

Recommendation **ITU-T H.431.1 (01/2024)**

SERIES H: Audiovisual and multimedia systems

Infrastructure of audiovisual services – Telepresence,
immersive environments, virtual and extended reality

Functional architecture for cloud virtual reality systems

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Recommendation ITU-T H.431.1

Functional architecture for cloud virtual reality systems

Summary

Recommendation ITU-T H.431.1, together with its related Recommendation ITU-T F.746.14, specifies the functional architecture of cloud virtual reality systems. It describes the overall functional architecture including control layer, resource layer, network layer, terminal layer, operation, administration and management, and security. This Recommendation also describes the basic functions of each layer, such as unified scheduling/technology integration/content distribution of the control layer, cloud-based operation on the resource layer and high-quality transmission by the network layer. The cloud virtual reality (VR) content can be run concurrently based on the cloud and is distributed to the terminal for presentation.

History *

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Cloud virtual reality, functional architecture, virtual reality.

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Recommendation ITU-T H.431.1

Functional architecture for cloud virtual reality systems

1 Scope

This Recommendation specifies the functional architecture for cloud virtual reality systems, and includes an overview of the functional architecture for cloud virtual reality systems as well as a description of the respective functions.

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 F.746.14] Recommendation ITU-T F.746.14 (2022), *Requirements and reference framework for cloud virtual reality systems*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

3.1.1 operations latency [ITU-T F.746.14]: The time it takes for the entire process from the terminal issuing a control command to the application content responding to the operation request and completing output.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AAC	Advanced Audio Coding
AI	Artificial Intelligence
APP	Application
AVI	Audio Video Interleave
AVS3	Audio Video Coding Standard 3
CDN	Content Delivery Network
CMAF	Common Media Application Format
CPU	Central Processing Unit
DRB	Data Radio Bearer
FMP4	Fragmented MP4

FOV	Field of View
gNB	The Next Generation Node B
GPU	Graphics Processing Unit
HTTPS	Hypertext Transfer Protocol Secure
IPsec	Internet Protocol Security
L2TP	Layer 2 Tunnelling Protocol
MP3	Moving Picture Experts Group Audio Layer III
MPEG	Moving Pictures Experts Group
OA&M	Operation, Administration and Management
OMAF	Omnidirectional Media Application Format
OpenVPN	Open Virtual Private Network
PPTP	Point-to-point Tunnelling Protocol
QoS	Quality of Service
RTMP	Real Time Messaging Protocol
SFTP	Secure File Transfer Protocol
SLA	Service Level Agreement
SRT	Subrip Text
STL	Standard Template Library
TSP	Truncated Square Pyramid projection format
VR	Virtual Reality
WAV	Waveform Audio File
Webvtt	The Web video text tracks format

5 Conventions

None.

6 Overview

With the concept of the metaverse rising, virtual reality (VR) as one of the basic technologies, has attracted more and more attention from the industry. VR technology is the basis for the construction of panoramic, three-dimensional and smooth interactive digital scenes in the metaverse. For the real-time multi-user remote online interactions and VR applications with large amounts of computation, the cloud mode or cloud operation and terminal collaboration is an optimal way to realize them. Therefore, cloud VR will undertake more and more important tasks for the VR ecosystem.

Cloud VR, which is based on cloud architecture and utilizes cloud capabilities, can effectively shield terminal differences, reduce the difficulty of application development, lower some specific industry entry barriers and promote the industry business chain cooperation.

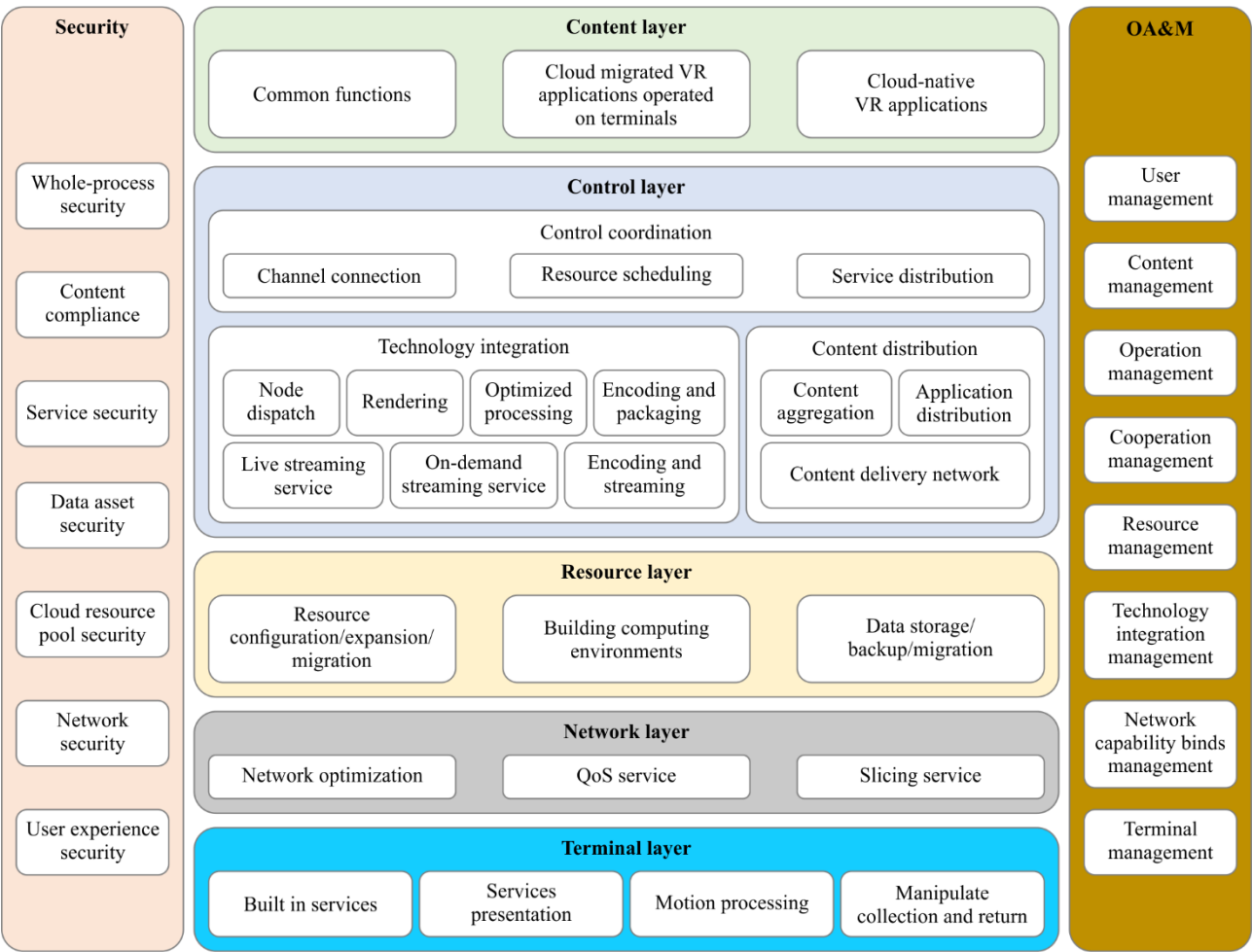
[ITU-T F.746.14] provides a reference framework and basic requirements for cloud VR systems. Based on them, it is necessary to analyse more systematically the functional architecture of cloud VR systems.

