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Recommendation

# ITU-T Y.3125 (09/2023)

SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities

Future networks

# Quality of service assurance requirements and framework for cloud gaming supported by the IMT-2020 network

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# Recommendation ITU-T Y.3125

## Quality of service assurance requirements and framework for cloud gaming supported by the IMT-2020 network


**Summary**

Recommendation ITU-T Y.3125 specifies quality of service assurance aspects for cloud gaming (CG) supported by the International Mobile Telecommunications-2020 (IMT-2020) network.

Recommendation ITU-T Y.3125 first provides an overview of CG supported by the IMT-2020 network and then specifies high-level requirements, functional requirements, and framework for CG with that support.



**History** *

| Edition | Recommendation | Approval | Study Group | Unique ID |
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**Keywords**

Cloud gaming, cloud-gaming centre, cloud-gaming edge, IMT-2020, QoS assurance.


* To access the Recommendation, type the URL https://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID.

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# Recommendation ITU-T Y.3125

## Quality of service assurance requirements and framework for cloud gaming supported by the IMT-2020 network

### 1 Scope

This Recommendation specifies quality of service (QoS) assurance requirements and a framework for cloud gaming (CG) supported by the International Mobile Telecommunications-2020 network (IMT-2020). This Recommendation provides:

- an overview;
- high-level requirements;
- functional requirements;
- a framework;
- security considerations.

### 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 G.1032] Recommendation ITU-T G.1032 (2017), *Influence factors on gaming quality of experience*.

[ITU-T Y.3076] Recommendation ITU-T Y.3076 (2020), *Architecture of ICN-enabled edge network in IMT-2020*.

[ITU-T Y.3101] Recommendation ITU-T Y.3101 (2018), *Requirements of the IMT-2020 network*.

[ITU-T Y.3106] Recommendation ITU-T Y.3106 (2019), *Quality of service functional requirements for the IMT-2020 network*.

### 3 Definitions

#### 3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

**3.1.1 cloud gaming** [ITU-T G.1032]: Cloud gaming is characterized by game content delivered from a server to a client as a video stream with game controls sent from the client to the server. The execution of the game logic, rendering of the virtual scene, and video encoding are performed at the server, while the client is responsible for video decoding and capturing of client input.

**3.1.2 IMT-2020** [b-ITU-T Y.3100]: Systems, system components, and related aspects that support to provide far more enhanced capabilities than those described in [b-ITU-R M.1645].

NOTE – [b-ITU-R M.1645] defines the framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000 for the radio access network.

**3.1.3 multi-access edge computing (MEC)** [b-ETSI GR MEC 001]: System which provides an IT service environment and cloud-computing capabilities at the edge of an access network which contains one or more type of access technology, and in close proximity to its users.

**3.1.4 quality of experience (QoE)** [b-ITU-T P.10]: The degree of delight or annoyance of the user of an application or service.

NOTE – Recognizing on-going research on this topic, this is a working definition which is expected to evolve for some time. (This note is not part of the definition.).

**3.1.5 quality of service (QoS)** [b-ITU-T P.10]: The totality of characteristics of a telecommunications service that bear on its ability to satisfy stated and implied needs of the user of the service (see [b-ITU-T E.800]).

**3.1.6 quality of service assurance** [b-ITU-T Y.3109]: Functionalities or mechanisms that enable service providers to make statements with a degree of confidence that the service meets the quality characteristics or objectives specified elsewhere.

## 3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

**3.2.1 cloud-gaming centre; CG centre**: A part of a cloud-gaming (CG) server located in the data network connected to IMT-2020 network to support global management functions of CG.

**3.2.2 cloud-gaming edge; CG edge**: A part of a cloud-gaming (CG) server located at the edge of IMT-2020 network for supporting computation-intensive and delay-sensitive functions of CG.

# 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

| | |
|---|---|
| AF | Application Function |
| AN | Access Network |
| CG | Cloud Gaming |
| CG-IMT2020 | Cloud Gaming supported by IMT-2020 network |
| CN | Core Network |
| E2E | End to End |
| IMT-2020 | International Mobile Telecommunications-2020 |
| MEC | Multi-Access Edge Computing |
| NACF | Network Access Control Function |
| NFR | Network Function Repository |
| NSSF | Network Slice Selection Function |
| PCF | Policy Control Function |
| RTT | Round-Trip Time |
| QoE | Quality of Experience |
| QoS | Quality of Service |
| RP | Reference Point |
| SMF | Session Management Function |
| UE | User Equipment |

| | |
|---|---|
| UPF | User Plane Function |
| USM | Unified Subscription Management |

## 5 Conventions

In this Recommendation:

The phrase "is required" indicates a requirement that must be strictly followed and from which no deviation is permitted, if conformance to this Recommendation is to be claimed.

