for purchased AM parts*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/ASTM 52900 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at ~~https://www.iso.org/obp~~

— IEC Electropedia: available at ~~https://www.electropedia.org/~~

3.1
additive manufacturing service platform
AMSP
platform that uses additive manufacturing technology and information technology to provide services according to users' requirements

Note 1 to entry: Examples of services provided include objects/parts manufactured by AM technology, 3D model designs and other services specific to the submission, design and creation of AM parts.

Note 2 to entry: A typical AMSP usually consists of an online platform to gather requirements of users, a group of skilled staff to deal with users' requirements, 3D scanning equipment, AM machines and different kinds of feedstock.

Note 3 to entry: A typical AMSP can sometimes cooperate with individuals or organizations professionalized in specific industries (e.g. aerospace, medicine, etc.).

3.2
user
individual or organization that needs parts manufactured by AM technology and would like to turn to an AMSP for service

3.3
designer
individual or organization that performs 3D modelling and 3D scanning assigned by agreement between user and AMSP

3.4
infrastructure as a service
IaaS
cloud service category in which the cloud capabilities type provided to the cloud service user is an infrastructure capabilities type

[SOURCE: ISO/IEC 17788:2014 3.2.24, modified — term "cloud service customer" replaced with "cloud service user".]

3.5
software as a service
SaaS
cloud service category in which the cloud capabilities type provided to the cloud service user is an application capabilities type

[SOURCE: ISO/IEC 17788:2014 3.2.36, modified — term "cloud service customer" replaced with "cloud service user".]

3.6
additive manufacturing centre
AM centre
place where AM parts are manufactured according to the user's requirement

Note 1 to entry: An AM centre may consist of several kinds of AM systems and corresponding feedstock.

Note 2 to entry: An AM centre can be operated by organizations that manage the AMSP or by organizations/individuals who operate AM systems qualified to be registered on the AMSP.

3.7
3-dimensional design model
3D design model
3D model
data set that contains 3-dimensional geometric elements representing the object/part to be manufactured

3.8
technical data package
data set that contains necessary information and can be exchanged or transformed to provide a format that can be used by an AMSP

Note 1 to entry: Examples of "necessary information" in this context include 3D model, colours, materials, lattices, textures, etc.

4 Overview

4.1 General

An Additive Manufacturing Service Platform (AMSP) provides an access interface (website, app, etc.) where stakeholders, including users, designers and AM centres, can have connections based on their own requirements. With the help of an AMSP, users can purchase specific AM objects/parts and relevant services as they are required rather than AM equipment and feedstock, without the need to have skilled staff trained in AM. There are no up-front costs or investments when turning to AMSP.

4.2 Stakeholders

Figure 1 describes the relationship and interaction among stakeholders including an AMSP, users, designers and AM centres.

