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Part 2:
Concepts

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives or www.iec.ch/members_experts/refdocs).

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 38, *Cloud computing and distributed platforms*.

This first edition of ISO/IEC 22123-2, together with ISO/IEC 22123-1 cancels and replaces ISO/IEC 17788:2014, which has been technically revised.

The main changes are as follows:

- cloud computing terminology has been moved to ISO/IEC 22123-1;
- the descriptions of the key characteristics have been expanded;
- the number and descriptions of the cloud service categories have been expanded;
- the cloud deployment model descriptions have been expanded and corrected;
- added differentiation between cloud computing parties and role;
- the descriptions of the cross-cutting aspects have been expanded;
- a new Clause 8 was added to address data and cloud services concepts;
- a new Clause 9 was added to address virtualization concepts;
- a new Clause 10 was added to address considerations when using multiple CSPs;
- a new Clause 11 was added to address logical and physical organization of cloud computing;
- Annex A was expanded to identify additional cloud service categories, not described in this document.

A list of all parts in the ISO/IEC 22123 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Information technology — Cloud computing —

Part 2: **Concepts**

1 Scope

This document specifies concepts used in the field of cloud computing. These concepts expand upon the cloud computing vocabulary defined in ISO/IEC 22123-1 and provide a foundation for other documents that are associated with cloud computing.

This document also provides detailed descriptions on the application of these concepts in cloud computing.

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/IEC 22123-1, *Information technology — Cloud computing — Part 1: Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 22123-1 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
PII principal
natural person to whom the personally identifiable information (PII) relates

Note 1 to entry: Depending on the jurisdiction and the particular data protection and privacy legislation, the synonym “data subject” can also be used instead of the term “PII principal.”

[SOURCE: ISO/IEC 29100:2011, 2.11]

3.2
PII controller
privacy stakeholder (or privacy stakeholders) that determines the purposes and means for processing personally identifiable information (PII) other than natural persons who use data for personal purposes

Note 1 to entry: A *PII controller* sometimes instructs others [e.g. *PII processors* (3.3)] to process PII on its behalf while the responsibility for the processing remains with the *PII controller*.

[SOURCE: ISO/IEC 29100:2011, 2.10]

3.3
PII processor
privacy stakeholder that processes personally identifiable information (PII) on behalf of and in accordance with the instructions of a *PII controller* (3.2)

[SOURCE: ISO/IEC 29100:2011, 2.12]

4 Symbols and abbreviated terms

API	application programming interface
CaaS	communications as a service
CDN	content distribution network
CompaaS	compute as a service
CPU	central processing unit
CSA	cloud service agreement
CSC	cloud service customer
CSN	cloud service partner
CSP	cloud service provider
CSU	cloud service user
DSA	data sharing agreement
DSaaS	data storage as a service
FaaS	function as a service
IaaS	infrastructure as a service
ICT	information and communication technology
NaaS	network as a service
PaaS	platform as a service
PII	personally identifiable information
PIMS	privacy information management system
PSTN	public switched telephone network
RAM	random access memory
SaaS	software as a service
SLA	service level agreement
SLO	service level objective
SQO	service qualitative objective
TCP/IP	transmission control protocol/internet protocol

TDM	time division multiplexing
VM	virtual machine
VPN	virtual private network

5 Cloud computing foundational concepts

5.1 General

ISO/IEC 22123-1 defines cloud computing and notes that examples of resources include servers, operating systems, networks, software, applications, and storage equipment.

The concepts in this document expand upon the cloud computing vocabulary defined in ISO/IEC 22123-1 and provide a foundation for other documents that are associated with cloud computing.

In this document, a name such as cloud service customer (CSC) or cloud service provider (CSP) represents a cloud computing party while CSC role or CSP role indicates a cloud computing role.

5.2 Key characteristics of cloud computing

5.2.1 General

Subclauses 5.2.2 to 5.2.7 identify and describe key characteristics of cloud computing.

