International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

Y.3503

(05/2014)

SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

Cloud Computing

Requirements for desktop as a service

Recommendation ITU-T Y.3503

ITU-T

International Telecommunication Union

ITU-T Y-SERIES RECOMMENDATIONS

GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Enhancements to NGN	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999
FUTURE NETWORKS	Y.3000–Y.3499
CLOUD COMPUTING	**Y.3500–Y.3999**

For further details, please refer to the list of ITU-T Recommendations.

Recommendation ITU-T Y.3503

Requirements for desktop as a service

Summary

As one of cloud computing service categories, desktop as a service (DaaS) provides cloud service customers with desktop functions remotely delivered by cloud service providers. Recommendation ITU-T Y.3503 introduces the concept of DaaS, and describes general and functional requirements. To derive those requirements relevant use cases are also presented.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T Y.3503	2014-05-22	13	11.1002/1000/12167

Keywords

Desktop as a service, DaaS, virtual desktop, virtual desktop infrastructure.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure, e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T Y.3503

Requirements for desktop as a service

1 Scope

This Recommendation provides use cases, general requirements and functional requirements for desktop as a service (DaaS).

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T X.1601] Recommendation ITU-T X.1601 (2014), *Security framework for cloud computing*.

[ITU-T Y.3501] Recommendation ITU-T Y.3501 (2013), *Cloud computing framework and high-level requirements*.

[ITU-T Y.3510] Recommendation ITU-T Y.3510 (2013), *Cloud computing infrastructure requirements*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 cloud service customer [ITU-T Y.3501]: A person or organization that consumes delivered cloud services within a contract with a cloud service provider.

3.1.2 cloud service provider [ITU-T Y.3501]: An organization that provides and maintains delivered cloud services.

3.1.3 hypervisor [ITU-T Y.3510]: A type of system software that allows multiple operating systems to share a single hardware host.

3.1.4 virtual machine [b-DMTF OVF]: The complete environment that supports the execution of guest software.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 DaaS client: A physical device and associated software running on the device that collectively enables a cloud service user to access desktop as a service (DaaS).

3.2.2 desktop as a service (DaaS): A cloud service category in which the capabilities provided to the cloud service customer are the ability to build, configure, manage, store, execute and deliver users' desktop functions remotely.

3.2.3 virtual desktop: An environment for accessing end user's desktop functions remotely.

NOTE – Examples of end user's desktop functions can include desktop interface functions for applications, data access functions for multimedia data, and control functions for input/output (I/O) devices.

3.2.4 virtual desktop infrastructure (VDI): A desktop as a service (DaaS) solution enabling the hosting of a desktop operating system within a virtual machine.

NOTE – In this Recommendation, VDI means that the virtual machine hosting the desktop operation system is running in a cloud computing environment.

3.2.5 virtual desktop template: A representation of a set of system configuration and application parameters with an option of including customer personalization, and other desired attributes.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

3D	Three Dimensional
3G	Third Generation
CPU	Central Processing Unit
CSC	Cloud Service Customer
CSP	Cloud Service Provider
CRM	Customer Relationship Management
DaaS	Desktop as a Service
DCN	Data Communication Network
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
DTLS	Datagram Transport Layer Security
ERP	Enterprise Resource Planning
FEC	Forward Error Correction
GPS	Global Positioning System
HD	High Definition
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
IaaS	Infrastructure as a Service
I/O	Input/Output
IT	Information Technology
LAN	Local Area Network
OS	Operating System
PLMN	Public Land Mobile Network
PSTN	Public Switched Telephone Network
QoE	Quality of Experience
RAM	Random Access Memory
SLA	Service Level Agreement

SSL	Secure Socket Layer
TCP	Transmission Control Protocol
UDP	User Datagram Protocol
VDI	Virtual Desktop Infrastructure
VM	Virtual Machine
VPN	Virtual Private Network

5 Convention

The keywords "**is required to**" indicate a requirement which must be strictly followed and from which no deviation is permitted if conformance to this Recommendation is to be claimed.

The keywords "**is recommended**" indicate a requirement which is recommended but which is not absolutely required. Thus this requirement need not be present to claim conformance.

The keywords "**can optionally**" indicate an optional requirement which is permissible, without implying any sense of being recommended. This term is not intended to imply that the vendor's implementation must provide the option and the feature can be optionally enabled by the network operator/service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with the specification.

In the body of this Recommendation and its annexes, the words shall, shall not, should, and may sometimes appear, in which case they are to be interpreted, respectively, as is required to, is prohibited from, is recommended, and can optionally. The appearance of such phrases or keywords in an appendix or in material explicitly marked as informative are to be interpreted as having no normative intent.

6 Introduction to desktop as a service (DaaS)

DaaS is defined as a cloud service category in which the capabilities provided to the cloud service customer (CSC) are the ability to build, configure, manage, store, execute and deliver users' desktop functions remotely. With DaaS, the user experience is achieved through a user interface, which is presented on a DaaS client over the network. Figure 6-1 shows the conceptual view of DaaS.