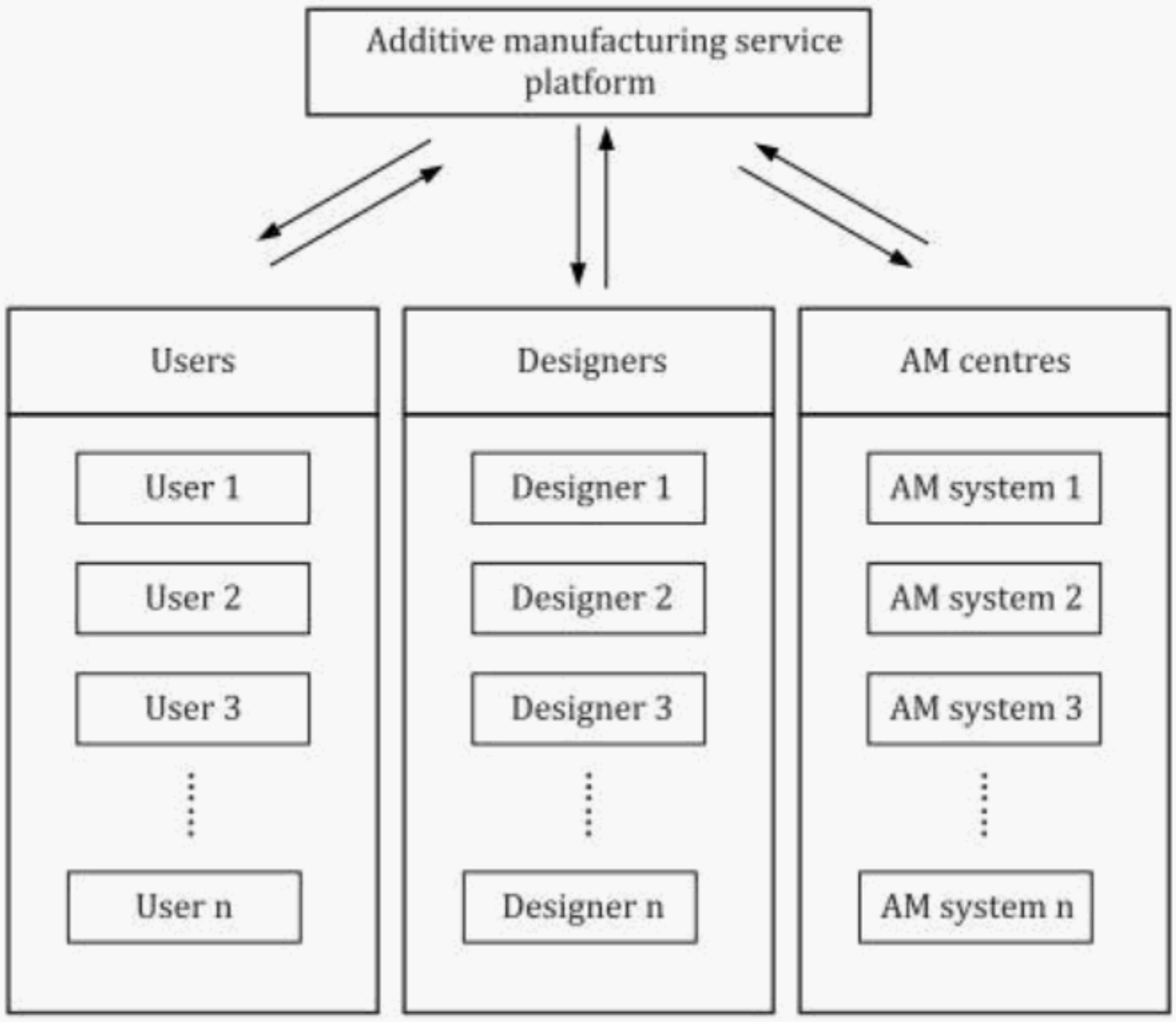

Figure 1 — Interaction among AMSP, users, designers and AM centres

4.3 Workflow

4.3.1 Introduction

Figure 2 describes a typical AMSP workflow.

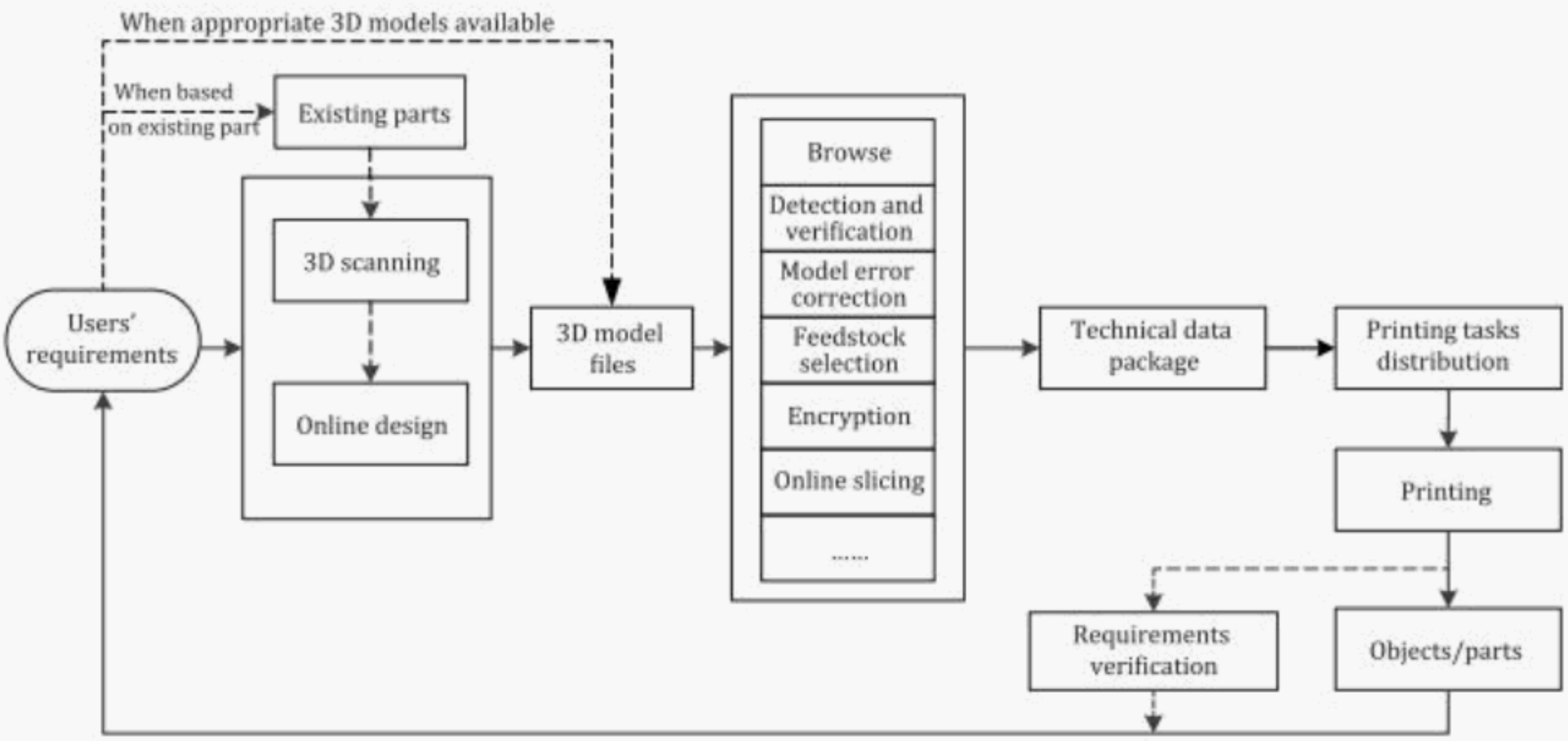

Figure 2 — Typical AMSP workflow

4.3.2 Release of users' requirements

Users are intended to be able to release their requirements on an AMSP in the following ways:

— by creating 3D models using accessible design software provided on the platform,

— by finding designers on an AMSP to help them achieve their ideas,

— by using 3D scanning technology to generate 3D models, or

— by selecting 3D models directly on an AMSP when there are already models that meet the users' requirements in the database.