The phrase "is recommended" indicates a requirement that is recommended but which is not absolutely required. Thus, this requirement need not be present to claim conformance.

The phrase "can optionally" indicates an optional requirement that 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 or service provider. Rather, it means the vendor may optionally provide the feature and still claim conformance with this Recommendation.

## 6 Overview

CG is characterized by game content delivered from a server to a client as a video stream with game controls sent from the client to the server. The execution of the game logic, rendering of the virtual scene and video encoding is performed on the server, while the client is responsible for video decoding and capturing of client input [ITU-T G.1032]. CG shifts the computationally intensive graphics rendering and processing from the player client devices to network servers, which means that players do not need high-performance hardware, but only basic capacities for video decoding, video display and network connection. Figure 6-1 shows a generic framework for CG.

CG begins by collecting game controls or user interaction from the client. Then the user interaction and other relevant information is uploaded to the CG server via a network. The CG server contains powerful hardware to quickly perform the necessary computing and graphic rendering needed to create the video frames corresponding to control inputs by players. The rendered video frames are then sent to the player devices and decoded by them.

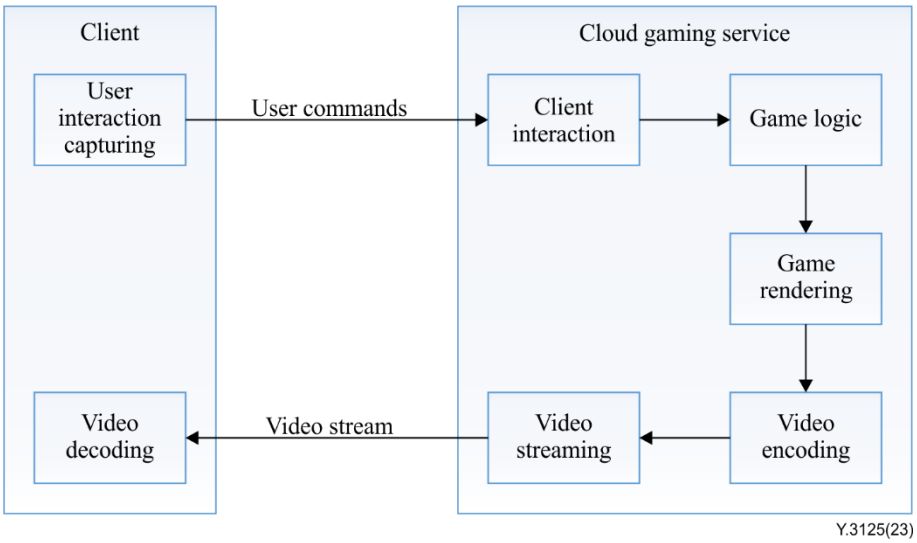


**Figure 6-1 – General concept of cloud gaming**

[ITU-T G.1032] presents a list of factors that may influence the QoE of CG. The influence factors are grouped according to origin: human; system; and context. Network transmission is one important

aspect of the system influence factor. Due to the highly interactive nature of CG, network distortion can negatively influence user experience. CG mostly suffers from latency, jitter, packet loss and insufficient bandwidth.

With the development of the IMT-2020 network and related technologies, such as network slicing and MEC, the network gains a high performance with low latency, high bandwidth, high reliability and high isolation, such performance meets the requirements of CG. CG is expected to take advantage of the low latency enabled by an IMT-2020 network and MEC to reduce the end-to-end (E2E) application level delay. When deploying a CG service, part of the functions can be deployed on the edge data network [ITU-T Y.3076] of the IMT-2020 network that contracts the distance between the user client and the gaming server, reduces the network latency and improves the CG experience.

Figure 6-2 shows a general framework for CG supported by an IMT-2020 network (CG-IMT2020), which consists of the CG client, CG edge and CG centre.