The concept of key characteristics refers to the fundamental properties of cloud computing that differentiate it from other Information Technology paradigms. Each key characteristic covers specific properties that are needed by users of cloud computing.

The key characteristics of cloud computing provide a high-level statement of the distinguishing features of cloud computing. The key characteristics are decomposed in order to understand the concepts of cloud computing for typical delivery scenarios.

The analysis of a key characteristic is not always definitive because the requirements for delivering a cloud service can vary depending on the CSC. All the involved parties in the use and provision of cloud services benefit from a verifiable statement describing what the characteristic means.

5.2.2 Broad network access

Broad network access is a characteristic in which the CSP’s physical and virtual resources are available over a network and accessed through standard mechanisms that promote use the CSC. The focus of this key characteristic is that cloud computing offers an increased level of convenience in that users can access resources from wherever they work, as long as it is network accessible, using a wide variety of devices such as mobile phones, tablets, laptops, and workstations.

Cloud services are widely accessible using network services from a variety of network providers. This can include the public internet, an exchange provider’s network or the CSP’s own network. This characteristic can apply to all cloud deployment models. Access is provided to cloud computing resources at all required times and locations from any CSC, within policy and security constraints.

Broad network access includes accessibility and interoperability for many forms of cloud service network including:

— user (client) access to cloud services;

— application access to cloud services;

— peer cloud service interaction (intra- and inter-cloud); and

— cloud management and control interaction including the use of application programming interfaces (APIs).

5.2.3 Measured service

Measured service is a characteristic in which the metered delivery of cloud services is such that usage can be monitored, controlled, reported, and billed. This is an important feature needed to optimise and validate the delivered cloud service. The focus of this key characteristic is that the customer only pays for the resources that they use. From the customers' perspective, cloud computing offers the users value by enabling a switch from a low efficiency and asset utilization business model to a high efficiency one.

Measured service can refer to a wide variety of metering functions that can be required for service operations, administration, maintenance, provisioning, and security. Consumption-based billing requires that cloud service use be measured using an agreed upon measuring algorithm which can be specified in a service level agreement (SLA) (see ISO/IEC 19086). Metered cloud services provide sufficient detail to meet cloud SLA requirements. This can include measurements for the underlying virtual and physical resources (see ISO/IEC TR 23613[15]).

5.2.4 Multi-tenancy

Multi-tenancy is a characteristic in which physical or virtual resources are allocated in such a way that multiple tenants and their computations and data are isolated from and inaccessible to one another. Typically, and within the context of multi-tenancy, the group of cloud service users (CSUs) that form a tenant all belong to the same CSC. Some cloud computing deployments, particularly public cloud and community cloud, can have a group of CSUs that are from multiple different CSCs. However, a given CSC can have many different tenancies with a single CSP representing different groups within the organization such as by department, division, or subsidiary. In some cases, this is for internal security and confidentiality. In other cases, it can be for regulatory compliance reasons. This can require identity and access management.

5.2.5 On-demand self-service

On-demand self-service is a characteristic in which a CSC can provision cloud services, as needed, automatically or with minimal interaction with the CSP. The focus of this key characteristic is that cloud computing offers users a relative reduction in costs, time, and effort needed to take an action, since it grants the user the ability to do what they need, when they need it, without requiring additional human user interactions or overhead.

The cloud services can be provisioned and configured by the CSC without operator interaction with the CSP. For example, changing the random access memory (RAM) available or disk space available can be done without human intervention.

5.2.6 Rapid elasticity and scalability

Cloud services can be rapidly and elastically adjusted, in some cases automatically, to quickly increase or decrease capacity. For the CSC, the resources of cloud services available for provisioning often appear to be unlimited and can be purchased in any quantity at any time, subject to constraints of service agreements. From the perspective of the CSC, there is no longer a concern about limited resources or possibly capacity planning.