Sometimes, after the release of users' requirements, designers will receive commissions distributed by an AMSP. Designers can communicate with the users to improve their ideas and modify the 3D models. More importantly, they can ensure that 3D models are suitable for printing.

When the 3D models are created, users can select colours, materials, lattices, textures, etc. according to their requirements.

4.3.3 Model processing

After receiving the users' requirements, an AMSP can finish several necessary model processing steps, such as model error detection and correction, slicing, data protection, etc. The AMSP then generates a corresponding technical data package and distributes the printing task to the AM centres.

Sometimes, model correction can be carried out by various automated, semi-automated and manual techniques.

Technical data packages can be large, and data compression may be necessary. Data compression should conform with, but is not limited to, ISO/IEC 21320-1. Data compression occurs prior to encryption, otherwise compression is not possible due to the pseudo-random nature of encryption results. In addition, it is recommended to limit the range of encryption to only sensitive or confidential portions of the data such as those requiring intellectual property protection. Excluding model metadata from encryption allows easier reference and access to that metadata and eliminates unnecessary decryption. Note that methodologies of encryption and decryption are out of scope of this document.

4.3.4 Printing and delivery

AM centres shall start printing services after receiving the printing task.

When necessary, an AMSP delivers the objects/parts to the users after the printing is finished.

For typical use cases of services an AMSP can provide, see ~~Annex A~~.

5 Requirements

5.1 General

AMSPs should support the points in the following subclauses in order to meet the basic requirements of users, but it should be noted that not all points listed below are mandatory. An AMSP is built or improved according to its own purposes, or even expands functions such as logistic service, online shops, etc.

5.2 User management

AMSPs should manage user information registered on an AMSP. AMSPs should also be able to ensure consistent and secure user authentication and login. An AMSP can also provide users registered on the AMSP with access to the various kinds of service that the AMSP can offer.

5.3 Product design

Users can log on to AMSPs either to upload 3D models they already have or to create 3D models online (using online design apps or 3D scanning equipment to scan existing objects/parts), or even find designers on an AMSP to help with the design. Usually, users can choose materials and specify colours, due dates, etc. to suit their own requirements. In order to ensure printability, AMSPs should check the 3D models either automatically or manually.

EXAMPLE In order to facilitate online design, an AMSP can provide databases for typical 3D models, feedstock and post processes to choose from.

NOTE While using 3D scanning technology to generate 3D models, users usually need to deliver existing objects/parts to an AMSP or go to offline AMSP shops when necessary.

5.4 3D intelligent detection and correction

An AMSP should detect 3D model data errors and make corrections or suggestions accordingly and intelligently.

5.5 Order management

After receiving 3D data models with necessary information such as colour, material, etc., the AMSP should generate a price for users. When the price has been confirmed, the AMSP may generate an order. The AMSP tracks the whole process while the objects/parts are being manufactured (including printing and post-processing when necessary).

Sometimes, in order to promote the efficiency of manufacturing, the AMSP should be able to rearrange the orders containing different objects/parts according to the size, material, and process of the objects/parts (see ~~Figure 1~~). In these circumstances the AMSP shall track the information about each object/part and be able to restore the original orders. Life-cycle tracking of the order is recommended.

NOTE It is sometimes possible for the AMSP to track the information after a user receives the finished objects/parts and to gather feedback from users' comments.

5.6 Printing service

A printing service is one of the core requirements of an AMSP. If necessary, an AMSP can slice the 3D models of objects/parts (sometimes with the help of skilled staff working for the AMSP) and send the technical data package to specific AM centres connected to it. The AM centres begin printing after confirming the order.

NOTE 1 In order to promote work efficiency, an AMSP sometimes separates the orders containing objects/parts with different properties such as size, material, quality, etc. Objects/parts with similar properties can also be combined for manufacturing with a single AM equipment as a printing group.

NOTE 2 An AMSP can send technical data packages directly to AM centres without slicing the models if the control allows this. Online slicing can still be necessary for simpler control or for stricter control, security, etc.

5.7 Security management

An AMSP should provide uniform security services, including hardware and network security. For example, there should be a data access security policy, user permission authentication system, system log record, etc.

5.8 Operation monitoring

An AMSP should monitor the entire manufacturing process and warn of anomalous events in advance. Major monitoring objects include platform data traffic, the number of concurrent users and business response rate, etc. to ensure that the AMSP works properly.

6 Framework

6.1 General

~~Figure 3~~ specifies a framework of an AMSP with seven layers. Note that not all seven layers in ~~Figure 3~~ are necessary. An AMSP is built or improved according to its own purpose, or can even expand to include more functions by adding more layers, such as logistic, API/SDK, etc.

