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SERIES F: NON-TELEPHONE TELECOMMUNICATION SERVICES

Multimedia services

Requirements for the cooperation of multiple edge gateways

Recommendation ITU-T F.743.13

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Recommendation ITU-T F.743.13

Requirements for the cooperation of multiple edge gateways

Summary

Recommendation ITU-T F.743.13 describes the requirements for a function that enables the cooperation of multiple edge gateways (CMEG) to complete complex tasks. It also describes the required capabilities and requirements of key components. The CEMG function can support the information exchanging among multiple edge gateways and deal with gateway failure cooperatively. It can also specify the central gateway which is responsible for selecting a cooperative gateway for each gateway, which in turn monitors the status of its partner gateway and manages the cooperative data and devices.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T F.743.13	2022-03-16	16	11.1002/1000/14954

Keywords

Cooperation, gateway failure, multiple edge gateways.

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FOREWORD

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Requirements for the cooperation of multiple edge gateways

1 Scope

This Recommendation describes requirements for a function that enables the cooperation of multiple edge gateways. This Recommendation covers the following:

– key components and functionalities;

– requirements of the cooperation of multiple edge gateways.

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

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

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 augmented reality [b-ITU-T J.301]: A type of mixed reality where graphical elements are integrated into the real world in order to enhance user experience and enrich information.

3.1.2 Internet of Things [b-ITU-T Y.2060]: A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

NOTE 1 – Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all kinds of applications, whilst ensuring that security and privacy requirements are fulfilled.

NOTE 2 – From a broader perspective, the IoT can be perceived as a vision with technological and societal implications.

3.1.3 network functions virtualization [b-ITU-T L.1361]: Principle of separating network functions from the hardware they run on by using virtual hardware abstraction.

3.1.4 quality of service [b-ITU-R BT.1833]: The collective effect of service performance which determines the degree of satisfaction of a user of the service.

3.1.5 virtual machine [b-ITU-T Q.1743]: A software program that simulates a hypothetical computer central processing unit. The programs executed by a virtual machine are represented as byte codes, which are primitive operations for this hypothetical computer.

3.2 Terms defined in this Recommendation

None

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AR Augmented Reality

CMEG Cooperation of Multiple Edge Gateways

IoT Internet of Things

NFV Network Functions Virtualization

QoS Quality of Service

VM Virtual Machine

5 Conventions

In this Recommendation:

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

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

6 Overview

With the technological development of user devices, such as smartphones, laptops, Internet of Things (IoT) devices, wearable devices and connected vehicles, many computationally intensive applications are emerging, such as face recognition, augmented reality (AR) services and self-driving [b-Pavel]. Due to limited computation and battery resources of user devices, cloud computing has been developed to provide computing power and storage to help user devices with their computationally sensitive applications. However, the long propagation latency between user devices to the cloud, limits the quality of service (QoS) for some latency-sensitive applications, for example, autonomous driving [b-Yuyi].

To reduce the response time and handle the rapidly increasing amount of data, it is a trend to offload some or all of the computing tasks to the edge network. Leveraging the computation resources and storage of gateways close to the user devices can provide high performance for computation-intensive and latency-sensitive applications. Using recent advancements in network functions virtualization (NFV), edge gateways can perform a service by creating a virtual machine (VM) for that service.

As shown in Figure 6-1, the cloud has vast computing resources but it is far away from the users, while edge gateways are much closer to the users and have a certain amount of computing resources. When there are large numbers of edge gateways in some scenarios, they can cooperate with each other to provide more computing resources to the users and help each other.