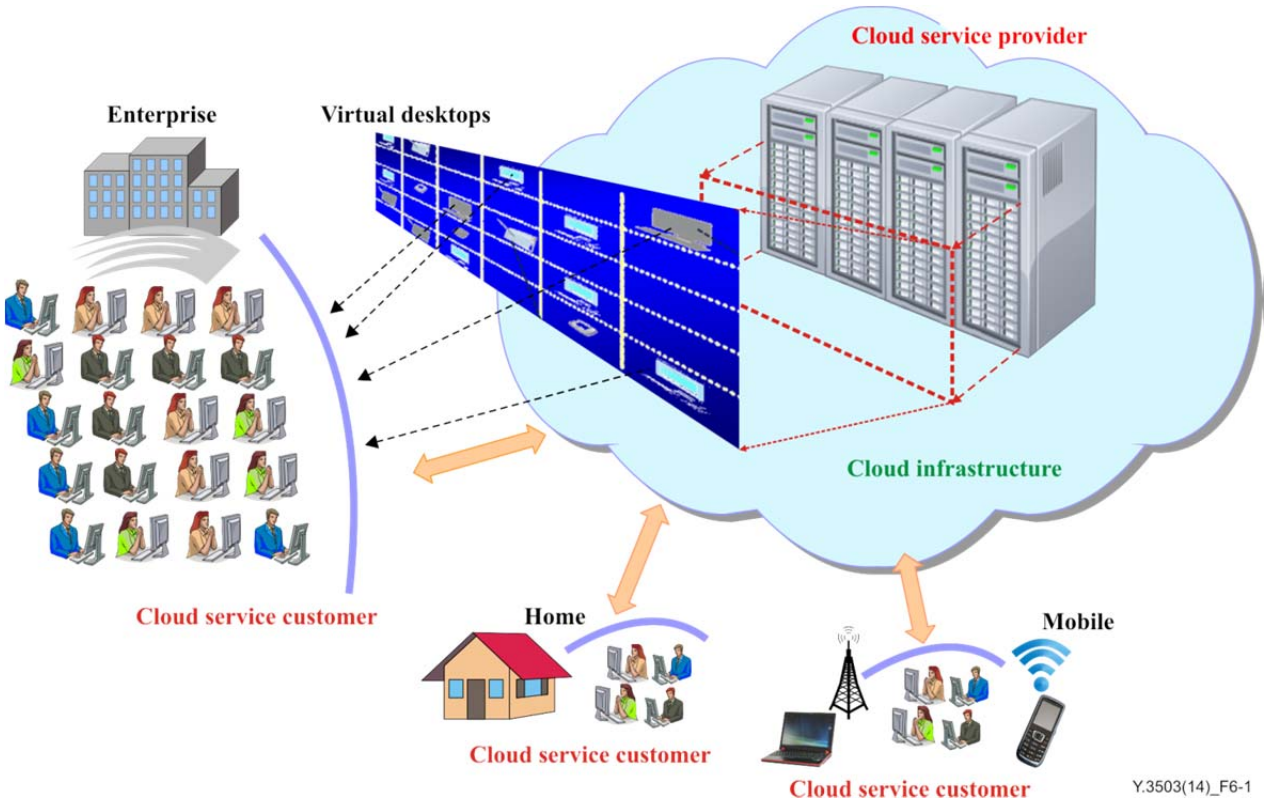


Figure 6-1 – Conceptual view of DaaS

Instead of maintaining and running a desktop operating system and applications on CSC devices, servers of a cloud service provider (CSP) located in the cloud are used to execute the instances of users' virtual desktops. This allows a party (e.g., an organization) to run end user's operating systems and applications, and keep their data in the cloud computing environment.

Based on application streaming and virtualization technologies, CSCs can access the virtual desktop environment through cloud infrastructure.

A few technologies can be used for providing services of the DaaS like virtual desktop infrastructure (VDI) and web-based solutions with various delivery protocols such as the virtual desktop delivery protocol and the web-based delivery protocol shown in Figure 6-2.

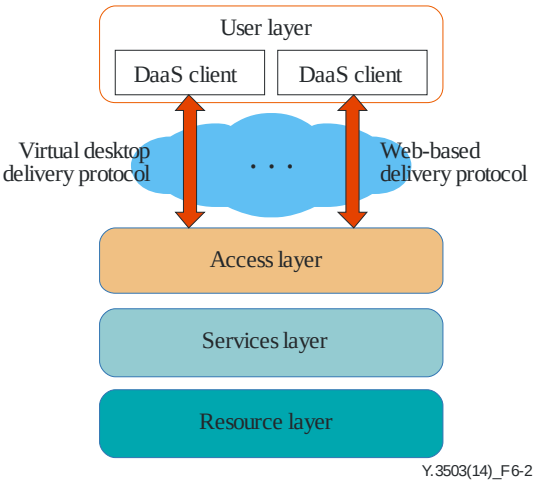


Figure 6-2 – DaaS delivery solutions

VDI supports the users' virtual desktop and recreates it in an environment hosted on a remote system. A virtual desktop is executed for each user from the server side. Users access this

environment remotely through DaaS clients, with all virtual desktop associated processing. A virtual desktop delivery protocol is used to deliver the virtual desktop.

In the web-based DaaS solution, a web-based server invokes application services from different servers and aggregates them to build a virtual desktop service. The web-based DaaS solution relies on cloud services provided through the use of web oriented technologies, i.e., based on the hypertext transfer protocol (HTTP), hypertext markup language (HTML) and the new features supported by HTML5 [b-W3C-HTML5].

6.1 Main advantages of DaaS

The main advantages of DaaS [b-ITU-T FGCC1] are:

- **Enhanced management and security**: Since all desktop applications actually run in a CSP server, they are more secure than if they were installed on each user's DaaS client since the CSP can focus more on security aspects.
- **Lower total cost of ownership**: By placing emphasis on the data centre rather than on individual user devices, DaaS promotes longer hardware life. Organizations or enterprises seeking to avoid additional costs can switch part of their information and communication technology infrastructure from capital expenditure to operating expenditure, as they now pay for virtual desktops. Also, decoupling the desktop operating system from the hardware permits the use of cost-effective user's devices.
- **Preservation of user experience**: DaaS allows for a rich user experience by enabling the possible choice among multiple operating systems and their customization. Conversely, shared service environments offer a user experience that may compromise between application compatibility and user customization.
- **Separation of CSP and CSC responsibilities**: DaaS allows separation between the responsibilities of the CSP and the CSC. The CSP is responsible for the infrastructure of virtual desktops delivery (i.e., servers, storage, virtualization software, etc.), while the virtual desktops (e.g., operating system (OS), application packaging, user profiles, etc.) is under the CSC responsibility.

6.2 General configuration for DaaS

Figure 6-3 shows the general configuration environment for DaaS logical components. The environment is based on a traditional client-server model and mainly consists of a DaaS client, a connection manager, a resource pool, a virtualization infrastructure and a virtual desktop delivery. Detailed interaction among these DaaS logical components are described in clause 6.3.

NOTE 1 – Relationship between DaaS logical components and the cloud computing reference architecture in [b-ITU-T FGCC2] is described in Appendix I. Further study of the DaaS architecture is needed to map the DaaS logical components to the cloud computing reference architecture.

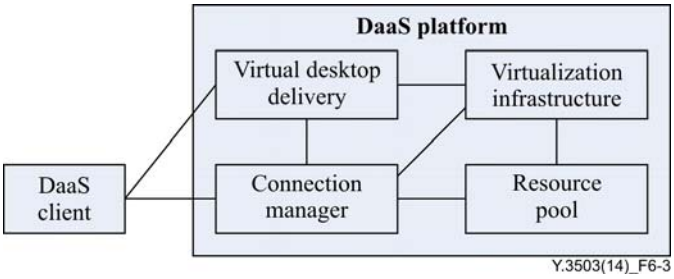


Figure 6-3 – General configuration for DaaS

The main logical DaaS components, shown in Figure 6-3, are as follows:

- DaaS client

  DaaS users can be provided with their virtual desktop remotely through their DaaS clients. To access a DaaS platform, DaaS users can employ one of the methods among dedicated software, general-purpose web browser and firmware depending on the type of DaaS client. More detailed information regarding DaaS clients is provided in Appendix II.

  NOTE 2 – Depending on the type of DaaS client, when the DaaS client is booted up, it starts a log in procedure to a corresponding virtual desktop with access information such as its identification, password and IP address. In case of termination of the corresponding virtual desktop, the DaaS client recognizes it and begins a log out procedure which includes turning off the virtual machine (VM) or the DaaS client.

- Connection manager

  This logical component is responsible for connecting a DaaS user to an available and suitable virtual desktop. The connection manager's tasks include:

  – user authentication and licence verification to validate the user and the user's application;

  – assignment of a virtual desktop;

  – coordination of a delivery protocol to be used between a DaaS client and a DaaS platform; and

  – allocation of necessary storage.

  In addition, the connection manager is responsible for load balancing and managing the number of users per DaaS platform, reconnecting a user to the virtual desktop.

  The connection manager uses the resource pool and the virtualization infrastructure to allocate the required resources such as computing, network and storage in virtualization infrastructure.

- Resource pool

  Resource pool is an abstraction of software resources such as OS, applications and user profiles. The software resources can be loaded from the resource pool to given resources in the virtualization infrastructure. A resource pool can offer provisioning information regarding the software resources on request by a connection manager.