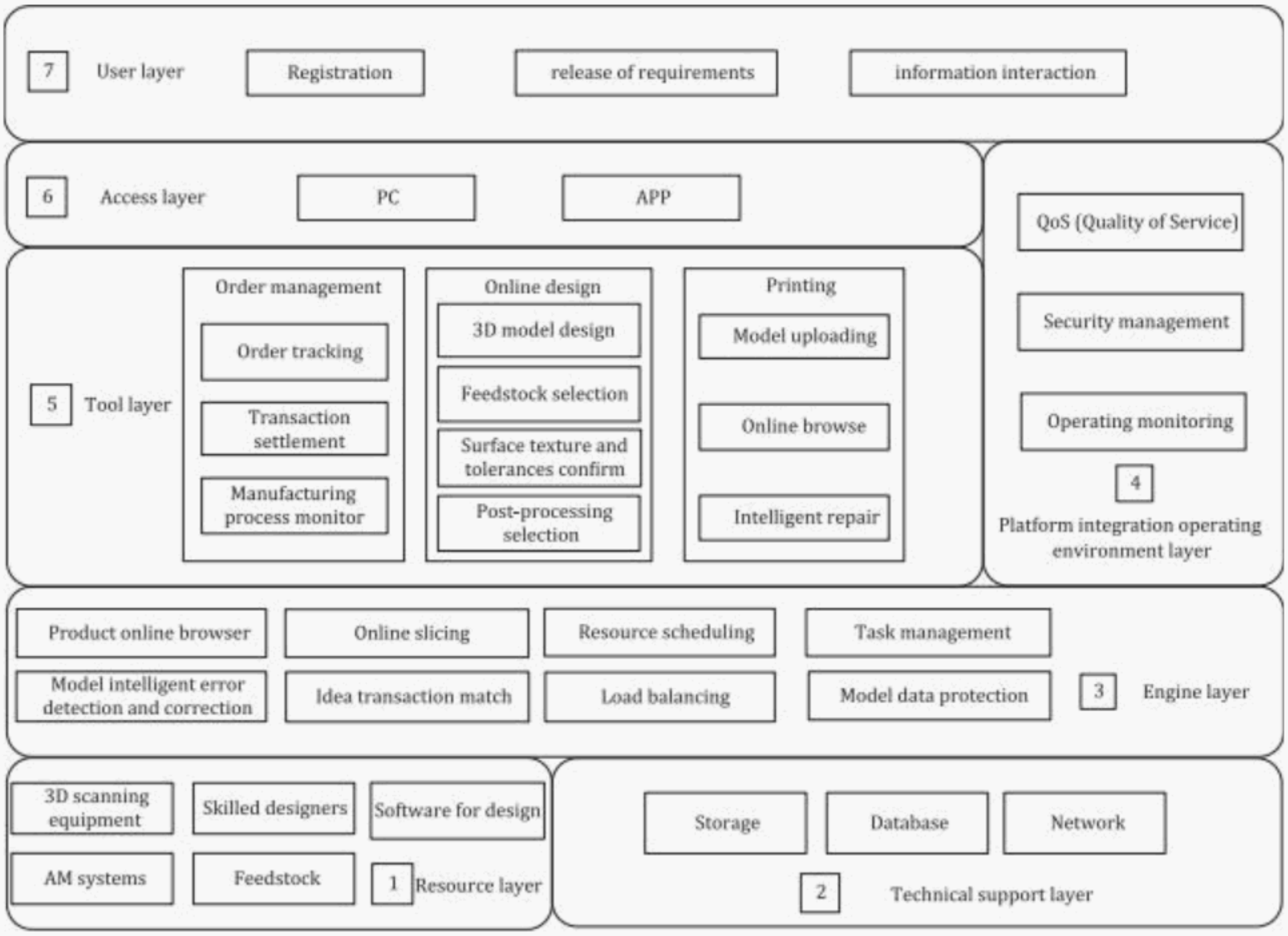

Figure 3 — Typical system framework of AMSP

6.2 Functions of the layers

6.2.1 Resource layer

6.2.1.1 General

The resource layer consists of necessary elements including 3D scanning equipment, software for design, AM systems and feedstock, etc. By using these elements, the resource layer is able to support the entire service procedure from 3D model design to objects/parts manufacturing.

6.2.1.2 3D scanning equipment

Within this framework, 3D scanning equipment is an apparatus with 3D scanning functions to obtain the 3D data of objects/parts to facilitate 3D model design.

NOTE 3D scanning equipment can also be used for other purposes (e.g. metrology) that are outside the scope of this document.

6.2.1.3 Software for design

Software for design is a software used for 3D model design. Software for design is installed in an AMSP and supports online design.

6.2.1.4 AM system

An AM system can produce AM parts. It is composed of hardware and associated control software.

NOTE An AM system, which is used in an AMSP, is a system with high quality, usually with a large scale of build chamber, good accuracy, high efficiency, etc. that is capable of dealing with various printing services.

6.2.2 Technical support layer

6.2.2.1 General

The technical support layer provides basic technical support for the platform including database (e.g. typical 3D models, processes, feedstock, post-processing, etc.), storage equipment, network, etc. An AMSP uses IaaS and SaaS to generate an environment both for users and designers of the platform.

6.2.3 Engine layer

6.2.3.1 General

An AMSP develops engines such as a product online browser, 3D model intelligent error detection and correction, online slicing, data protection, etc., to provide basic support for realizing the whole procedure from 3D model design to objects/parts manufacturing.

6.2.3.2 Product online browser

Product online browser is a software application for users to upload and browse the model of product that they design.

6.2.3.3 Online slicing

Online slicing provides the function of slicing a 3D model when the 3D model is created on an AMSP.

6.2.3.4 Model intelligent error detection and correction

Model intelligent error detection and correction allows printability testing of a 3D model. When an error is found, the user or staff of an AMSP receives a notification and a model intelligent error detection and correction engine can offer instructions for correction.