There are two possible directions for scalability with respect to cloud computing. Horizontal scaling is the term used for scalability where more instances of a given resource are allocated [e.g. running more virtual machines (VMs) or containers in parallel, each running an instance of the same application]. Vertical scaling is when an increase is made in the size of a resource allocated to a cloud service, for example when the amount of RAM or the number of central processing units (CPUs) allocated to a single virtual machine is increased, or the storage capacity of a single storage resource is increased. This can sometimes necessitate some delay while new capacity is added to an existing resource, in contrast to horizontal scaling which often has less latency. For a full description of elasticity and scalability, see ISO/IEC TS 23167[11].

The CSP describes the cloud services scalability features including any associated latency and any limitations. The CSC determines that the cloud service's scalability features, associated latency and limitations meet its requirements based on the CSP's description.

To the CSC, the resources available to a cloud service can be increased or decreased by any amount at any time, subject to any limitations imposed by the CSP or according to the pre-arranged policies in a cloud SLA. For the detailed information, refer to ISO/IEC 19086-1[3].

5.2.7 Resource pooling

Resource pooling is a characteristic in which a CSP's physical or virtual resources can be aggregated to serve one or more CSCs. CSPs are able to support multi-tenancy while also using abstraction to mask the complexity of the process from the CSC.

From the CSC's perspective, all they know is that the service works; they generally have no control or knowledge over how the resources are being provided or where the resources are located. This offloads some of the CSC's original workload, such as maintenance requirements, to the CSP.

Specifying a location at a higher level of abstraction is also possible in some environments.

Resources of a similar type (e.g. compute or storage) can be pooled in support of cloud service provision, but resources of different types cannot be pooled. The CSC can stipulate that the cloud resources are not shared by multiple CSCs or by multiple tenants.

Resource pooling includes but is not limited to:

- Two or more share cloud resources from a common resource pool.
- Two or more tenants share cloud resources from a common pool, using a multi-tenant model, regardless of how many CSCs are served.

The cloud service can appear to the CSC to be location independent because the CSC generally has no control or knowledge of the precise geographical location where the cloud service is being run. However, CSCs can generally specify a location for their instances of the cloud service at an abstract level.

5.3 Cloud capabilities types

A cloud capabilities type is a classification of the functionality provided by a cloud service to the CSC, based on the resources used. Cloud capabilities types follow the principle of separation of concerns, i.e. they have minimal functionality overlap between each other.

The cloud capabilities types are:

- application capabilities type: A cloud capabilities type in which the CSC can use the CSP's applications;
- infrastructure capabilities type: A cloud capabilities type in which the CSC can provision and use processing, storage or networking resources;
- platform capabilities type: A cloud capabilities type in which the CSC can deploy, manage and run customer-created or customer-acquired applications using one or more programming languages and one or more execution environments supported by the CSP.

NOTE - In this context "applications" includes scripts, containers, complete programs, partial programs, code and function libraries, microservices, AI training data, and other forms of compliable or executable software. There are only three cloud capabilities types defined in this document. These cloud capabilities types should not be confused with other categorizations of cloud services.

5.4 Cloud service categories

5.4.1 General

A cloud service category is a group of cloud services that possess some common set of qualities. A cloud service category can include capabilities from one or more cloud capabilities types.

The primary determining factors for categorizing a cloud service are:

— the cloud computing capabilities types that are provisioned (application, platform or infrastructure);

— its intended use.

Cloud service categories are typically referred to using *something* "as a service."

The three best known cloud service categories are:

— software as a service (SaaS), which offers application capabilities types (5.4.2);

— platform as a service (PaaS), which offers platform capabilities types (5.4.3);

— infrastructure as a service (IaaS), which offers infrastructure capabilities types (5.4.4).

However, there are many other examples of cloud service categories. One example often used in the telecom industry is network as a service (NaaS) (5.4.5) which offers networking-related application, platform or infrastructure capabilities types.

Some cloud service categories can offer two or all three of the cloud capabilities types. For example, communications as a service (CaaS) (5.4.6) can offer both platform and application capabilities types (see Annex A for more examples).

5.4.2 Software as a service (SaaS)

SaaS is a cloud service category in which the cloud capabilities type (5.3) provided to the CSC is an application capabilities type.