  NOTE 3 – A user profile can contain individual information about hardware configuration (i.e., central processing unit (CPU), random access memory (RAM), I/O), used OS, selected applications and user computing environment information (e.g., display resolution and Internet access means).

- Virtualization infrastructure

  The main role of the virtualization infrastructure is to support hardware and software resources and create virtual resources (e.g., VMs). The virtualization infrastructure can use a virtualization function, called a hypervisor, to manage hardware resource efficiently. A hypervisor can abstract physical hardware resources and assign them dynamically to a virtual desktop. In this case, the end user's application runs on the virtual desktops provided by the virtualization infrastructure. The virtualization infrastructure supports high availability features (e.g., multiple VMs are created from the same VM template) with pre-defined configuration parameters.

- Virtual desktop delivery

  This component is responsible for encapsulation and delivery of either access to an entire information system environment, or the environment itself to a remote DaaS client through the network. A protocol for virtual desktop delivery provides the communication channels between the DaaS client and the DaaS platform in order to transfer all the interaction information. The interaction information includes display information, control and configuration information, monitoring information, etc.

DaaS can be serviced by either a personalized virtual desktop or by a virtual desktop from a shared pool. In the case of a personal virtual desktop, there is a one-to-one mapping between a virtual desktop and a cloud service user. Each user is assigned a virtual desktop that can be personalized and customized. These changes are available to the user each time that user logs on to his or her personal virtual desktop. For a shared virtual desktop pool, a single OS image is replicated across many VMs and users can reuse a single VM over time. As users connect to the shared virtual pool, they are dynamically assigned a virtual desktop. A shared virtual pool allows for uniformed experience across all end users, while combined with simplified administration means.

6.3 Interaction between DaaS components

To illustrate the DaaS operation concepts based on Figure 6-3, the various steps of an example interaction for DaaS are shown as follows:

- A DaaS client accesses a connection manager through a security protocol (such as secure shell or transport layer security) and the connection manager validates the user with a user-ID and associated password.
- The connection manager identifies a corresponding user profile and, in order to assign appropriate virtual resources in the virtualization infrastructure, a provisioning operation helps the connection manager to allocate the virtual resources that satisfies the user's hardware configuration and is optimal to the computing environment.
- If there are no proper virtual resources, the connection manager requests the virtualization infrastructure to create such virtual resources according to the hardware configuration requested by the user or a pre-defined hardware configuration.
- After such virtual resources are assigned or created, the connection manager applies the user profile, including installation of OS and applications, to construct a virtual desktop.
- A connection to deliver a corresponding virtual desktop is created in the virtualization infrastructure and the information of the connection is dispatched to the connection manager.
- The connection manager sends the connection information to the DaaS client and the DaaS client connects to the virtual desktop in the virtualization infrastructure.
- The DaaS client communicates with the virtual desktop through the network using a delivery protocol for the virtual desktop.
- When a DaaS user terminates a virtual desktop service, the DaaS client executes a log out operation without loss of user data.
- During the log out operation, the connection manager updates the modified user profile in a user profile pool to keep the most recent information, and releases the VM resources.

7 DaaS general requirements

The DaaS general requirements are described in [ITU-T Y.3501] as follows:

- Quality of experience (QoE);
- Fast boot-up time;
- Configurability of the virtual environment;
- Single sign-on access control.

Additional general requirements of DaaS derived from use cases (cf. Appendix III) include (but are not limited to):

- **Support for high-definition (HD) and three-dimensional (3D) applications**: DaaS can optionally support execution of HD applications on virtual desktops for CSCs.

NOTE 1 – HD and/or 3D applications (e.g., high-definition 3D videos or games) are becoming one of the major user demands in the personal computing device market.

- **Extensible storage**: It is recommended that a CSP support the storage extension requested by a CSC.
- **Response time**: It is recommended that DaaS provide CSCs with acceptable QoE.

  NOTE 2 – Detailed relevant information on acceptable response time is described in Appendix IV.
- **High availability**: It is recommended that high availability in terms of delivery and operation of DaaS be assured by a CSP.
- **Resiliency to disaster**: In a case of a disaster, DaaS is recommended to provide and maintain an acceptable level of service.

  NOTE 3 – This includes preserving the system information and the users' data including their virtual desktop state such as power-on, power-off, suspend, etc.
- **Service continuity**: It is recommended that in case of temporarily unavailable resource access, a CSP provides the capability to preserve the state of the user session.
- **System scalability**: It is recommended that DaaS supports elastic scalability of:
  - Storage for DaaS user account information, virtual desktop environment settings, and active and inactive virtual desktop environments;
  - Processing and network capacity for the number of concurrent DaaS user connections and total DaaS users;
  - Underlying DaaS resources.
- **DaaS developer environments**: It is recommended to provide a developer environment for the service and contents regarding DaaS.
- **Diversity of DaaS client**: It is recommended that the CSP support a wide selection of DaaS clients.

  NOTE 4 – Examples of such DaaS clients are described in Appendix II.

8 DaaS functional requirements

8.1 Operation and management requirements

Operation and management requirements include:

- **Unified management interface**: It is recommended that the CSC be capable of deploying, configuring, managing and monitoring the DaaS through a unified management interface.
- **User account provisioning**: It is recommended that the CSP provide the method of operating and provisioning various types of accounts in accordance with CSC's characteristics based on the service level such as one-time usage and permanent account, types of virtual desktop environments, and allocating options for the virtual desktop environments.

  NOTE 1 – User account provisioning depending on the CSC types is described in Appendix V.
- **Virtual desktop lifecycle management**: It is required that the CSP support the full life cycle management of the virtual desktop, including set-up, test, delivery, use, maintenance, optimization, shutdown and deletion.
- **Support of virtual desktop template**: In order to achieve better delivery of DaaS, a desktop template can be optionally used for DaaS maintenance purposes.

  NOTE 2 – The virtual desktop template includes defining, publishing, verifying, revoking, deleting and other related operations.
- **User profile management**: It is required that the CSP manage the user profile information.

- **Server-side platform hardware resource maintenance**: It is required that the CSP maintain and allocate servers, storage, network and related hardware.
- **Service-related resource maintenance**: It is required that the CSP maintain DaaS service supporting applications and data, such as security auditing server, performance monitoring server, active directory, database, user configuration, file server, etc.
- **Status monitoring**: It is recommended that the current running status of virtualized resource be monitored to perform the change the status requested by a CSC.
- **System load monitoring**: In order to achieve an appropriate QoE, it is recommended that a CSP be capable of monitoring the system load to assign virtualized resources to a CSC.
- **Automated scriptable management interface**: It is recommended that the DaaS management solution be accessible through a consistent scripting interface.
- **Power management**: It can optionally be that the CSP is able to support the mechanism that monitors server's power and relevant usage in order to perform load balancing or save the power consumption in the server.
- **Accounting and charging**: It is recommended that the CSP collect accounting information based on computing power, network use, storage, memory and/or application licence fee. Accounting information is collected per service and per user. It is also recommended that the CSP provide a charging scheme based on the accounting information and charging information transparently.