6.2.3.5 Load balancing

Load balancing ensures normal and efficient operation of the platform when mass users are in high concurrency.

6.2.3.6 Task management

Task management tracks the whole procedure of an order until the final object/part is delivered to the user. When the user releases their requirements online, the AMSP shall generate an order. Sometimes, the task management engine even records information like an after-sale service situation.

6.2.4 Platform integration operating environment layer

6.2.4.1 General

The platform integration operating environment layer is a critical layer for improving the operating efficiency and security. The AMSP has the basic toolkit to monitor and manage the platform integration operating environment.

6.2.4.2 QoS (Quality of Service)

QoS solves problems of network delay and congestion, etc.

6.2.4.3 Security management

Security management shall provide security services mainly including hardware security and network security. It usually has data access security policies and functions such as user permission authentication and logs management, etc.

6.2.4.4 Operating monitoring

Operating monitoring keeps track of the entire operation of the platform, and provides warning of anomalous events in advance. The major monitoring objects include data traffic, the number of concurrent users and business response rate, etc.

6.2.5 Tool layer

An AMSP provides human-machine interaction applications for users. These tools will ensure the AMSP achieves convenient registration, order management, printing, etc.

6.2.6 Access layer

The access layer provides access for the users. The access methods include traditional PC, smart mobile app, and other kinds of access such as USB, CD, etc.

6.2.7 User layer

The user layer is the interface that provides users with access and browsing services as well as registration and release of user requirements. With a unique ID, an AMSP ensures users are able to log on to it in order to release requirements, track the orders, communicate with designers, etc.

6.3 Correlation between framework and requirements

Each layer of the framework is built upon the requirements identified in ~~Clause 5~~. Correlation of the functional layers and the requirements which are supported by specific corresponding layers are described in ~~Table 1~~.

Table 1 — Correlation of the functional layers and the requirements

	Resource layer	Technical support layer	Engine layer	Platform integration operating environment layer	Tool layer	Access layer	User layer
User management		x		x		x	x
Product design	x	x	x	x	x	x	x
Order management		x	x		x		
Printing service	x	x	x	x	x		
3D intelligent error detection and correction	x	x	x		x		

Table 1 *(continued)*

	Resource layer	Technical support layer	Engine layer	Platform integration operating environment layer	Tool layer	Access layer	User layer
Security management	x			x			
Operation monitoring	x	x	x	x	x		

7 Considerations

7.1 Copyright protection

An AMSP allows users to upload or create personalized 3D models online in a convenient manner. The data of 3D models is usually easily spread or stolen illegally through the transmitting procedure over the internet. Meanwhile, 3D models are also easily printed without permission, which can cause a loss to the designer or model provider. Therefore, the data security of the 3D model during the data storage, transmission and printing are ensured and the intellectual property of designers and model providers needs to be protected.

7.2 Quality inspection

The performance requirements and inspection methods of the final objects/parts delivered to the user from the AMSP should meet the requirements of ISO 17296-3 and ISO/ASTM 52901.

Annex A
(informative)

Use cases of an AMSP

A.1 Use case 1

Users may upload 3D models that have already been designed and create an order online (print physical product).

~~Figure A.1~~ is a sequential diagram of Use case 1. This use case involves users, an AMSP and AM centres but does not involve designers. An explanation of the numerical labels is provided after the figure.