The cloud service provisioned for the CSC uses the CSP's software application running on CSP resources. The use and provision of the cloud service category are in accordance with the cloud service agreement and its associated cloud SLAs. The applications are accessible from various CSC devices through either a thin client interface, such as a web browser (e.g. web-based email), or an Application Programming Interface (API). The customer does not manage or control the underlying resources including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

The CSP providing the SaaS product is typically responsible for making all aspects of the software service available including deploying, configuring, maintaining and updating the operation of the software applications on the CSP resources. It is worth noting that the entity responsible for making the service available can be different from the SaaS application developer.

Note that some SaaS services are extensible in that they include limited customer scripting or other code execution within their own functionality, however the execution of such code is not central to the service being offered.

5.4.3 Platform as a service (PaaS)

PaaS is a cloud service category in which the cloud capabilities type (5.3) provided to the CSC is a platform capabilities type.

The capability provided to the CSC is to develop or deploy onto the CSP resources customer-created or acquired applications created using programming languages, libraries, services, and tools supported by the CSP. This capability does not necessarily preclude the use of compatible programming languages, libraries, services, and tools from other sources.

The term “platform” in the PaaS context refers to a development or deployment platform for cloud-enabled applications. The term “platform” is broadly used in the computing industry. It therefore helps to understand the context of the term regarding PaaS. PaaS is distinguished from an extensible SaaS or web application by its primary customers: developers and operations staff versus end users.

The CSC does not manage or control the underlying resources including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment. The CSC can verify the service meets the requirements in accordance with the cloud service agreement and its associated SLAs. The CSUs of the CSC primarily design, implement, and deploy applications into the cloud computing environment.

5.4.4 Infrastructure as a service (IaaS)

IaaS is a cloud service category in which the cloud capabilities type (5.3) provided to the CSC is an infrastructure capabilities type.

The capability provided to the CSC is to provision physical or virtual processing, storage, networks, and other fundamental computing resources where the customer is able to deploy and run arbitrary software, which can include operating systems and applications. The CSC does not manage or control the underlying resources but has control over operating systems, storage, and deployed applications. They possibly have limited control of select networking components (e.g. host firewalls).

An IaaS service provides, for example, hosting of CSC-defined virtual machine images on a CSP-provided and operated hypervisor (see Clause 9). Because, in this example, each VM runs directly on virtualised hardware, there are fewer limits on the software choices available to the CSC, however this flexibility comes at the cost of requiring management and maintenance of all the software components they select and deploy.

The CSCs can create, install, monitor, and manage applications deployed in an IaaS cloud service. The CSC can verify the service meets their requirements in accordance with the cloud service agreement and its associated SLAs.

The terms “software” and “application” in the IaaS context refers to software and applications sourced and deployed by the CSC and which remain under the control of the CSC. It is typical that the CSP is unaware of what this software is and has no control over it. The term “arbitrary software” in this context means that the CSC can deploy and run any type of software, subject only to any limitations imposed by the nature of the environment made available by the cloud service.

5.4.5 Network as a service (NaaS)

NaaS is a cloud service category in which the capability provided to the CSC is transport connectivity and related network capabilities. NaaS can provide the application, platform and infrastructure cloud capabilities types.

The capability provided to the CSC is to provision and manage physical or virtual network connections. The CSC does not manage or control the underlying physical network infrastructure, but the CSC can control the creation, management and removal of network connections between their own choice of endpoints.

Note that these network connections can be quite sophisticated and can include the use of complex network resources such as physical or virtual switches, routers, transmission links, satellite uplinks and transponders, content distribution networks (CDNs), caches, proxies, firewalls, redundant links, relays, repeaters, multiplexors, or other network resources.

Note that, while the NaaS itself operates as a cloud service, the networks that it manages can include non-IP networking technologies such as time division multiplexing (TDM) connections, optical connections, or satellite transmission links. For example, a TV broadcaster can employ a NaaS to establish a high-