  NOTE 3 – Depending on the implementation of DaaS, the charging scheme may not be needed.
- **Managing and operating pre-configured environments**:
  - It is recommended that the CSP manage and operate the pre-configured environments which are prepared after configuring the service information (such as server processing capacity, the prediction of concurrent users and the resources capacity, etc.).
  - It is recommended that the CSP provide the preconfigured environment without the loss of user functionality and the degradation of performance when service is requested.

  NOTE 4 – The pre-configured environments are the environmental files such as images of OS and applications, which reflect the CSC's requirements including operating environment, installed applications, user data and level of service. The pre-configured environments are prepared in advance with the related operations (e.g., generating, creating, reproducing and cloning, etc.) and supplied in their use during service execution.
- **Monitoring and controlling DaaS**: It is recommended to monitor and control the activities of a DaaS platform without impacting the performance of the DaaS platform.

  NOTE 5 – A software agent can be used to communicate with a kernel or a hypervisor in order to create and control VMs.
- **DaaS client capability**: It is recommended that virtualization infrastructure supports making use of any available DaaS client capability on the CSC's device as and when required by application programs running in virtual desktop.
- **User log management**: It is recommended that the CSP keep the connection log information for all CSCs and their event logs for further security and/or incident analysis.

8.2 DaaS platform-side functional requirements

The DaaS platform-side functional requirements include:

- **Maintaining DaaS user status**: It is required that the CSC be capable of reconnecting to virtual desktop in the same virtual desktop state as left.

- **Optimized adaptation for content type**: It is recommended that the DaaS client be optimized for the content type involved (e.g., each type of content is encoded with a codec that is tuned to best support the content and the codec configuration can be automatically changed based on the content type such as multimedia, images and text).
- **Isolation between virtual desktop functions**: It is required that the operation of the virtual desktop functions of one CSC should not be negatively impacted by the use of virtual desktop functions by other CSCs.
- **Graphic processing acceleration support**: In order to provide ability to DaaS clients to work with graphic-intensive software packages (such as 3D computer-aided design or compression) running on the server, it is recommended that the CSP provide the acceleration of graphic processing to DaaS clients.
- **Server-side rendering**: In order to provide a consistent user experience to a wide range of DaaS clients as well as to improve user experience, it is recommended that the local desktop be composed and rendered on the host before the resulting image is encoded and sent to the DaaS client.
- **Standard video codec support**: For applicable video content, it is recommended to support standard codecs, such as specified in [b-ITU-T H.264] or [b-ITU-T H.265].
- **Progressive encoding support**: For networks with limited bandwidth, in order to improve user experience in case of a network bottleneck, it is recommended to use progressive encoding.

  NOTE – Progressive encoding and rendering means that the image can be encoded and sent over several stages, and the image quality becomes progressively clearer at each stage.
- **CSC environment backup**:
  - It is recommended that the CSP backup and restore the allocated virtual machines with user environment in order not to lose user data.
  - It is recommended that the CSP should not degrade the service performance from the process of backing up and restoring.
- **Standard audio encoder support**: It is recommended to support standard audio encoders.

8.3 DaaS client-side functional requirements

The DaaS client-side functional requirements include:

- **Resource request**: It is recommended that the CSC be capable of configuring the system resources in its use (e.g., CPU, memory, storage and other devices) during service execution.
- **Support of DaaS client peripherals**: It is recommended that DaaS applications be able to use DaaS client peripherals.

  NOTE 1 – Examples of DaaS client peripherals include USB port, flash memory, global positioning system (GPS), camera, etc.
- **Video decoder support**: For rendering video content on client, it is recommended to support standard codecs, such as specified in [b-ITU-T H.264] or [b-ITU-T H.265] to decode encoded images.
- **Standard audio decoder support**: It is recommended to support standard audio decoders.
- **Synchronization between DaaS client and DaaS platform**: It is recommended that DaaS support synchronization of DaaS user state when the connection is established and terminated.

  NOTE 2 – DaaS user state include desktop background and layout, user interface preferences, current DaaS user timezone, etc.

8.4 DaaS platform-DaaS client interaction functional requirements

The functional requirements related to the interaction between DaaS platform and DaaS client include:

- **Dynamic configuration adaptation**: To improve network throughput, it is recommended that a DaaS client be able to dynamically determine its access network types and adapt its configuration (including the network protocols and display resolution) accordingly to ensure network connectivity and improve the user experience.
- **Standard transport protocol support**: It is required to use standard transport protocols (e.g., transmission control protocol (TCP) [b-IETF RFC 793] and user datagram protocol (UDP) [b-IETF RFC 768]) to deliver DaaS.
- **High latency environment**:
  - For applications and elements that are less sensitive to packet loss and only dependent on low latency and jitter (such as for desktop rendering, audio, video streaming, or communications), a loss-tolerant transport (e.g., UDP) can optionally be used for allowing immediate delivery with some packet loss, without any need to wait for retransmission of lost packets.
  - For those applications and elements where data reliability is important (e.g., for typing), it is recommended to use the standard transports available for this purpose that allows recovering from losses without retransmissions, such as forward error correction (FEC).

  NOTE 1 – DaaS is very sensitive to latency and jitter (variation in latency). For example, when DaaS users type text or move a mouse they need to see this appear almost immediately on their screens. For this reason, retransmission is often unacceptable as a mean of error recovery. This constraint on latency and jitter imposes the following DaaS-specific requirements when suffering from latency.
- **Fall-back to alternative transport**: When the standard transport protocol is not available, it is recommended that an automatic fall-back to the alternative protocol is implemented by the DaaS application. An example would be a fall-back from UDP to TCP.
- **DaaS client reconnection**: When there is no response from the DaaS platform to a service request from a DaaS client, it is required that the DaaS client send a reconnection request to the DaaS platform. If the reconnection fails, it is also required that a DaaS user be notified of loss of service.
- **Display redirection**: It is required that the CSP redirect display to a CSC immediately after the completion of the connection between a DaaS platform and a DaaS client.
- **Hybrid resource configuration**: It is recommended that resources in both a DaaS platform and a DaaS client be used simultaneously to achieve the best performance and the CSP support the ability to modify their configuration to improve the performance.

  NOTE 2 – Hybrid means that there can be various combinations of resource configuration between a DaaS client and a DaaS platform.

8.5 DaaS security requirements

- **Standard security protocols support**: It is recommended to use standard security protocols for content delivery protection for DaaS (e.g., secure socket layer (SSL) [b-IETF RFC 6101] and datagram transport layer security (DTLS) [b-IETF RFC 6347]).
- **Network separation**: It is recommended that DaaS provide policy-based separation between the DaaS client's local network, DaaS provided network and the public Internet network. This separation can be logical (e.g., virtual private network (VPN)) or physical as appropriate.

NOTE – In addition to cloud-based resources, DaaS users may require access to local network resources (such as printers), or the public Internet.

9 Security considerations

It is recommended that the security requirements of [b-ITU-T Y.2201], [b-ITU-T Y.2701] and applicable X, Y and M series of ITU-T security Recommendations be taken into consideration, including access control, authentication, data confidentiality, communications security, data integrity, availability and privacy. It is also recommended that the security framework for cloud computing described in [ITU-T X.1601] be considered. [ITU-T X.1601] analyses security threats and challenges in the cloud computing environment, and describes security capabilities that could mitigate these threats and meet security challenges.