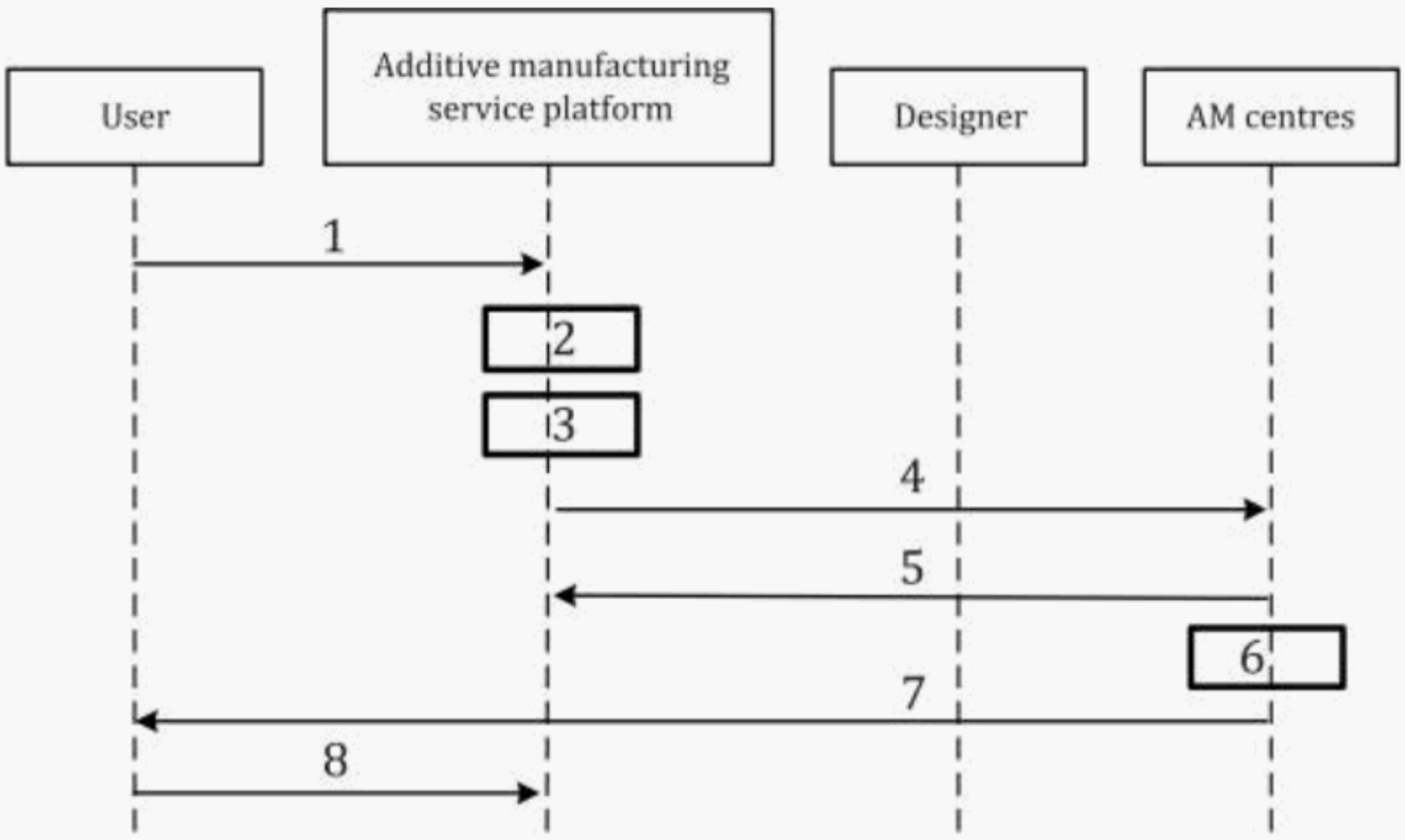

Figure A.1 — Sequential diagram of Use case 1

1) Users upload the designed 3D models and set parameters for requirements of the objects/parts on the AMSP according to ISO/ASTM 52901.

2) The AMSP detects whether the 3D models are feasible for printing and generates the technical data set according to the desired property of the objects/parts.

3) After confirming the orders, the AMSP rearranges the orders according to the size, material and process of the objects/parts (see ~~Figure A.2~~). Rearranging the order is especially efficient for industrial players who usually require a variety of different parts and materials for testing before proceeding to mass production.

4) The AMSP sends the rearranged orders to corresponding additive AM centres for manufacturing. Distributing the orders and allocating them into appropriate AM centres can save time and resources for all actors: users, the AMSP and AM centres.

5) AM centres receive and confirm order information.

6) Specific AM systems print the objects/parts according to the order information and inspected as described in ~~7.2~~.

7) The AMSP delivers the final objects/parts to the user when finished.

8) The user submits comments and feedback about the product and service quality to the platform after receiving the objects/parts.