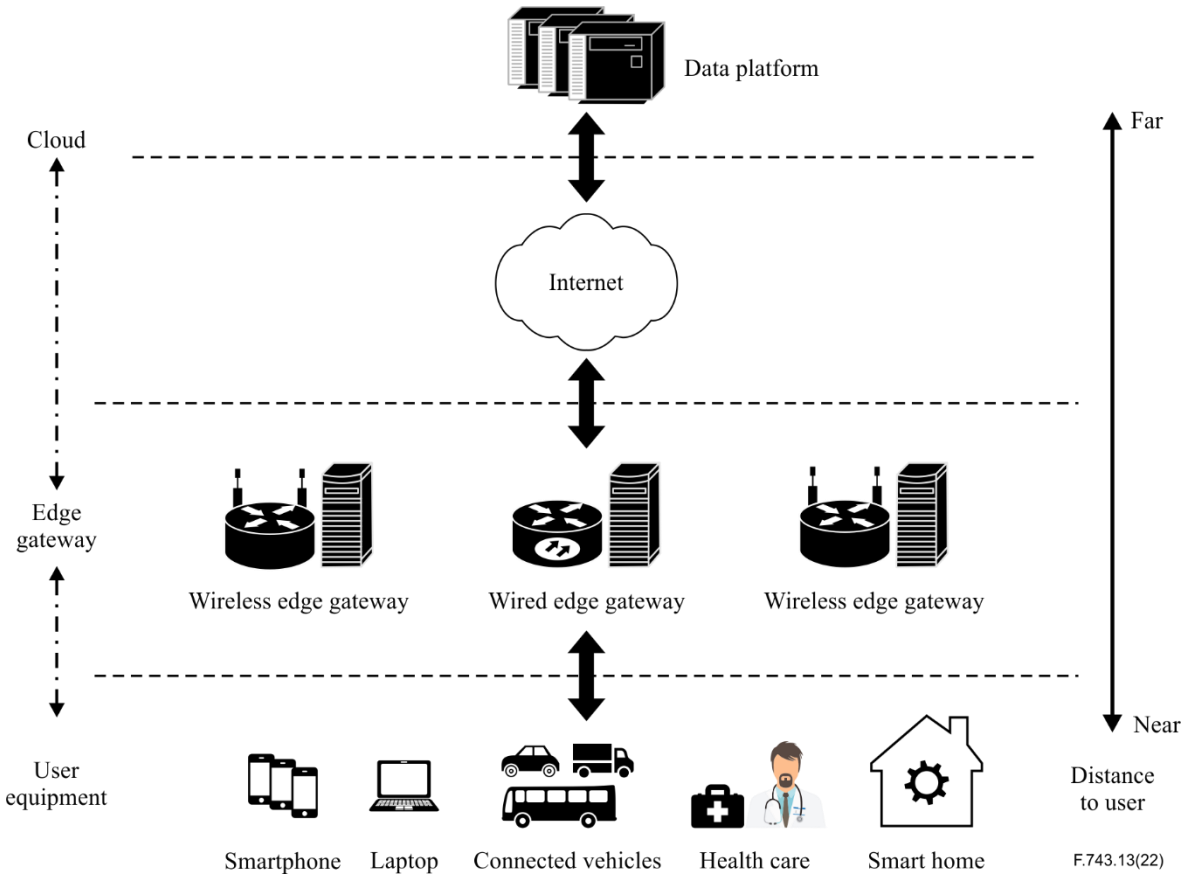

Figure 6-1 – An illustration of providing services using cloud and edge gateways

Four service scenarios are given in the appendix for informational purposes.

7 Key components of the CMEG function

This clause addresses the capabilities of the key components of the CMEG function.