Appendix I

Relationship between DaaS logical components and the cloud computing reference architecture

(This appendix does not form an integral part of this Recommendation.)

This appendix provides the relationship between DaaS logical components, which are described in clause 6.2, and the cloud computing reference architecture [b-ITU-T FGCC2].

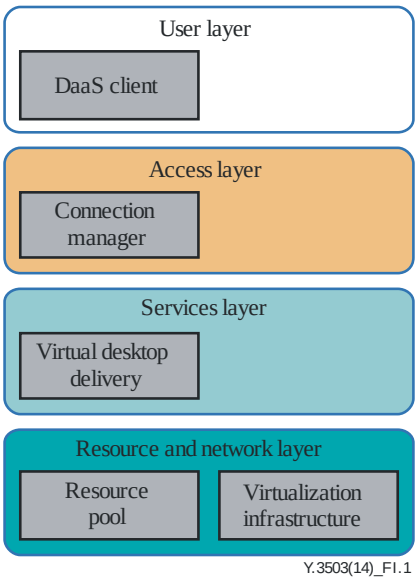


Figure I.1 – An example of location of DaaS logical components within the layers of the cloud computing reference architecture

Figure I.1 shows an example of the location of the DaaS logical components, which are related to layers in the cloud computing reference architecture.

Since the user layer provides the user interface between CSC and CSP, the DaaS client logical component can be related to this layer in that a DaaS CSC accesses the virtual desktop through this component.

The capability to provide the connection between DaaS CSCs and virtual desktops is the main role of the connection manager. This DaaS logical component corresponds to the access layer of the cloud computing reference architecture.

The virtual desktop delivery DaaS logical component facilitates the implementation of the virtual desktop by employing a delivery protocol. Therefore, this DaaS logical component is related to the services layer of the cloud computing reference architecture.

The resource pool and the virtualization infrastructure as DaaS logical components provide an abstraction of software and hardware resources. These two DaaS logical components are related with the resource and network layer of the cloud computing reference architecture.

Appendix II

DaaS client classification

(This appendix does not form an integral part of this Recommendation.)

DaaS users access their virtual desktops using networked DaaS clients, such as desktop computers, thin clients and mobile devices. Basically, most of these devices rely on computing power in DaaS platforms for all or a majority of their applications. Several ways to access virtual desktops from DaaS clients can be provided. Some DaaS clients support specific software dedicated to DaaS while some do not require specific software on the DaaS client and instead use a general web browser to interact with the DaaS platform. Still, some DaaS clients can directly connect without any software or browsers. Table II.1 shows the characteristics of various types of DaaS clients, including these access methods

Table II.1 – Characteristics of DaaS client

Categories	Personal computer	Thin client	Mobile device
Access method	Dedicated software web browser	Dedicated software Web browser	Dedicated software web browser
Network	Mainly wired	Mainly wired	Wireless
CPU	Performance-centric	Power-centric	Power-centric
RAM	Yes	Yes	Yes
Storage	Yes (Hard disk drive)	Yes/No (Flash memory)	Yes (Flash memory)

Appendix III

DaaS use cases

(This appendix does not form an integral part of this Recommendation.)

This appendix describes seven DaaS-related use cases in Tables III.1 to III.7.

Table III.1 – Office automation of development-oriented enterprise

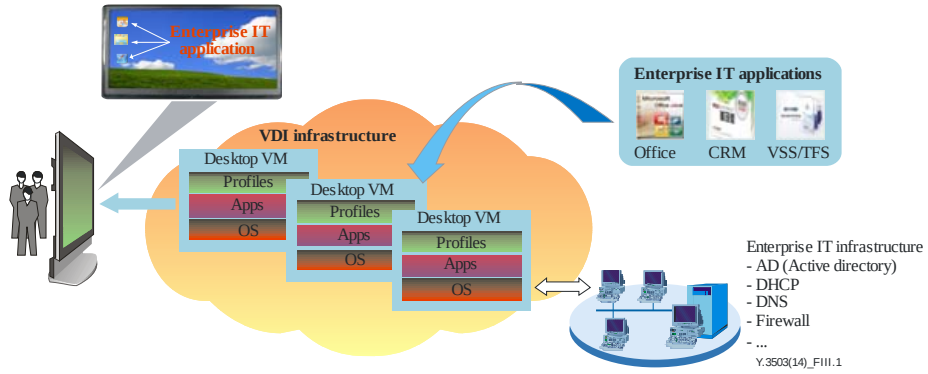
Legend	Use case
Use case title	Office automation of development-oriented enterprise
Use case description	In this scenario, the DaaS users access the enterprise applications and data hosted in virtual desktops which are created within a DaaS platform. Common applications of this type include online word processing, email, communication, co-operating development, etc. The sales staff also can view customer information and marketing records on the enterprise website. The DaaS platform interacts with traditional enterprise information and communication technology facilities to achieve many control tasks, for instance, using dynamic host configuration protocol (DHCP) to assign an IP address for thin client, leveraging internal domain name system (DNS) server to resolve local host names, and consulting authentication of user desktop sessions.
High-level figure describing the use case	
Derived requirements	– Single sign-on access control – QoE – Standard video codec support – Support of DaaS client peripherals – Standard security protocol support

Table III.2 – Customer service call centre

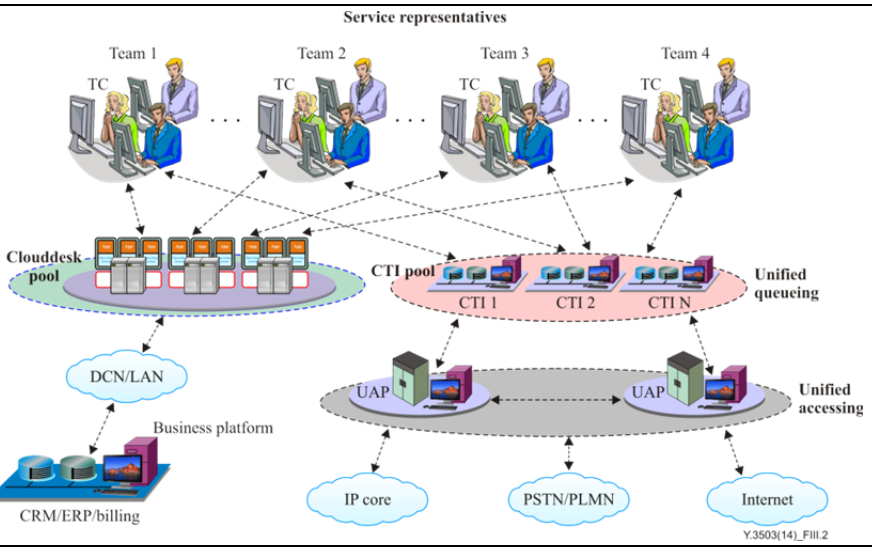
Legend	Use case
Use case title	Customer service call centre
Use case description	Virtual desktop pool supports distributed deployment model and can be deployed in the cloud computing infrastructure as a service (IaaS) resource pool with the dynamic stretching of resources. By adopting cloud computing technology (virtualization, distributed computing and storage, cluster, etc.) to consolidate queuing resource and desktop resources, unified phone call dispatching and delivery and maintenance of the desktop can be achieved in an intensive way.
High-level figure describing the use case	
Derived requirements	– Unified management interface – Automated scriptable management interface – Diversity of DaaS client