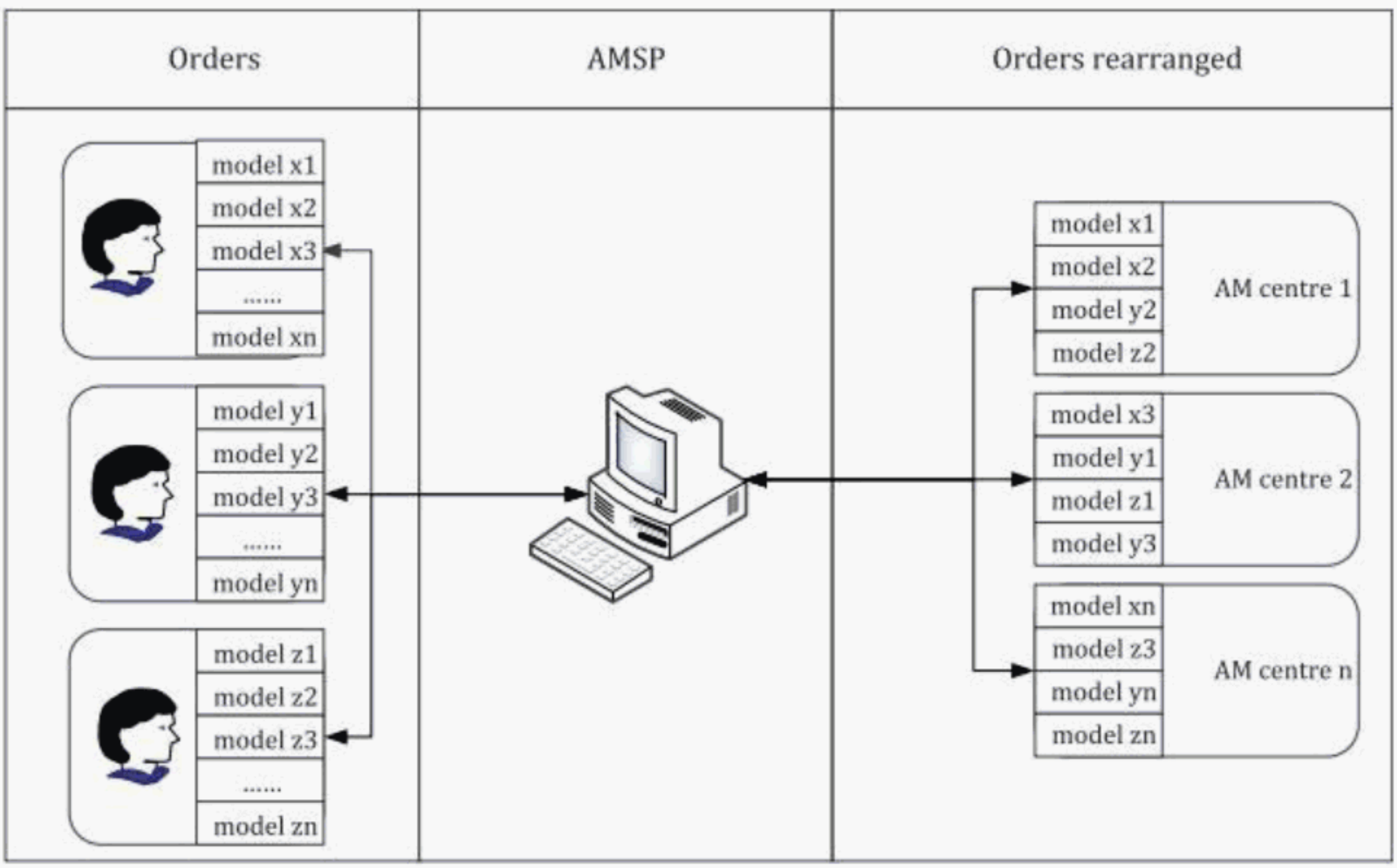

Figure A.2 — Rearrange orders

A.2 Use case 2

Users may design objects/parts directly on the AMSP and create an order online (print physical product).

Figure A.3 is a sequential diagram of Use case 2. This use case involves users, an AMSP and AM centres, but does not involve designers. An explanation of the numerical labels is provided after the figure.

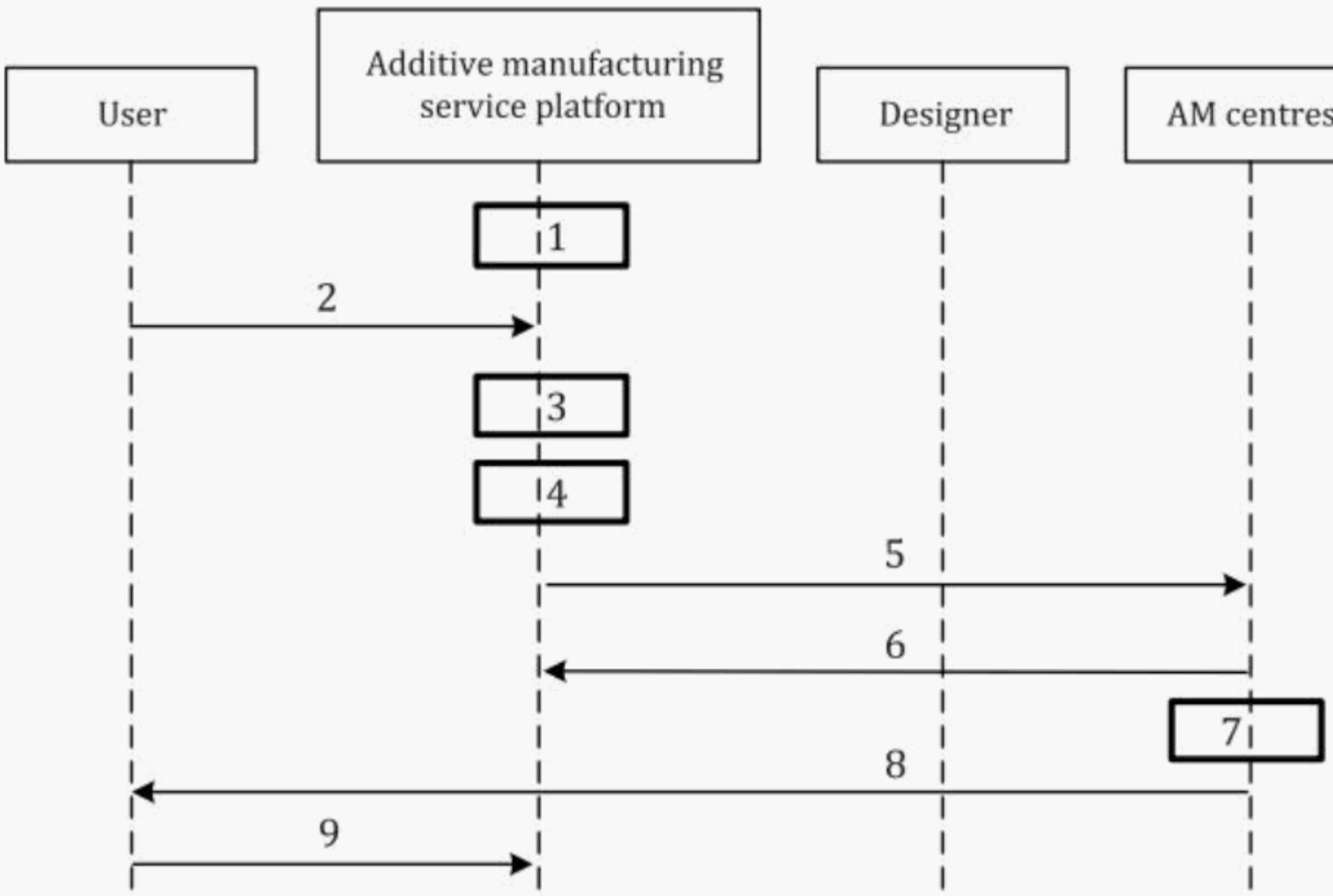

Figure A.3 — Sequential diagram of Use case 2

1) The AMSP provides a database containing typical 3D models and an accessible online design function.