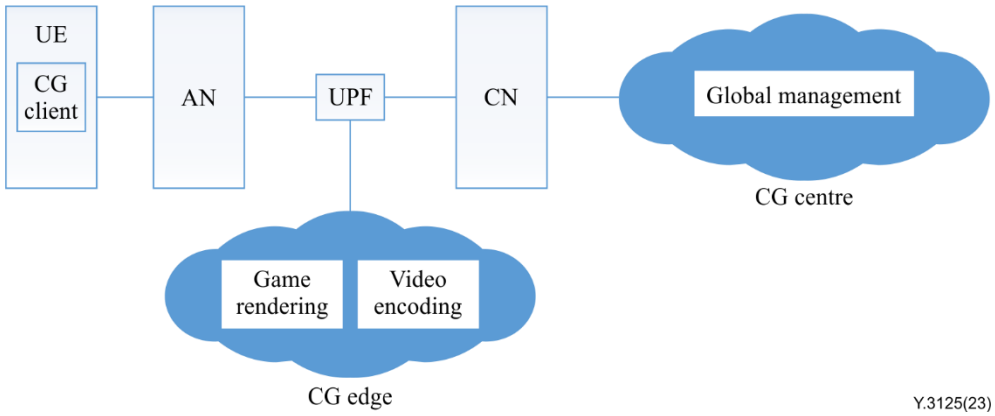


**Figure 6-2 – General framework for cloud gaming supported by an IMT-2020 network**

## 7 High level requirements

Since CG-IMT2020 is a vertical application of an IMT-2020 network, its QoS assurance is supported by the requirements and control mechanisms specified in [ITU-T Y.3101][ITU-T Y.3106]. Besides the common requirements, the CG-IMT2020-specific high level and functional ones for QoS assurance are specified in clause 7 and clause 8.

– CG-IMT2020 is required to assure the delay, bandwidth, jitter, and packet loss for CG.

– CG-IMT2020 is required to assure CG service scalability and reliability based on the collaboration between a CG centre and CG edge.

– CG-IMT2020 is required to assure mobility management of the CG edge.

## 8 Functional requirements

### 8.1 CG centre

– The CG centre is required to act as an IMT-2020 application function (AF) and to interact with the IMT-2020 policy control function (PCF) to exchange QoS subscription information. The subscription information may contain bandwidth, delay, jitter loss rate, etc.

– The CG centre is recommended to collect QoS data and report to the IMT-2020 PCF.

– The CG centre is required to perform global management functions (e.g., resource management).

– The CG centre is required to interact with CG-IMT2020 to customize the local shunting policies.

### 8.2 CG edge

– The CG edge is required to act as an IMT-2020 AF and to interact with IMT-2020 PCF to exchange QoS subscription information. The subscription information may contain bandwidth, delay, jitter loss rate, etc.

– The CG edge is recommended to collect QoS data and report to the IMT-2020 PCF.

– The CG edge is required to perform computation-intensive and delay-crucial functions (e.g., video encoding and game rendering).

– The CG edge is required to support video encoding and compression mechanisms to lower the network bandwidth requirement.

– Deployment of the CG edge is required at the edge of the IMT-2020 network close to the CG client.

– The CG edge is required to adjust video frame rate dynamically based on QoS monitoring data.

### 8.3 CG client

– The CG client is recommended to collect QoS data and report to the IMT-2020 PCF.

– The CG client is required to support local decoding and rendering to meet QoS assurance objectives.

### 8.4 Collaboration between CG centre and CG edge

– The CG centre is required to monitor the status of the CG edge.

– The CG centre is required to support dynamic scheduling and orchestration for the CG edge.

NOTE – Dynamic scheduling depends on the location of CG clients and the status of the CG edge.

## 9 Framework

Figure 9-1 shows the framework for CG supported by an IMT-2020 network. It consists of CG client (user equipment (UE)), CG edge and CG centre. A description of each part follows.