Table III.3 – Scenario of DaaS user

Legend	Use case
Use case title	Scenario of DaaS user
Use case description	Scenario of DaaS user is driven by a specific class of user. Common user types that benefit from DaaS are mobile workers, task workers (such as factory floor and call centre workers), contractor/offshore workers, and remote workers in branch offices. • Mobile workers: If an organization needs to support employees who are mobile, work from home or work from the road, a DaaS solution can enable employee productivity anywhere and increase effective user collaboration without compromising security. DaaS can offer secure access to desktops and applications over low-bandwidth connections without requiring new applications to be distributed to DaaS users. Employees will see a consistent set of applications and can access their own data regardless of location. If employees need access to a comprehensive desktop experience, they can be assigned a personal virtual desktop within the confines of the corporate data centre. This improves the DaaS offering available to users while keeping the environment securely managed. With the wide adoption of third-generation (3G) wireless networks, users are even more capable of experiencing a full-fidelity desktop remotely.

Table III.3 – Scenario of DaaS user

Legend	Use case
	• Task workers: If an organization includes structured task workers, such as in call centres and retail branches, DaaS can provide a more cost-effective and productive user experience because these user roles do not typically need access to multiple applications to complete business processes. Additionally, there are situations when the location is simply not capable of supporting a fully functioning client computer; instead, thin-client solutions are more applicable. The same experience can be provided even if the client computer is a legacy computer. This type of deployment can extend the reach of applications within the enterprise and is a valuable way to deliver the right business tools in a cost-effective way. • Contractor/Offshore workers: Many companies are leveraging workforce experience from around the world. Organizations will need to provide access to applications for users located both remotely and internationally. In order to provide access to resources while respecting corporate policies, providing a virtual desktop or virtual desktop pool becomes very attractive for organizations. This allows users to receive a first-class client on the network while allowing the organization to control where the virtual desktop is running, how the virtual desktop is accessed, how data is being run on the client computer and where data is stored. • Remote workers in branch offices: In an environment that relies on remote or branch offices, DaaS can provide enhanced capabilities to these sites and reduce the network bandwidth that the required applications use. For example, a bank might have essential financial software applications that would not be cost-effective to deploy and maintain in every branch. With DaaS, the software can be available at a central headquarters and accessed as needed by employees in different locations. A centralized-applications strategy often results in a reduction of application server infrastructure at various branches or locations, requiring much less maintenance and on-site support from the home office information technology (IT) staff.
High-level figure describing the use case	
Derived requirements	– Single sign-on access control – Service continuity – Diversity of DaaS client – Managing and operating pre-configured environment – Maintaining DaaS user status – CSC environment backup – Standard transport protocols support

Table III.4 – Local resource usage

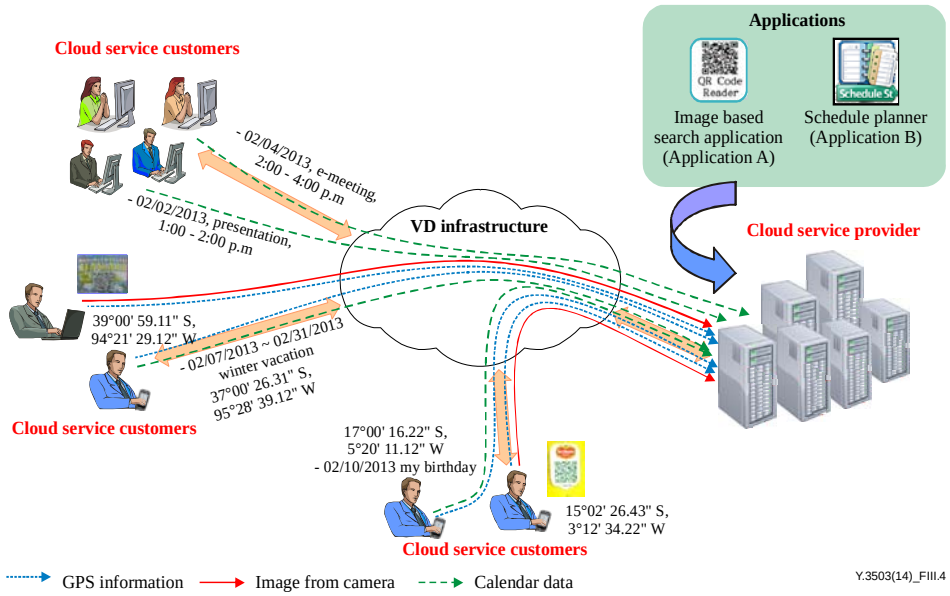
Legend	Use case
Use case title	Local resource usage
Use case description	In this scenario, an application hosted in a DaaS platform requires input from the local resources where a DaaS client is located, i.e., user terminal, to function properly. For instance, an image-based search application will require input from a camera on the terminal; the location based application may require GPS information from the GPS module running on the terminal; the schedule planner would require calendar data (meetings, task) from the terminal. For instance, Alice is using an application called "My locality" which provides a list of near-by attractions. This application makes use of GPS information, from the GPS module running in its host, to find the exact current user location. Since the application is being used remotely and hosted on the network, it needs the user terminal to provide its GPS information for the application to provide correct results (attractions near the user not near the server where the application is hosted). When Alice uses the application, local GPS data are sent to the server where they are used to provide correct results.
High-level figure describing the use case	
Derived requirements	– Support of DaaS client peripherals

Table III.5 – Service continuation for DaaS

Legend	Use case
Use case title	Service continuation for DaaS
Use case description	In this scenario, a consumer is using a particular DaaS. Due to network unavailability, the consumer gets disconnected from the DaaS platform. Later on and after network re-establishment, the consumer starts consuming the service from the same point where it got disconnected, enabling preservation of all user data and settings. Flow: • When a disconnected session is noticed, the DaaS platform identifies the related CSC and the virtual desktop. • The DaaS platform checks if user has opted for service continuity, i.e., no loss reconnection.

Table III.5 – Service continuation for DaaS

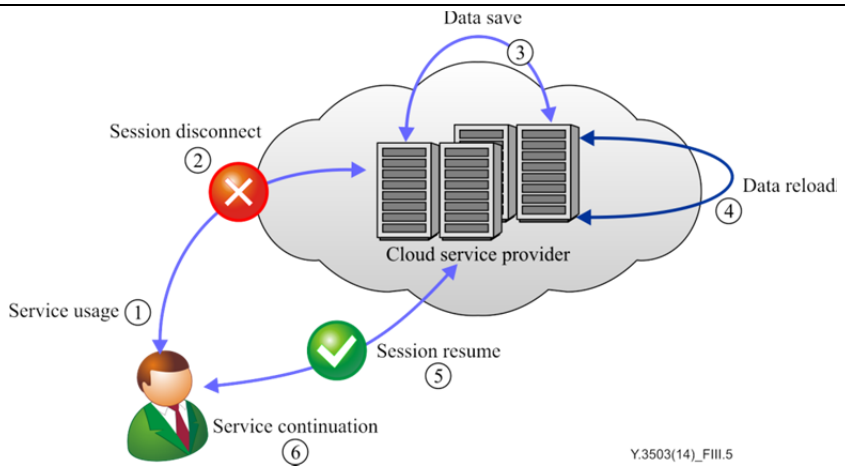
Legend	Use case
	• The DaaS platform saves the required data such as virtual machine data before releasing the resources. • On reconnection, the DaaS platform shall look for any saved data and reloads them before resuming the service.
High-level figure describing the use case	
Derived requirements	– Resiliency to disaster – Service continuity – Monitoring and controlling DaaS – Maintaining DaaS user status – CSC environment backup – DaaS client reconnection – Display redirection