2) Users are able to design objects/parts directly on the AMSP and set parameters for requirements of the objects/parts on the AMSP according to ISO/ASTM 52901.

The subsequent steps are the same as the steps 3) to 8) of use case 1.

A.3 Use case 3

Users find skilled designers registered on the AMSP to complete the design.

~~Figure A.4~~ is a sequential diagram of Use case 3. This use case involves users, an AMSP, designers and AM centres. An explanation of the numerical labels is provided after the figure.

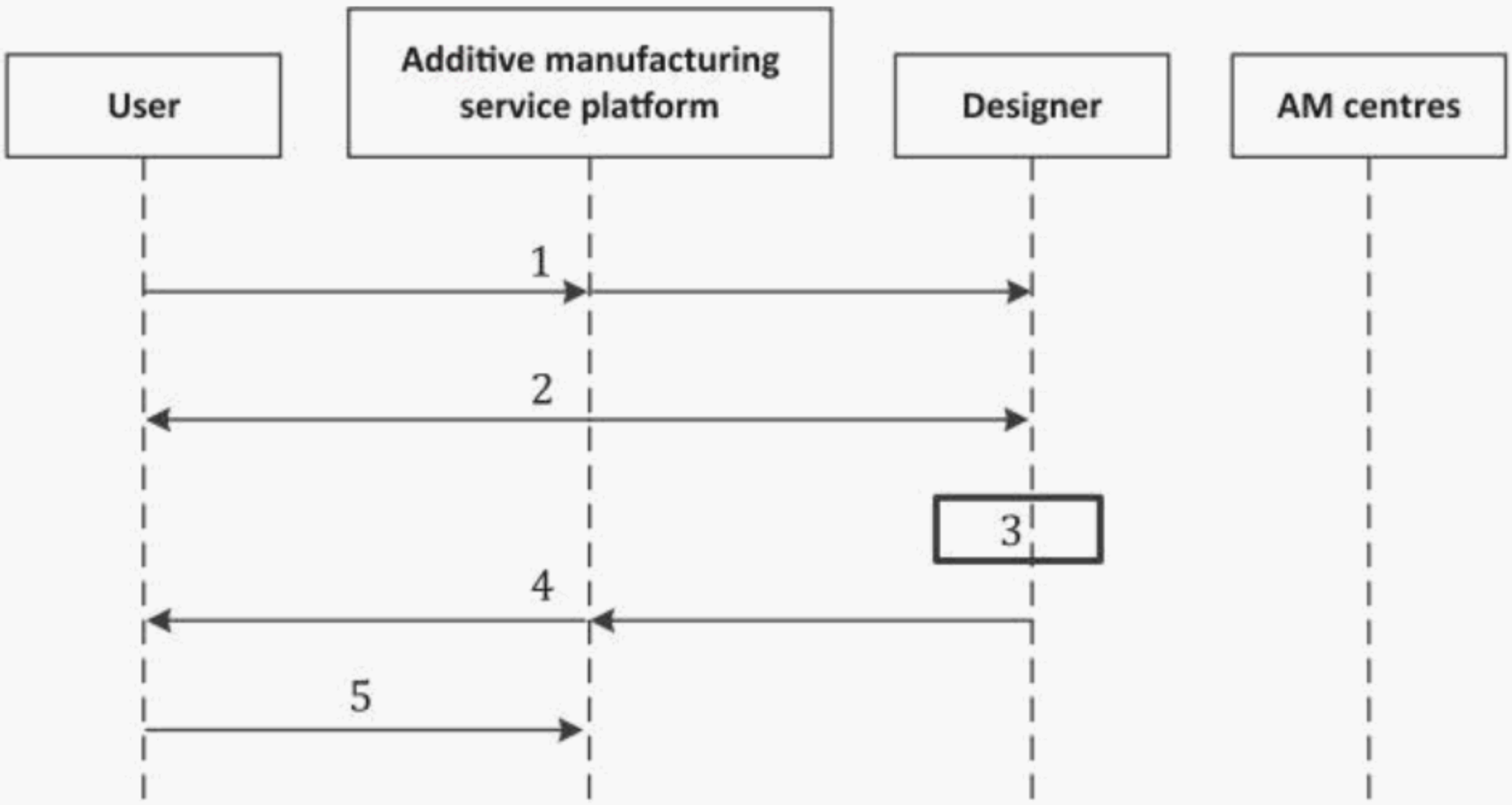

Figure A.4 — Sequential diagram of Use case 3

1) The user releases the design requirements (see Figure A.4) on the AMSP by description or other methods.

2) The AMSP sends design requirements to appropriate designers according to designer ability and the properties of the requirements. Designers vary from graphic designers or fashion designers to interior designers or industrial designers, etc. Users benefit from a wide range of different designers to meet their requirements.

3) Designers help to design the 3D models and can communicate with users to promote the design.

4) Designers can send the designed 3D models to users through the AMSP.

5) Users can submit comments and feedback about the 3D models and service quality to the AMSP and upload the 3D models after confirming the design.

Bibliography

[1] ISO 17296-3, *Additive manufacturing — General principles — Part 3: Main characteristics and corresponding test methods*

[2] ISO/IEC 17788:2014, *Information technology — Cloud computing — Overview and vocabulary*

[3] ISO/IEC 21320-1, *Information technology — Document Container File — Part 1: Core*

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