Cloud VR systems are the end-to-end service mode of VR based on cloud. Cloud VR systems are achieved based on unified resource and capacity control scheduling, operation, administration and management (OA&M) and security management, cloud resource computing power supply, low latency, high bandwidth and high security network transmission, and terminal's presentation. It is necessary to clarify the functional architecture of cloud VR systems, including the overall architecture of cloud VR systems and the functional components of cloud VR services.

This Recommendation can lay the foundation of functional architecture for other related standards of cloud VR systems.

7 Functional architecture for cloud virtual reality systems

The functional architecture for cloud VR systems is illustrated by Figure 7-1.



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Figure 7-1 – Functional architecture for cloud VR systems

The main function of the content layer of cloud VR systems is to support the common functions and the cloud-based operation of VR applications. From the perspective of operation modes, cloud VR applications mainly include cloud migrated VR applications operated on terminals and cloud-native VR applications.

- Cloud migrated VR applications operated on terminals are VR applications installed, loaded, operated, manipulated and displayed in the software and hardware environment of a VR terminal for the purpose of local operation of the VR terminal. To realize cloud-based operation, such VR applications need to carry out operation adaptation to cloud software and

hardware resource pool, data encapsulation / remote distribution of operation results, and acquisition / response to terminal remote control.

- Cloud-native VR applications run natively in the cloud, which can effectively connect with common cloud operating environments, and its installation, loading, operation and other related processes can effectively adapt to cloud resources and application data sharing mechanisms. It can effectively improve the utilization of cloud software and hardware resources, and has the advantage of content data resource sharing. Cloud-native VR applications also need to have access to remote control acquisition / response with the terminal side.

The control layer provides the functions of control coordination, technology integration, content distribution, etc.

- The control coordination schedules the resource layer including resources like cloud computing power resources according to the cloud VR operation requirements, completes the docks and distribution of various channels of cloud VR services, and connects the cloud VR terminal to realize remote manipulation mapping.
- The technology integration provides various cloud operation capabilities, including two scenarios named video-based scenarios and graphics service-based scenarios, corresponding to cloud VR weak interaction scenarios and strong interaction scenarios respectively. On the video-based scenarios, it involves services including real-time online live broadcast and offline on-demand through adaptive transcoding and encapsulation between different audio and video formats according to different applications' characteristics and terminal requests. Video-based scenarios generally belong to the category of weak interaction scenarios but can also be reflected in some strong interaction scenarios or strong and weak compatible scenarios. On the graphics service-based scenarios, it includes the nearest, efficient and reliable online operation for terminal users through the cloud-side coordinated service node dispatch as online graphics rendering, encoding and streaming, then the media processing results (such as graphics and sound) with audio and video mode transmitting to terminals.
- The content distribution function is a cross function of video-based scenarios and graphics service-based scenarios, which provides content transmission services bridging cloud side and terminal side based on different distribution channels, such as content aggregation, application distribution. At the same time, as one function of content distribution, the content delivery network is necessary for video-based scenarios.

The resource layer provides computing power for cloud VR based on cloud resource pools. It builds computing environments such as virtual machines, containers or application virtualization to operate on cloud-based VR functions. At the same time, it provides the functions of resource configuration/expansion/migration and data storage/backup/migration which can adapt to changes in operating conditions.

The network layer provides the communication capabilities for cloud VR, such as quality of service (QoS) service, slicing service, network optimization, etc.

The terminal layer provides built-in services of cloud VR based on various terminal types such as VR mobile phone, VR all-in-one machine and VR split machine, such as cloud VR service clients/applications (APPs), plug-ins/SDKs, etc. It also provides service presentation on the terminals and collects manipulations of the terminals to return the control layer.

The OA&M provides centralized operating, management and maintenance functions of cloud VR, such as the managements of content, user, technology integration, operation, resource, network capability docks and terminal.

The security of cloud VR provides multi-dimensional security mechanisms, such as the securities of content, service, data, cloud resource pool, network and user experience.