Table III.6 – Home application using DaaS

Legend	Use case
Use case title	Home application using DaaS
Use case description	CSCs access the home applications and data hosted in virtual desktops which are created within a DaaS platform in home. This type of service can support a computer for multi-users with own virtual desktops in small area. CSCs can access their own virtual machine with any DaaS clients through a delivery protocol for virtual desktops in home. Since CSC's access is taken in local area in this application, a certain access protocol can be adopted for the dedicated network or the dedicated DaaS client. CSP can distribute the package for server management and installation to support configuration functions by on-line or off-line ways.

Table III.6 – Home application using DaaS

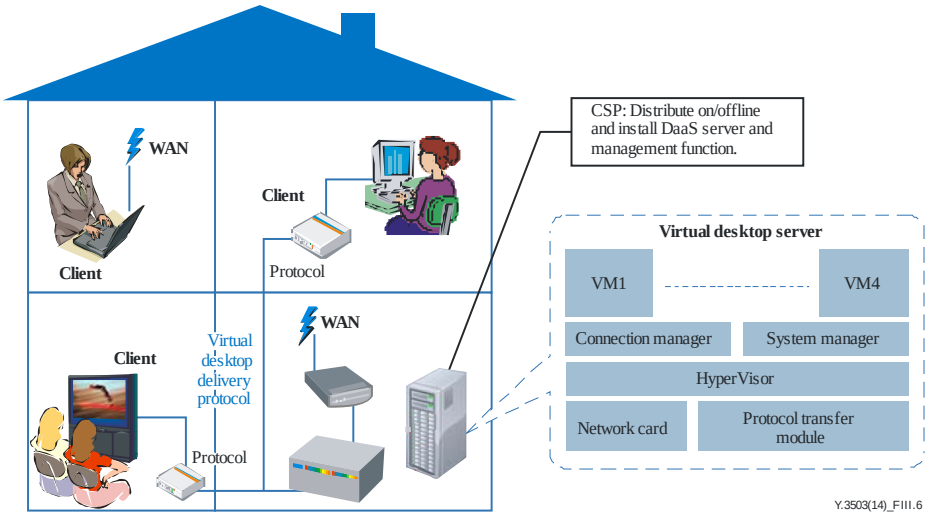
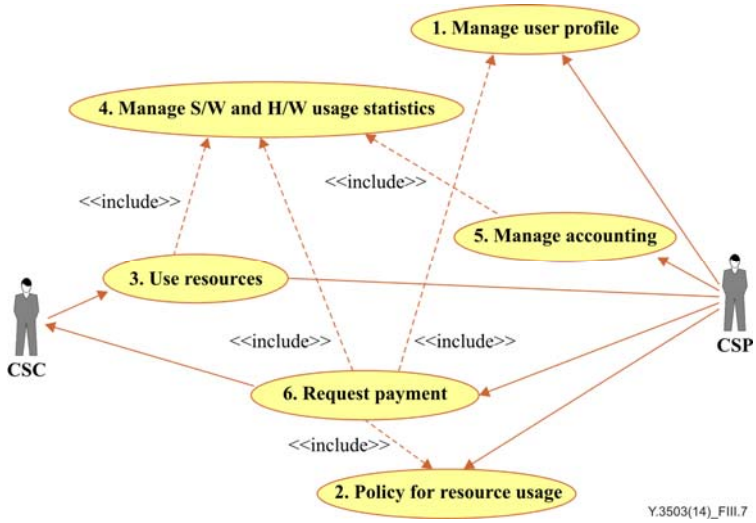
Legend	Use case
High-level figure describing the use case	
Derived requirements	– Unified management interface – Diversity of DaaS client – Optimized adaptation for content type – Dynamic configuration adaptation – Support of DaaS client peripherals

Table III.7 – Charging scheme for DaaS

Legend	Use case
Use case title	Charging scheme for DaaS
Use case description	This use case depicts the case where charging functionality is required in DaaS. The purpose of this use case is to show various environments of CSCs that use common resources provided by the same CSP. There are two actors in this diagram: CSC and CSP; they provide software and hardware. • The CSP needs to manage DaaS user profiles including the types of users. (#1 in figure). • As, depending on the type of users, the rate for using resource can be offered differently, the CSP manages the policy for resource usage. (# 2 in figure). • The CSC uses resources (#3 in figure) and the CSP manages software and hardware usage statics (#4 in figure). • The CSP manages accounting (#5 in figure) by monitoring software and hardware usage statistics (use case 3). The CSC can use storage, CPU and memory as in IaaS, and whenever an application (software) runs on CSP. DaaS also provides storage, CPU and memory. The CSP needs to store accounting information of software and hardware usage whenever the usage occurs. • Considering user profile, software and hardware usage statistics, and the policy of resource usage to reflect different types of usage, the CSP produces bills and requests payment to CSCs (#6 in figure).

Table III.7 – Charging scheme for DaaS

Legend	Use case
High-level figure describing the use case	
Derived requirements	– Accounting and charging – User account provisioning – User profile management – Server-side platform hardware resource maintenance – Service-related resource maintenance – Status monitoring – System load monitoring – Support for HD and 3D applications – Extensible storage – Resource request – User log management

Appendix IV

Value for response time limit

(This appendix does not form an integral part of this Recommendation.)

The response time is specified in clause 7 as a general requirement for DaaS. The value of the response time-limit is needed in order to meet the CSC's acceptable QoE.

This appendix only provides general information relevant to response time. However, the response time described in here is not specific to cloud computing and DaaS.

Figure IV.1 shows a response time model [b-Shneiderman].

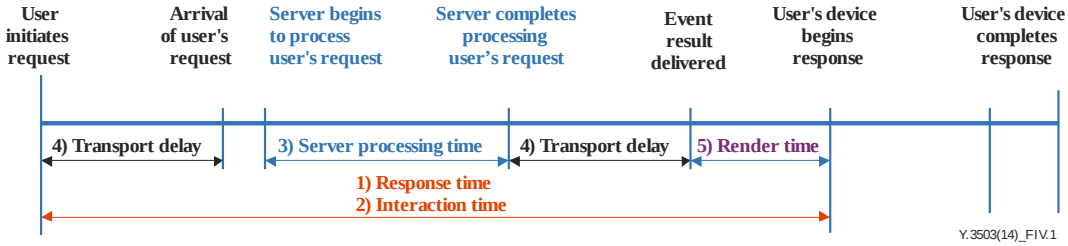


Figure IV.1 – Model of response time

As shown in Figure IV.1, the response time includes transport delays, server processing time and rendering time on a client as defined hereafter:

- Response time: An interval from the moment when user initiates an activity until that user's device begins to present its result on the display;
- Interaction time: The same as response time;
- Transport delay: An interval from the moment when user's request is sent until it is received by a server or the time from the moment a server sends;
- Server processing time: Operation time used by a server to process the user's request;
- Rendering time: Duration for generating an image with the received event results screen on the user's device.