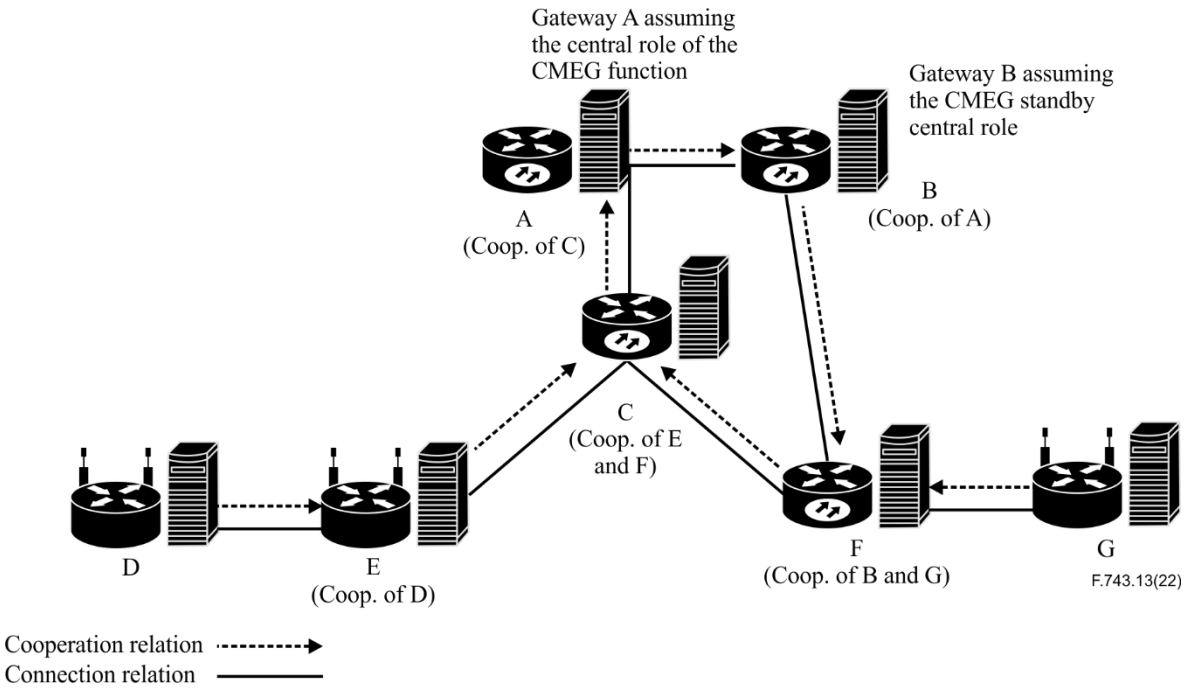

Figure 7-1 – Illustration of the CMEG function

Figure 7-1 shows an illustration of several edge gateways with CMEG function and each gateway connects to different user devices.

In this system, one edge gateway will take on the central role of the CMEG function and another gateway will take on the CMEG standby central role. These two gateways are selected based on their status, such as storage capacity, processing speed, average bandwidth, operating stability, and other parameters. The gateway assuming the central role will assign a cooperative gateway to each edge gateway based on the collected status of each edge gateway, such as location, energy situation, communication capability, etc. The cooperative gateway of an edge gateway is responsible for monitoring its status and backing up its data. For example, in Figure 7-1, E is the cooperative gateway for D and C is the cooperative gateway for E and F.

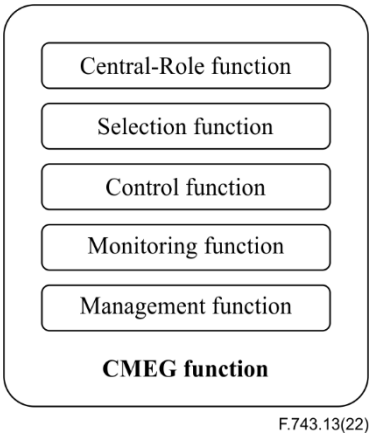

Figure 7-2 – Key components of the CMEG function

As shown in Figure 7-2, the core of the CMEG function is the gateway cooperation. To handle gateway cooperation, CMEG has four key functional units, namely, central role, selection, control, monitoring and management unit.

The central-role function is responsible for gathering various information about the edge gateways and assigning a cooperative gateway for each gateway.

The selection function is responsible for calculating its quality score, which represents its suitability for taking on the central role, based on the state of the gateway such as the parameters of its storage capacity, processing speed, average bandwidth and operating stability, and selecting appropriate gateways for the CMEG function, including identifying one gateway to assume the central role and another one for backup and assigning a cooperative gateway to each gateway.

The control function is responsible for controlling the cooperative relationship between gateways, including establishing/releasing the cooperative relationship.

The monitoring function is responsible for monitoring the activity status of the cooperative gateway.

The management function is responsible for managing the cooperative data and user devices of the cooperative gateway if necessary.

8 Requirements for CMEG

This clause addresses the requirements for CMEG.

8.1 General requirements

GEN-01: The CMEG function is required to support the exchange of information between multiple edge gateways, including control information and data.

GEN-02: The CMEG function is recommended to enable multiple edge gateways to cooperate on computational tasks.

GEN-03: The CMEG function is required to enable multiple edge gateways to cooperate in case of gateway failures.