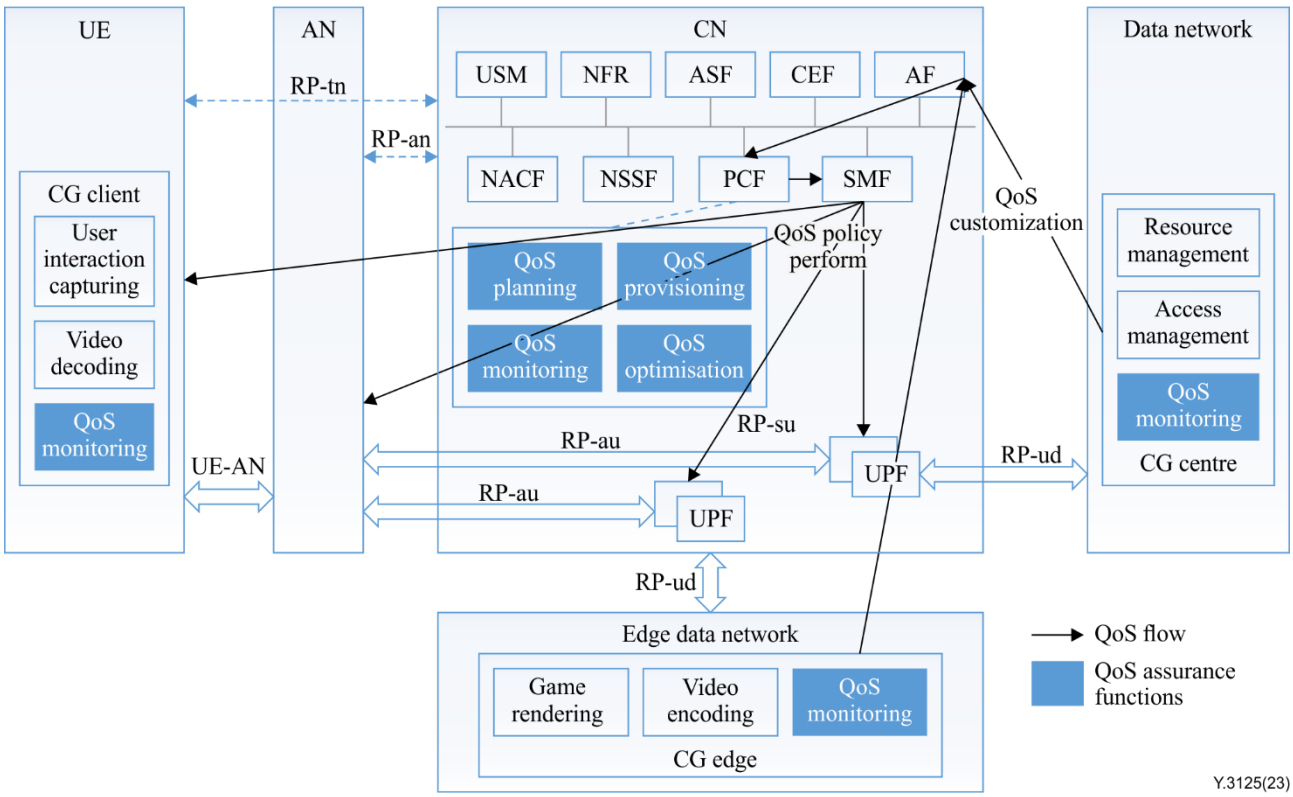


**Figure 9-1 – Framework for cloud gaming supported by IMT-2020**

– The IMT-2020 network exposes the QoS assurance-related network capabilities to the CG centre and the CG edge for QoS customization [b-ITU-T Y.3108] and supports E2E QoS control. The CG centre and CG edge act as an AF and may interact with the PCF in an IMT-2020 network for QoS customization in two ways:

i) with the PCF directly by acting as a trusted AF;

ii) with the PCF via the capability exposure function.

When the PCF receives QoS-related requests, it starts a new QoS flow or updates the existing QoS flow and the QoS policies are applied to the flow that spans the UE, access network (AN) and user plane function (UPF). The CG traffic is routed to the CG edge as local traffic and any other types of traffic is routed to the CG centre [b-ITU-T Y.3158].

– The CG client is thin, i.e., with basic hardware capacities. The CG client is responsible for:

i) decoding and displaying the video stream to CG players;

ii) capturing player interaction (input) and dispatch to the CG edge.

The CG client can also monitor and collect related QoS data and report to IMT-2020 PCF to optimize CG QoS. CG requires "playing everywhere", the CG client may move around and switch between different ANs or core networks (CNs).

– The CG centre is located in the data network and is responsible for global management functions, such as access and resources management; The CG centre acts as an AF in the IMT-2020 network and may interact with the PCF for QoS customization. The CG centre is also responsible for generating the traffic-steering policy applied on the UPF and selecting an appropriate CG edge. The CG centre can also collect QoS data and report to the IMT-2020 PCF to optimize CG QoS.

– CG edge is located at the edge near the CG client to reduce the round-trip time over the IMT-2020 network. It is managed by the CG centre and is responsible for game logic, video encoding and rendering, etc. The CG edge also collects CG QoS data and reports to the IMT-2020 PCF for QoS optimization.

– The CG centre and CG edge collaborates to support QoS assurance in mobility, scalability and reliability. When the CG client moves, based on the CG client location and the coverage of the CG edge, the CG centre schedules the serving CG edge on demand. The CG centre also interacts with the CG edge to acquire its status. It schedules or orchestrates the CG edge: more CG edge instances are created when the resource of the serving instances is insufficient. The serving instance is destroyed when it serves no CG client.