Values for acceptable response times may differ depending on the use case, but experimental studies show that a user starts to be bored or interrupts if there is no response within one second [b-Tolia]. It seems common that users are intolerable if the reaction time takes more than one second.

As shown in Table IV.1 [b-Tolia], in the range from 150 ms to one second users become increasingly aware of the response time, and unhappy after one second.

Table IV.1 – Impact of interactive response time [b-Tolia]

Response time	Subjective impression
< 150 ms	Crisp
150 ms to one second	Noticeable to annoying
One to two seconds	Annoying
Two to five seconds	Unacceptable
Longer than five seconds	Unusable

Appendix V

Service provisioning based on CSC types in DaaS

(This appendix does not form an integral part of this Recommendation.)

This appendix describes the service provisioning based on the various types of cloud service customers. Also, several considerations of the overall service provisioning for DaaS according to the user accounting provisioning are described.

V.1 Types of cloud service customer

In DaaS, various types of CSC can exist and there are many types of service provisioning according to the type of CSC. Therefore, the classification of CSC is categorized as below:

- Classification based on service level – The CSC can be classified with the various types of service level agreement (SLA).
- Classification based on virtual desktop environment – The CSC can be classified depending on the types of virtual desktop environment. For example, some CSCs can be serviced with a virtual desktop with OS desktop in itself, and others can be serviced with a web application of virtual desktop. Also, this is related with the type of virtual desktop.
- Classification based on the allocation of the virtual desktop environment – A CSC can be served with the permanently allocated virtual desktop environment, while others can be served with a temporary virtual desktop in a virtual desktop pool.
- Classification based on the demand of resources – A CSC can be served with the virtual desktop environment of the predefined configuration or the pre-set virtual image, while others can be served with the virtual desktop environment using CSC manual configuration and resource management.

V.2 User account provisioning based on CSC types in DaaS

In clause V.1, the various types of CSC are classified. User account provisioning could be implemented in accordance with these types of CSC, and user account should also be provisioned in accordance with service provisioning in DaaS. In general, CSC can request the account in order to use a virtual desktop environment. CSC can be registered by an administrator on the CSP side or the CSC can register the account automatically. The types of user account provisioning for DaaS are listed below.

- Discretionary account provisioning – This account allows administrators to decide for themselves. This approach can be applied to the small office or home application.
- Self-service account provisioning – This account allows the CSC to participate in some aspects of the provisioning process in order to reduce the administrator's overhead and to quickly supply the virtual desktop environment to the CSC according to the manually requested resources (such as the number of CPU, amount of memory, amount of hard disk resources etc.).
- Workflow-based account provisioning – This account obtains the approvals from the designated approvers before CSC access. Also, this approach can supply the virtual desktop environments to the CSCs according to the service level with a prior approval.
- Automatic account provisioning – This requires every account to be added, using one same method, with a centralized management application or data by using the predefined procedures.

V.3 Service provisioning in DaaS

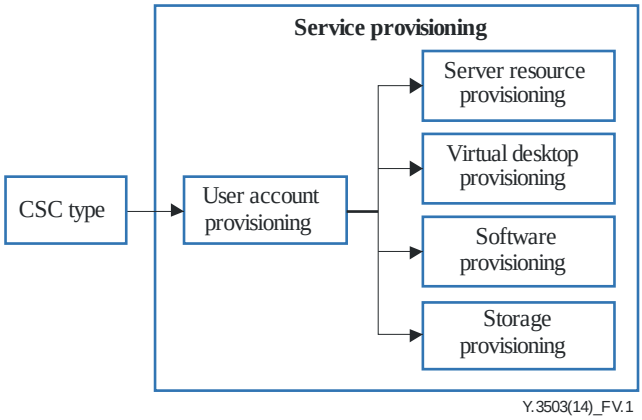


Figure V.1 – Service provisioning in DaaS system

As shown in Figure V.1, service provisioning is the design or modification of DaaS configuration to meet the various types of CSC. All types of CSC try to connect their virtual desktop environment with the client and the CSP provides the service in accordance with these types. Service provisioning consists of the following:

- Account provisioning: It makes and manages the CSC account with regard to CSC type.
- Server and resource provisioning: It supplies or manages hardware resources that are requested from the CSC.
- Virtual desktop provisioning: It generates, supplies and manages the virtual desktop environment to be allocated to the CSC.
- Software provisioning: It installs, manages or updates the software in the DaaS platform and virtual desktop environment.
- Storage provisioning: It manages and backs up offline files of virtual machine, user data and other storage-related files related to virtual desktop environment.

Bibliography

[b-ITU-T H.264] Recommendation ITU-T H.264 (2014), *Advanced video coding for generic audiovisual services*.

[b-ITU-T H.265] Recommendation ITU-T H.265 (2013), *High efficiency video coding*.

[b-ITU-T Y.2201] Recommendation ITU-T Y.2201 (2009), *Requirements and capabilities for ITU-T NGN*.

[b-ITU-T Y.2701] Recommendation ITU-T Y.2701 (2007), *Security requirements for NGN release 1*.

[b-ITU-T FGCC1] ITU-T Focus Group on Cloud Computing Technical Report (2012), *Part 1: Introduction to the cloud ecosystem: definitions, taxonomies, use cases and high-level requirements.*

[b-ITU-T FGCC2] ITU-T Focus Group on Cloud Computing Technical Report (2012), *Part 2: Functional requirements and reference architecture.*

[b-IETF RFC 768] IETF RFC 768 (1980), *User Datagram Protocol*.

[b-IETF RFC 793] IETF RFC 793 (1981), *Transmission Control Protocol*.

[b-IETF RFC 6101] IETF RFC 6101 (1996), The S*ecure Sockets Layer (SSL) Protocol Version 3.0*.

[b-IETF RFC 6347] IETF RFC 6347 (2012), *Datagram Transport Layer Security Version 1.2*.

[b-DMTF OVF] DMTF Standard DSP0243 (2009), *Open virtualization format specification*.

[b-W3C-HTML5] W3C, *A vocabulary and associated APIs for HTML and XHTML*, Available at http://www.w3.org/TR/html5/ .

[b-Shneiderman] Ben Shneiderman (1984), "*Response Time and Display Rate in Human Performance with Computers*", ACM Computing Survey, Vol. 16, pp. 265-285.

[b-Tolia] Niraj Tolia, David G. Andersen, and M. Satyanarayanan (2006), "*Quantifying Interactive User Experience on Thin Clients*", Computer, Vol. 39, Issue. 3, pp. 46-52.

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	Transmission systems and media, digital systems and networks
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
Series L	Construction, installation and protection of cables and other elements of outside plant
Series M	Telecommunication management, including TMN and network maintenance
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Terminals and subjective and objective assessment methods
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks, open system communications and security
Series Y	**Global information infrastructure, Internet protocol aspects and next-generation networks**
Series Z	Languages and general software aspects for telecommunication systems

Printed in Switzerland
Geneva, 2014