GEN-04: The CMEG function is recommended to support the cooperative management of computing, storage, and communication resources across edge gateways.

8.2 Requirements for the central role function

CR-01: The central role function is required to gather various information about the edge gateways, including the connectivity relationships between them.

CR-02: The central role function is required to assign a cooperative gateway to each gateway. The selected cooperating gateway should meet the predefined requirements, e.g., distance requirements.

CR-03: The central role function is required to assign a new cooperative gateway for one gateway, if the previously assigned cooperative gateway fails for an extended period of time.

CR-04: The central role function is required to assign a new cooperative gateway to a gateway if the previously assigned cooperative gateway feeds back that it does not have enough resources to support cooperation.

8.3 Requirements for the selection function

SU-01: The selection function of each gateway is required to calculate its quality score.

SU-02: The selection function of each gateway is required to exchange its Q value with the neighbouring gateways.

SU-03: The selection function of each gateway is required to select one gateway that will assume the central role based on the Q values collected from all the neighbouring gateways, using a common policy and algorithm.

SU-04: The selection function of each gateway can optionally send Q values to a third party (e.g., a cloud platform), which will determine the gateways that will take on the central and standby roles.

8.4 Requirements for the control function

CU-01: The control function of each gateway is required to receive assignment instructions from a central role for its cooperative gateway.

CU-02: The control function of each gateway is required to establish a connection with its cooperative gateway assigned by the central role and inform the other party of its resource requirements.

CU-03: After receiving the resource requirements from its cooperative gateway, the control function of this gateway is required to determine whether to establish a partnership or refuse to establish a partnership, depending on its own resources.

CU-04: The control function of each gateway is required to request the central role to assign a new cooperative gateway if the previous one refuses to establish a partnership.

8.5 Requirements for the monitoring function

MU-01: The monitoring function of each gateway is required to monitor the active status of its cooperative gateway, actively or passively.

MU-02: The monitoring function of each gateway is required to inform the central role in time if its cooperative gateway is offline.

MU-03: The monitoring function of the central role is required to determine whether a gateway is temporarily offline or permanently offline.

8.6 Requirements for management function

MU-01: The management function of each gateway is required to back up the data of its cooperative gateway.

MU-02: The management function of each gateway is required to delete the backup data stored locally of its cooperative gateway at the request of the latter.

MU-03: In case its cooperating gateway is offline, the management function of this gateway is recommended to send backup data of its cooperative gateway to the data platform.

MU-04: In case its cooperating gateway is offline for an extended period of time, the management function of this gateway is recommended to negotiate with the devices originally managed by the cooperative gateway and if possible, become the gateway to which they are connected.

9 Security considerations

It is recommended that the security requirements of [ITU-T Y.2201], [ITU-T Y.2701], and applicable ITU-T X-series, ITU-T Y-series, and ITU-T M-series security Recommendations be taken into consideration, which includes access control, authentication, data confidentiality, communications security, data integrity, availability and privacy.

Appendix I

Scenarios

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

Four typical service scenarios are described here, in which multiple edge gateways cooperate with each other supported by the CMEG function defined in this Recommendation.

1. A service for one user is split into multiple sub-tasks which are accomplished by multiple edge gateways in collaboration, and the results of the sub-tasks are returned to the user.
2. A service requires data collected from multiple locations. The data is collected and pre-processed by multiple edge gateways, and the results are then sent to the data platform. For example, an environmental monitoring service needs to collect data from multiple locations. Multiple IoT devices are connected to several gateways. These edge gateways cooperate with each other to collect data and pre-process these data as required.
3. A service needs to collect data from one set of devices and needs to trigger another set of devices connected to another edge gateway. For example, a fire monitoring service collects data from smoke detectors. If the edge gateway determines that a fire has occurred, it needs to notify a fire door connected to another edge gateway, triggering a fire alarm and closing the door at the same time.
4. Many edge gateways work in store-and-forward mode where they collect and store data in advance and report it to the platform when needed. The collected data might be lost due to the failure of the edge gateway. If one gateway has one backup gateway, referred to as a cooperative gateway in this Recommendation, to back up the collected data, when it fails, its cooperative gateway will discover the failure and upload the backup data on its behalf.

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