## 10 Security considerations

This Recommendation describes QoS assurance requirements and a framework for CG supported by the IMT-2020 network and general network security requirements and mechanisms in networks based on the Internet protocol and the IMT-2020 network should be applied [b-ITU-T Y.2701], [ITU-T Y.3101]. Security mechanisms, such as authentication, authority, accounting and encryption, should be adopted to ensure system security.

# Appendix I

## General quality of service considerations for cloud gaming

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

CG places substantial demands on a network in terms of delay, bandwidth, jitter, packet loss and mobility, for which QoS considerations are described as follows.

- Delay: This is time lag between the user command actions and the video refresh responses on the screen. Figure I.1 shows E2E delay in CG. The network requirements for CG depend largely on the desired quality of the video and gameplay experience. Since user input is sent from the client to the game server, this means that uplink delay must be as low and consistent as downlink delay. Smoothness of gameplay for the user depends on the number of video frames per second (fps) and delay. For example, while a 30 fps game requires a frame interval of 33.3 ms, a 60 fps game requires one of 16.67 ms. More frames per second demand lower delays. The E2E delay including command collection, uplink user interaction, processing and rendering, downlink streaming and display needs to be less than or equal to the time duration of each video frame. Removing client and game server internal processing delays such as command collection, processing, rendering and display, the round-trip time (RTT) delay over an IMT-2020 system should be less than 5 ms for 60 fps [b-3GPP TR 22.842]. Furthermore, the RTT delay is more relaxed for 30 fps. The uplink will likely be a shorter process than downlink because less data needs to be sent from the device compared to the stream data sent on the downlink.

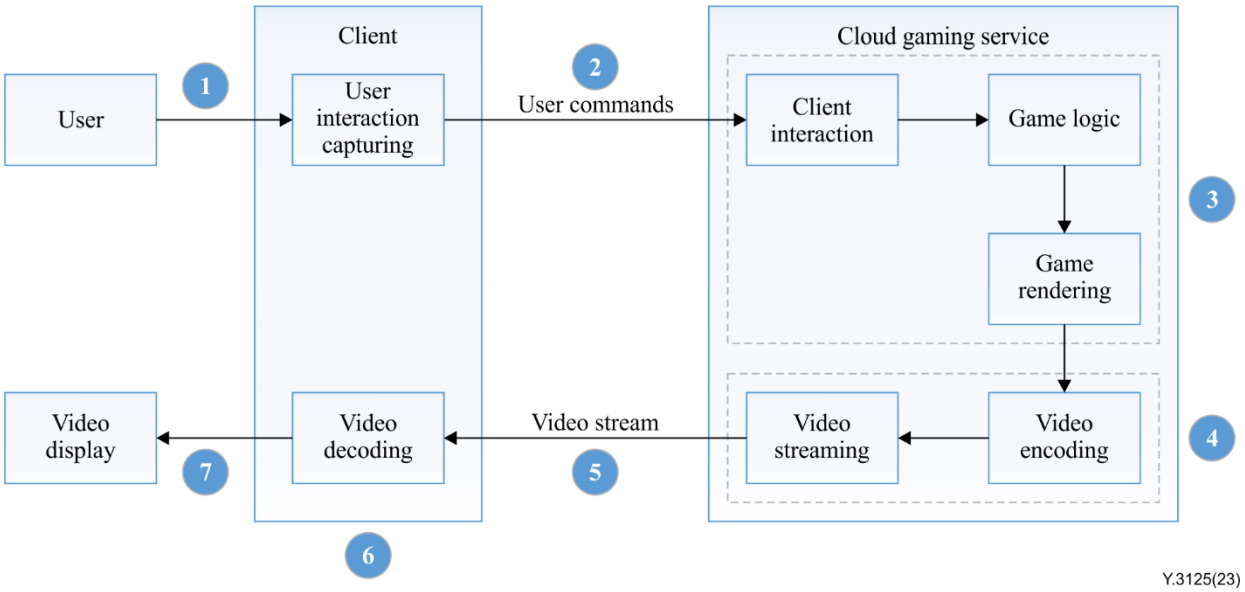


**Figure I.1 – End-to-end delay in cloud gaming**

List of components of E2E delay:

1. command data collection delay;
2. uplink transmission delay of user interaction;
3. delay in receiving, processing and rendering the picture;
4. graphic preparation delay;
5. downlink transmission delay of the video steam;
6. client decoding delay;
7. delay in displaying to the user.

- Bandwidth: Resolution in CG has a significant impact on the requirement for bandwidth and higher resolution usually offers a better user experience. When bandwidth is insufficient, packet loss or timeout retransmission of video streams can occur, which causes screen dullness and operation hysteresis. CG usually supports resolution such as 720 p and 1 080 p, higher resolutions 2K and 4K are also getting more popular since the IMT-2020 network provides high bandwidth. It is evaluated that 10 Mbit/s is required for 720 p, 30 Mbit/s is required for 1 080 p, 45 Mbit/s is required for 4K during the active part of CG ([b-Bell]). Besides resolution, many other factors can also affect requirements for network bandwidth, such as frame rate, compression algorithm and group of pictures. Often CG servers adjust video frame rate dynamically based on bandwidth and network round trip time.
- Jitter: E2E delay can vary from packet to packet, and the variation is referred to as delay jitter. Jitter determines the consistency of connection between the source and the destination. It has a perceivable influence on the CG experience because the client must receive, decode and display frames at a constant rate, and any late frames resulting from delay jitter can produce stuttering in game playback. While additional buffering can eliminate jitter in general streaming applications, but CG with high interactions and associated low E2E delay requires lower jitter.
- Packet loss: In CG, the effect of packet loss on the downlink is fragmentation of the video as well as keystroke loss on the uplink. A packet loss of 1% can very well compromise more than 20% of the picture in the video stream.
- Mobility: The user can enjoy CG services in high-speed mobile scenarios, such as in a high-speed train. As the user client connects to different ANs gradually, the delay with the original CG edge will increase. The client needs access to the appropriate CG edge based on user location in the IMT-2020 network.

# Appendix II

## General deployment use case

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

A general deployment of CG supported by IMT-2020 network is shown in Figure II.1. To meet the QoS requirement, CG service from a provider is divided into CG centre and CG edge. The CG edge is deployed in the MEC system provided by the network operator and the CG centre is deployed in the cloud from the service provider ([b-ITU-T Y.3500]). The UPF is deployed at the edge of the IMT-2020 network for better network performance; the CG traffic is routed as local traffic to the CG edge and any other types of traffic to the CG centre according to the local shunting policy, which is generated by the CG centre and sent to the IMT-2020 network.

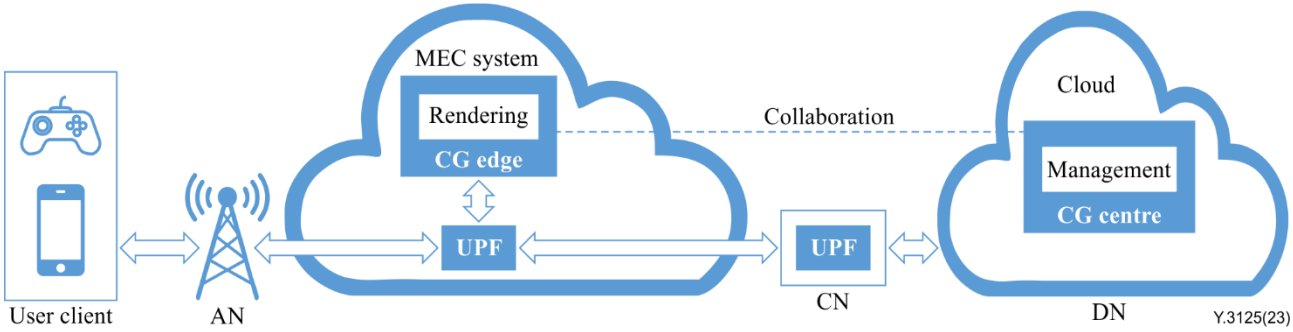


**Figure II.1 – General deployment of CG centre and CG edge**

Some essential collaboration issues between CG centre and CG edge for QoS assurance follow.

- The CG centre needs to collaborate with the CG edge for scheduling and orchestration of CG edge. For example, the game starts when the UE (players) sends a game access request to the CG centre. After receiving the request from the UE, the CG centre schedules the UE to an existing or new CG edge based on the location of UE and the status of MEC resources. When the UE is moving (e.g., on a high-speed train) and leaves the coverage of the MEC host or if the resources of the MEC host (e.g., network resource or computing resource) run out, the CG centre should shift the player to an appropriate CG edge to meet the QoS requirements. Also, as the number of players increases, the CG centre should be able to adjust or expand the availability of CG edge resources.

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